# Dione Scatterometry Rev 27

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- Sequence: s25
- Rev: 033
- Observation Id: di_033_1
- Target Body: Dione

## 1 Introduction

This memo describes one of the Cassini RADAR activities for the s25 sequence of the Saturn Tour. 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.

This IEB is for the third Dione distant scatterometer observation. A 3-hour warmup occurs first using the parameters shown in table 4. This observation splits a data allocation of about 300 Mbits with the nearby Rhea-27 observation.

## 2 CIMS and Division Summary

| CIMS ID | Start | End | Duration | Comments |
|---|---|---|---|---|
| 033OT_WARMUP4DI001_RIDER | 2006-324T22:00:00 | 2006-325T02:20:00 | 04:20:0.0 | Warmup for scatterometry and simultaneous radiometry of icy satellite. |
| 033DI_SCATTRAD002_PRIME | 2006-325T02:20:00 | 2006-325T04:00:00 | 01:40:0.0 | Point -Z axis at target and execute raster scans centered on target. Acquire simultaneous scatterometry and radiometry of target. |

Table 1: di_033_1 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.

| Division | Name | Start | Duration | Data Vol | Comments |
|---|---|---|---|---|---|
| a | distant_radiometer | 00:00:0.0 | 04:20:0.0 | 3.9 | Warmup |
| b | distant_radiometer | 04:20:0.0 | 00:23:6.0 | 1.4 | Warmup |
| c | distant_scatterometer | 04:43:6.0 | 00:01:54.0 | 22.8 | Scatterometer target-center stare with tone |
| d | distant_scatterometer | 04:45:0.0 | 00:01:54.0 | 22.8 | Scatterometer target-center stare with tone |
| e | distant_radiometer | 04:46:54.0 | 00:06:12.0 | 0.4 | Radiometer during turn transition |
| f | distant_scatterometer | 04:53:6.0 | 00:01:54.0 | 22.8 | Corner 1 Scatterometer stare with tone |
| g | distant_radiometer | 04:55:0.0 | 00:03:6.0 | 0.2 | Radiometer during turn transition |
| h | distant_scatterometer | 04:58:6.0 | 00:01:54.0 | 22.8 | Corner 1 Scatterometer stare with tone |
| i | distant_radiometer | 05:00:0.0 | 00:03:6.0 | 0.2 | Radiometer during turn transition |
| j | distant_scatterometer | 05:03:6.0 | 00:01:54.0 | 22.8 | Corner 1 Scatterometer stare with tone |
| k | distant_radiometer | 05:05:0.0 | 00:03:6.0 | 0.2 | Radiometer during turn transition |
| l | distant_scatterometer | 05:08:6.0 | 00:01:54.0 | 22.8 | Corner 1 Scatterometer stare with tone |
| m | distant_radiometer | 05:10:0.0 | 00:03:6.0 | 0.2 | Radiometer during turn transition |
| n | distant_scatterometer | 05:13:6.0 | 00:01:54.0 | 22.8 | Corner 1 Scatterometer stare with tone |
| o | distant_radiometer | 05:15:0.0 | 00:10:0.0 | 0.6 | Radiometer during turn transition |
| p | scat_compressed | 05:25:0.0 | 00:10:0.0 | 2.4 | Scatterometer on/off-target rcv only compressed |
| q | distant_radiometer | 05:35:0.0 | 00:25:0.0 | 1.5 | Closing radiometry |
| Total | | | | 170.4 | |

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 | 218156 | off target | 1.26 | off target |
| b | 75148 | off target | 0.44 | off target |
| c | 75450 | 75450 | 0.44 | 5131 |
| d | 75653 | 75653 | 0.44 | 5112 |
| e | 75881 | 75881 | 0.44 | 5091 |
| f | 76803 | 76906 | 0.45 | 5012 |
| g | 77138 | 77243 | 0.45 | 4985 |
| h | 77737 | 77830 | 0.45 | 4936 |
| i | 78135 | 78229 | 0.45 | 4905 |
| j | 78835 | 78935 | 0.46 | 4851 |
| k | 79292 | 79394 | 0.46 | 4816 |
| l | 80086 | 80173 | 0.46 | 4758 |
| m | 80601 | 80689 | 0.47 | 4720 |
| n | 81485 | 81585 | 0.47 | 4658 |
| o | 82053 | 82155 | 0.48 | 4618 |
| p | 85350 | 85350 | 0.50 | 4402 |
| q | 89114 | off target | 0.52 | 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

