

**Lunar Reconnaissance Orbiter
Cosmic Ray Telescope for the Effects of Radiation**

**CRaTER Science Operations Center
Test Plan**

Document 32-01212
Revision 01
July 31, 2007

Prepared by

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Cosmic Ray Telescope for the Effects of Radiation**

**CRaTER Science Operations Center
Test Plan**

**Release 01
July 31, 2007**

Approved:

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CRaTER Principal Investigator

Date

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Date

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1 Preface

This document describes the format and content of the Lunar Reconnaissance Orbiter (LRO) Cosmic Ray Telescope for the Effects of Radiation (CRaTER) Experiment Data Record archive.

1.1 Distribution list

Table 1: Distribution list

Name	Organization	Email
Arlin Bartels	GSFC/LRO	Arlin.Bartels@nasa.gov
David Bradford	BU/CAS	bradford@bu.edu
Rick Foster	MIT/MKI	rickf@space.mit.edu
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Justin Kasper	MIT/MKI	jck@space.mit.edu
William Mayer	MIT/MKI	wfm@space.mit.edu
Richard Saylor	GSFC/LRO	Richard.Saylor@gsfc.nasa.gov
Stanley R. Scott	GSFC/LRO	Stanley.R.Scott@nasa.gov
Mark Sharlow	UCLA/PDS/PPI	msharlow@igpp.ucla.edu
Harlan Spence	BU/Astro	spence@bu.edu
Erik Wilson	BU/Astro	wilsone@bu.edu

1.2 Document change log

Table 2: Document change log

Change	Date	Affected portion
Initial draft	07/31/07	All

1.3 TBD items

Table 3 lists items that are not yet finalized.

Table 3: List of TBD items

Item	Section(s)	Page(s)
E&PR Plan	§1.4	2
MOT–SOC Operations Agreement	§1.4	2
Description of SOC-PDS Test	Table 14	13
Untested Requirements	Appendix A	15

1.4 Applicable Documents

CRaTER Science Operation Center Requirements Document, 32–01209, Revision B, October 25, 2006.

Spacecraft to CRaTER Data Interface Control Document, 431-ICD-000104, Revision B, March 30, 2007.

CRaTER Instrument Team Data Management and Archive Plan, 32–01210, Revision A, October 25, 2006.

External Systems ICD for the LRO Ground System, 431–ICD–000049, Revision A.

LRO MOC Secure Filecopy Implementation Brief, Paul Swenson, September 28, 2006.

Operations Agreement between the LRO MOT and the CRaTER SOC, **TBD**.

CRaTER Science Team and the PDS PPI Node ICD, 32–02080, Revision B, November 21, 2006.

CRaTER Information Technology Security and Contingency Plan, 32–01208, Revision A, July 1, 2007.

CRaTER Standard Product Data Record and Archive Volume Software Interface Specification, 32–01211, Revision B, August 1, 2007.

CRaTER Functional Instrument Description and Performance Verification Plan, 32-05002, Rev. 01, June 20, 2006.

CRaTER Educational and Public Outreach Plan, **TBD**.

2 Introduction

2.1 Scope

The purpose and scope of this document is to define the CRaTER Science Operations Center (SOC) Test Plan to be used for verification of all the components that comprise the SOC. This Test Plan document supports the following objectives:

- Identify the CRaTER science operations components to be tested.
- Describe the testing strategies to be employed.
- List the deliverable elements and schedule of the test project.

2.2 Components

The CRaTER SOC comprises a rack of hardware components (see Figure 1), an internet connection, and a staff. The hardware comes in two flavors: very secure (the SOC-A and its backup, SOC-B) processors and the “Logger”, and not so secure (Crater-A and backup, Crater-B). All data transmission between the SOC and the LRO MOC is made from/to the secure processors, which are also responsible for all pipeline processing and data distribution.

The less secure hosts, Crater-A and -B, maintain copies of the pipeline data products and of the real-time housekeeping data stream. They provide platforms into which CRaTER team members can log in to work on scientific and engineering analysis. They also maintain web servers that can be accessed (securely) by the science team, and insecurely by the general public.

