IMAP SOC Test Plan

Interstellar Mapping and Acceleration Probe (IMAP)
Science Operations Center (SOC)
Integration and Test Plan
Document No. 166868
CDRL No. SW-005

Approvers List

Prepared By	Gabrelle Saurage, POC Lead
Prepared By	Kristopher Larsen, SOC Project Manager
Approved By	Evan Brookens, POC Operations Software Lead
Approved By	Greg Lucas, SDC Lead
Approved By	Karen Looney, SOC Software Quality Assurance Engineer
Approved By	Sanae Kubota, IMAP Mission Systems Engineer
Approved By	Matina Gkioulidou, IMAP Project Scientist
Approved By	Mark Tapley, IMAP Payload Systems Engineer
Approved By	Judy Furman, IMAP Payload Operations Systems Engineer
Approved By	Jamey Szalay, CAVA Project Lead
Approved By	Chelle Reno, IMAP Ground Segment Interface
Approved By	Nathan Schwadron, IMAP Deputy Principal Investigator
Approved By	Dave McComas, IMAP Principal Investigator

Distributed To	Instrument Representatives
Configuration Management	

Rev	Atlassian Version	Change Description	By
A		Draft release	PS, KL
B		Baseline release	GS, KL, MK
C	69	Updates between MCDR and MOR	GS
D	85	SIT updates	GS

Table of Contents

0.2 Table of Tables

0.3 Table of Figures

0.4 Reference Documents

Document Ref	Title
DOORS	SOC L4 requirements
7516-9006	IMAP Configuration Management Plan

0.5 Applicable Documents

Document Ref	Title
166873	IMAP POC Software Development Plan
166872	IMAP SDC Software Development Plan
167441	IMAP POC to Instruments ICD
167442	IMAP SDC to Instruments ICD
171412	IMAP SDC-CAVA ICD
171240	IMAP SOC I-ALiRT Participating Ground Station ICD
7516-9078	IMAP MOC to SOC ICD

0.6 Acronyms/Abbreviations

A complete acronyms list can be found within the IMAP Payload Flight Operations Plan, Appendix A: Acronyms.

0.7 Definitions

Archive Category: The type of archive applicable to a requirement, which may include: temporary (30/90 day); operational archive; mission archive; or final archive. **CSC:** The list of Computer Software Components (and associated CSCI) that a requirement impacts.

CSCI: The list of Computer Software Configuration Items that a requirement impacts. The following are CSCIs applicable to IMAP SOC (see IMAP POC SDP 166873 for table):

- CT-RT: Command & Telemetry, Real-time Monitoring
- CIA: Configurations, Infrastructure, and Automation
- DA: Data Analysis
- DB: Database Storage and Access
- DP: Data Processing
- MDM: Mission Data Management
- MP: Mission Planning
- WEB: Website & Web Applications

Verification Activity: An explanation of the activities involved with verifying the requirement.

Verification Criteria: A description of the factors that determine the success or failure of the Verification Method.

Verification Method: The means by which a requirement is verified. Test, inspection, analysis, and demonstration are possible methods.

Verification Strategy: A subset of the Verification Method that further describes the specific method employed. (Examples: Inspection of a manual procedure, CSC Unit Test, data volume analysis, software demonstration).

0.8 Current TBXs

Section	**Type**	**Description**	**Closure Plan**
2.1.1	TBC	DOORs 'Functionality Available' field	Consider adding in DOORS
3.3.2	TBS	Details of a potential CAVA-SIT 2.	Discussion with CAVA development team and science leadership to determine if CAVA SIT-2 will be needed
Appendix A		Needs snapshots from DOORS for all SITs	Need DOORS snapshot of verification Strategy, Activities, Methods, and Criteria for each SIT

1.0 Introduction

This document contains information that is as complete as possible. Any information at the time of release that is forthcoming, incomplete, or unknown will be marked appropriately.

1.1 Purpose

The IMAP SOC Test Plan, this document, describes the Testing, Verification, and Validation of the IMAP SOC Ground System (GS). The document's purpose is to define the verification activities of the SOC Level 4 (L4) ground support requirements, and validate the requirements' compliance of the SOC ground systems implementation as an integrated system.

1.2 Scope

The scope of this document is IMAP SOC GS support infrastructure and systems requirements verification for Instrument operations. The SOC team uses the APL DOORS requirements management system to track, review, and baseline requirements down to L4 level, which is the scope of this test plan. Verification strategies, activities, and methods are tracked in the APL DOORS system, which also serves as the Requirements Verification Matrix resource where all test activities, results, and closures are tracked per specific Software Integration Test (SIT). This test plan describes the following:

- The overall GS configuration
- Participating organizations, roles and responsibilities
- Test and integration logistics and progression
- Verification strategies, methods, and validation criteria
- Test activities and procedures approach
- Non-conformance resolutions

The POC will be located at the Laboratory for Atmospheric and Space Physics (LASP) facilities on the University of Colorado campus in Boulder, Colorado. LASP is a multi-mission Operations facility and utilizes shared software, hardware, and networking systems across multiple projects.

Figure 1 shows a high-level interface diagram depicting the key ground segment interfaces associated with the IMAP SOC and associated data flows.

