RADAR Titan Flyby during S87/T108

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- Sequence: s87
- Rev: 211
- Observation Id: t108
- Target Body: Titan
- Data Take Number: 265
- PDT Config File: S87_sip_port3_141013_pdt.cfg
- SMT File: s87smt_141008.rpt
- PEF File: z0870b.pef

1 Introduction

This memo describes the Cassini RADAR activities for the T108 Titan flyby. This SAR data collection occurs during the S87 sequence of the Saturn Tour. This is a partial radar pass with SAR imaging over the mystery island. 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

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. 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.

CIMS ID	Start	End	Duration	Comments
211TI_T108WRMUP001_RIDER	2015-011T14:33:35	2015-011T17:33:35	03:00:0.0	
211NA_SSRARDISA001_NA	2015-011T14:34:55	2015-011T14:34:56	00:00:1.0	The time given is the beginning time of RADAR FSW load. Disabling SSR auto repair program will be inserted around this time. Duration for the FSW load is less than 2 minutes.
211TI_T108INSCT001_PRIME	2015-011T17:33:35	2015-011T18:36:35	01:03:0.0	
211TI_T108IHSAR001_PRIME	2015-011T18:36:35	2015-011T19:17:35	00:41:0.0	
211TI_T108INALT001_PRIME	2015-011T19:18:35	2015-011T19:30:35	00:12:0.0	
211TI_T108IOSAR001_PRIME	2015-011T19:30:35	2015-011T20:06:35	00:36:0.0	
211TI_T108OTALT001_PRIME	2015-011T20:06:35	2015-011T20:18:35	00:12:0.0	
211TI_T108OHSAR001_PRIME	2015-011T20:40:35	2015-011T21:06:35	00:26:0.0	
211TI_T108OTSCT001_PRIME	2015-011T21:06:35	2015-011T22:03:35	00:57:0.0	
211TI_T108OTRAD001_PRIME	2015-011T22:03:35	2015-012T00:48:35	02:45:0.0	

Table 1: t108 CIMS Request Sequence

3 Overview

T108 is a partial pass. The observation starts with a radiometer scan followed by a scatterometer scan in the southern hemisphere. Following this is a high altitude imaging segment with 11 scan lines providing SAR imaging overlapping the T30 area and SAR imaging of the Paxsi crater. This is followed by regular altimetry and an atmospheric probe measurement. Then a regular SAR imaging segment, another atmospheric probe measurement and a close range altimetry segment follow. During the special close range altimetry,beam 3 collects regular altimeter data while beam 5 collects near nadir scatteormetery data using the altimeter bandwidth. This close range altimetry segment crosses over the Punga sea and is aimed at looking for bottom echoes and a depth measurement. The uncertainties on the backscatter measurements from beam 5 will be higher than normal scatterometry due to the high sensitivity to incidence angle near the specular point. Following the special close range altimetry is an atmospheric probe measurement, regular SAR imaging over the mystery island and another atmospheric probe measurement. Then we have a close-in altimetry followed by regular altimetry and compressed scatterometry. This is followed by high altitude imaging segment with 2 scan lines. The observation ends with a regular scatterometry and radiometry.

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 T108 data collections on a map of Titan. Different segments are color coded according to the legend. Figure 2 shows the coverage near closest approach on a polar projection.

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 3 shows the results from these equations using the parameters from the IEB as generated

