Origins Spectral Interpretation Resource Identification Security-Regolith Explorer (OSIRIS-REx) Project

Loss of SamCam Contingency Plan

OSIRIS-REx-Plan-0059

Revision -

June 18, 2015

Goddard Space Flight Center
Greenbelt, Maryland

CM FOREWORD

This document is an OSIRIS-REx Project controlled document. Changes to this document require prior approval of the OSIRIS-REx Project CCB Chairperson. Proposed changes shall be submitted to the OSIRIS-REx Project Configuration Management Office (CMO), along with supportive material justifying the proposed change.

In this document, a requirement is identified by “shall,” a good practice by “should,” permission by “may” or “can,” expectation by “will,” and descriptive material by “is.”

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OSIRIS-REx Project
Loss of SamCam Contingency Plan

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OSIRIS-REx
LOSS OF SAMCAM
CONTINGENCY PLAN

DOCUMENT CHANGE RECORD Sheet: 1 of 1

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LIST OF TBDs/TBRs

Section	Description	Responsible	Due Date

Contents

1 Introduction

1.1 Overview

SamCam provides the images of the surface as the flight system descends to attempt to collect a sample, and during the time the TAGSAM head is in contact with the surface. These images identify the surface location where sampling took place and provide visual evidence that contact occurred and the collection gas was fired. These images are also important for public outreach and communication of the success of sample collection.

SamCam is also used to examine the TAGSAM head before it is stowed to identify any regolith particles on its exterior that may interfere with stowage in the SRC, and provide further qualitative visual evidence that sample was collected. Given these key functions, this contingency plan is to identify what measures could be taken to recover this information if SamCam fails.

1.2 Scenario Description

The key requirement for imaging during TAG is:

MRD-380:	OSIRIS-REx shall image the sample collection event.
Rationale:	Documentation required to determine context of the acquired sample and assist in verification of sampling success.

However, there is no necessary contingency to fill in for SamCam not being available to take images during the TAG event because the baseline plan provides other images to aid in meeting MRD-380. The baseline reference mission includes collecting data from all available sensors to provide an accurate reconstruction. NavCam2 (also called NFTCam) images, MapCam images from 25m altitude, Lidar images, 200Hz IMU data, GN2 bottle pressure, and TAG trigger logic telemetry are just a few of the data sources that will still be collected and used to verify where TAG occurred and that GN2 gas was fired to collect sample. NavCam2 images will provide knowledge of where the sampler head impacts the surface, but with a slight accuracy degradation since images of the sampler head on the surface won’t be available. NavCam2 based orbit reconstruction will provide imagery of the nearby surface and knowledge of the camera to sampler head offsets will allow for estimates of contact location on the order of 1 cm. The PolyCam and MapCam images of the TAG site provide context to help know what material was collected. The Science analysis of how the surface responded to the TAG event will be impacted without the SamCam images. However, the Science Team’s Regolith Development Working Group is assuming that regolith liberated by the TAGSAM gas firing obscures the SamCam. The TAG Reconstruction data analysis treats SamCam images as “bonus” data, so the loss of SamCam would not impact the reconstruction process.

If SamCam is not able to perform the TAGSAM head inspection due to the camera not working properly, then this contingency shows that there is an alternative method using StowCam and NavCam1 to help fill in for the system deficiency. However, the SamCam images provide superior imaging of the sampling surface of the head since this camera was designed for this application. It should be noted that the TAGCAMS suite could be covered with dust after the TAG event. This plan assumes the lenses are not obscured too drastically to prevent successfully executing this contingency plan. If too must dust exists on the cameras, it has been decided we would okay to stow “in the blind” without imagery, with Sample Mass Measurement data verifying we collected sufficient sample. Successful capture can be verified without the StowCam because the SRC capture ring has Microswitches in the latches.