| Name | Nominal | a | b | Mismatch | Comments |
|---|---|---|---|---|---|
| mode | radiometer | radiometer | radiometer | no | |
| start_time (min) | varies | 0.0 | 260.0 | no | |
| end_time (min) | varies | 260.0 | 283.1 | no | |
| time_step (s) | varies | 1800.0 | 1800.0 | no | Used by radiometer only modes |
| bem | 00100 | 00100 | 00100 | no | |
| baq | don't care | 5 | 5 | no | |
| csr | 6 | 6 | 6 | no | |
| noise_bit_setting | don't care | 4.0 | 4.0 | no | |
| dutycycle | don't care | 0.38 | 0.38 | no | |
| prf (Hz) | don't care | 1000 | 1000 | no | |
| tro | don't care | 6 | 6 | no | |
| number_of_pulses | don't care | 8 | 8 | no | |
| n_bursts_in_flight | don't care | 1 | 1 | no | |
| percent_of_BW | don't care | 100.0 | 100.0 | no | |
| auto_rad | on | on | on | no | |
| rip (ms) | 34.0 | 34.0 | 34.0 | no | starting value for auto-rad |
| max_data_rate | 0.992 | 0.248 | 0.992 | yes | 1 Kbps - 1 s burst period which is adequate for slow radiometer scans |
| interleave_flag | off | off | off | no | |
| interleave_duration (min) | don't care | 10.0 | 10.0 | no | |

Table 4: di_033_1 Div ab distant_radiometer block

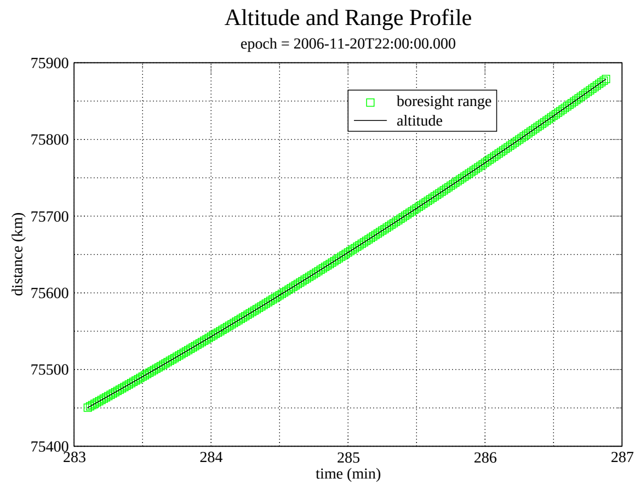


Figure 1: Div's D,E: Altitude and range to the boresight point

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. Subsequent sections will show and discuss the keyword selections made for each division. Each division table shows a set of nominal parameters that are determined by the operating mode (eg., distant scatterometry, SAR low-res inbound). The actual division parameters from the config file are also shown, and any meaningful mismatches are flagged.

# 3 Div's D,E: Dione Scatterometry

Figures 1 and 2 show the pointing design for the scatterometry stare from the merged ckernel. The angular size of the target is about 14.7 mrad during this division. The beam 3 beamwidth is 6 mrad.

The division parameters for the radiometer segments are shown in table 4. The division parameters for the compressed scatterometer receive only integrations are shown in table 5 and the tone target integration divisions are shown in table 5.

## 3.1 Scatterometer Receive Only Measurements

Div C is a place holder for manually placed receive only data that will survey attenuator settings in various modes. These blocks of instructions are placed in distant icy satellite observations if data volume and pointing permit. They will improve calibration of the radar in all modes. Div C covers the turn onto the target so there is off-target and on-target receive only data available. Div F covers the end of the stare and provides more receive only integration using scatterometer mode and the 9 dB attenuator setting used in the tone integrations. All of the receive only data is collected in compressed mode to get more integration time. The division PRF and number of pulses (1202 Hz and 160 respectively) are chosen to fill the science data buffer. These parameters give the best performance possible from the compressed mode.

