RADAR Titan Flyby during S79/T92

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- Sequence: s79
- Rev: 194
- Observation Id: t92
- Target Body: Titan
- Data Take Number: 250
- PDT Config File: S79_sip_port3_130422_pdt.cfg
- SMT File: s79_130422.smt
- PEF File: z0790b.pef

1 Introduction

This memo describes the Cassini RADAR activities for the T92 Titan flyby. This SAR data collection occurs during the S79 sequence of the Saturn Tour. This is a parital radar pass with SAR imaging in the north polar area crossing T16, T18 and T19. 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
194TI_T92WARMUP001_RIDER	2013-191T04:21:47	2013-191T07:21:47	03:00:0.0	
194TI_T92INRAD001_PRIME	2013-191T07:21:47	2013-191T11:06:47	03:45:0.0	
194TI_T92INSCAT001_PRIME	2013-191T11:06:47	2013-191T12:09:47	01:03:0.0	
194TI_T92IHISAR001_PRIME	2013-191T12:09:47	2013-191T12:50:47	00:41:0.0	
194TI_T92INALT001_PRIME	2013-191T12:51:47	2013-191T13:03:47	00:12:0.0	
194TI_T92INOSAR001_PRIME	2013-191T13:03:47	2013-191T13:39:47	00:36:0.0	
194TI_T92OUTALT001_PRIME	2013-191T13:39:47	2013-191T13:51:47	00:12:0.0	
194TI_T92OHISAR001_PRIME	2013-191T13:51:47	2013-191T14:21:47	00:30:0.0	

Table 1: t92 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

Division	Name	Start	Duration	Data Vol	Comments
a	Warmup	-9:00:0.0	03:15:0.0	11.6	Warmup
b	standard_radiometer_inbound	-5:45:0.0	00:05:0.0	0.3	radiometer quick-steps
c	standard_radiometer_inbound	-5:40:0.0	03:15:0.0	11.6	radiometer raster
d	standard_scatterometer_inbound	-2:25:0.0	00:59:0.0	106.2	Inbound scatterometry raster
e	scatterometer_imaging	-1:26:0.0	00:13:0.0	51.5	Inbound scatterometer imaging
f	scatterometer_imaging	-1:13:0.0	00:05:0.0	19.2	Inbound scatterometer imaging
g	scatterometer_imaging	-1:08:0.0	00:08:0.0	30.7	Inbound scatterometer imaging
h	scatterometer_imaging	-1:00:0.0	00:18:0.0	69.1	Inbound scatterometer imaging
i	scatterometer_imaging	-0:42:0.0	00:05:0.0	19.2	Inbound scatterometer imaging
j	scatterometer_imaging	-0:37:0.0	00:02:30.0	9.6	Inbound scatterometer imaging
k	scatterometer_imaging	-0:34:30.0	00:06:18.0	24.2	Inbound scatterometer imaging
l	standard_altimeter_inbound	-0:28:12.0	00:08:22.0	16.1	Inbound altimetry
m	standard_scatterometer_inbound	-0:19:50.0	00:00:4.0	0.6	Atmospheric Probe with Chirp
n	standard_scatterometer_inbound	-0:19:46.0	00:00:2.0	0.3	Atmospheric Probe with Tone
o	standard_sar_hi	-0:19:44.0	00:01:14.0	3.7	SAR Turn transition, beam 3 only
p	standard_sar_hi	-0:18:30.0	00:02:30.0	33.0	Inbound SAR ping-pong
q	standard_sar_hi	-0:16:0.0	00:14:30.0	200.1	Inbound SAR imaging
r	standard_sar_hi	-0:01:30.0	00:03:0.0	41.4	Hi-SAR Main Swath
s	standard_sar_hi	00:01:30.0	00:14:30.0	200.1	Outbound SAR imaging
t	standard_sar_hi	00:16:0.0	00:02:48.0	37.0	Outbound SAR ping-pong
u	standard_sar_hi	00:18:48.0	00:00:24.0	1.2	SAR Turn transition, beam 3 only
v	standard_scatterometer_outbound	00:19:12.0	00:00:4.0	0.6	Atmospheric Probe with Tone
w	standard_scatterometer_outbound	00:19:16.0	00:00:2.0	0.3	Atmospheric Probe with Chirp
x	standard_altimeter_outbound	00:19:18.0	00:05:42.0	10.9	Outbound altimetry
y	standard_altimeter_outbound	00:25:0.0	00:05:0.0	9.6	Outbound altimetry
z	scatterometer_imaging	00:30:0.0	00:07:0.0	26.9	Outbound scatterometer imaging
lbrace	scatterometer_imaging	00:37:0.0	00:06:30.0	25.0	Outbound scatterometer imaging
vbar	scatterometer_imaging	00:43:30.0	00:06:30.0	25.0	Outbound scatterometer imaging
rbrace	standard_radiometer_outbound	00:50:0.0	00:05:0.0	0.3	Outbound radiometry
Total				985.1	

