RADAR Titan Flyby during S50/T55

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- Sequence: s50
- Rev: 111
- Observation Id: t55
- Target Body: Titan
- Data Take Number: 193
- PDT Config File: S50_ssup_psiv1_090310_pdt.cfg
- SMT File: S50_090304.rpt
- PEF File: z0500c.pef

1 Introduction

This memo describes the Cassini RADAR activities for the T55 Titan flyby. This SAR data collection occurs during the S50 sequence of the Saturn Tour. This is a full radar pass. 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.

2 CIMS and Division Summary

CIMS ID	Start	End	Duration	Comments
111TI_T55WARMUP001_RIDER	2009-141T12:26:41	2009-141T18:56:41	06:30:0.0	
111TI_T55INSCAT001_PRIME	2009-141T18:56:41	2009-141T20:14:41	01:18:0.0	
111TI_T55IHISAR001_PRIME	2009-141T20:15:41	2009-141T20:56:41	00:41:0.0	
111TI_T55INALT001_PRIME	2009-141T20:56:41	2009-141T21:08:41	00:12:0.0	
111TI_T55INOSAR001_PRIME	2009-141T21:08:41	2009-141T21:44:41	00:36:0.0	
111TI_T55OUTALT001_PRIME	2009-141T21:44:41	2009-141T21:56:41	00:12:0.0	
111TI_T55OHISAR001_PRIME	2009-141T21:56:41	2009-141T22:16:41	00:20:0.0	
111TI_T55OUTSCT001_PRIME	2009-141T22:38:22	2009-141T23:56:41	01:18:19.0	

Table 1: t55 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. Table 1 shows the CIMS request summary for this observation.

Division	Name	Start	Duration	Data Vol	Comments
a	Warmup	-9:00:0.0	06:50:0.0	24.4	Warmup
b	scatterometer_imaging	-2:10:0.0	01:00:0.0	64.8	Inbound scatterometer imaging
c	scatterometer_imaging	-1:10:0.0	00:01:30.0	5.8	Inbound scatterometer imaging
d	scatterometer_imaging	-1:08:30.0	00:01:0.0	3.8	Inbound scatterometer imaging
e	scatterometer_imaging	-1:07:30.0	00:11:30.0	44.2	Inbound scatterometer imaging
f	scatterometer_imaging	-0:56:0.0	00:03:30.0	13.4	Inbound scatterometer imaging
g	scatterometer_imaging	-0:52:30.0	00:09:30.0	36.5	Inbound scatterometer imaging
h	standard_sar_low	-0:43:0.0	00:12:30.0	63.0	Inbound SAR-Low Imaging
i	standard_altimeter_inbound	-0:30:30.0	00:10:0.0	19.2	Inbound altimetry
j	standard_sar_hi	-0:20:30.0	00:02:0.0	6.0	Hi-SAR Turn transition, beam 3 only
k	standard_sar_pingpong	-0:18:30.0	00:02:30.0	35.4	Inbound ping-pong
l	standard_sar_hi	-0:16:0.0	00:14:0.0	198.2	Hi-SAR Main Swath
m	standard_sar_hi	-0:02:0.0	00:04:0.0	56.6	Hi-SAR Main Swath
n	standard_sar_hi	00:02:0.0	00:14:0.0	198.2	Hi-SAR Main Swath
o	standard_sar_pingpong	00:16:0.0	00:02:30.0	35.4	Outbound ping-pong
p	standard_sar_hi	00:18:30.0	00:01:30.0	4.5	Hi-SAR Turn transition, beam 3 only
q	standard_scatterometer_outbound	00:20:0.0	00:00:4.0	0.6	Atmospheric Probe with Chirp
r	standard_scatterometer_outbound	00:20:4.0	00:00:2.0	0.3	Atmospheric Probe with Tone
s	standard_altimeter_outbound	00:20:6.0	00:09:54.0	19.0	Outbound altimetry
t	standard_sar_low	00:30:0.0	00:03:0.0	11.2	Outbound SAR-Low
u	scatterometer_imaging	00:33:0.0	00:03:0.0	7.7	Outbound scatterometer imaging
v	scatterometer_imaging	00:36:0.0	00:02:30.0	6.5	Outbound scatterometer imaging
w	scatterometer_imaging	00:38:30.0	00:01:42.0	4.4	Outbound scatterometer imaging
x	scatterometer_imaging	00:40:12.0	00:02:48.0	7.2	Outbound scatterometer imaging
y	scatterometer_imaging	00:43:0.0	00:02:0.0	5.2	Outbound scatterometer imaging
z	scatterometer_imaging	00:45:0.0	00:05:0.0	12.9	Outbound scatterometer imaging
lbrace	standard_altimeter_outbound	00:50:0.0	00:22:0.0	42.2	Outbound high altitude altimetry
vbar	standard_scatterometer_outbound	01:12:0.0	00:53:0.0	57.2	Outbound scatterometer scan
rbrace	standard_radiometer_outbound	02:05:0.0	00:25:0.0	1.5	Outbound radiometry raster
Total				985.3	