| Name | Nominal | c | d | Mismatch | Comments |
|---|---|---|---|---|---|
| mode | scatterometer | scatterometer | scatterometer | no | |
| start_time (min) | varies | 283.1 | 285.0 | no | |
| end_time (min) | varies | 285.0 | 286.9 | no | |
| time_step (s) | don't care | 8.0 | 8.0 | no | Used when BIF > 1, otherwise set by valid time calculation |
| bem | 00100 | 00100 | 00100 | no | |
| baq | 5 | 5 | 5 | no | |
| csr | 0 | 0 | 0 | no | 0 - normal operation with fixed attenuator set to match Phoebe for easier cross-calibration |
| noise_bit_setting | 4.0 | 4.0 | 4.0 | no | Scat signal set higher than ALT/SAR |
| dutycycle | 0.70 | 0.70 | 0.70 | no | |
| prf (Hz) | varies | 8929 | 8929 | no | Set to cover doppler spread |
| tro | 6 | 6 | 6 | no | 6 - allows for some noise only data in time domain |
| number_of_pulses | varies | 200 | 200 | no | depends on PRF choice (can have more shorter pulses) |
| n_bursts_in_flight | varies | 3 | 3 | no | Used to increase PRF and data rate at long range |
| percent_of_BW | 0.0 | 0.0 | 0.0 | no | |
| auto_rad | on | on | on | no | |
| rip (ms) | 34.0 | 34.0 | 34.0 | no | |
| max_data_rate | 200.000 | 200.000 | 200.000 | no | Kbps - determines burst period |
| interleave_flag | off | off | off | no | |
| interleave_duration (min) | don't care | 10.0 | 10.0 | no | |

Table 5: di_033_1 Div cd distant_scatterometer block

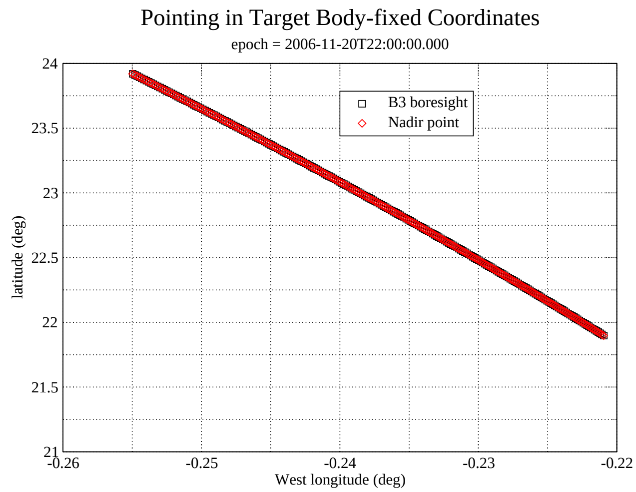


Figure 2: Div's D,E: Stare in target body-fixed coordinates

### 3.2 Scatterometer Performance

The detection performance is shown in figures 3, 4, and 5. Figure 5 shows that range processing not possible due to high $K_{pc}$. Disk integrated results should be very stable.

The maximum doppler spread in Div c is 5131 Hz which comes from rotation and spacecraft motion. The PRF needs to be higher than the doppler spread to support potential range-doppler processing, and is set by division parameter to 8929 Hz. With this PRF, the range amiguity spacing is 17 km while Dione is 560 km in radius. The range-spread of the beam depends on where it is pointed. For target centered pointing the cosine law can be applied to solve the geometry. At 75450 km range, the range-spread is 50 km.

## 4 Div G: Dione Radiometry

This observation does not have radiometry scans due to insufficient time. Radiometry data is always collected even during scatterometer mode, so there will be on-target and off-target radiometry data that can be used to determine the disk brightness temperature.

## 5 Revision History

1. Sep 27, 2007: Minor updates
2. Sep 27, 2006: Initial Release

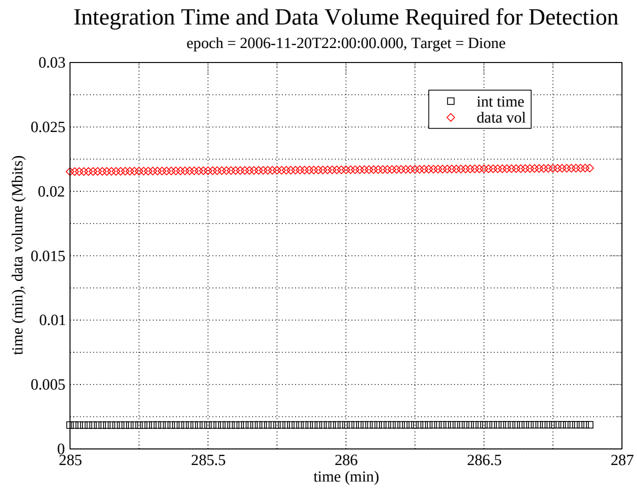


Figure 3: Scatterometry Div E: Detection integration time required for a single point detection using optimal chirp bandwidth

