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

MLN-FDS F4

Final Test Report

Revision Final

August 30, 2016

Goddard Space Flight Center
Greenbelt, Maryland

National Aeronautics and Space Administration

OSIRIS-REx Project

MLN-FDS F4 Final Test Report

SIGNATURE PAGE

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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."

Questions or comments concerning this document should be addressed to:

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REVISION LOG

Revision	Paragraphs affected	Change Description	Release Date
Draft	All		Aug 2. 2016
Final		Incorporated the draft comments	Aug 30, 2016

Contents

Tables

Figures

1. Introduction

1.1. Purpose

This document is the Maps for Landmark Navigation-Flight Dynamics System (MLN-FDS) Final Report.

1.2. Scope

This test report includes performance against test objectives, planned and actual activities, planned and actual requirements verification summary, and data product verification. The test report also includes problems encountered during test and disposition of all TDRs, verification status with corresponding TDRs and plan for resolution along with overall lessons learned from the test.

The objectives/success criteria for F4 are:

- Verifies the 75cm shape model requirements are met with data planned in DRM Rev C, including expected navigation and pointing errors
- Demonstrates ALT WG's and SPOC's portion of the End-to-End test
- Validates SPC procedures and tools

2. MLN-FDS F4 Test Summary/Results

2.1. Overview

The F4 test was broken into four major blocks:

- Block: Initial Load,
- Block: Adding Images,
- Block: Increasing Resolution,
- Block: Eval & Fix

As planned, the F4 test was not conducted with a one-to-one correlation between the test procedures and the work required because many procedures must be done numerous times with different data to build the shape model.

The "as-run" procedure can be found on ODOCS in the "OSIRIS-REx 09.0 Ground Systems/MLN-FDS/F4-F5 Run For Record" folder and contains the following information

- Test steps planned and executed

- Test participants and their responsibilities

- Test facilities, SISs, hardware, and software used to perform the test

- Procedure deviation, denoted via "redlines" and TDRs flags

- Lessons Learned

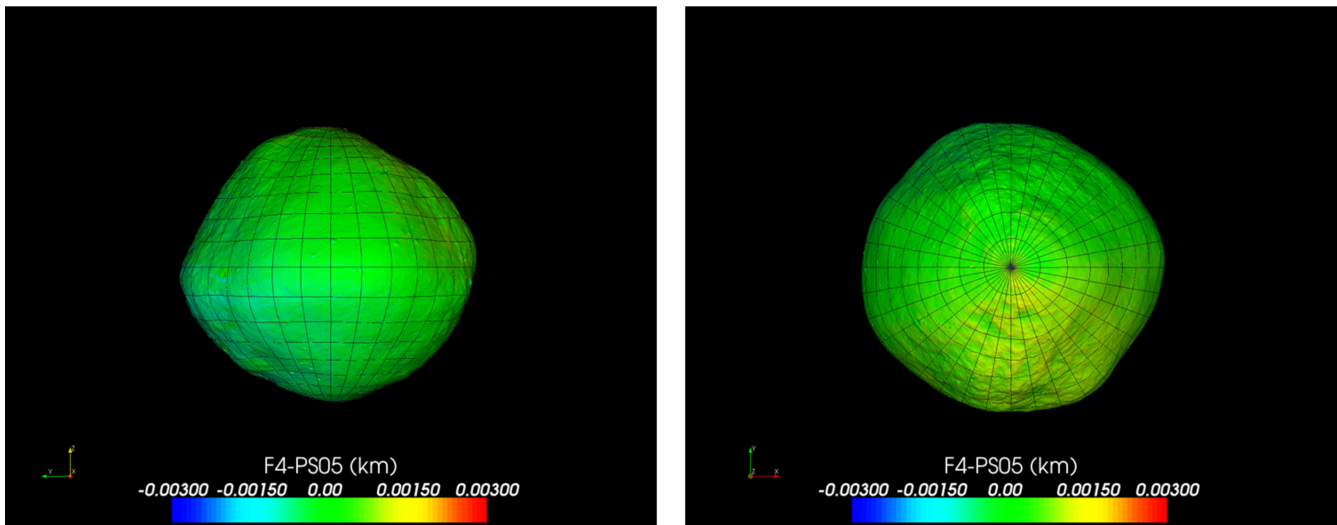Figure 21shows the Shape Model that was delivered to the FDS team for their MLN-FDS F5 test.

