

Clouds and the Earth's Radiant Energy System (CERES)

Data Management System

Software Requirements Document

Geolocate and Calibrate Earth Radiances
(Subsystem 1.0)

Release 1
Version 1

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February 1995

Preface

The Clouds and the Earth's Radiant Energy System (CERES) Data Management System supports the data processing needs of the CERES science research to increase understanding of the Earth's climate and radiant environment. The CERES Data Management Team works with the CERES Science Team to develop the software necessary to support the science algorithms. This software, being developed to operate at the Langley Distributed Active Archive Center, produces an extensive set of science data products.

The Data Management System consists of 12 subsystems; each subsystem represents a stand-alone executable program. Each subsystem executes when all of its required input data sets are available and produces one or more archival science products.

The documentation for each subsystem describes the software design at various significant milestones and includes items such as Software Requirements Documents, Data Products Catalogs, Software Design Documents, Software Test Plans, and User's Guides.

Acknowledgement is given to Troy Anselmo, for his patience in guiding the DMT through the software engineering methodology evidenced in this SRD; Robert Lee, Alan Gibson, Susan Thomas, and all members of the Radiance Count Conversion Team; Denise Cooper and Scott Quier, the StP Template Team.

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1.0 Introduction

The Clouds and the Earth's Radiant Energy System (CERES) is a key component of the Earth Observing System (EOS). The CERES instruments are improved models of the Earth Radiation Budget Experiment (ERBE) scanner instruments, which operated from 1984 through 1990 on the National Aeronautics and Space Administration's (NASA) Earth Radiation Budget Satellite (ERBS) and on the National Oceanic and Atmospheric Administration's (NOAA) operational weather satellites NOAA-9 and NOAA-10. The strategy of flying instruments on Sun-synchronous, polar orbiting satellites, such as NOAA-9 and NOAA-10, simultaneously with instruments on satellites that have precessing orbits in lower inclinations, such as ERBS, was successfully developed in ERBE to reduce time sampling errors. CERES will continue that strategy by flying instruments on the polar orbiting EOS platforms simultaneously with an instrument on the Tropical Rainfall Measuring Mission (TRMM) spacecraft, which has an orbital inclination of 57 degrees. In addition, to reduce the uncertainty in data interpretation, and to improve the consistency between the cloud parameters and the radiation fields, CERES will include cloud imager data and other atmospheric parameters. The first CERES instrument is scheduled to be launched on the TRMM spacecraft in 1997. Additional CERES instruments will fly on the EOS-AM platforms, the first of which is scheduled for launch in 1998, and on the EOS-PM platforms, the first of which is scheduled for launch in 2000.

1.1 Purpose and Objective of Document

This section provides purposes and objectives of this document, as well as general information that will help the reader to understand its content of this document.

The purpose of this document is to serve as the basis for designing and testing the Instrument Processing Subsystem (IPS) software. The intended audience for this document consists of the following groups: the IPS designers, implementers, and testers; the adjacent DMT Subsystem teams that utilize the output data products; and the science algorithm reviewers. This document may also be used as reference material for the EOSDIS developers expected to support the software run-time operating environment.

The objective of this document is to provide, as complete and as comprehensive as possible, a set of requirements necessary to guide the development of the Release 1 IPS software. This set of requirements addresses processes and data sets necessary to convert raw CERES instrument telemetry data into geolocated science radiance values. These processes involve count conversion algorithms and comprehensive radiance validations. Validations will require extensive instrument evaluation software. To support the validation process, a high level of detail is included in this Software Requirements Document (SRD) on the instrument engineering data (analog and digital) measurements and relationships. As additional information about certain instrument design and operational processes becomes available, process requirement specifications will be completed to the same level of detail.

The scope of this document is organized to identify the concepts driving the Subsystem requirements (Section 2.0), describe the analysis used to determine high level requirements approach and tradeoffs (Section 3.0), describe the external interface requirements (Section 4.0), and describe the decomposition process model that identifies the software functional requirements (Section 5.2). Detailed information describing the input Level 0 and output Level 1 data products can be found in the Data Products Catalog (Reference 1).

The identification and completeness of Subsystem requirements is expressed in this document through the development of a structured data flow model. This model is used to decompose the problem domain encompassing the IPS.

Experience with modern software engineering is helpful to follow and understand the decomposition methodology.

The layout of the model within this document is by vertical decomposition. That is, each high level process (or bubble) is described by vertical decomposition as opposed to describing each layer in document sections.

Model criteria include cohesiveness, coupling, and logical data set and processes grouping. Processes either describe a collection of lower level requirements or specify requirements at the lowest levels. Low level requirements are considered testable items and begin with "Shall."

1.2 System Overview

The Geolocate and Calibrate Earth Radiance, Instrument Processing Subsystem (IPS), is the front-end of the CERES Data Management System (DMS). Level 0 spacecraft and sensor telemetry are inputs which use instrument calibration coefficients to convert raw instrument data into geolocated filtered radiances and housekeeping data into engineering units. These output Level 1b data are temporally organized into an archived, 24-hour BiDirectional Scans (BDS) data product. The BDS product contains the full set of raw telemetry data along with the converted engineering and science values. The BDS filtered radiances are used in the follow-on ERBE-like Subsystems. The IPS also produces an intermediate, 1-hour internal radiance product called Instrument Earth Scans (IES) that is spatially organized for the CERES instrument follow-on science Subsystems (e.g., Clouds, SARB, and TISA).

The primary data input is a 24-hour, Level 0 instrument data stream and associated ephemeris data. This instrument stream contains chronologically ordered data packets containing 6.6 seconds of measurement data. These packets are formatted according to the Consultative Committee for Space Data Standards (CCSDS) communication protocol. These packets include header information, such as instrument identifier and time stamp, as well as a comprehensive set of analog, digital, processor, sensor position, and radiance data. Ephemeris data are provided to compute geolocation vectors and for evaluating high level spacecraft conditions that influence instrument results. In addition, there are a number of ancillary data files that support the data processing conversion and validation algorithms.

The primary output data products are the 24-hour BiDirectional Scan (BDS) and 24 1-hour Instrument Earth Scan (IES) data products. The BDS is archivable; the IES is an internal data product. In addition, extensive processing quality control and validation reports are output. The BDS is organized in chronological 6.6-second records that coincide with the input 6.6-second instrument packets. Each record contains raw and converted values. The IES is organized as a collection of spatially ordered footprint records. Processing status flags are also included for all output radiance measurements.

This Subsystem performs all of the software functions necessary to produce validated Level 1 geolocated radiance data from the raw Level 0 CERES instrument data. This software implements the following major functions:

1. Converts the raw data into their physical engineering or scientific representations.
2. Calculates the corresponding instrument field-of-view measurement vectors into geophysical Earth locations.
3. Performs quality control and validation on this data to ensure quality science data.

Several secondary functions are also performed within this Subsystem to support the verification and validation of quality science data. These include the following functions:

1. Evaluate and update radiance conversion coefficients based on instrument calibration data from internal sources, solar views, and deep space views.
2. Evaluate instrument diagnostic data to determine the operational performance characteristics of the instrument and the impact on the science data.
3. Perform extensive validation checks and trend analysis on all instrument engineering measurements to ensure that the health and safety of the instrument is maintained.
4. Process instrument quick-look data.

These functions are captured in five logically sequenced processes that are illustrated in [Figure 5-1](#). This diagram represents the Level 0 functional model used to describe the comprehensive and complete set of IPS requirements. The five processes are described as follows:

1. **CHECK HEADER and CONVERT ENGINEERING DATA:** This process checks and validates all input file and instrument packet headers, converts all instrument and spacecraft engineering data into engineering units, and performs quality control checks on the engineering and ephemeris data.
2. **CONVERT SCIENCE DATA:** This process calculates the instrument field-of-view, Earth geolocated vectors, converts and quality checks science radiances, identifies nighttime conditions, and spatially sorts the IES data.
3. **CONVERT CALIBRATION DATA:** This process calculates the instrument calibration fields-of-view, converts and quality checks calibration radiances, evaluates and validates radiance coefficients against calibration history and approved algorithms, and updates validated radiance conversion algorithm coefficients.

4. **CONVERT DIAGNOSTIC DATA:** This process converts instrument diagnostic data into physical representations, validate conversion data, and evaluate operational characteristics of the instrument to determine science impacts.
5. **TREND DATA and OUTPUT RESULTS:** This process performs statistical analysis on instrument engineering data, develops history logs, evaluates and validates performance trends, generates output reports, and outputs science and quality control data.

2.0 Key Concepts

The following key concepts are embodied in the Instrument Subsystem which Geolocates and Calibrates Earth Radiances. Concepts include: Input Data Organization, Geolocation, Calibration, Instrument Performance and Operation Evaluation, Output Product Considerations, Production and Processing Environment, Metadata and Error Handling, and Data Quality.

Input Data Organization: The primary input Level 0 instrument data are contained in three distinct data files that are organized by Application Identifiers (APIDs) in 24-hour segments. These APIDs correspond to Science, Solar Calibration, and Diagnostic data. Science APID data consist of all normal "science" (radiance and scanner position) and "nonscience" housekeeping data measured during the instrument's fixed azimuth or biaxial gimbal rotating, normal Earth-scan configuration. Solar calibration APID data consist of the same data measured during a fixed azimuth, Sun-viewing scan configuration. Diagnostic APID consist of all "other" data that are not expected to be archived.

All CERES instrument data are organized into CCSDS packets containing 6.6 seconds of instrument data. Each packet contains a block of digital engineering and 660 "records" of science, calibration, or instrument diagnostic measurements with associated instrument analog engineering measurements. The "records" are formatted into either science or diagnostic packet formats. There is only one science data format, but there are several types of diagnostic data formats. These data formats are: memory, gimbal error, processor, and fixed pattern.

Geolocation: To properly interpret the CERES radiance measurements, it is essential that accurate Earth fields-of-view (FOV) be determined for each instrument measurement. This is accomplished by knowing the instrument detector elevation and azimuth angles for each measurement, the corresponding spacecraft ephemeris (sample time, position, velocity, and attitude), and the various vector coordinate system geometries. Earth locations are calculated by a series of coordinate transformations into unit pointing vectors, then determining a pierce point for both the top-of-atmosphere (TOA) and surface geoid. Various pointing error budgets will need to be considered in the computation process and will need to include timing accuracy of instrument measurements and spacecraft-to-detector measurements to Universal time, definitive spacecraft accuracy, and detector-to-instrument and instrument-to-spacecraft mechanical alignments.

Calibration: In order to ensure meaningful science quality, accurate knowledge of the radiance detection and measurement process is required. This is accomplished by ground and in-flight calibration processes. Ground calibrations will provide characterization data for the three radiance detectors and the instrument calibration sources as a function of detector temperatures, voltages, and measurement references and spectral variations using "standard" calibration sources. These data (such as spectral correction coefficients) will be utilized during production processing to verify and evaluate in-flight calibration and radiance detector performances.

In-flight calibrations utilize solar and internal calibration sources. Solar viewing Mirror Attenuator Mosaics (MAMs) are used for calibrating the shortwave and total detector channels. Solar calibrations are expected to be performed approximately every two weeks throughout the mission. To perform this calibration requires a special sensor scan profile to accommodate MAM views.

Internal calibration sources include blackbodies for calibrating total and longwave (i.e., window) channels, and a ShortWave Internal Calibrator Source (SWICS) for calibrating the shortwave channel. The internal calibration sources (blackbodies and SWICS) are viewed each science scan, although they are normally not active. These sources will be activated normally during scheduled internal calibration events only. In addition, it is anticipated that the platform(s) will perform a special on-orbit maneuver sometime during the mission to allow the instrument to view deep space, thereby, identifying scanner position-dependent influences.

Calibration data will be used for verifying, validating, and possibly adjusting the radiance conversion coefficients based on in-flight calibration processes. The radiance conversion coefficients are expected to be updated periodically throughout the mission to accommodate natural instrument degradation effects. The update process is expected to follow EOSDIS procedures being defined as the EOSDIS system evolves. The suggested concept is to flag in-flight calibration data that have exceeded predefined criteria for review by the CERES Science Team. Upon evaluation and approval, conversion coefficients may be updated in the production environment.

Instrument Performance and Operation Evaluation: Science radiance quality is heavily dependent on successfully verifying and validating the performance and operation of the CERES instrument. Instrument performance involves a comprehensive evaluation of all digital and analog measurements (e.g., radiance, temperature, power, and position measurements). Evaluations involve limit (edit) checks; rate of change checks; trending limit checks; parameter validation; statistical averaging and deviation analyses; and fault isolation, verification, and validation. Extensive instrument configuration and command verification, logic tree comparisons, and historical tracking is expected to be implemented. Instrument operations require extensive analysis of the command structure within normal packets and diagnostic packet processor operations, memory dumps, and gimbal error output data. Diagnostic evaluations will determine data processing changes that may be required.

It is planned that data analyst procedures performed off-line during the ERBE mission will now be automated as part of on-line processing. These include expanded trending evaluations, on-line plotting, and fault isolation. Plotting capabilities will be automatically invoked by anomalous production and instrument data conditions. This will assist the data analyst in troubleshooting efforts.

Output Product Considerations: Output products are determined and driven by two major considerations - Subsystem interface data structure requirements and instrument validation efforts. Interface requirements are dictated by and coordinated with Subsystem 2.0 (ERBE-like Inversion) and Subsystem 4.0 (Clouds). Both of these Subsystems require Level 1b radiance data. These interface data products are categorized as archival or intermediate data. Instrument validation efforts generate comprehensive processing reports and statistical data that will be "archived." A common output concept is the "footprint," which is a multi-band structure containing radiance, geolocation, and quality information associated with one instrument sampling period. This structure is called a footprint to differentiate it from the "pixel" organization of the cloud imager products used in subsequent subsystems. The output products are summarized below:

1. The BiDirectional Scan (BDS) data organization reflects ERBE heritage and the downstream ERBE-like processing consistency requirements. These data are organized into 24-hour files with 6.6-second records. This output product also provides two additional capabilities:
 - a) Satisfy the EOSDIS requirement for being able to "reconstruct" Level 0 data from Level 1b data. The BDS will contain a copy of the Level 0 data to accomplish this.
 - b) Provide a full set of converted instrument engineering data to aid in instrument anomaly investigations.
2. The Instrument Earth Scan (IES) data organization reflects the need to coordinate with cloud imager data that are processed in the CERES-unique Subsystems. These data are organized into 1-hour files containing spatially ordered footprints. No engineering data are passed.
3. Instrument validation outputs include all engineering statistical analyses, trending parameters, and processing error reports.

Production and Processing Environment: The Subsystem code will conform to EOSDIS concepts for supporting staging and ingesting data, utilizing system resources, incorporating operating protocols, and insuring timely results. Detailed impacts on the code development have been deferred until more information is available from EOSDIS. In the interim, some assumptions about the processing environment have been made. These include the following:

1. File header verification and validation is anticipated to be handled by the system; however, the IPS software will also perform this function.
2. Staging data and executing code will be performed by Product Generation Executive (PGE) scripts.
3. System operator interaction messages will be generated by the Subsystem, using PGS toolkit functions.
4. Subsystem operational guidelines will be established for all IPS processing scenarios.
5. Run time user information (e.g., environment variables) may need to be passed into the program.

Metadata and Error Handling: Metadata and error handling will conform to the EOSDIS operating environments, which are currently being defined. Details regarding metadata and error handling have been deferred until more information on the operating environment is available. It is expected that efficient and user-friendly error handling procedures will be developed.

Data Quality: All bad Level 0 data packets due to EOSDIS transmission processes are expected to have been eliminated from the input data stream. Examples of bad data include packet dropouts or incorrectly reconstituted data via the TRDSS error correction algorithms. All bad Level 1 generated BDS and IES data will either be flagged as bad or will not be output.

3.0 Requirements Approach and Tradeoffs

This section discusses the approach and trade-offs that were made in developing the software requirements for the Instrument Processing Subsystem.

Using the context diagram (see [Section 4.0](#)) to show the logical external data interfaces, a set of high-level functional requirements was established. These are based on the primary science objectives, the capabilities of the instrument, and the data interfaces. This information can be found in the Interface Requirements Document, the Algorithm Theoretical Basis Document, and the CERES Instrument Operations Manual ([References 2, 3, 4](#)). Seven high-level functional requirements were identified and are listed below, including associated rationales.

1. Access, process, and validate all raw Level 0 instrument and spacecraft data files and all associated data files necessary to process this data.

Input data files that must be processed include the following:

- a) All Earth-orbiting instrument and platform data. These data files are Level 0 time ordered data records with no duplicate or erroneous data gaps. The 24-hour production data sets begin at midnight Greenwich time.
- b) Formatted and packetized data from instrument ground tests and computer simulations.
- c) Auxiliary data needed to process instrument, spacecraft ancillary, and ephemeris data.

Rationale:

1. While the PGE is supposed to ensure that the correct files are available for processing, the IPS will need to validate the contents of the header and to verify the user's production requests.
2. File header contents are used to validate packet header contents, which will require a temporary data store of all file header information. The packet headers must be verified against the CCSDS standards for Packet Telemetry and Time Code Formats ([References 5, 6](#)).
3. Under the EOSDIS, all data are treated as files. Thus, auxiliary data used internally to the IPS will need to be verified using standard file formats.

2. Convert, edit, validate, and analyze all nonscience data records within the input data files.

Rationale:

1. After file checks, instrument and spacecraft ancillary data packet headers need to be validated and verified against the PGE user-specified parameters and input data file headers.
2. All nonscience data should be converted and validated to verify proper instrument and spacecraft operating performance before converting science data and to ensure meaningful results. The information must meet the specifications identified by the In-Flight Measurements List, DRL-64 ([Reference 7](#)).
3. This is the logical place to validate both ephemeris and spacecraft ancillary data. This assumes these data have been converted to their physical representations on input to the

IPS. However, the possibility exists that EOSDIS may have converted and validated this information, in which case a Toolkit call will be required to retrieve the information.

3. Edit and validate raw CERES radiance measurements and compute, edit, and analyze science radiances.

Rationale:

1. This is the normal production processing of science data.
 2. This does not include any calibration or diagnostic application identifier (APID) information, but uses the latest, calibration processed coefficients.
 3. This process will allow raw radiance values to be processed from instrument, ground, or simulation sources
4. Edit and validate raw CERES calibration data and compute, edit, and analyze radiance and calibration coefficients.

Rationale:

1. CERES calibration is a complex process involving internal calibration sources, instrument engineering measurements which influence these sources and the radiometric sources, and radiance measurements from solar calibrations.
 2. This process is used to update radiance and calibration count conversion algorithm coefficients.
 3. The calibration data processing algorithm may be updated throughout the instrument lifetime.
5. Compute, edit, validate, and analyze raw CERES instrument diagnostic data.

Rationale:

1. The CERES instrument contains extensive diagnostic capabilities which support instrument performance analysis.
 2. Deep space radiance data are input in the diagnostic data set identified by the diagnostic APID and will be used to support the calibration process.
 3. Instrument diagnostic data will be analyzed and the results output as reports for instrument engineers to assess science quality impacts.
6. Compute and validate the location of the radiance measurement sources with respect to specified coordinate frames and sampling schemes.

Rationale:

1. The location of radiance measurements is a critical component of the science investigation, and location accuracy, resolution, and quality is important.
 2. The algorithms for computing BDS location references and the IES location references are computationally intensive.
7. Output all science, engineering, and report data produced by this Subsystem.

Rationale:

1. All science data must conform to EOSDIS format requirements and be organized to support downstream science processing needs.
2. All QC, validation, and instrument diagnostic data need to be reported and stored for post-processing evaluations by data analysts and instrument engineers.

A logical data processing sequence was developed from these functional requirements. For the IPS, the following suggested sequence was developed based on the grouping of input data sets by science, calibration, and diagnostic APIDs.

1. File information is checked and verified to perform the particular production run.
2. Level 0 packets are checked and verified against the file and PGE parameters.
3. Instrument operational configurations are identified, edit checked, and verified.
4. Instrument engineering parameters are converted. The data will be logically grouped according to their conversion algorithms as identified in DRL-64 ([Reference 7](#)). Data parameters are named according to the CERES Standard Parameter Abbreviations ([Reference 8](#)).
5. The footprint locations are calculated.
6. Radiance conversions are performed. The data will be converted using the algorithms identified in Algorithm Theoretical Basis Document ([Reference 3](#)) and merged with the converted geolocations.
7. The output data products are temporally and spatially sorted. The IES creation will require overlap data from the last hour of the previous day. The last hour of the current day will be stored for the following day production run.
8. Secondary processes will be performed for calibrations and instrument diagnostics.
 - a) Calibration processing updates the radiance conversion parameters based on solar, deep space, and internal quick-look data. The data will be converted using the algorithms identified in the Algorithm Theoretical Basis Document ([Reference 3](#)).
 - b) Diagnostic evaluations are performed on instrument engineering data output using the diagnostic APID.
9. Perform trend analysis on engineering, radiance, calibration, and geolocation calculations.
10. Output validation, quality control, and summary reports for all data runs.

Trade-offs and assumptions that were made while developing the software requirements include the following considerations.

1. All radiance calculations can be made independent of location and FOV calculations.
2. Data are grouped logically according to their interdependency with the science and location data rather than by their common conversion algorithms. The latter grouping can be done in the design phase.
3. Calibration processes are grouped by data source, although the algorithms are similar.
4. No BDS and IES restart capability exists in this first release of the CERES Data Management System.
5. All input Level 0 data on the context diagram makes no assumption as to the data source. Consequently, instrument data is not shown by platform, even though there are minor differences between the EOS-AM and TRMM data packets. The primary difference is the

inclusion of platform ephemeris in the instrument data stream and the inclusion of a quick-look flag in the packet secondary header for the EOS-AM platform.

6. Quick-look data will only generate validation and quality control reports. No BDS or IES data products will be generated. Calibration and radiance coefficients will be evaluated using quick-look data.

NOTE: The quick-look data stream will issue a special notice to the PGS staging manager that is to invoke a separate calibration trend process in the normal PDS data stream containing the same data. This trending is to begin 2 hours before an internal or solar calibration process and end at the end of the calibration process.

7. Ephemeris and Ancillary data files that come separately from the instrument data stream are assumed to be in engineering units. The ephemeris and ancillary data within the EOS-AM instrument data stream are assumed to be raw counts.
8. Details regarding limit tests, exhaustive fault tests, and error hierarchy have been deferred to the design phase. e.g., pass/no-pass conditions and the level of information associated with error conditions during production and ancillary data runs. Some suggested analysis has been provided.
9. No detailed file header information will be provided until the PGS operating environment and designs have been formalized. These will be filled as the ECS Requirements Specifications, the ECS Operations Concept, and the PGS Toolkit Requirements Specifications documents are updated ([References 9, 10, 11](#)).
10. Error handling requirements will be, in general, dictated by the PGS environment. Errors are divided into four levels: success, warning, failure, or abort. File level errors generated will, in general, abort a production run. Production is expected to continue in its entirety despite warning or failure errors. However, certain processes or functions will not be performed, depending on the nature of the errors. Some of these conditions have been identified and the corresponding actions have been indicated throughout this document.
11. This document addresses requirements based on EOS-AM and TRMM flight opportunity information. The IPS requirements were developed to allow future flight opportunities such as EOS-PM to be easily accommodated.
12. Discussions within this document involve science versus nonscience data. Discussions of science data principally involve radiometric output and pointing knowledge data. Discussions of nonscience data principally involve instrument digital and analog engineering data.
13. Solar, Internal Calibration, and Deep Space radiance data will be stored as part of the Instrument Calibration Coefficient (ICCOEF) ancillary data file.
14. It has been assumed that all data days will be processed in chronological sequence. No contingency requirements were developed for nonchronological or missing data sequences.
15. It has been assumed that calibration (internal and solar) and memory dump diagnostic operations do not overlap midnight; thereby requiring multi-day processing. However, provisions for such overlap will be considered during the IPS software design phase until definitive scheduling requirements are dictated otherwise by mission operation agreements.

4.0 External Interface Requirements

This section provides information on the interface requirements which must be satisfied between the system and each of its external input/output entities. These interfaces are depicted graphically in the Context Diagram (Figure 4-1). The subparagraphs following the context diagram provide the detailed requirements for each of the data interfaces represented in the diagram.

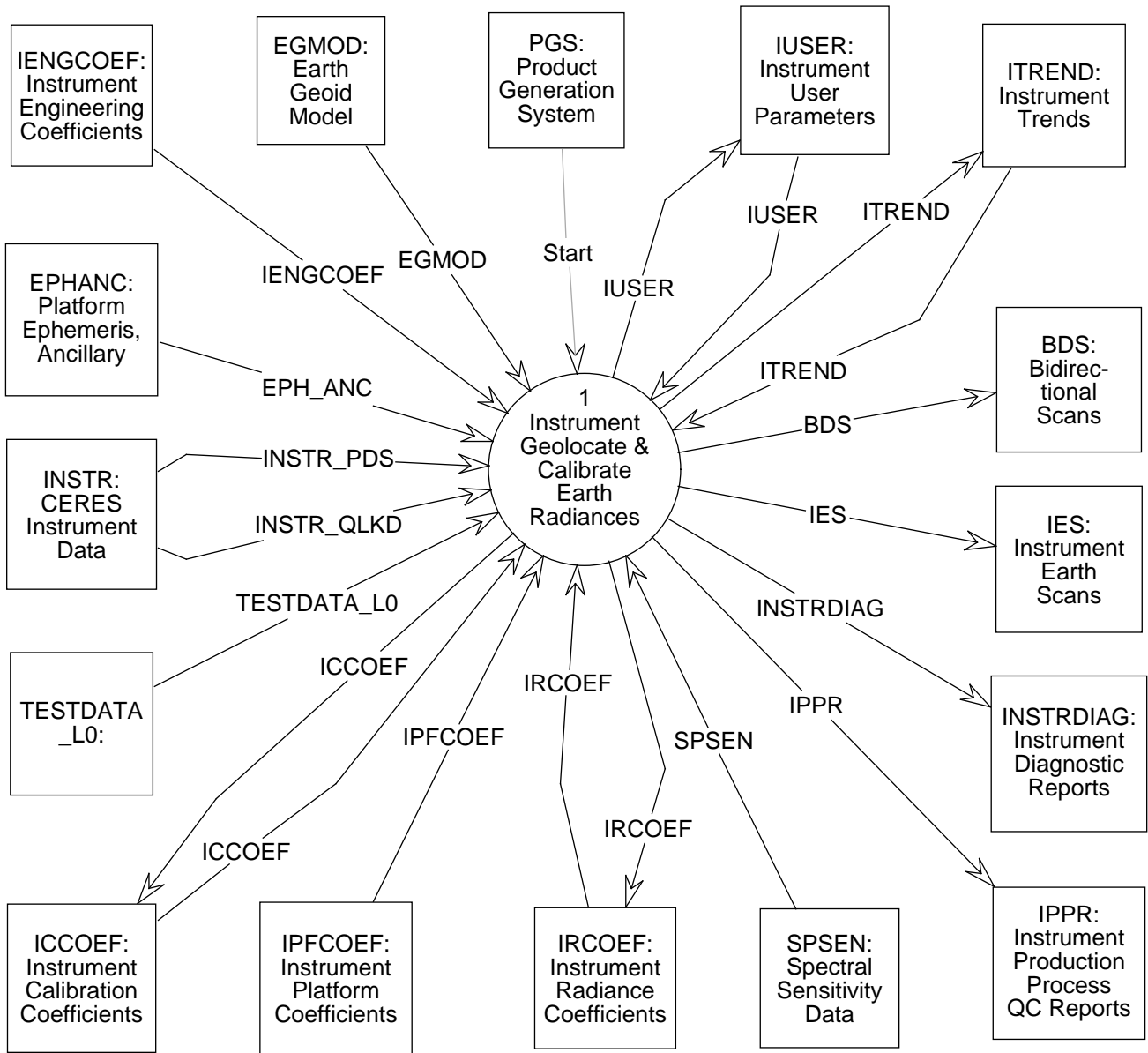


Figure 4-1. Context Diagram

4.1 Input Data

4.1.1 INSTR PDS

The Instrument Production Data Set (INSTR_PDS) is the Level 0 raw data from the CERES instrument as structured by the instrument itself and is programmed by the instrument developer, TRW. All CERES instrument output is formatted according to the CCSDS packet concept; and all CERES instrument packets contain the same data output formatting options, although some instrument data packets contain data unique to a particular spacecraft. The seven basic pieces of information contained in a normal CERES data packet (i.e., science output format) are

1. Packet Header
2. Time (in secondary header)
3. Radiometric Detector Outputs
4. Instrument Gimbal Pointing Knowledge
5. Instrument Engineering Data (Temperatures and Voltages)
6. Instrument Digital Status

There are several packet content variations possible for the CERES instruments; some of these variations are due to spacecraft differences and some are due to instrument output differences. These differences are noted in the data structure as selections. The data structure labelled EOS_Quick-look_Statword represents an 8-bit piece of the secondary header on the EOS platform that will contain a 1-bit quick-look flag and 7 bits of user-definable flags. Data packets from the TRMM spacecraft do not contain these extra 8 bits in the secondary header, so the EOS_Quick-look_Statword structure is not valid for TRMM packets.

Another selection shown in the data structure is the INSTR_Digital_Status_Block. Only one of the two selection possibilities can be present in any given CERES data packet; either the actual instrument digital status information is present, or a 'fixed pattern' of bits is present. This fixed pattern will be present when the instrument is outputting data in the fixed-pattern data format.

The INSTR_Science_Data data structure is another selection where only one of the selection possibilities can be present in any given CERES data packet. The selection options here are based on the different data output formats of the instrument: science, memory dump, gimbal operation, processor operation, and fixed-pattern.

Finally, the INSTR_EOS_Ancillary_Data structure is a spacecraft-dependent structure. The spacecraft ancillary data is only appended to data packets output by a CERES instrument on an EOS spacecraft; the data packets output by a CERES instrument on a TRMM spacecraft will not have this information.

4.1.2 INSTR QLKD

The Instrument Quick-Look data (INSTR_QLKD) consists of Level 0 data downlinked by a spacecraft from a CERES instrument during one TDRSS contact. The data packets are formatted

like any other CERES data packet (see INSTR_PDS discussion for the format of a CERES data packet), but the packets are contained in a single file that holds up to three groups of time-ordered packets, where each group has a separate APID. This data structure primarily contains solar and deep space calibration data and instrument diagnostic data. During normal operations, it is expected that three quick-look data files will be needed for each instrument every 2 weeks to support calibration activities. For monthly storage sizing purposes, however, an estimate of one quick-look data file per instrument per day was used. This larger estimate is used to factor in instrument anomalies or instrument diagnostic modes that do not occur during normal operations.

4.1.3 EPH ANC

The EPH_ANC (Satellite Ephemeris and Ancillary) data stream contains information about spacecraft position and velocity, spacecraft attitude errors and attitude error rates, Sun and moon positions, and additional spacecraft information needed to process CERES instrument data, such as spacecraft direction or spacecraft mode. These additional spacecraft data are mission-dependent.

The position and attitude data are used to geolocate each CERES footprint and to calculate viewing geometry. The Sun position data are necessary to identify the proper Angular Distribution Model based on the geometry of the CERES footprint relative to the Sun.

4.1.4 TESTDATA L0

The TESTDATA_L0 auxiliary data is a file containing data that are formatted and packetized to look like CERES instrument data. These data could originate from computer simulations, end-to-end models, or ground test sources. Test data will be used to validate the IPS operations and algorithms prior to launch. BDS and IES data products could be generated from this information. In order to flow through the IPS, the test data packets need to be formatted exactly the same as a valid CERES data packet structure. Separate APID's will be assigned for test data.

4.1.5 IENGCOEF

The IENGCOEF (Instrument Engineering Coefficients) auxiliary data consists of three sets of parameters used to convert raw engineering measurements and to edit the quality of the converted values.

1. EConvAna is a set of coefficients required in the conversion algorithms for analog engineering measurements. Some conversion coefficients will be different for each instrument. The set of parameters for the instrument aboard the TRMM platform is listed in [Reference 10](#).
2. EConvDig is a set of definitions corresponding to the numeric values of the digital status parameters. The set of parameters is expected to be essentially the same for all instruments. The set of parameters for the instrument aboard the TRMM platform is listed in [Reference 10](#).

3. EEdit is a set of data required to edit the quality of converted engineering data. Data include parameters to edit the magnitude (hi/low) and/or the rate of change of the analog measurements. Data to edit the digital data will include parameters to be used in logical tests. TRW will develop an initial set of these parameters during ground tests that may be modified based on flight experience.

4.1.6 IPFCOEF

The IPFCOEF (Instrument Platform Coefficients) auxiliary data stream contains information necessary to evaluate spacecraft ancillary data. This includes platform configuration and edit limit check data. The exact content of this data set will be spacecraft-dependent.

4.1.7 EGMOD

The EGMOD (Earth Geoid Model) auxiliary data are required to support Earth-location calculations of the CERES instrument measurement sources and intermediate geometry calculations. These data will define the reference geoid or Earth model. Since EOSDIS intends to provide standard Earth-location tools through the PGS Toolkit, these data are owned by EOSDIS and are provided to the LaRC DAAC by EOSDIS.

4.1.8 SPSEN

The SPSEN (Spectral Sensitivity) auxiliary data stream consists of ground data used to characterize the instrument detectors. These data will be used during the calibration process, and will be used to validate science radiance results.

4.1.9 Start

The START control command is generated by the PGS via the instrument PGE. This command is sent when two conditions are satisfied. The first is when there are valid instrument and spacecraft data files. These consist of a 24-hour, Level 0 INSTR_PDS or a INSTR_QLKD data file and the corresponding EPH_ANC data file. The second is when all of the auxiliary data files necessary to support the production run are available.

4.2 Output Data

4.2.1 BDS

The BDS data product is an archival product containing Level 1b CERES scanner data obtained for a 24-hour period. All science scan modes are included in the BDS, including the fixed and rotating azimuth scan modes that perform normal Earth, internal calibration, and short scan elevation profiles. The BDS product includes samples taken at all scan elevation positions (including space looks and internal calibration views).

The BDS includes the raw count data stream and the converted engineering representative data. These data are divided into the following seven groups that are carried forward from the Level 0 product:

1. Time
2. Instrument Status
3. Radiometric Channel Counts
4. Instrument Telescope Pointing (elevation and azimuth)
5. Temperatures
6. Voltages and Currents
7. Satellite Ephemeris and Ancillary Data

In addition, we add the following filtered radiance data from the three radiometric channels and their associated field-of-view location geometry:

8. Filtered Radiances, including quality flags
9. Earth Location Geometry, including quality flags

In the BDS data product, the filtered radiances and the Earth location geometry are considered a multiband, single data element footprint. Quality flags are used to indicate the reliability of the radiance and Earth location measurements. This product is also used to diagnose instrument performance conditions.

