RADAR Titan Flyby during S94/T120

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March 20, 2017

- Sequence: s94
- Rev: 236
- Observation Id: t120
- Target Body: Titan
- Data Take Number: 276
- PDT Config File: S94_sip_port3_160211_pdt.cfg
- SMT File: s94_160211.smt
- PEF File: S94_SIP_PORT3_160211.pef

1 Introduction

This memo describes the Cassini RADAR activities for the T120 Titan flyby. This SAR data collection occurs during the S94 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
236TI_T120WRMUP001_RIDER	2016-159T09:06:17	2016-159T13:36:17	04:30:0.0	
236NA_SSRARDISA001_NA	2016-159T09:07:37	2016-159T09:07:38	00:00:1.0	The time given is the beginning time of RADAR FSW load, 6EXT_MEM_LOAD. Disabling PING PONG and SSR auto repair program will be inserted around this time. Duration for the FSW load is less than 2 minutes.
236TI_T120INALT001_PRIME	2016-159T13:36:17	2016-159T13:48:17	00:12:0.0	
236TI_T120INSAR001_PRIME	2016-159T13:48:17	2016-159T14:06:17	00:18:0.0	
236TI_T120OTRAS001_PRIME	2016-159T14:06:17	2016-159T14:21:17	00:15:0.0	
236TI_T120OTRAS002_RIDER	2016-159T14:06:17	2016-159T14:12:17	00:06:0.0	
236TI_T120OTALT001_PRIME	2016-159T14:21:17	2016-159T14:36:17	00:15:0.0	
236TI_T120OHSAR001_PRIME	2016-159T14:58:17	2016-159T15:43:17	00:45:0.0	
236TI_T120OTSCT001_PRIME	2016-159T15:43:17	2016-159T16:21:17	00:38:0.0	

Table 1: t120 CIMS Request Sequence

3 Overview

T120 is a partial pass. The observation starts with inbound altimetry including atmospheric probe sequences at the end. Following this is the SAR main swath. At closest approach SAR imaging becomes a ride-along observation with INMS. Radar pointing resumes at 18 minutes past closest approach with outbound altimetry which includes another atmospheric probe sequence. The observation then concludes with a high-altitude scatterometer imaging sequence.

3.1 Coverage Layout

Figure 1 shows the layout of the different T120 data collections on a map of Titan. The red jagged lines show the beam centers of the ride-along SAR swath as it sweeps from the southern hemisphere to the northern hemisphere. The cyan symbols show the high altitude imaging in the southern hemisphere. The green symbols show the altimeter tracks.

The high altitude scatterometer imaging of the South polar area is also shown on this figure.

3.2 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.