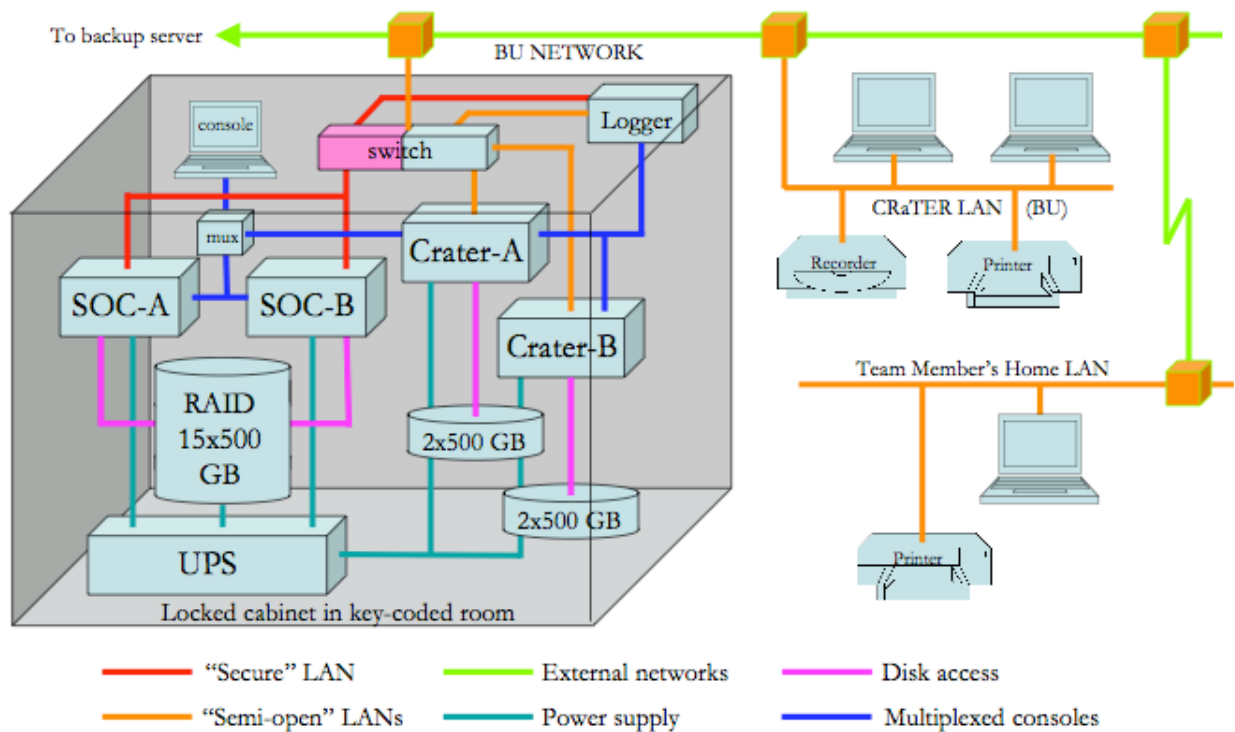


Figure 1. The CRaTER SOC Hardware Layout

In addition to these local functions, several interfaces are defined. SOC-A and -B receive real-time ITOS telemetry from the MOC and return CRaTER command files to the MOC. They also relay real-time telemetry and data products to Crater-A and -B. They are also accessible from the “Logger”, a secure processor dedicated to security tasks, and via secure shell (*ssh*) login from Crater-A and -B.

Crater-A and -B receive real-time telemetry and copies of pipeline products from SOC-A and -B. They run data servers that distribute real-time telemetry to team members and they are responsible for creating and validating the archive products that are sent to the Planetary Data System. They also maintain HTTP (public web) and HTTPS (secure web) servers to distribute CRaTER products and information.

The SOC requirements to be tested are defined in the CRaTER Science Operation Center Requirements Document (32–01209) and will be related to specific tests via the traceability matrix in Appendix A, below. The functions that are local to the various SOC machines are described in the Data Management and Archive Plan (32–01210). Security aspects are further described in the IT Security and Contingency Plan (32–01208). The interface to the MOC is described in the External Systems ICD for the LRO Ground System (431–ICD–000049) and further elaborated in the Secure Filecopy Implementation Brief and in the Operations Agreement between the LRO MOT and the CRaTER SOC. Refer to §1.4 for references to these documents.

2.3 Testing Approach

The SOC’s methodology breaks the task of testing down into three steps. In the first, the requirements are segregated according to the following categories:

Functional	Requirements that define the fundamental actions that must take place in accepting and processing the inputs and in processing and generating the outputs.
Performance	Requirements placed on the software or on human interaction with the software as a whole
Constraint of Design	Specifying design constraints that can be imposed by other standards, hardware limitations, etc.
Security	Specifying the factors that protect the system from accidental or malicious access, use, modification, destruction, or disclosure.