4.2.2 IES

The IES data product contains the equivalent of 1-hour of data from a single CERES scanner. The data records are ordered along the orbital ground track, with each footprint position related to the spacecraft's suborbital point at the start of the hour. The spatial ordering of records within this product will ease the comparison of CERES data with cloud imager data in Subsystem 4. The footprint record is the basic data structure for this data product. This record contains the following kinds of information:

1. Time of observation
2. Geolocation data (at both the Top of Atmosphere (TOA) and at Earth's surface)
3. Filtered radiances (at satellite altitude), with associated quality measures
4. Spacecraft orbital data
5. Footprint viewing geometric data

The IES data product contains only measurements that view the Earth. For the TRMM mission, this means that approximately 225 Earth-viewing footprints (records) are stored on the IES from each 3.3-second half-scan. Because the Earth scan pattern of the CERES instrument in the biaxial scan mode is irregular, the exact number of pixels in each IES data product varies. This variation is caused by the lack of predictability of the azimuth position at both the start and end of the hour. If the azimuth angle near the start (or end) of an hour is near the cross-track position, then the

number of footprints in the IES product is near the estimated value given below. If the azimuth angle is near the alongtrack position, some of the footprints are instead spatially located within the previous (or next) hour's IES. Thus, we have used an estimate of the number of 3.3-second half-scans per hour (approximately 1091) times the number of Earth-viewing measurements in a half-scan (TRMM estimate is 225, EOS estimate is 195) to arrive at our IES product sizing. For TRMM, this is estimated as 245475 measurements per IES data product, and for EOS the estimate is 212745 measurements. The larger of these two measures is used to determine product sizing.

4.2.3 INSTRDIAG

The INSTRDIAG (Instrument Diagnostic) data stream contains quality control and validation information on diagnostic data generated by the instrument. At this point, we have very little information on the nature of data contained in the instrument diagnostic modes. Further detail will be added to this data set when the uses of the diagnostic modes are better understood.

4.2.4 IPPR

The IPPR (Instrument Production Process Report) auxiliary data stream contains all of the quality control results from a production run. This includes statistical summaries, error occurrences, and edit and validation results. These reports are generated for all production runs of INSTR_PDS and INSTR_QLKD.

4.3 Input/Output Data

4.3.1 IUSER

The IUSER (Instrument User parameters) auxiliary data stream contains run time and file processing parameters used to ensure valid production runs. The details of this data stream will be finalized as the PGS design progresses.

4.3.2 IRCOEF

The IRCOEF (Instrument Radiance Coefficient) auxiliary data stream contains the radiance conversion coefficients necessary to convert raw instrument radiance measurements to radiance units. Input parameters include calculation coefficients, detector offset values, and point-spread-function time delay data. The radiance coefficients can be updated based on calibration and radiance validation operations.

4.3.3 ITREND

The ITREND (Instrument Trend) auxiliary data stream contains all of the data pertaining to instrument operations. This information is used by the analyst to validate long-term operational trends of the instrument. Particular emphasis on instrument configuration, temperatures, and

power are considered. It is expected that hourly and daily statistics will be based on all instruments; weekly and monthly statistics will be based on statistical components from the hourly and daily results. It will be used to verify the quality of the science data results. As an input file, it contains the historical data for long-term engineering evaluations. As an output file, the data from the current production run are stored for future use.

4.3.4 ICCOEF

The ICCOEF (Instrument Calibration Coefficient) auxiliary data stream contains all data pertaining to instrument calibration operations. As an input file, it consists of the algorithm coefficients to calculate the radiance values when viewing calibration sources, as well as gain and offset information. Edit limit checks and previous solar, internal, and deep space information is also provided. As an output file, these data may be updated when instrument calibrations are performed.

5.0 Requirements Specifications

This section provides the specifications of requirements which must be satisfied by the Subsystem. Included are functional requirements, internal data elements, performance requirements, security requirements, and implementation constraints. In addition, the final subparagraph in this section identifies design goals which, will be addressed during the design of the system. These goals are distinguished from the requirements by the fact that it is not possible to include formal tests for the design goals in the system Test Plan.

5.1 Operating Modes

The IPS will need to operate under several operating conditions. The IPS will operate in both production and quick-look mode, and will accept multiple APID/data format combinations in both production and quick-look.

5.2 Functional Requirements

This section identifies the specific functional requirements, which are depicted graphically in the Data Flow Diagram for Level 0 (Figure 5-1). This diagram represents the first level decomposition of the system Context Diagram (see Figure 4-1). The subparagraphs following the Data Flow Diagram for Level 0 provide the detailed requirements (process descriptions and specifications) for each of the processes shown in Figure 4-1. Where appropriate, data flow diagrams are included for the next level of decomposition of individual processes. The process specifications will be used to define the testing requirements for the system at the time of preparation of the system Test Plan.

5.2.1 Check Header and Convert Engg Data - Process 1.1

Input Data Flows

- EPH ANC
- IENGCOEF
- INSTR PDS
- INSTR QLKD
- IPFCOEF
- ITREND
- IUSER
- TESTDATA L0

Output Data Flows

- EPH ANC Record
- Instr Cal Record
- Instr Diag Record
- Instr Sci Record

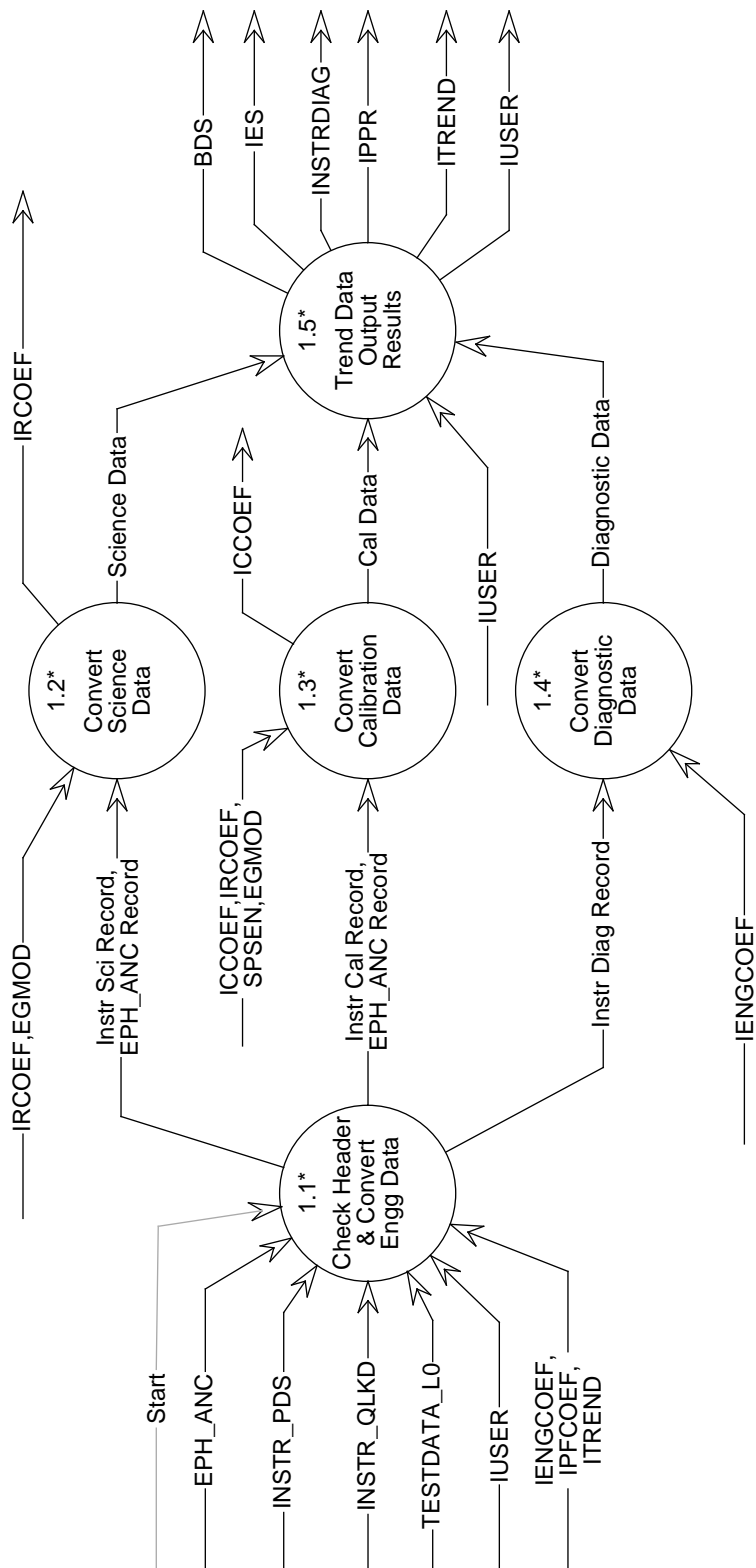


Figure 5-1. Data Flow Diagram for Geolocate and Convert Radiances

Process Description (Figure 5-1):

1. Access, process, and validate all raw Level 0 instrument and spacecraft data files and all associated data files necessary to process this data.
 - a) Access and accept as a minimum, the following input data files:
 - 1) CERES instrument data from EOS-AM or TRMM platforms.
 - 2) CERES quick-look data from EOS-AM or TRMM platforms.
 - 3) Spacecraft ancillary from EOS-AM or TRMM platforms.
 - 4) Spacecraft ephemeris from EOS-AM or TRMM platforms.
 - 5) Formatted and packetized data from instrument ground tests and computer simulations.
 - 6) Auxiliary engineering count conversion coefficients and limit values.
 - 7) Auxiliary engineering, mathematical, and science constants.
 - 8) Auxiliary PGS environment variables and other parameterized input.
 - 9) Auxiliary platform evaluation parameters.
 - b) Process and validate data file headers for the above input files and correlate this information with the PGE user data.
 - c) Temporarily store input file parameters.
 - d) Process quick-look data to generate validation and quality control reports only (i.e., no BDS or IES data products).
 - e) Halt production should any file headers be missing or erroneous, and inform operator/analyst.
2. Convert, edit, validate, and analyze all nonscience data records within the input data files.
 - a) Decompose, convert, edit, and validate CERES instrument, spacecraft ancillary, and ephemeris data file record headers and verify data corresponds to stored input file parameters.
 - b) Decompose, convert, edit, and validate CERES instrument engineering and status data.
 - c) Validate spacecraft ancillary and ephemeris data.
 - d) Validate all converted engineering, ancillary, and ephemeris data and deduce and evaluate instrument and spacecraft status and operating performance.

The decomposition of this function is shown in [Figure 5-2](#).

5.2.1.1 Validate File & Packet Headers - Process 1.1.1

Input Data Flows

EPH ANC
IENGCOEF
INSTR PDS
INSTR QLKD
IPFCOEF
ITREND
IUSER
TESTDATA L0

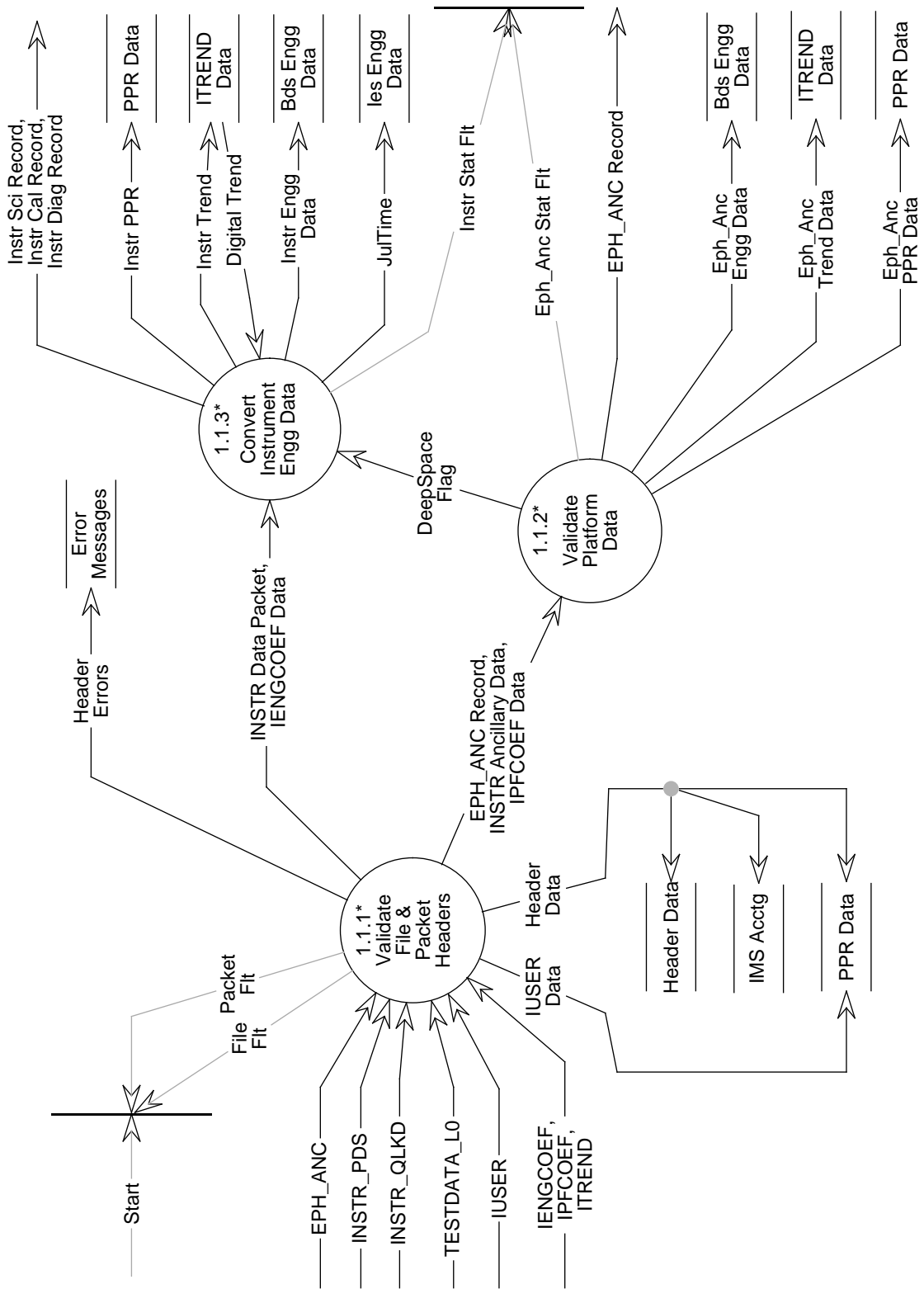


Figure 5-2. Data Flow Diagram for Check Header Convert Engg Data

Output Data Flows

- EPH ANC Record
- Header Data
- Header Errors
- IENGCDEF Data
- INSTR Ancillary Data
- INSTR Data Packet
- IPFCDEF Data
- IUSER Data

Process Description (Figure 5-2):

1. Verify and validate instrument, ephemeris, and spacecraft ancillary data file headers for each daily processing.
 - a) Temporarily store file headers and accounting information for packet validations and report generations.
 - b) Generate a daily quality control report identifying file parameters, file processing errors, and packet dropouts.
2. Verify and validate instrument, ephemeris, and spacecraft ancillary data packet headers for each daily processing.
 - a) Temporarily store packet headers for instrument and spacecraft validations and report generations.
 - b) Keep the last packet in a 24-hour file which includes data in the next day.
 - c) Generate a daily quality control report identifying file parameters, file processing errors, and packet dropouts.
3. Accept and verify auxiliary data files. This includes, as a minimum, the following information:
 - a) Engineering count conversion coefficients and limit values.
 - b) Engineering, mathematical, and science constants.
 - c) PGS environment variables and other parameterized input.
 - d) History trend data.
 - e) Platform evaluation parameters.
 - f) Halt production processing after checking all data file headers for completeness if any errors were identified.

The decomposition of this function is shown in [Figure 5-3](#).

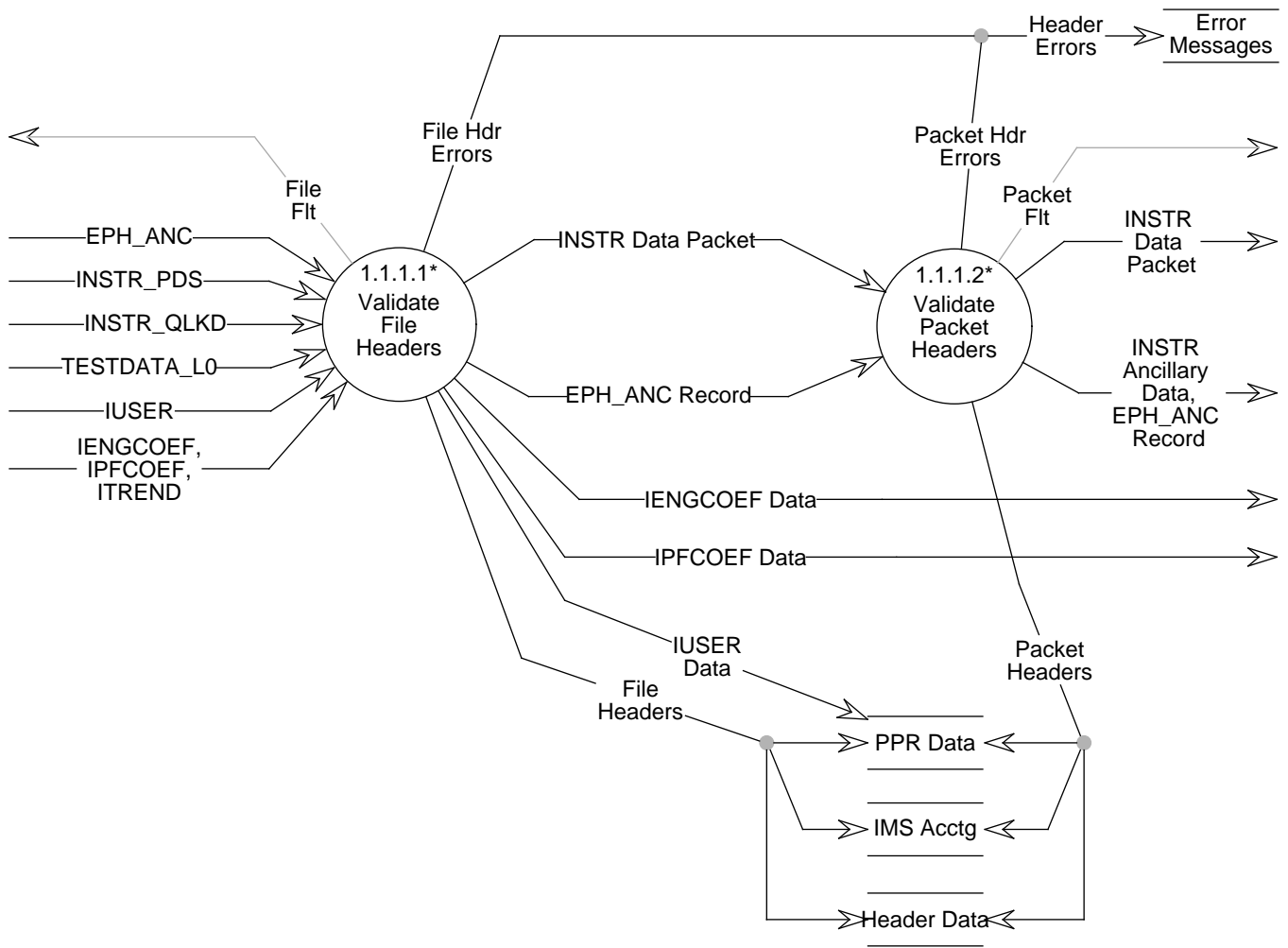


Figure 5-3. Data Flow Diagram for Validate File & Packet Headers

5.2.1.1.1 Validate File Headers - Process 1.1.1.1

Input Data Flows

EPH ANC
 IENGCOEF
 INSTR PDS
 INSTR QLKD
 IPFCOEF
 ITREND
 IUSER
 TESTDATA L0

Output Data Flows

- EPH ANC Record
- File Hdr Errors
- File Headers
- Header Errors
- IENGCOEF Data
- INSTR Data Packet
- IPFCOEF Data
- IUSER Data

Process Description (Figure 5-3):

1. Verify and validate instrument, ephemeris, and spacecraft ancillary data files for each daily processing. Verify that file headers are consistent with the following file format requirements:
 - a) INSTR_PDS and TESTDATA_L0 are separated into time ordered packets by APID.
 - b) INSTR_QLKD include all quick-look data grouped by the same APID within the file.
 - c) EPH_ANC beginning and ending times encompass the INSTR_PDS/INSTR_QLKD Level 0 beginning and ending times. If not, fetch and verify previous or following data file that overlaps the current INSTR_PDS/INSTR_QLKD data file.
2. Temporarily store file headers and accounting information for packet validations and report generations.
3. Generate a daily quality control report identifying file parameters, file processing errors, and packet dropouts.

Note: The EPH_ANC is assumed to contain converted engineering and status data. It is expected to be used principally for processing TRMM data.

The decomposition of this function is shown in [Figure 5-4](#).

5.2.1.1.1.1 Verify Instrument File Header - Process 1.1.1.1.1

Input Data Flows

- INSTR PDS
- INSTR QLKD
- IUSER
- TESTDATA L0

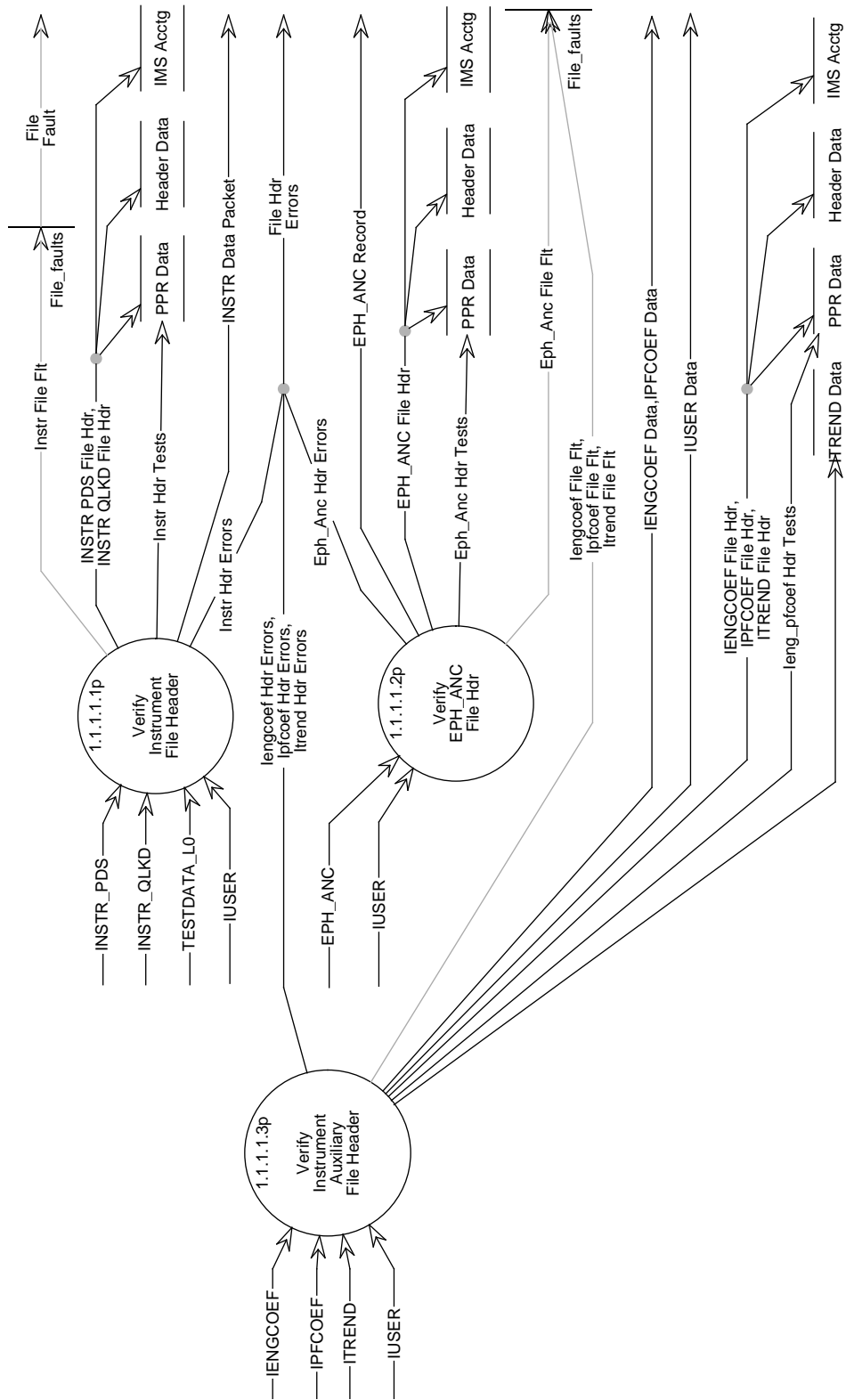


Figure 5-4. Data Flow Diagram for Validate File Headers

Output Data Flows

- File Hdr Errors
- INSTR Data Packet
- INSTR PDS File Hdr
- INSTR QLKD File Hdr
- Instr Hdr Errors
- Instr Hdr Tests

Process Specification (Figure 5-4):

1. Shall validate file accounting information and verify that the correct files are utilized for daily processing by comparing against the IMS database. Detailed data contents will be identified by the EOSDIS ECS program and will be available during the CERES software development phase. Validation results are to be output as Instr_Hdr_Tests to update the IMS Accounting.
2. Shall verify that the CERES instrument Level 0 data and Level 0 quick-look data file headers indicate that the data packets have been decommutated, time ordered, packetized and formatted, and contain no transmission errors.
3. Shall accept and verify formatted and packetized ground test and simulated Level 0 instrument data files.
4. Shall verify that the level 0 data file indicates that the data begins no earlier than the first whole packet after midnight Greenwich time and ends no later than with the last whole packet that overlaps midnight Greenwich time 24 hours later.
5. Shall verify that the header indicates that the INSTR_PDS instrument scan data are organized into separate APID data files.
 - a) Shall validate APIDs as either science, solar calibration, diagnostic, or test pattern values.
6. Shall verify that the header indicates that the INSTR_QLKD instrument scan data are organized by separate APID data sets within a single data file.
 - a) Shall validate APID's as either science, solar calibration, diagnostic, or test pattern values.
7. Shall verify that each generated APID data set contains a minimum of one instrument scan record and a maximum of 13090 instrument scan records.
8. Shall validate beginning and ending times and shall correct end-of-the-day times using the ephemeris-supplied correction factor.
9. Shall generate a daily quality control report identifying file parameters, file processing errors, and packet dropouts.
 - a) Shall output a copy of the file header for packet verification in the Header_Data store.
10. Shall halt production processing after all data files have been checked for completeness if any errors are identified.
 - a) Shall generate a Instr_File_Flt and a corresponding Instr_Hdr_Errors message identifying the fault(s).
11. Shall generate error reports for the analyst.

5.2.1.1.1.2 Verify EPH ANC File Hdr - Process 1.1.1.1.2

Input Data Flows

EPH ANC
IUSER

Output Data Flows

EPH ANC File Hdr
EPH ANC Record
Eph Anc Hdr Errors
Eph Anc Hdr Tests
File Hdr Errors

Process Specification (Figure 5-4):

1. Shall validate EPH_ANC (ephemeris and ancillary) file accounting information and verify that the correct files are utilized for daily processing by comparing against the IMS database. Detailed data contents will be identified by the EOSDIS ECS program and will be available during the CERES software development phase. Validation results will be stored for IMS Accounting updates via Eph_Anc_Hdr_Tests.
2. Shall verify that the EPH_ANC data file header indicates that the data records have been decommutated, time ordered, packetized and formatted, and contains no transmission errors.
3. Shall verify that the Level 0 data file header indicates that the data begins with the first whole packet after midnight Greenwich time and ends no later than with the last whole packet that overlaps midnight Greenwich time 24 hours later.
4. Shall verify that all platform ephemeris and ancillary data necessary to process the corresponding CERES instrument data for the specific production run are available.
5. Shall verify the EPH_ANC data is converted engineering and status data.
6. Shall generate a daily Quality Control (QC) report identifying file parameters, file processing errors, and packet dropouts. Header data shall be stored for record data validation.
7. Shall halt production processing after all data file headers have been checked for completeness if any errors are identified.
 - a) Shall generate a Eph_Anc_File_Flt and Eph_Anc_Hdr_Errors messages identifying any faults.
8. Shall generate error reports for the analyst.

5.2.1.1.1.3 Verify Instrument Auxiliary File Header - Process 1.1.1.1.3

Input Data Flows

IENGCOEF
IPFCOEF
ITREND
IUSER

Output Data Flows

File Hdr Errors
IENGCOEF Data
IENGCOEF File Hdr
IPFCOEF Data
IPFCOEF File Hdr
ITREND Data
ITREND File Hdr
IUSER Data
Ieng pfcoef Hdr Tests
Iengcoef Hdr Errors
Ipfcoef Hdr Errors
Itrend Hdr Errors

Process Specification (Figure 5-4):

1. Shall accept auxiliary data files necessary to process a given 24-hour instrument or quick-look data set:
 - a) Shall contain as a minimum the following information needed for processing:
 - 1) Engineering count conversion coefficients and limit values.
 - 2) Engineering, mathematical, and science constants.
 - 3) Coordinate system references.
 - 4) PGS environment variables and other parameterized input.
 - 5) History trend data.
 - 6) Platform evaluation parameters.
 - 7) Previously generated IES data from the last hour of the previous day for INSTR_PDS processing.
2. Shall validate file accounting information and verify that the data headers indicate the correct files are utilized for daily processing by comparing against the PGS database. Detailed data contents will be identified by the EOSDIS ECS program and will be available during the CERES software development phase.
 - a) Shall store validation results as Ieng_pfcoef_Hdr_Tests to update the PGS Accounting.
3. Shall output ITREND_Data to a data store for production updating.
4. Shall generate a daily quality control report identifying file parameters, file processing errors, and packet dropouts.
 - a) Shall store headers for production and validation reports.
5. Shall halt production processing after checking all data files for completeness if any errors are identified.
 - a) Shall generate an Iengcoef_File_Flt, Ipfcoef_File_Flt, or a Itrend_File_Flt and corresponding error messages.
6. Shall generate a report for the analyst.

5.2.1.1.2 Validate Packet Headers - Process 1.1.1.2

Input Data Flows

EPH ANC Record
INSTR Data Packet

Output Data Flows

EPH ANC Record
Header Errors
INSTR Ancillary Data
INSTR Data Packet
Packet Hdr Errors
Packet Headers

Process Description (Figure 5-3):

1. Verify and validate instrument, ephemeris, and spacecraft ancillary data packet headers for each daily processing. Verify packet headers are consistent with file headers.
2. Verify EPH_ANC record(s) begin and end times encompass the current INSTR_PDS/INSTR_QLKD packet being processed. Identify ephemeris source: i.e. if EOS, use ancillary data from the INSTR_PDS/INSTR_QLKD; and if TRMM, use the EPH_ANC data.
3. Adjust packet time for spacecraft time errors affecting packet time and convert to Universal time. Convert instrument and spacecraft time to Julian day and time.
4. Identify the last packet of a 24-hour INSTR_PDS file and keep that record.
5. Temporarily store packet headers for instrument and spacecraft validations and report generations.
6. Generate a daily quality control report identifying file parameters, file processing errors, and packet dropouts.

The decomposition of this function is shown in [Figure 5-5](#).

5.2.1.1.2.1 Verify Instrument Packet Header - Process 1.1.1.2.1

Input Data Flows

INSTR Data Packet

Output Data Flows

INSTR Ancillary Data
INSTR Data Packet
INSTR Packet Hdr
Instr Packet Count
Instr Packet Hdr Errors
Instr Packet Hdr Tests
JulDay Scan

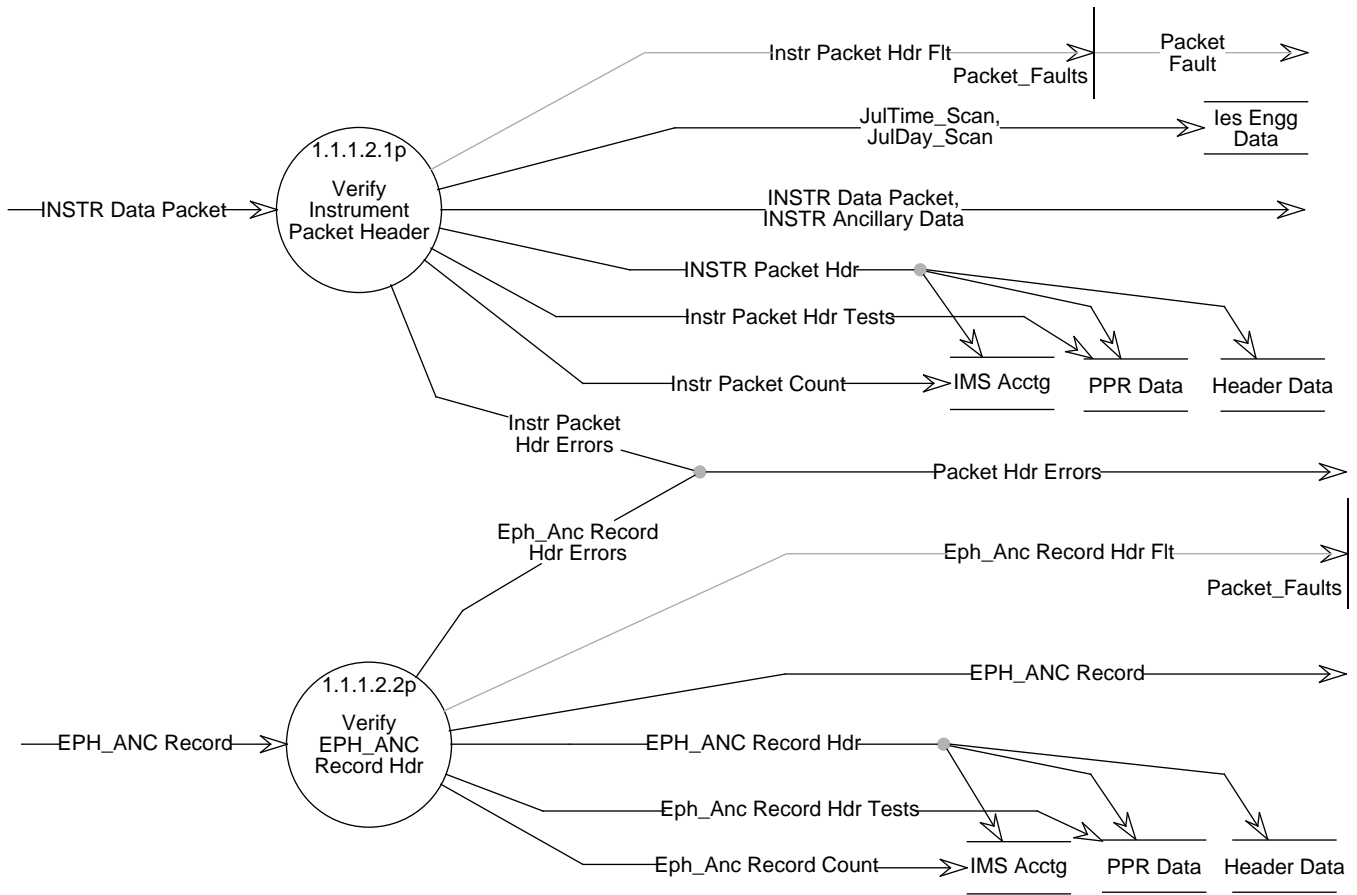


Figure 5-5. Data Flow Diagram for Validate Packet Headers

JulTime Scan
Packet Hdr Errors

Process Specification (Figure 5-5):

1. Shall verify CERES packet header data, as shown in Table 5-1, is consistent with CCSDS header format and platform information.
2. Shall verify CERES packet header is consistent with the APID within the file header.
3. Shall validate time stamp within each and all packet headers and verify sequential progress.
4. Shall convert time to Universal time and to Julian day and time based on the CCSDS time code conversion algorithm associated with the specific platform.
5. Shall correct time to adjust for spacecraft time errors and leap seconds.
6. Shall process the last data packet in the 24-hour data file.
7. Shall not continue processing a packet should errors occur in the headers.
8. Shall generate a daily log file for showing packet and time header status and error discrepancies.
9. Shall count the number of packets processed for IMS accounting.

