

**SOFTWARE REQUIREMENTS SPECIFICATION
FOR THE
MODERATE RESOLUTION IMAGING SPECTRORADIOMETER
(MODIS)
LEVEL 1B SOFTWARE SYSTEM**

P200-CD-001-001

Developed by
The MODIS Characterization Support Team

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Signature Page

MODIS Level 1B Software Requirements
Specification

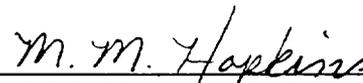
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1.0 INTRODUCTION

The Moderate Resolution Imaging Spectroradiometer (MODIS) is designed to make long-term spectral observations of the Earth's land surface, ocean surface layer, and lower atmosphere.

The MODIS Characterization Support Team (MCST), working under the direction of the MODIS Science Team Leader, has the primary responsibility for developing the characterization and calibration algorithms for the MODIS instruments. In this context, calibration refers to the application of calibration coefficients to instrument data to create at-satellite radiance values. Characterization refers to the processing of instrument data to derive instrument characteristics and calibration coefficients.

MODIS Level 1B data, designated as MODIS data product MOD02, is defined to be radiometrically corrected and fully calibrated instrument data in physical units at the original instrument spatial and temporal resolutions. If practical, corrections will be made for scattered light. The computer software which produces the MODIS Level 1B data product is called the MODIS Level 1B software process.

1.1 Identification of Document

This is the Software Requirements Specification (SRS) for the Version 2 release of the MODIS Level 1B software. Version 2 is the launch ready version.

1.2 Scope of Document

This SRS describes the baseline requirements of the Version 2 release of the MODIS Level 1B software. The MCST is responsible for developing the MODIS Level 1B algorithm and the software system which implements it. This software will be installed at the Goddard Space Flight Center (GSFC) Software Data Processing System (SDSP) and is expected to have an operational lifetime on the order of 15 years. The software development effort complies with National Aeronautics and Space Administration (NASA) Earth Observing System (EOS) Data and Information System (EOSDIS) requirements and guidelines and Science Data Support Team (SDST) guidelines.

1.3 Purpose and Objectives of Document

The purpose of this SRS is to specify the functional, performance, and interface requirements for the MODIS Level 1B software. This includes requirements approach and trade-off results. This document also specifies the major characteristics, implementation constraints, and design goals for the software.

Each requirement is uniquely identified to ensure traceability to the lowest level of implementation.

1.4 Document Status and Schedule

This SRS will be updated to describe and support the software delivery milestones below.

| | |
|---|----------------|
| Version 2 Launch Ready Delivery | February, 1997 |
| Version 2.1 Pre-Launch Update | February, 1998 |
| Version 2.2 Post A&E (Launch + 6 months) | January, 1999 |

1.5 Document Organization

Section 1 describes the scope of this document.

Section 2 describes related documents.

Section 3 describes the requirements approach and tradeoffs.

Section 4 describes the external interface requirements.

Section 5 specifies the requirements.

Section 6 provides traceability to parent's design.

Section 7 describes partitioning for phased delivery.

Section 8 defines abbreviations and acronyms used in this document.

Section 9 is the glossary.

Section 10 contains notes.

Section 11 contains the appendices.

2.0 RELATED DOCUMENTATION

2.1 Parent Documents

The requirements specified in the following parent documents are binding on the MODIS Level 1B and software development effort. These parent documents are the source from which the contents of this MODIS Level 1B Software Requirements Specification are derived.

- (a) *Functional and Performance Requirements Specification for the Earth Observing System Data and Information System (EOSDIS) Core System*, 423-41-02, June 2, 1994.
- (b) *Team Leader Working Agreement for MODIS Between MODIS Team Leader, and EOS AM and PM Projects*, 25 April 1994.

2.2 Applicable Documents

Information in the following applicable documents applies to this SRS

- (a) *MODIS Software Plan*, M100-CD-002-002, May 25, 1995.
- (b) *MODIS Calibration Support Team (MCST) Management Plan*, NASA Technical Memorandum, MODIS Technical Report Series. Draft. January 1995.
- (c) *Product Specification DIDS, Requirements NASA DID P200*, NASA Software Documentation Standard, Software Engineering Program, NASA-STD-1200-91.
- (d) *MODIS Level 1A Software Baseline Requirements*, NASA Technical Memorandum 104594, Vol. 1, MODIS Technical Report Series. July 1994.
- (d) *MODIS Level 1 Geolocation, Characterization and Calibration Algorithm Theoretical Basis Document, Version 1*. NASA Technical Memorandum 104594, Vol. 2, MODIS Technical Report Series. April 1994.