Figure 21 Final Shape Model

2.2. Test Discrepancies Reports Status

Table 21contains the status for the TDRs that were opened during test execution. All TDRs can be found on ODOCS in the "OSIRIS-REx 09.0 Ground Systems/MLN-FDS/F4-F5 Run For Record" folder.

Table 21 TDR Status

TDR #	Title	Status
MLN-FDS-003	SPOC to ALTWG ICD	Open
MLN-FDS-004	MapCam Kernels Incorrect for Preliminary Survey	Closed

2.2.1. MLN-FDS-003 SPOC to ALTWG ICD

Problem: The SPOC to ALTWG ICD, needs to be approval prior to the ALTWG shape Model verification activities or approximately May 16, 2016.

Resolution: Open.

The SPOC to ALTWG ICD is still in review; however, this posed no concern to test execution since the interfaces were accomplished in accordance with the current draft revision. No changes are expected as a result of this test.

2.2.2. MLN-FDS-004 MapCam Kernels Incorrect for Preliminary Survey

Problem: MapCam images for some portions of Preliminary Survey could not be correctly positioned.

Resolution: Closed. The following steps were performed

1. Identify problem kernels and regenerate them;

2. Regenerate images from corrected kernels;

3. Replace the testing kernels (perturbed PS MapCam) in the test directory; and

4. Delete the old PS MapCam images from the model and re-ingest them into the model. Continue the test with step 4.2.4.

3. Requirements Verification Summary

Table 31shows the verification status of the MLN-FDS F4 applicable requirements. There were no descoped requirements

Table 31 Requirement Verification Status

Req. ID	Requirement Description	Verification
MRD-678	The Ground System shall, for > 80% of the asteroid surface, produce a set of DTMs at < 0.75 m in ground sample distance (sample resolution). Note: Ground sample distance is defined as the sample spacing of the surface in m/pix.	PASS
MRD-680	The Ground System shall, for > 80% of the asteroid surface, produce a set of DTMs with post-fit residual RMS < 0.38 m (1-sigma) for each maplet. Note: Post-fit residual of a maplet is defined as the (pixel, line) difference between predicted model and observed images of the maplet.	PASS
MRD-682	The Ground System shall, for > 80% of the asteroid surface, produce a set of DTMs with a 3D RMS accuracy < 1m (1-sigma).	PASS
MRD-684	The Ground System shall provide the global 75cm DTM product to FDS within 14 days of downlink of all Preliminary Survey OCAMS and OLA data.	PASS

NOTE: 80% percent of the asteroid surface is determined by the following process:

- Run SPC "residuals" to define which landmarks have the lowest residual
- Remove the 20% worse landmarks
- Extract the "Central Vector" of the remaining landmarks to form a "Point Cloud"
    - Simple file of x, y, z vertices
- Compare this point cloud with the truth model
    - It evaluates only those vertices
    - 5cm GSD shape model is evaluated every 2.5m

3.1. MRD-678 and MRD-682 Summary of Verification Evidence

The requirements state:

- MRD-678- The Ground System shall, for > 80% of the asteroid surface, produce a set of DTMs at < 0.75 m in ground sample distance (sample resolution).
    Note: Ground sample distance is defined as the sample spacing of the surface in m/pix.