Table 5-1. Instrument Packet Header Data Elements

INSTR Packet Header			
Parameter	No. of Bits	Value/Range	Meaning
Primary Header: 48 Total Bits			
Version_Number	3	= 000 (binary)	-> TRMM/EOS Telemetry Source Packet
Packet_Type	1	= 0	-> a telemetry packet
Secondary_Header_Flag	1	= 1	-> secondary header exists
APID	11	= 54 = 55 = 56 = 131 = 132 = 133 = 167 = 168 = 169 = TBD*	-> TRMM Science APID -> TRMM Calibration APID -> TRMM Diagnostic APID -> EOS-AM (Fore) Science APID -> EOS-AM (Fore) Calibration APID -> EOS-AM (Fore) Diagnostic APID -> EOS-AM (Aft) Science APID -> EOS-AM (Aft) Calibration APID -> EOS-AM (Aft) Diagnostic APID -> EOS-PM APIDs
Segment_Flags	2	= 11 (binary) = TBD*	-> Value for TRMM and EOS-PM -> Reserved on EOS-AM for users
Source_Sequence_Count	14	= 0 -> 16383	-> packet sequential order by APID
Packet_Length	16	= 0 -> 65535	-> size of the data packet in octets
Secondary Header: 64 Total Bits (TRMM), 72 Total Bits (EOS-AM and EOS-PM)			
FOR TRMM:			
INSTR_Time_Data	64	Varies	-> CCSDS Unsegmented Time Code
FOR EOS-AM:			
Secondary_Header_ID_Flag	1	= 0	-> Non-CCSDS secondary header
INSTR_Time_Data	63	Varies	-> CCSDS Day Segmented Time Code
Quick-look_Flag	1	= 0 = 1	-> production data -> quick-look data
User_Flags	7	= TBD*	-> Reserved for users (currently set to 0s)
FOR EOS-PM:			
Secondary_Header_ID_Flag	1	= 0	-> Non-CCSDS secondary header
Quick-look_Flag	1	= 0 = 1	-> production data -> quick-look data
User_Flags	6	= TBD*	-> Reserved for users (currently set to 0s)
INSTR_Time_Data	64	Varies	-> CCSDS Unsegmented Time Code (with explicit P-field)

*TBD will be finalized during software development phase.

5.2.1.1.2.2 Verify EPH ANC Record Hdr - Process 1.1.1.2.2

Input Data Flows

EPH ANC Record

Output Data Flows

EPH ANC Record
EPH ANC Record Hdr
Eph Anc Record Count
Eph Anc Record Hdr Errors
Eph Anc Record Hdr Tests
Packet Hdr Errors

Process Specification (Figure 5-5):

1. Shall verify CERES packet header is consistent with CCSDS header format and platform information. Detailed data content will be available during the CERES software development phase.
2. Shall verify CERES packet header is consistent with the APID within the file header.
3. Shall interrogate and verify platform ancillary data record header.
4. Shall interrogate and verify platform ephemeris data record header.
5. Shall validate time record within each and all record/packet headers and verify sequential progress. Verify begin and end times encompasses INSTR_PDS/INSTR_QLKD packet times. Fetch and verify overlapping records if necessary.
6. Shall convert record spacecraft time to Julian day and time.
7. Shall not continue processing a record/packet should errors occur in the headers.
8. Shall generate a daily log file for showing record/packet and time header status and error discrepancies.
9. Shall count the number of records/packets processed for IMS accounting.

5.2.1.2 Validate Platform Data - Process 1.1.2

Input Data Flows

EPH ANC Record
INSTR Ancillary Data
IPFCOEF Data

Output Data Flows

DeepSpace Flag
EPH ANC Record
Eph Anc Engg Data
Eph Anc PPR Data
Eph Anc Trend Data

Process Description (Figure 5-2):

1. Interrogate, verify, and validate platform ancillary data.
 - a) Convert status data from the EOS-AM sourced INSTR Ancillary Data to their corresponding representations.
 - b) Interrogate ancillary status data to determine operating modes, command history, attitude control configurations, and spacecraft
 - c) Generate a daily log file for showing time ordered processor commands, instrument state, and any comparison error discrepancies.
2. Interrogate, verify, and validate ephemeris data.
 - a) Compute engineering units from engineering count data for EOS-AM sourced INSTR Ancillary Data and perform limit checks on all data.
 - b) Verify ephemeris position data by comparing to predicted angles and spacecraft commands.
3. Output EOS-AM sourced INSTR Ancillary Data or TRMM sourced EPH Anc Record data as converted EPH Anc Record.

The decomposition of this function is shown in Figure 5-6.

5.2.1.2.1 Evaluate Ephemeris Record - Process 1.1.2.1

Input Data Flows

EPH Anc Record
INSTR Ancillary Data
IPFCOEF Data
Orbital Ephemeris

Output Data Flows

EPH Anc Record
Eph Anc Engg Data
Eph Anc PPR Data
Eph Anc Trend Data
Eph Engg Data
Eph PPR Data
Eph Trend Data
Orbital Ephemeris

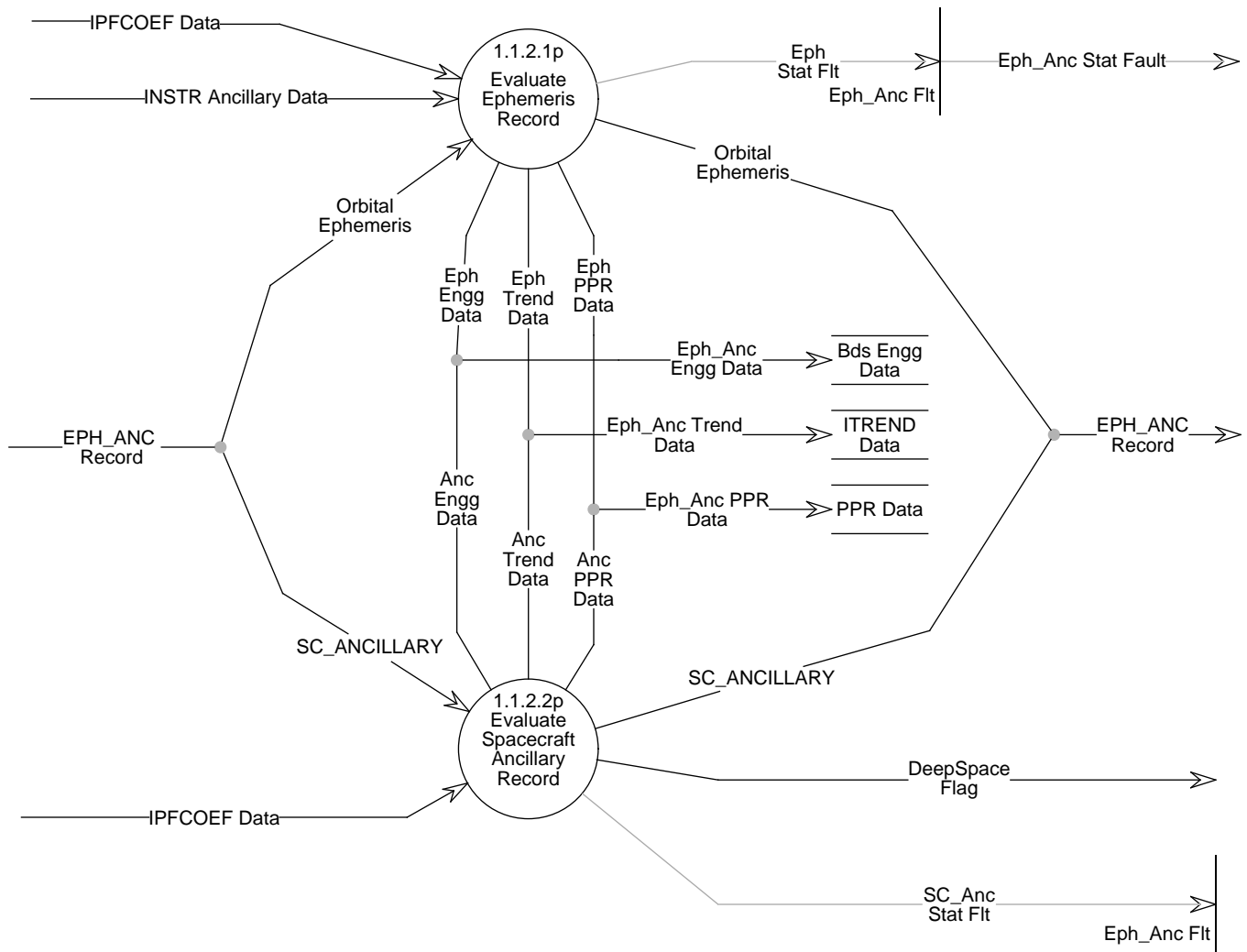


Figure 5-6. Data Flow Diagram for Validate Platform Data

Process Specification (Figure 5-6):

1. Shall verify engineering values and perform limit checks on the input ephemeris data (Table 5-2).
 - a) Shall convert raw INSTR ancillary data from the instrument data packet to physical ephemeris representations.

Table 5-2. Orbital Ephemeris Data Elements

Orbital Ephemeris	
Parameter	Value/Range
Time_Eph	= TBD *
Dist_SC_Alt	= TBD *
Dist_Earth_Sun	= TBD *
OrbNum	= TBD *
Postn_SC_X	= TBD *
Postn_SC_Y	= TBD *
Postn_SC_Z	= TBD *
Vel_SC_X	= TBD *
Vel_SC_Y	= TBD *
Vel_SC_Z	= TBD *
Att_SC_Roll	= TBD *
Att_SC_Pitch	= TBD *
Att_SC_Yaw	= TBD *
Rate_SC_Roll	= TBD *
Rate_SC_Pitch	= TBD *
Rate_SC_Yaw	= TBD *
Postn_Sol_X	= TBD *
Postn_Sol_Y	= TBD *
Postn_Sol_Z	= TBD *
Postn_Lun_X	= TBD *
Postn_Lun_Y	= TBD *
Postn_Lun_Z	= TBD *

*TBD's will be defined during the software development phase when spacecraft parameters become known.

- b) Shall edit check the Orbital Ephemeris data.
2. Shall perform daily trending of all position, velocity, attitude, and rate data.
3. Shall report erroneous data results and halt processing of the current CERES science, calibration, or diagnostic record.

Note: Interpolating and calculating spacecraft, solar, and lunar positions corresponding to CERES samples is performed during geolocation operations.

5.2.1.2.2 Evaluate Spacecraft Ancillary Record - Process 1.1.2.2

Input Data Flows

EPH ANC Record
 IPFCOEF Data
 SC ANCILLARY

Output Data Flows

Anc Engg Data
 Anc PPR Data
 Anc Trend Data
 DeepSpace Flag
 EPH ANC Record
 Eph Anc Engg Data
 Eph Anc PPR Data
 Eph Anc Trend Data
 SC ANCILLARY

Process Specification (Figure 5-6):

1. Shall interrogate EOS-AM ancillary status data to determine operating modes, command history, attitude control configurations, and spacecraft direction.
2. Shall interrogate TRMM ancillary status data to determine operating modes, command history, attitude control configurations, and spacecraft direction.
3. Shall identify deep space platform maneuvers and set a flag for deep space calibration processing.
4. Shall use the spacecraft ancillary data parameters shown in Table 5-3 to perform the above requirements:

Table 5-3. Spacecraft Ancillary Data Elements

Spacecraft Ancillary Data	
Parameter	Value/Range
Dir_SC	= TBD *
Statword_SC_Mode	= TBD *
Cmd_SC	= TBD *
Cur_Sol_Array	= TBD *

*TBD's will be defined during software development phase when platform details are known.

5. Shall generate a daily log file for showing time ordered processor commands, spacecraft state, and any comparison error discrepancies.
6. Shall identify erroneous trends and determine if downstream processing of current record should continue.
 - a) Shall report results.

5.2.1.3 Convert Instrument Engg Data - Process 1.1.3

Input Data Flows

DeepSpace Flag
Digital Trend
IENGCDEF Data
INSTR Data Packet

Output Data Flows

Instr Cal Record
Instr Diag Record
Instr Engg Data
Instr PPR
Instr Sci Record
Instr Trend
JulTime

Process Description (Figure 5-2):

1. Convert and Evaluate Instrument Digital Status Data
 - a) Convert instrument digital status data to their physical representations.
 - b) Interrogate instrument status data to determine operating modes, command history, servo control configurations, internal calibration configuration, scan profile operation, and instrument processor state.
 - c) Compare status data to previous packet in the current data file to identify and verify change.
 - d) Generate a daily log file for showing time ordered processor commands, instrument state, and any comparison error discrepancies.
2. Convert and Evaluate Instrument Engineering Data
 - a) Compute engineering units from engineering count data and perform limit checks on converted data.
 - b) Identify erroneous data and determine if downstream processing should continue with the current packet, report results.

Note: Daily time series plots of all temperature and power measurements showing minimum, mean, and maximum values are performed during trending operations.

The decomposition of this function is shown in [Figure 5-7](#).

5.2.1.3.1 Convert & Evaluate Digital Status - Process 1.1.3.1

Input Data Flows

Digital Trend
IENGCOEF Data
INSTR Data Packet
Iengcoef Digital

Output Data Flows

Bds Digital Data
Digital PPR
Digital Trend
Instr Engg Data
Instr PPR
Instr Trend
Status Control

Process Description (Figure 5-7):

1. Convert instrument digital status data representing general instrument operation, covers, solar sensors, and calibration statuses to their physical representations.
2. Interrogate instrument digital status data to determine operating modes, command history, servo control configurations, internal calibration configuration, scan profile operation, and instrument state.
3. Compare status data to previous record to identify and verify change.
4. Generate a daily log file for showing time ordered processor commands, instrument state, and any comparison error discrepancies.

Note: The "Statword_" prefix used in the following digital status evaluation processes indicates instrument parameters that have discrete (i.e., integer) values.

The decomposition of this function is shown in [Figure 5-8](#).

5.2.1.3.1.1 Cover Status Check - Process 1.1.3.1.1

Input Data Flows

Cover Param
Prev Cover State
Raw Cover Op Status
Valid Cover

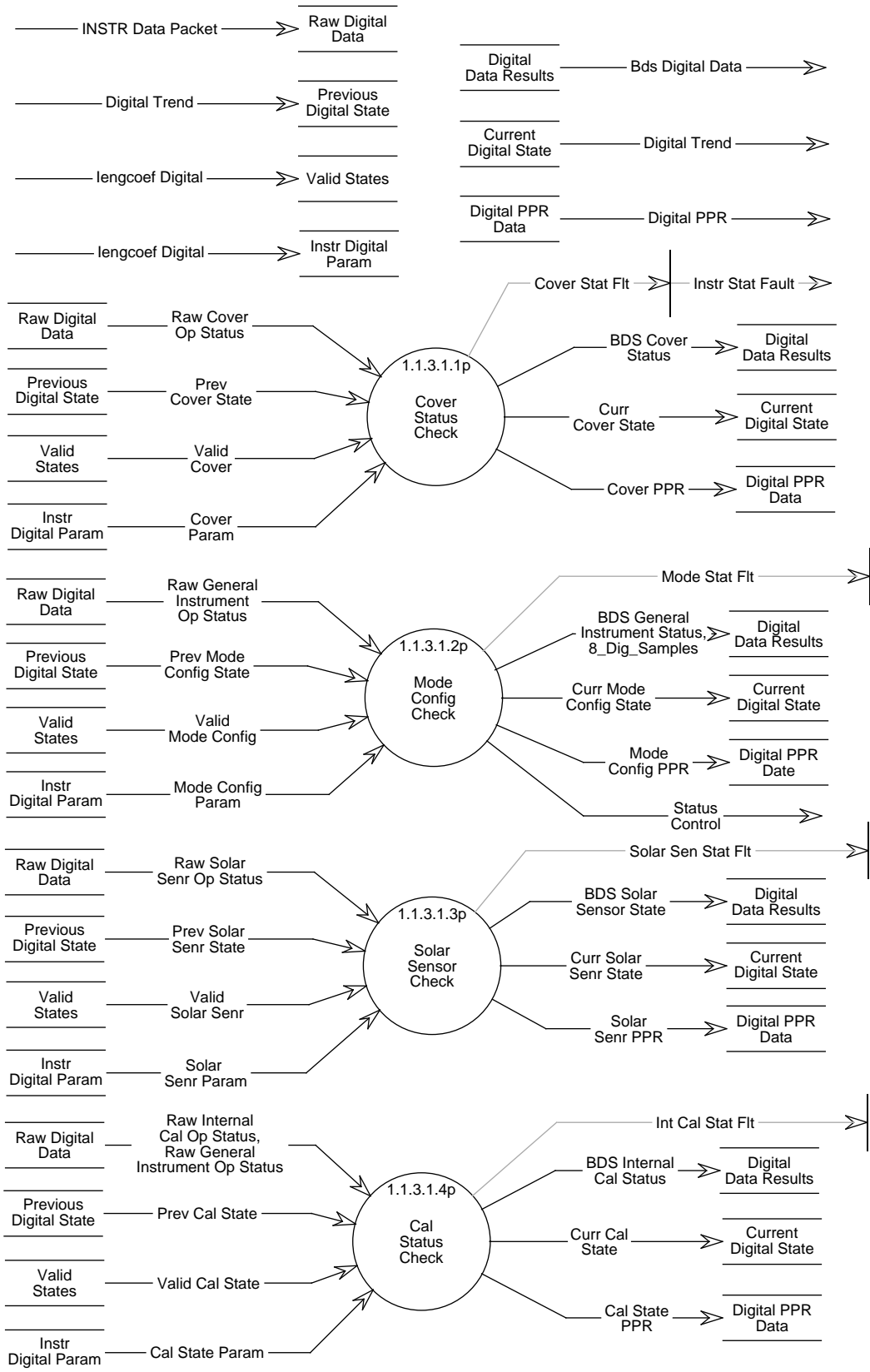


Figure 5-8. Data Flow Diagram for Convert & Evaluate Digital Status

Output Data Flows

BDS Cover Status
 Cover PPR
 Curr Cover State

Process Specification (Figure 5-8):

1. Shall verify instrument main and MAM cover statuses correspond to the valid representations shown in Tables 5-4 and 5-5.

Table 5-4. Raw Main Cover Status Data Elements

RAW_Main_Cover_Status	
Parameter	Value/Range
Statword_Cmd_Maincvr	0 = Stop 1 = Open 2 = Close 4 = Fixed Step Opening 5 = Fixed Step Closing 3,6-15 Not Used
Statword_Maincvr_Motion	0 = Cover Stopped 1 = Cover Opening 2 = Cover Closing 4 = Cover Stepping Forward 5 = Cover Stepping Reverse 3,6-14 Not Used 15 = Cover Started Moving
Statword_Maincvr_Pos	0 = Not at Open or Closed Position 1 = At Open Position 2 = At Closed Position 4 = Potential Bad Sensor 3,5-15 Not Used
Statword_Maincvr_Pos_Senr	0 = Cover Sensor 1 Active 1 = Cover Sensor 2 Active 2,3 Not Used
Statword_Maincvr_Cmd_Pos	0 -> 4095
Statword_Maincvr_Step_Cnt	0 -> 65535
Statword_Maincvr_Close_Pos_Def	0 -> 4095
Statword_Maincvr_Open_Pos_Def	0 -> 4095
Statword_Maincvr_Close_Margin_Def	0 -> 4095
Statword_Maincvr_Open_Margin_Def	0 -> 4095

then verify Cmd_Maincvr = 0	-> command to stop
or Cmd_Maincvr = 1	-> command to open
or Cmd_Maincvr = 4	-> command to fixed step open
or verify Maincvr_Pos = 2	-> at closed position
then verify Maincvr_Motion = 0	-> cover stopped
then verify Cmd_Maincvr = 0	-> cover commanded to stop
or Cmd_Maincvr = 2	-> close
or Cmd_Maincvr = 5	-> fixed step close

MAM Cover:

Verify MAMcvr_Pos_Senr = 0 or 1	-> position sensor active
then verify MAMcvr_Pos = 1	-> at open position
then verify MAMcvr_Motion = 0	-> cover stopped
then verify Cmd_MAMcvr = 0	-> command to stop
or Cmd_MAMcvr = 1	-> command to open
or Cmd_MAMcvr = 4	-> command to fixed step open
or verify MAMcvr_Pos = 2	-> at closed position
then verify MAMcvr_Motion = 0	-> cover stopped
then verify Cmd_MAMcvr = 0	-> cover commanded to stop
or Cmd_MAMcvr = 2	-> close
or Cmd_MAMcvr = 5	-> fixed step close

3. Shall verify main and MAM covers are opened for science and solar calibration APID data.
4. Shall store converted digital status data for comparisons with analog data.
5. Shall not process current science, calibration, or diagnostic packet if above conditions are false.
6. Shall generate a quality control report.

5.2.1.3.1.2 Mode Config Check - Process 1.1.3.1.2

Input Data Flows

Mode Config Param
 Prev Mode Config State
 Raw General Instrument Op Status
 Valid Mode Config

Output Data Flows

8 Dig Samples
BDS General Instrument Status
Curr Mode Config State
Mode Config PPR
Status Control

Process Specification (Figure 5-8):

1. Shall verify instrument mode statuses correspond to the valid representations shown in Table 5-6.

Table 5-6. Raw General Instrument Op Status Data Elements (1 of 2)

RAW_General_Instrument_Op_Status	
Parameter	Value/Range
Statword_Pckt_Data_Indic	0 = Normal Science Data Packet 1 = Calibration Data Packet 2 = Memory Dump Data Packet 3 = Gimbal Data Packet 4 = Execution Time Data Packet 5 = 'No Arch' Science Data Packet 6-15 Not Used
Statword_Pckt_Data_Versn	0 -> 32
Statword_Timecode_Indicr	0 = Timecode based on Spacecraft Timing 1 = Timecode based on Instrument Timing
Statword_Pckt_Cnt	0 -> 65535
Statword_InstrNum	0 = FTM 1 = PFM 2 = FM1 3 = FM2 4 = FM3 5 = FM4 6 = FM5 7-63 Not Used
Statword_Instr_Mode	0 = Safe Mode 1 = Standby Mode 2 = Crosstrack Mode 3 = Biaxial Mode 4 = Solar Calibration Mode 5 = Diagnostic Configuration Mode 6-14 Unused Modes 1-9, Respectively 15 = Internal Calibration Mode 16-31 Not Used

Table 5-6. Raw General Instrument Op Status Data Elements (2 of 2)

RAW_General_Instrument_Op_Status	
Parameter	Value/Range
Statword_Instr_Prev_Mode	0 = Safe Mode 1 = Standby Mode 2 = Crosstrack Mode 3 = Biaxial Mode 4 = Solar Calibration Mode 5 = Diagnostic Configuration Mode 6-14 Unused Modes 1-9, Respectively 15 = Internal Calibration Mode 16-31 Not Used
Statword_Mode_Chg	0 = Command 1 = Safe Hold 2 = Solar Avoidance 3-7 Not Used
Statword_Instr_Cmd_Cnt	0 -> 65535
Statword_Instr_Err_Cnt	0 -> 65535
Statword_Seq_Cmd_Indx	0 -> 29
Statword_Seq_Exec	0 = Executing Sequence Commands 1 = Waiting for Next Scan Period 2 = Sequence Complete 3-7 Not Used
Statword_Seq_Next_Cmd	0 -> 255
Statword_SC_Safhld_A_Inp	0 = Normal Operation 1 = Spacecraft Safe Hold
Statword_SC_Safhld_B_Inp	0 = Normal Operation 1 = Spacecraft Safe Hold
Statword_SC_Safhld_A_Resp	0 = Response Disabled 1 = Response Enabled
Statword_SC_Safhld_B_Resp	0 = Response Disabled 1 = Response Enabled
RAW_8_Dig_Samples	
Statword_Instr_Cmd_Echo	N/A *
Statword_Instr_Err_Stack	N/A *

*Indicates that these values have not been defined by TRW in DRL-64.

2. Shall test for the following valid logic conditions (The Statword_ prefix has been eliminated for simplicity):

Verify SC_Safhld_A_Inp = 0	-> normal operation
and SC_Safhld_A_Resp = 1	-> response enabled
Verify SC_Safhld_B_Inp = 0	-> normal operation
and SC_Safhld_B_Resp = 1	-> response enabled
Verify Mode_Chg = 0	-> command
Verify Seq_Exec = 2	-> sequence complete
then verify Instr_Mode = 2	-> crosstrack mode
then verify Instr_Prev_Mode = 1	-> standby mode
or Instr_Prev_Mode = 3	-> biaxial mode
or Instr_Prev_Mode = 15	-> internal calibration mode
and Pckt_Data_Indicr = 0	-> normal science data packet
or verify Instr_Mode = 3	-> biaxial mode
then verify Instr_Prev_Mode = 1	-> standby mode
or Instr_Prev_Mode = 2	-> crosstrack mode
or Instr_Prev_Mode = 15	-> internal calibration mode
and Pckt_Data_Indicr = 0	-> normal science data packet
or verify Instr_Mode = 4	-> solar calibration mode
then verify Instr_Prev_Mode = 1	-> standby mode
and Pckt_Data_Indicr = 1	-> calibration data packet
or verify Instr_Mode = 5	-> diagnostic configuration mode
then verify Instr_Prev_Mode = 0	-> safe mode
and Pckt_Data_Indicr = 2	-> memory dump data packet
or Pckt_Data_Indicr = 3	-> gimbal data packet
or Pckt_Data_Indicr = 4	-> execution time data packet
or verify Instr_Mode = 15	-> internal calibration mode
then verify Instr_Prev_Mode = 2	-> crosstrack mode
or Instr_Prev_Mode = 3	-> biaxial mode

and Pckt_Data_Indicr = 0	-> normal science data packet
or verify Mode_Chg = 2	-> solar avoidance
Verify Seq_Exec = 2	-> sequence complete
then verify Instr_Mode = 3	-> biaxial mode
then verify Instr_Prev_Mode = 1	-> standby mode
or Instr_Prev_Mode = 2	-> crosstrack mode
or Instr_Prev_Mode = 3	-> biaxial mode
or Instr_Prev_Mode = 15	-> internal calibration mode
and Pckt_Data_Indicr = 0	-> normal science data packet

3. Shall verify valid configurations are consistent with file and packet header information.
4. Shall verify modes and configurations are consistent for collecting science data in fixed azimuth or biaxial modes.
5. Shall compare current packet state with previous packet state and report changes.
6. Shall store converted digital status data for comparison with converted analog data.
7. Shall not process science, calibration, or diagnostic configuration packets if above conditions are not valid.
8. Shall generate a summary report on current state of the instrument for each production run.

5.2.1.3.1.3 Solar Sensor Check - Process 1.1.3.1.3

Input Data Flows

Prev Solar Senr State
Raw Solar Senr Op Status
Solar Senr Param
Valid Solar Senr

Output Data Flows

BDS Solar Senr Status
Curr Solar Senr State
Solar Senr PPR

Process Specification (Figure 5-8):

1. Shall verify the solar sensor statuses correspond to the valid representations shown in Table 5-7.

Table 5-7. Raw Solar Senr Op Status Data Elements

RAW_Solar_Senr_Op_Status	
Parameter	Value/Range
Statword_Sol_Warning	0 = no solar present (*) 1 = SPS1 solar present, action taken (*) 2 = SPS2 solar present, action taken (*)
Statword_Sol_Warn_Sample	0 -> 659
Statword_Sol_Warn_Scan_Period	0 -> 65535
Statword_Scan_Time_Resp_Cntl	0 = response disabled (*) 1 = response enabled (*)
Statword_Scan_Time_Maint	0 -> 1 = TBD *
Statword_Scan_Time_Event	0 -> 1 = TBD *
Statword_Scan_Time_Period	0 -> 65535
Statword_Scan_Init_Cnt	0 -> 659
Statword_Scan_Curr_Cnt	0 -> 659
Statword_Pres_SPS1	0 = no solar present (*) 1 = solar present (*)
Statword_Resp_Cntl_SPS1	0 = sensor disabled (*) 1 = sensor enabled (*)
Statword_NoI_Thres_SPS1	0 -> 4095
Statword_Scal_Numer_Thres_SPS	0 -> 64
Statword_Cnt_Thres_SPS1	0 -> 63
Statword_Cnt_Max_Scan_SPS1	0 -> 60
Statword_Pres_SPS2	0 = no solar present (*) 1 = solar present (*)
Statword_Resp_Cntl_SPS2	0 = sensor disabled (*) 1 = sensor enabled (*)
Statword_NoI_Thres_SPS2	0 -> 4095
Statword_Scan_Numer_Thres_SPS2	0 -> 64
Statword_Cnt_Thres_SPS2	0 -> 63
Statword_Cnt_Max_Scan_SPS2	0 -> 60

*TBD's indicate undefined statuses based on TRW's DRL-64.

2. Shall verify that the Solar Presence Sensors did not detect solar interference during science data collection.
3. Shall store converted digital status data for comparison with analog data.
4. Shall not process science data records if any of the above conditions are invalid or the Sun was present.
5. Shall report results.

5.2.1.3.1.4 Cal Status Check - Process 1.1.3.1.4

Input Data Flows

- Cal State Param
- Prev Cal State
- Raw General Instrument Op Status
- Raw Internal Cal Op Status
- Valid Cal State

Output Data Flows

- BDS Internal Cal Status
- Cal State PPR
- Curr Cal State

Process Specification (Figure 5-8):

1. Shall verify that calibration statuses correspond to the valid representations shown in Table 5-8.

Table 5-8. Raw Internal Cal Op Status Data Structure

RAW_Internal_Cal_Op_Status	
Parameter	Value/Range
Statword_BB_Temp_Setpt	0 -> 4095
Statword_BB_Temp_Cntl	0 = Temperature Control Off 1 = Temperature Control On 2,3 Not Used
Statword_Cmd_Inten_SWICS	0 = SWICS Lamp Off 1 = SWICS Lamp @ Level 1 2 = SWICS Lamp @ Level 2 3 = SWICS Lamp @ Level 3

2. Shall test the following logic conditions for validity (the Statword_ prefix has been eliminated for simplicity):

If Instr_Mode = 15

-> internal calibration

then verify BB_Temp_Cntl = 1	-> temperature control on
or BB_Temp_Cntl = 0	-> temperature control off
then verify Cmd_Inten_SWICS = 0	-> lamp off
or Cmd_Inten_SWICS = 1	-> lamp @ Level 1
or Cmd_Inten_SWICS = 2	-> lamp @ Level 2
or Cmd_Inten_SWICS = 3	-> lamp @ Level 3

3. Shall not process internal calibration data if above conditions are not valid.
4. Shall store converted digital status data for comparison with analog data.
5. Shall report results.

5.2.1.3.2 Convert & Evaluate Digital Operation Status - Process 1.1.3.2

Input Data Flows

Digital Trend
 IENGCOEF Data
 INSTR Data Packet
 Iengcoef Digital

Output Data Flows

Bds Digital Data
 Digital PPR
 Digital Trend
 Instr Engg Data
 Instr PPR
 Instr Trend

Process Description (Figure 5-7):

1. Convert instrument digital status data representing digital engineering, gimbal operation, and processor operation information to their engineering equivalents.
2. Interrogate gimbal status data to determine operating modes, command history, servo control configurations, sensor bridge balances, scan profile operation, and instrument processor states.
3. Compare status data to previous packet to identify and verify change.
4. Generate a daily log file for showing time ordered processor commands, instrument state, and any comparison error discrepancies.

The decomposition of this function is shown in [Figure 5-9](#).

