National Aeronautics and
Space Administration

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Radiation Budget Instrument
RBI

Mission Concept of Operations Document
(MCOD)

SIGNATURE PAGE

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

1.1 PURPOSE AND SCOPE

This Mission Concept Operations Document (MCOD) describes the systems, operational concepts, and organizations required to develop, implement, and conduct the Radiation Budget Instrument (RBI) mission. The objective of the MCOD is to document the functionality of the RBI operations and to define system segments, associated functions, and operational descriptions. The MCOD represents the operational approaches used to develop the mission requirements and provides the operational framework for execution of the major components of the RBI mission. Following an operational handover that occurs approximately 90 days after a successful launch and a post on-orbit activation and check-out period, the RBI will become the responsibility of the Earth Radiation Budget Science Team (ERBST), formerly the Radiation Budget Measurement Program (RBMP).

The MCOD is not a requirements document, but rather it provides a functional view of the RBI mission based upon high-level project guidance, stakeholder expectations, and systems analysis. All functions, scenarios, figures, timelines, and flow charts are conceptual only and are subject to change. They are not intended to provide actual design definition. Therefore, while the objective of the MCOD is to capture all necessary functionality of the RBI operations, some functions may ultimately be modified or allocated to different segments at a later time.

1.2 CHANGE AUTHORITY/RESPONSIBILITY

Proposed changes to this document shall be submitted by a RBI Change Request (CR) to the appropriate the RBI Change Control Board (CCB) for consideration and disposition as defined by the RBI Configuration & Data Management Operating Procedure, RBI–CDMOP-01-002.

All such requests will adhere to the above document Change Control Process.

2 APPLICABLE AND REFERENCE DOCUMENTS

This section identifies documents that are applicable to the project activities. The current version is assumed unless otherwise noted. Reference documents are for information only.

2.1 APPLICABLE DOCUMENTS

The following documents include specifications, models, standards, guidelines, handbooks, and other special publications. The documents listed in this paragraph are applicable to the extent specified herein.

Table 2-1 Applicable Documents

Document Number	Document Revision	Document Title
470-00031		JPSS Level 1 Requirements (JPSS-REQ-1001)

Document Number	Document Revision	Document Title
470-00032		JPSS Level 1 Requirements Supplement (JPSS-REQ-1002)
470-00072		Joint Polar Satellite System-2 (JPSS) Mission Concept of Operations
470-00029		JPSS System Architecture and Concept of Operations (SACO)
470-00101		JPSS-2 Mission Systems Specifications (MSS)
472-00244	D	JPSS Data Formats Requirements Document (DFRD)
472-00290		JPSS-2 Mission Data Format ICD
474-00054		JPSS Ground System Concept of Operations (GS ConOps)
TBS		Recommended Operations Procedures (ROPS)
TBS		Flight Activation Operations Plan
472-00TBD		Command and Telemetry Definition (TBR)
472-00TBD		JPSS-2 Mission Data Format Control Book (MDFCB)
475-00596		JPSS PROC Style Guide
475-00598		JPSS SOP Style Guide
474-00604		MOST JPSS Display Page Style Guide
474-00818		JPSS-2 Integrated Mission Timeline Management Plan
472-00374		JPSS Flight Project C&T Database Management Plan
472-00253		JPSS Instrument Mission Assurance Requirements (MAR)
420-01-01	C	RBI Program Level Requirements Appendix (PLRA) U
472-00267	B	RBI Performance Requirements Document (PRD).
RBI-SEMP-02-001		RBI Systems Engineering Management Plan
472-00283	C	RBI-JPSS 2 Interface Control Document
472-00287	B	RBI-JPSS 2 Mechanical Interface Control Document
RBI–CDMOP-01-002		RBI Configuration & Data Management Operating Procedure

2.2 Reference Documents

The following documents contain reference, guidance, and consideration for applicability for product requirement documents.

Table 2-2 Reference Documents

Document Number	Document Revision	Document Title
NASA/SP-2007-6105	Rev. 1	NASA Systems Engineering Handbook
NPR 7120.5E	Rev. E	NASA Space Flight Program and Project Management Handbook
NPR 7150.2B	Rev. B	NASA Software Engineering Requirements
LMS-OP-1400	Rev. C	Processing of Global Satellite Science Data

2.3 Instrument Documents

The following documents contain a list of planned vendor supplied information that can help the user understand the full context of this document.

Table 2-3 Instrument Documents

Document Number	Document Revision	Document Title
SE-01		Systems Engineering Management Plan
SE-03		System Performance Verification Plan
SE-04		Instrument Performance Specification
SE-05		Indentured Drawing List and Drawing Trees
SE-06		Engineering Drawings
SE-08		Instrument System Performance Verification Report
SE-10		Instrument Performance Trend Analysis Report
SE-14		Instrument Data Sets
SE-15		Requirements Verification Matrices
MA-01		Mission Assurance Implementation Plan
MA-17		Limited-Life, Limited Use, and Expendable Items List
MA-18		Software Assurance Plan
MA-32		End Item Data Package
SW-04		Flight Software Requirements Specification

SW-05		Flight Software Design Document
SW-06		Flight Software Test Procedures
SW-09		Flight Software User's Guide
SW-10		Ground Software Requirements Specification
SW-12		Ground Software Test Procedures
SW-15		Ground Software User's Guide
SW-17		Software Acceptance Review Data Package
IT-02		Environmental Test and Verification Plan
IT-03		Test Procedures
IT-04		Test Reports
IT-06		EGSE Operations Manual and Procedures
CV-01		Calibration System Requirements
CV-02		Relative Spectral Response (RSR) Component Measurements and System RSR Analysis
CV-03		Flight Calibration Sources
CV-04		Ground Calibration Sources and Parameters Report
CV-05		Calibration & Validation Plan
CV-06		Calibration / Validation Procedures
CV-07		Calibration / Validation Reports and Summaries
OO-01		Instrument Concept of Operations Document
OO-02		Instrument User's Manual
OO-03		Instrument Command Telemetry, Science and Engineering Data Description
OO-04		Instrument Constraints, Restrictions, and Warnings/Alerts Document

3 MISSION OVERVIEW

3.1 RBI MISSION

The Radiation Budget Instrument (RBI) on-board the Joint Polar Satellite System - 2 (JPSS-2) satellite will continue NASA's long-term measurement of Earth's radiation budget. The RBI follows the successful legacy of the Clouds and the Earth's Radiant Energy System (CERES) instruments onboard NASA's Tropical Rainfall Measuring Mission (TRMM) satellite, NASA's Earth Observing System (EOS) Terra and Aqua satellites, and the NOAA Suomi National Polar-orbiting Partnership (S-NPP) and JPSS-1 satellites. Data produced by the RBI will facilitate production of Earth Radiation Budget (ERB) Climate Data Records as specified in the RBI Program Level Requirements Appendix (PLRA) document. Data produced by the RBI will be suitable to facilitate the reprocessing and scientific analysis necessary for supporting climate applications of the JPSS data records. This will lead to a better quantification and understanding of how the Earth's climate system is changing, what are the forcing functions that effect climate change, what are the global impacts to people and property, and for developing mitigations for climate change. See Figure 3-1.

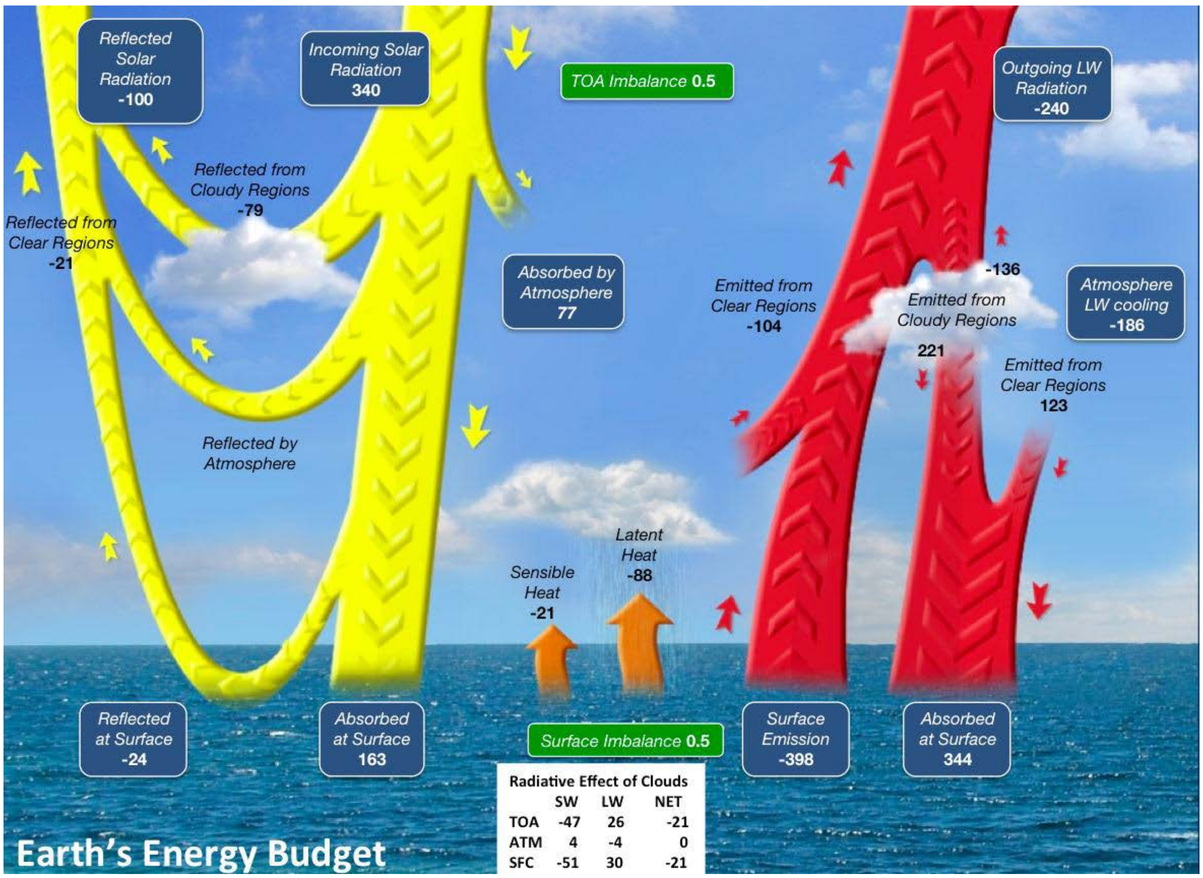

Figure 3-1 RBI Measurements

The RBI will be a broadband scanning radiometer capable of measuring Earth's reflected solar and emitted thermal energy in three spectral bands: (1) Short Wave (SW) Reflected Solar, 0.3 to 5.0 microns; (2) Long Wave (LW) Emitted Thermal, 5.0 to >50.0 microns, and (3) Total, 0.3 to >100.0 microns. The RBI data products include radiant fluxes at the top of the Earth's atmosphere, at the Earth's surface, and flux divergences within the atmosphere. Additional products include cloud data that are provided in terms of measured area coverage, altitude condensed water density, and short-wave (SW) and long-wave (LW) optical depths.