- (e) *Recommended Approach to Software Development*, SEL-81-305, Revision 3. June 1992.
- (f) *MODIS Science Computing Facilities Plan*. September 7 1993.
- (g) *PGS Toolkit User's Guide for the ECS Project*. February 4, 1994.
- (h) *Data Production Software and Science Computing Facility (SCF) Standards and Guidelines*, EOSDIS document 423-16-01. January 14, 1994.
- (i) *MODIS Level 1B Software Test Plan*. Draft.

2.3 Information Documents

The following documents are provided for background information.

- (a) *Defense System Software Development*, DoD-STD-2167A. 29 February 1988.
- (b) *Technical Reviews and Audits for Systems, Equipment, and Computer Software*, MIL-STD-1521B. 1 June 1985.
- (c) *Structured Analysis and System Specification*, Tom DeMarco, Yourdon Press, 1979.
- (d) *MODIS-HIRIS Ground Data Systems Commonality Report*, NASA Technical Memorandum 100718, December 1988.
- (e) *MODIS Information, Data, and Control System (MIDACS) Level II Functional Requirements*, NASA Technical Memorandum 100718, December 1988.
- (f) *MODIS Information, Data, and Control System (MIDACS) Operations Concepts*, NASA Technical Memorandum 100720, December 1988.
- (g) *MODIS Information, Data, and Control System (MIDACS) System Specifications and Conceptual Design* NASA Technical Memorandum 100721, December 1988.

- (h) *Science User's Guide and Operations Procedure Handbook for the ECS Project, Part 4: Software Developer's Guide to Preparation, Delivery, Integration and Test with ECS, EOSDIS Core System Project 205-CD-002-001, January 1995.*

3.0 REQUIREMENTS IDENTIFICATION

The MODIS requirements for science software are given in the *Team Leader Working Agreement for MODIS Between MODIS Team Leader, and EOS AM and PM Projects*. The MCST has performed an analysis of the MODIS Level 1B requirements. The requirements are formulated to be quantifiable and testable.

The MODIS Level 1B software requirements have been developed from the parent documents identified in Section 2.1 and from interviews with members of the MODIS team. Members of the MCST Algorithms Team (MAT), the MCST, the SDST, and Science Team users of the MOD02 data product provided input. Once identified, each requirement was entered into CADRE's Teamwork Computer Aided Software Engineering (CASE) tool. Teamwork automates the generation of a structured requirements specification and directly supports Demarco's structured analysis methodology. Cadre's requirements traceability tool shall be employed in the design phase to support the allocation of these requirements to the software modules within the MODIS Level 1B software system.

The MODIS Level 1B Software Requirements Specification is baselined and under configuration control of the MCST Configuration Control Board (CCB) with this release. Subsequent changes to these requirements shall be reviewed and approved by the MCST CCB.

4.0 EXTERNAL INTERFACE REQUIREMENTS

The MODIS Level 1B process operates within the EOSDIS Core System (ECS)/Science Data Processing System (SDPS) environment. Functionally, the Level 1B process ingests Level 1A data; performs limited data monitoring and quality determination; calibrates the sensor data and transforms it to radiances; reports the processing status; and produces the Level 1B products. This processing must meet the following requirements associated with external interfaces.

IF01: Initiate Execution. The MODIS Level 1B software shall accept an initiation message from the Product Generation Executive (PGE) identifying the mode of processing and the input data.

IF03: Terminate Execution upon Completion. The MODIS Level 1B software shall terminate execution upon completion of all processing functions for the data specified at initiation of execution.

IF04: Input Data. The MODIS Level 1B software shall ingest the MODIS Level 1A data product.

IF05: Ancillary Input Data. The MODIS Level 1B software shall ingest ancillary data determined by the Level 1B ATBD.

IF06: Input Data Limitation. The MODIS Level 1B software shall use as input only those input datasets and parameters as directed by the PGE in the production environment.

IF07: Create Level 1B Data Product. The MODIS Level 1B software shall create the MODIS Level 1B data product.

IF08: Create Metadata. The MODIS Level 1B software shall create Level 1B metadata.