1.3 Scope

This plan describes the activities that will allow the Flight Team (FT) to continue the mission in the event SamCam cannot successfully collect the TAGSAM head inspection images. This is not a step-by-step plan since the applicability of the actions/activities can vary depending on the circumstances. Instead this document identifies the actions/activities that must be considered to collect the head inspection images to the best extent possible and help ensure no particles on the exterior of the head would prevent successful stowage into the SRC.

1.4 Applicable Documents

Document Number	Title
OSIRIS-REx-RQMT-0001	OSIRIS-REx Mission Requirements Document
OSIRIS-REx-OPS-0001	Design Reference Mission
NFP3-PN-13-0183	Baseline Reference Mission
OSIRIS-REx-PLAN-0054	Anomalous Sampling Attempt Contingency Plan
OSIRIS-REx-SC-CDRL-0153	Coordinate Systems Definition Document

2 Actions

For Loss of Instrument contingencies there are no decisions to be made so this section covers the adjustments that must be made for replacing the loss.

2.1 Overview

This contingency plan will be entered if SamCam cannot provide inspection images of the sampler head. The high level flow chart of key questions and activities to continue with stowing the TAGSAM head into the SRC is shown here.

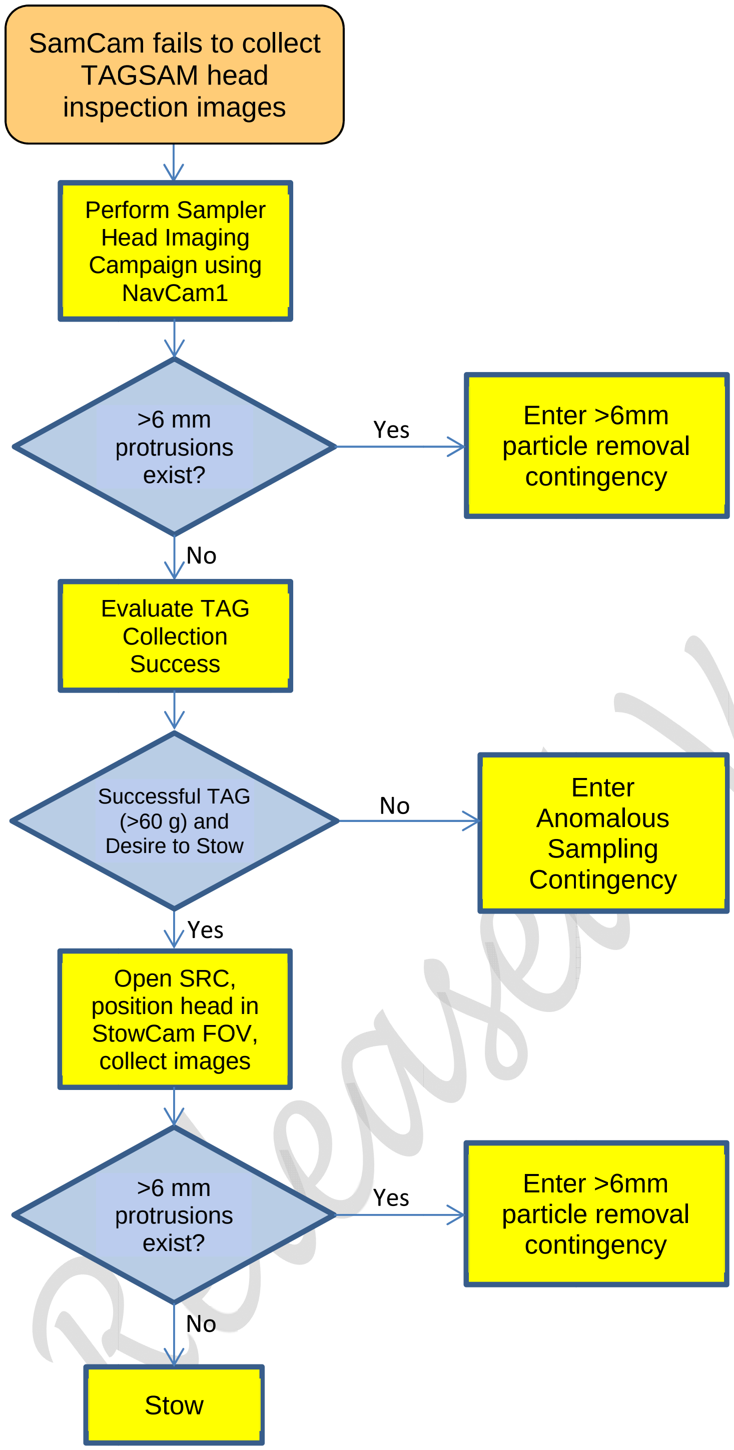

Figure 2-1 Decision Flow Diagram

2.2 Spacecraft in Danger

The FT must collect images of the sampler head face to ensure no protrusions of >6mm exist, which could prevent head stowage into the SRC. The baseline plan uses SamCam images to determine if such obstacles exist, and this activity is performed prior to opening the SRC.

If SamCam is unavailable, the FT should still perform the Imaging Campaign of the sampler head but use the NavCam1 instead. The spacecraft geometry is supportive of collecting images of the head, however, the camera depth of field is not guaranteed to provide quality resolution at the short range as it was only designed to support imaging of the surface at a closest range of 5m.