For RBI to maintain the climate record begun by the CERES mission, it must perform in a similar CERES manner both functionally and radiometrically. The RBI meets the functional requirements of providing spectrally integrated observations of Shortwave (SW), Longwave (LW), and Total (TOT) radiance that are temporally and spatially coincident. The RBI accomplishes this by having an optical module with three coaligned telescopes, one for each spectral channel, that have fields of view, detector time constants, band pass filtering, and scan rates that match the CERES measurement response (spectral and spatial [point spread function]). It also has scanning sampling rates that match CERES. The field of view scanning capability is similar to CERES and provides similar cross-track and bi-axial scanning for full-disk Earth coverage, as well as solar and lunar observations as required by the user. The RBI has multiple on-board calibration sources that will be used to provide high-quality calibrated data products. The infrared and visible targets will help improve the accuracy in long-term knowledge capability not found on previous missions.

The RBI improves on the radiometric performance of CERES by providing low short-term radiometric uncertainty through using detectors that are Johnson-noise limited with very little 1/f noise and free of thermal transients. Additionally, the RBI's sensor module and calibration targets are thermally controlled, and utilize stable electronics to reduce thermal variations. Periodic views of space and the calibration targets remove offset and gain drifts on many timescales. The RBI enhances mission performance by providing low long-term radiometric uncertainty.

3.2 RBI Science

Science data collection will be performed using one of two science "modes". The primary mode will be the "Cross-Track" mode. In this mode the elevation gimbal performs a routine spacelook-to-spacelook, forward and backward scan profile while the azimuth gimbal remains at a fixed position. The resultant scan plan is orthogonal to the ground track path. The cross-track Earth viewing pattern is shown in Figure 3-2.

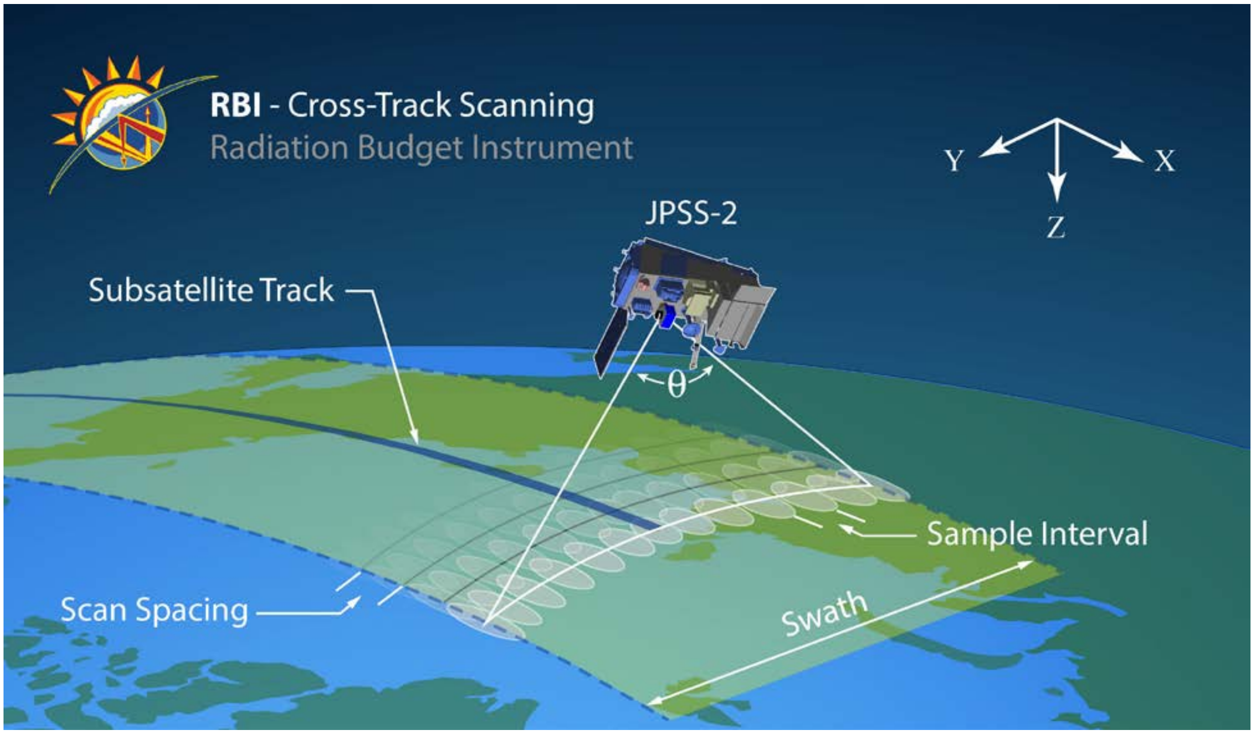

Figure 3-2 Cross-Track Viewing Geometry

The alternative science data collection mode is known as the "Bi-Axial" mode. In this mode, the elevation scan profile remains the same as performed during Cross-Track, but the azimuth gimbal is allowed to scan ±90°. This allows for the capability of the radiometric sensor to view the Earth over a 360° range. The Bi-Axial Earth viewing pattern is shown in Figure 3-3.

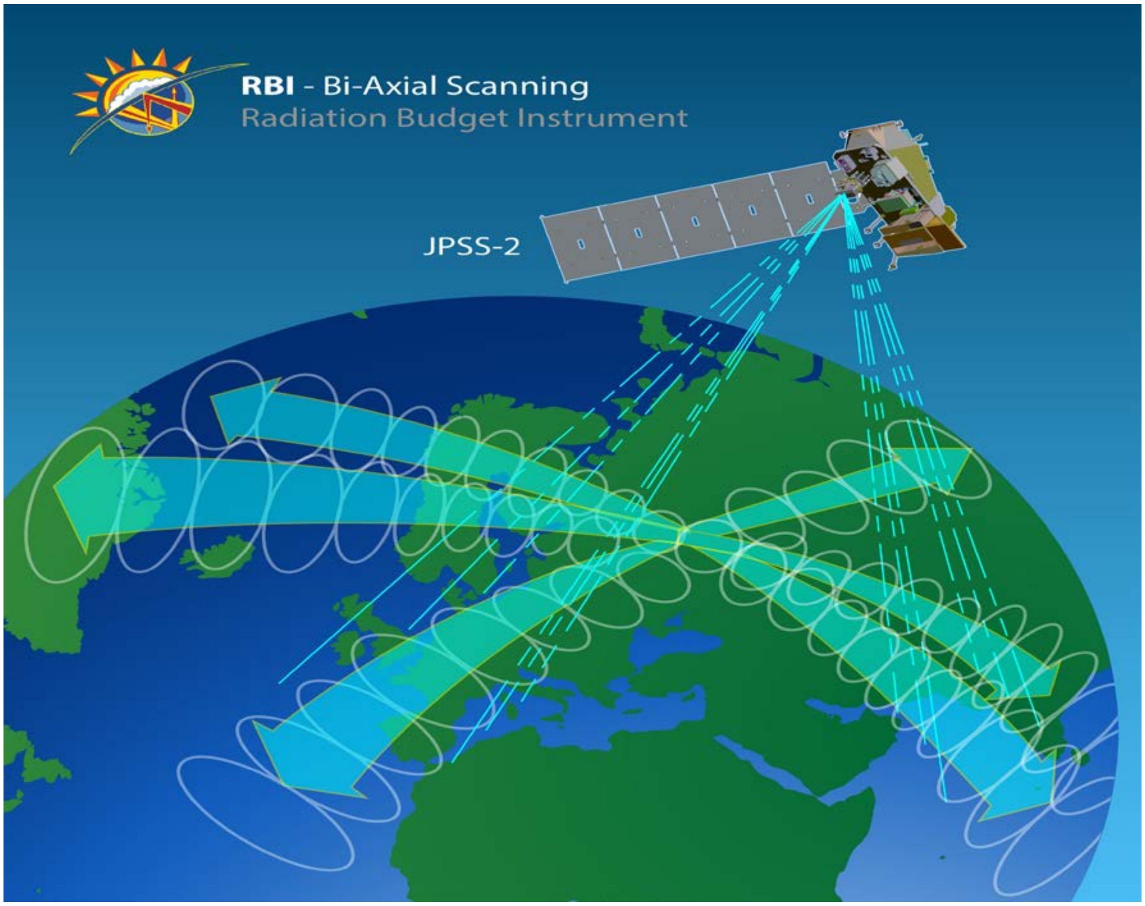

Figure 3-3 Bi-Axial Viewing Geometry

3.3 INSTRUMENT

The Instrument is shown conceptually in Figure 3-4. The instrument coordinate frame is defined so that the +Z-axis points to Nadir, the +X-axis points in the direction of spacecraft velocity, and the +Y-axis completes the right-handed system. For the purposes of instrument scanning, motion along the X-axis is referred to as "along track" and along the Y-axis represents "cross track". The RBI consists primarily of a Cross-Track Scan Module (CSM), an Azimuth Rotation Module (ARM), an Electronics Unit (EU), an Optical Module (OM), internal calibration targets, and structural elements. The EU contains several Circuit Card Assemblies (CCAs), including a single board computer (SBC), which controls operations and communication of the RBI. The SBC hosts the flight software, contains the volatile and non-volatile memory, and includes the internal bus communications hardware.

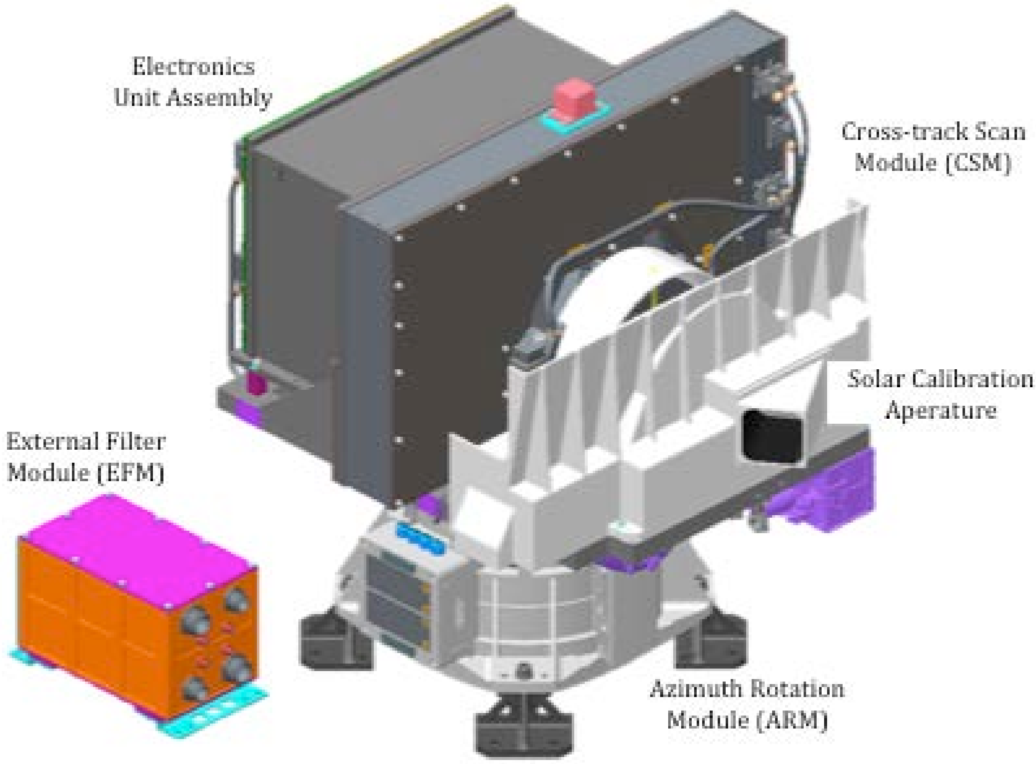

Figure 3-4 Instrument Concept

3.4 ARCHITECTURE

3.4.1 Mission Segments

The RBI Mission is decomposed into three segments: the Space Segment, the Ground Segment, and the Science Segment. The RBI Architecture is illustrated in Figure 3-5.