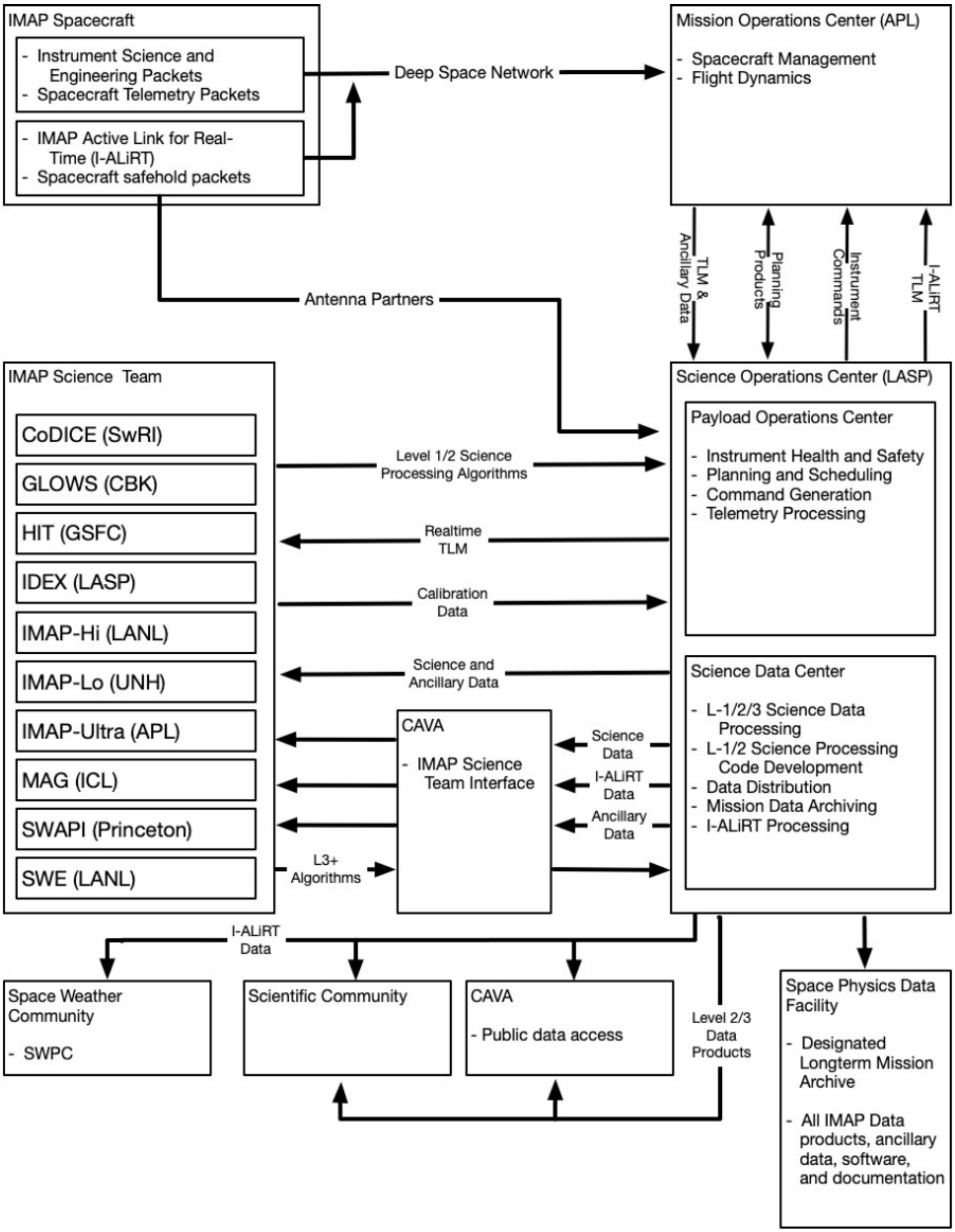

Figure 1: IMAP SOC High Level Interfaces

1.3 IMAP Mission Overview

IMAP is a Principal Investigator (PI)-led mission as part of NASA's Solar Terrestrial Probes Program, managed by Goddard Space Flight Center (GSFC). The IMAP is a revolutionary mission that simultaneously investigates two of the most important overarching issues in heliophysics today—the acceleration of energetic particles and interaction of the solar wind with the local interstellar medium. IMAP consists of a spinning observatory that operates in a Lissajous orbit at L1 for a primary mission of 2 years. IMAP is a Category 2, Class C NASA Space Flight Mission. JHU/APL is responsible for overall project management, mission development and integration, as well as development of the spacecraft, ground system, and mission operations. Southwest Research Institute (SwRI) is responsible for management and systems engineering for the instrument payload. The PI institution is Princeton University. The Laboratory for Atmospheric and Space Physics (LASP) at the University of Colorado in Boulder is responsible for payload and science operations.

The IMAP instrument suite and lead institutions are listed in the following Table.

Table 1-1: IMAP Instrument Suite

Instrument	Lead Institution	Measurement Type
IMAP-Lo	UNH	Energetic Neutral Atoms (ENA) and Interstellar Neutral Atoms
IMAP-Hi	LANL	
IMAP-Ultra	JHU/APL	
MAG	Imperial College of London	Interplanetary or Vector Magnetic Fields
SWE	LANL	Solar Wind Electrons
SWAPI	Princeton	Solar Wind, Pickup, Suprathermal, and Energetic Ions, Energetic Electrons
CoDICE-Hi	SwRI	
CoDICE-L0	SwRI	
HIT	GSFC	
IDEX	LASP	Dust
GLOWS	CBK PAN	UV

IMAP is also responsible for integrating and operating a continuous near real-time space weather capability. The IMAP Active Link for Real-Time (I-ALiRT) enhances space weather forecasting of geomagnetic storms as well as solar energetic particle events (SEPs) by providing a small subset of IMAP space weather measurements continuously to a supporting ground station network.

1.4 IMAP SOC Overview

The IMAP Science Operations Center (SOC) is responsible for managing and conducting instrument operations and serves as the central hub for all instrument and ancillary data required for instrument suite operations support, data processing, data distribution, and science analysis. The SOC is located at the University of Colorado's Laboratory for Atmospheric and Space Physics (LASP) in Boulder, Colorado, USA.

The SOC is functionally divided into the Payload Operations Center (POC) for instrument operations and the Science Data Center (SDC) for data production, storage, archival, and distribution functions. In addition to core IMAP instrument operations and data handling, the SOC will also support IMAP space weather requirements by capturing I-ALiRT packets received from antenna partners, processing these packets into near-real-time space weather products using algorithms provided by instrument teams, and making the data available to the space weather community.

For IMAP science operations, the Science Operations Center (SOC) is responsible for instrument operations, telemetry data acquisition, data processing, data archiving, and data dissemination. It serves as the central hub for all instrument and ancillary data management, dissemination, and archiving. It will be the primary interface between the instrument/science team and the Mission Operations Center (MOC) located at JHU/APL. The SOC will perform the following major functions:

- Preparing observing sequences and generating/transmitting instrument suite command products
- Monitoring and controlling each IMAP instrument
- Performing telemetry data processing, checking, and distribution
- Performing science data processing, dissemination, and archiving
- Support for pre-integration instrument development (Phases C & D only)
- Support for observatory I&T instrument operations (Phase C & D only)
- Conduct commissioning operations of the IMAP instrument suite (Phase D)
- Support mission science planning and execution

The IMAP SOC will be located within LASP's existing mission and instrument operations facilities at the LASP Space Technology Research Center in Boulder, Colorado. LASP currently operates multiple spacecraft and more than 100 science instruments. Many of the facilities, personnel, hardware, software, and a portion of the communications links needed to implement the IMAP SOC are already in place. The IMAP SOC will be supported with software, hardware, processes, and personnel used in a shared capacity with other missions, with additions and modifications tailored to meet the specific needs of the IMAP mission.

1.4.1 POC Overview

Once the primary science phase begins, the POC will be responsible for instrument operations, will interface directly with instrument teams for operational needs, and will utilize LASP's mature and operational multi-mission operations facility to conduct instrument operations activities.