After performing the imaging campaign, it is recommended to still evaluate for 6mm particles via additional images beyond the baseline plan using StowCam. To do so, the SRC must be opened first before safely moving the TAGSAM head into the StowCam FOV for imaging and obstacle detection. The SRC is nominally kept closed until SamCam images confirm no protrusions >6mm, as this helps prevent any obstacles to inadvertently enter the capture ring mating interface and prevent head stowage. However, the SRC can be open/closed multiple times to support this contingency if necessary.

2.3 Implementation Details

Refer to the DRM or BRM to see the nominal, baseline sequence of events during post-TAG activities, including TAGSAM head images and stowing activities.

This contingency plan includes the activities described above:

1) Shows the images available during the sampler head imaging campaign using NavCam1 instead of SamCam.
2) Describes the process to perform StowCam imaging for 6mm particle detection: opening the SRC, moving the sampler head into the StowCam FOV, collecting the images and evaluating on the ground, then continuing with stowage if no >6mm protrusions exist.

2.3.1 NavCam1 for Sampler Head Imaging Campaign

The following two figures show what NavCam1 images could provide during the sampler head imaging campaign. See the Coordinate Systems Definition Document for spacecraft reference frame information. The TAGSAM joint angles are included in the captions, and it should be noted that these could be updated slightly as needed to get better coverage of the sampler head. At a minimum the wrist joint angles would be driven per the baseline plan to collect images at 15 deg increments between 0 and 90 deg. Similarly, the sun angles are included which could be updated to perform imaging at multiple sun angles. The timelines and slew profiles to keep the spacecraft safe would need to be further analyzed, but some key solar constraints are described in section 2.3.2.

Figure 1: NavCam1 image of sampler head with shoulder at 151.0 deg, elbow at 86.7 deg, and wrist at 90 deg. Sun is shining on the spacecraft -Y and +X axes equally with no Z component.

Figure 2: NavCam1 image of sampler head with shoulder at 151.0 deg, elbow at 86.7 deg, and wrist at 0 deg. Sun is shining on the spacecraft -Y and +X axes equally with no Z component. Notice the sun illuminates the sampler head face but the sun does not reach the mylar flap. Thus, sample temperatures will remain <75C while imaging of the sampler head face can determine if large particles exist (which would need to be removed prior to stowing).