Division	Name	Start	Duration	Data Vol	Comments
a	Warmup	-5:15:0.0	03:15:0.0	11.6	Warmup
b	standard_scatterometer_inbound	-2:00:0.0	00:44:0.0	79.2	Inbound scatterometry raster
c	scatterometer_imaging	-1:16:0.0	00:11:0.0	52.8	Inbound scatterometer imaging
d	scatterometer_imaging	-1:05:0.0	00:07:0.0	33.6	Inbound scatterometer imaging
e	scatterometer_imaging	-0:58:0.0	00:06:0.0	28.8	Inbound scatterometer imaging
f	scatterometer_imaging	-0:52:0.0	00:07:0.0	33.6	Inbound scatterometer imaging
g	scatterometer_imaging	-0:45:0.0	00:16:48.0	80.6	Inbound scatterometer imaging
h	standard_altimeter_inbound	-0:28:12.0	00:08:32.0	16.9	Inbound altimetry
i	standard_scatterometer_inbound	-0:19:40.0	00:00:4.0	0.6	Atmospheric Probe with Chirp
j	standard_scatterometer_inbound	-0:19:36.0	00:00:2.0	0.3	Atmospheric Probe with Tone
k	standard_sar_hi	-0:19:34.0	00:00:58.0	4.1	SAR Turn transition transition from scat, beam 3 only
l	standard_sar_hi	-0:18:36.0	00:16:36.0	229.1	Hi-SAR Main Swath
m	standard_sar_hi	-0:02:0.0	00:02:54.0	40.0	Hi-SAR Main Swath
n	standard_scatterometer_outbound	00:00:54.0	00:00:4.0	0.6	Atmospheric Probe with Tone
o	standard_scatterometer_outbound	00:00:58.0	00:00:2.0	0.3	Atmospheric Probe with Chirp
p	standard_altimeter_outbound	00:01:0.0	00:03:6.0	40.9	Outbound close range altimetry
q	standard_scatterometer_outbound	00:04:6.0	00:00:4.0	0.6	Atmospheric Probe with Tone
r	standard_scatterometer_outbound	00:04:10.0	00:00:2.0	0.3	Atmospheric Probe with Chirp
s	standard_sar_hi	00:04:12.0	00:08:36.0	119.7	Hi-SAR Main Swath
t	standard_scatterometer_outbound	00:12:48.0	00:00:4.0	0.6	Atmospheric Probe with Tone
u	standard_scatterometer_outbound	00:12:52.0	00:00:2.0	0.3	Atmospheric Probe with Chirp
v	standard_altimeter_outbound	00:12:54.0	00:07:6.0	93.7	Outbound close range altimetry
w	standard_altimeter_outbound	00:20:0.0	00:08:0.0	15.8	Outbound altimetry
x	scatterometer_compressed	00:28:0.0	00:01:30.0	0.3	Compressed Scatt/Rad scan
y	scatterometer_compressed	00:29:30.0	00:23:0.0	4.1	Compressed Scatt/Rad scan
z	scatterometer_imaging	00:52:30.0	00:02:48.0	13.4	Outbound scatterometer imaging
lbrace	scatterometer_imaging	00:55:18.0	00:19:42.0	94.6	Outbound scatterometer imaging
vbar	standard_scatterometer_outbound	01:15:0.0	01:00:0.0	108.0	Outbound scatterometry raster
rbrace	standard_radiometer_outbound	02:15:0.0	03:00:0.0	10.7	Outbound radiometry
Total				1115.0	

Div	Alt (km)	Slant range (km)	B3 Size (target dia)	B3 Dop. Spread (Hz)
a	100365	off target	0.13	off target
b	37015	off target	0.05	off target
c	22760	23627	0.03	351
d	19207	19664	0.03	408
e	16950	17417	0.02	455
f	15021	15463	0.02	505
g	12778	13298	0.02	579
h	7478	7478	0.01	886
i	4901	4901	0.01	1192
j	4881	4882	0.01	1196
k	4872	4872	0.01	1197
l	4591	4663	0.01	1244
m	1033	1283	0.00	2472
n	983	983	0.00	2507
o	985	985	0.00	2506
p	986	986	0.00	2505
q	1229	1229	0.00	2345
r	1237	1237	0.00	2340
s	1242	1242	0.00	2337
t	2995	2995	0.01	1601
u	3012	3012	0.01	1596
v	3021	3021	0.01	1594
w	4998	4998	0.01	1177
x	7416	7416	0.01	892
y	7881	off target	0.01	off target
z	15180	16604	0.02	501
lbrace	16080	17365	0.02	476
vbar	22435	22876	0.03	355
rbrace	41876	41876	0.06	210