IF09: Append Metadata. The MODIS Level 1B software shall append the metadata to the MODIS Level 0 and Level 1A metadata.

IF10: MODIS Processing Log. The MODIS Level 1B software shall post all relevant processing events to the MODIS processing log.

IF11: Concurrent Execution. The MODIS Level 1B software shall allow concurrent execution of multiple Level 1B processes.

IF12: Termination Report. The MODIS Level 1B software shall generate an accounting report which shall be available externally.

IF13: Alarm Messages. The MODIS Level 1B software shall generate alarm messages to describe serious processing problems.

IF14: Overlapping Data. The MODIS Level 1A data granules shall contain data overlap, with type and extent TBD.

IF15: Sun Angles. The MODIS Level 1B software shall ingest as input from Level 1A the angle of incidence and azimuth angle of the sun relative to Solar Diffuser geometry, for each scan during Solar Diffuser operation.

IF16: Pixel Angles. The MODIS Level 1B software shall ingest as input from Level 1A the pixel-satellite vector and the pixel-sun vector for each pixel along a scan line for one typical detector.

IF17: Lunar Vector. The MODIS Level 1B software shall ingest as input from Level 1A the lunar vector with respect to the spacecraft coordinate system,

IF18: Normal Termination. Upon completion of processing the input data, the MODIS Level 1B software shall perform an orderly termination in which the datasets are properly closed and posted, processing log entries are posted, and metadata are written.

IF19: Abnormal Termination. Termination of the MODIS Level 1B software which is not explicitly handled by the code shall be handled by the PGE.

5.0 REQUIREMENTS SPECIFICATION

5.1 Process and Data Requirements

The requirements in this section are imposed on the MODIS Level 1B software functions and data.

5.1.1 Functional Requirements

FN01: Processing Scope. The MODIS Level 1B software shall perform all and only those functions which are necessary for characterization of the instrument, calibration of the data, and meeting other specific requirements issued by the MODIS science Team Leader.

FN02: Reprocessing. The MODIS Level 1B software shall reprocess Level 1A products as required.

FN03: Solar Diffuser. The MODIS Level 1B software shall process the Solar Diffuser data as defined in the Level 1B ATBD.

FN04: Solar Diffuser Stability Monitor. The MODIS Level 1B software shall process the Solar Diffuser Stability Monitor data as defined in the Level 1B ATBD.

FN05: Spectroradiometric Calibration Assembly (SRCA) Radiometric Mode. The MODIS Level 1B software shall process the SRCA data taken in radiometric mode as defined in the Level 1B ATBD.

FN06: SRCA Spatial Mode. The MODIS Level 1B software shall process the SRCA data taken in spatial mode as defined in the Level 1B ATBD.

FN07: SRCA Spectral Mode. The MODIS Level 1B software shall process the SRCA data taken in spectral mode as defined in the Level 1B ATBD.

FN08: Space View. The MODIS Level 1B software shall process the Space View data as defined in the Level 1B ATBD.

FN09: Black Body. The MODIS Level 1B software shall process the Black Body data as defined in the Level 1B ATBD.

FN10: Lunar Look. The MODIS Level 1B software shall process the Lunar Look data as defined in the Level 1B ATBD.

FN11: Calibration Coefficients. The MODIS Level 1B software shall determine the calibration coefficients for each detector, as defined in the Level 1B ATBD.

FN12: Calibration Updates. The MODIS Level 1B software shall apply updates to the calibration for each detector, as defined in the Level 1B ATBD.

FN13: Earth View Data. The MODIS Level 1B software shall apply the calibration equations to the Earth view data using the chosen coefficients.

FN15: Engineering Data. The MODIS Level 1B software shall transform the engineering data to engineering units.

FN16: Quality Assurance (Q/A). The MODIS Level 1B software shall perform quality assurance processing on the MODIS data.

5.1.2 Data Requirements

FN17: Input Data Verification. The MODIS Level 1B software shall verify that the input data is the MODIS Level 1A data specified in the initiate execution message, and log the result of this verification.

FN18: Metadata Contents. The MODIS Level 1B metadata shall contain all information required by the ECS, results of instrument characterizations, all characterization of the On Board Calibrators (OBC's), and coefficients used in calibrating the data.

FN19: Data Format. The MODIS Level 1B data product format shall conform to the ECS standards for metadata and file format, and shall be defined by the MODIS Level 1B Product Specification.