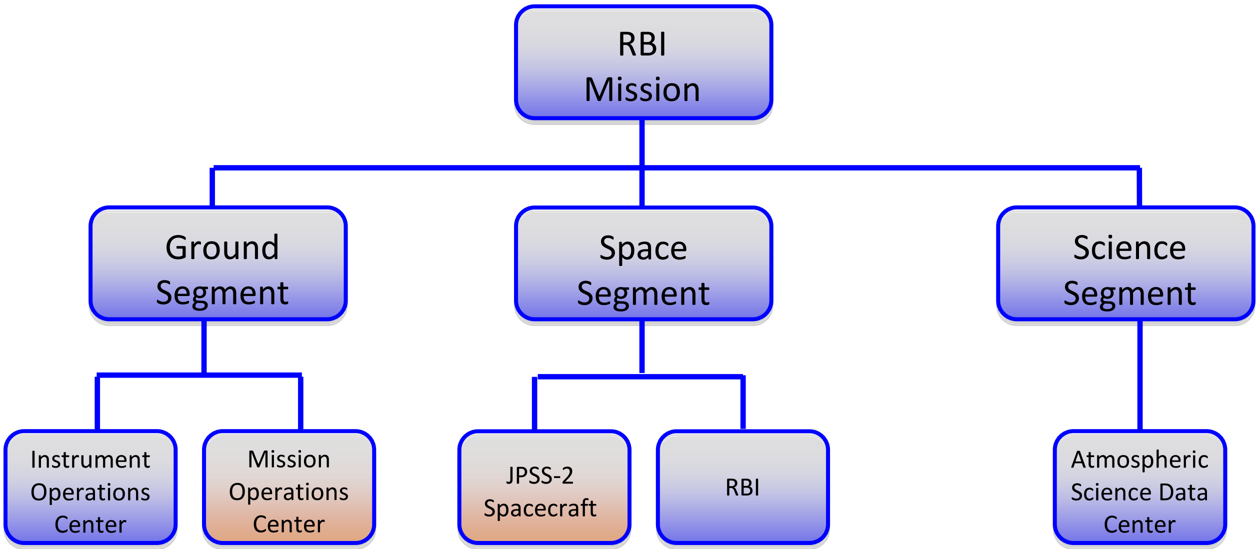

Figure 3-5 RBI Mission Segments

The RBI Space Segment consists of the instrument and the interface to the JPSS-2 spacecraft. The instrument includes the instrument hardware and all of its assemblies, subassemblies, and software components. The Instrument will take measurements over the entire globe as described in Section 3.1. The Instrument will interface with the JPSS-2 Spacecraft for structural mounting, power, thermal conditioning, science data transfer, and command and telemetry transfer. The JPSS program provides the JPSS-2 Spacecraft and the capabilities and services of the Mission Operations Center (shown in orange) to support the RBI mission.

The RBI Ground Segment consists of the RBI Instrument Operations Center (IOC), which will reside at NASA LaRC and the JPSS Mission Operations Center (MMC) which will reside at NOAA. The primary functions of the Ground Segment are to command and control the Instrument, to monitor and trend Instrument health and status, and to receive and transfer data from the Instrument to the IOC and Atmospheric Science Data Center (ASDC).

The RBI Science Segment includes all of the systems and facilities that will be used to receive science and telemetry data from the MMC, perform all science data processing to generate science products, provide all data products to end users and to archive the data.

3.5 Mission Architecture

The RBI Mission Architecture integrates the mission segments to ensure successful execution. Figure 3.6 illustrates the following Mission Architecture features:

- The RBI is on the JPSS-2 Spacecraft in polar orbit
- The JPSS-2 Spacecraft Launch Vehicle
    - Launch location and launch vehicle type will be determined by the JPSS project.

- The JPSS MMC, which operates the JPSS-2 Spacecraft and transmits data and commands between the IOC and the Instrument via the JPSS-2 Spacecraft
  - The MMC location and details, including any additional ground facilities that support the RBI are provided by the JPSS project
- The IOC located at LaRC's Science Directorate facility and will be responsible for operating the RBI
- The ASDC at LaRC will process, distribute, and archive the science data from the RBI

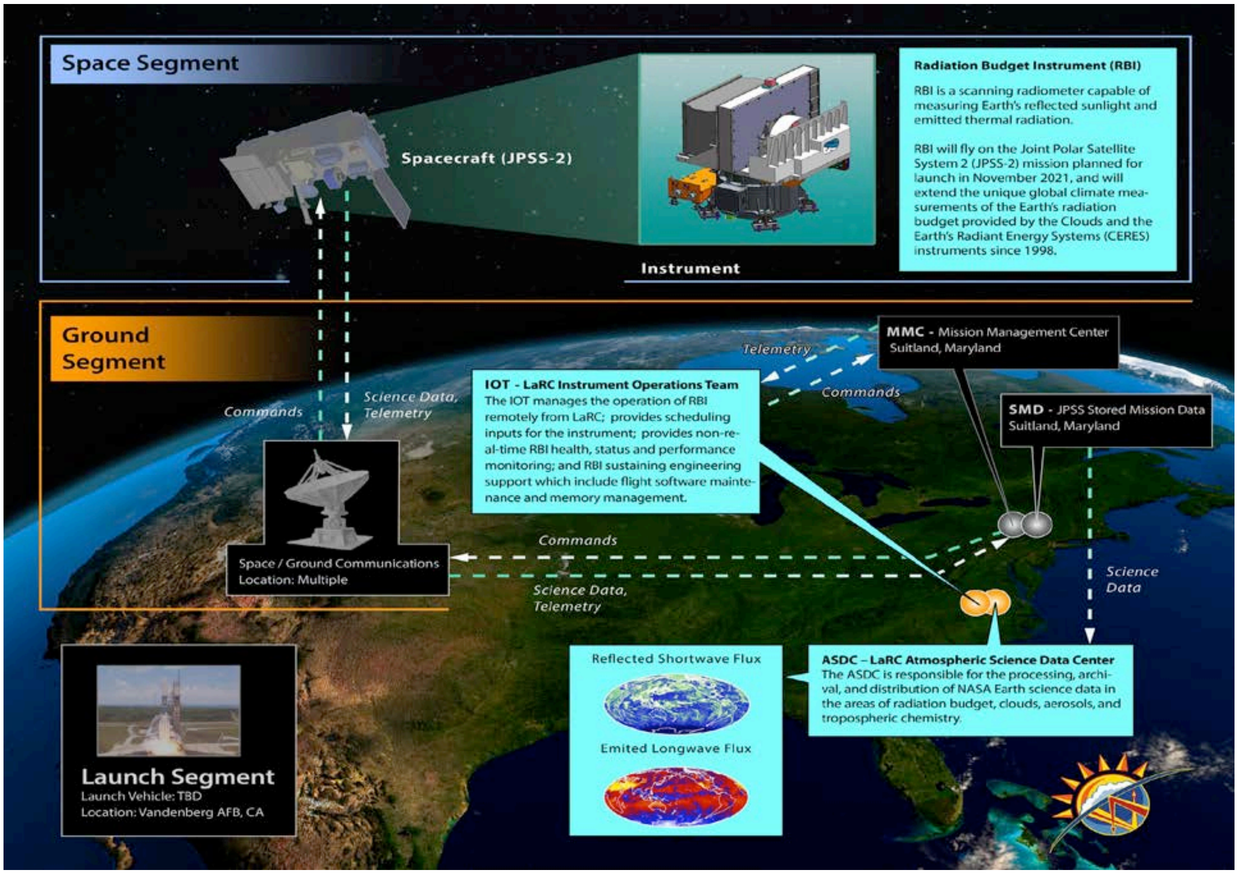

Figure 3-6 RBI Mission Architecture

3.6 Mission Phases

The JPSS Mission can be characterized by the following major phases: Pre-Launch Operations, Launch and Commissioning Operations, Routine Operations, and End-of-Life (EOL) Decommissioning. Non-frequent and contingency operations are considered part of the Routine Operations phase. Example activities are illustrated in the Figures 3-7 and 3-8.

Mission Phase	Mission Activities	GS ConOps Threads
Pre-Launch/ Launch Readiness	• *Spacecraft/Satellite I&T, Space/ground segment testing, End-to-End testing, as well as mission operations preparation and ground system readiness testing leading up to launch*	• *Pre-Launch & Launch Readiness Support*
Launch & Commissioning Operations	• *Western Range Launch (Vandenberg AFB)* • *Orbit Raising to Mission Orbit* ***in Constellation with S-NPP & JPSS-1*** *separated by at least 20 min at same 1330 LTAN)* • *Autonomous activation sequence following LV separation places satellite in power-positive orientation (TDRSS-supported)* • *Spacecraft Aliveness/Functional Testing & Instrument Activation jointly executed by MOT & SC/Instrument Support Teams* • *90 day post-launch checkout prior to commissioning & operations management transition from NASA JPSS to NOAA OSPO*	• *Launch and Early Orbit* • *Space Network Support*
Routine Operations	• *See next slide*	
Routine Operations – (non-frequent)	• *MOT performs mission orbit maintenance based on established criteria (control box), as well as instrument calibration slews and collision avoidance (on as-needed basis)* • *TDRSS provides alternate SMD downlink and T&C capability (including MOT proficiency)* • *Flight software and ground system upgrades/maintenance that have minimal impact on mission operations* • *Provide Field Terminal users JPSS processing software* • *Manage commands encrypted keys (AES)*	• *Orbit Maintenance* • *Space Network Support* • *Solid State Recorder Playback* • *Data Accounting and Recovery* • *Flight Software Upgrade* • *Key Management* • *System Maintenance and Upgrade*
Contingency Operations	• *Flight & Ground systems designed to detect and respond to pre-determined set of mission-critical faults or failures* • *MOT responsible for the fault/failure detection, isolation and timely recovery*	• *System Fault Analysis* • *System Maintenance and Upgrade* • *Flight Software Upgrade*
Decommissioning	• *Controlled re-entry planning and execution*	• *Decommissioning*