In the second step, each requirement is further classified by the way or ways in which it is proposed to test that the requirement has been correctly implemented:

Analysis	Analysis is a verification method utilizing techniques and tools such as analytical assessments, simulations, models, or prior test data.
Inspection	Inspection is a method of verifying physical characteristics without the use of special laboratory or test equipment, procedures, test support items, or services. Standard methods such as visual gauges, etc. are used to verify

compliance with the requirements. Inspection also includes the review of design documentation, material lists, code, plans, etc.

Test Test is a quantitative method of verification wherein performance requirements are verified by measurement during and after the controlled application of functional and environmental stimuli. These measurements usually require the use of special test equipment, recorded data, procedures, laboratory equipment, or services.

Demonstration A direct demonstration of capability as in showing a computer display, GUI, or an instance of how the system appears/responds.

Finally, tests belonging to the same classification are grouped into test procedures. Each procedure will be described in the current document by the following properties:

<u>Test Title:</u>	Name of the test
<u>Test Objectives:</u>	Identifies the functional capabilities being exercised.
<u>Test Configuration:</u>	Provides a block diagram showing the major processing elements, data flows, and data communication mechanisms; includes details, as necessary, of how the major processing elements are configured for this test.
<u>Participants & Support Requirements:</u>	Identifies the participating organizations and equipment, laboratory circuits, and personnel support provided.
<u>Test Data:</u>	Describes and identifies by file name, script name, or other designation required for test data sets; provides the source and physical locations of the data. [Description of the test data should include volumes and errors or insertion of anomalous conditions associated with the data.]
<u>Test Case Descriptions:</u>	Supplies a brief narrative description of the test case along with the high-level success criteria.
<u>Requirements List:</u>	Provides a list of requirements to be verified by this test case; included in each test procedure package is a requirements matrix.
<u>Test Procedures:</u>	Provides major event-level procedures covering the test set-up, test execution, test result evaluation, and test termination.

Each SOC test is contained in an command-line executable script located in the `~soc/test` directory on a SOC-A/B processor and mirrored on Crater-A/B. Each script generates a report in the `~/soc/test_report` directory. For example, `~soc/test/pipeline_01.sh` generates a report named `~soc/test_report/pipeline_01_001.txt`, where “001” indicates that this is the first time that this particular script has been run. All reports are text files in human-readable ASCII format.

Whenever a particular requirement has been tested, the report will contain a line of the form

Result: `testid version requirement {PASS,FAIL}`

For instance, if `~soc/test/backup_01.sh` (see Table 8) determines that there is sufficient off-line

backup capacity to satisfy FN_060, a report, e.g., `~soc/test_report/backup_01_001.txt` will contain a line

```
Result: FN_060 backup_01 1 PASS
```

In this way, the current status of all SOC tests can be displayed by executing the command

```
grep ^Result: ~soc/test_report/*.txt
```

2.4 Testing Schedule

Table 4: SOC Testing Schedule

	2007						2008												
	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
Standard Products SIS*	2																		
Pipeline Software		.																	
Publish Test Plan*		1	2																
Write Test Procedures		.	.	.															
PDS SIS Peer Review				.															
Special Products SIS*						1		2											
Special Products Software								.											
Local Testing			.	.	.	.	.	.	.			
SOC-PDS Testing					.	.	.												
SOC-MOC Testing					.	.	.	.	.	.	.	.	.
Publish Test Report*								1					2						
Acceptance Testing									.	.	.	.			

* 1 = draft, 2 = final version

2.5 Testing Team Members and their Roles

Table 5: SOC Testing Team

Name	Function	Address	Phone	Email
Michael Golightly Deputy Project Scientist & SOC Lead (from 2008)	Write test report, conduct PDS and MOC tests.	BU CAS Room 406 725 Commonwealth Ave. Boston MA 02215	+001 617 358 4864	mgolight@bu.edu
Peter Ford SOC Lead (to 2008)	Write test plan & procedures	MIT 37-571 70 Vassar Street Cambridge MA 02139	+001 617 253 6485	pgf@space.mit.edu
David Bradford Systems Manager	Hardware and systems testing	BU CAS 511 725 Commonwealth Ave. Boston MA 02215	+001 617 353 4884	bradford@bu.edu
Erik Wilson Software Engineer	Software testing	BU CAS 416 725 Commonwealth Ave. Boston MA 02215	+001 617 358 4423	wilsone@bu.edu

3 Process for Testing SOC Requirements

3.1 Materials

- Functioning SOC hardware (see Figure 1) and software, and SOC documentation.

