ORBITAL C PARTICLE MONITORING

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Purpose

The purpose of this document is to describe the observation plan for the Orbital C phase of the mission. It is intended to provide information for the science teams and instruments teams to ensure that the plan is consistent with the instrument capabilities and that it meets the observation constraints, or where it does not, the plan is nevertheless acceptable. Engineering details sufficient to determine if the plan fits within the spacecraft capabilities and available mission resources are provided here and in the Mission Plan Workbook.

The first half of this document focuses on the description of the observation plan. The second half of this document describes requirements, the constraints needed to meet those requirements and whether the constraints are met in the plan, and the resulting data products.

Inputs

Observation Constraints Spreadsheet:
OSIRIS-REx Bennu Proximity Operations\Science Planning (All Access)\UA-OPS-4.0-1001_Observation Constraints_CCv0068.xlsx
Mission Plan Workbook: OSIRIS-REx 02.0 PSE\Mission Plan\Mission Plan Workbook\Mission_Plan_Workbook_2019-05-06
Observation Envelope and Templates: OrbitC_Templates.r1.xlsx

Kernel Set:

- naif0012.tls
- pck00010.tpc
- bennu_v14.tpc
- de424.bsp
- orx_190608_200101_190415_od126-R-M1B-P-M2C_v1.bsp
- orx_v14.tf
- orx_struct_polycam_v01.bc
- orx_struct_mapcam_v01.bc
- orx_navcam_v01.ti
- orx_ocams_v07.ti
- orx_ola_v01.ti
- orx_otes_v00.ti
- orx_ovirs_v00.ti
- orx_rexis_v01.ti
- orx_struct_v00.ti
- g_12580mm_spc_obj_0000n00000_v020.bds
- ORX_SCLKSCET.00042.tsc

FDS delivery of products used for science planning are described here:
OSIRIS-REx Mission Operations System 7.0\Science Operations Planning Group (NON-US persons access)\Supporting Material\Orbital C\ROD126_Notes.pptx

MRD Overview

The Mission Requirements Document (MRD) Rev K includes 2 requirements that drive science operations during Orbital C. Monitoring of particles will allow the identification of potential spacecraft hazards, particle ejection source regions, particle impact regions, as well as providing trending data on the temporal and energy frequency of ejection events.

The 2 driving requirements include:

1. Dust and Gas Plume Search (MRD-142)
2. Natural Satellite Search (MRD-144)

Orbital C Overview

Orbital C runs from August 5 through September 8, 2019, with a trim burn scheduled in the first week to raise the orbit to a 1750-m semi-major axis. Particle monitoring is scheduled to take place over 30 days from August 10 through September 8 and will utilize nadir pointed NavCam-1 imagery.

Table 1. Orbit parameters

Semi-major axis (m)	Orbit Period (hrs)	# Bennu Rotations
1750	**57.64**	**13.4**

The Science Observation Window (SOW) for all nominal science days will be 16 hours and 20 minutes. Four variable contingency burns days are scheduled during which the SOW is reduced to 9 hours and 40 minutes.

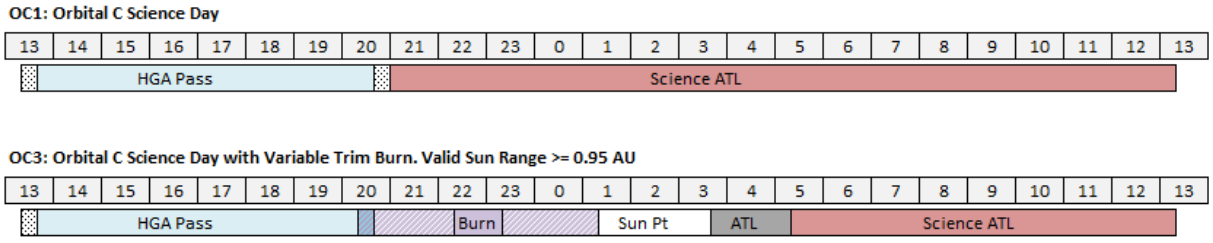

Figure 1 Orbital C templates displaying the nominal 16 hours and 20 minutes Science Observation Window and the shortened windows during trim burn days.

Particle Monitoring Observation Plan Summary

All of the particle monitoring will be done with NavCam-1 using a single nadir pointed target. Two images with 5-second exposures will be taken at each target, spaced by 138 seconds, to determine which points are true particles vs. points generated by cosmic rays or other artifacts. This is the same spacing used during Orbital A particle monitoring.