Figure 3-7 JPSS Mission Phases

Mission Phase	Mission Activities	GS ConOps Threads
Routine Operations	• *Mission Instruments: Primary - VIIRS, CrIS, ATMS, OMPS-N, instruments of opportunity -* ***OMPS-L, RBI****. All are fully operational, continuously scanning & collecting sensor data. JPSS-2 instruments become primary sensors; JPSS-1 instruments are secondary sensors.*	• *Ground Operations* • *Stored Mission Data Handling*
	• *Mission Operations: NSOF (Suitland, MD) / Alternate Site: Consolidated Backup Facility (Fairmont, WV)* • ***MOT operates JPSS-2****, JPSS-1 & S-NPP* ***in mission constellation*** *(coordination of ground contacts & orbit maintenance)* • *Command Uplink and TLM Downlink: One T&C ground contact scheduled each orbit (Svalbard with Fairbanks/Troll as Alternates), Mission Operations Team (MOT) uplinks command loads once a week and other instrument configuration loads; Uplink commands are encrypted using AES. H/K TLM is received and processed for Health and Safety monitoring and trending*	• *Mission Planning and Scheduling* • *Space Operations* • *Ground Operations* • *Flight Vehicle Simulation* • *Orbit Maintenance* • *Attitude Ground Support* • *Sensor Ops and Payload Support* • *Continuity of Operations* • *Fleet/Ground Operations* • *System Status*
	• *Data Downlink: Two polar ground contacts scheduled each orbit for Ka band SMD downlink (Svalbard & McMurdo) to meet 80/96 min data latency, where each contact dumps a complete orbit at each polar ground site. Alternate sites includes Fairbanks and Troll* • *Data Product Generation: xDRs are generated for distribution to the meteorological operational users. Data quality is monitored in near real-time.* • *Data Archive: NOAA CLASS is the long term archive facility for data storage*	• *Solid State Recorder Playback* • *Stored Mission Data Handling* • *Mission Support Data Handling* • *Data Accounting and Recovery* • *Data Quality Assurance*
	• *Initial On-Orbit Instrument Calibration & Validation of Data Product Processing Algorithms and Calibration tables (up to 1 year post-launch), including a pre-planned series of spacecraft maneuvers* • *Long Term Cal/Val: Instrument and data product calibration and validation are performed throughout the mission lifetime*	• *Cal/Val of Data Products* • *Algorithm Development and Maintenance*
	• *Field Terminal Support: Continuous High Rate Data (HRD) X band transmission from spacecraft to Field Terminal (FT) users. Mission support data is made available to the FT users to enable their data processing*	• *Field Terminal User Support* • *Direct Broadcast Quality Monitoring*

Figure 3-8 JPSS Mission Phases - Routine Operations

3.6.1 Pre-Launch

The Pre-Launch mission phase includes satellite and RBI integration and test and checkout of all flight and ground systems (including flight-ground interfaces) leading up to launch. During this phase, the RBI project will continue to focus on characterizing the engineering and calibration performance of the instrument. Data trends will be updated to establish that the sensors are stable and are ready for shipment to the launch site. At the launch site, the observatory is mated to the launch vehicle. The RBI project will support any launch readiness testing as may be required.

3.6.2 Launch and Commissioning

The Launch and Commissioning phase begins with mission system readiness for launch at the launch site, continues with the final countdown, liftoff, ascent, and separation of the payload (satellite) from the launch vehicle and placement of the satellite in the mission injection orbit by the launch vehicle.

The satellite commissioning phase typically involves the Launch, Early Orbit checkout & Activation (LEO&A) plan and begins with spacecraft activation and checkout after separation from the launch vehicle in the mission injection orbit. Once the spacecraft has been check-out, the RBI activation process will begin. Comprehensive functional and performance tests will be performed to verify instrument operations and establish initial on-orbit baseline performance references. Comprehensive calibrations are anticipated to be performed during this period for comparison to ground test results

Following the satellite checkout, the satellite is formally commissioned for routine operations. Operational management responsibilities transition from NASA JPSS to NOAA approximately 90 days post-launch. The RBI will be turned over to Earth Radiation Budget Science Team (ERBST) at OHR.

3.6.3 Routine Operations

The Mission Operations phase is the period that follows commissioning and lasts until the end of life activities begin at the start of the Decommissioning phase. This phase of the mission will be the responsibility of the ERBST. During this phase, the RBI will involve four different types of operations:

- Routine,
- Non-Routine,
- Contingency Operations,
- Intensive Calibration and Validation

3.6.4 End of Life Decommissioning

The ERBST is responsible for the end of life decommissioning of the instrument. The RBI team will work with JPSS on a plan and procedure for when the RBI and/or the spacecraft reaches the end of its operational lifetime. This will include steps so that the Instrument mechanism positions are set and the Instrument is simply powered down to complete passivation. JPSS will provide for a controlled re-entry for mission disposal, as per the NASA Standard 8719.14A, Process for Limiting Orbital Debris.

4 SPACE SEGMENT

The space segment is a satellite comprised of a spacecraft bus and a payload consisting of various instruments. The spacecraft bus contains all of the supporting subsystems needed to control the spacecraft and transmit the collected data to the ground. Representative supporting subsystems include structures, thermal control, power, attitude control, payload data processing and storage, command and control, and communications. The sensors onboard each satellite makes observations of environmental phenomena that support the NOAA JPSS L1RD and Supplement requirements. These data are transmitted to the ground primarily as Stored Mission Data (SMD).

Planned for a 7 year mission lifetime, the hosting JPSS-2 mission satellite will operate in a polar, sun-synchronous mission orbit at a nominal altitude of 824 km and a 1330 local time of ascending node crossing (LTAN). This is the same mission orbit as the Suomi NPP and JPSS-1 missions which the JPSS-2 mission is designed to succeed. If the Suomi NPP and JPSS-1 missions are still functional in the JPSS-2 mission launch timeframe, then the missions will be operated in a constellation, where each will maintain the necessary operational and residual phasing that minimizes ground contact conflicts. It is anticipated that JPSS-2 will fly ≈50 minutes (½ orbit) in front of JPSS-1. S-NPP will fly ≈20 minutes (¼ orbit) from JPSS-1.

The JPSS-2 mission instrument complement includes the Visible Infrared Imaging Radiometer Suite (VIIRS), the Cross-Track Infrared Sounder (CrIS), the Advanced Technology Microwave Sounder (ATMS), the Ozone Mapping Profiler Suite-Nadir Profiler (OMPS-N) as a minimum, and will accommodate the RBI and Ozone Mapping Profiler Suite-Limb (OMPS-L) if they are available.

Environmental sensor data is acquired continuously and stored on-board the satellite as stored mission data (SMD), for subsequent Ka-band downlink to a ground network for capture, preprocessing, and routing to the ground system. Additionally, a continuous real-time High Rate Data (HRD) direct broadcast capability using X-band is provided for transmitting environmental data from the JPSS-2 satellite to ground users equipped to receive these data at field terminals (FT) and direct readout (DR) stations. The JPSS-2 Satellite can also use Ka-band service through TDRSS for SMD downlink if needed.

The space segment interfaces with both the launch segment and the ground segment.

5 GROUND SEGMENT

The RBI Ground Segment consists of the IOC facility at LaRC and the Mission Operations Center (MOC) at the JPSS MMC. Figure 5-1 shows the interfaces between the MOC (within the NOAA NSOF) and the IOC, and between the EOS Data and Operations System (EDOS) and the ASDC. Detailed interfaces will be documented in separate Interface Control Documents (ICDs).

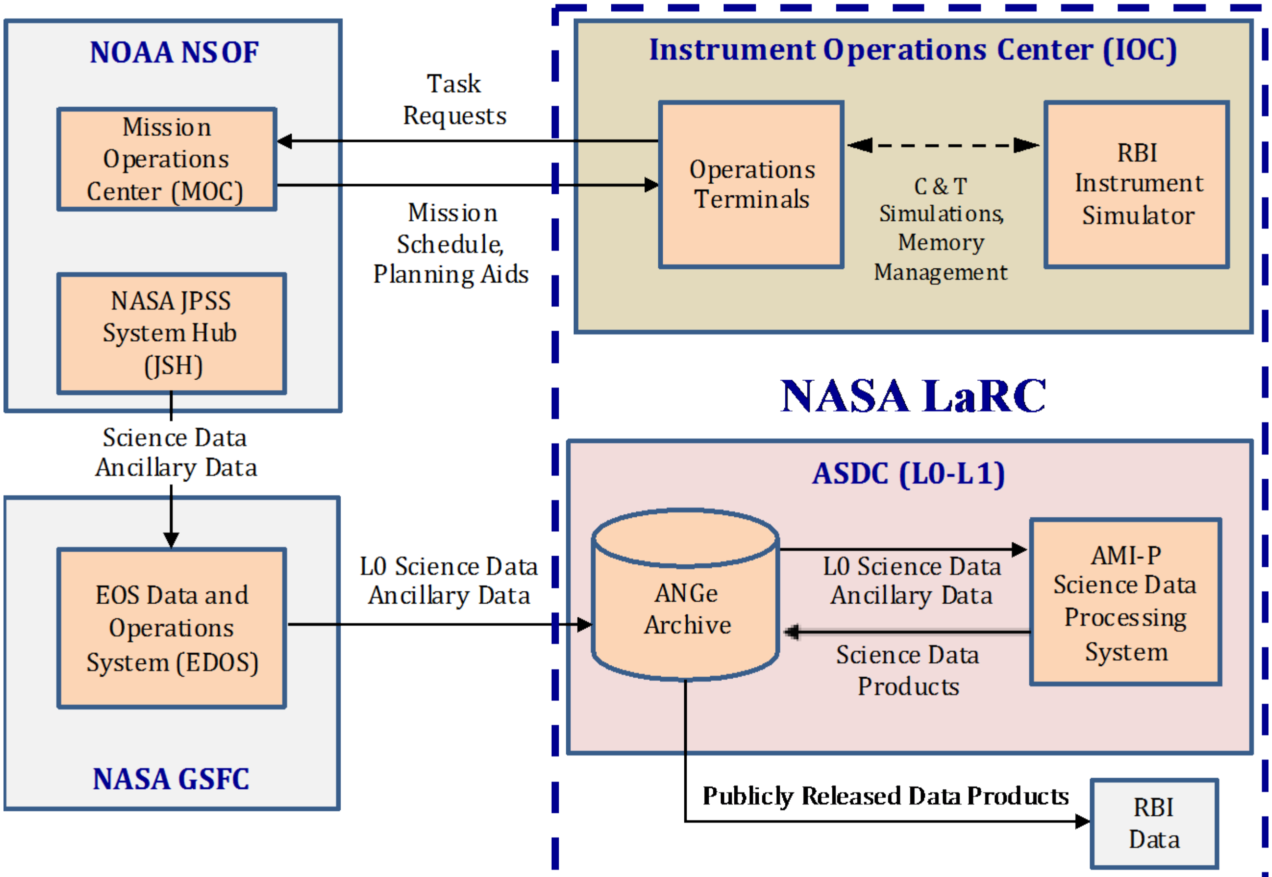

Figure 5-1 RBI Ground Segment (dashed box)

5.1.1 Mission Operations Center (MOC)

The Ground Segment for JPSS-2 will primarily operate from four sites. The NOAA Satellite Operations Facility (NSOF) in Suitland, MD will house the primary control center including Mission Management (MM), Product Generation (PG), and Product Distribution (PD) functions. The Backup Control Center (BCC) will be located at the Consolidated Backup Facility (CBU) located in Fairmont, WV and will function as a completely independent backup for designated MM, PG, and PD functions for the production and delivery of products and will be capable of remote operation from the NSOF. The Kongsberg Satellite Services (KSAT) Svalbard SG-22 in Norway and McMurdo MC1/MC2 antennas in Antarctica will provide primary space communications services and selected Ground Segment functions.