The POC will have primary responsibility for monitoring and controlling the IMAP suite of instruments, and will interface with the MOC, NOAA-managed I-ALiRT antenna partners, the SDC, and the IMAP instrument and science team members. The POC will regularly coordinate with instrument teams to establish operations baselines. The POC will perform planning/scheduling, generate and deliver command load products, conduct real-time instrument commanding, perform health/safety analysis and execute anomaly responses.
Principal POC responsibilities are summarized here:

- Planning, scheduling, and generating instrument commands
- Short -term and long-term monitoring of instrument health and safety
- Notifying the Instrument Teams of anomalous conditions and responding as instructed
- Processing and providing Instrument Teams access to telemetry and ancillary data
- Instrument Real Time Command and Control
- Instrument Operations Data Processing and Management
- Generate and transmit instrument time-tagged command products via the MOC
- Receive I-ALiRT data from antenna partners and make available to the SDC and the MOC
- General Instrument Operations Support

1.4.2 SDC Overview

After science operations begins, the SDC has primary responsibility for generation, management, and dissemination of all IMAP science data. In collaboration with the IMAP science team, the SDC will maintain and operate the needed computing, data storage and distribution/access mechanisms and ensure that data are processed and released to the science community within mission requirements, and in compliance with NASA Data Policy.

Data processing software used to produce standard science data products will be formally controlled and maintained by SDC staff at the SDC in cooperation with instrument and science team members. Produced data will be version controlled, indexed, and made available to the science community through a centralized IMAP mission Science Data Center web site. Data products will also be delivered to the NASA Space Physics Data Facility (SPDF) for long-term archiving and secondary data dissemination.

The IMAP SDC implementation is based on a multi-mission SDC architecture that has been successfully used by LASP on other missions, which centrally manages all science data within

the LASP-resident SDC. The IMAP SDC will also provide both team and public sites for science data products and associated information. The SDC incorporates a production pipeline workflow, tasking/scheduling, data processing, data management, data archiving, and distribution services tailored to IMAP requirements and will operate in a highly automated fashion to routinely produce data products. Extensive reuse is expected, in which the existing and proven LASP SDC systems are used, thus minimizing significant areas of new core system development.
Principal SDC responsibilities are summarized here.

- Provide a centralized data system for all science data processing, distribution, and data handling needs
- Develop, maintain, and manage instrument science processing software used to generate standard science data products up to Level-2
- Routinely perform Level 1/2/3 science processing of instrument suite data to generate, store, and manage all standard science data products
- Perform periodic reprocessing activities following algorithm or calibration updates
- Routinely generate IMAP I-ALiRT near-real-time space weather science data products
- Provide a team-accessible web site and data system for team data coordination activities
- Maintain instrument team access to shared elements of the SDC data system for team data coordination activities
- Disseminate science data products to the public via a publicly accessible web site and access tools
- Disseminate space weather data to the science community
- Disseminate space weather data to SWPC using the same or largely similar interfaces that are used for science community access
- Provide data access interfaces, basic display tools, and science team-provided analysis tools to the public via the SDC web site
- Maintain an archive of all IMAP science data for the life of the mission
- Coordinate with and perform deliveries to the designated long-term archive facility (SPDF)

2.0 Logistics, Methodology, and Approach

The basic unit of test is the SOC Integration Test, or SIT. A SIT verifies and validates a subset of SOC L4 requirements compliance, with related software and infrastructure support releases. SITs build on each other, from basic system framework functionality verification, to flight-ready, full system verification and validation. There are a total of **14** SITs, described in subsequent sections below.

2.1 Test Philosophy and Approach

The SIT test philosophy follows 'Test Like You Fly (TLYF) – Fly Like You Test' GSFC GOLD (Goddard Open Learning Design) Rule. Therefore, as applied to the SOC GS system, all tests are performed in an operational-like environment exercising the fully released operations and ground support software as much as possible. SITs are intended to follow TLYF such that all simulations and activities are based on flight scenarios and planned data transfers, using realistic flight-like sequences of events. These tests do ***not*** necessarily follow actual operation timelines – the SIT program is to verify requirements and functionality. The methods used in testing the time dependent requirements will demonstrate the system's ability to meet the operations timing requirements levied against it.

The tests also cover the CM (Configuration Management) implementation and support infrastructure, with its released processes, backup, and archiving capabilities, to ensure that the system will remain stable through testing and flight, and can easily be recovered given a major GS failure or infrastructure loss.

2.1.1 TLYF Exceptions and Deviations

All exceptions from TLYF are noted in the test procedures and reports. The test report may explain how a simulated test data set or operations activity accomplishes the task of verifying the applications or systems tested at the time. For example, if a data set is produced by already integrated and verified flight hardware and software, that data is assumed to be flight-like and ready to use for testing ground systems within the confines of the respective data set intended usage. The burden of noticing and logging all detailed or benign TLYF non-conformances should not unduly impede the SOC test or development teams through the test activities.

TLYF deviations are noted against software and applications not fully flight released at the time of test. A feature may be functionally available to be used during a SIT, while its parent CSCI may not be fully flight released at the time. The use of the respective application is based on the need to verify downstream applications or systems. *Known TLYF deviations are noted in the DOORS Verification Module, under the 'Functionally Available' field, per the availability and use for a specific SIT (TBC).*

2.1.2 Test Waivers

Major or repeated failures may require a specific requirement modification or waiver. Both of these actions follow the guidelines stipulated in the *APL waiver request process (7516-9006 IMAP Configuration Management Plan).*

2.1.3 Regression Testing

Regression testing is performed within the scope of the element-level software changes of the system being updated. Since the SITs build on each other, it is expected that in a majority of cases, non-impacting test failures can be tested during a future SIT. The guidelines for regression testing are geared towards keeping the test time and scope within reasonable parameters, in order to reduce costs and undue burden to developers and the SOC resources.

SITs and their supporting test procedures are built upon modular functionality. Should regression testing be deemed necessary at a CSCI level, the related test procedures are rerun. Minor CSC functions are re-tested by the OSW team using the previously exercised functional test cases and procedures. The prevailing software update approach is to release one update at a time after requirements verification closure, rather than stack multiple changes or updates against major releases that require more attention and resources. This model is conducive to isolating modules in need of retest, having the potential to increase development efficiencies and reduce costs.

2.1.4 Test Items

There are three main item categories tested: software, operational procedures, and hardware. SITs focus on software and flight supporting procedures. However, support hardware readiness is implicit to GS software performance, and as such verified from the SOC GS usability viewpoint. Hardware failures are raised to the responsible element through the problem report initiated during the SIT activities.

2.2 Roles and Responsibilities

The POC FOT (Flight Operations Team) and SDC personnel are responsible for testing, verification, and validation of the SOC L4 requirements. This follows the lower tier, or SOC L5 requirements, operations software integration tests, which verify CSCI (Computer Software Configuration Item) and CSC (Computer Software Component) requirements specifications. Verification of lower tier software packages, applications, and component release for the POC and SDC is the responsibility of the LASP MODS (Mission Operations and Data Systems) OSW (Operations Software) and Data Systems Groups, respectively, and are performed by their respective software development process testing standards. For more detailed information of the IMAP POC and SDC development and verification processes, please see the IMAP POC Software Development Plan (166873) and the IMAP SDC Software Development Plan (166872).