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

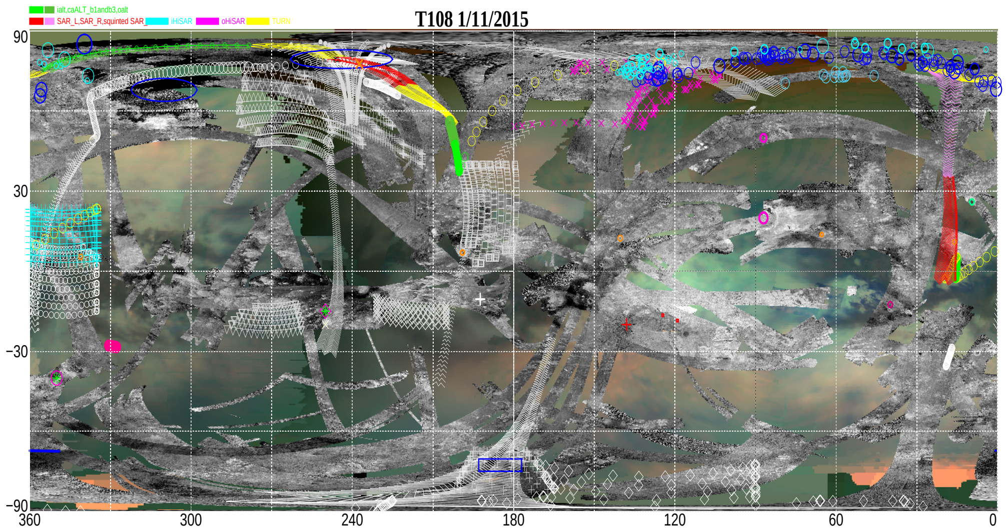

Figure 1: Coverage areas overlaid on Titan map showing prior optical and radar imaging.