2.3.2 StowCam Imaging for 6mm Particle

The following six figures show what spacecraft geometries and sun illuminations are available for the StowCam images of the sampler head:

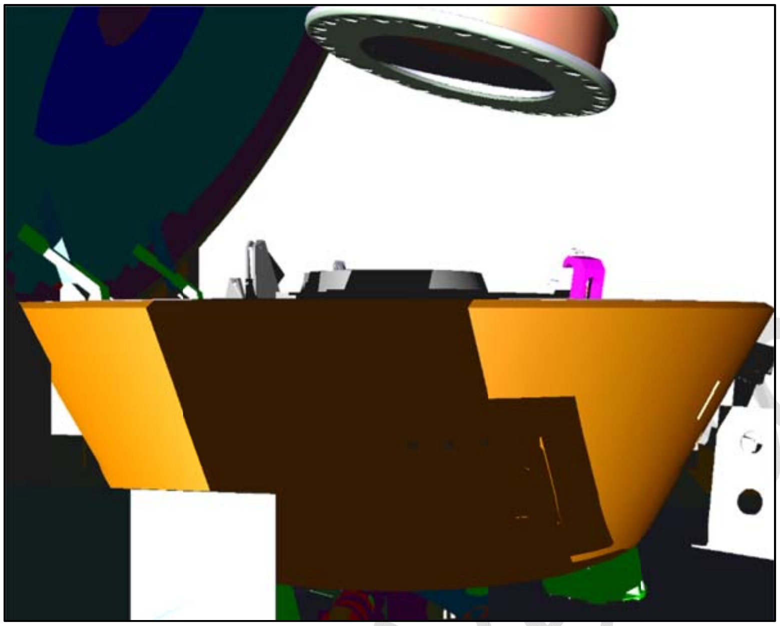

Figure 3: StowCam image of sampler head with U-joint angle of 0 deg (nominal) and the sun lighting behind StowCam and 15 deg towards +X axis (notice no SRC shadow on sampler head).

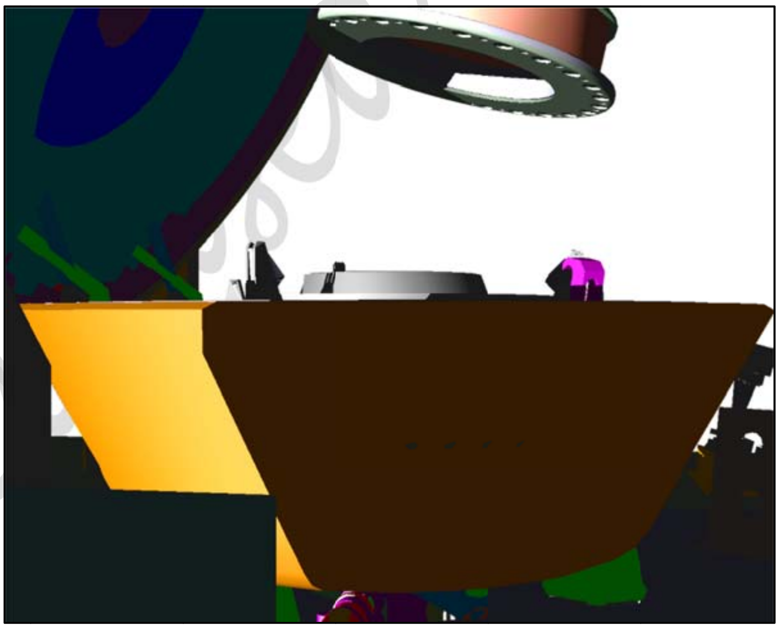

Figure 4: StowCam image of sampler head with U-joint angle of 0 deg (nominal) and the sun lighting behind StowCam and 30 deg towards +X axis (notice SRC shadow casted on left side of sampler head).