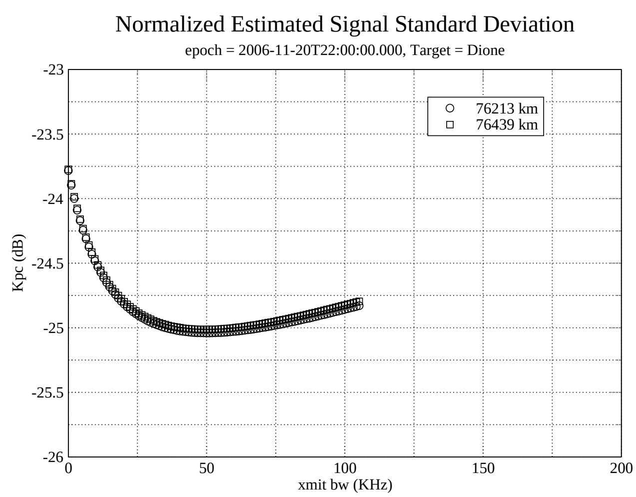


Figure 4: Outbound observation Div E: Normalized estimated signal standard deviation for a disk integrated observation using optimal chirp bandwidth and assuming all the bursts occur at minimum range, and 15 minutes away from minimum range.

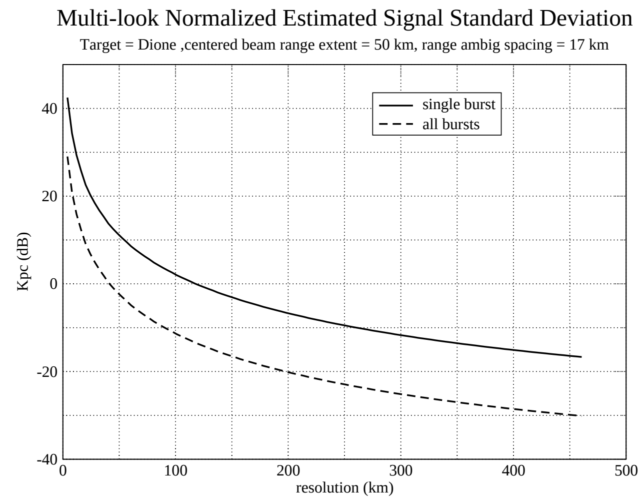


Figure 5: Outbound observation Div C: Normalized estimated signal standard deviation for a range/doppler cell as a function of resolution. Range/doppler resolution elements are both set equal to the specified resolution. Results are shown for a single burst, and for all the bursts in this division. Calculations are performed using the geometry at the start of the division. The presence of ambiguities are not shown.

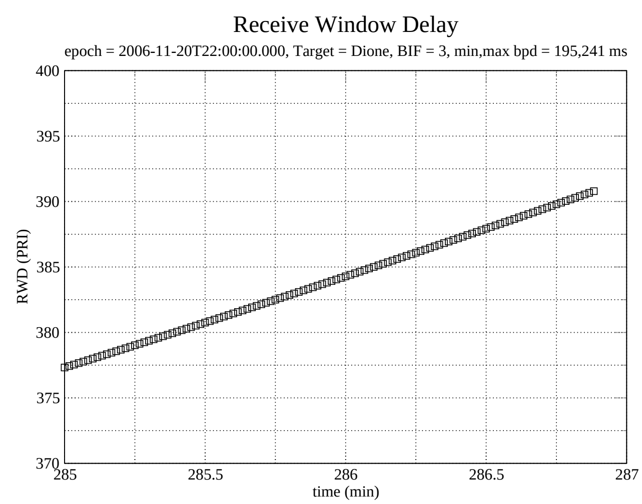


Figure 6: Div D: Scatterometer receive window delay. Subtitle shows the minimum and maximum burst periods that are in principle compatible with the division selected number of bursts in flight.

## 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 |