3.2 External Data Requirements

- CRaTER raw data files covering at least 24 hours of a calibration run, containing known abnormalities, e.g., data gaps, corrupted packet headers, etc.
- SPICE kernels covering the same period as the raw files describing a body in lunar orbit, with a suitable CRaTER instrument frame kernel.
- Housekeeping calibration coefficients that refer to the serial number of the instrument that generated the raw data files.

3.3 Test Scenarios

Table 6: Pipeline Test

	PIPELINE_01
<u>Test Title:</u>	
<u>Test Objectives:</u>	The SOC can process measurement data to produce CRaTER standard data products, and can update those products as required. The data products shall include: a) a time-ordered listing of event amplitude in each detector; b) linear energy transfer for each processed event; c) a time-ordered listing of secondary science data; d) a time-ordered listing of housekeeping data.
<u>Test Configuration:</u>	Run on either the Crater-A or Crater-B processor, and then repeated on either SOC-A or SOC-B (see Figure 1).
<u>Participants & Support Requirements:</u>	To be performed by the SOC software test engineer.
<u>Test Data:</u>	Raw CRaTER calibration data spanning more than 24 hours Dummy SPICE kernels spanning more than 24 hours Housekeeping coefficients compatible with the raw data
<u>Test Case Descriptions:</u>	<ol style="list-style-type: none"> 1. The script begins by running the <i>ccat</i> command with the “-r” option and with input from a raw CRaTER calibration data file. The output is compared with that of the <i>rtlm.pl</i> command with the same input, to verify that the CRaTER object library produces the same output as the <i>rtlm</i> script. 2. The next step is to run the <i>Crater_Pipeline</i> command and generate a set of Level 0, 1, and 2 data products. Their PDS labels and format files are verified by means of the Java-based Vtool command supplied by the PDS. 3. Finally, the script examines the Level 0, 1, and 2 data

	products in detail to verify that the individual data fields are within specified limits, that time fields are in ascending order, and that the delimiters in the ASCII files (commas, quotes, carriage returns, and newlines) are in their expected locations.
<u>Requirements List:</u>	FN_010, FN_020, FN_030, FN_090.
<u>Test Procedures:</u>	<code>~soc/test/pipeline_01.sh</code>

Table 7: Online Resources Test

<u>Test Title:</u>	RESOURCE_01
<u>Test Objectives:</u>	To verify that there are sufficient on-line resources to satisfy the operational requirements.
<u>Test Configuration:</u>	SOC-A, SOC-B, Crater-A, and Crater-B (see Figure 1).
<u>Participants & Support Requirements:</u>	To be performed by the SOC software test engineer.
<u>Test Data:</u>	None.
<u>Test Case Descriptions:</u>	The test script runs a series of commands, e.g., <i>ls</i> , <i>df</i> , to determine whether adequate resources are available. The script may also ask Yes/No questions of the form “Does adequate <i>resource</i> exist to satisfy the following requirement: <i>text of FN_xxx</i> ”.
<u>Requirements List:</u>	FN_050, FN_060, FN_070, FN_500, PF_060, PF_070, PF_080.
<u>Test Procedures:</u>	<code>~soc/test/pipeline_01.sh</code>

Table 8: Backup Test

<u>Test Title:</u>	BACKUP_01
<u>Test Objectives:</u>	Verify that all online SOC data and software are backed up to off-site storage, and can be fully or selectively restored without breaking the security rules laid down in the CRaTER IT security plan.
<u>Test Configuration:</u>	Run on either Crater-A or Crater-B (see Figure 1).
<u>Participants & Support Requirements:</u>	To be performed by the SOC software test engineer.
<u>Test Data:</u>	File systems on the SOC RAID, mounted on SOC-A or -B File systems local to Crater-A or -B
<u>Test Case Descriptions:</u>	Immediately prior to scheduled off-line backups, listings are

	made of the contents of the SOC RAID and of the Crater–A and –B local file systems. Sample files are then restored from the backups and compared to the originals.
<u>Requirements List:</u>	FN_060 PS–7, CP–9, CP–10.
<u>Test Procedures:</u>	<code>~soc/test/backup_01.sh</code>