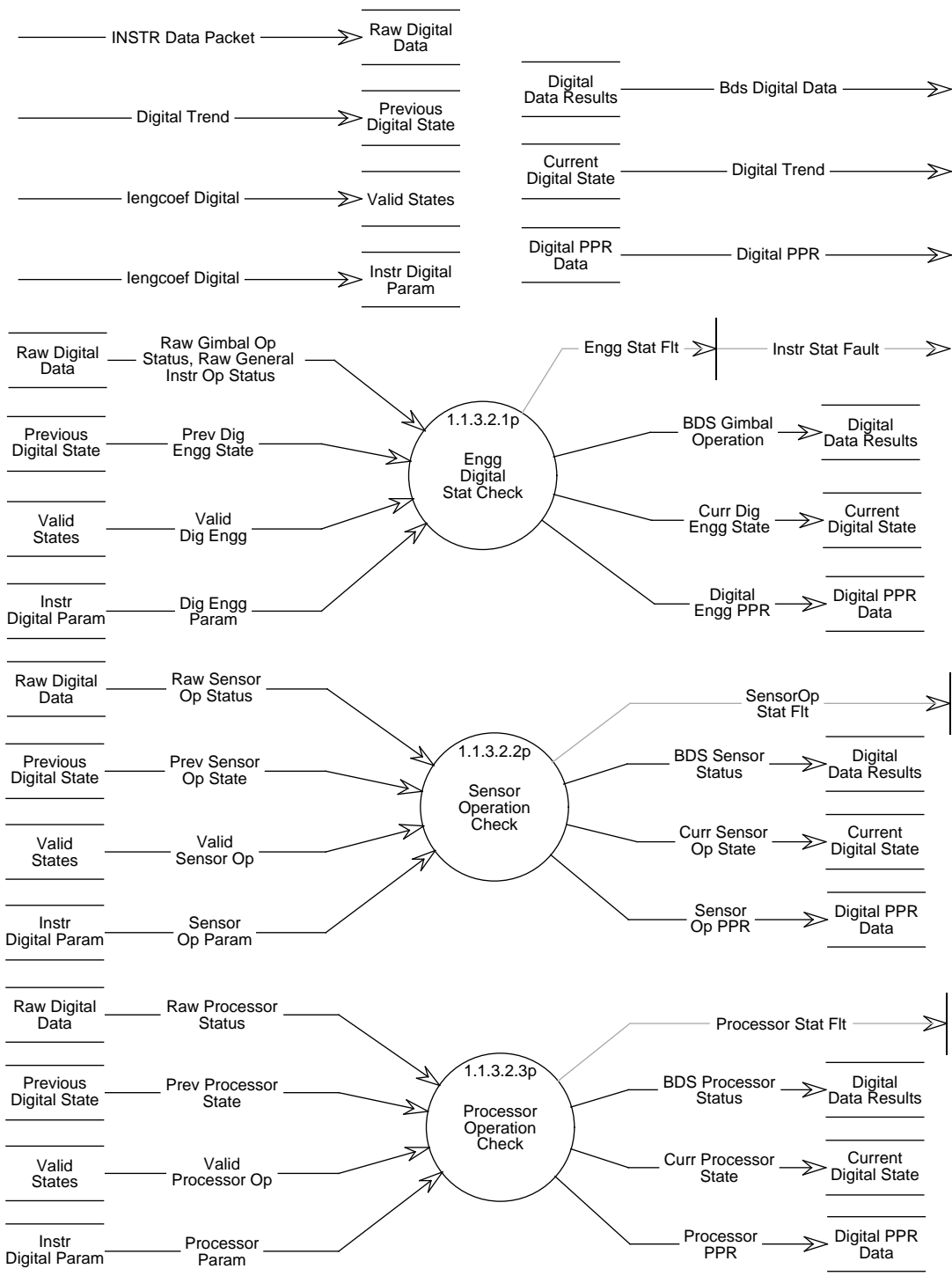


Figure 5-9. Data Flow Diagram for Convert and Evaluate Digital Operation Status

5.2.1.3.2.1 Engg Digital Stat Check - Process 1.1.3.2.1

Input Data Flows

Dig Engg Param
 Prev Dig Engg State
 Raw General Instrument Op Status
 Raw Gimbal Op Status
 Valid Dig Engg

Output Data Flows

BDS Gimbal Operation
 Curr Dig Engg State
 Digital Engg PPR

Process Specification (Figure 5-9):

1. Shall verify that digital engineering statuses correspond to the valid representations shown in Table 5-9.

Table 5-9. Raw Gimbal Op Status Data Elements (1 of 4)

Raw_Gimbal_Op_Status	
Parameter	Value/Range
RAW_Elevation_Status	
Statword_Elev	0 = Nominal Scan Operation 1 = Initialization In-Progress 2 = Elevation at Initialized Position 3 Not Used
Statword_Elev_Scan_Mode	0 = Stow 1 = Normal Earth Scan 2 = Short Earth Scan 3 = MAM Scan 4 = Nadir Scan 5-15 = Spares 1-11, respectively 16-31 Not Used
Statword_Cmd_Ondk_Elev_Scan	0 = Stow 1 = Normal Earth Scan 2 = Short Earth Scan 3 = MAM Scan 4 = Nadir Scan 5-15 = Spares 1-11, respectively 16-31 Not Used

Table 5-9. Raw Gimbal Op Status Data Elements (2 of 4)

Raw_Gimbal_Op_Status	
Parameter	Value/Range
Statword_Elev_Motor	0 = Drive Disabled 1 = Drive Enabled
Statword_Elev_LED_Lev	0 = Low Encoder LED Intensity 1 = High Encoder LED Intensity
Statword_Elev_Stall	0 = Elevation Motor Not Stalled (?) 1 = Elevation Motor Stalled (?)
Statword_Elev_Offset_Corr	0 -> 360
Statword_Elev_Stall_Error	0 -> 65535
Statword_Elev_Error_Cnt	0 -> 65535
RAW_Azimuth_Status	
Statword_Az_Scan_Mode	0 = Go to Crosstrack 1 = Go to Position A 2 = Go to Position B 3 = Go to Solar Calibration Angle 4 = Go to Cage 5-7 = Go to spare position 1-3, respectively 8 = Scan A to B Asynchronously 9 = Scan A to B Synchronously 10 = Stop Azimuth 11-15 Not Used 16-31 Not Available
Statword_Az_Motion	0 = Stopped 1 = Moving
Statword_Az_Direct	0 = Forward 1 = Reverse
Statword_Az_Pos	0 = At Go to Position 1 = At Stopped Position 2 = At Initial Position 3 = At Scan Position 4 = In Motion 5-15 Not Used
Statword_Az_Motor	0 = Drive Disabled 1 = Drive Enabled
Statword_Az_LED_Lev	0 = Low Encoder LED Intensity 1 = High Encoder LED Intensity
Statword_Az_Stall	0 = Azimuth Motor Not Stalled (?) 1 = Azimuth Motor Stalled (?)

Table 5-9. Raw Gimbal Op Status Data Elements (3 of 4)

Raw_Gimbal_Op_Status	
Parameter	Value/Range
Statword_Az_Offset_Corr	0 -> 360
Statword_Az_Stall_Error	0 -> 65535
Statword_Az_Error_Cnt	0 -> 65535
RAW_Azimuth_Definition_Status	
Statword_Postn_Defn_Xtrk	0 -> 360
Statword_Postn_Defn_Cal	0 -> 360
Statword_Postn_Defn_A	0 -> 360
Statword_Postn_Defn_B	0 -> 360
Statword_Postn_Defn_Cage	0 -> 360
Statword_Postn_Defn_Spare1	0 -> 360
Statword_Postn_Defn_Spare2	0 -> 360
Statword_Postn_Defn_Spare3	0 -> 360
Statword_Rate_Defn_Norm	4 -> 6
Statword_Rate_Defn_Unsync	4 -> 6
Statword_Rate_Defn_Sync	4 -> 6
Statword_Brk_Cmd	0 = Stop 1 = Cage 2 = Apply 3 = Release 4 = Fixed Step Toward Cage 5 = Fixed Step Toward Applied 6-15 Not Used
Statword_Brk_Motion	0 = Stopped 1 = Caging 2 = Applying 3 = Releasing 4 = Forward Stepping 5 = Reverse Stepping 6-14 Not Used 15 = Start Moving

Table 5-9. Raw Gimbal Op Status Data Elements (4 of 4)

Raw_Gimbal_Op_Status	
Parameter	Value/Range
Statword_Brk_Pos	0 = Not At Release or Cage Position 1 = At Caged Position 2 = At Applied Position 3 = At Released Position 4 = Potential Bad Position Sensor 5-15 Not Used
Statword_Brk_Cmd_Pos	0 -> 4095
Statword_Brk_Step_Cnt	0 -> 65535
Statword_Brk_Rels_Postn_Defn	0 -> 4095
Statword_Brk_App_Postn_Defn	0 -> 4095
Statword_Brk_Cage_Postn_Defn	0 -> 4095
Statword_Brk_Rels_Margin	0 -> 4095
Statword_Brk_App_Margin	0 -> 4095
Statword_Brk_Cage_Margin	0 -> 4095

Note: Values with a (?) are TBD values.

2. Shall test the following elevation gimbal logic conditions for validity (the Statword_ prefix has been eliminated for simplicity):

```

If Instr_Mode = 2                                -> crosstrack mode

    then verify Elev_Motor = 1                    -> enabled
         and verify Elev_Stall = 0                -> not stalled

    then verify Elev = 0                          -> nominal scan operation

         and verify Elev_Scan_Mode = 1            -> normal Earth scan
         or   Elev_Scan_Mode = 4                  -> nadir scan

If Instr_Mode = 3                                -> biaxial mode

    then verify Elev_Motor = 1                    -> enabled
         and verify Elev_Stall = 0                -> not stalled

    then verify Elev = 0                          -> nominal scan operation
    
```


- | | |
|---|-------------------------------|
| and verify Elev_Scan_Mode = 1 | -> normal Earth scan |
| or Elev_Scan_Mode = 2 | -> short Earth scan |
| or Elev_Scan_Mode = 4 | -> nadir scan |
|
If Instr_Mode = 4 |
-> solar cal mode |
| then verify Elev_Motor = 1 | -> enabled |
| and verify Elev_Stall = 0 | -> not stalled |
|
then verify Elev = 0 |
-> nominal scan operation |
| and verify Elev_Scan_Mode = 3 | -> MAM scan |
|
If Instr_Mode = 15 |
-> internal calibration |
| then verify Elev_Motor = 1 | -> enabled |
| and verify Elev_Stall = 0 | -> not stalled |
|
then verify Elev = 0 |
-> nominal scan operation |
| and verify Elev_Scan_Mode = 1 | -> normal Earth scan |
|
3. Shall test the following azimuth gimbal logic conditions for validity (the Statword_ prefix has been eliminated for simplicity): | |
|
If Instr_Mode = 2 |
-> crosstrack mode |
| then verify Az_Motor = 1 | -> drive enabled |
| and verify Az_Stall = 0 | -> not stalled |
|
then verify Brk_Pos = 3 |
-> at released position |
|
then verify Az_Pos = 3 |
-> at scan position |
|
then verify Az_Motion = 0 |
-> stopped |
|
then verify Az_Scan_Mode = 0 |
-> go to crosstrack |
|
If Instr_Mode = 3 |
-> biaxial mode |
| then verify Az_Motor = 1 | -> drive enabled |
| and verify Az_Stall = 0 | -> not stalled |
|
then verify Brk_Pos = 3 |
-> at released position |
|
then verify Az_Pos = 4 |
-> in motion |

then verify Az_Motion = 1	-> moving
then verify Az_Scan_Mode = 8 or Az_Scan_Mode = 9	-> scan A/B asynchronously -> scan A/B synchronously
If Instr_Mode = 4	-> solar cal mode
then verify Az_Motor = 1 and verify Az_Stall = 0	-> drive enabled -> not stalled
then verify Brk_Pos = 3	-> at released position
then verify Az_Pos = 0	-> at Go To position
then verify Az_Motion = 0	-> stopped
then verify Az_Scan_Mode = 3	-> go to solar calibration angle

4. Shall store converted digital engineering data for comparison in analog engineering conversion process for validations.
5. Shall not process science, calibration, or diagnostic data records if any of the above conditions are not valid.
6. Shall report all results.

5.2.1.3.2.2 Sensor Operation Check - Process 1.1.3.2.2

Input Data Flows

Prev Sensor Op State
Raw Sensor Op Status
Sensor Op Param
Valid Sensor Op

Output Data Flows

BDS Sensor Status
Curr Sensor Op State
Sensor Op PPR

Process Specification (Figure 5-9):

1. Shall verify digital sensor operation statuses correspond to the valid representations shown in [Table 5-10](#).

Table 5-10. Raw Sensor Op Status Data Element (1 of 2)

RAW_Sensor_Op_Status	
Parameter	Value/Range
RAW_Detector_Controls	
Statword_SW_Temp_Setpt	0 -> 4095
Statword_Wn_Temp_Setpt	0 -> 4095
Statword_Tot_Temp_Setpt	0 -> 4095
Statword_SW_Temp_Cntl	0 = Temperature Control Off 1 = Temperature Control On 2,3 Not Used
Statword_Wn_Temp_Cntl	0 = Temperature Control Off 1 = Temperature Control On 2,3 Not Used
Statword_Tot_Temp_Cntl	0 = Temperature Control Off 1 = Temperature Control On 2,3 Not Used
RAW_Total_Det_Bridge_Bal	
Statword_Tot_Cors_Brid_DAC	0 -> 4095
Statword_Tot_Fine_Brid_DAC	0 -> 4095
Statword_Tot_Brid_Cntl	0 = Bridge Balance Off 1 = Bridge Balance Maintenance 2 = Bridge Balance Reset 3-7 Not Used
Statword_Tot_Brid_DAC_Update	0 = DAC Value Changed 1 = DAC Value Unchanged
Statword_Tot_Brid_Reset_Cnt	0 -> 24 25-31 Not Used
RAW_SW_Det_Bridge_Bal	
Statword_SW_Cors_Brid_DAC	0 -> 4095
Statword_SW_Fine_Brid_DAC	0 -> 4095
Statword_SW_Brid_Cntl	0 = Bridge Balance Off 1 = Bridge Balance Maintenance 2 = Bridge Balance Reset 3-7 Not Used
Statword_SW_Brid_DAC_Update	0 = DAC Value Changed 1 = DAC Value Unchanged

Table 5-10. Raw Sensor Op Status Data Element (2 of 2)

RAW_Sensor_Op_Status	
Parameter	Value/Range
Statword_SW_Brid_Reset_Cnt	0 -> 24 25-31 Not Used
RAW_Wn_Det_Bridge_Bal:	
Statword_Wn_Cors_Brid_DAC	0 -> 4095
Statword_Wn_Fine_Brid_DAC	0 -> 4095
Statword_Wn_Brid_Cntl	0 = Bridge Balance Off 1 = Bridge Balance Maintenance 2 = Bridge Balance Reset 3-7 Not Used
Statword_Wn_Brid_DAC_Update	0 = DAC Value Changed 1 = DAC Value Unchanged
Statword_Wn_Brid_Reset_Cnt	0 -> 24 25-31 Not Used
RAW_Bridge_Bal_Status:	
Statword_Wn_Brid_Low	0 -> 4095
Statword_Wn_Brid_Hi	0 -> 4095
Statword_Brid_Setpt	0 -> 4095
Statword_Start_Brid_Spacck	0 -> 659
Statword_End_Brid_Spacck	0 -> 659
Statword_Updt_Brid_DAC	0 -> 659
RAW_Space_Look_Status	
Statword_SW_Spacck_Avg	0 -> 4095
Statword_Wn_Spacck_Avg	0 -> 4095
Statword_Tot_Spacck_Avg	0 -> 4095

2. Shall test the following logic conditions for validity (the Statword_ prefix has been eliminated for simplicity):

Detector Controls:

Verify Tot_Temp_Cntl = 1	-> temperature control on (i.e., enabled)
Verify SW_Temp_Cntl = 1	-> temperature control on (i.e., enabled)
Verify Wn_Temp_Cntl = 1	-> temperature control on (i.e., enabled)

Bridge Balance Controls:

Verify Tot_Brid_Cntl = 1 -> bridge balance maintenance
and Tot_Brid_DAC_Update = 1 -> DAC value unchanged

Verify SW_Brid_Cntl = 1 -> bridge balance maintenance
and SW_Brid_DAC_Update = 1 -> DAC value unchanged

Verify Wn_Brid_Cntl = 1 -> bridge balance maintenance
and Wn_Brid_DAC_Update = 1 -> DAC value unchanged

3. Shall store converted digital engineering data for comparison in analog engineering conversion process for validations.
4. Shall not process science, calibration, or diagnostic data records if any of the above conditions are not valid.
5. Shall report results.

5.2.1.3.2.3 Processor Operation Check - Process 1.1.3.2.3

Input Data Flows

Prev Processor State
Processor Param
Raw Processor Status
Valid Processor Op

Output Data Flows

BDS Processor Status
Curr Processor State
Processor PPR

Process Specification (Figure 5-9):

1. Shall verify digital processor statuses correspond to the valid representations shown in Table 5-11.

Table 5-11. Raw Processor Status Data Elements (1 of 2)

RAW_Processor_Status	
Parameter	Value/Range
RAW_DAP_Status	
Statword_DAP_Boot	0 = Reset Not Caused by Watchdog Timer 1 = Reset Caused by Watchdog Timer
Statword_DAP_Wtchdg_Enable	0 = Disarm Watchdog Timer 1 = Arm Watchdog Timer
Statword_DAP_PROM_Pwr	0 = PROM Power Off 1 = PROM Power On
Statword_DAP_Scan_Cnt	0 -> 65535
Statword_DAP_Mem_Dump_Start_Add_Ofst	0000 -> FFFF
Statword_DAP_Mem_Dump_Start_Add_Segm	0000 -> FFFF
Statword_DAP_Mem_Dump_End_Add_Ofst	0000 -> FFFF
Statword_DAP_Mem_Dump_End_Add_Segm	0000 -> FFFF
Statword_DAP_Mem_Dump_Pckt_Add_Ofst	0000 -> FFFF
Statword_DAP_Mem_Dump_Pckt_Add_Segm	0000 -> FFFF
Statword_Exec_Time_Min_DAP	0.0 -> 10.0
Statword_Exec_Samp_Min_DAP	0 -> 659
Statword_Exec_Time_Max_DAP	0.0 -> 10.0
Statword_Exec_Samp_Max_DAP	0 -> 659
Statword_DAP_RAM_Code_Cksum	0000 -> FFFF
Statword_DAP_ROM_Cksum	0000 -> FFFF
RAW_ICP_Status	
Statword_ICP_DAP_Comm	0-3 = TBD *
Statword_ICP_Boot	0 = Reset Not Caused by Watchdog Timer 1 = Reset Caused by Watchdog Timer
Statword_ICP_Wtchdg_Enable	0 = Disarm Watchdog Timer 1 = Arm Watchdog Timer
Statword_ICP_PROM_Pwr	0 = PROM Power Off 1 = PROM Power On
Statword_ICP_Scan_Cnt	0 -> 65535

Table 5-11. Raw Processor Status Data Elements (2 of 2)

RAW_Processor_Status	
Parameter	Value/Range
Statword_ICP_Mem_Dump_Start_Add_Ofst	0000 -> FFFF
Statword_ICP_Mem_Dump_Start_Add_Segm	0000 -> FFFF
Statword_ICP_Mem_Dump_End_Add_Ofst	0000 -> FFFF
Statword_ICP_Mem_Dump_End_Add_Segm	0000 -> FFFF
Statword_ICP_Mem_Dump_Pckt_Add_Ofst	0000 -> FFFF
Statword_ICP_Mem_Dump_Pckt_Add_Segm	0000 -> FFFF
Statword_Exec_Time_Min_ICP	0.0 -> 10.0
Statword_Exec_Samp_Min_ICP	0 -> 659
Statword_Exec_Time_Max_ICP	0.0 -> 10.0
Statword_Exec_Samp_Max_ICP	0 -> 659
Statword_ICP_RAM_Code_Cksum	0000 -> FFFF
Statword_ICP_ROM_Cksum	0000 -> FFFF

*TBD's indicate values not defined by TRW in the current DRL-64.

2. Shall test the following logic conditions for validity (the Statword_ prefix has been eliminated for simplicity):

DAP controls:

Verify DAP_Wtchdg_Enable = 1	-> arm watchdog timer
and DAP_PROM_Pwr = 0	-> PROM power off

ICP controls:

Verify ICP_DAP_Comm = TBD	-> valid ICP/DAP communication
and ICP_Wtchdg_Enable = 1	-> arm watchdog timer
and ICP_PROM_Pwr = 0	-> PROM power off

3. Shall store converted digital engineering data for comparison in analog engineering conversion process for validations.
4. Shall not process science, calibration, or diagnostic data packets if any of the above conditions are not valid.
5. Shall report all results.

5.2.1.3.3 Convert and Evaluate Instr Engg - Process 1.1.3.3

Input Data Flows

DeepSpace Flag
IENGCOEF Data
INSTR Data Packet
Iengcoef Analog
Status Control

Output Data Flows

Analog PPR
Analog Trend
Bds Analog Data
Instr Cal Record
Instr Diag Record
Instr Engg Data
Instr PPR
Instr Sci Record
Instr Trend
JulTime

Process Description (Figure 5-7):

1. Compute engineering units from engineering count data and perform limit checks on converted data.
2. Identify erroneous data and determine if downstream processing should continue with the current packet, report results.

Note: Daily time series plots of all temperature and power measurements showing minimum, mean, and maximum values are performed during trending operations.

The decomposition of this function is shown in [Figure 5-10](#).

5.2.1.3.3.1 Convert Non-Rad Analog Count - Process 1.1.3.3.1

Input Data Flows

Analog Coefficients
Raw Analog Data

Output Data Flows

Analog Engg Unit Data
Bds Analog Data
JulTime

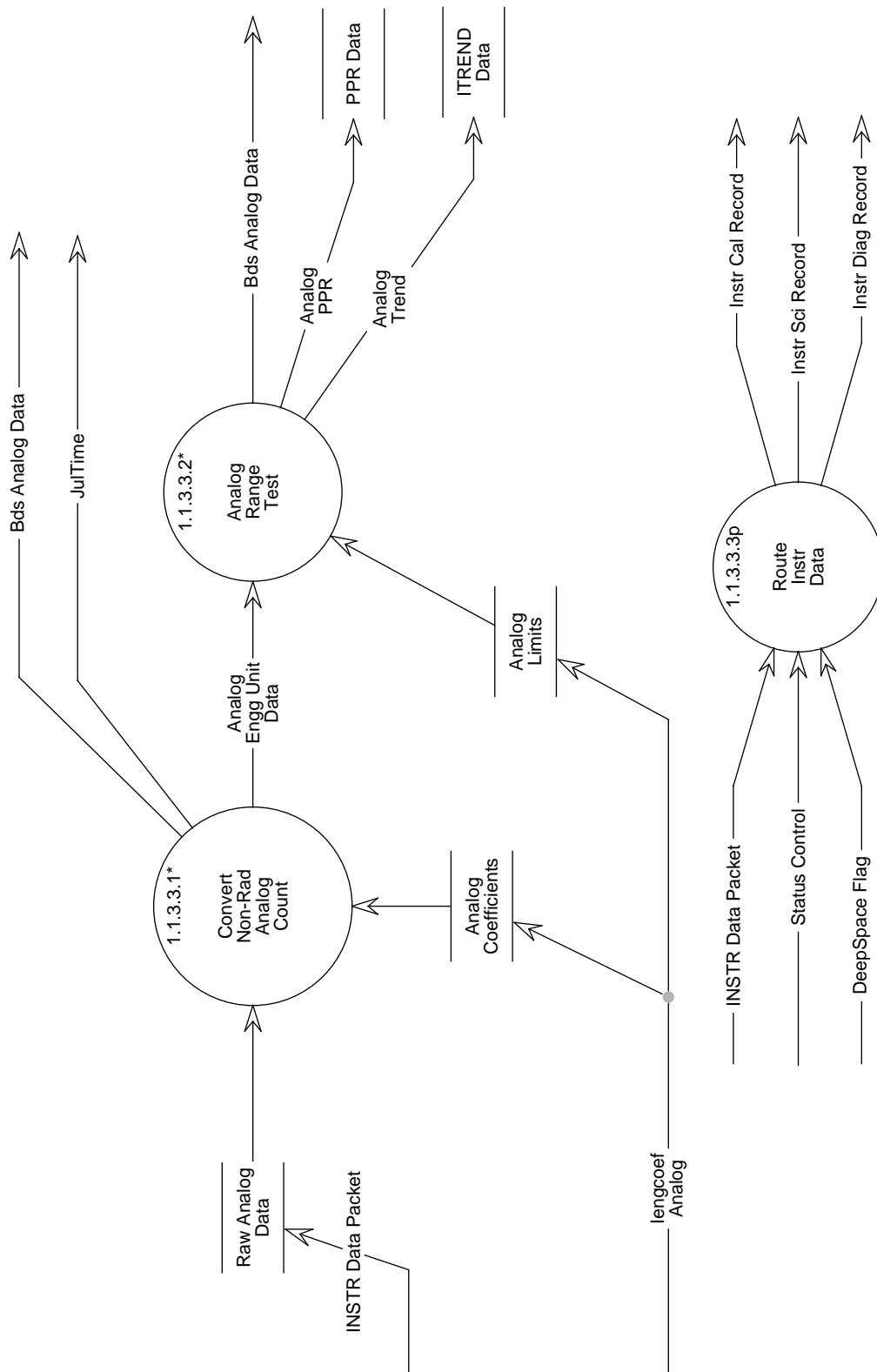


Figure 5-10. Data Flow Diagram for Convert and Evaluate Instr Engg

Process Description (Figure 5-10):

1. Compute engineering units from engineering count data.
2. Generate an error discrepancies report.

Note: Daily time series plots will be developed during trending operations.

The decomposition of this function is shown in Figure 5-11.

5.2.1.3.3.1.1 Convert Raw Temp Counts - Process 1.1.3.3.1.1

Input Data Flows

CERES Temp Coefficients
Instr Raw Temperature Count

Output Data Flows

Instr Convert Temperature

Process Specification (Figure 5-11):

1. Shall convert the raw instrument temperatures to degrees Centigrade based on the associated conversion algorithm (see Table 5-12).
2. Shall use the conversion algorithms identified in DRL-64.
3. Shall report results.

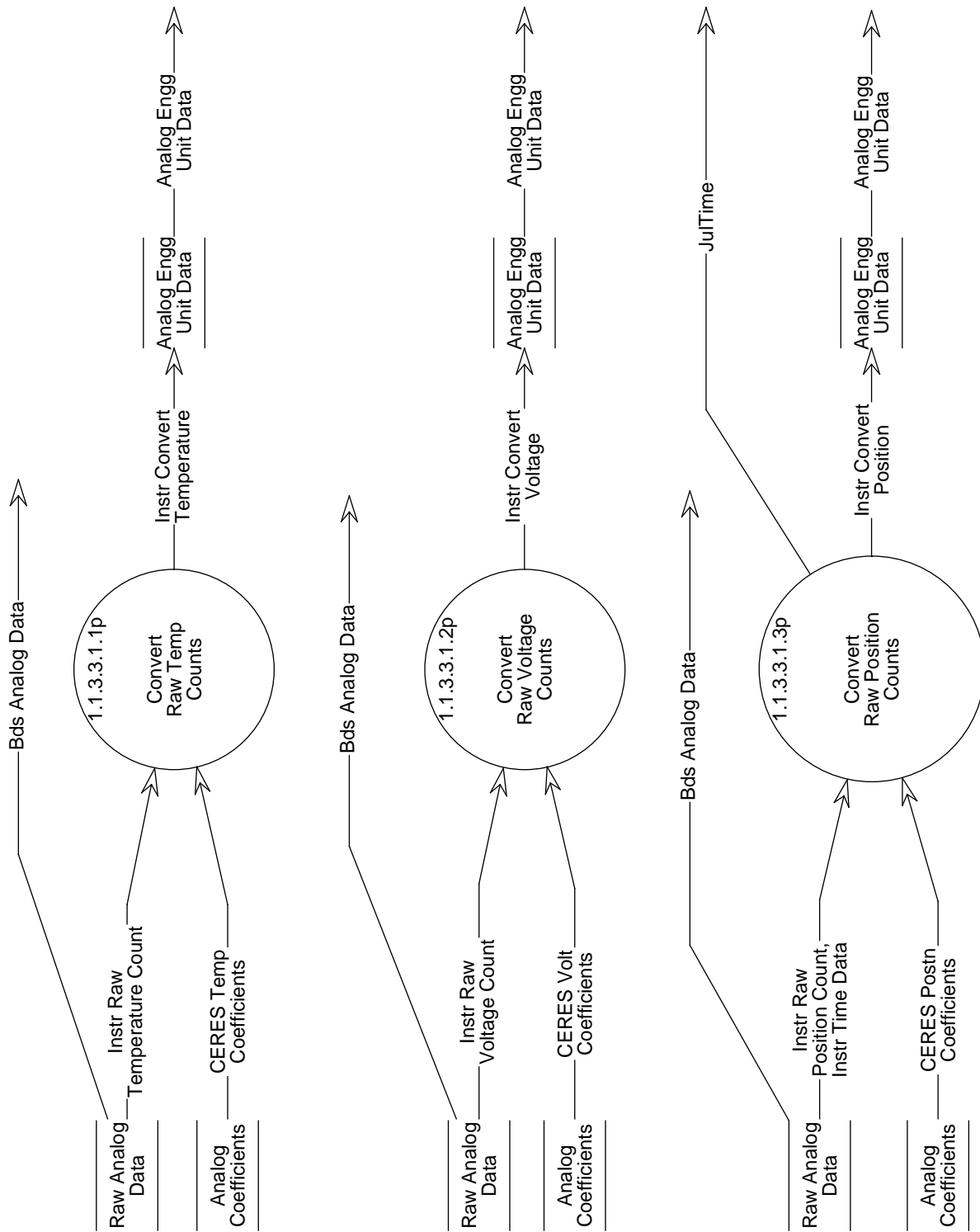


Figure 5-11. Data Flow Diagram for Convert Non-Rad Analog Count

Table 5-12. Raw Instrument Temperatures to Degrees Centigrade (1 of 2)

Parameter	Equation Indicator (from DRL-64 Reference)
12 Samples per scan:	
Statword_Tot_Htr_DAC	N/A *
Statword_SW_Htr_DAC	N/A *
Statword_Wn_Htr_DAC	N/A *
Statword_BB_Htr_DAC	N/A *
Temp_SW_Cntl_Cnt	2
Temp_SW_Montr_Cnt	3A
Temp_Wn_Cntl_Cnt	2
Temp_Wn_Montr_Cnt	3A
Temp_Tot_Cntl_Cnt	2
Temp_Tot_Montr_Cnt	3A
Temp_LW_BB_Cnt	1
Temp_Tot_BB_Cnt	1
3 Samples per scan:	
Temp_Elev_Spn_Motor_Cnt	3B
Temp_Elev_Spn_Cbw_Cnt	3B
Temp_Elev_Brg_Motor_Cnt	3C
Temp_Elev_Brg_Cbw_Cnt	3C
Temp_SWICS_Photdio_Cnt	3C
Temp_Senr_Modul_Cnt	3B
Temp_Senr_Elect_Cnt	3B
Temp_Main_Cvr_Motor_Cnt	3C
Temp_Tot_MAM_Baf1_Cnt	3C
Temp_Tot_MAM_Baf2_Cnt	3C
Temp_SW_MAM_Assy_Cnt	3C
Temp_Tot_MAM_Assy_Cnt	3C
Temp_DAA_Radr_Cnt	3B (C? like ICA/ECA)

Table 5-12. Raw Instrument Temperatures to Degrees Centigrade (2 of 2)

Parameter	Equation Indicator (from DRL-64 Reference)
Temp_DAA_CPU_Elect_Cnt	3C
Temp_DAA_Prom_Elect_Cnt	3C
Temp_DAA_RAM_Elect_Cnt	3C
Temp_DAA_ADC_Elect_Cnt	3C
Temp_ECA_Radr_Cnt	3C
Temp_ECA_Elect_Cnt	3C
Temp_ACA_Elect_Cnt	3C
Temp_Az_Low_Brg_Cnt	3C
Temp_Az_Hi_Brg_Cnt	3C
Temp_ICA_Radr_Cnt	3C
Temp_ICA_CPU_Elect_Cnt	3C
Temp_ICA_Prom_Elect_Cnt	3C
Temp_ICA_RAM_Elect_Cnt	3C
Temp_ICA_ADC_Elect_Cnt	3C
Temp_PCA_Radr_Cnt	3C
Temp_PCA_Elect_Cnt	3C
Temp_PCA_Q1_Transist_Case_Cnt	3C
Temp_Ped_1_Cnt	3C
Temp_Ped_2_Cnt	3C

5.2.1.3.3.1.2 Convert Raw Voltage Counts - Process 1.1.3.3.1.2

Input Data Flows

CERES Volt Coefficients
Instr Raw Voltage Count

Output Data Flows

Instr Convert Voltage

Process Specification (Figure 5-11):

1. Shall convert the following raw instrument power measurements into their engineering units (see [Table 5-13](#)):

Table 5-13. Instrument Power Conversions

Parameter	Equation Indicator (from DRL-64 Reference)
3 Samples per scan	
Volt_Senr_Pos120_Bias_Cnt	4E
Volt_Senr_Neg120_Bias_Cnt	4F
Volt_SWICS_Photdio_Cnt	N/A *
Volt_SWICS_Lamp_Curr_Cnt	4L
Volt_ICA_Dig_Pos5_Cnt	4J
Volt_ICA_Pos15_Cnt	4A
Volt_ICA_Neg15_Cnt	4B
Volt_ICA_Pos18_Cnt	4A
Volt_ICA_Neg18_Cnt	4B
Volt_ICA_Int_Pos15_Cnt	4A
Volt_ICA_Int_Neg15_Cnt	4B
Volt_DAA_Gnd_1_Cnt	4J
Volt_DAA_Gnd_2_Cnt	4J
Volt_Ref_DAA_Neg10_Cnt	4B
Volt_DAA_Pos130_Cnt	4C
Volt_DAA_Neg130_Cnt	4D
Volt_DAA_Pos12_Cnt	4A
Volt_DAA_Neg12_Cnt	4B
Volt_DAA_Pos15_Cnt	4A
Volt_DAA_Neg15_Cnt	4B
Volt_DAA_Pos18_Cnt	4A
Volt_DAA_Neg18_Cnt	4B
12 Samples per scan	
Cmd_Elev_Torq_Cnt	4H
Cmd_Az_Torq_Cnt	4I

*Indicates a conversion algorithm has not been defined by TRW in DRL-64.

2. Shall use the linear conversion algorithm with the coefficients currently listed in DRL-64 (see Table 5-14).

$$\text{Value} = (m \times \text{Cnt}) + b \quad (\text{units})$$

3. Shall report all results.

Table 5-14. Linear Conversion Algorithm Coefficients

Type	Slope (m)	Intercept (b)	Units
4A.	0.0048840	0.000	Volts
4B.	0.0058610	- 20.000	Volts
4C.	0.0600480	0.000	Volts
4D.	0.0039950	-135.819	Volts
4E.	0.0024420	115.001	Volts
4F.	0.0024420	-125.000	Volts

4H.	0.0445950	- 91.560	in-oz
4I.	0.1033770	-212.250	in-oz
4J.	0.0019536	0.000	Volts

4L.	0.0305250	0.000	mA

5.2.1.3.3.1.3 Convert Raw Position Counts - Process 1.1.3.3.1.3

Input Data Flows

CERES Postn Coefficients
Instr Raw Position Count
Instr Time Data

Output Data Flows

Instr Convert Position
JulTime

Process Specification (Figure 5-11):

1. Shall convert the following instrument position information into engineering units:

Table 5-15. Instrument Position Conversion Table

Parameter	Equation Indicator (from DRL-64 Reference)
3 Samples per scan:	
Postn_ACA_TrkA_Cnt	N/A *
Postn_ACA_TrkB_Cnt	N/A *
Postn_ECA_TrkA_Cnt	N/A *
Postn_ECA_TrkB_Cnt	N/A *
Postn_Maincvr1_Cnt	N/A *
Postn_Maincvr2_Cnt	N/A *
Postn_MAMcvr_Cnt	N/A *
Postn_Az_Brk_Cnt	N/A *
60 Samples per scan:	
Postn_Nar_Fld_SPS1_Cnt	6 *
Postn_Wide_Fld_SPS1_Cnt	6 *
Postn_Nar_Fld_SPS2_Cnt	6 *
Postn_Wide_Fld_SPS2_Cnt	6 *
660 Samples per scan:	
Postn_Elev_Cnt	4K
Postn_Az_Cnt	4K

*Indicates a conversion algorithm has not been defined by TRW in DRL-64.

2. Shall use the following conversion algorithm currently listed in DRL-64.

4K. Value = $0.0054932 \times \text{Cnt}$ degrees

3. Shall compute the Julian time corresponding to each of the 660 elevation measurement samples. Use the corrected packet time and add in increments of 0.01 seconds (UT) to each corresponding sample. Output parameter is known as JulTime.
4. Shall report all results.

5.2.1.3.3.2 Analog Range Test - Process 1.1.3.3.2

Input Data Flows

Analog Engg Unit Data
Analog Limits

Output Data Flows

Analog PPR
Analog Trend
Bds Analog Data

Process Description (Figure 5-10):

1. Edit check converted engineering data.
2. Generate an error discrepancies report.

The decomposition of this function is shown in Figure 5-12.

5.2.1.3.3.2.1 Temperature Edit Tests - Process 1.1.3.3.2.1

Input Data Flows

CERES Temp Limits
Instr Convert Temperature

Output Data Flows

Analog Temp Faults
BDS Converted Temperature
Temperature
Temperature PPR Data

Process Specification (Figure 5-12):

1. Shall edit check the following instrument engineering temperatures to their prescribed limits. Range limits are TBD's and will be defined during the software development phase.