2.2.1 Project Manager (PM)

The Project Manager (PM) is the supervisor of the team responsible for the system to be tested. The PM has the following responsibilities, as related to SOC systems test and verification:

1. Review and approve the test plan and procedures
2. Supervise Test Readiness Reviews (TRR), Run for Record (RFR) activities, and Post-Test Reviews (PTR)
3. Oversee test scheduling and coordination of needed assets, facilities, and personnel
4. Resolve organizational resource conflicts for overall SITs activities support

Formally approve the verification and validation of requirements from the SITs.

2.2.2 Test Director

The Test Director reports to the PM and oversees all phases of SITs. The Test Director is responsible for the following:

1. Develop and approval of test plan and procedures
2. Conduct test review meetings

3. Schedule, organize, and lead test activities
4. Ensure all procedures used are approved and all reports are acceptable
5. Requirements verification and validation, including DOORS verification module updates
6. Approve non-conformance activities and actions

2.2.3 Test Conductor

The Test Conductor reports to the Test Director and generally run the tests. The Test Conductor responsibilities are:

1. Develop test procedures
2. Conducts tests in accordance with the latest approved and released procedures
3. Document all test operations and activities
4. Record, summarize, and compile test data and reports, following the test report guidelines

2.3 Test Sequence and Activities

High-level SIT scheduling is tied to systems readiness progression requirements, as coordinated with the mission I&T activities, MOC systems development, and Instrument systems development schedules. SOC systems development is laid out such that each SIT is preceded by the completion and verification of lower tier requirements specifications of the needed CSCI and CSC releases.
The lower tier, L5, verification activities are scheduled to complete two weeks prior to each SIT that verifies the totality of parent L4 requirements. It is also expected that all outside SOC participating organization will be ready for the test at the same time, with systems and test procedures ready two weeks ahead of test schedule time. The two weeks prior to each SIT are dedicated to dry runs and Test Readiness Reviews. The POC FOT coordinates with the OSW group to ensure adequate and efficient software expertise support throughout the test activities. SITs are organized in the following activity sequences: Dry Runs, Test Readiness Reviews (TRR), the test itself or Run for Record (RFR), and Post-Test Reviews (PTR).

Table 2-1: Generic SIT Schedule

Timeline	Step
T – 6 weeks	Test Director publishes 1st draft of test plan. All participating elements will begin development of their test procedure(s) and work with the Test D.
T – 2 weeks	Dry runs. L5 verification activities are complete. Clarify ambiguities in element test procedures and familiarize personnel with activities.
In the week prior to T	Test Readiness Review (TRR)
T	Conduct the test – Run for Record (RFR). Daily/Weekly progress meetings may be held as agreed to in the TRR.

~T + 2 weeks	Post-Test Review (PTR)

2.3.1 Dry Runs

The Test Director or Test Conductor will dry run the test procedure, engaging key system elements related to the upcoming SIT. The approach is to fully complete the test procedure flow, not necessarily at one time, with developer support available for clarifications and guidelines. The dry run may include actual application execution, as needed to clarify specific test procedure steps and test case assumptions.

2.3.2 Test Readiness Review

The Test Readiness Review (TRR) brings all participants together in preparation for the upcoming SIT. The main subjects to be reviewed are:

- SIT readiness from all element's standpoint
- Objectives and success criteria, with functional requirements to be verified
- Prerequisites, such as data sets, and external systems readiness
- Review and assess TLYF exceptions and deviations
- Review test procedures and sequence of events
- Personnel support, infrastructure, and networking resources
- Overall test schedule and run-time coordination logistics

2.3.3 Run for Record

The execution of the test is also known as the Run for Record (RFR). This activity takes place during a SIT, when Test Conductor execute the tests. The RFR approach is characterized by gathering all required information as the test develops. This process is materialized by recording dates, times, and events as they occur during the test in the test procedure(s). There can be multiple RFR instances. The respective run's dates and times are recorded in the test procedure such that a clear differentiation of events is apparent. All redlines and corrections during an execution are incorporated, approved during a PostTest Review, and released to be used for subsequent RFRs of the same test procedure.

2.3.4 Post-Test Review

During the Post-Test Review, all completed test procedures with their respective reports and verified requirements are reviewed by all involved elements. All failures and issued problem reports are reviewed. The requirements verification scorecard is updated and presented to show the progression through the SOC L4 requirements verification. The team makes recommendations for a development fix and/or subsequent re-test or future regression testing if feasible.

2.4 Documentation

Test procedures and reports are the two formal documents used during testing at the IMAP SOC and tracked by the Mission Operations Configuration Management (CM) system. Test procedures are approved prior to the Test Readiness Review. All testing and verification activities, including any deviations from test procedures or abnormal events, are documented at the time of the test or shortly thereafter to ensure the accuracy of record. Documentation of related events does not have to strictly appear or fit within the formal test report or procedure format.

2.4.1 Test Procedures

Test procedures outline the steps necessary to complete the test case, as well as the requirements verified during the test. Each SIT contains the necessary test procedures to complete all its related testing and verification activities. A test procedure may verify multiple requirements. The test procedure outlines:

- Description of activities and test sequence
- Functional requirements verified with verification criteria
- Prerequisites, data sources, and test setup
- Step-by-step activities to be performed
- Location of output data and/or available process output logs
- Reference placeholders for outside entity(s) procedure document numbers and steps

2.4.2 Test Reports

Test reports are intrinsically tied to test procedures and may appear in the same physical document as the procedure reported upon. The report should contain test results in the form of output data files with their archive location, logs, or screen shots, unless the conditions make this impossible, in which case a test conductor's note could suffice. The report will contain pass/fail criteria with the related significant analysis and recommended actions for re-test.

The test report documentation also includes updating the SOC DOORS verification module with any respective SIT related information.

2.4.3 Non-Conformance Approach

Test Reports will note failures and discrepancies, with the related test analysis, criteria, and recommended actions. There are five levels of failure severity defined in the table below.

Table 2-2 : Pass/Fail Severity Levels

SEVERITY	DESCRIPTION

Severity 1	The specified test will not execute at all; the system crashes, a safety or equipment hazard exists.
Severity 2	The test runs, but clearly fails a requirement; a major function does not work.
Severity 3	A requirement fails or a major function does not work according to a procedure but a workaround exists or there is an acceptable alternative.
Severity 4	A minor function does not work or something impedes or degrades the ability of an operator to easily perform a task on the system.
Severity 5	A minor display/presentation flaw exists. An enhancement or feature is requested.