Nominal Office of Satellite and Product Operations Mission Operations Team (OSPO MOT) staffing levels for JPSS-2 are designed to support post LEO&A operations with a highly automated control center. A one-to-one correspondence between individuals and staffing position should not be implied.

5.1.2 Instrument Operations Center (IOC)

The overall JPSS Mission Operations is not presently within the scope of the RBI Project. JPSS mission operations is performed by NOAA and supported by NASA through the NASA ERBST, a separately funded NASA project. Any development of a mission operations plan is the responsibility of the ERBST. The RBI project is responsible for supporting the RBI during the pre-launch JPSS-2 spacecraft I&T activity and through launch and on-orbit activation. At approximately launch plus 90 days the RBI is handed over as an asset to the ERBST for its use over the JPSS-2 mission lifetime. The RBI will be supported during the mission by an Instrument Operations Team (IOT) which will leverage their CERES experience on S-NPP and JPSS-1.

On JPSS-2, the RBI primarily operates in the cross-track scanning mode, although periodic calibration and characterization operations will take the RBI out of cross-track mode. Various types of calibrations are required and consequently scheduled on a weekly, bi-weekly, monthly, and quarterly basis. In addition to the scheduled calibrations, the RBI instrument performs coincident measurements on an irregular basis to support calibration/validation activities.

After launch and the RBI activation, the IOT will perform remote, non-real-time instrument monitoring in support of the OSPO MOT, command and control requests, activity planning and scheduling in coordination with the MOT, flight software and memory management, load validation of special command requests, and memory loads. The IOT will also provide analysis of housekeeping data, generate daily logs and status reports, and update long-term housekeeping data trends. The RBI IOT supports the RBI anomaly investigation and resolution led by the MOT, and is responsible for coordinating the RBI engineering support of anomaly resolution. The RBI IOT interfaces remotely with the MOT utilizing the Work Request System (WRS) via an Extranet Web site or via a Secure File Transfer Protocol (SFTP) Server. The RBI IOT coordinates with the MOT through email, telecom meetings, and direct telephone communication.

The RBI IOT utilizes the JPSS ground system Command, Control and Communications Segment (C3S) planning aid data products to assist in performing plan and schedule instrument tasks, generate instrument commands, monitor instrument performance, analyze health and safety, perform instrument troubleshooting, and maintain the onboard instrument software. Most of these activities are accomplished through regularly scheduled Mission Management Tasks (MMT). Irregularly-scheduled activities also require a MMT. Before a task can be added, it must go through the Work Request Review Panel (WRRP) and be defined and approved in the MMT Database by the JPSS Operations Configuration Control Board (OCCB).

6 SCIENCE SEGMENT

The Science Segment primarily consists of elements required for transmitting the RBI downloaded mission data into a level 0 format that can be ingested into the LaRC Atmospheric Science Data Center (ASDC) and processed into level 1 science data and ancillary related products.

TBD

Figure 6-1 ASDC Interfaces

6.1.1 Atmospheric Science Data Center

The ASDC will provide the data processing, verification, and distribution of RBI data products. The ASDC is normally staffed 8 hours a day, 5 days a week which entails highly automated processes for achieving 24/7 timely delivery of the resultant HDF5 formatted data sets. The ASDC is also responsible for processing the RBI level 2 and 3 data products. The Level 3 data products are intended for the ERB climate data record evaluations. Details of processing are described in the Science Data Management Plan.

6.1.2 Science Data Management

The Langley RBI Project provides overall data management of the instrument science and engineering data from inception through such time as the instrument is accepted as operational at the successful completion of the Operational Hand-over Review. Harris manages all data associated with the acquisition of the instrument until instrument delivery and acceptance. Data management following instrument delivery to the spacecraft and prior to the instrument's confirmation as operational during the Operational Hand-over Review is the responsibility of the RBI project including: spacecraft I&T, launch vehicle I&T, pre-launch, launch, post-launch, and operations prior to the confirmation of the instrument as operational.

Data management after the instrument is confirmed as operational is the responsibility of the RBM Project. Following delivery of the instrument, the RBI project assumes responsibility to safeguard and manage the configuration of the instrument engineering data supplied in the End-Item-Data Package. Processing of Instrument data to produce science data is done by the RBM Project and leverages CERES heritage algorithms, implemented with adjustments for the RBI. Public distribution of science data during the mission is done by the RBM Project, using the NASA accepted process of clearly designating the maturity of the data products. The NASA Langley Atmospheric Sciences Data Center (ASDC) performs the generation, archival, and distribution of RBM Project data products, in close collaboration with the RBM Project team.

6.1.3 Science Support Teams

To support the science verification and validation objectives, LaRC utilizes the support of several teams that provide subject matter expertise. These include the Instrument Working Group (IWG) and the Calibration/Validation (Cal/Val) Team. The IWG is responsible for overseeing the evaluation of all RBI data and developing algorithm corrections that may be needed to the science data. The Cal/Val group is responsible for assessing the quality of the processed data (e.g., quality control (QC)), evaluating the sensor measurements that view calibration targets, and provide recommendations for corrections to the data to remove instrument induced artifacts (e.g., degradation effects).

7 Operations Descriptions

NASA/JPSS has overall responsibility for the JPSS-2 mission and is in charge of operations until approximately 90 days after launch. The NASA/JPSS Mission Operations Support Team (MOST) is responsible for and will operate the JPSS-2 satellite, including the instrument sensors prior to the 90 days post launch. Upon successful commissioning of the satellite (spacecraft and sensors), NASA/JPSS will transfer satellite command authority to the NOAA Office of Satellite and Product Operations (OSPO) for ongoing mission operations. This transfer of authority corresponds to the Operations Hand-over Review (OHR) milestone. Following JPSS-2 handover to NOAA, the NOAA Mission Operations Team (MOT) will have primary responsibility for JPSS-2 mission operations support.

The MOST will be focused on pre-launch preparations and rehearsals, and checkout of the post-launch Launch, Early Orbit and Activation (LEO&A) and then transition normal operations activities to OSPO after commissioning. The MOST is led by the JPSS Mission Operations Manager (MOM) who will provide overall operational directions for the JPSS-2 mission. The MOST will develop operations products, coordinate satellite and ground training, develop the Integrated Mission Timeline (IMT), rehearse as a mission team, and execute the LEO&A mission timeline. The Flight Readiness Lead (FRL) is responsible for all pre-launch test plans, procedures, methodologies, and on-orbit activities and checkout. The FRL oversees the MOST execution of the IMT. Details on operations policies and procedures prior to the OHR can be found in the JPSS LEO&A Management Plan and the JPSS-2 IMT Plan.

7.1 Operations Goals

TBD.

7.2 Spacecraft Operations (JPSS MOT)

TBD.

7.2.1 MOT Responsibilities

Following the OHR, the OSPO MOT will assume full responsibility for JPSS-2 operations and report to the JPSS MOM for day-to-day operations. The MOT serves as the first line for monitoring operations and reporting any anomalous behavior or out of limit conditions to the MOM. The MOT is also responsible for the execution of the daily operations plan, anomaly resolution plan, and special activity plan.

7.2.2 Spacecraft Modes

The Figure 7-1 depicts the Spacecraft mode and sub-mode configurations and Spacecraft mode transitions from pre-launch through on-orbit operations and decommissioning.

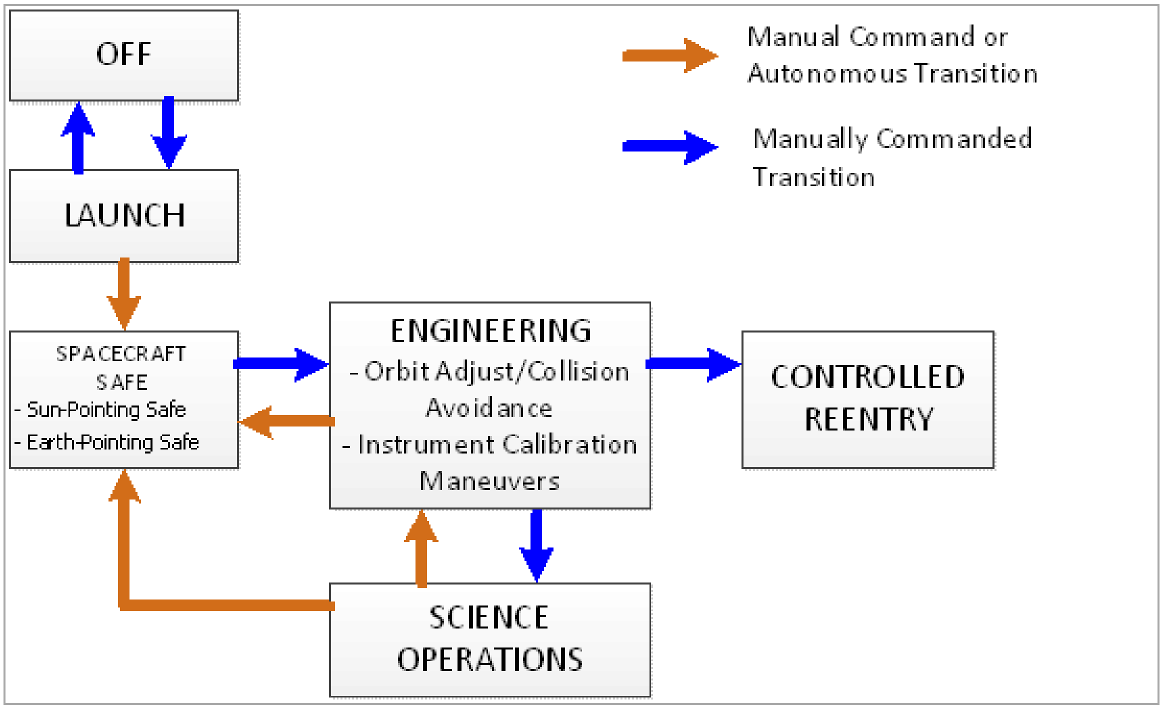

Figure 7-1 Spacecraft Mode Transitions

7.2.2.1 OFF

The Spacecraft shall be able to be remotely commanded into Off Mode during ground operations. Off Mode is defined as having all power removed including internal battery power.

7.2.2.2 Launch

TBD.

7.2.2.3 Spacecraft Safe Mode

The spacecraft Safe Mode is intended to place the spacecraft and all instruments into a configuration that will prevent potentially catastrophic or mission ending operations that may occur due to anomalous conditions. Power system anomalies and attitude system anomalies are examples of conditions that could result in the entry into the spacecraft Safe Mode. This mode could involve changing the nominal mission attitude of the Spacecraft. This is an emergency mode and, as such, is a power conservation mode. While in Safe mode, the spacecraft may be configured into an Earth-Pointing or Sun-Pointing configuration as described in the JPSS Concept of operations document.

7.2.2.4 Engineering

Under nominal operations where the spacecraft is under control, there is an engineering mode that allows for several types of spacecraft operations to support station keeping and/or specific instrument requirements. These include the following examples.

1. Orbit adjustments such as delta-V and inclination maneuvers.
2. Collision avoidance maneuvers.
3. Spacecraft maneuvers to support instrument calibration activities that may require minor roll, pitch, or yaw motions.

7.2.2.5 Science Operations

The science operations mode is expected to be the primary mode of operations. For the spacecraft this involves maintaining the required, finely tuned orientation to support the payload missions.