FN20: Data Contents. The MODIS Level 1B data product content shall be described in the MODIS Level 1B Product Specification.

FN21: Calibration Sources. The MODIS Level 1B software shall have the capability to selectively apply the contributions from the various on-board calibrators and other calibration sources, including ground based calibration sources, as defined in the Level 1B ATBD.

FN22: Non-Nominal Conditions. Processing of the science data during non-nominal conditions is TBD.

FN23: Radiance Sensor Data. The MODIS Level 1B software shall transform the sensor data from the MODIS solar reflecting bands to normalized radiances, as defined in the Level 1B ATBD.

FN24: Infrared Sensor Data. The MODIS Level 1B software shall transform the sensor data from the MODIS infrared bands to radiances in scientific units, as defined in the Level 1B ATBD.

FN25: Reflectance Sensor Data. The MODIS Level 1B software shall transform the sensor data from the MODIS solar reflecting bands to reflectance in scientific units, as defined in the Level 1B ATBD.

5.2 Performance and Quality Engineering Requirements

The requirements in this section are imposed on the performance and quality of the MODIS Level 1B software

PR01: Error Recovery. The MODIS Level 1B software shall continue processing upon the detection of a specified list of error conditions TBD in the MODIS Level 1B Software Design Document.

PR02: Trending. The MODIS Level 1B software shall monitor and report on both long-term and short-term trending of calibration data to determine optimal calibration parameters.

PR03: Error Abort The MODIS Level 1B software shall perform an orderly termination upon the detection of a specified list of error conditions TBD in the MODIS Level 1B Software Design Document.

5.3 Safety Requirements

There are no safety requirements for the MODIS Level 1B software.

5.4 Security and Privacy Requirements

There are no security or privacy requirements for the MODIS Level 1B software.

5.5 Implementation Constraints

OR01: Scope. The MODIS Level 1B software shall implement the calibration algorithms documented in the Level 1B ATBD.

OR02: Toolkits. The MODIS Level 1B software shall use the tools provided in the SDP and SDST toolkits whenever applicable.

OR03: Maintainability. The MODIS Level 1B software shall be implemented and documented with maintainability as an objective, according to NASA, EOSDIS and SDST standards. -

OR04: Portability. The MODIS Level 1B software shall be implemented with machine and architecture portability as an objective.

OR05: Reliability. The MODIS Level 1B software shall be implemented with performance reliability as an objective.

OR06: Evolution. The MODIS Level 1B software shall be implemented in a way that accommodates the evolutionary nature of the technical content of the Level 1B ATBD.

5.6 Site Adaptation

MCST will cooperate with SDST and coordinate the development effort to minimize modifications required to ensure site adaptability to the production environment.

6.0 TRACEABILITY TO PARENT'S DESIGN

The requirements in this document are derived from the EOS Program Level 1 Requirements and the Implementation Agreement for the MODIS Team Leader, Statement of Work Execution/Operations Phase.

| ID | Title | Source |
|------|-------------------------------------|-------------------------------------|
| IF01 | Initiate Execution | Portability |
| IF02 | Deleted | |
| IF03 | Terminate Execution upon Completion | Portability |
| IF04 | Input Data | MODIS Level 1B ATBD |
| IF05 | Ancillary Input Data | MODIS Level 1B ATBD |
| IF06 | Input Data Limitation | Team Leader Working Agreement 3.4.2 |
| IF07 | Create Level 1B Data Product | Team Leader Working Agreement 3.3.2 |
| IF08 | Create Metadata | Team Leader Working Agreement 3.4.1 |
| IF09 | Append Metadata | |
| IF10 | MODIS Processing Log | ECS Requirement EOSD0780 |
| IF11 | Concurrent Execution | ECS Requirement EOSD4020 |
| IF12 | Termination Report | Reliability |
| IF13 | Alarm Messages. | Reliability |
| IF14 | Overlapping Data | MODIS Level 1B ATBD |
| IF15 | Sun Angles | MODIS Level 1B ATBD |
| IF16 | Pixel Angles | MODIS Level 1B ATBD |
| IF17 | Lunar Vector | MODIS Level 1B ATBD |
| IF18 | Normal Termination. | Reliability |
| IF19 | Abnormal Termination. | Reliability |
| FN01 | Processing Scope. | Team Leader Working Agreement 3.3.4 |
| FN02 | Reprocessing | ECS Requirement EOSD1040 |
| FN03 | Solar Diffuser | MODIS Level 1B ATBD |
| FN04 | Solar Diffuser Stability Monitor | MODIS Level 1B ATBD |
| FN05 | SRCA Radiometric Mode | MODIS Level 1B ATBD |
| FN06 | SRCA Spatial Mode | MODIS Level 1B ATBD |
| FN07 | SRCA Spectral Mode | MODIS Level 1B ATBD |
| FN08 | Space View | MODIS Level 1B ATBD |

