Iapetus Scatterometry Rev 049

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- Sequence: s33
- Rev: 049
- Observation Id: ia_049_1
- Target Body: Iapetus

1 Introduction

This memo describes one of the Cassini RADAR activities for the s33 sequence of the Saturn Tour. A sequence design memo provides the science context of the scheduled observations, an overview of the pointing design, and guidlines for preparing the RADAR IEB.

This IEB is one of five for the third Iapetus distant scatterometer observation around Sep 09 2007. The usual warmup parameters are used during the first three hours as shown in table 4

2 CIMS and Division Summary

CIMS ID	Start	End	Duration	Comments
049OT_WARMUP4IA003_RIDER	2007-252T02:10:00	2007-252T04:55:00	02:45:0.0	Warmup for scatterometry and simultaneous radiometry of icy satellite.
049IA_SCATTRAD003_PRIME	2007-252T04:55:00	2007-252T09:50:00	04:55:0.0	Point -Z axis at target and execute raster scan(s) centered on target. Obtain simultaneous scatterometry and radiometry.

Table 1: ia_049_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.

Division	Name	Start	Duration	Data Vol	Comments
a	distant_warmup	00:00:0.0	02:45:0.0	9.8	Warmup
b	distant_warmup	02:45:0.0	00:06:0.0	0.4	Warmup
c	distant_radiometer	02:51:0.0	01:14:0.0	4.4	Saturn Engineering Tests
d	distant_radiometer	04:05:0.0	01:05:0.0	3.9	Radiometer fill
e	distant_radiometer	05:10:0.0	01:37:12.0	5.8	Radiometer for Iapetus Raster
f	distant_scatterometer	06:47:12.0	00:17:48.0	213.6	Scatterometer target-center stare with tone
g	distant_scatterometer	07:05:0.0	00:05:0.0	60.0	Scatterometer target-center stare with tone
h	scat_compressed	07:10:0.0	00:10:0.0	2.6	Scatterometer on to off-target receive only compressed
i	distant_radiometer	07:20:0.0	00:10:0.0	0.6	Radiometer during final stare and turn to waypoint
Total				301.0	

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	302919	off target	1.37	off target
b	279787	off target	1.26	off target
c	278946	off target	1.26	off target
d	268568	off target	1.21	off target
e	259450	off target	1.17	off target
f	245813	245813	1.11	110
g	243316	243316	1.10	109
h	242614	242614	1.09	108
i	241211	off target	1.09	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	165.0	no	
time_step (s)	varies	2700.0	no	Used by radiometer only modes - saves commands
bem	00100	11111	yes	
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: ia_049_1 Div a distant_warmup block

Name	Nominal	Actual	Mismatch	Comments
mode	radiometer	radiometer	no	
start_time (min)	varies	310.0	no	
end_time (min)	varies	407.2	no	
time_step (s)	varies	1800.0	no	Used by radiometer only modes
bem	00100	00100	no	
baq	don't care	5	no	
csr	6	6	no	
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	6	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	starting value for auto-rad
max_data_rate	0.992	0.992	no	1 Kbps - 1 s burst period which is adequate for slow radiometer scans
interleave_flag	off	off	no	
interleave_duration (min)	don't care	10.0	no	

Table 5: ia_049_1 Div e distant_radiometer block

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.

3 Radiometer Scans

Div E supplies radiometer parameters for 1-second integrations during the raster scan of Iapetus. The raster scan can be processed into a calibrated brightness temperature for the disk.

4 Receive Only Engineering Test Measurements

Before the target observation, this data take performs a series of receive only measurements in all four bandwidth modes, and with various attenuator settings while the spacecraft sweeps the central beam back and forth across Saturn.