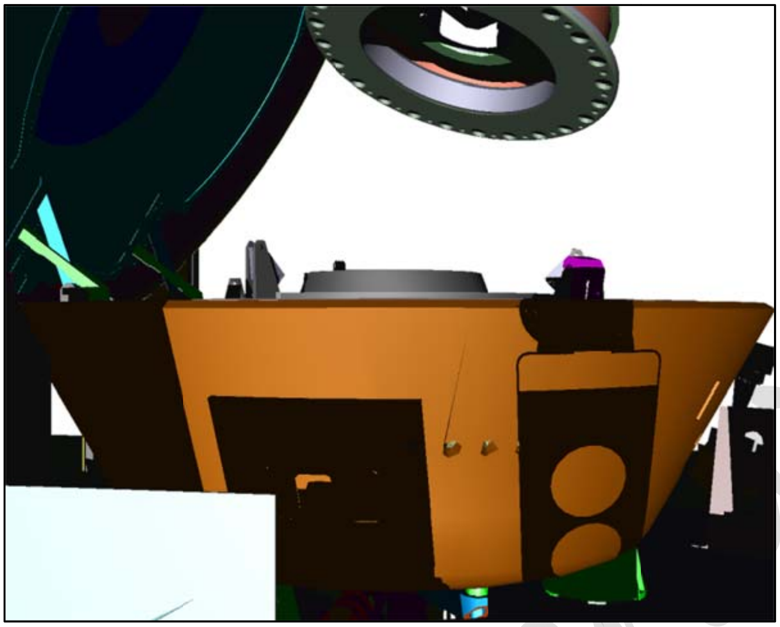

Figure 5: StowCam image of sampler head with U-joint angle of +15 deg (off-nominal extreme, best case) and the sun lighting behind StowCam (sun actually aligned with spacecraft Y axis, and StowCam is 10 deg off-axis).

Figure 6: StowCam image of sampler head with U-joint angle of -15 deg (off-nominal extreme, worst case). The bottom is not visible to detect 6mm protrustions. However, this is an unlikely U-joint angle since the convoluted gas tube should mostly restore the angle to 0 deg.

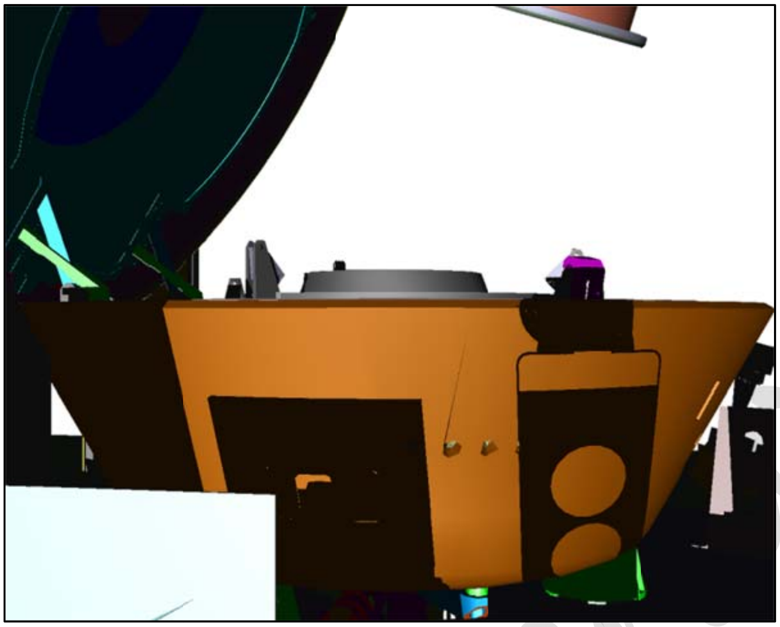

Figure 7: StowCam image of sampler head with U-joint angle of -15 deg (off-nominal extreme, worst case). This is the image where a 6mm protrusion on the bottom may be first visible, which cannot be taken of the entire sampler head face.