Division	Name	Start	Duration	Data Vol	Comments
a	Warmup	-5:00:0.0	04:20:0.0	15.5	Warmup
b	scatterometer_compressed	-0:40:0.0	00:08:0.0	1.4	Compressed Scatt/Rad scan
c	standard_altimeter_inbound	-0:32:0.0	00:12:14.0	24.2	Inbound altimetry
d	standard_scatterometer_inbound	-0:19:46.0	00:00:4.0	0.6	Atmospheric Probe with Chirp
e	standard_scatterometer_inbound	-0:19:42.0	00:00:2.0	0.3	Atmospheric Probe with Tone
f	standard_sar_hi	-0:19:40.0	00:01:4.0	3.2	SAR Turn transition transition from scat, beam 3 only
g	standard_sar_pingpong	-0:18:36.0	00:02:36.0	34.3	Inbound SAR ping-pong
h	standard_sar_hi	-0:16:0.0	00:21:0.0	289.8	Hi-SAR Main Swath
i	standard_sar_hi	00:05:0.0	00:02:0.0	27.6	Hi-SAR Main Swath
j	scatterometer_compressed	00:07:0.0	00:11:0.0	2.0	Compressed Scatt/Rad off target
k	scatterometer_compressed	00:18:0.0	00:00:12.0	0.0	Compressed Scatt/Rad off target
l	standard_sar_hi	00:18:12.0	00:01:26.0	5.2	SAR Turn transition transition from scat, beam 3 only
m	standard_scatterometer_outbound	00:19:38.0	00:00:4.0	0.6	Atmospheric Probe with Tone
n	standard_scatterometer_outbound	00:19:42.0	00:00:2.0	0.3	Atmospheric Probe with Chirp
o	standard_altimeter_outbound	00:19:44.0	00:09:4.0	18.0	Outbound altimetry
p	standard_sar_hi	00:28:48.0	00:01:24.0	5.0	SAR Turn transition transition from alt, beam 3 only
q	scatterometer_imaging	00:30:12.0	00:24:0.0	100.8	Outbound scatterometer imaging
r	scatterometer_imaging	00:54:12.0	00:11:6.0	46.6	Outbound scatterometer imaging
s	scatterometer_imaging	01:05:18.0	00:02:48.0	11.8	Outbound scatterometer imaging
t	scatterometer_imaging	01:08:6.0	00:05:36.0	23.5	Outbound scatterometer imaging
u	scatterometer_imaging	01:13:42.0	00:02:48.0	11.8	Outbound scatterometer imaging
v	scatterometer_imaging	01:16:30.0	00:09:12.0	38.6	Outbound scatterometer imaging
w	scatterometer_imaging	01:25:42.0	00:05:54.0	24.8	Outbound scatterometer imaging
x	scatterometer_imaging	01:31:36.0	00:02:12.0	9.2	Outbound scatterometer imaging
y	scatterometer_imaging	01:33:48.0	00:05:12.0	21.8	Outbound scatterometer imaging
z	scatterometer_imaging	01:39:0.0	00:02:30.0	10.5	Outbound scatterometer imaging
lbrace	scatterometer_imaging	01:41:30.0	00:07:0.0	29.4	Outbound scatterometer imaging
vbar	scatterometer_imaging	01:48:30.0	00:11:30.0	48.3	Outbound scatterometer imaging
rbrace	standard_radiometer_outbound	02:00:0.0	00:15:0.0	0.9	Outbound radiometry
Total				806.0	

Div	Alt (km)	Slant range (km)	B3 Size (target dia)	B3 Dop. Spread (Hz)
a	95684	off target	0.12	off target
b	11222	off target	0.02	off target
c	8690	8690	0.01	807
d	4949	4949	0.01	1199
e	4929	4929	0.01	1202
f	4919	4919	0.01	1203
g	4608	4725	0.01	1255
h	3869	3948	0.01	1397
i	1356	1691	0.00	2283
j	1689	2805	0.01	2106
k	4435	5631	0.01	1285
l	4493	5236	0.01	1275
m	4910	4910	0.01	1205
n	4929	4929	0.01	1202
o	4939	4939	0.01	1200
p	7691	7761	0.01	884
q	8127	8721	0.01	849
r	15778	16172	0.02	508
s	19365	20343	0.03	432
t	20271	21243	0.03	417
u	22086	22813	0.03	390
v	22994	24052	0.03	378
w	25979	26913	0.04	345
x	27895	28708	0.04	328
y	28610	29520	0.04	322
z	30299	31046	0.04	309
lbrace	31111	31819	0.04	304
vbar	33387	34056	0.05	289
rbrace	37125	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

