RADAR Titan Flyby during S68/T77

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- Sequence: s68
- Rev: 149
- Observation Id: t77
- Target Body: Titan
- Data Take Number: 229
- PDT Config File: S68_sip_psiv_110222_pdt.cfg
- SMT File: SP_S68_SIP_PORT3_DATAPOL_110216.rpt
- PEF File: S68_SIP_PORT2_UG1_110128.pef

1 Introduction

This memo describes the Cassini RADAR activities for the T77 Titan flyby. This SAR data collection occurs during the S68 sequence of the Saturn Tour. This is a partial radar pass with ride-along main swath SAR imaging. 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
149TI_T77WARMUP001_RIDER	2011-171T06:27:00	2011-171T16:02:01	09:35:1.0	
149TI_T77INSCAT001_PRIME	2011-171T16:02:01	2011-171T17:20:01	01:18:0.0	
149TI_T77IHISAR001_PRIME	2011-171T17:20:01	2011-171T18:02:01	00:42:0.0	
149TI_T77INALT001_PRIME	2011-171T18:02:01	2011-171T18:14:01	00:12:0.0	
149TI_T77INOSAR001_PRIME	2011-171T18:14:01	2011-171T18:50:01	00:36:0.0	
149TI_T77OUTALT001_PRIME	2011-171T18:50:01	2011-171T19:02:01	00:12:0.0	
149TI_T77OHISAR001_PRIME	2011-171T19:02:01	2011-171T19:44:01	00:42:0.0	
149TI_T77OUTSCT001_PRIME	2011-171T19:44:01	2011-171T21:02:01	01:18:0.0	

Table 1: t77 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	-12:30:0.0	10:23:0.0	37.1	Warmup
b	standard_radiometer_inbound	-2:07:0.0	00:01:0.0	0.1	radiometer raster
c	standard_radiometer_inbound	-2:06:0.0	00:39:0.0	2.3	radiometer raster
d	scatterometer_imaging	-1:27:0.0	00:25:0.0	82.5	Inbound scatterometer imaging
e	scatterometer_imaging	-1:02:0.0	00:03:0.0	10.4	Inbound scatterometer imaging
f	scatterometer_imaging	-0:59:0.0	00:24:0.0	96.5	Inbound scatterometer imaging
g	standard_scatterometer_inbound	-0:35:0.0	00:05:0.0	9.0	Inbound scatterometry during turn to altimetry
h	standard_altimeter_intbound	-0:30:0.0	00:07:42.0	14.3	Inbound altimetry
i	standard_sar_hi	-0:22:18.0	00:03:42.0	13.3	SAR Turn transition, beam 3 only
j	standard_sar_pingpong	-0:18:36.0	00:02:36.0	36.8	Inbound SAR ping-pong
k	standard_sar_hi	-0:16:0.0	00:11:0.0	155.8	Inbound standard Hi-SAR
l	standard_sar_hi	-0:05:0.0	00:03:0.0	42.5	SAR Turn transition
m	standard_sar_hi	-0:02:0.0	00:02:24.0	7.2	SAR Turn transition, beam 3 only
n	standard_scatterometer_outbound	00:00:24.0	00:00:4.0	0.6	Atmospheric Probe with Chirp
o	standard_scatterometer_outbound	00:00:28.0	00:00:2.0	0.3	Atmospheric Probe with Tone
p	standard_altimeter_outbound	00:00:30.0	00:09:30.0	103.7	Outbound altimetry
q	standard_altimeter_outbound	00:10:0.0	00:08:0.0	87.4	Outbound altimetry
r	standard_scatterometer_outbound	00:18:0.0	00:06:0.0	10.8	Outbound scatterometry during turn to scatterometer imaging
s	scatterometer_imaging	00:24:0.0	00:38:0.0	152.8	Outbound scatterometer imaging
t	scatterometer_imaging	01:02:0.0	00:23:0.0	75.9	Outbound scatterometer imaging
u	standard_radiometer_outbound	01:25:0.0	01:05:0.0	3.9	Outbound radiometry
Total				943.0	

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	249726	off target	0.32	off target
b	40065	off target	0.05	off target
c	39734	41161	0.05	321
d	26867	27433	0.04	398
e	18652	19860	0.03	513
f	17670	18744	0.03	534
g	9900	11316	0.02	826
h	8321	8321	0.01	939
i	5957	5957	0.01	1188
j	4871	5038	0.01	1357
k	4141	4261	0.01	1501
l	1713	1807	0.01	2339
m	1418	1427	0.01	2511
n	1361	1361	0.00	2547
o	1362	1362	0.00	2546
p	1362	1362	0.00	2546
q	2630	2630	0.01	1930
r	4700	4700	0.01	1388
s	6469	7876	0.01	1123
t	18653	19723	0.03	512
u	26210	27202	0.04	404

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

T77 is a partial pass. The observation starts with radiometry scans, switching to high altitude imaging and then to regular inbound altimetry. Inbound Hi-SAR consists of 10 scan lines and covers a region overlaping part of the T3 SAR swath filling in some unobserved area just to the South. Near closest approach, the spacecraft turns to nadir pointing for a low altitude high-resolution altimeter pass that sweeps over the western half of Xanadu providing topographic measurements over this important feature. This altimeter pass starts at 30 sec past c/a and uses a high data rate similar to the T30 altimeter pass to permit doppler sharpening. Preceeding the close altimeter pass is an atmospheric probe taking advantage of the low altitude and improved SNR. The close approach altimetry runs into regular outbound altimetry using a slower data rate. Outbound Hi-SAR consists of 11 scan lines and is left looking to

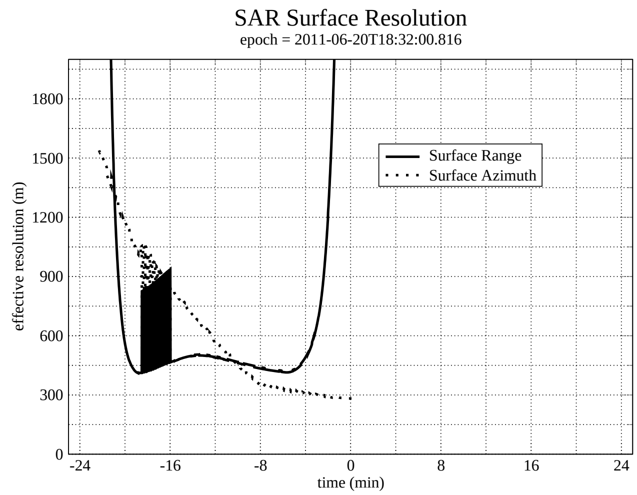

Figure 1: SAR projected range and azimuth resolution. These values are computed from the IEB parameters and are not related to the pixel size in the BIDR file. The pixel size was selected to be always smaller than the real resolution.

cover Tui Regio. There are no outbound regular scatterometry or radiometry raster scans.

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 21, 2012: 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