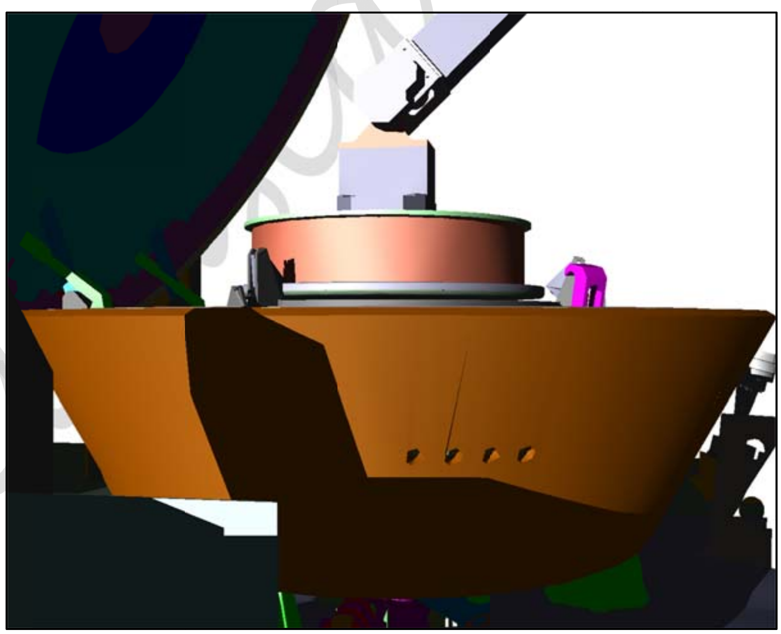

Figure 8: StowCam image of sampler head in SRC

A power and thermal constraint exists on this spacecraft orientation with respect to the sun. Near perihelion, the sun can shine directly on spacecraft +Y or -Y for a maximum of 35 minutes before thermal limits are reached. Therefore it will likely be necessary to perform the SRC opening and TAGSAM articulations while in nominal Sun Point attitude. Then, after achieving the spacecraft configuration for the imaging, slew so the sun is behind StowCam to provide the images shown above. This detail is also to be refined for the nominal StowCam imaging activities and will be documented in the BRM. The BRM also includes the necessary arm articulations to prevent sun from shining into TAGSAM's mylar flap, which prevents the sample from exceeding the 75C requirement.

It is likely optimal to collect images over multiple sun angles with multiple exposures as the spacecraft is slewing. A budget for the collected images to be downlinked is as follows:

<u>Images to collect:</u>

- Sun 30 deg off +Y axis, 5 images to bound exposures
- Sun 15 deg off +Y axis, 5 images to bound exposures
- Sun 0 deg off +Y axis (10 deg off StowCam boresight), 5 images to bound exposures
  Total = 15 images.

Once these 15 images are evaluated, it may be desired to repeat the above activity with a different TAGSAM wrist or shoulder position. It may be possible to move the arm while collecting these images as well, which should be considered further if this contingency is executed. The exact vehicle-to-sun attitudes to execute in flight are hard to determine until the TAGSAM u-joint angle is determined via imaging. Care must be taken to prevent sun from illuminating the mylar flap, but it's also important to get sun shining on the sampler head face to determine if obstructions exist which could prevent successful stowage. Repeating the StowCam image collection activity requires sufficient time to charge the battery and reach thermal equilibrium. A conservative estimate for the cooling time needed is 4 hours.

APPENDIX A: ACRONYMS

BRM – Baseline Reference Mission

DRM - Design Reference Mission

FOV – Field of View

FT – Flight Team

GN2 – Gaseous Nitrogen

IMU – Inertial Measurement Unit

NFT – Natural Feature Tracking

OCAMS – OSIRIS-REx Camera Suite

OSIRIS-REx – Origins, Spectral Interpretation, Resource Identification, Security Regolith Explorer

TAG – Touch-and-Go

TAGSAM – Touch and Go Sample Acquisition Mechanism

SRC – Sample Return Capsule