Low	Low	High	High
Red	Yellow	Yellow	Red
Limit	Limit	Limit	Limit

12 samples per scan:
Statword_Tot_Htr_DAC
Statword_SW_Htr_DAC
Statword_Wn_Htr_DAC
Statword_BB_Htr_DAC
Temp_SW_Cntl
Temp_SW_Montr
Temp_Wn_Cntl

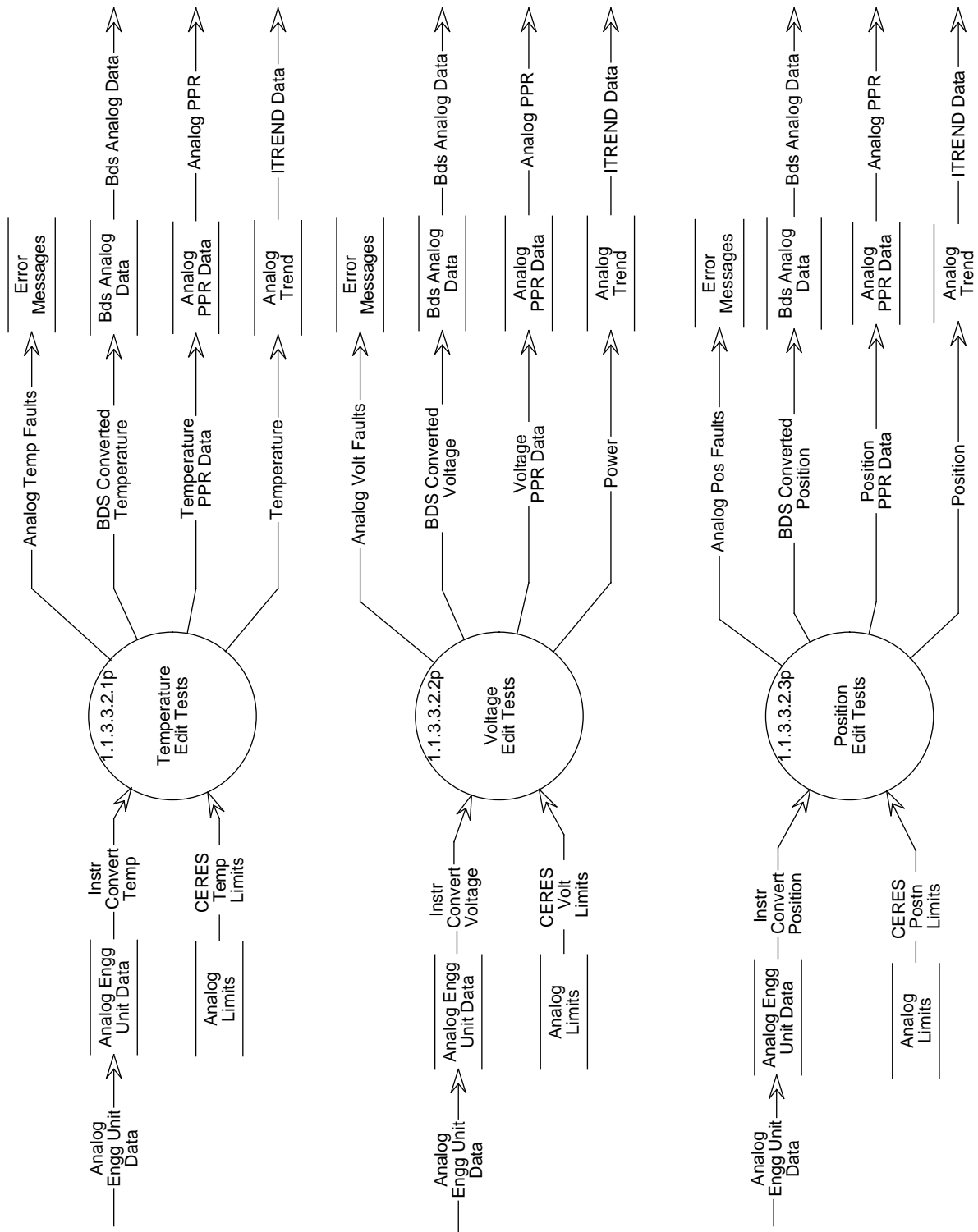


Figure 5-12. Data Flow Diagram for Analog Range Test

Temp_Wn_Montr
Temp_Tot_Cntl
Temp_Tot_Montr
Temp_LW_BB
Temp_Tot_BB

3 samples per scan:

Temp_Elev_Spn_Motor
Temp_Elev_Spn_Cbw
Temp_Elev_Brg_Motor
Temp_Elev_Brg_Cbw
Temp_Senr_Modul
Temp_Senr_Elect
Temp_Main_Cvr_Motor
Temp_SWICS_Photdio
Temp_Tot_MAM_Baf1
Temp_Tot_MAM_Baf2
Temp_SW_MAM_Assy
Temp_Tot_MAM_Assy
Temp_DAA_Radr
Temp_DAA_CPU_Elect
Temp_DAA_Prom_Elect
Temp_DAA_RAM_Elect
Temp_DAA_ADC_Elect
Temp_ECA_Radr
Temp_ECA_Elect
Temp_ACA_Elect
Temp_Az_Low_Brg
Temp_Az_Hi_Brg
Temp_ICA_Radr
Temp_ICA_CPU_Elect
Temp_ICA_Prom_Elect
Temp_ICA_RAM_Elect
Temp_ICA_ADC_Elect
Temp_PCA_Radr
Temp_PCA_Elect
Temp_PCA_Q1_Transist_Case
Temp_Ped_1
Temp_Ped_2

Note: The statwords are converted for validation purposes only. The converted values are not stored in the BDS.

2. Shall report all out-of-limit results.

5.2.1.3.3.2.2 Voltage Edit Tests - Process 1.1.3.3.2.2

Input Data Flows

CERES Volt Limits
Instr Convert Voltage

Output Data Flows

Analog Volt Faults
BDS Converted Voltage
Power
Voltage PPR Data

Process Specification (Figure 5-12):

1. Shall edit check the following instrument engineering power values to verify within prescribed limits. Range limits are TBD's and will be defined during the software development phase.

Low	Low	High	High
Red	Yellow	Yellow	Red
Limit	Limit	Limit	Limit

3 samples per scan:

Volt_Senr_Pos120_Bias
Volt_Senr_Neg120_Bias
Volt_SWICS_Photdio
Volt_SWICS_Lamp_Curr
Volt_ICA_Dig_Pos5
Volt_ICA_Pos15
Volt_ICA_Neg15
Volt_ICA_Pos18
Volt_ICA_Neg18
Volt_ICA_Int_Pos15
Volt_ICA_Int_Neg15
Volt_DAA_Gnd_1
Volt_DAA_Gnd_2
Volt_Ref_DAA_Neg10
Volt_DAA_Pos130
Volt_DAA_Neg130
Volt_DAA_Pos12
Volt_DAA_Neg12
Volt_DAA_Pos15
Volt_DAA_Neg15
Volt_DAA_Pos18
Volt_DAA_Neg18

12 samples per scan:
Cmd_Elev_Torq
Cmd_Az_Torq

2. Shall report all out-of-limit results.

5.2.1.3.3.2.3 Position Edit Tests - Process 1.1.3.3.2.3

Input Data Flows

CERES Postn Limits
Instr Convert Position

Output Data Flows

Analog Pos Faults
BDS Converted Position
Position
Position PPR Data

Process Specification (Figure 5-12):

1. Shall edit check the following instrument position engineering values to verify that the values are within prescribed limits. Range limits are TBDs and will be defined during the software development phase.

Low	Low	High	High
Red	Yellow	Yellow	Red
Limit	Limit	Limit	Limit

3 samples per scan:
Postn_ACA_TrkA
Postn_ACA_TrkB
Postn_ECA_TrkA
Postn_ECA_TrkB
Postn_Maincvr1
Postn_Maincvr2
Postn_MAMcvr
Postn_Az_Brk

60 samples per scan:
Postn_Nar_Fld_SPS1
Postn_Wide_Fld_SPS1
Postn_Nar_Fld_SPS2
Postn_Wide_Fld_SPS2

660 samples per scan:

Postn_Elev

Postn_Az

2. Shall report all out-of-limit results.

5.2.1.3.3.3 Route Instr Data - Process 1.1.3.3.3

Input Data Flows

DeepSpace Flag

INSTR Data Packet

Status Control

Output Data Flows

Instr Cal Record

Instr Diag Record

Instr Sci Record

Process Specification (Figure 5-10):

1. Shall route the Instrument Science, Calibration, or Diagnostic Data Packet based on status results from the following data parameters.

From the Instr Data Packet data structure:

APID

From the Status Control data structure:

Statword_Pckt_Data_Indicr

Statword_Instr_Mode

Statword_Elev_Scan_Mode

Statword_Az_Scan_Mode

From packet header evaluation process:

DeepSpace Flag

2. Shall route instrument data packets according to the following decision logic when selected data parameters are valid and true:

Output Instr Sci data packet when:

APID

= Science

Statword_Pckt_Data_Indicr

= Normal Science Data Packet

Statword_Instr_Mode

= Crosstrack Mode or Biaxial

Statword_Elev_Scan_Mode

= Normal Earth Scan or

Short Earth Scan or

Statword_Az_Scan_Mode	Nadir Scan = Goto Crosstrack or Scan A/B asynchronously or Scan A/B synchronously
-----------------------	--

Output Instr Cal data packet when:

APID	= Science or Solar Calibration
Statword_Pckt_Data_Indicr	= Normal Science Data Packet or Calibration Data Packet
Statword_Instr_Mode	= Internal Calibration Mode or Solar Calibration Mode
Statword_Elev_Scan_Mode	= Normal Earth Scan or MAM Scan
Statword_Az_Scan_Mode	= Goto Crosstrack or Scan A/B asynchronously or Scan A/B synchronously or Goto Solar Calibration Angle

or when:

Deep Space Flag	= True
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Output Instr Diag data packet when:

APID	= Diagnostic
Statword_Pckt_Data_Indicr	= Normal Science Data Packet or Memory Dump Data Packet or Gimbal Data Packet or Execution Time Data Packet
Statword_Instr_Mode	= Diagnostic Configuration
Statword_Elev_Scan_Mode	= Stowed or Normal Earth Scan or Short Scan or Nadir Scan or MAM Scan
Statword_Az_Scan_Mode	= Stop Azimuth or Goto Crosstrack or Scan A/B asynchronously or Scan A/B synchronously

Else do not output any instrument data record.

5.2.2 Convert Science Data - Process 1.2

Input Data Flows

EGMOD
EPH ANC Record
IRCOEF
Instr Sci Record

Output Data Flows

IRCOEF
Science Data

Process Description (Figure 5-1:

1. Access, process, and validate all associated data files necessary to process this data.
 - a) Access and accept as a minimum the following input data files:
 - 1) Auxiliary engineering, mathematical, and science constants.
 - 2) Auxiliary radiometric count conversion coefficients and limit values.
 - 3) Auxiliary coordinate system references.
 - 4) Auxiliary PGS environment variables and other parameterized input.
 - 5) Auxiliary history trend data.
 - 6) Previously generated Instrument Earth Scan (IES) overlap footprint data.
 - b) Process and validate data file headers for the above input files and correlate this information with the PGE user data.
 - c) Temporarily store file parameters.
 - d) Halt production should any file headers be missing or erroneous, and inform operator/analyst.
2. Compute and validate the locations of the radiance measurement sources with respect to specified coordinate frames and sampling schemes.
 - a) Compute the locations and individual vector components for each of the detector pointing vectors at the source of each CERES detector measurement with respect to the following coordinate systems:
 - 1) Fixed Spacecraft Frame.
 - 2) Spacecraft Local Horizon Frame.
 - 3) Earth-centered Fixed Frame.
 - 4) Earth-centered Inertial Frame.
 - b) Compute the following angular measurements associated with each CERES footprint:
 - 1) Viewing and solar zeniths.
 - 2) Relative azimuth.
 - 3) Viewing azimuth with respect to north.
 - 4) Cross-track and along-track angles.
 - 5) Cone and clock angles and rates of change of cone and clock angles.
 - c) Edit and validate all locations, and report results.
3. Edit and validate raw CERES radiance measurements, and compute, edit, and validate science radiances.

- a) Verify that the detector engineering parameters are within tighter detector-required specifications to enable footprint radiance conversions.
- b) Compute, edit, analyze, and validate values of filtered radiance for each raw instrument measurement.
- c) Verify space clamp performance.

The decomposition of this function is shown in [Figure 5-13](#).

5.2.2.1 AuxRad File Header Check - Process 1.2.1

Input Data Flows

EGMOD
IRCOEF

Output Data Flows

EGMOD Data
EGMOD File Hdr
Egmod Hdr Errors
IRCOEF Data
IRCOEF File Hdr
Ircoef Hdr Errors

Process Specification ([Figure 5-13](#)):

1. Shall access, verify, and validate the file headers for the following input data files:
 - a) Auxiliary engineering count conversion coefficients and limit values.
 - b) Auxiliary engineering, mathematical, and science constants.
 - c) Auxiliary radiometric count conversion coefficients and limit values.
 - d) Auxiliary coordinate system references.
 - e) Auxiliary PGS environment variables and parameterized input from the PGE.
 - f) Auxiliary history trend data.
 - g) Auxiliary detector spectral sensitivity data.
 - h) Previously generated Instrument Earth Scan (IES) overlap footprint data file.
2. Shall halt production should any file headers be missing or erroneous, generate error message reports, and inform operator analyst.

5.2.2.2 Calculate Science Radiance Location - Process 1.2.2

Input Data Flows

BDS Converted Position
EGMOD Data
EPH ANC Record
IRCOEF Data

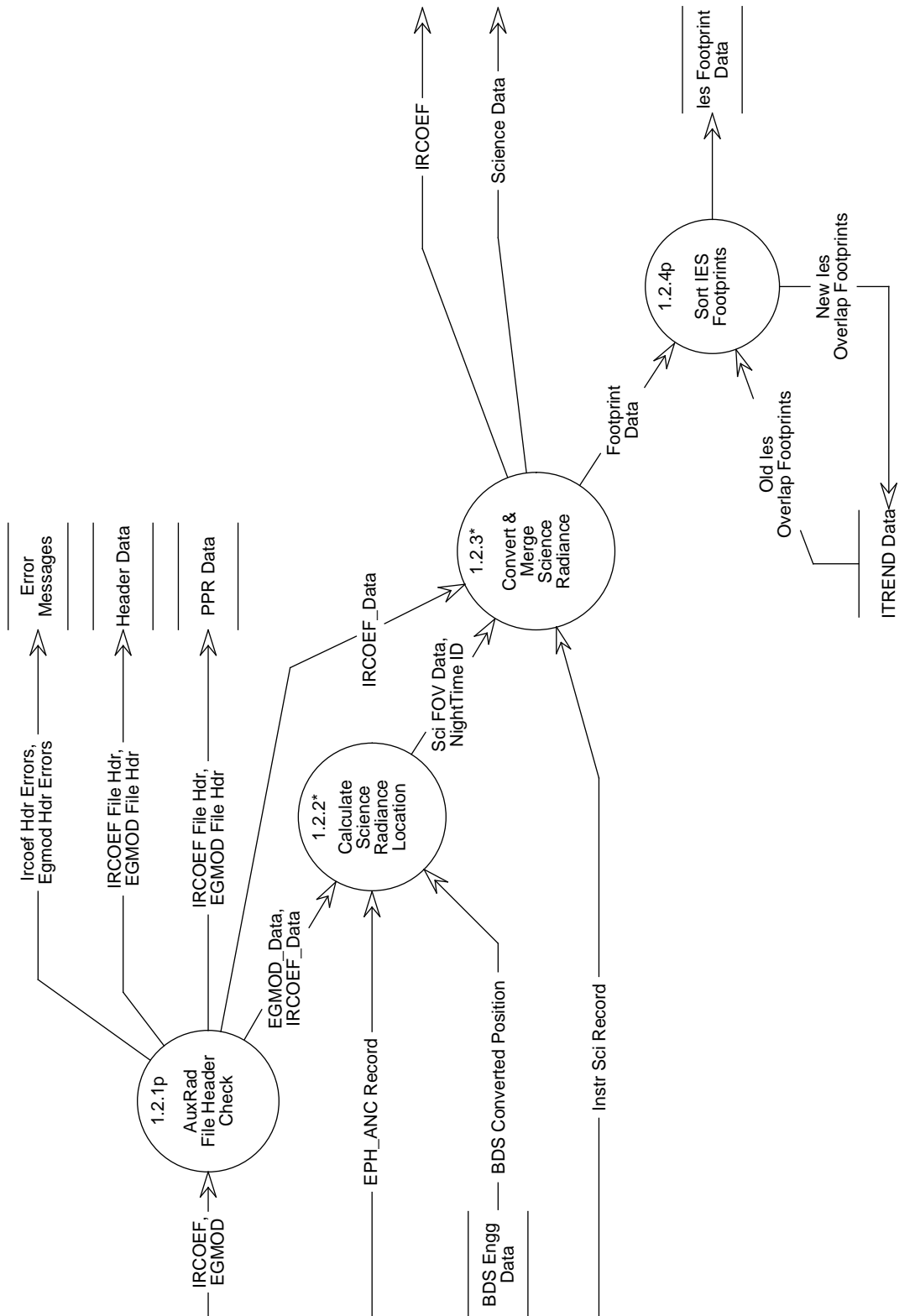


Figure 5-13. Data Flow Diagram for Convert Science Data

Output Data Flows

NightTime ID
Sci FOV Data

Process Description (Figure 5-13):

1. Compute and validate the locations of the radiance measurement sources with respect to specified coordinate frames and sampling schemes.
 - a) Compute the locations and individual vector components for each of the detector pointing vectors at the source of each CERES detector measurement with respect to the following coordinate systems:
 - 1) Fixed Spacecraft Frame.
 - 2) Spacecraft Local Horizon Frame.
 - 3) Earth-centered Fixed Frame.
 - 4) Earth-centered Inertial Frame.
 - b) Compute the following angular measurements associated with each CERES footprint:
 - 1) Viewing and solar zeniths.
 - 2) Relative azimuth.
 - 3) Viewing azimuth with respect to north.
 - 4) Cross-track and along-track angles.
 - 5) Cone and clock angles and rates of change of cone and clock angles.
 - c) Edit and validate all locations, and report results.
 - d) Compute and report all cross-products and dot-products for each transformation.
 - e) Edit and validate all locations, and report results.

Note: The local horizon for the TRMM spacecraft is expected to be the CO₂ atmospheric level (approximately 60 km). Geolocation calculations may have to accommodate this transformation.

The decomposition of this function is shown in [Figure 5-14](#).

5.2.2.2.1 Locate Footprints - Process 1.2.2.1

Input Data Flows

BDS Converted Position
EGMOD Data
EPH ANC Record
IRCOEF Data

Output Data Flows

Footprint Location
QC RadLoc Data
RadLoc Data

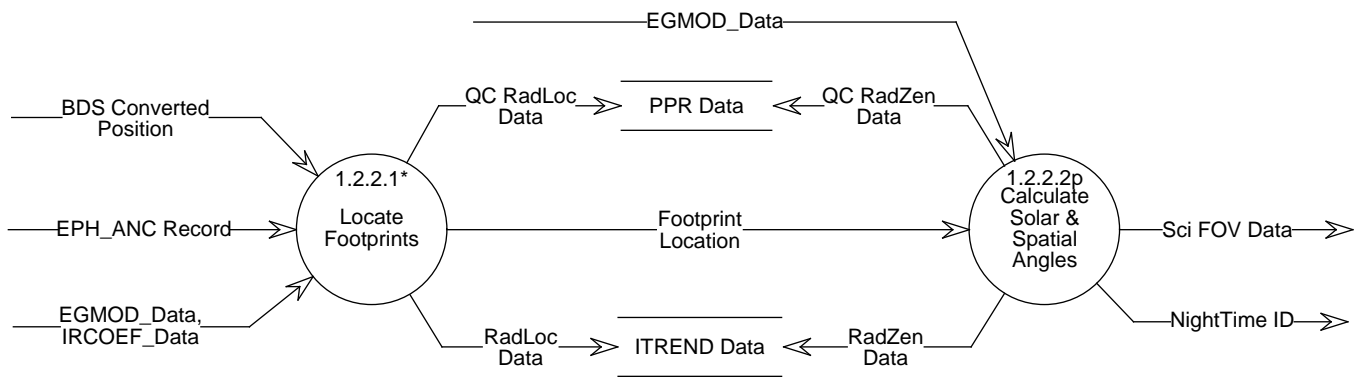


Figure 5-14. Data Flow Diagram for Calculate Science Radiance Location

Process Description (Figure 5-14):

1. Compute and validate the locations of the radiance measurement sources with respect to specified coordinate frames and sampling schemes.
 - a) Compute the locations and individual vector components of the detector pointing vectors for the source of each CERES detector measurement with respect to the following coordinate systems:
 - 1) Fixed Spacecraft Frame.
 - 2) Spacecraft Local Horizon Frame.
 - 3) Earth-centered Fixed Frame.
 - 4) Earth-centered Inertial Frame.
 - b) Calculate cross-products and dot-products for all location transformations, including orbit deviations.
 - c) Adjust for TRMM's CO₂ local horizon, if necessary.
 - d) Edit, validate, and analyze all locations, and report all results.

The decomposition of this function is shown in [Figure 5-15](#).

5.2.2.2.1.1 Calculate Fixed Platf Vectors - Process 1.2.2.1.1

Input Data Flows

- BDS Converted Position
- DetMisAlign
- IRCOEF Data
- InstrMisAlign

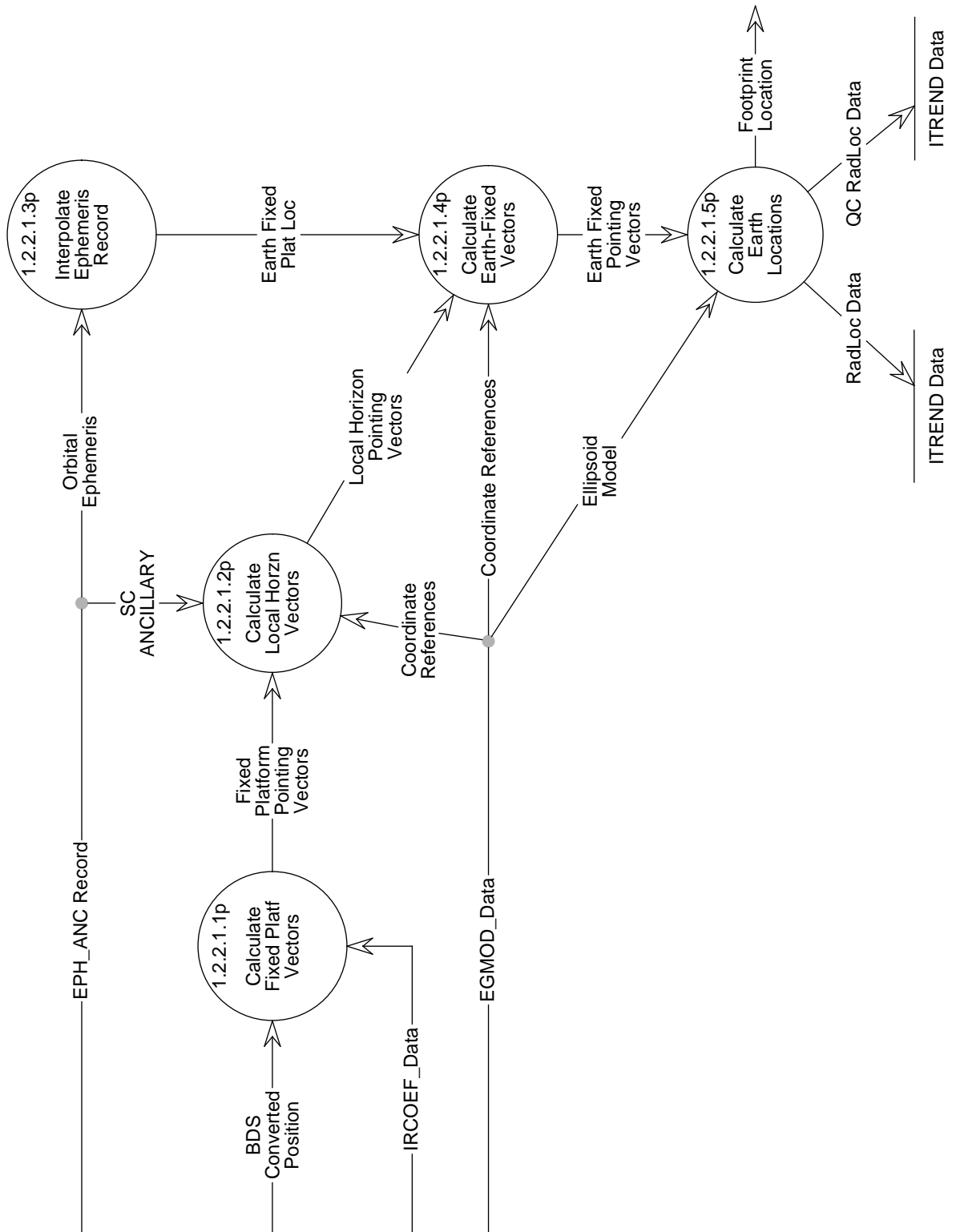


Figure 5-15. Data Flow Diagram for Locate Footprints

Output Data Flows

Fixed Platform Pointing Vectors

Process Specification (Figure 5-15):

1. Shall correct converted elevation angle by subtracting the detector time lag angle.
Note: This time lag angle will be supplied by either TRW or the CERES Science Team.
2. Shall transform detector pointing knowledge (corrected elevation angle, azimuth angle) to pointing vectors in the fixed instrument coordinate system.
3. Shall adjust pointing vectors in the fixed instrument coordinate system by correcting for detector-to-instrument misalignments.
Note: This 'adjustment' information will be supplied by TRW and will consist of one set of adjustment parameters per instrument.
4. Shall transform pointing vectors in the fixed instrument coordinate system to pointing vectors in the fixed-platform coordinate system.
5. Shall adjust the pointing vectors in the fixed instrument coordinate system by correcting for instrument-to-platform misalignments.
Note: This 'adjustment' information will be supplied by TRW or the platform integrator and will consist of one set of adjustment parameters per instrument.

5.2.2.2.1.2 Calculate Local Horzn Vectors - Process 1.2.2.1.2

Input Data Flows

Coordinate References
EGMOD Data
EPH ANC Record
Fixed-Platform Pointing Vectors
SC ANCILLARY

Output Data Flows

Local Horizon Pointing Vectors

Process Specification (Figure 5-15):

Shall, for all CERES samples, transform the pointing vectors in the fixed-platform coordinate frame to pointing vectors in the local horizon coordinate frame by applying the platform attitude data to the appropriate transformation matrices.

5.2.2.2.1.3 Interpolate Ephemeris Record - Process 1.2.2.1.3

Input Data Flows

EPH ANC Record
Orbital Ephemeris

Output Data Flows

Earth Fixed Plat Loc

Process Specification (Figure 5-15):

1. Shall, for each CERES sample, find two specific ephemeris records: one with its (ephemeris) time closest to the CERES sample time but not greater than the CERES sample time, and the second with its (ephemeris) time closest to the CERES sample time but not less than the CERES sample time.
2. Shall interpolate the ephemeris state vectors to individual CERES sample times using the two ephemeris records identified above.
Note: The method of interpolation is TBD.
3. Shall convert the ephemeris state vectors (in the ECI coordinate frame) to the Earth-fixed coordinate system using the relationship between inertial longitude and Greenwich longitude.

This results in spacecraft position in the Earth-fixed coordinate system for all CERES sample times.

5.2.2.2.1.4 Calculate Earth-Fixed Vectors - Process 1.2.2.1.4

Input Data Flows

Coordinate References
EGMOD Data
Earth Fixed Plat Loc
Local Horizon Pointing Vectors

Output Data Flows

Earth Fixed Pointing Vectors

Process Specification (Figure 5-15):

1. Shall calculate heading angle of spacecraft for each CERES sample.
Note: The heading angle is the angle between north and the projection of the velocity vector in a plane tangent to the sample point on the geoid surface.
2. Shall transform local horizon pointing vectors to local geodetic pointing vectors.
3. Shall, for all CERES samples, transform the pointing vectors in the local geodetic coordinate system to pointing vectors in the Earth-fixed coordinate system.

5.2.2.2.1.5 Calculate Earth Locations - Process 1.2.2.1.5

Input Data Flows

EGMOD Data
Earth Fixed Pointing Vectors
Ellipsoid Model

Output Data Flows

Footprint Location
QC RadLoc Data
RadLoc Data

Process Specification (Figure 5-15):

Shall compute, for each CERES sample, the pierce point of the pointing vector in the Earth-fixed coordinate system with both the Earth geoid model and the 30 km TOA model.

Note: This computation results in a longitude and colatitude value for each CERES sample.

5.2.2.2.2 Calculate Solar and Spatial Angles - Process 1.2.2.2

Input Data Flows

EGMOD Data
Footprint Location

Output Data Flows

NightTime ID
QC RadZen Data
RadZen Data
Sci FOV Data

Process Specification (Figure 5-14):

1. Shall calculate the solar beta angle for each CERES scan.
Note: The solar beta angle is defined as the angle between the spacecraft velocity vector and the direction of the Sun.
2. Shall calculate viewing zenith angle for each CERES sample.
Note: The viewing zenith angle is defined as the angle between a sample's local zenith direction and the detector pointing direction.
3. Shall calculate solar zenith angle for each CERES sample.
Note: The solar zenith angle is defined as the angle between a sample's local zenith direction and the direction of the Sun.
4. Shall calculate relative azimuth angle for each CERES sample.
Note: The relative azimuth angle is defined as the angle between the direction which is 180 degrees away from the sample location to the subsolar point and the direction from the sample location to the subsatellite point, measured in a clockwise direction in a plane that is tangential to the sample's location on the surface of the Earth.
5. Shall calculate azimuth angle with respect to north for each CERES sample.
Note: The azimuth angle with respect to north is defined as the angle between the sample location and the direction to north and the direction from the sample location to the subsatellite point, measured in a clockwise direction in a plane that is tangential to the sample's location on the Earth's surface.

6. Shall calculate local solar time for each CERES sample.
7. Shall calculate along-track and cross-track angles for each CERES sample, to be used when organizing the IES.
 Note: The cross-track angle is defined as the angular offset of the sample point from the perpendicular point on the ground-track, measured from the center of the Earth. The angle is positive when the sample is between the ground-track and the positive momentum vector and negative if the sample is between the ground-track and the negative momentum vector. The alongtrack angle is defined as the difference between the satellite ground-track position at the start of an hour and the point on the ground-track which is perpendicular to the sample point.
8. Shall calculate the cone and clock angles, and cone and clock angle rates of change, for each CERES sample.
9. Shall determine the lighting conditions for each CERES sample. The lighting conditions may be classified as space-look, space (motion), day, terminator, night, internal, or MAM.

5.2.2.3 Convert and Merge Science Radiance - Process 1.2.3

Input Data Flows

IRCOEF Data
 Instr Sci Record
 NightTime ID
 Sci FOV Data

Output Data Flows

Footprint Data
 IRCOEF
 Science Data

Process Description (Figure 5-13):

1. Edit and validate raw CERES radiance measurements and compute, edit, and validate science radiances.
 - a) Verify detector engineering parameters are within specifications to determine if footprint radiance conversions are viable.
 Note 1: This verification process is routinely done in the instrument engineering conversion process (Process 1.1.3).
 Note 2: The primary purpose of this verification process is to determine if the radiance conversion process will be valid based on specific instrument parameters that are expected to influence detector performance.
 - b) Identify and validate space clamp occurrences and values.
 - c) Compute, edit, analyze, and validate values of filtered radiance for each raw instrument measurement.
 - d) Verify nighttime Shortwave channel data and compare Longwave and Total channel nighttime measurements.

- e) Merge geolocation data with converted radiance data to produce footprint groupings for BDS and IES output data products.

The decomposition of this function is shown in [Figure 5-16](#).

5.2.2.3.1 Evaluate Detector Engg Data - Process 1.2.3.1

Input Data Flows

BDS Sensor Operation
Bds Analog Data

Output Data Flows

Detector Data
Space-Look Flag

Process Specification ([Figure 5-16](#)):

1. Shall verify that the following detector engineering parameters are within tighter specifications required to enable footprint radiance conversions. Ranges are TBD and will be defined during the software development phase.

Output Detector Data consisting of:

Analog Values:

Range:

Postn_Elev
Postn_Az

Temp_Tot_Montr
Temp_SW_Montr
Temp_Wn_Montr

Volt_Sensr_Pos120_Bias
Volt_Sensr_Neg120_Bias
Volt_Ref_DAA_Neg10

Digital Values:

Detector_Controls (Temperatures)
Statword_Tot_Temp_Setpt
Statword_Tot_Temp_Cntl
Statword_SW_Temp_Setpt
Statword_SW_Temp_Cntl
Statword_Wn_Temp_Setpt
Statword_Wn_Temp_Cntl

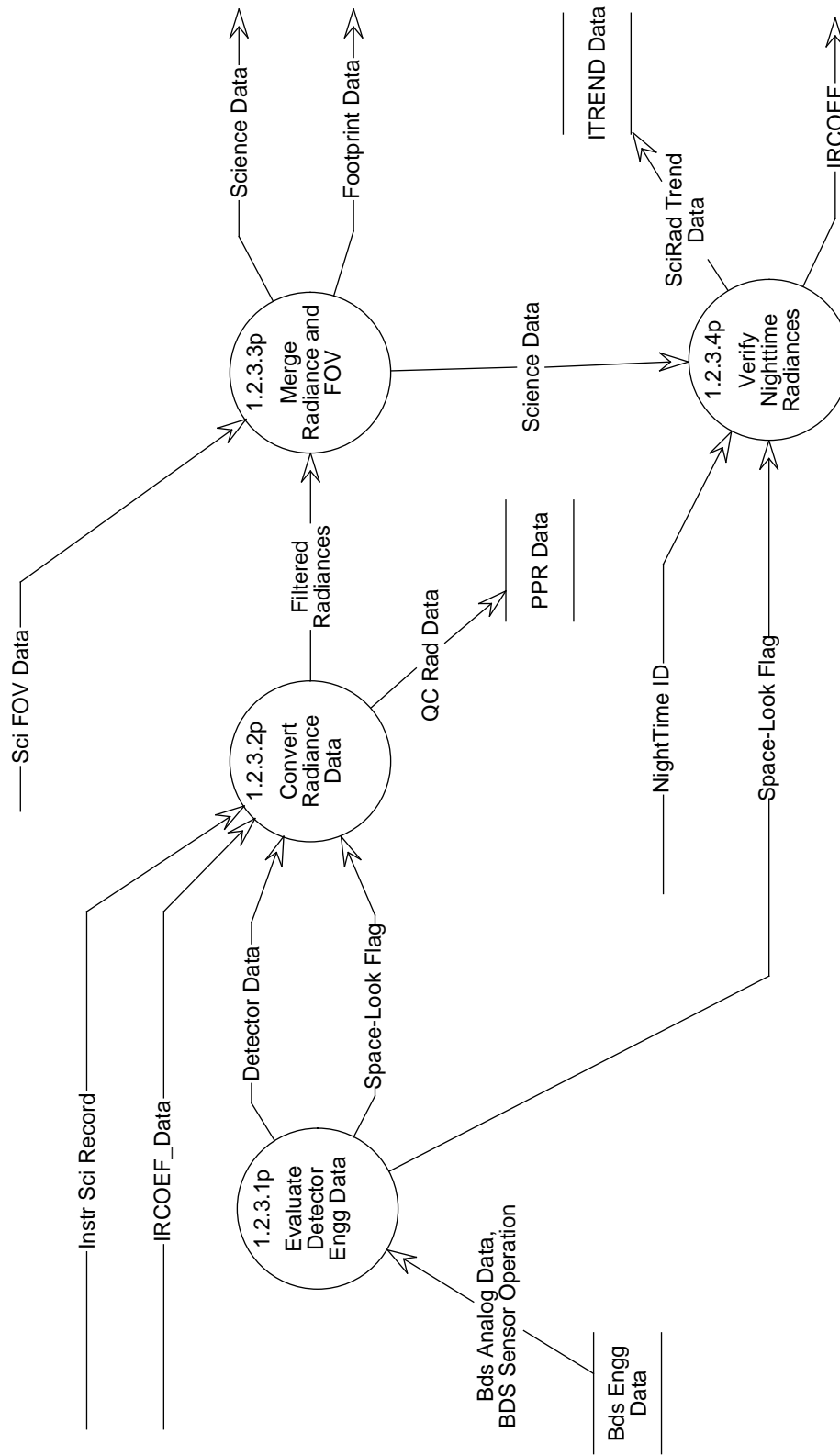


Figure 5-16. Data Flow Diagram for Convert and Merge Science Radiance

Total_Detector_Bridge_Bal:
 Statword_Tot_Cors_Brid_DAC
 Statword_Tot_Fine_Brid_DAC
 Statword_Tot_Brid_Cntl
 Statword_Tot_Brid_DAC_Update
 Statword_Tot_Brid_Reset_Cnt

SW_Detector_Bridge_Bal:
 Statword_SW_Cors_Brid_DAC
 Statword_SW_Fine_Brid_DAC
 Statword_SW_Brid_Cntl
 Statword_SW_Brid_DAC_Update
 Statword_SW_Brid_Reset_Cnt

Wn_Detector_Bridge_Bal
 Statword_Wn_Cors_Brid_DAC
 Statword_Wn_Fine_Brid_DAC
 Statword_Wn_Brid_Cntl
 Statword_Wn_Brid_DAC_Update
 Statword_Wn_Brid_Reset_Cnt

INSTR_Bridge_Balance_Status
 Statword_Brid_Setpt
 Statword_Start_Brid_Spaclk
 Statword_End_Brid_Spaclk
 Statword_Updt_Brid_DAC
 Statword_Brid_Low
 Statword_Brid_High

2. Shall generate a space clamp flag based on the criteria shown in [Table 5-16](#):

Table 5-16. Elevation Angle Positions

	EOS	TRMM
Postn_Elev (Angle)	18 & 162 deg	11 & 169 deg
Postn_Elev Sample Numbers (approximate):		
Forward Scan	0-49, 277-298	0-32, 283-301
Reverse Scan	361-382, 610-659	358-376, 627-659

3. Shall verify space-look view with geolocation.
 - a) Shall not set flag if not viewing space.
4. Shall flag current science record as having a bad space clamp if any of the above conditions are not satisfied.