In general, a test passes if there are no Severity 1, 2, or 3 problems encountered during the test. Severity levels 4 and 5 require notes regarding workarounds, discrepancies, or requirements clarifications. Moreover, the Test Conductor may pass a test with a Severity 3 problem if the workaround is deemed acceptable and the Test Director approves. Workarounds are considered within the perspective of deviations and waivers during the Post-Test Review.

2.5 Verification Strategy

The verification strategies used for ground system testing are intended to exercise all ground systems as close as possible to flight environments and, at the same time, utilize the ground system elements for testing as efficiently as possible. Test procedures may be integrated within mission simulations, which in turn may be coordinated with hardware I&T activities to utilize flight generated data for GS testing. Moreover, test procedures may be coordinated with the higher-level Ground System testing activities. Test reports will note the SIT coordination activities during the test execution. The planned verification strategies are listed in the IMAP DOORS verification module. A DOORS snapshot of verification Strategy, Activities, Methods, and Criteria are listed per SIT in Appendix A.

2.6 Verification Methods

The verification methods used to verify functional requirements are: test, analysis, inspection, and demonstration.

2.6.1 Test (T)

Verification by test is the actual operation of ground equipment supported by the necessary test support equipment, data inputs, and test environment to verify compliance with requirements. Functional requirements are verified via approved procedures and processes using controlled conditions such as released software and production hardware. The production application displays, messages, output and archive directories are checked for expected results.

2.6.2 Analysis (A)

Analysis is a verification method utilizing techniques and tools such as analytical assessments, simulations, models, or prior test data. Verification by analysis is a process used in lieu of (or in addition to) testing to verify compliance to requirements.

The selected analysis techniques may include statistics and qualitative analysis, computer and hardware simulations, and computer modeling. Analysis should be used only when all of the following conditions apply: rigorous and accurate analysis is possible; testing is not feasible or cost effective; or verification by inspection is not adequate.

2.6.3 Inspection (I)

As applied to software, inspection verifies the output products by comparing them to interface control documents or design documents and ensuring each product matches these standards in form and content. The GS will also use the inspection method to validate procedures, plans, and other documentation.

2.6.4 Demonstration (D)

Demonstration is a witnessed, one-time observed activity that demonstrates a specific capability.

2.6.5 Roll Up (RU)

Verification by roll up is the process of verifying high level requirements by verification of all lower level child requirements. This method is only allowed if the combination of the child requirements fully encompasses the scope of the requirement.

3.0 Software Integration Test (SIT) Descriptions

Table 3-1: SOC Software Integration Test (SIT) Summary

Test Label	Title	Planned Date
POC SIT-1	Instrument Development Workstation Checkout	May 26, 2021
SDC SIT-1	Infrastructure, Databases, file ingest	February 2023
SDC SIT-2	SDC Infrastructure, API, Archive delivery	August 2023
POC SIT-2	POC RSS Workstation Checkout	July 2023
POC SIT-3	POC I&T Capability – Realtime Command and Control	December 2023
POC SIT-4	POC I&T Capability – Data Processing and Support	January 2024
POC SIT-5	POC Realtime Command and Control	February 2024

SDC SIT-3	Level 0, 1 processing pipeline	April 2024
SDC SIT-3.5	Quarternion processing and pointing accuracy	June 2024
POC SIT-6	POC Planning and Scheduling, Operations Readiness	March 2024
SDC SIT-4	Level 2 processing pipeline	February 2025
I-ALiRT SIT	End to end test, including ingest of packets to processed space weather data	February 2025
CAVA SIT-1	Processing of L3 product including CAVA routines	December 2024 (NET)
SDC SIT-5	Web services and information dissemination	March 2025
CAVA SIT-2	Other products to be defined by the IMAP team	January 2025 (NET)

Summaries of the POC, SDC, CAVA and I-ALiRT SIT tests are provided within the applicable sections below.

3.1 POC SIT Descriptions

3.1.1 POC SIT-1: Instrument Development Workstation Checkout

Table 3-2: POC SIT-1

Functionality Tested	Required Components	Associated Milestone(s)

• Issue Instrument commands from OASIS-CC (GSEOS/SCE Interface). • Receive Instrument Telemetry in OASIS-CC (GSEOS/SCE Interface). • Control Spacecraft Emulator Configurable Items. • Import Command and Telemetry Definitions into OASIS-CC. • Create and Update OASIS-CC Display Panels.	**Hardware / Infrastructure** • OASIS/GSEOS Workstation connected to Spacecraft Emulator **OSW CSC's** • OASIS-CC Core • IMAP MOE • OIS (GSEOS/SCE interface) • CT Apps (Realtime Components) • CSTOL Syntax Checker **Ops Products** • Basic OASIS-CC Display Panels • Basic CT Definition Spreadsheet	IDEX/HIT Workstation Delivery Dates. Negotiated with Instrument teams relative to Instrument CDRs. **Executed Date: 5/26/2021**

3.1.1.1 Objectives
Verify functionality of workstations prior to delivery to Instrument Teams by the POC for Instrument Development.

3.1.1.2 Participating Organizations

- POC
- Instrument Teams (deliverables)

3.1.1.3 Prerequisites

- Delivery of CT products from instrument teams.
- Spacecraft emulator from JHU/APL.

3.1.1.4 Additional Considerations

None at this time.

3.1.2 POC SIT-2: POC Realtime Support System (RSS) Workstation Checkout

Table 3-3: POC SIT-2

Functionality Tested	Required Components	Associated Milestone(s)

• Issue Instrument commands from OASIS-CC (I&T MOC Interface). • Verify POC Telemetry Request Protocol (TRP) client connection to MOC. • Receive Instrument Telemetry in OASIS-CC (I&T MOC Interface). ○ From instrument simulator data servered by the MOC. • Receive MOC Ground System (Status) Telemetry in OASIS-CC. • Receive Spacecraft Telemetry in OASIS-CC (Testbed I&T MOC Interface). • Verify command verification functionality to be used in MOC I&T Interface. • Verify Tlmrelay Functionality (POC RSS server). • Verify POC's ability to retrieve data from the MOC Data Server. • Incorporate and test Instrument CSTOL scripts necessary to perform I&T into the POC repository. • OASIS-CC Display Panels developed and tested. • Maintain Instrument Command &	**Hardware / Infrastructure** • POC RSS Workstation **OSW CSC's** • OASIS-CC Core • IMAP MOE • OIS (I&T MOC Interface) • Tlmrelay (POC RSS) • File Transfer Utilities (POC RSS to POC) **Ops Products** • Instrument OASIS-CC Display Panels • Baseline Instrument CT Definition Spreadsheets • Instrument I&T CSTOL Scripts	Delivery of POC RSS Workstation prior to Instrument Integration onto Spacecraft Bus. **Executed Date: 7/10/2023**

Telemetry Databases in POC systems.		