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	174212	off target	0.22	off target
b	110861	off target	0.14	off target
c	109232	off target	0.14	off target
d	45557	off target	0.06	off target
e	26260	26396	0.04	316
f	22015	22760	0.03	368
g	20384	21271	0.03	394
h	17778	18882	0.03	444
i	11948	13594	0.02	620
j	10344	12158	0.02	697
k	9547	11205	0.02	742
l	7559	7560	0.01	888
m	5002	5002	0.01	1187
n	4982	4982	0.01	1190
o	4972	4972	0.01	1191
p	4610	4722	0.01	1251
q	3893	3965	0.01	1390
r	1001	1138	0.00	2514
s	1001	1138	0.00	2514
t	3893	3972	0.01	1390
u	4698	4708	0.01	1236
v	4815	4815	0.01	1217
w	4835	4835	0.01	1213
x	4844	4844	0.01	1212
y	6566	6566	0.01	984
z	8124	8124	0.01	841
lbrace	10344	10840	0.02	697
vbar	12431	13128	0.02	600
rbrace	14531	off target	0.02	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

show a high-level view of the sequence design. Table 1 shows the CIMS request summary for this observation. 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

T92 is a partial pass. The observation starts with two radiometer scans followed by a scatterometer scan in the northern hemisphere. Following this is a high altitude imaging segment with 8 scan lines providing beam 3 only SAR imaging of the northern polar region. This is followed by regular altimetry and an atmospheric probe measurement. Then the radar collects standard SAR imaging data followed by another atmospheric probe measurement and regular altimetry. Then we have high altitude imaging with 6 scan lines covering an area just south of the equator and adjacent to the T8 swath. The radar collection ends after the output high altitude imaging.

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 selected performance highlights are illustrated in figures and explained in the following subsections.

4.1 Coverage Layout

Figure 1 shows the layout of the different T92 data collections on a map of Titan. The SAR swath starts off left looking from -18 to -12 minutes to capture some coverage of the small lakes region near the North pole, then shifts to right looking with a -9 degree incidence angle offset from -10 to -3.5 minutes to center the swath on the methane sea called Ligea. After passing over Ligea the swath moves back to regular incidence and right looking from 1.5 to 18 minutes.

4.2 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 2 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 and during the close approach altimetry segment.

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.