5.2.2.3.2 Convert Radiance Data - Process 1.2.3.2

Input Data Flows

Detector Data
 IRCOEF Data
 Instr Sci Record
 Space-Look Flag

Output Data Flows

Filtered Radiances
 QC Rad Data

Process Specification (Figure 5-16):

1. Shall average the radiance counts for each detector during the samples shown in [Table 5-17](#), to obtain a space-clamp value when indicated by the Space-Look Flag and to then correct for the space clamp (i.e. zero radiance) value:
 - a) Shall verify space clamp values are within TBD standard deviations.
 - b) Shall verify space clamp values are within TBD limit values if value failed the standard deviation test.
 - c) Shall flag failed space clamp if value doesn't pass validation test.

Note: This will require two passes through the data - 1st to find and average space-look values, and 2nd to then correct the scan data.

Table 5-17. Space-Look Flag

	EOS	TRMM
Postn_Elev Sample Numbers (approximate):		
Forward Scan	0-49, 277-298	0-32, 283-301
Reverse Scan	361-382, 610-659	358-376, 627-659

2. Shall compute, edit, and validate values of filtered radiance for each of the following raw instrument measurements.

The input parameters are

Rad_Tot_Det_Cnt -> 0 - 4095
 Rad_SW_Det_Cnt -> 0 - 4095
 Rad_Wn_Det_Cnt -> 0 - 4095

3. Shall use the following engineering parameters to calculate radiances.

Analog Values:
 Postn_Elev
 Postn_Az

Temp_Tot_Montr
Temp_SW_Montr
Temp_Wn_Montr

Volt_Sensr_Pos120_Bias
Volt_Sensr_Neg120_Bias
Statword_Tot_Htr_DAC
Statword_SW_Htr_DAC
Statword_Wn_Htr_DAC

Digital Values:

Detector_Controls (Temperatures)
Statword_Tot_Temp_Setpt
Statword_Tot_Temp_Cntl
Statword_SW_Temp_Setpt
Statword_SW_Temp_Cntl
Statword_Wn_Temp_Setpt
Statword_Wn_Temp_Cntl

Total_Detector_Bridge_Bal
Statword_Tot_Cors_Brid_DAC
Statword_Tot_Fine_Brid_DAC
Statword_Tot_Brid_Cntl
Statword_Tot_Brid_DAC_Update
Statword_Tot_Brid_Reset_Cnt

SW_Detector_Bridge_Bal
Statword_SW_Cors_Brid_DAC
Statword_SW_Fine_Brid_DAC
Statword_SW_Brid_Cntl
Statword_SW_Brid_DAC_Update
Statword_SW_Brid_Reset_Cnt

Wn_Detector_Bridge_Bal
Statword_Wn_Cors_Brid_DAC
Statword_Wn_Fine_Brid_DAC
Statword_Wn_Brid_Cntl
Statword_Wn_Brid_DAC_Update
Statword_Wn_Brid_Reset_Cnt

INSTR_Bridge_Balance_Status
Statword_Brid_Setpt
Statword_Start_Brid_Spaclk
Statword_End_Brid_Spaclk
Statword_Updt_Brid_DAC

Statword_Brid_Low
Statword_Brid_High

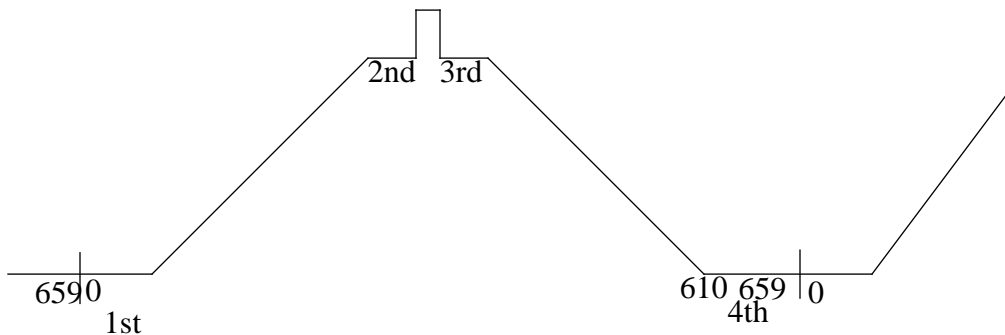
4. Shall use the radiance count conversion algorithm to convert raw detector counts to engineering units. This algorithm will be defined during the software development phase.
 - a) Shall correct the raw radiance counts using average and interpolated space clamp count values. Interpolated space clamp values are determined based on the following suggested procedure and referring to the figure below.
 - 1) Shall interpolate between the two scan averages for the anti-Sun side views at the beginning and end of each packet (set 1 and 4).
 - 2) Shall interpolate between the two scan averages for the Sun side views for the current packet on both sides of the internal calibration view should the anti-Sun views be invalid (set 2 and 3).
 - 3) Shall use the internal calibration sources for radiance adjustments should the Sun side views be invalid. No interpolation is performed.
 - 4) Shall not process radiances for current packet if the internal calibrations are invalid.

Note 1: Option 1) is generally used for correction in both normal and short scan mode. In the case of bad space value in the first and/or last set, Option 2) will be used. If all the space clamp values cannot be used, Option 3) will be used. Options 2) and 3) are used only for the normal scan mode.

Note 2: A fourth option that can be considered is to interpolate between first and second space clamp averages and use it for the forward scan; interpolate between third and fourth space clamp averages to use for backward scan.

Note 3: A fifth option that can be considered is to interpolate the 2nd/3rd sets from two adjacent packets; the current and the next. The fourth and fifth options should be evaluated as part of the design phase.

Note 4: The numbers shown in the table above, and the options discussed above, are for the normal Earth-scan. Different options will be used for the other scan profiles. These options will be developed during the design phase.



- b) Shall offset radiances using position dependent corrections, should they be required.
- c) Shall calculate the radiance engineering unit based on the corrected raw radiances.

5.2.2.3.3 Merge Radiance and FOV - Process 1.2.3.3

Input Data Flows

Filtered Radiances
Sci FOV Data

Output Data Flows

Footprint Data
Science Data

Process Specification (Figure 5-16):

1. Shall verify that the footprint radiance and geolocation data are coincident before merging.
2. Shall only merge coincident footprint converted radiance and geolocated FOV data.

5.2.2.3.4 Verify Nighttime Radiances - Process 1.2.3.4

Input Data Flows

NightTime ID
Science Data
Space-Look Flag

Output Data Flows

IRCOEF
SciRad Trend Data

Process Specification (Figure 5-16):

1. Shall verify that the nighttime shortwave radiance is zero within TBD error. Nighttime is identified during geolocation calculations.
 - a) Shall edit check the nighttime radiances.
 - b) Shall flag out-of-bound radiances.
2. Shall compare the nighttime Total and Longwave channel measurements.
3. Shall compare the two space clamp average values against the nighttime Nadir radiance values for each channel.
4. Shall update the radiance data file.
 - a) Shall collect a daily history of nighttime radiances.

5.2.2.4 Sort IES Footprints - Process 1.2.4

Input Data Flows

Footprint Data
Old Ies Overlap Footprints

Output Data Flows

Ies Footprint Data
New Ies Overlap Footprints

Process Specification (Figure 5-13):

1. Shall sort and group footprint location and radiance measurement information into 1-hour data files.
2. Shall sort footprint information by increasing alongtrack angle from beginning of 1-hour time reference.
 - a) Shall include footprints pointing up-range from the last hour of the previous day.
 - Note 1: This infers that the previous day's process is not complete until the subsequent day has been processed.
 - Note 2: This will also require contingency plans for unavailable subsequent data.
3. Shall generate overlap data file for footprints to be included in the first hour of the next day.
 - Note: This will require contingency plans for unavailable previous data.
4. Shall include converted radiometric and geolocation data for each footprint.
5. Shall output this data product only from data generated within the science mode (fixed and biaxial azimuth modes) and elevation profiles including normal Earth-, short-, and nadir-scan profiles.

5.2.3 Convert Calibration Data - Process 1.3

Input Data Flows

EGMOD
EPH ANC Record
ICCOEF
IRCOEF
Instr Cal Record
SPSEN

Output Data Flows

Cal Data
ICCOEF

Process Description (Figure 5-1):

1. Access, process, and validate all raw Level 0 instrument and spacecraft data files and all associated data files necessary to process this data.

- a) Access and accept as a minimum the following input data files:
 - 1) Auxiliary engineering, mathematical, and science constants.
 - 2) Auxiliary radiometric count conversion coefficients and limit values.
 - 3) Auxiliary calibration conversion values.
 - 4) Auxiliary coordinate system references.
 - 5) Auxiliary PGS environment variables and other parameterized input.
 - 6) Auxiliary history trend data.
 - 7) Auxiliary detector spectral sensitivity data.
 - b) Process and validate data file headers for the above input files and correlate this information with the PGE user data.
 - c) Temporarily store file parameters.
 - d) Halt production should any file headers be missing or erroneous and inform operator/analyst.
2. Compute and validate the locations of the radiance measurement sources with respect to specified coordinate frames and sampling schemes.
 - a) Compute the locations and individual vector components for each of the detector pointing vectors at the source of each CERES detector measurement with respect to the following coordinate systems:
 - 1) Fixed Spacecraft Frame.
 - 2) Spacecraft Local Horizon Frame.
 - 3) Earth-centered Fixed Frame.
 - 4) Earth-centered Inertial Frame.
 - b) Compute the following angular measurements associated with each CERES footprint:
 - 1) Viewing and solar zeniths.
 - 2) Relative azimuth.
 - 3) Viewing azimuth with respect to north.
 - 4) Cross-track and along-track angles.
 - 5) Cone and clock angles, and rates of change of cone and clock angles.
 - c) Edit and validate all locations and report results.
 3. Edit and validate raw CERES calibration and radiance data and compute, edit, and validate calibration parameters.
 - a) Verify that the detector engineering parameters are within specifications to enable footprint radiance conversions.
 - b) Compute, edit, analyze, and validate values of filtered radiance for each raw instrument measurement.
 - c) Calculate, evaluate, and analyze calibration data including, but not limited to, internal Longwave and Total Blackbody and Shortwave SWICS calibration data, solar calibration data, and selected normal science data.
 - d) Verify space clamp performance.
 - e) Update auxiliary data files containing calibration parameters.

The decomposition of this function is shown in [Figure 5-17](#).

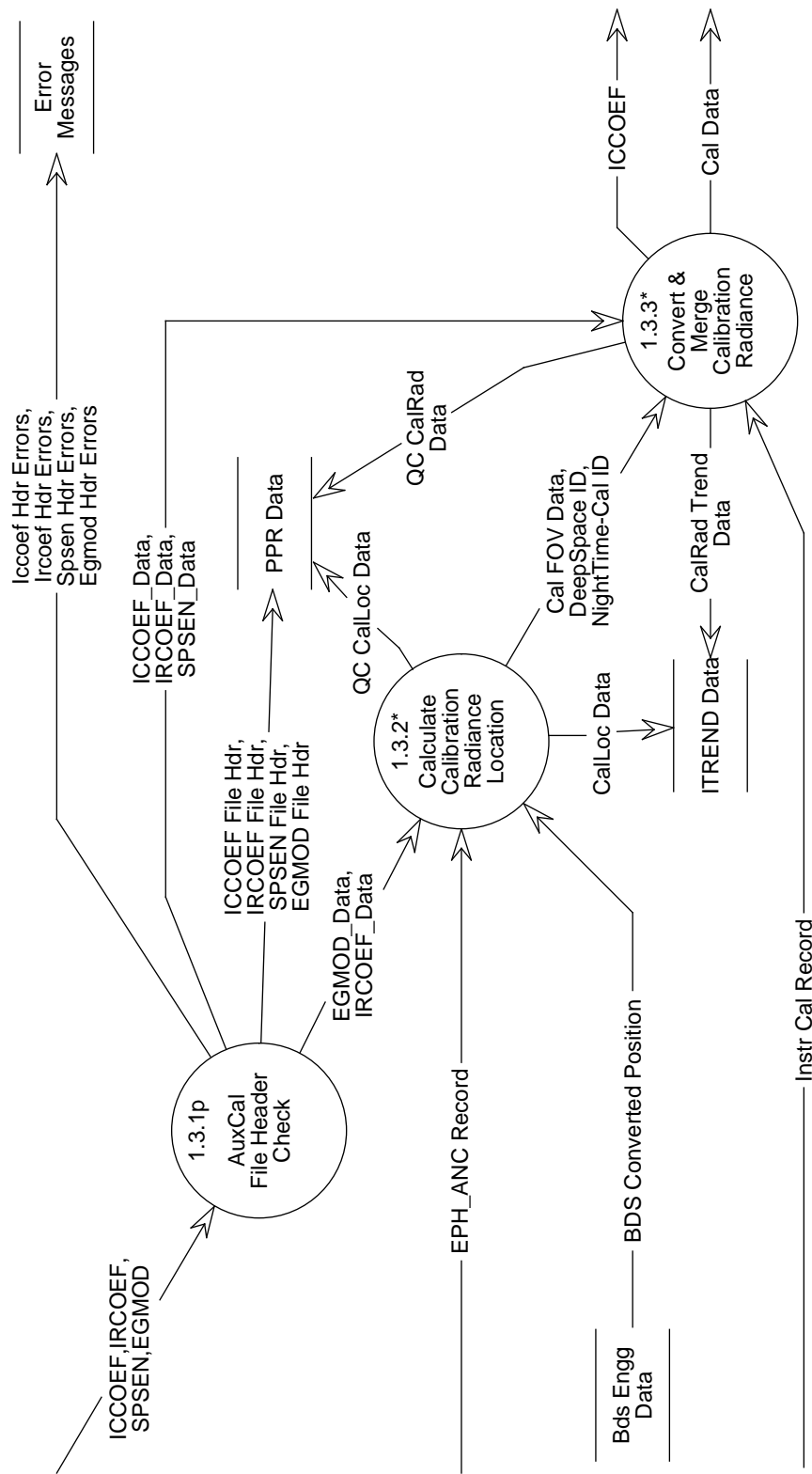


Figure 5-17. Data Flow Diagram for Convert Calibration Data

5.2.3.1 AuxCal File Header Check - Process 1.3.1

Input Data Flows

EGMOD
ICCOEF
IRCOEF
SPSEN

Output Data Flows

EGMOD Data
EGMOD File Hdr
Egmod Hdr Errors
ICCOEF Data
ICCOEF File Hdr
IRCOEF Data
IRCOEF File Hdr
Iccoef Hdr Errors
Ircoef Hdr Errors
SPSEN Data
SPSEN File Hdr
Spsen Hdr Errors

The decomposition of this function is shown in Figure 5-18.

Process Specification (Figure 5-17):

1. Shall access, verify, and validate the file headers for the following input data files:
 - a) Auxiliary engineering count conversion coefficients and limit values.
 - b) Auxiliary engineering, mathematical, and science constants.
 - c) Auxiliary radiometric count conversion coefficients and limit values.
 - d) Auxiliary coordinate system references.
 - e) Auxiliary PGS environment variables and other parameterized input.
 - f) Auxiliary history trend data.
2. Shall halt production should any file headers be missing or erroneous, generate error message reports, and inform operator/analyst.

The decomposition of this function is shown in Figure 5-18.

5.2.3.2 Calculate Calibration Radiance Location - Process 1.3.2

Input Data Flows

BDS Converted Position
EGMOD Data
EPH ANC Record
IRCOEF Data

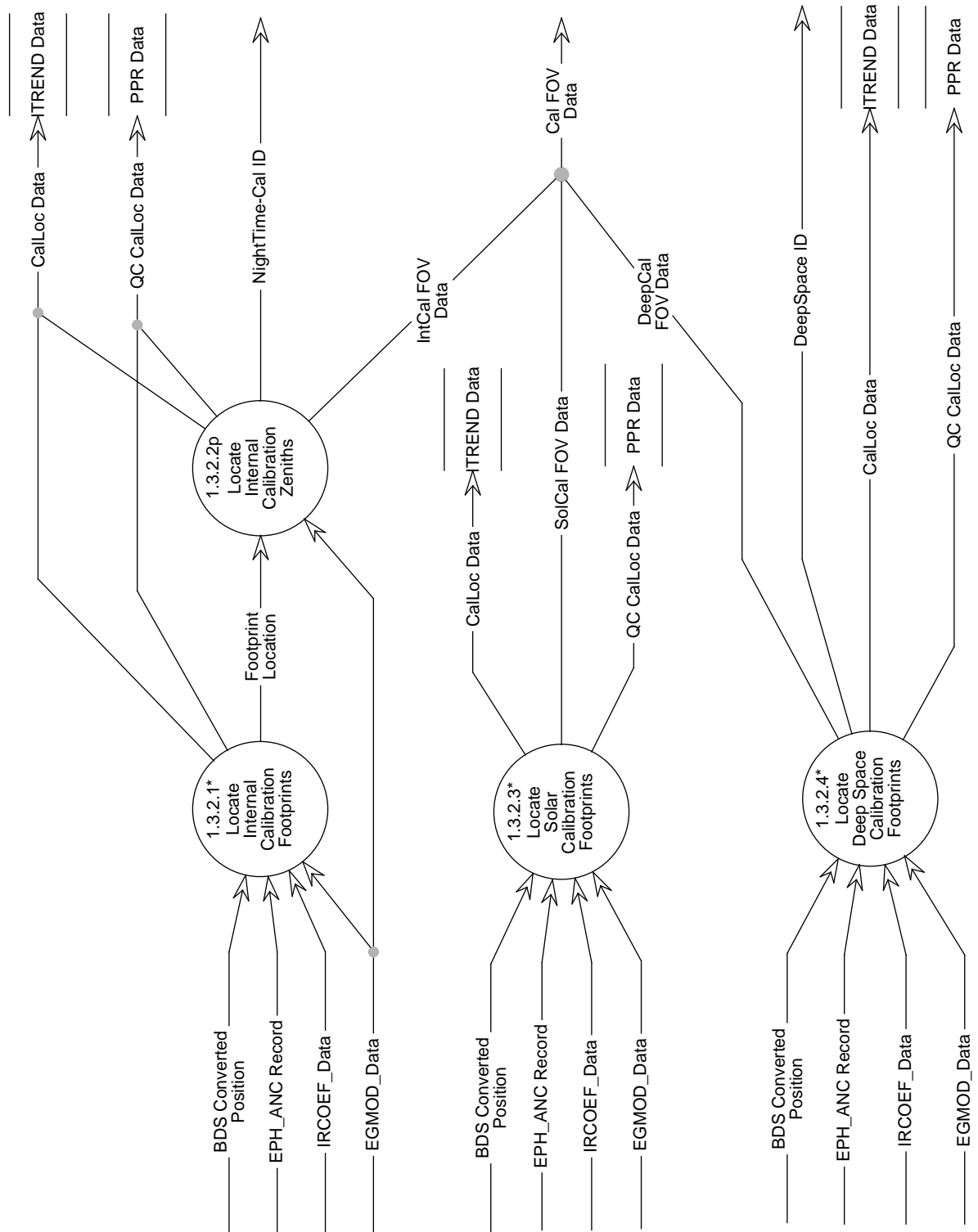


Figure 5-18. Data Flow Diagram for Calculate Calibration Radiance Location

Output Data Flows

CalLoc Data
Cal FOV Data
DeepSpace ID
NightTime-Cal ID
QC CalLoc Data

Process Description (Figure 5-18):

1. Compute and validate the locations of the radiance measurement sources with respect to specified coordinate frames and sampling schemes.
 - a) Compute the locations and individual vector components of the detector pointing vectors for the source of each CERES detector measurement with respect to the following coordinate systems:
 - 1) Fixed Spacecraft Frame.
 - 2) Spacecraft Local Horizon Frame.
 - 3) Earth-centered Fixed Frame.
 - 4) Earth-centered Inertial Frame.
 - b) Compute the following angular measurements associated with each CERES footprint:
 - 1) Viewing and solar zeniths.
 - 2) Relative azimuth.
 - 3) Viewing azimuth with respect to north.
 - 4) Cross-track and Along-track angles.
 - 5) Cone and clock angles and rates of change of cone and clock angles.
 - c) Calculate cross-products and dot-products for all location transformations, including orbit deviations.
 - d) Adjust for TRMM's CO₂ local horizon, if necessary.
 - e) Edit, validate, and analyze all locations, and report all results.

5.2.3.2.1 Locate Internal Calibration Footprints - Process 1.3.2.1

Input Data Flows

BDS Converted Position
EGMOD Data
EPH ANC Record
IRCOEF Data

Output Data Flows

CalLoc Data
Footprint Location
QC CalLoc Data

Process Description (Figure 5-18):

1. Compute and validate the locations of the radiance measurement sources with respect to specified coordinate frames and sampling schemes.
 - a) Compute the locations and individual vector components of the detector pointing vectors for the source of each CERES detector measurement with respect to the following coordinate systems:
 - 1) Fixed Spacecraft Frame.
 - 2) Spacecraft Local Horizon Frame.
 - 3) Earth-centered Fixed Frame.
 - 4) Earth-centered Inertial Frame.
 - b) Calculate cross-products and dot-products for all location transformations, including orbit deviations.
 - c) Adjust for TRMM's CO₂ local horizon, if necessary.
 - d) Edit, validate, and analyze all locations, and report all results.

The decomposition of this function is shown in [Figure 5-19](#).

5.2.3.2.1.1 Calculate Fixed Platf Vectors-Cal - Process 1.3.2.1.1

Input Data Flows

BDS Converted Position
DetMisAlign
IRCOEF Data
InstrMisAlign

Output Data Flows

Fixed-Platform Pointing Vectors

Process Specification (Figure 5-19):

1. Shall correct converted elevation angle by subtracting the detector time lag angle.
Note: This time lag angle will be supplied by either TRW or the CERES Science Team.
2. Shall transform detector pointing knowledge (corrected elevation angle, azimuth angle) to pointing vectors in the fixed instrument coordinate system.
3. Shall adjust pointing vectors in the fixed instrument coordinate system by correcting for detector-to-instrument misalignments.
Note: This 'adjustment' information will be supplied by TRW and will consist of one set of adjustment parameters per instrument.
4. Shall transform pointing vectors in the fixed instrument coordinate system to pointing vectors in the fixed-platform coordinate system.
5. Shall adjust the pointing vectors in the fixed instrument coordinate system by correcting for instrument-to-platform misalignments.

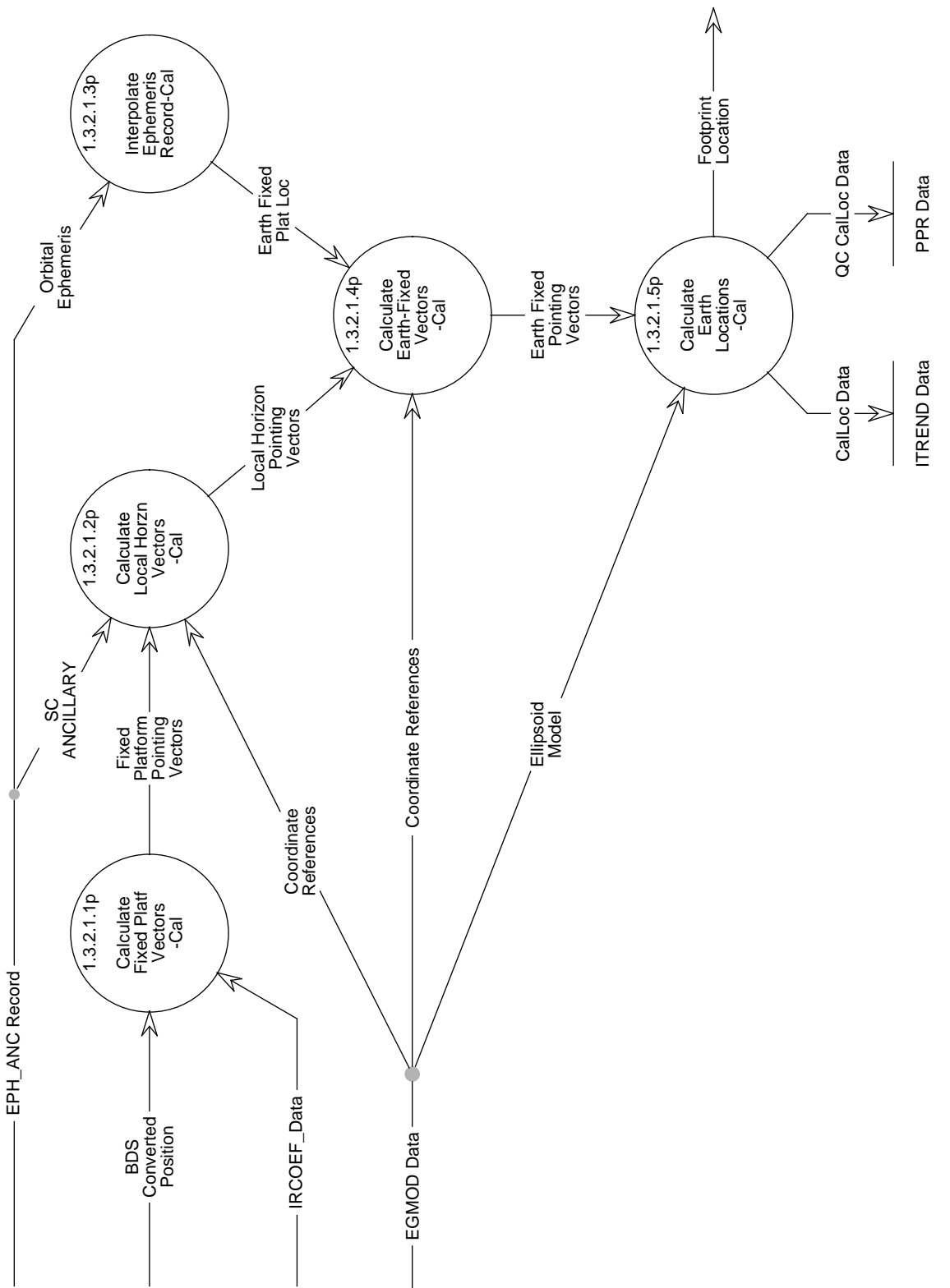


Figure 5-19. Data Flow Diagram for Locate Internal Calibration Footprints

Note: This 'adjustment' information will be supplied by TRW or the platform integrator and will consist of one set of adjustment parameters per instrument.

5.2.3.2.1.2 Calculate Local Horzn Vectors-Cal - Process 1.3.2.1.2

Input Data Flows

Coordinate References
EGMOD Data
EPH ANC Record
Fixed-Platform Pointing Vectors
SC ANCILLARY

Output Data Flows

Local Horizon Pointing Vectors

Process Specification (Figure 5-19):

Shall, for all CERES samples, transform the pointing vectors in the fixed-platform coordinate frame to pointing vectors in the local horizon coordinate frame by applying the platform attitude data to the appropriate transformation matrices.

5.2.3.2.1.3 Interpolate Ephemeris Record-Cal - Process 1.3.2.1.3

Input Data Flows

EPH ANC Record
Orbital Ephemeris

Output Data Flows

Earth Fixed Plat Loc

Process Specification (Figure 5-19):

1. Shall, for each CERES sample, find two specific ephemeris records: one with its (ephemeris) time closest to the CERES sample time but not greater than the CERES sample time, and the second with its (ephemeris) time closest to the CERES sample time but not less than the CERES sample time.
2. Shall interpolate the ephemeris state vectors to individual CERES sample times using the two ephemeris records identified above.
Note: The method of interpolation is TBD.
3. Shall convert the ephemeris state vectors (in the ECI coordinate frame) to the Earth-fixed coordinate system using the relationship between inertial longitude and Greenwich longitude.

This results in spacecraft position in the Earth-fixed coordinate system for all CERES sample times.

5.2.3.2.1.4 Calculate Earth-Fixed Vectors-Cal - Process 1.3.2.1.4

Input Data Flows

Coordinate References
EGMOD Data
Earth Fixed Plat Loc
Local Horizon Pointing Vectors

Output Data Flows

Earth Fixed Pointing Vectors

Process Specification (Figure 5-19):

1. Shall calculate heading angle of spacecraft for each CERES sample.
Note: The heading angle is the angle between north and the projection of the velocity vector in a plane tangent to the sample point on the geoid surface.
2. Shall transform local horizon pointing vectors to local geodetic pointing vectors for each CERES sample.
3. Shall, for all CERES samples, transform the pointing vectors in the local geodetic coordinate system to pointing vectors in the Earth-fixed coordinate system.

5.2.3.2.1.5 Calculate Earth Locations-Cal - Process 1.3.2.1.5

Input Data Flows

EGMOD Data
Earth Fixed Pointing Vectors
Ellipsoid Model

Output Data Flows

CalLoc Data
Footprint Location
QC CalLoc Data

Process Specification (Figure 5-19):

Shall compute, for each CERES sample, the pierce point of the pointing vector in the Earth-fixed coordinate system with both the Earth geoid model and the 30 km TOA model.

Note: This computation shall result in a longitude and colatitude value for each CERES sample.

5.2.3.2.2 Locate Internal Calibration Zeniths - Process 1.3.2.2

Input Data Flows

EGMOD Data
Footprint Location

Output Data Flows

CalLoc Data
Cal FOV Data
IntCal FOV Data
NightTime-Cal ID
QC CalLoc Data

Process Specification (Figure 5-18):

1. Shall calculate the solar beta angle for each CERES scan.
Note: The solar beta angle is defined as the angle between the spacecraft velocity vector and the Sun's direction.
2. Shall calculate viewing zenith angle for each CERES sample.
Note: The viewing zenith angle is defined as the angle between a sample's local zenith direction and the detector's pointing direction.
3. Shall calculate solar zenith angle for each CERES sample.
Note: The solar zenith angle is defined as the angle between a sample's local zenith direction and the Sun's direction.
4. Shall calculate relative azimuth angle for each CERES sample.
Note: The relative azimuth angle is defined as the angle between the direction which is 180 degrees away from the sample location to the subsolar point and the direction from the sample location to the subsatellite point, measured in a clockwise direction in a plane that is tangential to the sample's location on the Earth's surface.
5. Shall calculate azimuth angle with respect to north for each CERES sample.
Note: The azimuth angle with respect to north is defined as the angle between the sample location and the direction to north and the direction from the sample location to the subsatellite point, measured in a clockwise direction in a plane that is tangential to the sample's location on the Earth's surface.
6. Shall calculate local solar time for each CERES sample.
7. Shall calculate along-track and cross-track angles for each CERES sample, to be used when organizing the IES.
Note: The cross-track angle is defined as the angular offset of the sample point from the perpendicular point on the ground track, measured from the center of the Earth. The angle is positive when the sample is between the ground-track and the positive momentum vector, and negative if the sample is between the ground track and the negative momentum vector. The along-track angle is defined as the difference between the satellite ground-track position at the start of an hour and the point on the ground track which is perpendicular to the sample point.
8. Shall calculate the cone and clock angles, and cone and clock angle rates of change, for each CERES sample.
Note: The cone angle is defined as the angle between the direction to the center of the Earth and the direction of the pointing vector. The clock angle is defined as the angle between the projection of the velocity vector in the spacecraft local horizon XY plane and the projection of the pointing vector in the spacecraft local horizon XY plane.
9. Shall determine the lighting conditions for each CERES sample. The lighting conditions may be classified as space-look, space (motion), day, terminator, night, internal, or MAM.

5.2.3.2.3 Locate Solar Calibration Footprints - Process 1.3.2.3

Input Data Flows

BDS Converted Position
EGMOD Data
EPH ANC Record
IRCOEF Data

Output Data Flows

CalLoc Data
Cal FOV Data
QC CalLoc Data
SolCal FOV Data

Process Description (Figure 5-18):

1. Compute and validate the locations of the radiance measurement sources with respect to specified coordinate frames and sampling schemes.
 - a) Compute the locations and individual vector components of the detector pointing vectors for the source of each CERES detector measurement with respect to the following coordinate systems:
 - 1) Fixed Spacecraft Frame.
 - 2) Spacecraft Local Horizon Frame.
 - 3) Earth-centered Fixed Frame.
 - 4) Earth-centered Inertial Frame.
 - b) Calculate cross-products and dot-products for all location transformations, including orbit deviations.
 - c) Adjust for TRMM's CO₂ local horizon, if necessary.
 - d) Edit, validate, and analyze all locations, and report all results.

Note: Geolocation calculations only need to be performed on the few samples that are taken outside of the instrument housing during a solar calibration.

The decomposition of this function is shown in [Figure 5-20](#).

