

Enceladus Scatterometry Rev 4

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- Sequence: s09
- Rev: 004
- Observation Id: en_004_1
- Target Body: Enceladus
- Data Take Number: 47
- PDT Config File: S09_ssup-psiv1_050107_pdt.cfg
- SMT File: S09_2005-01-20.rpt
- PEF File: z0090d.pef

1 Introduction

This memo describes one of the Cassini RADAR activities for the s09 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.

This IEB controls the second Enceladus distant scatterometer observation on Mar 09 2005. A warmup of 110 minutes was allocated to this observation, so additional warmup will occur in the primary observation time. The usual warmup parameters are used as shown in table 4

2 CIMS and Division Summary

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. Table 1 shows the CIMS request summary for this observation.

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

CIMS ID	Start	End	Duration	Comments
004OT_WARM4SCAT001_RIDER	2005-068T10:18:01	2005-068T12:08:01	01:50:0.0	Warmup for calibration and science data collection.
004EN_SCATTRAD001_PRIME	2005-068T12:08:01	2005-068T14:08:01	02:00:0.0	Point -Z axis at target and execute raster scan(s) centered on target. Obtain simultaneous scatterometry and radiometry.

Table 1: en_004_1 CIMS Request Sequence

Division	Name	Start	Duration	Data Vol	Comments
a	distant_warmup	-2:00:0.0	02:00:0.0	1.8	Warmup
b	distant_radiometer	00:00:0.0	00:10:0.0	0.1	Radiometer during initial stare
c	distant_scatterometer	00:10:0.0	00:10:0.0	132.0	Scatterometer target-center stare with chirp
d	distant_scatterometer	00:20:0.0	00:17:0.0	188.7	Scatterometer target-center stare with tone
e	distant_scatterometer	00:37:0.0	00:09:0.0	74.5	Scatterometer target-center stare with tone
f	distant_radiometer	00:46:0.0	01:14:0.0	4.4	Radiometer during raster scans
Total				401.6	

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

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 Division Tables and Plots

The remaining tables and plots summarize the IEB design used for this observation. Performance considerations are similar to other distant icy satellite observations. Refer to previous icy satellite sequence design memos for more details.

Figures 1 and 2 show the pointing design for the scatterometry stare from the merged ckernel. The angular size of the target is about 6.4 mrad during this division. The beam 3 beamwidth is 6 mrad.

3.1 PRF Setting

The maximum doppler spread in Div c is 1313 Hz which comes from rotation and spacecraft motion. The PRF would normally be set higher than the doppler spread to support potential range-doppler processing, however, this would result in a range ambiguity spacing smaller than half of the range spread of the target which would eliminate any ambiguity free ranges. This observation is barely close enough to contemplate doing range-doppler processing. To allow the possibility, the PRF is set by division parameter to 938 Hz which is lower than the doppler spread, but makes the range ambiguity spacing equal to the range spread of the 2-way half-power beam pattern. Some doppler aliasing will occur, and the usable image area will be a truncated annulus with the usual North-South ambiguity. With this PRF,

Div	Alt (km)	Slant range (km)	B3 Size (target dia)	B3 Dop. Spread (Hz)
a	23669	off target	0.31	off target
b	72118	off target	0.94	off target
c	76018	76018	0.99	1261
d	79864	79864	1.04	1313
e	86257	86257	1.12	1405
f	89557	89557	1.16	1457

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	-120.0	no	
end_time (min)	varies	0.0	no	
time_step (s)	varies	600.0	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 (KHz)	don't care	1.00	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	0.250	0.248	yes	Kbps - set for slowest burst period
interleave_flag	off	off	no	
interleave_duration (min)	don't care	10.0	no	

Table 4: en_004_1 div_a distant_warmup block

Name	Nominal	b	f	Mismatch	Comments
mode	radiometer	radiometer	radiometer	no	
start_time (min)	varies	0.0	46.0	no	
end_time (min)	varies	10.0	120.0	no	
time_step (s)	varies	600.0	1800.0	no	Used by radiometer only modes
bem	00100	00100	00100	no	
baq	don't care	5	5	no	
csr	6	6	6	no	
noise_bit_setting	don't care	4.0	4.0	no	
dutycycle	don't care	0.38	0.38	no	
prf (KHz)	don't care	1.00	1.00	no	
number_of_pulses	don't care	8	8	no	
n_bursts_in_flight	don't care	1	1	no	
percent_of_BW	don't care	100.0	100.0	no	
auto_rad	on	on	on	no	
rip (ms)	34.0	34.0	34.0	no	starting value for auto-rad
max_data_rate	1.000	0.248	0.992	yes	1 Kbps - 1 s burst period which is adequate for slow radiometer scans
interleave_flag	off	off	off	no	
interleave_duration (min)	don't care	10.0	10.0	no	