- MRD-680 - The Ground System shall, for > 80% of the asteroid surface, produce a set of DTMs with a 3D RMS accuracy < 1m (1-sigma).
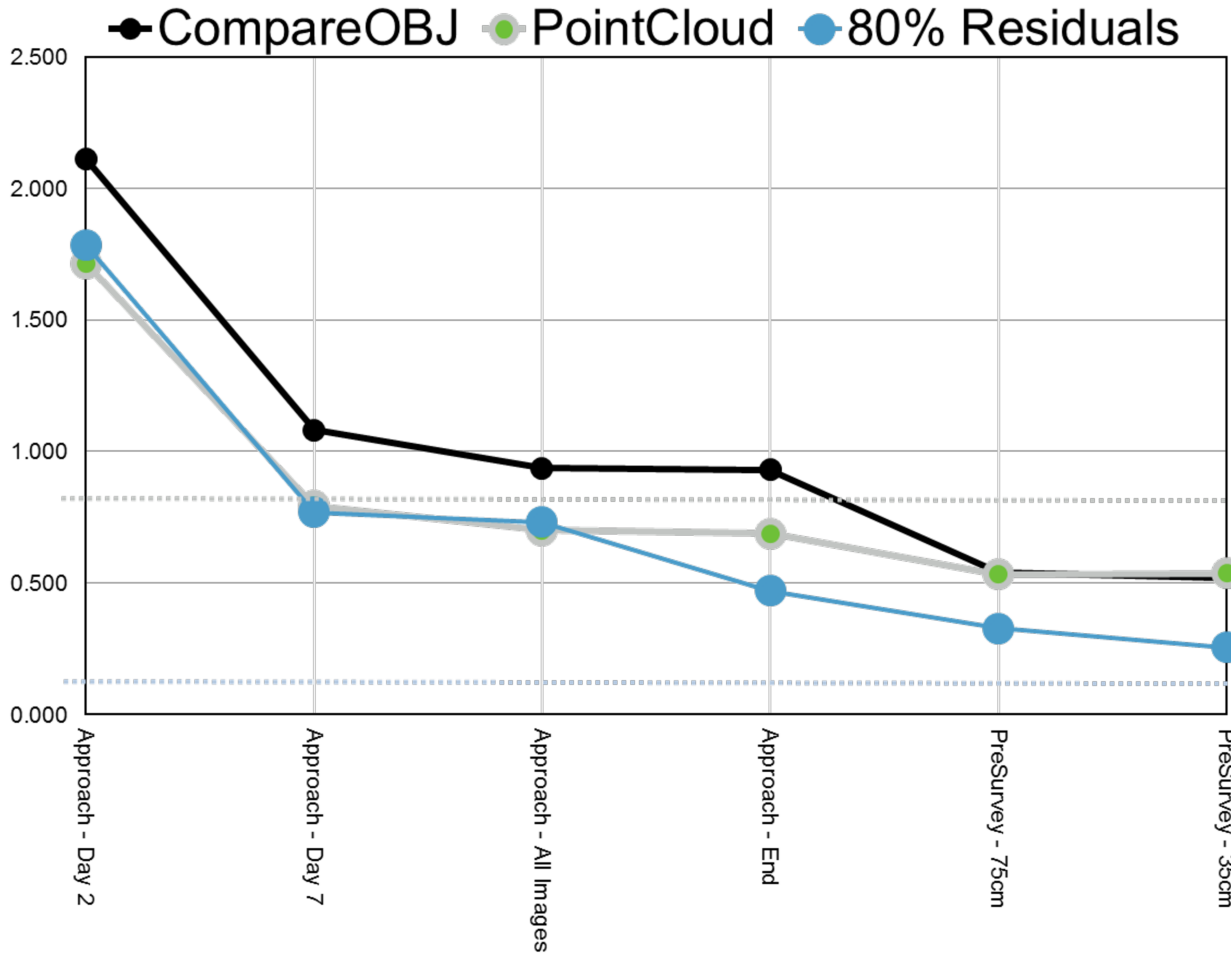
Figure 31 F4 75cm Shape Model Results

Figure 31 contains the Benchmarks showing the improvement of the shape model throughout the test. RMS values (in meters) are calculated two different ways: 1) CompareOBJ, which is calculated over the whole shape model (black line), and 2) PointCloud, which is calculated over the best 80% of the asteroid (grey line). Dotted grey line shows 75cm, the accuracy requirement. Residuals are a benchmark that accounts for the internal consistency of the model, calculated for the best 80% landmarks of the 75cm maplets. Dotted blue line shows 38cm, the residual requirement. CompareOBJ and PointCloud methods require a truth model, the residual method does not.