3.1.2.1 Objectives
Verify functionality of POC RSS workstation prior to delivery to I&T Facility at APL.

3.1.2.2 Participating Organizations

- POC

3.1.2.3 Prerequisites

- POC SIT-1 was successfully completed

3.1.2.4 Additional Considerations.

None at this time.

3.1.3 POC SIT-3: POC I&T Capability - Realtime Command and Control

Table 3-4: POC SIT-3

Functionality Tested	**Required Components**	**Associated Milestone(s)**

• Issue Instrument commands from OASIS-CC (I&T MOC Interface). • Receive Instrument Telemetry in OASIS-CC (I&T MOC Interface). • Receive MOC Ground System. • Telemetry in OASIS-CC. • Verify command verification functionality to be used in MOC I&T Interface. • Verify Tlmrelay Functionality (LASP POC server). • Verify remote desktop console capability. • Instrument CSTOL scripts necessary to perform I&T incorporated into POC repository and tested. • OASIS-CC Display Panels developed and tested. • Instrument Command and Telemetry Databases up to date in POC systems.	**Hardware / Infrastructure** • IMAP Environment/Network to be used to support realtime operations during I&T • IMAP I&T Consoles • IMAP Telemetry Relay Server **OSW CSC's** • OASIS-CC Core • IMAP MOE • OIS (I&T MOC Interface) • Tlmrelay (LASP POC) **Ops Products** • Instrument OASIS-CC Display Panels • Baseline Instrument CT Definition Spreadsheets • Instrument I&T CSTOL Scripts	First Instrument Integration onto Observatory 7 Months before MSIM2 **Executed Date: 12/6/2023**

3.1.3.1 Objectives

Verify POC systems are capable of controlling instruments after they are integrated onto the Observatory during I&T.

3.1.3.2 Participating Organizations

- POC
- JHU/APL I&T
- Instrument Teams

3.1.3.3 Prerequisites

- POC SIT-2 was successfully completed.

3.1.3.4 Additional Considerations

None at this time.

3.1.4 POC SIT-4: POC I&T Capability - Data Processing and Support

Table 3-5: POC SIT-4

Functionality Tested	Required Components	Associated Milestone(s)
• Receive and Process telemetry into L0 and L1 products. • Operational Procedures necessary to conduct I&T Testing developed and verified. • I&T Documentation System (JIRA) ready. • Verify WebTCAD and Web Functionality. • Verify ability to make historic I&T data available to Instrument Teams.	**Hardware / Infrastructure** • IMAP Environment/Network to be used to support realtime operations during I&T • IMAP Data Processing and Storage Hardware **OSW CSC's** • TDP • Extractpkts • PODA • CT Apps (TDP Components) • Operations Website • WebTCAD • ATS • WEB Coordination Tools • File Transfer Utilities (I&T) • Archive (I&T) **Ops Products** • JIRA Configurations and Workflows • Manual Procedures required to conduct I&T	First Instrument Integration onto Observatory 5 Months before MSIM2 **Planned Date: Jan 2024**

3.1.4.1 Objectives
Verify POC systems are capable of processing I&T data and performing other I&T support functions.

3.1.4.2 Participating Organizations

- POC
- JHU/APL I&T
- Instrument Teams

3.1.4.3 Prerequisites

3.1.4.4 Additional Considerations

None at this time.

3.1.5 POC SIT-5 POC Realtime Command and Control

Table 3-6: POC SIT-5

Functionality Tested	Required Components	Associated Milestone(s)
• Issue Instrument commands from OASIS-CC (MOC Interface). • Receive Instrument Telemetry in OASIS-CC (MOC Interface). • Receive MOC Ground System Telemetry in OASIS-CC. • Verify command verification functionality to be used in MOC Interface. • Verify Tlmrelay Functionality in Flight configuration. • Verify MOC/POC File Transfer. • Validate Routine Instrument Commanding Scripts. • Validate Instrument Commissioning Scripts.	**Hardware / Infrastructure** • IMAP Environment/Network to be used to support realtime operations during flight • IMAP Operations Consoles **OSW CSC's** • OASIS-CC Core • IMAP MOE • OIS (MOC Interface) • Tlmrelay (LASP POC) • File Transfer Utilities (Flight) • Archive (Flight) **Ops Products** • Instrument CSTOL Procedures for Operations • Instrument CSTOL Procedures for Commissioning • Manual Procedures - Realtime Functions	Preparation for Mission Simulation 2: ***"Instrument Commissioning Activities, MOC-SOC Interfaces, Instrument Routine Activities, Data Product Verification, Primarily realtime Operations" - August 2023*** 3 months before MSIM2 **Planned Date: Feb 2024**

3.1.5.1 Objectives
Verify POC systems are capable of controlling instruments after launch.

3.1.5.2 Participating Organizations

- POC
- MOC
- Instrument Teams

3.1.5.3 Prerequisites

3.1.5.4 Additional Considerations

None at this time.

3.1.6 POC SIT-6 POC Planning and Scheduling, Operations Readiness

Table 3-7: POC SIT-6

Functionality Tested	**Required Components**	**Associated Milestone(s)**

• Ingest input files into OASIS-PS. • Create Planning Products with OASIS-PS. • Encode Queued and Time-Tagged Command Files. • Verify Mission Events ingest and access. • Verify limit checking of recorded Instrument Data. • Verify Alarm Notification System. • Verify Data Accounting System. • Verify Routine Trending on Operations Website. • Verify Instrument Access to Telemetry Packets.	**Hardware / Infrastructure** • IMAP Environment/Network to be used to support planning operations during flight **OSW CSC's** • OASIS-PS • Mission Events • SPAM • DPC **Ops Products** • Time-Tagged Commanding Activity Definitions • OASIS-PS Command Templates • Manual Procedures - Planning Functions • Manual Procedures - "Shift Checklists"	Preparation for Mission Simulation 3: ***"Multi-Day Ops Tests with Instruments, Planning Process, Command Sequence Execution, Data Product Verification" - March 2024***

3.1.6.1 Objectives

3.1.6.2 Participating Organizations

- POC
- Instrument Teams

3.1.6.3 Prerequisites

3.1.6.4 Additional Considerations

None at this time.