5.2.3.2.3.1 Calculate Fixed Platf Vectors-Sol - Process 1.3.2.3.1

Input Data Flows

BDS Converted Position
DetMisAlign
IRCOEF Data
InstrMisAlign

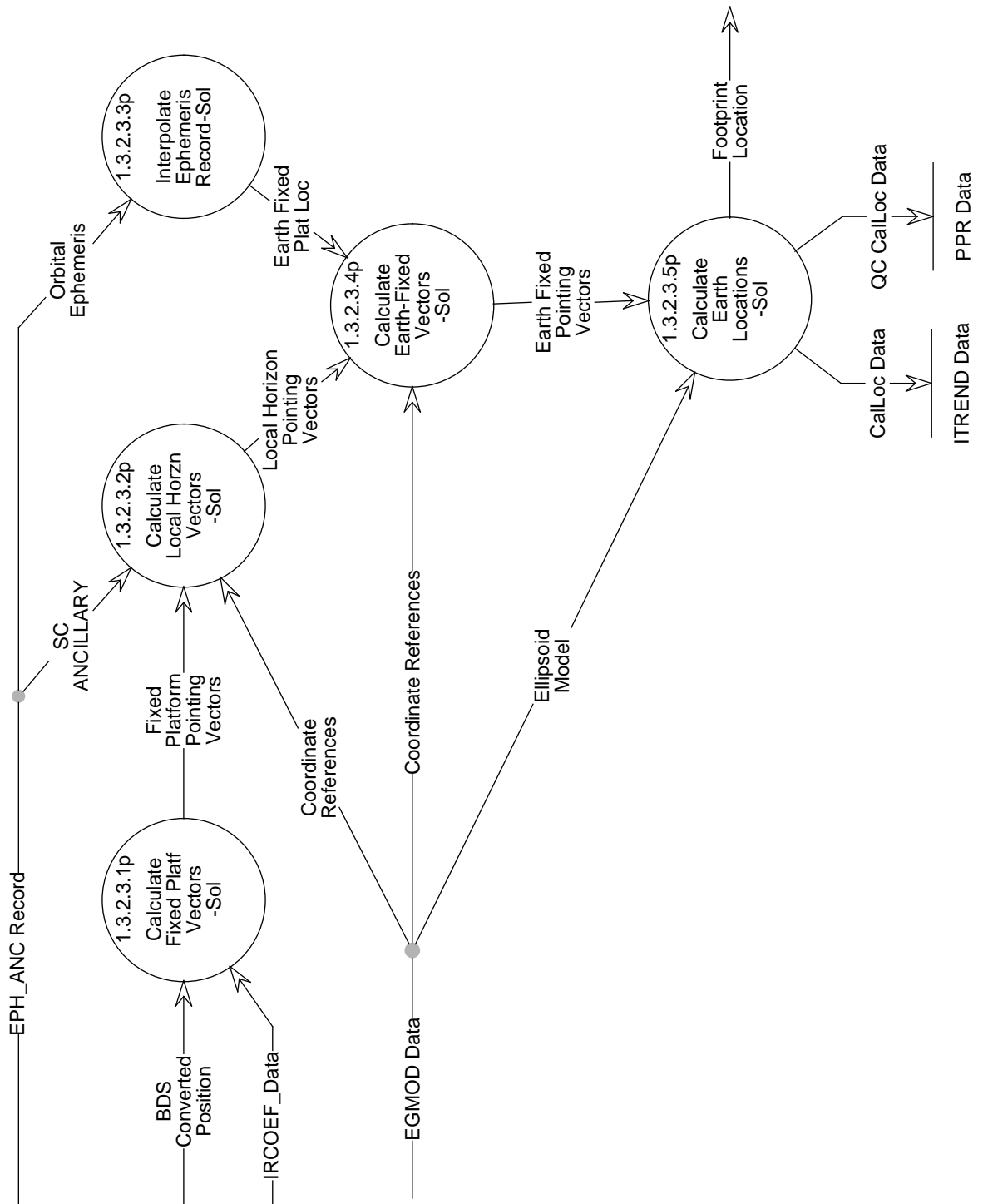


Figure 5-20. Data Flow Diagram for Locate Solar Calibration Footprints

Output Data Flows

Fixed-Platform Pointing Vectors

Process Specification (Figure 5-20):

Shall, for all CERES samples, transform the pointing vectors in the fixed-platform coordinate frame to pointing vectors in the local horizon coordinate frame by applying the platform attitude data to the appropriate transformation matrices.

5.2.3.2.3.2 Calculate Local Horzn Vectors-Sol - Process 1.3.2.3.2

Input Data Flows

Coordinate References
EGMOD Data
EPH ANC Record
Fixed-Platform Pointing Vectors
SC ANCILLARY

Output Data Flows

Local Horizon Pointing Vectors

Process Specification (Figure 5-20):

Shall, for all CERES samples, transform the pointing vectors in the fixed-platform coordinate frame to pointing vectors in the local horizon coordinate frame by applying the platform attitude data to the appropriate transformation matrices.

5.2.3.2.3.3 Interpolate Ephemeris Record-Sol - Process 1.3.2.3.3

Input Data Flows

EPH ANC Record
Orbital Ephemeris

Output Data Flows

Earth Fixed Plat Loc

Process Specification (Figure 5-20):

1. Shall, for each CERES sample, find two specific ephemeris records: one with its (ephemeris) time closest to the CERES sample time but not greater than the CERES sample time, and the second with its (ephemeris) time closest to the CERES sample time but not less than the CERES sample time.

2. Shall interpolate the ephemeris state vectors to individual CERES sample times, using the two ephemeris records identified above.
Note: The method of interpolation is TBD.
3. Shall convert the ephemeris state vectors (in the ECI coordinate frame) to the Earth-fixed coordinate system, using the relationship between inertial longitude and Greenwich longitude.

This results in spacecraft position in the Earth-fixed coordinate system for all CERES sample times.

5.2.3.2.3.4 Calculate Earth-Fixed Vectors-Sol - Process 1.3.2.3.4

Input Data Flows

Coordinate References
EGMOD Data
Earth Fixed Plat Loc
Local Horizon Pointing Vectors

Output Data Flows

Earth-Fixed Pointing Vectors

Process Specification (Figure 5-20):

1. Shall calculate heading angle of spacecraft for each CERES sample.
Note: The heading angle is the angle between north and the projection of the velocity vector in a plane tangent to the sample point on the geoid surface.
2. Shall transform local horizon pointing vectors to local geodetic pointing vectors for each CERES sample.
3. Shall, for all CERES samples, transform the pointing vectors in the local geodetic coordinate system to pointing vectors in the Earth-fixed coordinate system.
4. Shall calculate the Sun position relative to the MAM position (as a difference in elevation/azimuth) for the period when the instrument is in solar calibration mode.

5.2.3.2.3.5 Calculate Earth Locations-Sol - Process 1.3.2.3.5

Input Data Flows

EGMOD Data
Earth-Fixed Pointing Vectors
Ellipsoid Model

Output Data Flows

CalLoc Data
Footprint Location
QC CalLoc Data

Process Specification (Figure 5-20):

Shall compute, for each CERES sample, the pierce point of the pointing vector in the Earth-fixed coordinate system with both the Earth geoid model and the 30 km TOA model.

Note: This computation shall result in a longitude and colatitude value for each CERES sample.

5.2.3.2.4 Locate Deep Space Calibration Footprints - Process 1.3.2.4

Input Data Flows

BDS Converted Position
EGMOD Data
EPH ANC Record
IRCOEF Data

Output Data Flows

CalLoc Data
Cal FOV Data
DeepCal FOV Data
DeepSpace ID
QC CalLoc Data

Process Description (Figure 5-18):

1. Compute and validate the locations of the radiance measurement sources with respect to specified coordinate frames and sampling schemes.
 - a) Compute the locations and individual vector components of the detector pointing vectors for the source of each CERES detector measurement with respect to the following coordinate systems:
 - 1) Fixed Spacecraft Frame.
 - 2) Spacecraft Local Horizon Frame.
 - 3) Earth-centered Fixed Frame.
 - 4) Earth-centered Inertial Frame.
 - b) Calculate cross-products and dot-products for all location transformations, including orbit deviations.
 - c) Adjust for TRMM's CO₂ local horizon, if necessary.
 - d) Edit, validate, and analyze all locations, and report all results.

The decomposition of this function is shown in Figure 5-21.

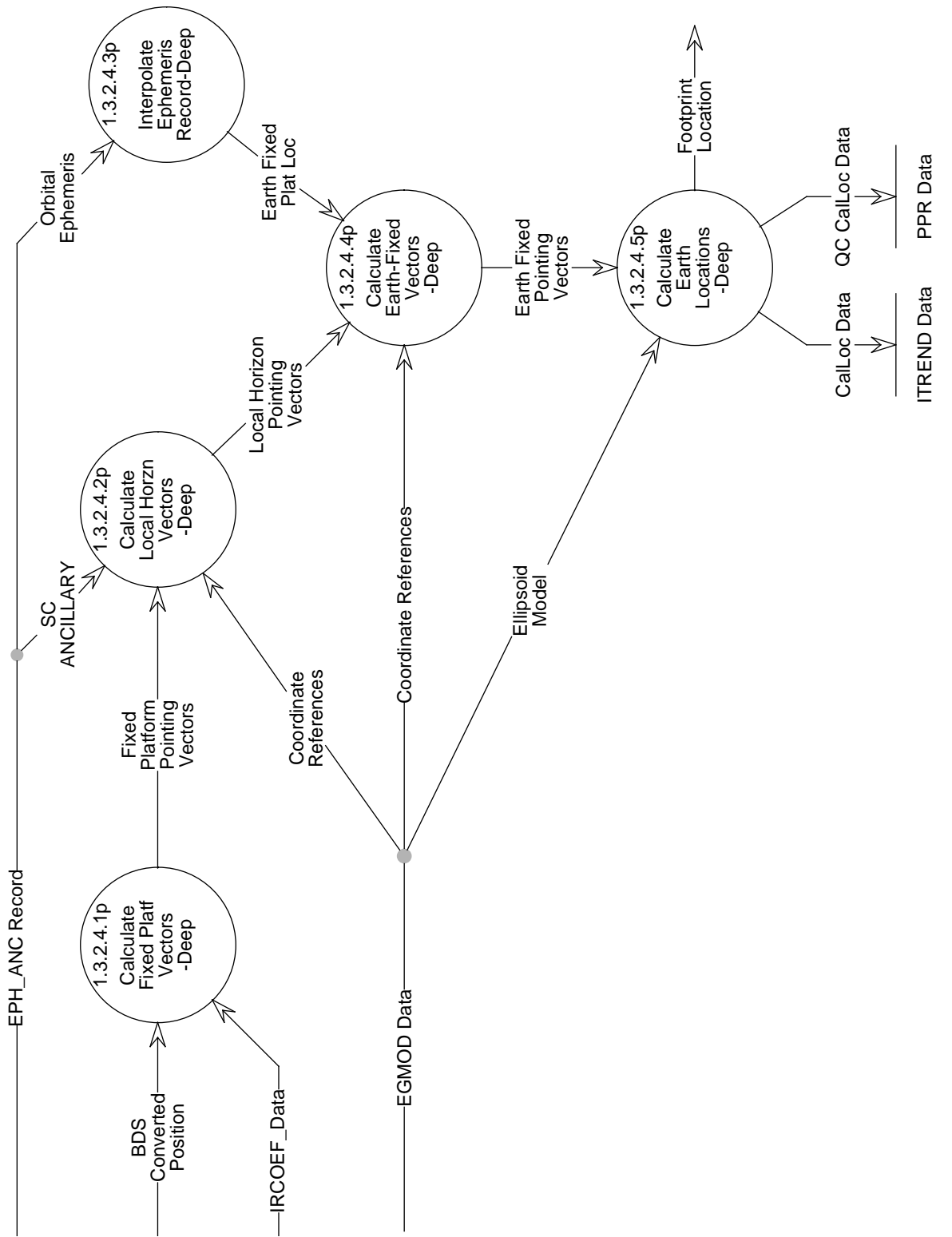


Figure 5-21. Data Flow Diagram for Locate Deep Space Calibration Footprints

5.2.3.2.4.1 Calculate Fixed Platf Vectors-Deep - Process 1.3.2.4.1

Input Data Flows

BDS Converted Position
DetMisAlign
IRCOEF Data
InstrMisAlign

Output Data Flows

Fixed-Platform Pointing Vectors

Process Specification (Figure 5-21):

1. Shall correct converted elevation angle by subtracting the detector time lag angle.
Note: This time lag angle will be supplied by either TRW or the CERES Science Team.
2. Shall transform detector pointing knowledge (corrected elevation angle, azimuth angle) to pointing vectors in the fixed-instrument coordinate system.
3. Shall adjust pointing vectors in the fixed-instrument coordinate system by correcting for detector-to-instrument misalignments.
Note: This 'adjustment' information will be supplied by TRW, and will consist of one set of adjustment parameters per instrument.
4. Shall transform pointing vectors in the fixed-instrument coordinate system to pointing vectors in the fixed-platform coordinate system.
5. Shall adjust the pointing vectors in the fixed-instrument coordinate system by correcting for instrument-to-platform misalignments.
Note: This 'adjustment' information will be supplied by TRW or the platform integrator, and will consist of one set of adjustment parameters per instrument.

5.2.3.2.4.2 Calculate Local Horzn Vectors-Deep - Process 1.3.2.4.2

Input Data Flows

Coordinate References
EGMOD Data
EPH ANC Record
Fixed-Platform Pointing Vectors
SC ANCILLARY

Output Data Flows

Local Horizon Pointing Vectors

Process Specification (Figure 5-21):

Shall, for all CERES samples, transform the pointing vectors in the fixed-platform coordinate frame to pointing vectors in the local horizon coordinate frame by applying the platform attitude data to the appropriate transformation matrices.

5.2.3.2.4.3 Interpolate Ephemeris Record-Deep - Process 1.3.2.4.3

Input Data Flows

EPH ANC Record
Orbital Ephemeris

Output Data Flows

Earth Fixed Plat Loc

Process Specification (Figure 5-21):

1. Shall, for each CERES sample, find two specific ephemeris records: one with its (ephemeris) time closest to the CERES sample time but not greater than the CERES sample time, and the second with its (ephemeris) time closest to the CERES sample time but not less than the CERES sample time.
2. Shall interpolate the ephemeris state vectors to individual CERES sample times, using the two ephemeris records identified above.
Note: The method of interpolation is TBD.
3. Shall convert the ephemeris state vectors (in the ECI coordinate frame) to the Earth-fixed coordinate system, using the relationship between inertial longitude and Greenwich longitude.

This results in spacecraft position in the Earth-fixed coordinate system for all CERES sample times.

5.2.3.2.4.4 Calculate Earth-Fixed Vectors-Deep - Process 1.3.2.4.4

Input Data Flows

Coordinate References
EGMOD Data
Earth Fixed Plat Loc
Local Horizon Pointing Vectors

Output Data Flows

Earth Fixed Pointing Vectors

Process Specification (Figure 5-21):

1. Shall calculate heading angle of spacecraft for each CERES sample.
Note: The heading angle is the angle between north and the projection of the velocity vector in a plane tangent to the sample on the geoid surface.
2. Shall transform local horizon pointing vectors to local geodetic pointing vectors for each CERES sample.
3. Shall, for all CERES samples, transform the pointing vectors in the local geodetic coordinate system to pointing vectors in the Earth-fixed coordinate system.

5.2.3.2.4.5 Calculate Earth Locations-Deep - Process 1.3.2.4.5

Input Data Flows

EGMOD Data
Earth Fixed Pointing Vectors
Ellipsoid Model

Output Data Flows

CalLoc Data
Footprint Location
QC CalLoc Data

Process Specification (Figure 5-21):

Shall compute, for each CERES sample, the pierce point of the pointing vector in the Earth-fixed coordinate system with both the Earth geoid model and the 30 km TOA model.

Note: This computation shall result in a longitude and colatitude value for each CERES sample.

5.2.3.3 Convert and Merge Calibration Radiance - Process 1.3.3

Input Data Flows

Cal FOV Data
DeepSpace ID
ICCOEF Data
IRCOEF Data
Instr Cal Record
NightTime-Cal ID
SPSEN Data

Output Data Flows

CalRad Trend Data
Cal Data
ICCOEF
QC CalRad Data

Process Description (Figure 5-17):

1. Edit and validate raw CERES calibration radiance measurements and compute, edit, and validate science and calibration radiances.
 - a) Verify that the detector and calibration source engineering parameters are within specifications to enable footprint radiance conversions. Note this process is routinely done in the engineering conversion process (1.1.3).
 - b) Identify and validate space clamp occurrences and values.
 - c) Compute, edit, analyze, and validate values of filtered radiance for each raw instrument measurement.
 - d) Verify that the nighttime Shortwave channel data is zero within TBD error and compare Longwave and Total channel nighttime measurements.
 - e) Merge geolocation data with converted radiance data to produce footprint groupings for BDS and IES output data products.

The decomposition of this function is shown in [Figure 5-22](#).

5.2.3.3.1 Evaluate Detector Engg Data-Cal - Process 1.3.3.1

Input Data Flows

BDS Sensor Operation
Bds Analog Data
DeepSpace ID

Output Data Flows

Detector Data
Space-Look Flag

Process Specification (Figure 5-22):

1. Shall verify that the following detector engineering parameters are within the tighter specifications required to enable footprint radiance conversions. Range values are TBDs and will be defined during the software development phase.

Output Detector Data consisting of:

Analog Values:	Range:
Postn_Elev	
Postn_Az	
Temp_Tot_Montr	
Temp_SW_Montr	

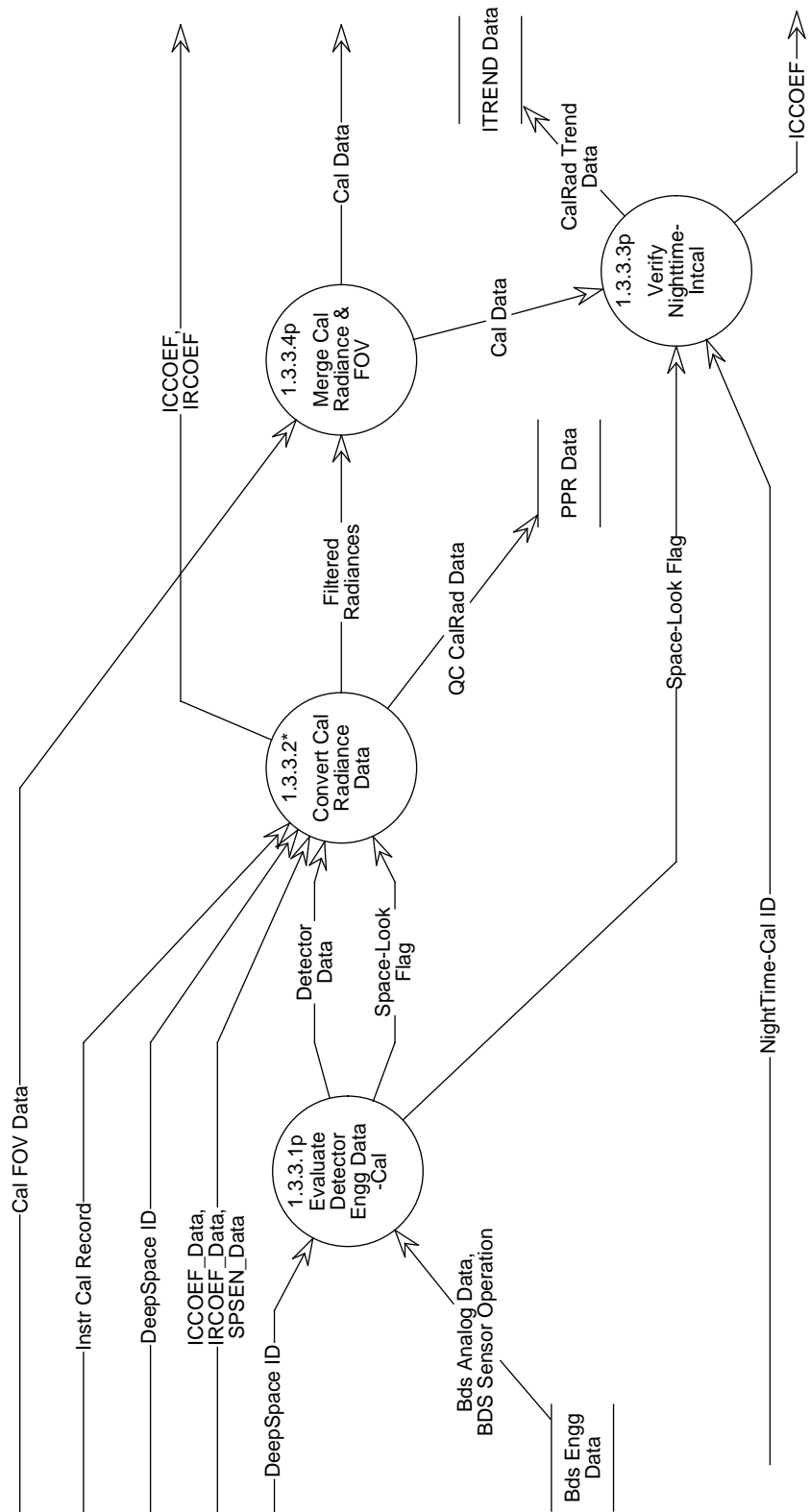


Figure 5-22. Data Flow Diagram for Convert and Merge Calibration Radiance

Temp_Wn_Montr
Temp_Tot_BB
Temp_LW_BB
Temp_SWICS_Photdio
Temp_Tot_MAM_Baf1
Temp_Tot_MAM_Baf2
Temp_SW_MAM_Assy
Temp_Tot_MAM_Assy

Volt_Sensr_Pos120_Bias
Volt_Sensr_Neg120_Bias
Volt_SWICS_Photdio
Volt_SWICS_Lamp_Curr
Volt_Ref_DAA_Neg10

Digital Values:

Detector_Controls (Temperatures)
Statword_Tot_Temp_Setpt
Statword_Tot_Temp_Cntl
Statword_SW_Temp_Setpt
Statword_SW_Temp_Cntl
Statword_Wn_Temp_Setpt
Statword_Wn_Temp_Cntl

Total_Detector_Bridge_Bal:
Statword_Tot_Cors_Brid_DAC
Statword_Tot_Fine_Brid_DAC
Statword_Tot_Brid_Cntl
Statword_Tot_Brid_DAC_Update
Statword_Tot_Brid_Reset_Cnt

SW_Detector_Bridge_Bal:
Statword_SW_Cors_Brid_DAC
Statword_SW_Fine_Brid_DAC
Statword_SW_Brid_Cntl
Statword_SW_Brid_DAC_Update
Statword_SW_Brid_Reset_Cnt

Wn_Detector_Bridge_Bal:
Statword_Wn_Cors_Brid_DAC
Statword_Wn_Fine_Brid_DAC
Statword_Wn_Brid_Cntl
Statword_Wn_Brid_DAC_Update
Statword_Wn_Brid_Reset_Cnt

INSTR_Bridge_Balance_Status:

Statword_Brid_Setpt
 Statword_Start_Brid_Spaclk
 Statword_End_Brid_Spaclk
 Statword_Updt_Brid_DAC
 Statword_Brid_Low
 Statword_Brid_High

2. Shall generate a space-look flag for internal calibration and solar calibration processing based on the criteria shown in [Tables 5-18 and 5-19](#).

Table 5-18. Space-Look Flag for Internal Calibration

	EOS	TRMM
Postn_Elev (Angle)	18 & 162 deg	11 & 169 deg
Postn_Elev Sample Numbers (approximate):		
Forward Scan	0-49, 277-298	0-32, 283-301
Reverse Scan	361-382, 610-659	358-376, 627-659

Table 5-19. Space-Look Flag for Solar Calibration

	EOS	TRMM
Postn_Elev (Angle)	162 deg	169 deg
Postn_Elev Sample Numbers (approximate):		
"First 1/2 of Scan"	0-46, 157-205, 283-330	0-49, 154-208, 280-330
"Second 1/2 of Scan"	331-377, 487-535, 613-659	331-380, 484-538, 610-659

- a) Shall set space-look flag only if elevation and geolocation values indicate instrument is viewing space.
- b) Shall use the higher elevation angle values for the solar calibration process.
3. Shall flag current calibration record as having a bad space clamp if any of the above conditions are not satisfied.

5.2.3.3.2 Convert Cal Radiance Data - Process 1.3.3.2

Input Data Flows

DeepSpace ID

Detector Data
ICCOEF Data
IRCOEF Data
Instr Cal Record
SPSEN Data
Space-Look Flag

Output Data Flows

Filtered Radiances
ICCOEF
IRCOEF
QC CalRad Data

Process Description (Figure 5-22):

1. Edit check converted engineering data.
2. Generate an error discrepancies report.

The decomposition of this function is shown in [Figure 5-23](#).

5.2.3.3.2.1 Convert and Validate Int Cal Data - Process 1.3.3.2.1

Input Data Flows

Detector Data
ICCOEF Data
IRCOEF Data
Instr Cal Record
Previous Scan Data
SPSEN Data
Space-Look Flag

Output Data Flows

Cal Data Updates
Filtered Radiances
QC CalRad IntCal Data

Process Specification (Figure 5-23):

1. Shall average the radiance counts for each detector during the samples shown in [Table 5-20](#), to obtain a space clamp value when indicated by the space-look flag and to offset the raw science radiance.

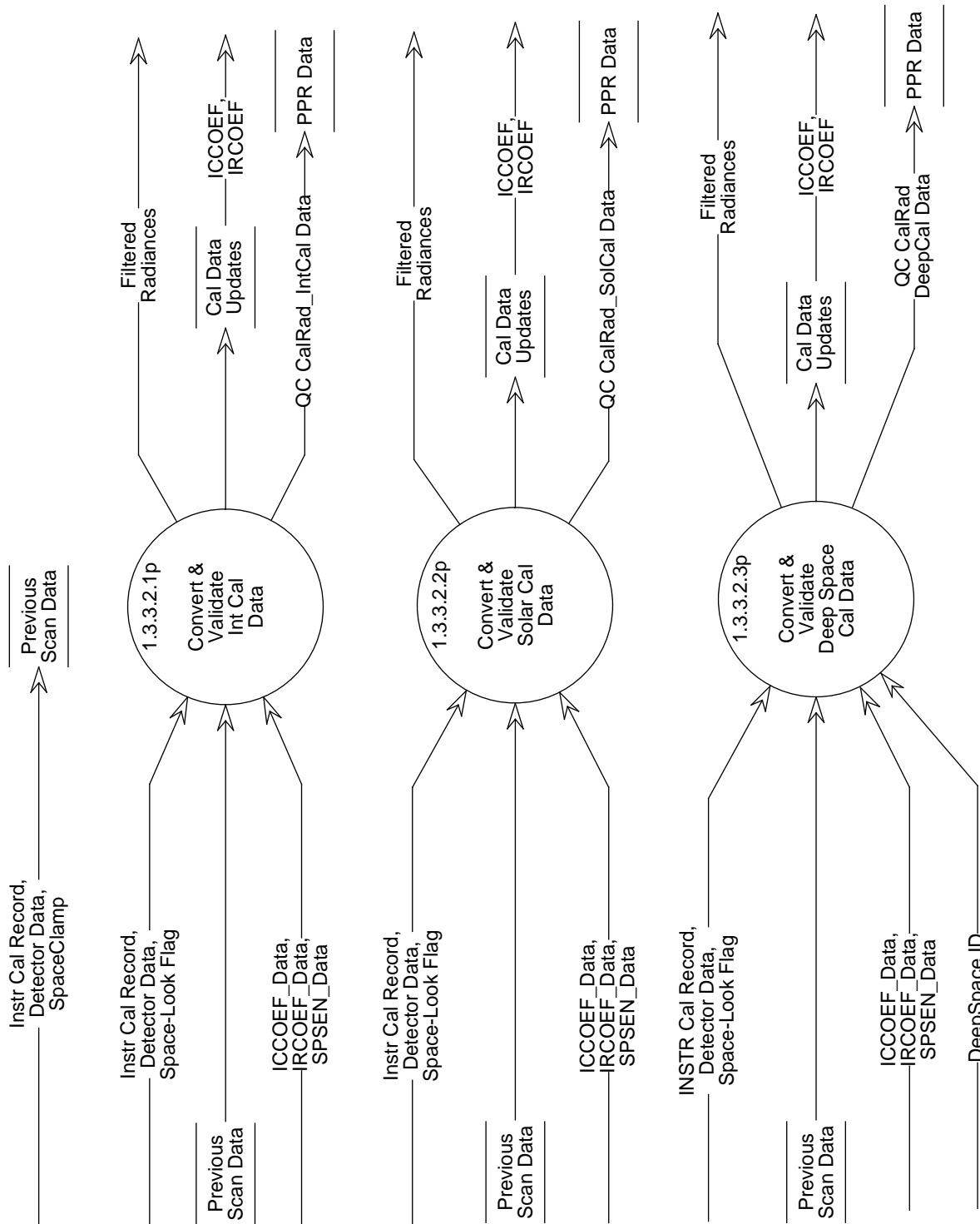


Figure 5-23. Data Flow Diagram for Convert Cal Radiance Data

Table 5-20. Space-Look Flag to Offset Raw Internal Cal Science

	EOS	TRMM
Postn_Elev (Angle)	18 & 162 deg	11 & 169 deg
Postn_Elev Sample Numbers (approximate):		
Forward Scan	0-49, 277-298	0-32, 283-301
Reverse Scan	361-382, 610-659	358-376, 627-659

- a) Shall verify space clamp is within TBD standard deviations.
- b) Shall verify space clamp is within TBD limits if failed standard deviation test.
- c) Shall set error flag if space clamp fails validation tests.
 Note: This will require two passes through the data - 1st to find and average space-look values, and 2nd to then correct the scan data.
2. Shall compute detector gain parameters from the instrument Longwave and Total blackbody and SWICS.
3. Shall incorporate the following measurement groups to compute calibration parameters:
 - a) detector voltages
 - b) detector bias voltage
 - c) analog-to-digital converter reference voltage
 - d) detector heater control temperature

Radiance Voltages:

Rad_Tot_Det_Cnt -> 0 - 4095
 Rad_SW_Det_Cnt -> 0 - 4095
 Rad_Wn_Det_Cnt -> 0 - 4095

Analog Values:

Temp_Tot_Montr
 Temp_SW_Montr
 Temp_Wn_Montr
 Temp_Tot_BB
 Temp_LW_BB
 Temp_SWICS_Photdio
 Temp_Tot_MAM_Baf1
 Temp_Tot_MAM_Baf2
 Temp_SW_MAM_Assy
 Temp_Tot_MAM_Assy

 Volt_Sensr_Pos120_Bias
 Volt_Sensr_Neg120_Bias
 Volt_SWICS_Photdio
 Volt_SWICS_Lamp_Curr
 Statword_Tot_Htr_DAC

Statword_SW_Htr_DAC
Statword_Wn_Htr_DAC
Statword_BB_Htr_DAC

Digital Values:

Detector_Controls (Temperatures)
Statword_Tot_Temp_Setpt
Statword_Tot_Temp_Cntl
Statword_SW_Temp_Setpt
Statword_SW_Temp_Cntl
Statword_Wn_Temp_Setpt
Statword_Wn_Temp_Cntl

Total_Detector_Bridge_Bal
Statword_Tot_Cors_Brid_DAC
Statword_Tot_Fine_Brid_DAC
Statword_Tot_Brid_Cntl
Statword_Tot_Brid_DAC_Update
Statword_Tot_Brid_Reset_Cnt

SW_Detector_Bridge_Bal
Statword_SW_Cors_Brid_DAC
Statword_SW_Fine_Brid_DAC
Statword_SW_Brid_Cntl
Statword_SW_Brid_DAC_Update
Statword_SW_Brid_Reset_Cnt

Wn_Detector_Bridge_Bal
Statword_Wn_Cors_Brid_DAC
Statword_Wn_Fine_Brid_DAC
Statword_Wn_Brid_Cntl
Statword_Wn_Brid_DAC_Update
Statword_Wn_Brid_Reset_Cnt

INSTR_Bridge_Balance_Status
Statword_Brid_Setpt
Statword_Start_Brid_Spaclk
Statword_End_Brid_Spaclk
Statword_Updt_Brid_DAC
Statword_Brid_Low
Statword_Brid_High

Space Clamp

4. Shall use the radiance count conversion algorithm to convert raw detector counts to engineering units. This algorithm will be defined during the software development phase.

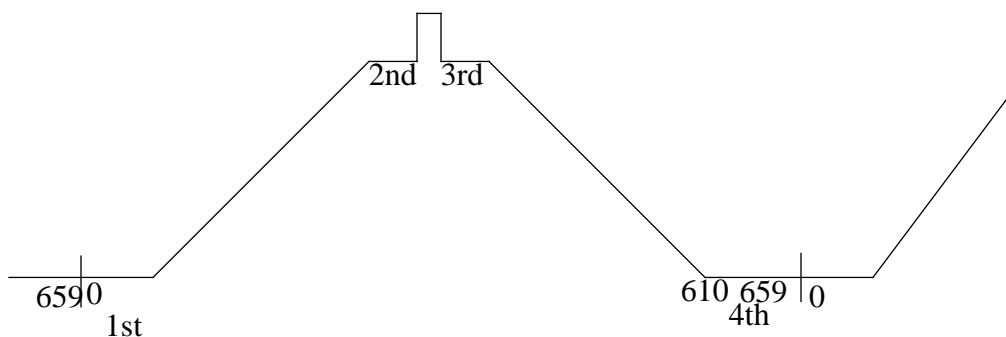
- a) Shall correct the raw radiance counts using average and interpolated space clamp count values. Interpolated space clamp values are determined based on the following suggested procedure and referring to the figure below.
- 1) Shall interpolate between the two scan averages for the anti-Sun side views at the beginning and end of each packet (set 1 and 4).
 - 2) Shall interpolate between the two scan averages for the Sun-side views for the current packet on both sides of the internal calibration view should the anti-Sun views be invalid (set 2 and 3).
 - 3) Shall use the internal calibration sources for radiance adjustments should the Sun-side views be invalid. No interpolation is performed.
 - 4) Shall not process radiances for current packet if the internal calibrations are invalid.

Note 1: Option 1) is generally used for correction in both normal and short scan mode. In the case of bad space value in the first and/or last set, Option 2) will be used. If all the space clamp values cannot be used, Option 3) will be used. Options 2) and 3) are used only for the normal scan mode.

Note 2: A fourth option that can be considered is interpolating between first and second space clamp averages and use it for the forward scan, and interpolate between third and fourth space clamp averages to use for backward scan.

Note 3: A fifth option that can be considered is to interpolate the 2nd/3rd sets from two adjacent packets; the current and the next. The fourth and fifth options should be evaluated as part of the design phase.

Note 4: The numbers shown in the table above, and the options discussed above, are the normal Earth-scan. Different options will be used for the other scan profiles. These options will be developed during the design phase.



- b) Shall offset radiances using position-dependent corrections, should they be required.
 - c) Shall compute the radiances for each of the SWICS set levels and BB measurements.
 - d) Shall compute radiances in engineering units based on corrected raw radiance counts.
5. Shall update the radiance coefficient files used for science production data when coefficients computed here exceed TBD limits.
- a) Shall notify analyst and scientist of changes made to calibration parameter files.

6. Shall generate quality control reports for evaluating calibration performance.
 - a) Shall evaluate the gain stability (gain and offset determinations) of these detectors by comparing current values to historical trends.