Figure 31 shows that 100% of the surface was covered at 75 cm. The figure also shows the accuracy of 3D RMS < 1m (1-sigma) also exceeded requirements as shown below:
- CompareOBJ 100%: 52.0 cm
- CompareOBJ w/ Translate/Rotate: 33.6 c
- Point Cloud over 80%: 53.7 cm

3.2. MRD-680 Summary of Verification Evidence

The requirements states: The Ground System shall, for > 80% of the asteroid surface, produce a set of DTMs with post-fit residual RMS < 0.38 m (1-sigma) for each maplet.

Note: Post-fit residual of a maplet is defined as the (pixel, line) difference between predicted model and observed images of the maplet.
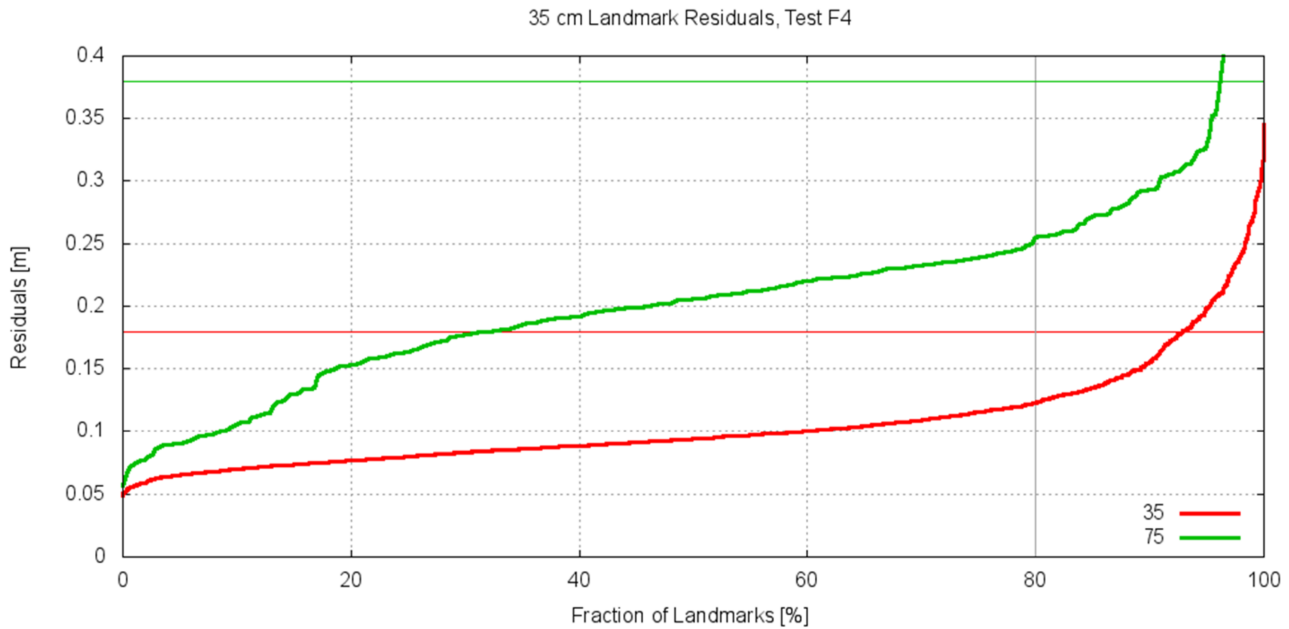