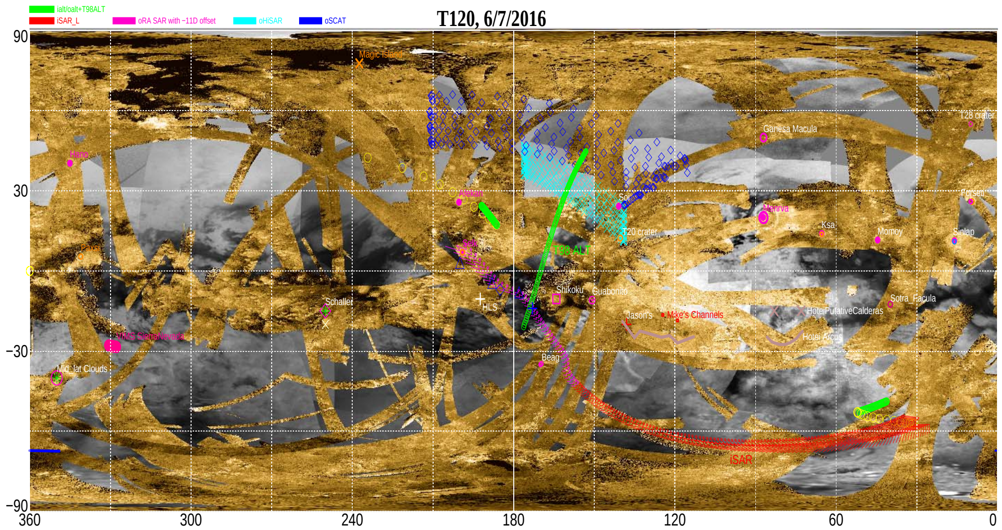

Figure 1: Coverage areas overlaid on Titan map showing prior optical and radar imaging.

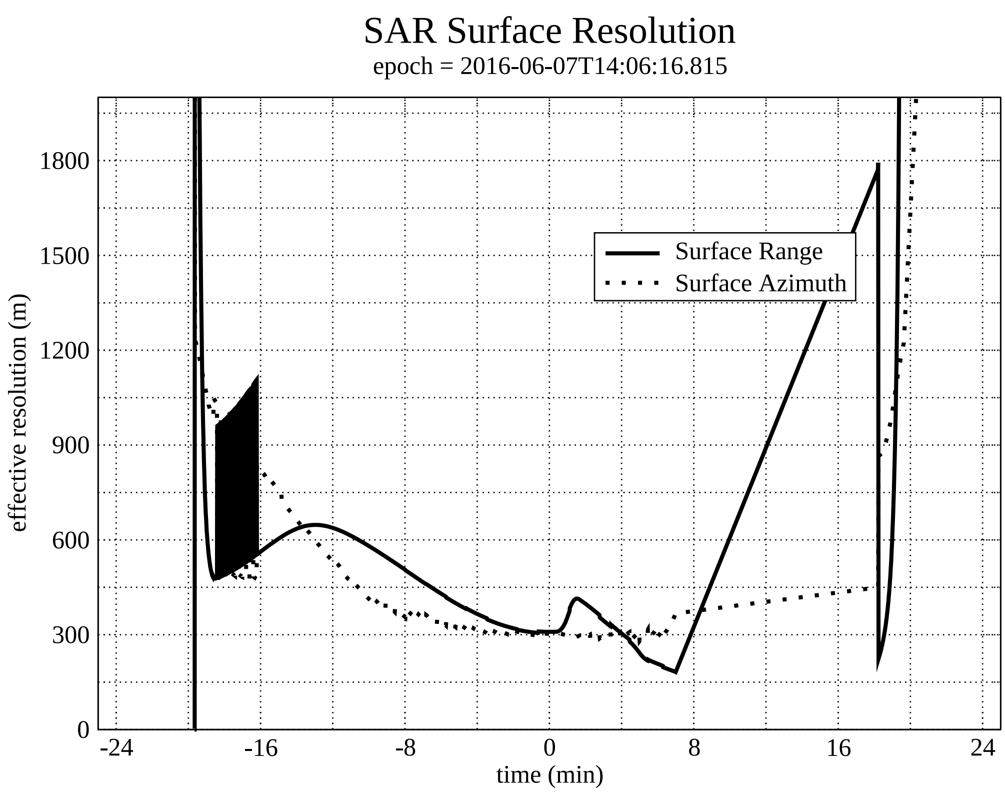

Figure 2: SAR projected range and azimuth resolution. These values are computed from the IEB parameters and are not related to the pixel size in the BIDR file. The pixel size was selected to be always smaller than the real resolution.

4 Revision History

1. Jun 8, 2016: Initial release

5 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