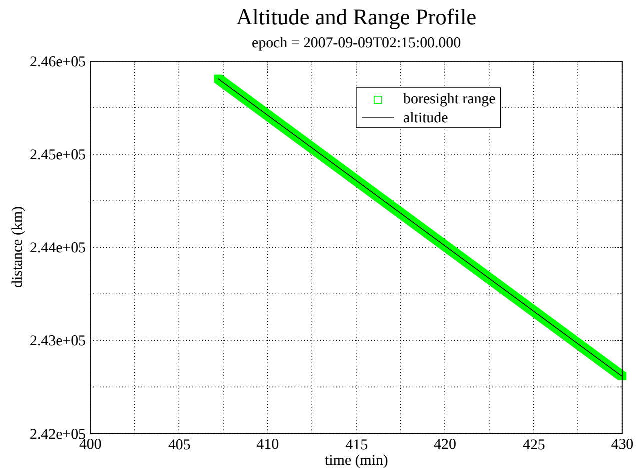

Figure 1: Div F,G: Altitude and range to the boresight point

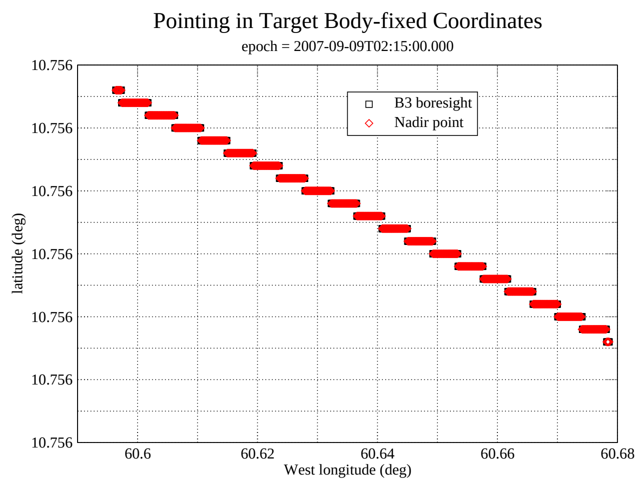

Figure 2: Div's F,G: Stare in target body-fixed coordinates

These data can then be used to assess system gain and stability. A mixture of compressed mode data, and 8 bit straight data are collected. About one half of the total data volume is used in this part of the data collection.

After the actual scatterometer integration, one measurement will be collected in receive only mode while slewing off of the target. This measurement lasts 10 minutes and uses the compressed mode to acquire a solid noise measurement without using much data volume. These measurements can then be used to determine system gain and receiver noise temperature for the scatterometer mode right before the actual target measurement. The division PRF and number of pulses (1202 Hz and 150 respectively) are chosen to fill the science data buffer. These parameters give the best performance possible from the compressed mode. The parameters are shown in table 6.

5 Div's F-G: Scatterometry

Iapetus is 718 km in radius, Figures 1 and 2 show the pointing design for the scatterometry stare from the merged ckernel. The angular size of the target is about 5.4 mrad during this division. The beam 3 beamwidth is 6 mrad and a single point stare is used.

Name	Nominal	Actual	Mismatch	Comments
mode	scat_compressed	scat_compressed	yes	
start_time (min)	varies	430.0	no	
end_time (min)	varies	440.0	no	
time_step (s)	don't care	20.0	no	Set by valid time calculation
bem	00100	00100	no	
baq	3	3	no	3 - PRI summation
csr	1	1	no	0 - normal operation with fixed attenuator set to match Phoebe for easier cross-calibration
noise_bit_setting	4.0	4.0	no	9 dB setting used by all low SNR scatterometry
dutycycle	0.70	0.38	yes	
prf (Hz)	1200	1200	no	Set with num pulses to fill science data buffer
tro	don't care	6	no	automatically set to 6
number_of_pulses	150	150	no	Set with the PRF to fill the science data buffer - Only 2 PRI's worth of data are downlinked.
n_bursts_in_flight	1	1	no	
percent_of_BW	100.0	0.0	yes	
auto_rad	on	on	no	
rip (ms)	34.0	34.0	no	
max_data_rate	8.000	4.300	yes	
interleave_flag	off	off	no	
interleave_duration (min)	don't care	10.0	no	

Table 6: ia_049_1 Div h scat_compressed block

Name	Nominal	f	g	Mismatch	Comments
mode	scatterometer	scatterometer	scatterometer	no	
start_time (min)	varies	407.2	425.0	no	
end_time (min)	varies	425.0	430.0	no	
time_step (s)	don't care	12.0	12.0	no	Used when BIF > 1, otherwise set by valid time calculation
bem	00100	00100	00100	no	
baq	5	5	5	no	
csr	0	0	0	no	0 - normal operation with fixed attenuator set to match Phoebe for easier cross-calibration
noise_bit_setting	4.0	4.0	4.0	no	Scat signal set higher than ALT/SAR
dutycycle	0.70	0.35	0.35	yes	
prf (Hz)	varies	252	252	no	Set to cover doppler spread and to allow CSF = integer multiple
tro	6	6	6	no	6 - allows for some noise only data in time domain
number_of_pulses	varies	23	23	no	depends on PRF choice (can have more shorter pulses)
n_bursts_in_flight	varies	2	2	no	Used to increase PRF and data rate at long range
percent_of_BW	0.0	0.0	0.0	no	
auto_rad	on	on	on	no	
rip (ms)	34.0	34.0	34.0	no	
max_data_rate	200.000	200.000	200.000	no	Kbps - determines burst period
interleave_flag	off	off	off	no	
interleave_duration (min)	don't care	10.0	10.0	no	

Table 7: ia_049_1 Div fg distant_scatterometer block

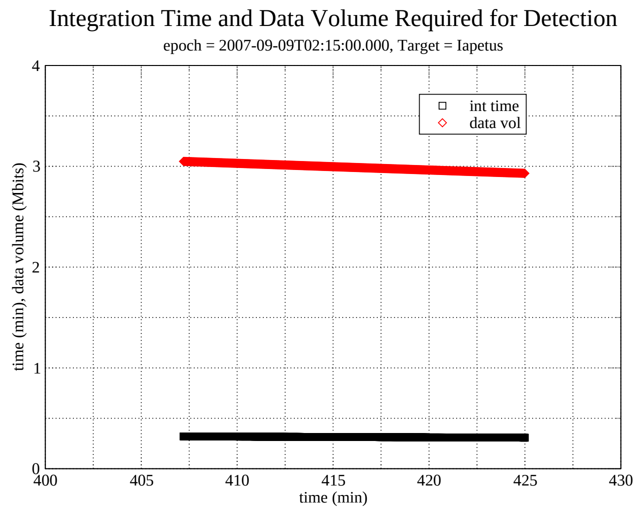

Figure 3: Scatterometry Div F: Detection integration time required for a single point detection using optimal chirp bandwidth