Table 9: Documentation Inspection Test

<u>Test Title:</u>	DOCUMENT_01
<u>Test Objectives:</u>	Verify that existing SOC documentation adequately describes the stated requirements, and that this documentation has been reviewed and accepted.
<u>Test Configuration:</u>	None.
<u>Participants & Support Requirements:</u>	To be performed by the SOC software test engineer.
<u>Test Data:</u>	None.
<u>Test Case Descriptions:</u>	The script asks the tester to verify the mention of the various requirements in specific documents. The tester responds PASS/FAIL to each.
<u>Requirements List:</u>	FN_510, FN_520, IF_010, IF_020, IF_030, IF_040, IF_050, IF_060, IF_070, IF_500, IF_510, PF_030, PF_040, PF_050, PL-4, CA-1, PS-1, AC-13, AC-14, AU-1, SC-1, MA-1, SA-5, SA-6, SA-7, SA-8, IA-1, IA-2, IA-4, IA-5, IA-6, CA-7, CM-6, SI-3, MP-2, MA-4, IR-1, IR-6
<u>Test Procedures:</u>	<code>~soc/test/document_01.sh</code>

4 Process for Testing the MOC Interface

4.1 Materials

- At the SOC, these tests require fully operational SOC–A/B processors and a correctly configured switch between the secure SOC VLAN and the internet (see Figure 1). REALTIME_01 also requires a Crater–A/B processor and a screen on which to view the *CHouse* display.
- The materials required at the MOC are unknown.

4.2 Data Requirements

- These vary according to the particular test.

4.3 Test Activities

Table 10: MOC Command Test

<u>Test Title:</u>	COMMAND_01
<u>Test Objectives:</u>	Verify that CRaTER command files can be transmitted to the MOC and that the SOC operator can subsequently verify their receipt and their contents.
<u>Test Configuration:</u>	Run on either SOC–A or SOC–B (see Figure 1).
<u>Participants & Support Requirements:</u>	To be performed by the SOC software test engineer.
<u>Test Data:</u>	One or more LRO Activity Request forms (ARFs) in <i>~soc/arf</i> .
<u>Test Case Descriptions:</u>	The test script performs checks to ensure that the SOC–A/B host is secure, and then transmits one or more ARFs to the MOC host. It then invokes the approved secure MOC interface and asks the test operator to verify that the transfer has taken place. If possible, it requests that the ARFs be copied back to the SOC and compared against the originals.
<u>Requirements List:</u>	IF_510. CA–3, CA–4, AC–1, AC–3, AC–7, AC–8, AC–17, SC–5, SC–7.
<u>Test Procedures:</u>	<i>~soc/test/command_01.sh</i>

Table 11: MOC Realtime Test

<u>Test Title:</u>	REALTIME_01
<u>Test Objectives:</u>	Verify that LRO telemetry from the MOC/ITOS can be received at the SOC and distributed via the realtime interface.

<u>Test Configuration:</u>	Run the TCP receiver on either SOC–A or SOC–B, <i>pdist</i> on Crater–A or Crater–B, and display tools (e.g., <i>CHouse</i>) on science workstations (see Figure 1).
<u>Participants & Support Requirements:</u>	To be performed by the SOC software test engineer.
<u>Test Data:</u>	Housekeeping decalibration files at the SOC. CRaTER housekeeping and secondary science data at the MOC.
<u>Test Case Descriptions:</u>	The script starts the TCP receiver locally and starts <i>pdist</i> and <i>CHouse</i> on Crater–A/B. It waits while the test engineer requests that the MOC begin sending test data. The script verifies that a certain number of packets have been received, lists the number of dropouts and corrupted packets, and asks the operator whether the <i>CHouse</i> output was acceptable.
<u>Requirements List:</u>	FN_110, FN_510, IF_030, PF_020, PF_100. CA-3, CA-4. AC-1, AC-3, AC-7, AC-8, AC-17, SC-5, SC-7, IA-2, IA-4, IA-5, IA-6, CA-7, CM-6, SI-3, MP-2, MA-4.
<u>Test Procedures:</u>	<code>~soc/test/realtime_01.sh</code>

Table 12: MOC Data Test

<u>Test Title:</u>	DATA_01
<u>Test Objectives:</u>	Verify that the SOC can receive the data products described in the MOC External ICD (431-ICD-000049, see §1.4).
<u>Test Configuration:</u>	Run on either SOC–A or SOC–B (see Figure 1).
<u>Participants & Support Requirements:</u>	To be performed by the SOC software test engineer.
<u>Test Data:</u>	None at the SOC. Numerous data products from the MOC, viz. MOC-2 SLCK Clock Correlation MOC-3 Spacecraft Housekeeping Data MOC-4 CRaTER Housekeeping Data MOC-5 CRaTER Raw Measurement Data MOC-7 Daily Command Load Report MOC-33 Event Kernel MOC-40 Frame Kernels MOC-42 Definitive Spacecraft Orientation (CK) MOC-46 CRaTER Housekeeping Summary MOC-47 CRaTER Raw Measurement Summary FDF-29 Definitive Spacecraft Ephemeris (SPK)
<u>Test Case Descriptions:</u>	The test engineer starts the script, which waits while s/he contacts the MOC and requests for the files to be transferred.