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	177763	off target	0.23	off target
b	41472	off target	0.06	off target
c	21471	21673	0.03	403
d	20972	21300	0.03	411
e	20640	20895	0.03	416
f	16822	17041	0.02	490
g	15664	15865	0.02	519
h	12531	12823	0.02	620
i	8461	8461	0.01	839
j	5314	5314	0.01	1166
k	4710	4831	0.01	1262
l	3976	4057	0.01	1402
m	1032	1165	0.00	2538
n	1032	1165	0.00	2538
o	3976	4057	0.01	1402
p	4710	4787	0.01	1262
q	5162	5162	0.01	1189
r	5182	5182	0.01	1186
s	5192	5192	0.01	1184
t	8300	8300	0.01	851
u	9267	9741	0.01	783
v	10240	10848	0.02	726
w	11056	11820	0.02	684
x	11612	12517	0.02	658
y	12530	13448	0.02	620
z	13188	13943	0.02	595
lbrace	14837	14837	0.02	542
vbar	22135	22135	0.03	394
rbrace	39801	off target	0.05	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

Although the CIMS requests show Low-SAR intervals, in reality the radar will be operated in Hi-SAR mode through most of this flyby.

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. Table 3 shows a summary of some key geometry values for each division.

3 Overview

T55 has an inbound and an outbound high altitude imaging segment. The inbound high altitude imaging segment consists of four scan lines and the outbound imaging segment consists of two scan lines. This observation starts with a high altitude imaging segment next to the TA pass, switching to altimetry and then to regular SAR crossing T48 ridealong, reaching the south polar region and then switching to high altitude imaging. The high altitude segment is laid next to lake Ontario followed by outbound high altitude altimetry, scatterometry and radiometry. A short atmospheric probe observation is inserted with the outbound sweep turn when close to nadir pointing

4 Mode Specific Operation and Performance

Many details of standard radar sequencing during the 4 main modes (Radiometry, Scatterometry, Altimetry, and SAR) have been discussed in previous sequence memos for prior observations. Refer to these for details. Some selecte performance highlights are illustrated in figures and explained in the following subsections.

4.1 SAR Resolution Performance

For all of the SAR divisions the effective resolution can be calculated from the same equations used in the high-altitude imaging discussion. Figure 1 shows the results from these equations using the parameters from the IEB as generated by RMSS. The calculations are performed for the boresight of beam 3 which is the center of the swath.

Projected range increases with decreasing incidence angle, so the range resolution varies across the swath with better resolution at the outer edge. The SAR pointing profile decreases the incidence angle as time progresses and altitude increases, so there is progressive deterioration of range resolution away from closest approach. The projected range resolution rapidly deteriorates as the incidence angle decreases toward zero at the very beginning and end of the swath.

Azimuth resolution is a function of the synthetic aperture size which is determined by the length of the receive window in each burst (assuming the receive window is always filled with echos). Azimuth resolution deteriorates less quickly because the number of pulses and the length of the receive window are increased as altitude increases which mitigates the increasing doppler bandwidth of the beam patterns. The receive window length increases to fill the round trip time until the science data buffer is filled. At this point it is no longer possible to extend the receive window, and azimuth resolution starts to deteriorate more rapidly.

5 Revision History

1. March 23, 2010: Final release

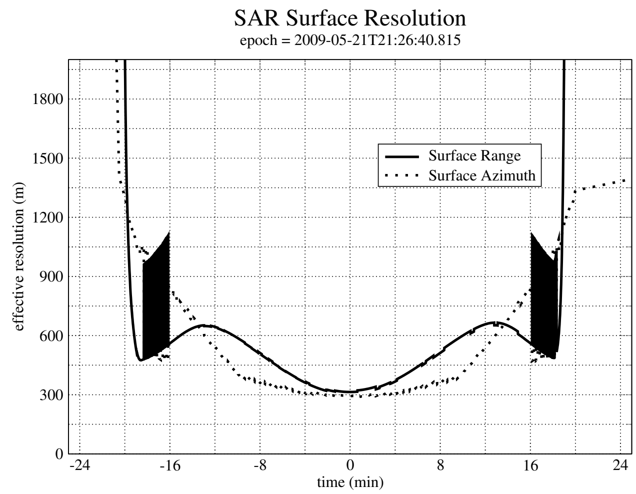

Figure 1: SAR projected range and azimuth resolution. These values are computed from the IEB parameters and are not related to the pixel size in the BIDR file. The pixel size was selected to be always smaller than the real resolution.

6 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