7.2.2.6 Controlled Reentry

At the end of mission life, the JPSS-2 spacecraft is expected to be decommissioned and returned to Earth via controlled reentry.

7.3 INSTRUMENT OPERATIONS (LARC IOT)

7.3.1 IOT Responsibilities

The RBI IOT is primarily responsible for the operation of the RBI instrument during all phases of the mission. The RBI IOT performs activity planning and scheduling, creates command and control requests using the Work Request System (WRS), and performs non-mission critical health, status, and performance monitoring. The RBI IOT coordinates with the JPSS-2 Mission Planner and sensor analysts. The IOT also provides analysis of housekeeping data, creates daily operations logs and status reports, performs Long-Term Trend Analysis, and provides sustaining engineering support.

7.3.2 Instrument Modes

The RBI instrument modes have been driven by JPSS-2 specifications that have been provided to all payload instruments. At the high level, typical instrument mode transitions are illustrated in the Figure 7-2.

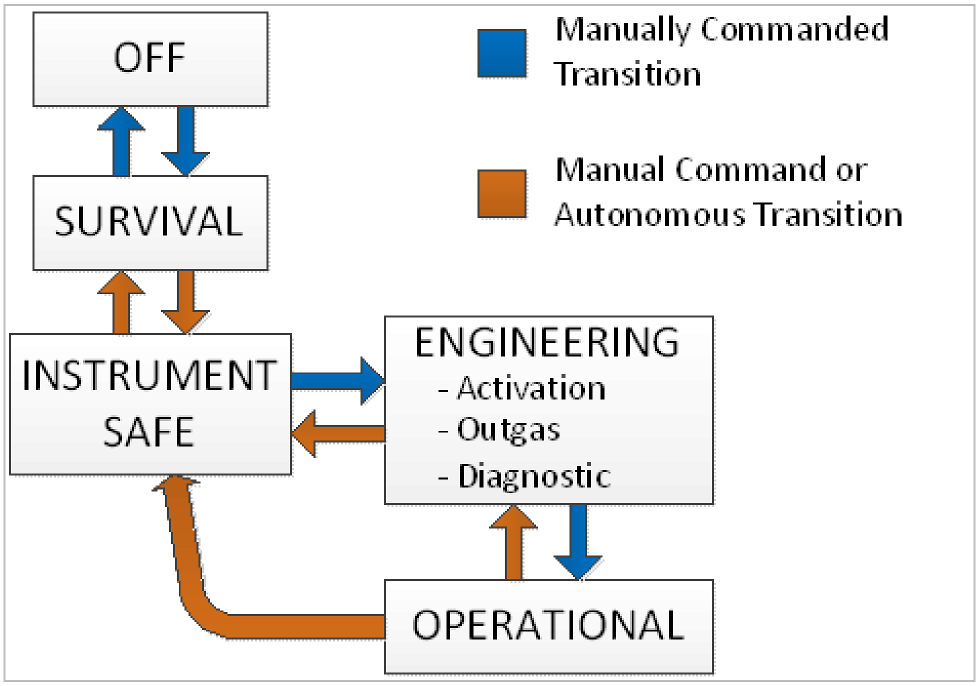

Figure 7-2 Typical Instrument Mode Transition Diagram

Based on Figure 7-2, the RBI instrument is being designed and built using the following Figure 7-3 illustration. A description of each of the instrument modes is provided in the following subsections based primarily on the OO-01 Instrument Concept of Operations.

Note: The descriptions below are provided in the Instrument Concept of Operations and are developed based on the vendor's understanding of the RBI requirements. LaRC originally envisioned the RBI to closely mimic the operational aspects of the predecessor CERES instruments. Thus, this mission concept of operations document may include additional notes that are intended to help clarify these LaRC intentions in order to assess the impacts to the operators and science evaluators that will be continuing the RBI legacy.

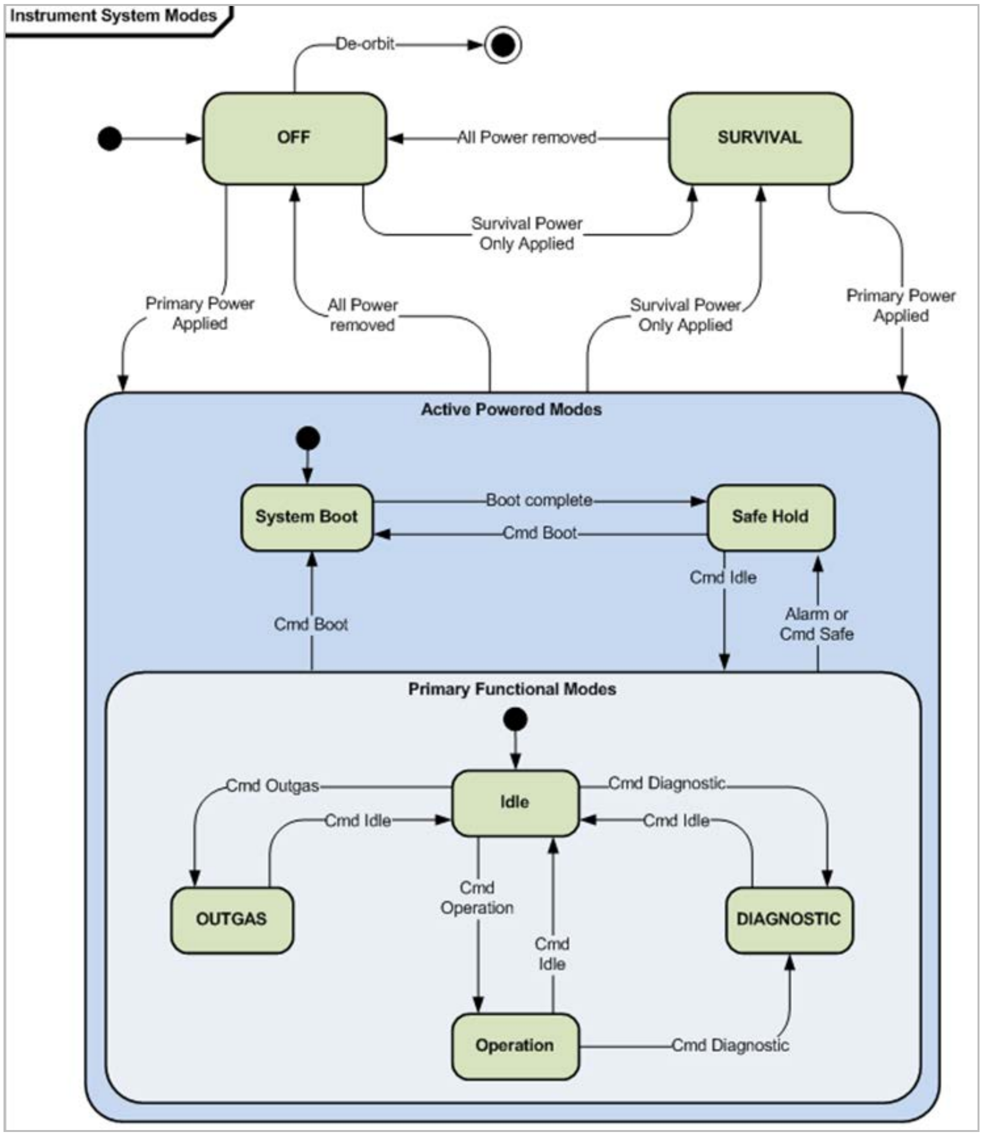

Figure 7-3 RBI Modes and Mode Transitions

7.3.2.1 OFF Mode

In Off mode, no operational electrical power is made available to the RBI. Consequently, no subsystems are powered, and therefore no functionality is provided. The Spacecraft will be responsible for sampling critical instrument temperatures via the instrument passive analog temperature sensors. The RBI does not report any telemetry while in Off mode.

The nominal transition out of Off mode is to the Survival mode. This is accomplished by enabling the primary and redundant survival heater power buses. These buses are expected to be available for use at all times from launch to the end of the mission.

7.3.2.2 Survival Mode

In Survival mode, the survival heaters have been sized for maintaining proper temperatures during worse case orbit environments. Care should be observed when operating the Survival heaters during ambient ground operations.

7.3.2.3 System Boot Mode

The System Boot mode is essentially a transitory mode, that when completed will place the instrument into the Safe Hold Mode. This mode is initiated by one of the following events:

1. Application of Operational bus power.
2. Instrument or Spacecraft commanded reset.
3. Missing a configurable number of time of day (TOD) pulses or TOD packets.

Note, it is understood that the Survival power may still be applied at the same time Operational power is applied. The cross-track scan module (CSM) uses a relative encoder. This will require the CSM to execute a "find home position", which corresponds to 90° (nadir view), during undesired portions of the orbit. e.g., potential direct sun views or high contamination conditions.

7.3.2.4 Safe Hold Mode

In Safe Hold Mode, the operational power is primarily applied to the on-board computer sub-module to allow command communication with the spacecraft. The remainder of the instrument is anticipated to be powered off in preparation for possible spacecraft safe-hold events.

7.3.2.5 Idle Mode

In Idle Mode, operational power is applied to all instrument sub-modules. This allows for the instrument to become operationally stable in preparation for performing engineering or science data collection.

7.3.2.6 Outgas Mode

In Outgas mode, the intent of to elevate various heater elements for some period of time after the first post-launch application of Operational power. This mode is intended to be a onetime event to support instrument contamination acclimation to the space environment.

7.3.2.7 Diagnostic/Engineering Mode

In Diagnostic (Engineering) mode, the intent is to exercise various non-science sub-components of the instrument to evaluate engineering performance. These tests are generally used to detect potential system degradations and anomalies.
Example may include higher sampling rates of the gimbal error positions for evaluating friction changes.

7.3.2.8 Operational Mode

In operational mode, the instrument is configured to perform science data collection. The primary configuration involves executing Cross-Track (Swath) commands. This command executes an elevation scan profile that moves from space-look on one side of the earth to space-look on the other side of the Earth and back, all within a 6.6 second period. The period is the basic data packet used for the earth radiation science research. A secondary configuration involves Bi-Axial (ADM) commands. In addition to the elevation scanning profile, the azimuth gimbal also executes a scan profile. This profile typically moves over a range of ±90° from the nominal cross-track orientation. This results in a 360° viewing geometry that allows for measurements that can be used for the development of Angular Distribution Models (ADMs).

7.4 Flight and Ground Software Management

The RBI Instrument Operations Software Support (IOSS), provided by the instrument vendor, will be used by the IOT for evaluating flight software changes. This includes developing, testing and validating updates before going through the configuration management processes at LaRC and JPSS. Once under configuration control, any updates can be made available for uplink to the RBI on the spacecraft.

7.5 Flight Simulators

The JPSS project has mandated the use of instrument simulators as a means of checking out and verifying all aspects of spacecraft and instrument operations independent of the observatory itself. The capabilities of these simulators will be determined as mission design parameters are finalized.

7.6 Training

This section will address the appropriate training activities for operators and support personnel to develop the RBI knowledge for operating the RBI on the JPSS-2 mission. These include understanding how to schedule instrument operations, perform flight simulations, and monitor telemetry trends.