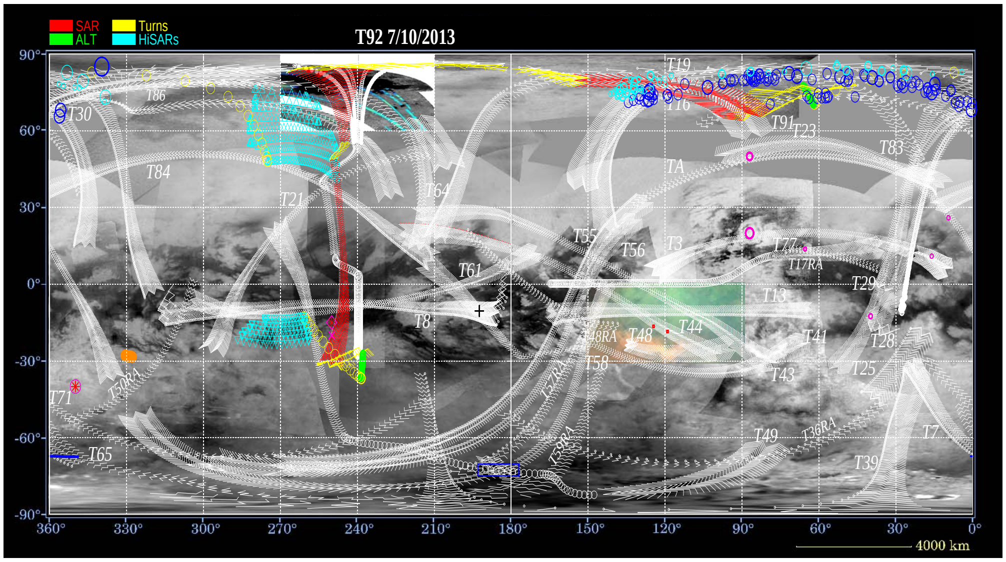

Figure 1: Coverage areas overlaid on Titan map showing prior optical and radar imaging.

5 Revision History

1. June 16, 2014: Final release

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

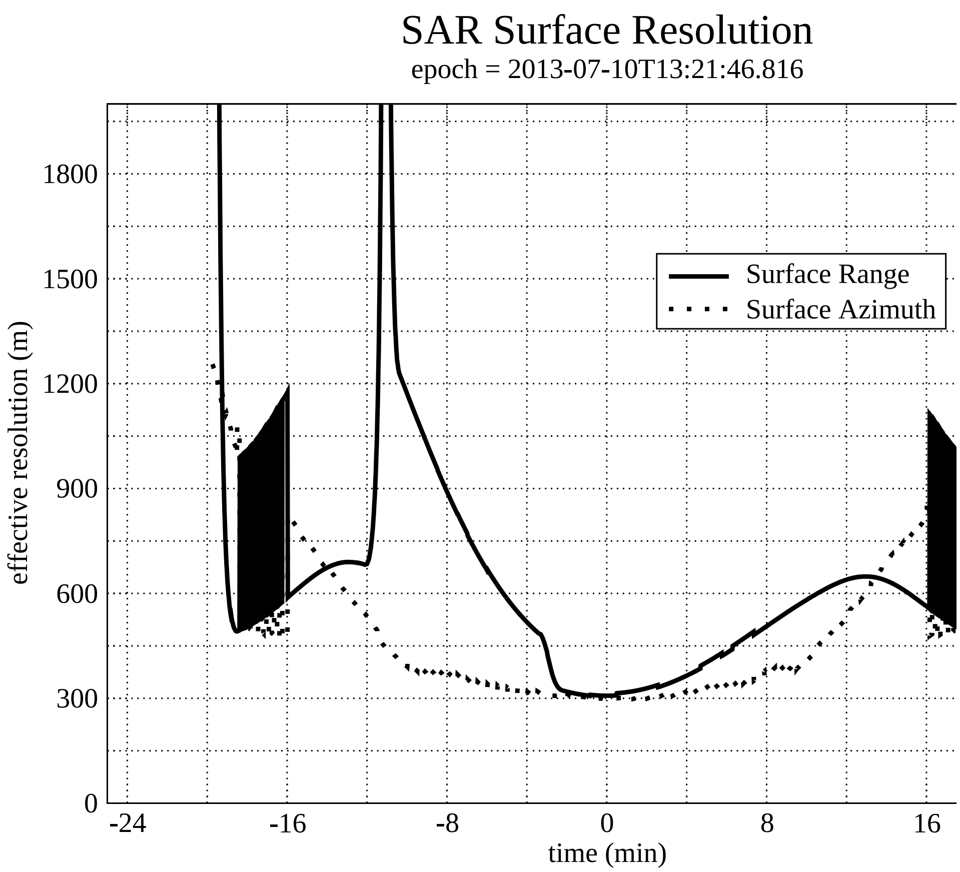

Figure 2: SAR projected range and azimuth resolution. These values are computed from the IEB parameters and are not related to the pixel size in the BIDR file. The pixel size was selected to be always smaller than the real resolution.