When they have arrived, the script verifies the contents of the raw CRaTER data (MOC-4,5) and the SPICE kernels (MOC-2,40,42 and FDF-29) by executing the pipeline. The gap files are compared against MOC-46,47.

Requirements List:

FN_510, IF_010, IF-020, IF-030, IF_040, IF_050, IF_060, IF_070, PF_010, PF_100.
CA-3, CA-4, AC-1, AC-3, AC-7, AC-8, AC-17, SC-5, SC-7, IA-2, IA-4, IA-5, IA-6, CA-7, CM-6, SI-3, MP-2, MA-4.

Test Procedures:

~soc/test/data_01.sh

5 Process for Testing the PDS Interface

5.1 Materials

- These tests require fully operational Crater–A/B processors (see Figure 1) and a directory tree populated with a test archive.
- The materials required at the PDS PPI node are unknown.

5.2 Data Requirements

- CRaTER Level 0, 1, and 2 products, e.g., those resulting from the PIPELINE_01 test, along with their PDS labels, gap, and index files. The standard product types generated by the CRaTER SOC are listed in Table 13.

Table 13: CRaTER Data Set Types and Contents

Data Set	Key/Physical Parameters	NASA Level	CODMAC Level
CRAT_L0_PRI CRAT_L0_SEC CRAT_L0_HK	Raw CRaTER Experiment Data Record: pulse heights, secondary science, and instrument housekeeping	0	2
CRAT_L1_PRI CRAT_L1_SEC CRAT_L1_HK	CRaTER Calibrated Data Record, split into primary and secondary science data, and housekeeping	1	3
CRAT_L2_PRI CRAT_L2_SEC	CRaTER Derived Data Record, part 1: LET deposition in silicon. (Pulse heights converted into energy deposited within unit path length through each detector.)	2	3/4 ¹

- PDS label (.LBL), format (.FMT), and catalog (.CAT) files describing the CRaTER standard products.
- Ancillary files as described in the CRaTER Standard SIS (32–01211, see §1.4).

5.3 Test Scenario

Table 14: PDS Archive Test

Test Title:	PDS_01
Test Objectives:	Run the software that creates an archive delivery file (tarball) from the local SOC archive, and transmits it electronically to the PDS PPI node, where it is unpacked and examined.
Test Configuration:	Run on Crater–A or Crater–B (see Figure 1).
Participants & Support Requirements:	To be performed by the SOC software test engineer.

¹ The CR_L2_HK and CR_L2_SS products are CODMAC Level 3, CR_L2_PS is Level 4.

<u>Test Data:</u>	See above.
<u>Test Case Descriptions:</u>	TBD.
<u>Requirements List:</u>	FN_040, FN_520, IF_500. CA-3, CA-4, AC-1, AC-3, AC-7, AC-8, AC-17, SC-5, SC-7.
<u>Test Procedures:</u>	<code>~soc/test/pds_01.sh</code>

5.4 Additional Data validation

The CRaTER EDR data archive volume set will include all CRaTER data acquired during the LRO mission. The archive validation procedure described in this section applies to volumes generated during both the cruise and prime phases of the mission.

PDS standards recommend that all data included in the formal archive be validated through a peer-review process. This process is designed to ensure that both the data and documentation are of sufficient quality to be useful to future generations of scientists.

The CRaTER team and the PDS will therefore convene a peer-review of the first archive volume that they create using data from the nominal LRO mission. This review will determine whether the archived data are appropriate to meet the stated science objectives of the instrument. The panel will also review the archive product generation process for robustness and ability to detect discrepancies in the end products; documentation will be reviewed for quality and completeness. One of the primary questions addressed during the peer-review process will be: “Can an expert in the use of similar data meet the stated science objectives of the experiment using only the data and documentation included in this archive?” The peer-review panel may suggest changes to any of the areas under review if the answer to this question is not affirmative.

As expertise with the instrument and data develops the CRaTER team may decide that changes to the structure or content of its standard data products are warranted. Should these changes be implemented the new data product and archive volume will be subjected to a full PDS peer review, and this document will be fully revised to reflect the modified archive.

Additionally, the CRaTER team may generate and archive special data products that cover specific observations or data-taking activities. This document does not specify how, when, or under what schedule, any such special archive products will be validated.