8 Nominal Operational Activities

Routine operational activities of JPSS missions rely on the capabilities of a highly automated ground system, the ability of the JPSS satellite to perform in an automated manner, and the ability of the mission operation team (MOT) to manage these integrated ground and space assets. Nominal operations includes routine operations after the operations handover where the JPSS spacecraft and the RBI are designed to operate with minimal operator interaction. Under nominal operations, command and control will be accomplished from the NOAA Satellite Operations Facility (NSOF). These activities are illustrated in the following Table 8.1. The JPSS on-orbit philosophy for routine mission operations required in order to meet mission objectives includes:

- The health and safety of the satellite is paramount and checked every orbit.
- NSOF MOT supports nominal operations with a highly automated control center.
- The satellite is to be kept earth pointing and instruments powered on to the maximum extent possible during mission life.
- Ground stations for polar contacts typically involve Svalbard, Norway and McMurdo Station, Antarctica. Additional TDRSS contacts will be available and typically go through White Sands, NM. These stations are available to JPSS missions on every orbit. The Solid State Recorder (SSR)/Data Storage Unit (DSU) will be played back on scheduled contacts. The ground system handles downloaded SMD from each contact for processing into mission-unique data products.
- Spacecraft and instrument commanding is accomplished on board via Detailed Activity Schedules (DAS).

Table 8-1 Routine Mission Operations Activities

Routine Mission Operations Activities	**Every Pass**	**Daily**	**Weekly**	**Monthly**	**Continuously**	**As needed**
Health & Safety						
• Check Satellite Health & Safety (through Housekeeping TLM)	X					
• Dump Error Logs • Trending and Performance Monitoring • Perform Mission Orbit & Collision Avoidance Analysis		X				
• Perform Proficiency Activities using Alternate T&C/SMD sites • Exercise Ground System Backup Components				X		
• Orbit maintenance and constellation management • Ground System upgrades • Decommissioning						X
Command & Control						
• Prepare Command Load Files • Uplink Stored Command Load			X			
• Update Instrument Calibration & Configuration Tables						X
• Exercise manual procedure/commanding sequences						X
• Spacecraft and Instrument software loads • Instrument Calibration Maneuvers						X
Planning & Scheduling						
• Plan and schedule mission activities (includes DAS)			X			
• Schedule Space Network (SN) contacts						X
• Plan and execute Collision Avoidance maneuvers						X

Stored Mission Data and Direct Broadcast						
• Dump SMD from SSR • SMD Processing	X					
• High Rate Data (HRD) direct broadcast quality checks		X				
• Distribute Data Products • Data product calibration/validation and monitoring					X	
• SSR Retransmission						X

8.1 MISSION PLANNING

The planning and scheduling of the RBI on-orbit operations tasks will be the responsibility of the LaRC Instrument Operations Team (IOT). Plans will be generated based on science requirements, vendor recommendations, trade-off analyses, and historical experience gained from the CERES instrument. The major on-orbit operational tasks are broken down into Nominal, Calibration, and Supplemental. The nominal task is focused on routine science collection. The calibration task involves calibration activities required for verifying the accuracy of the science measurements. Supplemental tasks (sometimes referred to as User-Defined modes) involve activities that are performed on an as needed basis.

8.1.1 Nominal

The section is intended to describe the nominal operations tasks that will be performed to support the science mission objectives. There are two primary RBI science sub-modes planned and the requirement specifications are shown below for reference.

1. Swath, aka "Cross-track": The Instrument shall have an elevation scan plane that is parallel to the Instrument Y-Z plane defined in RB_PRD-186 to within ±0.05° and move the IFOV at a constant rate between a viewing zenith angle (VZA) of 90° on the Spacecraft +Y and -Y side of the ground track while in Cross-track (Swath) sub-mode. (RB_PRD-789)
2. Angular Distribution Model (ADM), aka "Bi-Axial": The Instrument shall simultaneously rotate the elevation scan plane about the Instrument +Z axis and move the IFOV at a constant rate between a viewing zenith angle (VZA) of 90° on the Instrument +Y and -Y side of Nadir while in Bi-Axial sub-mode. (RB-PRD-791)

The current plan is that most of the science measurements will be collected in the Swath/Cross-track mode. The frequency of use of the ADM/Bi-Axial will likely be determined post-launch depending on the state of on-orbit or planned climate sensors and needs associated with validating RBI measurement fluxes.

8.1.2 Calibrations

This section is intended to describe the various on-orbit calibration tasks that may be operationally performed. The intention of these calibrations include the following:

1. Utilize available and internal and external calibration sources for all three sensor channels.
2. The on-board calibration sources should verify the accuracy and repeatability of the

sensor performance over mission life.
3. Provide traceability of radiometric performance to NIST references.
4. Identify degradation trends in the sensor as well as the calibration sources.
5. Provide a means for independent, cross-calibration of sensor measurements to identify trending elements.

Currently, the on-orbit Cal/Val plan proposed by Harris achieves the 1% accuracy for reflected solar and 0.5% for emitted thermal radiances over the 7-year lifetime of the mission. This is achieved by performing daily calibrations using the Infrared Calibration Target (ICT) for the Total and LW channels and the Visible Calibration Target (VCT) for the shortwave channels. In addition, solar calibrations have been proposed to occur twice in a month. The LaRC Cal/Val plan will be based on the Harris proposed Cal/Val plan subject to revision based on the instrument's performance on orbit. Certain calibration modes or frequency of calibrations may need to be altered based on the performance of the instrument orbit. This flexibility to modify the on orbit calibration methodology is essential as there is a dearth of reliable data to characterize the exact nature of the degradation of broadband radiometers while operating in earth's orbit.

Calibrations using the Solar Calibration Target (SCT) will also need to be revisited once in orbit after observing the nature and magnitude of degradation of the Spectralon. The frequency of calibration as well as the instrument operations required to perform these calibrations may be revised once the performance of the Spectralon target is better understood.

Based on the CERES precedence, the following calibrations are anticipated to be part of the nominal operations plan:

1. Weekly Total and Longwave/Window using the ICT and Longwave/Shortwave using the VCT.
2. Additional Total and Longwave/Window blackbody using the ICT on Mondays and Fridays. (Added based on Cal/Val analyses.)
3. Solar calibration raster scan operations using the SCT biweekly for ≈10 min. always performed during orbital sunsets.
4. Lunar calibration raster scan operations performed for ≈1 min. always performed during orbital moonsets. Typically 11 orbital events are involved that coincide with the lunar phase between 5°-12° on both sides of the full moon and once during a full moon. An illustration of the orbital sequence is shown in Figure 8-1.

TBD

Figure 8-1 Lunar Calibrations

8.1.3 Supplemental

This section is intended to describe various other on-orbit operations that may be performed based on the CERES heritage. These tasks are typically not considered part of routine mission operations. Example operations that may be planned during RBI operations include the following.

1. Ground site overpasses to support radiometric standards validations.
2. Airborne over-flight campaigns that typically involve ground, atmospheric, and space based sensors.
3. Inter-satellite, inter-instrument ground co-aligned measurement scans.
4. Principal Plane Scans (PPS) to evaluate Angular Distribution Model (ADM) using higher solar signal scattering results.
5. Deep space calibration

Specific earth target over-flight campaigns are performed using one of two targeting modes:

1. Earth target: where the elevation scan performs a nominal scan profile while the azimuth is rotated using stepped commands. The viewing scans will intersect the earth target over a large area, but allows different viewing geometries and is analogous to bi-axial operations.
2. Targeted Earth Tracking: where the elevation and azimuth gimbals continually orient the sensor to fixed earth location and "locks" that site within the telescope field-of-view.

8.1.3.1 Post-Launch Early Orbit and Activation (LEO&A)

This section is intended to describe operations plans immediately following launch through the currently proposed 90-day Operational Handover date. The RBI activation schedule will be driven by contamination plans and the spacecraft and other payload instrument checkout plans. The IOT is proposing to divide this period into 3 phases:

1. Initial power up, out gas, and idle.
2. Comprehensive Functional Testing (CFT).
3. Extensive engineering and calibration operations, including supplemental ops.

Due to concerns regarding contaminants depositing on the telescopes, the IOT will activate the instrument through the use of real-time commands.

8.2 Real-time Operations

Real-time operations refer to any on-orbit instrument operations that are to be commanded and/or monitored during spacecraft-to-ground communications contact periods. These operations will be defined as the instrument design becomes finalized.

9 Contingency (Anomaly) Operations

All non-nominal situations that affect the satellite, instruments, or systems / subsystems, including ground assets can be considered anomalies. Anomalies can have various degrees of severity, and many that are associated with the health and safety of the satellite, can be detected and responded to autonomously. The JPSS ground segment supports spacecraft health and safety monitoring and produces mission data products that should meet Key Performance Parameters (KPP), even in the event of on orbit failures.

9.1 Spacecraft Anomalies

If the MOT determines that a spacecraft anomalous condition exists, the MOT will take steps to ensure the safety of the spacecraft and place the RBI into a TBD mode depending on the nature of the anomaly. The MOT will then notify the appropriate on-call RBI IOT member(s) by telephone and send an email to an IOT predefined distribution list (in that order). The MOT will continue through the list of on-call personnel until contact has been made with the RBI IOT.

9.2 Instrument Anomalies

Instrument anomalies are usually detected via three operational entities: the Mission Operations Team (MOT), the Instrument Operations Team (IOT), and/or the Science team. This section is intended to convey examples of how anomalies may be detected and the remedies that may be utilized.

9.2.1 MOT Detected Anomaly

TBD

9.2.2 IOT Detected Anomaly

TBD

9.2.3 Science Team Detected Anomaly

TBD

9.3 Ground System Anomaly

In the event of outages of ground support systems that affect the MOT to IOT interface and/or operation of an instrument, the MOT will contact the IOT via telephone or e-mail. The MOT will advise the IOT of the nature of the outage and if known the expected time of recovery. Conversely, the IOT will notify the MOT in the same manner in the event of an outage that will affect the IOT to MOT interface and/or the operation of the instrument.

10 Scheduling Timelines

This section is intended primarily to illustrate notional operational scheduling of the RBI by the Instrument Operations Team (IOT) following launch. This schedule will be based on the proposed RBI vendor schedule and on CERES historical experience. The elements of these schedules include some of the following:

1. Science, Calibration, and Engineering requirements.
2. Spacecraft operational capabilities.
3. Mission operations planning and scheduling requirements and constraints.
4. Ground system interfaces

There are several assumptions related to scheduling the RBI operational timeline and including some of the following considerations:

1. Instrument command scheduling is the province of the RBI Instrument Operations Team (IOT).
2. Scheduling commands is typically bracketed to complete activities within the midnight-to-midnight (GMT) periods. (e.g. solar calibration)
3. The instrument continues ongoing operations based on the last command or sequence issued. (e.g. perform cross-track scanning until told otherwise)
4. Calibration activity plans are subject to change based on ground test data and initial on-orbit trends.

10.1 Daily

On a typical day, the instrument will be primarily performing Swath (Cross-Track) science operations. The alternative science operation involves ADM (Bi-Axial) operations that consist of simultaneous, continuous elevation and azimuth scans. Each sub-mode will be operated as a minimum of one full day. The science team will provide guidance for the duration of any Bi-Axial operations as there is a requirement to limit the number of azimuth cycling to approximately 2 cumulative years over mission life.