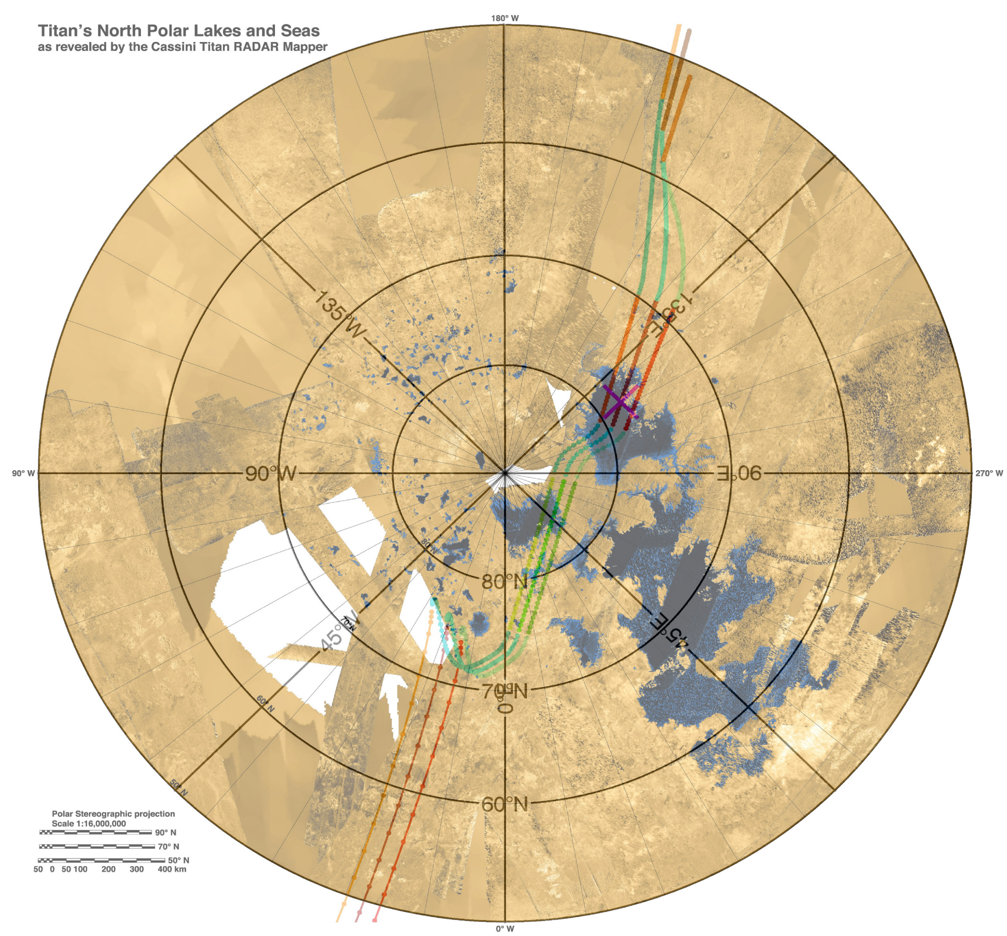

Figure 2: Coverage areas overlaid on polar stereographic Titan map showing prior optical and radar imaging.

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.

5 Revision History

1. Dec 17, 2015: 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

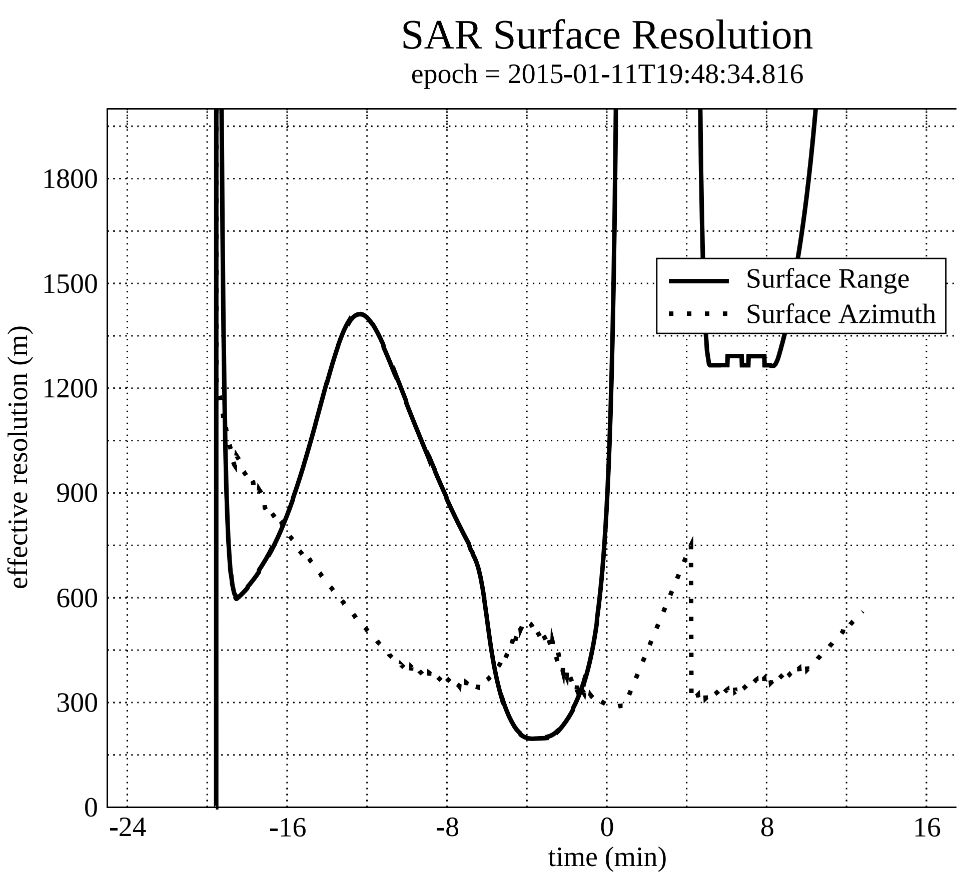

Figure 3: SAR projected range and azimuth resolution. These values are computed from the IEB parameters and are not related to the pixel size in the BIDR file. The pixel size was selected to be always smaller than the real resolution.