| ID | Title | Source |
|------|--------------------------|--------------------------------------|
| FN09 | Black Body | MODIS Level 1B ATBD |
| FN10 | Lunar Look | MODIS Level 1B ATBD |
| FN11 | Calibration Coefficients | Team Leader Working Agreement 3.3.4 |
| FN12 | Calibration Updates | Team Leader Working Agreement 3.3.4 |
| FN13 | Earth View Data | MODIS Level 1B ATBD |
| FN14 | Deleted | — |
| FN15 | Engineering Data. | Team Leader Working Agreement 3.3.2 |
| FN16 | Quality Assurance | Team Leader Working Agreement 3.3.5 |
| FN17 | Input Data Verification | Reliability |
| FN18 | Metadata Contents | ECS Requirement IMS0320 |
| FN19 | Data Format | Maintainability |
| FN20 | Data Contents | Maintainability |
| FN21 | Calibration Sources | Team Leader Working Agreement 3.3.4 |
| FN22 | Non-Nominal Conditions | Team Leader Working Agreement 3.3.2 |
| FN23 | Radiance Sensor Data | Science Teams |
| FN24 | Infrared Sensor Data | Science Teams |
| FN25 | Reflectance Sensor Data | Science Team |
| PR01 | Error Recovery | Team Leader Working Agreement 3.4.2 |
| PR02 | Trending | Team Leader Working Agreement 3.3.4 |
| PR03 | Error Abort | Team Leader Working Agreement 3.4.1 |
| OR01 | Scope | Team Leader Working Agreement 3.4.1 |
| OR02 | Toolkits | Team Leader Working Agreement 3.4.1 |
| OR03 | Maintainability | Team Leader Working Agreement 3.4.2 |
| OR04 | Portability | Team Leader Working Agreement 3.4.2 |
| OR05 | Reliability | Team Leader Working Agreement 3.4.2 |
| OR06 | Evolution | Team Leader Working Agreement 3.3.4. |

7.0 PARTITIONING FOR PHASED DELIVERY

MCST is using a prototype development model with three delivery phases. The requirements in this document are being met incrementally with each phase of the delivery schedule. Upon delivery of the Version 2 system, the full scope of the requirements specified here will be met. The purposes of each delivery are shown below.

- β Test migration from the SCF to the EOSDIS;
exercise interfaces;
test execution in the operational environment;
provide sizing information.
- V1 Correct any problems in the β version;
complete operator interfaces;
generate all messages.
- V2 Software ready for launch.
Final integration;
test of operations procedures
training of operations staff.

8.0 ABBREVIATIONS AND ACRONYMS

| | |
|--------|---|
| A&E | Activation and Evaluation |
| ATBD | Algorithm Theoretical Basis Document |
| CASE | Computer Aided Software Engineering |
| CCB | Configuration Control Board |
| DAAC | Distributed Active Archive Center |
| ECS | EOSDIS Core System |
| EOS | Earth Observing System |
| EOSDIS | EOS Data and Information System |
| GSFC | Goddard Space Flight Center |
| MAT | MCST Algorithms Team |
| MCST | MODIS Characterization Support Team |
| MODIS | Moderate Resolution Imaging Spectroradiometer |
| NASA | National Aeronautics and Space Administration |
| OBC | On Board Calibrator |
| PGE | Product Generation Executive |
| Q/A | Quality Assurance |
| SCF | Science Computing Facility |
| SDPS | Science Data Processing System |
| SDST | Science Data Support Team |
| SRCA | Spectroradiometric Calibration Assembly |
| SRS | Software Requirements Specification |
| TBD | To be determined |
| TLCF | Team Leader Computing Facility |

9.0 GLOSSARY

10.0 NOTES

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11.0 APPENDICES