Table 5: en_004_1 div_bf distant_radiometer block

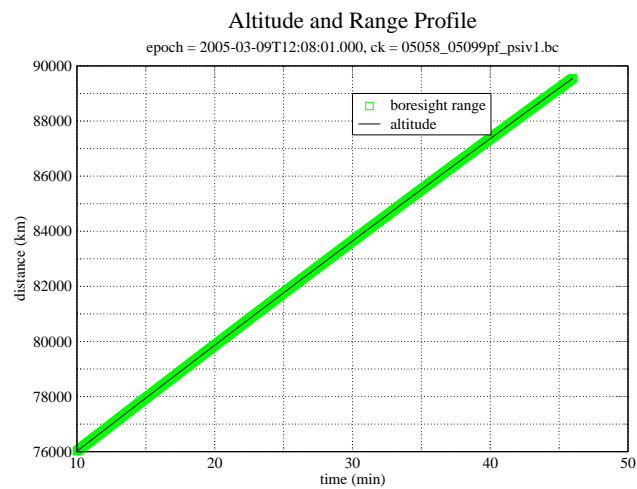


Figure 1: Div's C,D,E: Altitude and range to the boresight point

Name	Nominal	c	d	e	Mismatch	Comments
mode	scatterometer	scatterometer	scatterometer	scatterometer	no	
start_time (min)	varies	10.0	20.0	37.0	no	
end_time (min)	varies	20.0	37.0	46.0	no	
time_step (s)	don't care	6.0	12.0	6.0	no	Used when BIF > 1, otherwise set by valid time calculation
bem	00100	00100	00100	00100	no	
baq	5	5	5	5	no	
csr	0	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	4.0	no	Scat signal set higher than ALT/SAR
dutycycle	0.70	0.70	0.70	0.70	no	
prf (KHz)	varies	0.94	2.23	3.91	no	Set to space range ambiguities equal to range spread
number_of_pulses	varies	40	40	40	no	depends on PRF choice (can have more shorter pulses)
n_bursts_in_flight	varies	2	3	4	no	Used to increase PRF and data rate at long range
percent_of_BW	0.0	100.0	0.0	0.0	yes	
auto_rad	on	on	on	on	no	
rip (ms)	34.0	34.0	34.0	34.0	no	
max_data_rate	200.000	220.000	185.000	138.000	yes	Kbps - determines burst period
interleave_flag	off	off	off	off	no	
interleave_duration (min)	don't care	10.0	10.0	10.0	no	

Table 6: en_004_1 div_cde distant_scatterometer block

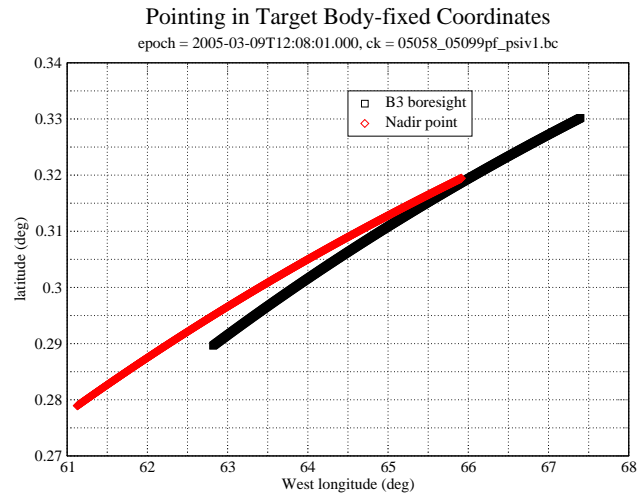


Figure 2: Div's C,D,E: Stare in target body-fixed coordinates

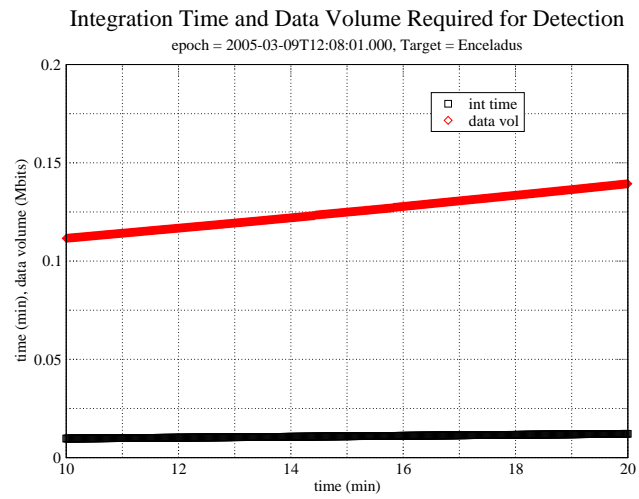


Figure 3: Scatterometry Div C: Detection integration time required for a single point detection using optimal chirp bandwidth