In addition to the nominal science operations, calibration activities of the instrument may be performed based on the repetitive sequences shown in Table 9.1. The actual daily timeline will vary seasonally and will need to take into account thermal and stray light considerations in the detailed planning of data collection. Solar calibration (via the SCT) for solar radiometric data occurs with a frequency of once per day (as currently required in the SOW) but may occur as a bi-weekly goal.

Table 10-1 Nominal Calibration Schedule Plan

Calibration and Other Activities	Harris Proposed Nominal Frequency[1]	LaRC Goal Frequency[2,3]
ICT Thermal Radiometric (Repeatability) [4]	**1x per day**	**1x per 2-3 orbits (LEO&A) 1x per day - nominal**
ICT Gain Linearity	**1x per month**	**1x per day (LEO&A) 3x per week - nominal**
VCT Reflective Radiometric (Repeatability, no ESR) [4]	**1x per day**	**1x per 2 orbits (LEO&A) 1x per day - nominal**
VCT Gain Linearity, with ESR	**1x per month**	**1x per day(LEO&A) 2x per week - nominal**
VCT Reflective Spectral, with ESR	**1x per month**	**1x per day(LEO&A) 2x per week - nominal**
Solar Radiometric Calibrations (Target 1)	**Bi-weekly**	**1x per day(LEO&A) 1x per week - nominal (1 orbit TL, 1 orbit LW)**
Solar Radiometric Calibrations (Target 2)	**Quarterly**	**1x per TBD (LEO&A) Quarterly - nominal**

		(1 orbit TL, 1 orbit LW)
Solar Radiometric Calibrations (Target 3)	**Annually**	**1x per TBD (LEO&A)** **Annually - nominal** **(1 orbit TL, 1 orbit LW)**
Lunar Spatial Scanning, typ. 11 orbits	**Monthly**	**Monthly - nominal**
Diagnostic Dwells	**n/a**	**Bi-monthly/Quarterly**
Episodic cal/val campaign support utilizing coincident measurement modes	**n/a**	**As needed**

[1] Frequency of mission calibration proposed believed to satisfy mission uncertainty requirements.

[2] LEO&A frequency likely from early commissioning through first ½ year which may reduce Science viewing time.

[3] Nominal frequency to maximize science collection while minimizing calibration uncertainties needed for science validation.

[4] Requires ICT/VCT earth-scan profile, TBD.

The RBI Ground and Science Segment personnel conduct operations daily. A typical routine "day-in-the-life" of the RBI operations throughout the Ground and Science Segment members involves the following group of activities, which are instrumental in meeting the mission objectives:

1. Generate Command Sequences and Table Loads
2. Perform Mission Planning Activities
3. Routine Communications Activities
    a. Verify Command Path and Telemetry
    b. Uplink Commands and Table Loads as needed
    c. Monitor Instrument Performance using Real-time Telemetry
4. Stored Mission Data (SMD) Handling and Transport
5. Data Product Processing and Distribution
6. Data Archive
7. User Distribution Broadcast
8. Trending and Performance Monitoring
9. Trending and Performance Monitoring of Product Quality

10.2 WEEKLY

The RBI science observations are planned at the IOT on a weekly schedule, in coordination with the Science Team, the IOT, and the IWG. An example schedule is shown in the following Figure 11-1. The Infrared Calibration Target (ICT) will be used to determine sensor gain and offset linearity changes for the Total and Longwave channels. The Visible Calibration Target (VCT) will also be used to determine sensor gain and offset linearity changes for the Total and Shortwave channels. This is planned using a single laser diode that will be focused through a series of neutral density filters that change the power levels that shine into the VCT. The Total and Shortwave spectral characteristics can also be ascertained using the VCT by using a series of different laser diode wavelengths. The scheduling of these calibrations are TBD.

TBD

Figure 10-1 Week in the Life

10.3 MONTHLY

Lunar Calibrations are operationally performed every month. Based on the RBI paradigm, lunar viewing is performed during orbital Moon sets (passing over the South Pole) where the luminance phase angle is approximately between 5°-12° on both sides of the full moon. One orbit is also used for viewing a Full moon. The following figure 11-2 illustrates when viewing is typically planned.

TBD

Figure 10-2 Month in the Life

10.4 QUARTERLY

Nominal activities planned to be performed every 3 months (quarterly) include the following:

1. Solar Calibration using the SCT surface #2, which is dedicated for this purpose. The number of solar calibrations that will be executed is a minimum of 1 and may be TBD more depending on science evaluations
2. Detector Stow Dwell diagnostics used for evaluating sensor electronic noise trends when viewing in the elevation stowed (park @-175°, launch @-180°) position.
3. Gimbal Error diagnostics for evaluating the sample-to-sample position errors and torque trends to identify degradations.
4. Other diagnostic evaluations recommended by the vendor.
5. Instrument redundant side (e.g., B-side) activation and performance of comprehensive ICT and VCT calibrations (TBD).

Used for cross-calibrating evaluations and, hopefully, establish a science performance trend that could be used to maintain the climate continuity records, without discontinuities, should the instrument need to be fully operational on the redundant side for the remainder of the mission.

10.5 ANNUALLY

Nominal activities planned to be performed annually involve performing a solar calibration using the SCT surface #3 that is dedicated for this purpose.

10.6 SUPPLEMENTAL

Operations described in this section involve anticipated on-orbit operations that the RBI may be asked to performed that are not covered as part of routine operations. Examples include the following, some which may occur on a semi-frequent basis.

1. Earth Target Scans that involve performing elevations scans whose scan plane will intercept an earth target location by using stepped azimuth motions.

2. Targeted Earth Tracking that involve keeping the telescopes "locked" onto a fixed earth target. This process will likely require near continuous azimuth and elevation changes in motion positions and velocity rates.
3. Deep-space scans should the spacecraft be able to perform a pitch-over or inertial hold that will allow instruments to view space throughout their full field-of-view.

APPENDIX A: Acronyms

ADM	Angular Distribution Model
AFWA	Air Force Weather Accuracy
APID	Application Process IDentifier
ARM	Azimuth Rotational Module (Gimbal)
ASDC	Atmospheric Science Data Center
ATMS	Advanced Technology Microwave Sounder
C3S	Command, Control and Communications Segment
CBU	Consolidated Backup Facility
CDMOP	Configuration and Data Management Operating Procedure
CDR	Climate Data Record
CFT	Comprehensive Functional Testing
CLASS	Comprehensive Large-Array Data Stewardship System
CR	Change Request
CrIS	Cross-Track Infrared Sounder
CSM	Cross-track Scanning Module
DAAC	Distributed Active Archive Center
DAS	Detailed Activity Schedules
DFRD	Data Formats Requirements Document
DMT	Data Management Team
DoD	Department of Defense
DR	Direct Readout
DSU	Data Storage Unit
EBRST	Earth Budget Radiation Science Team
EDOS	ESDIS Data Operations System
EDR	Environmental Data Record
EGSE	Electrical Ground Support Equipment
EOS	Earth Observing System
ERB	Earth Radiation Budget
ESDIS	Earth Science Data and Information System
ESPC	Environmental Satellite Processing Center
FNMOC	Fleet Numerical Meteorology and Oceanography Center'
FRL	Flight Readiness Lead
FT	Field Terminals
GBL	Government Bills of Lading
GS	Ground System
GSE	Ground Support Equipment
HRD	High Data Rate
ICD	Interface Control Document
ICV	Intensive Calibration/Validation
IMT	Integrated Mission Timeline
IOA	Instrument Operator Analyst (JPSS)

IOC	Instrument Operations Center
IOT	Instrument Operations Team
IP	Intermediate Products
IWG	Instrument Working Group
JPSS	Joint Polar Satellite System
KPP	Key Performance Parameters
KSAT	Kongsberg Satellite Services
LEO&A	Launch, Early Orbit and Activation
LSP	Launch Services Program
LTAN	Local Time of Ascending Node
LV	Launch vehicle
LW	Long wave
MAR	Mission Assurance Requirements
MCOD	Mission Concept of Operations Document
MDFCB	Mission Data Format Control Book
MGSE	Mechanical Ground Support Equipment
MICD	Mechanical Interface Document
MM	Mission Management
MMC	Mission Management Center
MMT	Mission Management Task
MOC	Mission Operations Center
MOM	Mission Operations Manager
MOST	Mission Operations Support Team (JPSS)
MOT	Mission Operations Team (JPSS)
MSS	Mission Systems Specifications
NAVOCEANO	Naval Oceanographic Office
NESDIS	National Environmental Satellite, Data, and Information Service
NOAA	National Oceanic and Atmospheric Administration
NSOF	NOAA Satellite Operations Facility
NWS	National Weather Service
OCCB	Operations Configuration Control Board
OHR	Operations Hand-over Review
OMPS-L	Ozone Mapping Profiler Suite-Limb
OPMS-N	Ozone Mapping Profiler Suite-Nadir Profiler
OSPO	Office of Satellite and Product Operations
PD	Product Distribution
PFF	Polar Free-Flyer
PG	Product Generation
PLRA	Program Level Requirements Appendix
PPS	Principal Plane Scans
PRD	Performance Requirements Document
RBI	Radiation Budget Instrument
RBMP	Radiation Budget Measurement Program
RDR	Raw Data Records

ROPS	Recommended Operations Procedures
SCT	Solar Calibrations
SDMP	Science Data Management Plan
SDPC	Science Data Processing Center
SDPWA	Science and Data Products Working Agreement
SDR	Sensor Data Records
SDS	Science Data Segment
SEMP	Systems Engineering Management Plan
SFTP	Secure File Transfer Protocol
SMD	Stored Mission Data
SOC	Spacecraft Operations Center
SOW	Statement of Work
SSR	Solid State Recorder
NPP	National Polar-Orbiting Project
SW	Short Wave
TBD	To Be Determined
TBR	To Be Reviewed
TBS	To Be Specified
TDR	Temperature Data Records
TOT	Total Channel
TRMM	Tropical Rainfall Measuring Mission
VAFB	Vandenberg Air Force Base
VIIRS	Visible Infrared Imaging Radiometer Suit
VZA	Viewing Zenith Angle
WRP	Review Panel
WRS	Work Request System

APPENDIX B: TBXs

TBD/ TBR	Section	Description	Explanation of TBD/TBR	Estimated Completion Date
TBD	Header	Release Date		Dec. 2017
TBD	Header	Effective Date		Dec. 2017
TBR	2.1	Command and Telemetry Definition		Dec. 2017
TBD	6.1	Fig. 6-1		Dec. 2017
TBD	7.1	Operations Goals		Dec. 2017
TBD	7.2	Spacecraft Operations		Dec. 2017
TBD	7.2.2.2	Launch		Dec. 2017
TBD	8.1.2	Fig. 8-1		Dec. 2017
TBD	9.1	Spacecraft Anomalies	Mode Reference	Dec. 2017
TBD	9.2.1	MOT Detected Anomaly		Dec. 2017
TBD	9.2.2	IOT Detected Anomaly		Dec. 2017
TBD	9.2.3	Science Detected Anomaly		Dec. 2017
TBD	10.1	Table 10-1	Note	Dec. 2017
TBD	10.2	“scheduling of these calibrations are TBD.		Dec. 2017
TBD	10.2	Fig. 10-1		Dec. 2017
TBD	10.3	Fig. 10-2		Dec. 2017
TBD	10.4	Item 1, SCT		Dec. 2017
TBD	10.4	Item 5, Redundant side calibrations		Dec. 2017