Figure 32 F4 Residuals Results

The red and green line plots, Figure 32, show the cumulative Residual as a fraction of the landmarks (best to worst) at the end of the test. The green line plot shows the residual value for each 75 cm maplets, and the red shows 35 cm maplets. The green and red horizontal lines show the residual requirement for the best 80% of the landmarks for Preliminary Survey and Detailed Survey respectively. The residual value exceeds the requirement (38cm) by a huge margin so that 97% of the landmarks pass (rather than only 80%).   This requirement has been met. Although there are no requirements for the 35 cm maplets in this test, that requirement was also satisfied.
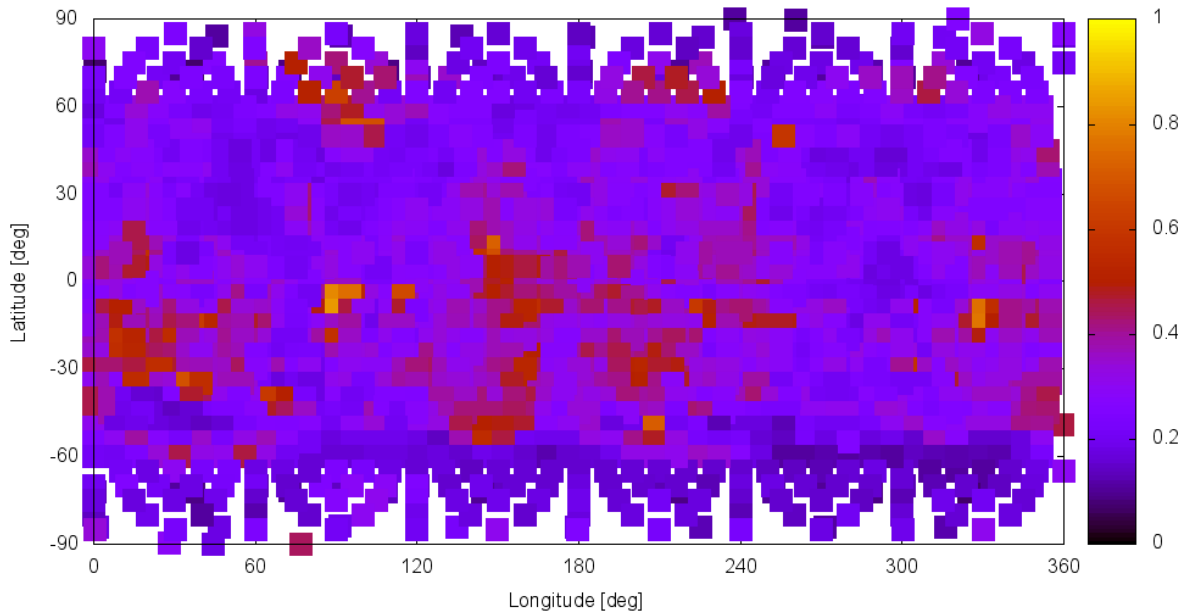
Figure 33 F4 Residuals Spatially Results

Figure 33 shows the residuals of maplets as a function of latitude and longitude. Color coding shows the residual for each landmark in meters.

3.3. MRD-684 Summary of Verification Evidence

The requirement stated: The Ground System shall provide the global 75cm DTM product to FDS within 14 days of downlink of all Preliminary Survey OCAMS and OLA data.

The execution log recorded the actual calendars days it took to complete the 75 cm DTM, steps 4.2.3 thru 4.2.7. It took eighteen days to complete those steps however TDR MLN-FDS-004 caused a six day delay. Thus the time to complete steps 4.2.3 thru 4.2.7 was twelve days.

In addition to the twelve days for the ATLWG to build and verify the 75 cm DTM this allows 1-2 days for FDS to deliver the reconstructed trajectories. The Navigation Plan, paragraph, 6.3.1.1, states "Reconstructed trajectories should be available 1–2 days after the observations in Preliminary Survey for science processing". Thus the requirement to deliver the 75 cm DTM within 14 days is satisfied.

4. Plan for Re-Testing

There are no plans for any re-testing.

5. Other Findings/Issues and Plan for Resolution

Not Applicable

6. Lessons Learned

The following are the lessons learned:

1. If at all possible a through dry run with the final inputs should be accomplished. If this had been done TDR-004 would have been found during the dry run and avoided a week delay in testing.