5.1 Scatterometer Performance

The detection performance is shown in figures 3, 4, and 5. The maximum doppler spread in Div f is 110 Hz which comes from rotation and spacecraft motion. The PRF needs to be higher than the doppler spread to support potential range-doppler processing, and is set by division parameter to 252 Hz. With this PRF, the range amiguity spacing is 595 km while Iapetus is 718 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 245813 km range, the range-spread is 717 km. Although range ambiguity spacing does permit range processing, Fig. 5 shows that range processing is not practical due to high K_{pc}. Fig. 4 shows that disk integrated results should be reasonably stable.

6 Revision History

1. Jul 17, 2007: Initial Release

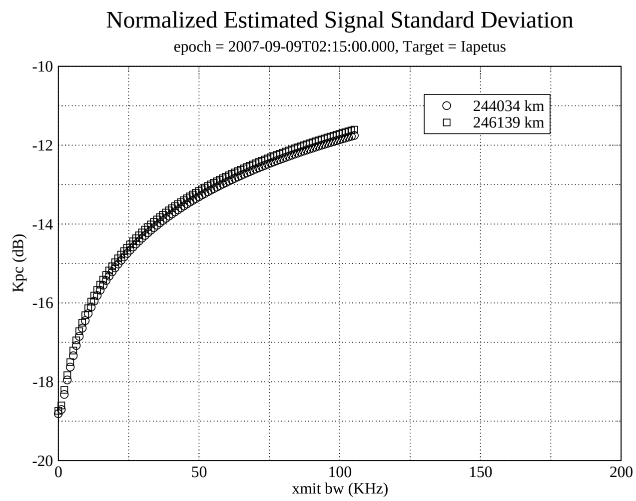

Figure 4: Outbound observation Div F: Normalized estimated signal standard deviation for a disk integrated observation using optimal chirp bandwidth and assuming all the bursts occur at minimum range, and 15 minutes away from minimum range.

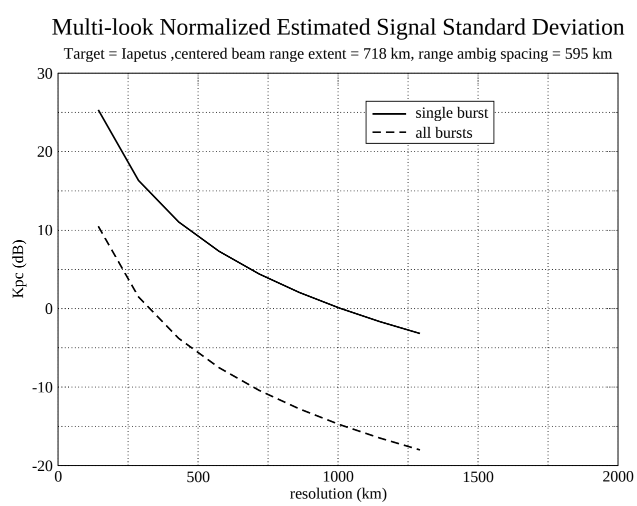

Figure 5: Outbound observation Div F: Normalized estimated signal standard deviation for a range/doppler cell as a function of resolution. Range/doppler resolution elements are both set equal to the specified resolution. Results are shown for a single burst, and for all the bursts in this division. Calculations are performed using the geometry at the start of the division. The presence of ambiguities are not shown.

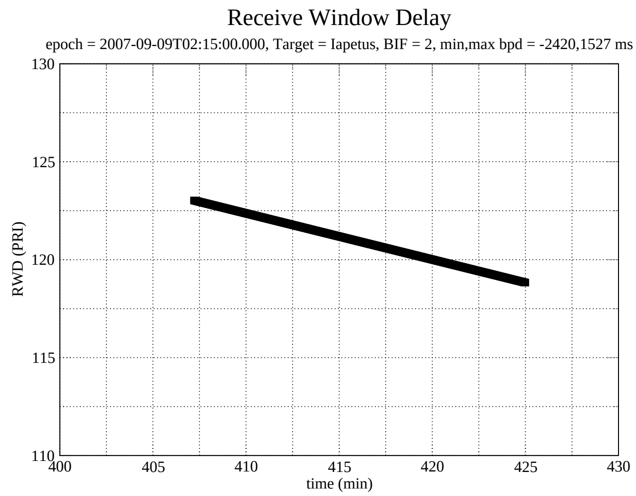

Figure 6: Div F: Inbound scatterometer receive window delay. Subtitle shows the minimum and maximum burst periods that are in principle compatible with the division selected number of bursts in flight.

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