3.2 SDC SIT Descriptions

Table 3-8 : SDC SIT Summary

SIT	Title and Description	Required Components	Associated Milestone(s)	Planned Date
SIT SDC-1	SDC Infrastructure, Databases, file ingest.	**SDC CSC's** • Identity Manager • Role Manager • Policy Manager • Message Handler • Log Manager • System Monitor • Drop Box Manager • Database Manager	SOC CDR + 12 months	Feb 2023
SIT SDC-2	SDC Infrastructure, API, Archive delivery.	**SDC CSC's** • Processing Manager • User Access Manager • Data Access • Backup Manager • Download Manager • Archive Data Manager	SIT SDC-1 + 6 months	Aug 2023

SIT SDC-3	Level 0, 1 processing pipeline architecture.	**SDC CSC's** • Processing Manager • Data Access • Data Services Manager • Access Manager • Message Handler • Container Manager	L-12 months	Apr 2024
SIT SDC-3.5	Quarternion Ingest and Pointing Accuracy	**SDC CSC's** • Drop Box Manager • Data Access • Processing Manager • Data Services Manager	MSIM #2	Jun 2024
SIT SDC-4	End to end test, including level 2 and 3 processing.	**SDC CSC's** • Processing Manager • Archive Data Manager • Message Handler • Container Manager	L-2 months	Feb 2025

SIT SDC-5	Web Services, including Team and Public access and data download.	**SDC CSC's** • Team and Public User Access Manager • Team and Public Data Access • Team and Public Download Manager	LRD	Mar 2025

3.2.1 SDC SIT-1: Infrastructure, Databases, file ingest

3.2.1.1 Objectives
The purpose of this test is to verify that the SDC is ready to support initial instrument science processing system development. At the time of this SIT, external interfaces, a software staging environment, and limited data management capabilities will be available.

3.2.1.2 Participating Organizations
The entities required to support this SIT are the qualified science data processing personnel from the SDC and select instrument teams.

3.2.1.3 Functionality Tested
The following functionality will be tested:

- Software requests to the SDC's Telemetry interface returns the correct Level-0 packets. This test will include requests for time ranges corresponding to onboard timestamps as well as ground receipt times.
- Interfaces to the shared storage system (e.g. ancillary, Level-1 products) work as expected.
- Each science data processing pipeline software has read/write access to the directories needed to perform data processing activities.
- SDC Drop Box functionality to receive science and ancillary data works as expected.
- Creation and management of user accounts within the SDC framework.

3.2.1.4 Prerequisites

- SDC cloud based infrastructure will need to be sufficiently mature to support external interfaces,

3.2.1.5 Additional Considerations
None at this time.

3.2.1.6 GSRT Coordination

None Needed.

3.2.2 SDC SIT-2: SDC Infrastructure, API, Archive delivery

3.2.2.1 Objectives
The purpose of this test is to verify that the SDC can internally manage all the expected data files and types within the processing framework, deliver them to the Space Physics Data Facility (SPDF), and demonstrate the capability of the API for internal and external users to interact with data files.

3.2.2.2 Participating Organizations
The entities required to support this SIT are the qualified science data processing personnel from the SDC, select instrument teams, and the CAVA development team.

3.2.2.3 Functionality Tested
The following functionality will be tested:

- Ability to deploy and test software in the SDC Staging environment.
- Software can be successfully promoted from the SDC Staging Environment to the SDC Data Production Environment.
- Delivery of data files to the SPDF for routine archival purposes.
- Use of the API data interfaces by both SDC personnel as well as instrument teams.
- Demonstrate the SDC's ability to trigger jobs based on data availability and launch necessary processing containers.

3.2.2.4 Prerequisites

- Dummy data files to demonstrate data management.
- Dummy data files to demonstrate transfer to external users.

3.2.2.5 Additional considerations
None at this time.

3.2.2.6 GSRT Coordination

None Needed.

3.2.3 SDC SIT-3: Level 0, 1 processing pipeline

3.2.3.1 Objectives
This is a readiness test to verify that the SDC is capable of performing selected nominal post-

flight daily operations for the lower-level data processing pipelines. At this point, the SDC will be capable of producing Level-1 data products and verifying that routine archiving functions will be operational.

3.2.3.2 Participating Organizations
The entities required to support this SIT are the qualified science data processing personnel from the SDC, representatives of instrument teams, and personnel from the SPDF.

3.2.3.3 Functionality Tested

- Automated scripts that initiate data processing activities work as expected.
- Decommutation of instrument level science data packets into valid Level-0 data products.Level 1 processing pipelines function as expected and create valid Level-1 data products.
- That automated scripts that manage the instrument processing pipeline function as expected.
- CDR file writing utilities create valid and complete SPASE-compliant products.
- Automatic notification to SDC personnel when pipeline issues arise.

3.2.3.4 Prerequisites
The SDC will need an initial release of Level-1 software. This software should have been previously tested in the SDC Staging Environment and promoted to the SDC Production Environment. The SDC will also need simulated raw CCSDS packets from instrument teams with which to test the pipeline.

3.2.3.5 Additional Considerations
None at this time.

3.2.3.6 GSRT Coordination

None Needed.

3.2.4 SDC SIT-3.5: Quarternion and Spin-Pulse Processing and Pointing Accuracy

3.2.4.1 Objectives

This SIT will test the ingest, processing, and availability of raw quarternion and spin-pulse products from the MOC and additional SPICE and navigation products necessary to verify and validate pointing accuracy knowledge and spin-phase accuracy.

3.2.4.2 Participating Organizations

The entities required to support this SIT are the qualified science data processing personnel from the SDC, personnel from the MOC, and representatives of instrument teams.

3.2.4.3 Functionality Tested

- Interfaces between the SDC and POC to ingest raw quarternion products as made available to the POC by the MOC.
- Interfaces between the SDC and POC to ingest spin-pulse information as made available to the POC by the MOC.
- Availability of raw quaternion products to the processing pipeline and instrument teams via SDC API.
- Availability of spin-pulse data and associated products (spin times per individual spin) to the processing pipeline and instrument teams via SDC API.
- Ability to access and plot trends in raw quarternions and ancillary spacecraft pointing data to determine changes in pointing and spin phase accuracy.
- Ability to access and plot trends in spin times for individual spin and ancillary spacecraft data to determine changes in the spin times through each day.

3.2.4.4 Prerequisites

The MOC will need to have sample raw and processed quarternion data files available for transfer to the SOC as well as additional spacecraft data. The MOC will need to have sample raw spin pulse data files available for transfer to the SOC as well as associated spacecraft data to determine the timing of individual spins.

3.2.4.5. Additional Considerations

None at this time.

3.2.5 SDC SIT-4: Level 2 processing pipeline

3.2.5.1 Objectives
This SIT will test an initial release of the Level-2 science processing software in the SDC system and demonstrate the end-to-end processing pipeline.

3.2.5.2 Participating Organizations
The entities require to support this SIT are the qualified science data processing personnel from the SDC, representatives of instrument teams, and the CAVA development team.

3.2.5.3 Functionality Tested

- Automated scripts that initiate data processing activities work as expected.
- All associated software expected to run at the SDC produces correct output.
- Preliminary Level-2 data products are generated and available instrument teams to download and review.
- Level-3 data processing pipelines function as expected and produce data from synthetic inputs
- Data is ingested, fully processed, and delivered to archive facilities.