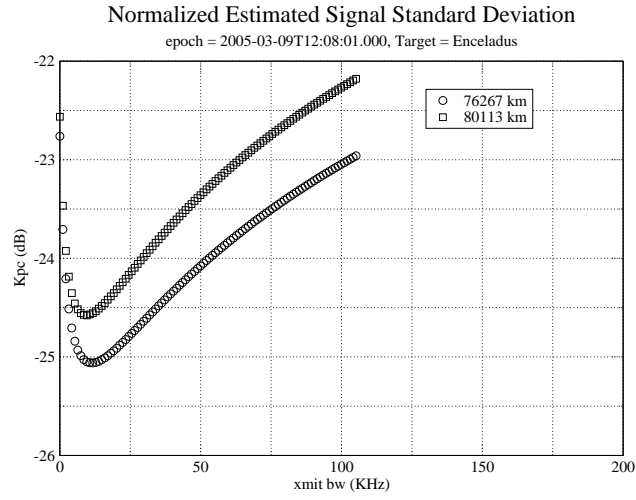


Figure 4: Scatterometry Div C: Normalized estimated signal standard deviation for a disk integrated observation using optimal chirp bandwidth and assuming all the bursts occur at minimum range, and 15 minutes away from minimum range.

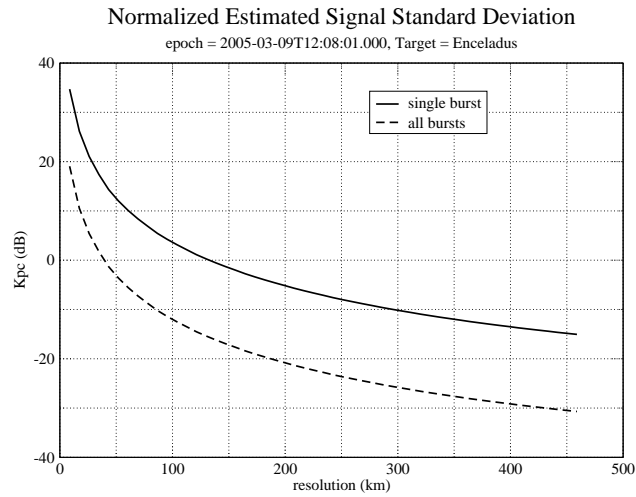


Figure 5: Scatterometry Div C: Normalized estimated signal standard deviation for a range/doppler cell as a function of resolution. Range/doppler resolution elements are both set equal to the specified resolution. Results are shown for a single burst, and for all the bursts in this division. Calculations are performed using the geometry at the start of the division. The presence of ambiguities are not shown; to be useful, the range resolution needs to be less than the range ambiguity spacing.

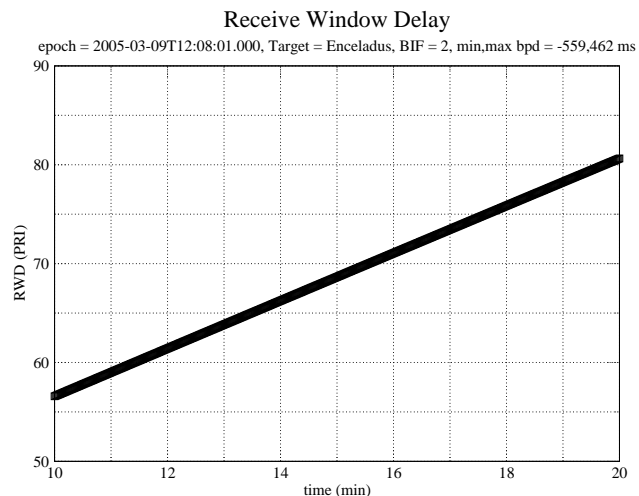


Figure 6: Div C: Scatterometer receive window delay. Subtitle shows the minimum and maximum burst periods that are in principle compatible with the division selected number of bursts in flight.

the range ambiguity spacing is 160 km while Enceladus is 249 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 76018 km range, the range-spread is 161 km.

4 Revision History

1. Jan 28, 2004: Corrected division table comments and CIMS table
2. Jan 27, 2004: Initial Release

5 Acronym List

AL	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