Appendix A. Requirements Traceability Matrix

The following table shows the relationship between the tests defined in the current document and either the “Requirement” stipulated in the CRaTER Science Operation Center Requirements Document (32–01209), or the “Operational Controls” listed in the CRaTER Information Security and Contingency Plan (32–01208). The methodology of each test is classified as **A**(nalysis), **I**(nspection), **T**(est), or **D**(emonstration).

Requirement	Description	Type	Tests
Operational requirements (Functional)			
FN_010	The SOC shall perform measurement data processing to produce CRaTER standard data products.	T	PIPELINE_01
FN_020	The SOC shall perform measurement data reprocessing to update CRaTER standard data products as required by the science team. Rationale: If it is determined that, for example, the calibration of the detectors has changed during the course of the mission, the CRATER standard data products will need to be reprocessed.	T	PIPELINE_01
FN_030	The SOC shall create the following CRaTER primary data products: a. Time-ordered listing of event amplitude in each detector b. Linear Energy Transfer (LET) for each processed event c. Time-ordered listing of secondary science data d. Time-ordered listing of housekeeping data	T	PIPELINE_01
FN_040	The SOC shall provide the CRaTER data products (CRATER_FN_030) and Level 0 data to the PDS Planetary Plasma Interactions (PPI) Node for archive and distribution.	T	PDS_01
FN_050	The SOC shall provide sufficient disk space for: a. 10 days of incoming data from the MOC. b. 10 days of Level 1 derived products. c. 10 days of Level 2 derived products.	D	RESOURCE_01
FN_060	The SOC shall provide backup storage for disk space used for software development, user accounts and on-line disk space used for analysis.	D	BACKUP_01
FN_070	The SOC shall provide sufficient disk resources to stage PDS deliverables.	D	RESOURCE_01
FN_080	The SOC shall support priority assignment of processing jobs based on input from the science team. Rationale: For particularly interesting or important events (large Solar Energetic Particle (SEP) events in particular) the SOC may reprioritize the normal processing queue to make these events quickly available to the wider community.	I	TBD
FN_090	The SOC shall be capable of providing operational and testing configurations.	T	PIPELINE_01
FN_110	The SOC networking connections shall be capable of capturing, storing and processing CRATER science and housekeeping at the maximum data rate possible.	T	REALTIME_01

Requirement	Description	Type	Tests
Testing requirements (Functional)			
FN_500	The SOC shall provide resources to support the development and maintenance of CRATER measurement data processing software.	D	RESOURCE_01
FN_510	The SOC shall provide resources to support testing with the LRO Ground System.	I, T	REALTIME_01 DATA_01 DOCUMENT_01
FN_520	The SOC shall provide resources to support testing with the PDS Planetary Plasma Interactions Node.	I, T	PDS_01 DOCUMENT_01
Import requirements (Design)			
IF_010	The SOC shall obtain on a per orbit basis CRATER instrument Level 0 science data from the LRO MOC.	T, I	DATA_01 DOCUMENT_01
IF_020	The SOC shall obtain on a per orbit basis CRATER instrument housekeeping data from the LRO MOC.	T, I	DATA_01 DOCUMENT_01
IF_030	The SOC shall obtain real-time housekeeping data provided by the MOC.	T, I	REALTIME_01 DOCUMENT_01
IF_030	The SOC shall obtain the daily stored command load from the LRO MOC.	T, I	DATA_01 DOCUMENT_01
IF_040	The SOC shall obtain LRO SPICE SPK data from the LRO MOC on a monthly basis.	T, I	DATA_01 DOCUMENT_01
IF_050	The SOC shall obtain LRO SPICE CK data from the LRO MOC on a monthly basis.	T, I	DATA_01 DOCUMENT_01
IF_060	The SOC shall obtain CRATER Level 0 data needed for reprocessing from the LRO MOC.	T, I	DATA_01 DOCUMENT_01
IF_070	The SOC shall obtain LRO SPICE SCLK, LSK and FK kernels from the LRO as needed.	T, I	DATA_01 DOCUMENT_01
Export requirements (Design)			
IF_500	The SOC shall provide the PDS Planetary Plasma Interactions Node with the following CRATER data products: a) Energy deposited in each detector for every processed event; b) Linear energy transfer in each detector for every processed event; c) CRaTER mass model.	I, T	PDS_01 DOCUMENT_01
IF_510	The SOC will provide to the LRO MOC instrument command sequences.	I,T	COMMAND_01 DOCUMENT_01
Performance requirements			
PF_010	The SOC shall take action to start the ingest of incoming data within 3 hours after they are made available by the LRO MOC.	T	DATA_01
PF_020	The SOC shall receive data from the LRO MOC on a daily basis 24 hours per day, 7 days per week, and 52 weeks per year.	T	REALTIME_01
PF_030	The SOC shall process CRATER measurement data for the entire nominal mission.	I	DOCUMENT_01