3.2.5.4 Prerequisites

- An initial release of Level-2 data product definition and processing algorithms will need to be available from each instrument team.
- All Level-2 processing software will need to be available and released
- Instrument teams will need to have delivered Level-3 processing codes to the SDC.

3.2.5.5 Additional Considerations
None at this time.

3.2.5.6 GSRT Coordination
None Needed.

3.2.6 SDC SIT-5: Web services and information dissemination

3.2.6.1 Objectives
This SIT will verify that the basic functionality of the SDC's science website will be capable of disseminating documentation and mission-related science news. Additional testing will be performed to validate team-member access, and access to the general public.

3.2.6.2 Participating Organizations
The GS entities required to support this SIT are the qualified science data processing personnel from each of the instrument teams and the SDC. The SPDF will be needed to verify that they can retrieve IMAP data products. Instrument team personnel and science team members will be asked to test the usability of the SDC website for science data discovery and ease of data retrieval. Additionally, the CAVA development team will be required to ensure compatibility.

3.2.6.3 Functionality Tested

- IMAP Level 1 and 2 data products are available for retrieval through the website.
- The SDC Website is available to both the science team login and the general science community access.
- Web services to disseminate Level-1 and Level 2 data products to registered science team members.
- Web services to disseminate Level-2 data products the general public.
- Website HTML interfaces that interact with the web services to retrieve and display data products.
- Basic data visualization capabilities work as expected.

3.2.6.4 Prerequisites

- The SDC Website infrastructure will need to be completely in place at this time.
- Science team members will need to be registered in Website.

3.2.6.5 Additional Considerations
None at this time.

3.2.6.6 GSRT Coordination

None Needed.

3.3 CAVA SIT Descriptions

Table 3-9 : CAVA SIT Summary

SIT	Title and Description	Required Components	Associated Milestone(s)	Planned Date
SIT CAVA-1	Processing of L3 product including CAVA routines	Integration of CAVA code into SDC pipeline	NET Dec 2024 (SIT SDC-4) scheduled as part of CAVA development in coordination with SDC test plan	
SIT CAVA-2	Other products to be defined by the IMAP team.	Appropriate access and processing of such products	NET Jan 2025 (SIT SDC-5) scheduled as part of CAVA development in coordination with SDC test plan	

3.3.1 CAVA SIT-1: CAVA

3.3.1.1 Objectives
This SIT will verify the processing of L3 data products based on the CAVA routines and pipeline.

3.3.1.2 Participating Organizations
The entities required to support this SIT are the SDC, CAVA development team, and relevant instrument team personnel.

3.3.1.3

- The ability of the SDC pipeline to initiate a CAVA instance.
- The integration of CAVA based routines with integral SDC routines (such as the CDR writing routines.)
- The successful creation of valid Level-3 data products.

3.3.1.4 Prerequisites

- All Level-2 processing software will need to be functional and be capable of producing, or simulating, Level-2 data products.
- The CAVA software environment will have to be complete and stable.

3.3.1.5 Additional Considerations
None.

3.3.1.6 GSRT Coordination

None.

3.3.2 CAVA SIT-2: CAVA

3.3.2.1 Objectives
This SIT will verify, if found necessary, the use of CAVA within the SDC to create additional standard mission data products. These products, not yet defined, may be determined necessary by the IMAP science team.

3.3.2.2 Participating Organizations
The entities necessary to support this SIT will be determined if and when this SIT is required.

3.3.2.3

TBS

3.3.2.4 Prerequisites

TBS

3.3.2.5 Additional Considerations
TBS

3.3.2.6 GSRT Coordination
TBS

3.4 I-ALiRT SIT Descriptions

Table 3-10: I-ALiRT SIT Summary

SIT	Title and Description	Required Components	Associated Milestone(s)	Planned Date

SIT I-ALiRT-A	POC-MOC end to end test verifying reception of packets from antenna partners, successful distribution to the MOC, and POC reception/extraction of I-ALiRT packets from the nominal MOC data-stream.	IOIS TDP OASIS-CC Core IMAP MOE OIS File Transfer Utilities	L-6 months	Oct 2024
SIT I-ALiRT-B	POC-SDC end to end test verifying POC ingestion of packets into shared database, successful SDC query of data, timely production of space-weather products, and successful alerting on abnormal conditions.	IOIS TDP DPC SPAM/OpsGenie	L-2	Feb 2024

3.4.1 I-ALiRT SIT A: I-ALiRT

3.4.1.1 Objectives
This SIT will verify the core functionality of the I-ALiRT POC-MOC processing system - including ingestion of the nominal realtime data stream from the MOC and sending broadcasted I-ALiRT data to the MOC.

3.4.1.2 Participating Organizations
The entities required to support this SIT are the POC and the MOC. Additionally, if Ground Station antenna partners are available during this time, they will be allowed to participate, but not a required entity.

3.4.1.3

- The ability to receive Frames from a remote resource.
- The SOC will create a mock ground station from a remote server if no participating ground stations are available to send test I-ALiRT Frames.

- Create Raw Record files of the contents streamed from the ground stations.
- Capability to push packet files to the MOC every 10 minutes, in accordance with the MOC-SOC ICD.
- The MOC will verify receipt of these files.
- The ability to handle duplicate data streams

3.4.1.4 Prerequisites

- MOC-SOC file transfer interface established
- Intitialization of the Mission Database and Broadcast-Only I-ALiRT Table

3.4.1.5 Additional Considerations
None at this time.

3.4.1.6 GSRT Coordination

None.

3.4.2 I-ALiRT SIT B: I-ALiRT

3.4.1.1 Objectives
This SIT will verify the core functionality of the I-ALiRT POC-SDC processing system, timining requirements, and alert notification system - including availability of the processed space weather data products.

3.4.1.2 Participating Organizations
The entities required to support this SIT are the SDC and the POC. Additionally, if Ground Station antenna partners are available during this time, they will be allowed to participate, but not a required entity.

3.4.1.3

- The SOC will create a mock ground station from a remote server if no participating ground stations are available to send test I-ALiRT Frames.
- The ability to handle data streams and populate the shared I-ALiRT database.
- Capable of processing the data on a set cadence within the required 5-minute latency period.
- Ensure the ability to handle missing data.
- Verify ability to produce and publish space-weather products, externally, for general science community access.

3.4.1.4 Prerequisites

- POC-SDC AWS infrustructure initialized
- OpsGenie licences

3.4.1.5 Additional Considerations
None at this time.

3.4.1.6 GSRT Coordination

None.

Appendix A - Verification Tables

The planned verification strategies are listed in the IMAP DOORS verification module. Here is a DOORS snapshot of verification Strategy, Activities, Methods, and Criteria listed per SIT