The nominal plan will be to take 76 nadir pairs per Science Observation Window, with an approximately 13 minute period. This plan results in 152 particle monitoring images per day, which is the amount we can downlink each day with 5 hours of downlink. On days of planned trim burns, we can only collect data for 9:40 hours, which results in only 44 image pairs.

OpNav images will be taken in nadir point during this subphase and will be interspersed with the particle monitoring images.

Operational Considerations for Orbital C

The default slew config file will be used during Orbital C. The entire Orbital C phase is done with nadir tracking so no slewing is required other than the ATF begins with a 12-minute nadir slew. These slews are required by J-Asteroid planning, but they are not required to be completed before data collection is initiated because we are expecting to be in nadir point at the beginning of each ATF.

All science instruments will be powered off during Orbital C.

Data Management: As currently planned, Orbital C takes place with a downlink rate of 916.7 kbps. The data collection is planned assuming a full 5 hours of downlink available for science each day other than on the four days of planned contingency trim burns, where 3.5 hours of downlink is assumed.

NavCam images for particle monitoring will be routed to the OCAMS partition during Orbital C. During this time OCAMS will not be observing and the OCAMs partition is therefore fully available for these observations.

CONOPS: These observations will be planned with the shortened 5 week planning and implementation timeline used for Orbital B. The OpNav Request will be the mechanism that outlines the proposed particle imaging for each week. These observations will be acquired using the landmark OpNav block.

These observations will be commanded with one 16.3 hour ATF per Science Observation Window (SOW). For days with shortened SOWs due to variable trim burn contingency placeholders, we will use the 16.3 hour ATF but with an early cutoff. The same ATF will be reused throughout Orbital C unless the OCAMS partition looks like it will overflow in the future. If needed, we can make an ATF with fewer particle images but still containing the full complement of OpNav images. With the delivery of the Pass 0 Background Sequence information at E-4 weeks, we will know the planned downlink times and we can make adjustments accordingly. If it looks like the OCAMS partition may become full, the number of image pairs will be decreased, but the pair spacing will not change.

Requirements

Active Asteroid Characterization

Requirement:

MRD-142: Search for dust and gas plumes originating from the asteroid surface and characterize their source regions, particle re-impact sites, and column densities

MRD-144: Detect with 95% confidence natural satellites >10-cm diameter with albedo ≥0.03 within 35 km of Bennu

Observation Constraints:

Instrument	Constraint	Fulfilled in SPP	Notes
NavCam1	**Spacecraft Pointing:** Nadir	✓	No additional slewing is required for particle imaging.
	Image Cadence: Image pair every 13 min.	✓	Cadence is driven by data volume and downlink opportunities.
	Pair Spacing: 138 sec.	✓	Pairs allow for determination of points that are true particles vs. points that are generated by cosmic rays or other artifacts.
	Image Exposure Time: 5 sec.	✓	
	Frequency: Continuous for 30 days.	✓	Nominal Science Operation Windows (SOWs) are 16 hours and 20 mins long. Truncated SOWs will be used on days with scheduled trim burns and trim burn contingency placeholders. Truncated SOWs are 9 hours 40 minutes in duration.

Ideal Observation Constraints:

Type of particle events (events type #)	Instrument	Pairs	Pair Spacing	Exposure Time	Mosaic Size	Cadence (between pairs)	Frequency
Large Ejection Events (1) >20 particles per event	NavCam1 (and/or 2)	Yes	~2-5 min	~5 sec	2x2	~10 min	Every 60 degrees of Bennu orbit, ~2.4 months for 2 weeks
Small Ejection Events (2)* <20 particles per event	NavCam1 (and/or 2)	Yes	~2-5 min	~5 sec	2x2	~20 min	Every 60 degrees of Bennu orbit, ~2.4 months for 2 weeks
Individual Satellites: Orbit	NavCam1 (and/or 2)	Yes	~2-5 min	~5 sec	2x1	~20 min	Every 60 degrees of Bennu orbit, ~2.4 months for 2 weeks;

Determination (3)*							or before we move to a lower altitude
Individual Satellites: Number Density (4)	NavCam1 (and/or 2)	Yes	~2-5 min	~5 sec	Single nadir pointed image	~2 hours	Continuous (rest of encounter)

*Individual ejection events can also lead to short-lived ballistic and hyperbolic trajectories

*These objects are considered part of events 2 and 3