Requirement	Description	Type	Tests
PF_040	The SOC shall be capable of processing CRATER measurement data for an extended mission, should the mission be extended.	I	DOCUMENT_01
PF_050	The SOC shall provide standard data products to the PDS PPI Node every 3 months starting at launch +6 months.	I	DOCUMENT_01
PF_060	The SOC shall provide adequate on-line storage to buffer 10 days of incoming data.	I	RESOURCE_01
PF_070	The SOC shall provide adequate on-line storage to buffer 10 days of outgoing data.	I	RESOURCE_01
PF_080	The SOC shall provide adequate on-line storage for 10 days of CRATER standard data products.	I	RESOURCE_01
PF_100	The SOC shall provide a mechanism for the science team to validate incoming data. Rationale: Examination of the raw data is not enough to determine if the instrument is functioning properly. The SOC will need to produce quicklook plots that succinctly summarize the incoming data to aid in spotting detector issues.	T	REALTIME_01 DATA_01
PF_110	The SOC shall provide performance and trending information.	T	TBD
Security requirements			
PL-4, CA-1 PS-1, AC-13 AC-14, AU-1 SC-1, MA-1	These requirements relate to the availability of written rules and regulations covering IT usage at the SOC, its dissemination to all SOC user, and their express acknowledgement of the rules and of the penalties if these rules are not followed.	I	DOCUMENT_01
SA-5, SA-6 SA-7, SA-8 IA-1	These requirements relate to the availability of documentation for specific system and user-supplied software to legitimate SOC users.	I	DOCUMENT_01
CA-3, CA-4 AC-1, AC-3 AC-7, AC-8 AC-17, SC-5 SC-7	These requirements relate to the provision of an interface between the SOC and external networks.	T,D	COMMAND_01 REALTIME_01 DATA_01 PDS_01
IA-2, IA-4 IA-5, IA-6 CA-7, CM-6 SI-3, MP-2 MA-4	These requirements relate to the provision of security controls within the SOC itself, ensuring that access control and monitoring is effective.	I,D	REALTIME_01 DATA_01
PS-7, CP-9 CP-10	These requirements relate to reliability and security issues affecting the interface between the SOC and external entities. In this case, the only identified entity is the BU off-site back-up facility.	D	BACKUP_01
IR-1, IR-6	These requirements relate to incident reporting.	I	DOCUMENT_01
AC-2, AU-2 AU-4, AU-5 AU-9, AU-11	These requirements relate to the provision and maintenance of SOC user accounts.	D	TBD

Appendix B. Abbreviations

Table 15: Abbreviations and their meaning

Abbreviation	Meaning
ARF	Activity Request Form
ASCII	American Standard Code for Information Interchange
BU	Boston University
CAS	College of Arts and Sciences (BU)
CDR	Calibrated Data Record
CK	C-matrix Kernel (NAIF orientation data)
CRaTER	Cosmic Ray Telescope for the Effects of Radiation
CRC	Cyclic Redundancy Check
DDR	Derived Data Record
E&PO	Educational and Public Outreach
EDR	Experiment Data Record
FTP	File Transfer Protocol
GB	Gigabyte(s)
GSFC	Goddard Space Flight Center
HK	Housekeeping
HTML	Hypertext Markup Language
ICD	Interface Control Document
LRO	Lunar Reconnaissance Orbiter
MB	Megabyte(s)
MIT	Massachusetts Institute of Technology
MKI	MIT Kavli Institute for Astrophysics and Space Research
MOC	Missions Operations Center (GSFC, LRO)
MOT	Mission Operations Team (GSFC, LRO)
NAIF	Navigation and Ancillary Information Facility (JPL)
NASA	National Aeronautical and Space Administration
ODL	Object Description Language
PCK	Planetary Cartographic and Physical Constants Kernel (NAIF)
PDS	Planetary Data System
PPI	Planetary Plasma Interactions Node (of the PDS)
SCET	Spacecraft Event Time
SCLK	Spacecraft Clock
SIS	Software Interface Specification
SPICE	Spacecraft, Planet, Instrument, C-matrix, and Events (NAIF data format)
SPK	SPICE (ephemeris) Kernel (NAIF)
TBC	To Be Confirmed
TBD	To Be Determined