Note: Time series plots for all three detectors will be generated during the trending operation.

5.2.3.3.2.2 Convert and Validate Solar Cal Data - Process 1.3.3.2.2

Input Data Flows

Detector Data
 ICCOEF Data
 IRCOEF Data
 Instr Cal Record
 Previous Scan Data
 SPSEN Data
 Space-Look Flag

Output Data Flows

Cal Data Updates
 Filtered Radiances
 QC CalRad SolCal Data

Process Specification (Figure 5-23):

1. Shall average the radiance counts for each detector during the samples shown in Figure 5-21, to obtain a space clamp value when indicated by the Space-look flag and to offset the raw science radiance.
 - a) Shall verify space clamp is within TBD standard deviations.
 - b) Shall verify space clamp is within TBD limits if failed standard deviation test.
 - c) Shall set error flag if space clamp fails validation tests.

Note: This will require two passes through the data - 1st to find and average space clamp values, and 2nd to then correct the scan data.

Table 5-21. Space-Look Flag for Solar Calibration

	EOS	TRMM
Postn_Elev (Angle)	162 deg	169 deg
Postn_Elev Sample Numbers (approximate):		
"First 1/2 of Scan"	0-46, 157-205, 283-330	0-49, 154-208, 280-330
"Second 1/2 of Scan"	331-377, 487-535, 613-659	331-380, 484-538, 610-659

2. Shall incorporate the following measurement groups to compute radiances.
 - a) detector voltages
 - b) detector bias voltage
 - c) analog-to-digital converter reference voltage
 - d) detector heater control temperatures

Radiance Voltages:

Rad_Tot_Det_Cnt -> 0 - 4095
 Rad_SW_Det_Cnt -> 0 - 4095
 Rad_Wn_Det_Cnt -> 0 - 4095

Analog Values:

Temp_Tot_Montr
 Temp_SW_Montr
 Temp_Wn_Montr
 Temp_Tot_BB
 Temp_LW_BB
 Temp_SWICS_Photdio
 Temp_Tot_MAM_Baf1
 Temp_Tot_MAM_Baf2
 Temp_SW_MAM_Assy
 Temp_Tot_MAM_Assy

 Volt_Sensr_Pos120_Bias
 Volt_Sensr_Neg120_Bias
 Volt_SWICS_Photdio
 Volt_SWICS_Lamp_Curr
 Statword_Tot_Htr_DAC

Digital Values:

Detector_Controls (Temperatures)
 Statword_Tot_Temp_Setpt
 Statword_Tot_Temp_Cntl
 Statword_SW_Temp_Setpt
 Statword_SW_Temp_Cntl
 Statword_Wn_Temp_Setpt
 Statword_Wn_Temp_Cntl

Total_Detector_Bridge_Bal
 Statword_Tot_Cors_Brid_DAC
 Statword_Tot_Fine_Brid_DAC
 Statword_Tot_Brid_Cntl
 Statword_Tot_Brid_DAC_Update
 Statword_Tot_Brid_Reset_Cnt

SW_Detector_Bridge_Bal
Statword_SW_Cors_Brid_DAC
Statword_SW_Fine_Brid_DAC
Statword_SW_Brid_Cntl
Statword_SW_Brid_DAC_Update
Statword_SW_Brid_Reset_Cnt

Wn_Detector_Bridge_Bal
Statword_Wn_Cors_Brid_DAC
Statword_Wn_Fine_Brid_DAC
Statword_Wn_Brid_Cntl
Statword_Wn_Brid_DAC_Update
Statword_Wn_Brid_Reset_Cnt

INSTR_Bridge_Balance_Status
Statword_Brid_Setpt
Statword_Start_Brid_Spaclk
Statword_End_Brid_Spaclk
Statword_Updt_Brid_DAC
Statword_Brid_Low
Statword_Brid_High

Space Clamp

3. Shall use the radiance count conversion algorithm to convert raw detector counts to engineering units. This algorithm will be defined during the software development phase.
 - a) Shall correct the raw radiance counts using average and interpolated space clamp count values. Interpolated space clamp values are determined based on the following suggested procedure.
 - 1) Shall interpolate between the four scan averages.
 - 2) Shall use the internal calibration sources for radiance adjustments should the space views be invalid. No interpolation is performed.
 - 3) Shall not process radiances for current packet if the internal calibrations are invalid.
 - b) Shall offset radiances using position dependent corrections, should they be required.
 - c) Shall compute radiances in engineering units based on corrected raw radiance counts.
4. Shall analyze radiance values measured during solar calibrations when viewing the MAM.
5. Shall update the radiance coefficient files used for science production data when coefficients computed here exceed TBD limits.
 - a) Shall notify analyst and scientist of changes made to calibration parameter files.
6. Shall generate quality control reports for evaluating calibration performance.
 - a) Shall evaluate the gain stability (gain and offset determinations) of these detectors by comparing current values to historical trends.

Note: Time series plots for all three detectors will be generated during trending operations.

5.2.3.3.2.3 Convert and Validate Deep Space Cal Data - Process 1.3.3.2.3

Input Data Flows

DeepSpace ID
 Detector Data
 ICCOEF Data
 INSTR Cal Record
 IRCOEF Data
 Previous Scan Data
 SPSEN Data
 Space-Look Flag

Output Data Flows

Cal Data Updates
 Filtered Radiances
 QC CalRad DeepCal Data

Process Specification (Figure 5-23):

1. Shall average the radiance counts for each detector during the samples shown in [Table 5-22](#), to obtain a space clamp value when indicated by the space-look flag and to offset the raw science radiance:
 - a) Shall verify space clamp is within TBD standard deviations.
 - b) Shall verify space clamp is within TBD limits if failed standard deviation test.
 - c) Shall set error flag if space clamp fails validation tests.

Note 1: This will require two passes through the data - 1st to find and average space clamp values, and 2nd to then offset scan data.

Note 2: This procedure may not be necessary for deep space calibrations.

Table 5-22. Space-Look Flag for Deep Space Calibration

	EOS	TRMM
Postn_Elev (Angle)	18 & 162 deg	11 & 169 deg
Postn_Elev Sample Numbers (approximate):		
Forward Scan	0-49, 277-298	0-32, 283-301
Reverse Scan	361-382, 610-659	358-376, 627-659

2. Shall compute detector gain parameters from the instrument Longwave and Total blackbody and SWICS.
 Note: Active Internal Calibration sources during deep space calibrations have not been determined.
3. Shall incorporate the following measurement groups to compute radiances.
 - a) detector voltages

- b) detector bias voltage
- c) analog-to-digital converter reference voltage
- d) detector heater control temperatures

Radiance Voltages:

Rad_Tot_Det_Cnt -> 0 - 4095
 Rad_SW_Det_Cnt -> 0 - 4095
 Rad_Wn_Det_Cnt -> 0 - 4095

Analog Values:

Temp_Tot_Montr
 Temp_SW_Montr
 Temp_Wn_Montr
 Temp_Tot_BB
 Temp_LW_BB
 Temp_SWICS_Photdio
 Temp_Tot_MAM_Baf1
 Temp_Tot_MAM_Baf2
 Temp_SW_MAM_Assy
 Temp_Tot_MAM_Assy

 Volt_Sensr_Pos120_Bias
 Volt_Sensr_Neg120_Bias
 Volt_SWICS_Photdio
 Volt_SWICS_Lamp_Curr
 Statword_Tot_Htr_DAC
 Statword_SW_Htr_DAC
 Statword_Wn_Htr_DAC

Digital Values:

Detector_Controls (Temperatures)
 Statword_Tot_Temp_Setpt
 Statword_Tot_Temp_Cntl
 Statword_SW_Temp_Setpt
 Statword_SW_Temp_Cntl
 Statword_Wn_Temp_Setpt
 Statword_Wn_Temp_Cntl

 Total_Detector_Bridge_Bal
 Statword_Tot_Cors_Brid_DAC
 Statword_Tot_Fine_Brid_DAC
 Statword_Tot_Brid_Cntl
 Statword_Tot_Brid_DAC_Update
 Statword_Tot_Brid_Reset_Cnt

 SW_Detector_Bridge_Bal

Statword_SW_Cors_Brid_DAC
Statword_SW_Fine_Brid_DAC
Statword_SW_Brid_Cntl
Statword_SW_Brid_DAC_Update
Statword_SW_Brid_Reset_Cnt

Wn_Detector_Bridge_Bal
Statword_Wn_Cors_Brid_DAC
Statword_Wn_Fine_Brid_DAC
Statword_Wn_Brid_Cntl
Statword_Wn_Brid_DAC_Update
Statword_Wn_Brid_Reset_Cnt

INSTR_Bridge_Balance_Status
Statword_Brid_Setpt
Statword_Start_Brid_Spaclk
Statword_End_Brid_Spaclk
Statword_Updt_Brid_DAC
Statword_Brid_Low
Statword_Brid_High

Space Clamp

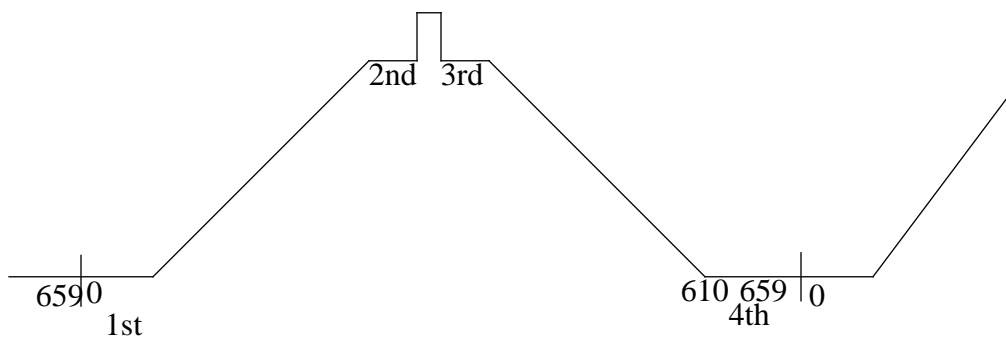
4. Shall compute raw measurement correction coefficients for abnormal space zero-radiance measurements.
5. Shall use the radiance count conversion algorithm to convert raw detector counts to engineering units. This algorithm will be defined during the software development phase.
 - a) Shall correct the raw radiance counts using average and interpolated space clamp count values. Interpolated space clamp values are determined based on the following suggested procedure and referring to the figure below.
 - 1) Shall interpolate between the two scan averages for the anti-Sun side views at the beginning and end of each packet (set 1 and 4).
 - 2) Shall interpolate between the two scan averages for the Sun side views for the current packet on both sides of the internal calibration view should the anti-Sun views be invalid (set 2 and 3).
 - 3) Shall use the internal calibration sources for radiance adjustments should the Sun side views be invalid. No interpolation is performed.
 - 4) Shall not process radiances for current packet if the internal calibrations are invalid.

Note 1: Option 1) is generally used for correction in both normal and short scan mode. In the case of bad space value in the first and/or last set, Option 2) will be used. If all the space clamp values cannot be used, Option 3) will be used. Options 2) and 3) are used only for the normal scan mode.

Note 2: A fourth option that can be considered is, interpolating between first and second space clamp averages and use it for the forward scan; and interpolate between third and fourth space clamp averages to use for backward scan.

Note 3: A fifth option that can be considered is to interpolate the 2nd/3rd sets from two adjacent packets; the current and the next. The fourth and fifth options should be evaluated as part of the design phase.

Note 4: The numbers shown in [Table 5-22](#) and the options discussed above are for the normal Earth-scan. Different options will be used for the other scan profiles. These options will be developed during the design phase.



- b) Shall offset radiances using position dependent corrections, should they be required.
- c) Shall compute radiances in engineering units based on corrected raw radiance counts.
- 6. Shall update the calibration and radiance coefficient files used for science production data when coefficients computed here exceed TBD limits.
 - a) Shall notify analyst and scientist of changes made to calibration parameter files.
- 7. Shall generate quality control reports for evaluating calibration performance.
 - a) Shall evaluate the gain stability of these detectors by comparing current values to historical trends.

Note: Time series plots for all three detectors will be generated during trending operations.

5.2.3.3.3 Verify Nighttime-IntCal - Process 1.3.3.3

Input Data Flows

Cal Data
NightTime-Cal ID
Space-Look Flag

Output Data Flows

CalRad Trend Data
ICCOEF

Process Specification (Figure 5-22):

1. Shall verify that the nighttime shortwave radiance is zero within TBD error. Nighttime is identified during geolocation calculations.
 - a) Shall edit check the nighttime radiances.
 - b) Shall flag out-of-bound radiances.
2. Shall compare the Total and Longwave channel measurements.
3. Shall compare the two space clamp radiance values against the nighttime Nadir radiances for each channel.
4. Shall update the calibration files.
 - a) Shall collect a daily history of nighttime radiances.

5.2.3.3.4 Merge Cal Radiance & FOV - Process 1.3.3.4

Input Data Flows

Cal FOV Data
Filtered Radiances

Output Data Flows

Cal Data

Process Specification (Figure 5-22):

1. Shall verify that the footprint radiance and geolocation data are coincident before merging.
2. Shall only merge coincident footprint converted radiance and geolocated FOV data.

5.2.4 Convert Diagnostic Data - Process 1.4

Input Data Flows

IENGCOEF
Instr Diag Record

Output Data Flows

Diagnostic Data

Process Description (Figure 5-1):

1. Compute, edit, validate, and analyze raw CERES instrument diagnostic data.
 - a) Compute, edit, validate, and analyze CERES instrument diagnostic nonscience data for the following data packet formats:
 - 1) Memory Dump
 - 2) Processor Data
 - 3) Gimbal Error
 - 4) Fixed Pattern

- b) Edit and validate CERES instrument diagnostic science data input in the science data packet format.

The decomposition of this function is shown in [Figure 5-24](#).

5.2.4.1 AuxDiag File Check - Process 1.4.1

Input Data Flows

IENGCDEF

Output Data Flows

IENGCDEF Data
IENGCDEF File Hdr
Iengcoef Hdr Errors
Iengcoef Hdr Tests

Process Specification ([Figure 5-24](#)):

1. Shall access and accept as a minimum the following input data files:
 - a) Auxiliary engineering count conversion coefficients and limit values.
 - b) Auxiliary engineering, mathematical, and science constants.
 - c) Auxiliary PGS environment variables and other parameterized input.
 - d) Auxiliary history trend data.
2. Shall process and validate data file headers for the above input files and correlate this information with the PGE user data.
3. Shall temporarily store file parameters.
4. Shall halt production should any file headers be missing or erroneous and inform operator/analyst.

5.2.4.2 Evaluate Memory Dump - Process 1.4.2

Input Data Flows

IENGCDEF Data
Instr Diag Record

Output Data Flows

Diagnostic Data

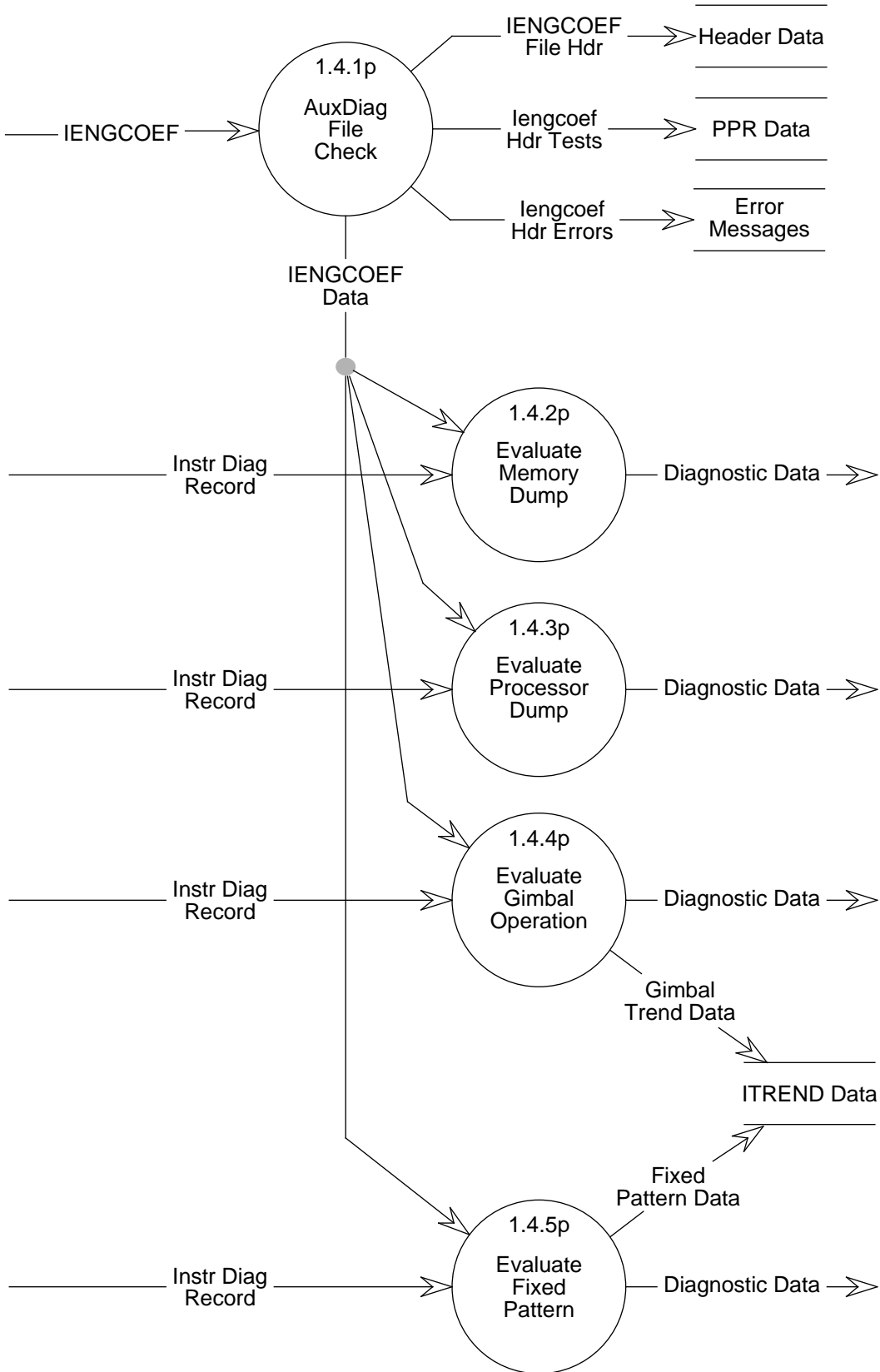


Figure 5-24. Data Flow Diagram for Convert Diagnostic Data

Process Specification (Figure 5-24):

1. Shall convert data to physical representations, edit, and validate the CERES instrument diagnostic nonscience memory dump data.
2. Shall perform comparison analysis on configuration and status data and compare to normal operational conditions.
3. Shall report anomalous conditions to the analyst.

5.2.4.3 Evaluate Processor Dump - Process 1.4.3

Input Data Flows

IENGCOEF Data
Instr Diag Record

Output Data Flows

Diagnostic Data

Process Specification (Figure 5-24):

1. Shall convert data to physical representations, edit, and validate the CERES instrument diagnostic nonscience processor dump data.
2. Shall perform comparison analysis on configuration and status data and compare to normal operational conditions.
3. Shall report anomalous conditions to the analyst.

5.2.4.4 Evaluate Gimbal Operation - Process 1.4.4

Input Data Flows

IENGCOEF Data
Instr Diag Record

Output Data Flows

Diagnostic Data
Gimbal Trend Data

Process Specification (Figure 5-24):

1. Shall convert data to physical representations, edit, and validate the CERES instrument diagnostic nonscience gimbal operations data.
2. Shall perform comparison analysis on configuration and status data and compare to normal operational conditions.
3. Shall perform calculations to verify gimbal position accuracy.
4. Shall report anomalous conditions to the analyst.

5.2.4.5 Evaluate Fixed Pattern - Process 1.4.5

Input Data Flows

IENGCDEF Data
Instr Diag Record

Output Data Flows

Diagnostic Data
Fixed Pattern Data

Process Specification (Figure 5-24):

1. Shall convert data to physical representations, edit, and validate the CERES instrument diagnostic nonscience fixed pattern data.
2. Shall perform comparison analysis on configuration and status data and compare to expected patterns.
3. Shall report anomalous conditions to the analyst.

5.2.5 Trend Data Output Results - Process 1.5

Input Data Flows

Cal Data
Diagnostic Data
IUSER
Science Data

Output Data Flows

BDS
IES
INSTRDIAG
IPPR
ITREND
IUSER

Process Description (Figure 5-1):

1. Perform trend and statistical analyses on all instrument, spacecraft, and ephemeris data. Edit check all results.
2. Perform separate calibration trend analysis beginning two hours before active internal or solar calibrations. The two hour lead-in is indicated by an PGE time marker generated by the preceding quick-look data.
3. Perform production error analysis and report ABORT results.

4. Perform fault analysis in instrument, spacecraft, or ephemeris data to identify possible source(s) of faults.
5. Format output BDS and IES data products only for instrument production data (INSTR_PDS).
6. Output validation and QC reports for all data (e.g. INSTR_PDS, INSTR_QLKD, EPH Anc, calibration, instrument engineering, and data processing diagnostic data).

The decomposition of this function is shown in [Figure 5-25](#).

5.2.5.1 Trend IPS Data - Process 1.5.1

Input Data Flows

- Bds Engg Data
- Cal Data
- Diagnostic Data
- Header Data
- IMS Acctg
- ITREND
- ITREND Data
- IUSER
- Ies Engg Data
- Science Data

Output Data Flows

- ITREND Data
- IUSER
- QC Validation Data
- Science& Instrument Data
- Trend Results

Process Description ([Figure 5-25](#)):

1. Trend all instrument, spacecraft, and ephemeris data produced by this Subsystem by time blocks and moving averages.
 - a) Perform hourly, daily, weekly, and monthly averages beginning at each time unit (Greenwich time). The rate of change for engineering parameters is to be calculated. Hourly and daily averages are computed from all parameter values; weekly and monthly averages are computed from the hourly statistical components.
 - b) Perform hourly, daily, weekly, and monthly moving averages starting at the beginning of mission science collection. The rate of change for engineering parameters is to be calculated.

Note: Trending on an hourly basis is expected to be used to validate mission operations data. Trending on a weekly basis is expected to identify drift conditions faster than by trending on a monthly basis.

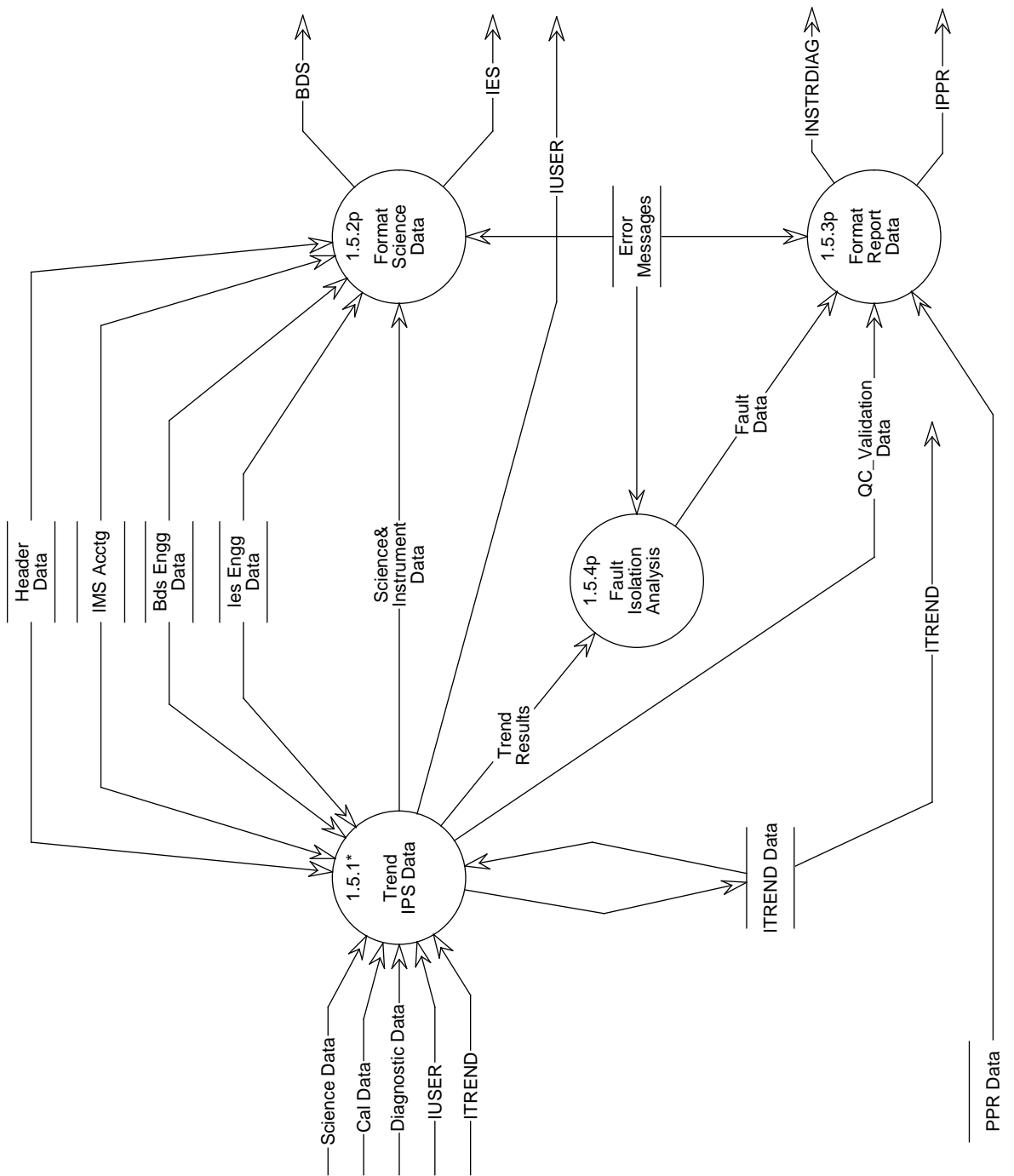


Figure 5-25. Data Flow Diagram for Trend Data Output Results

- c) Perform separate two-hour calibration trends on INSTR_PDS data when IUSER supplies a time flag.
2. Compare quick-look calibration data trends with historic trends and identify adverse conditions that could erroneously affect the corresponding production data set containing the same data. Identify the 2-hour lead-in time flag required for the PDS data trending requirements. Set a variable equal to this time value so that it can be used for subsequent production processing.
3. Analyze data by performing statistical calculations and edit checks on instrument analog data, any spacecraft analog data, and ephemeris and geolocation data. Statistics to be calculated and edit checked include mean, maximum, minimum, standard deviation, and variance values. Rates of change are to be edit checked.
4. Report trend results.

The decomposition of this function is shown in [Figure 5-26](#).

5.2.5.1.1 Analyze Engineering Data - Process 1.5.1.1

Input Data Flows

Bds Engg Data
 Header Data
 IMS Acctg
 ITREND
 ITREND Data
 Ies Engg Data

Output Data Flows

Bds Packet Count
 ITREND Data
 IUSER
 Ies Packet Count
 Science& Instrument Data

Process Specification ([Figure 5-26](#)):

1. Shall perform trending on all instrument, spacecraft, and ephemeris engineering data.
 - a) Shall perform hourly, daily, weekly, and monthly averages and range error calculations on all engineering data. For example, average the elevation position for the normal Earth-scan profile for each 6.6-second record. Deviation from an ideal average indicates improper control or stiction.
 - b) Shall perform hourly, daily, weekly, and monthly running averages and range error calculations on all engineering data. This will be useful for identifying long-term drifts and variations.
 - c) Shall perform separate trending for calibration related data (within INSTR_PDS files) based on the flag set during the preceding quick-look (INSTR_QLKD) file processing.

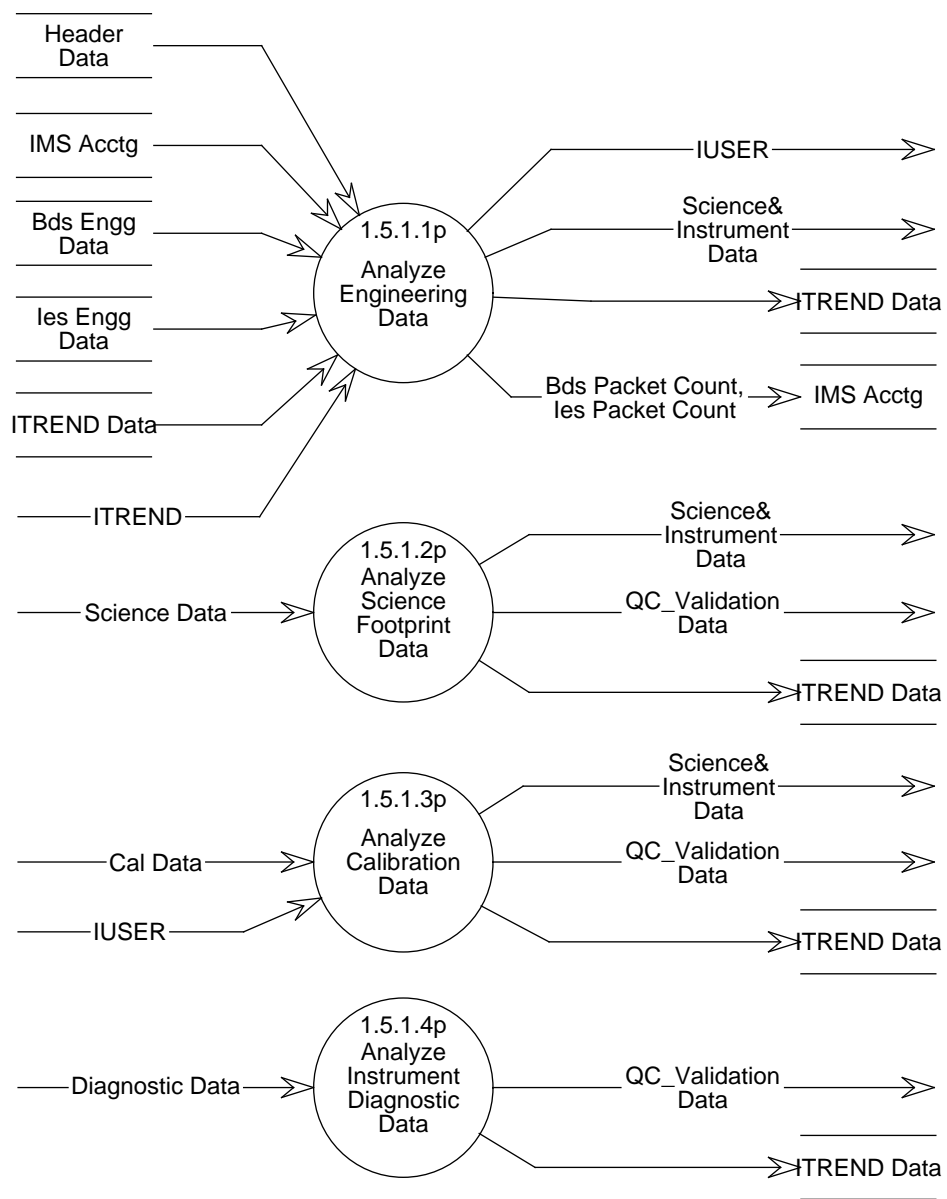


Figure 5-26. Data Flow Diagram for Trend IPS Data

- d) Shall calculate the rates of change for all engineering parameters.
 - e) Shall generate daily and monthly log files for all statuses and errors.
 - f) Shall generate IES footprint sort log to identify the number of footprints for each 1-hour data file to be used for metadata updates.
2. Shall identify and set a special calibration trend flag during quick-look (INSTR_QLKD) data file processing.
 - a) Shall compare trends within quick-look data against historical trends to identify adverse conditions. Advise operator/analyst to determine how to process subsequent INSTR_PDS processing.
 - b) Shall identify a time marker(s) that begins 2 hours prior to start of calibration data.
 3. Shall perform statistical calculations and edit check analyses on all instrument, spacecraft, and ephemeris engineering data.
 - a) Shall compare packet accounting data against file accounting data and identify discrepancies.
 - b) Shall count the number of BDS and IES records being processed.
 - c) Shall compute the minimum, maximum, mean, standard deviation, and variance on all engineering parameters.
 - d) Shall edit check the rates of change for all engineering parameters.
 4. Shall report all results.

5.2.5.1.2 Analyze Science Footprint Data - Process 1.5.1.2

Input Data Flows

Science Data

Output Data Flows

ITREND Data

QC Validation Data

Science& Instrument Data

Process Specification (Figure 5-26):

1. Shall perform trending and statistical analyses on all science radiance data.
 - a) Shall compare number of science records processed against packet accounting data and file accounting data and identify discrepancies.
 - b) Shall compute the minimum, maximum, mean, standard deviation, and variance on all radiance parameters; including science, and space clamp values.
 - c) Shall perform hourly, daily, weekly, and monthly averages and range error calculations on all radiance data.
 - d) Shall perform hourly, daily, weekly, and monthly running averages and range error calculations on all radiance data.
 - e) Shall perform daily trending of all radiance data.
2. Shall report all results.

5.2.5.1.3 Analyze Calibration Data - Process 1.5.1.3

Input Data Flows

Cal Data
IUSER

Output Data Flows

ITREND Data
QC Validation Data
Science& Instrument Data

Process Specification (Figure 5-26):

1. Shall perform trending and statistical analyses on all calibration-to-calibration radiance and related engineering data. Data includes the packets beginning 2 hours prior to the calibration sequence as identified by the variable previously set during the INSTR_QLKD processing.
 - a) Shall compare number of records processed against packet accounting data and file accounting data and identify discrepancies.
 - b) Shall compute the minimum, maximum, mean, standard deviation, and variance on all radiance and related engineering parameters.
 - c) Shall perform hourly, daily, weekly, and monthly averages and range error calculations on all related engineering data.
 - d) Shall perform daily, weekly, and monthly running averages and range error calculations on all related engineering data.
 - e) Shall perform daily trending of all radiance data.
2. Shall report all results.

5.2.5.1.4 Analyze Instrument Diagnostic Data - Process 1.5.1.4

Input Data Flows

Diagnostic Data

Output Data Flows

ITREND Data
QC Validation Data

Process Specification (Figure 5-26):

1. Shall perform a statistical analysis on all instrument diagnostic data.
 - a) Shall compare number of records processed against packet accounting data, and file accounting data and identify discrepancies.
 - b) Shall compute the minimum, maximum, mean, standard deviation, and variance on all diagnostic engineering parameters.

- c) Shall perform hourly, daily, weekly, and monthly averages, and range error calculations on all diagnostic engineering data.
 - 1) Shall average the elevation position and position error parameters to identify stiction.
 - d) Shall perform hourly, daily, weekly, and monthly running averages, and range error calculations on all diagnostic engineering data.
 - e) Shall generate daily and monthly log files for all status errors.
 - f) Shall generate log file of memory dump and processor dump data.
 - g) Shall generate gimbal error table for plotting.
 - h) Shall generate log file identifying fixed pattern errors.
2. Shall report all results.

5.2.5.2 Format Science Data - Process 1.5.2

Input Data Flows

Bds Engg Data
 Error Messages
 Header Data
 IMS Acctg
 Ies Engg Data
 Science& Instrument Data

Output Data Flows

BDS
 IES

Process Specification (Figure 5-26):

1. Shall output a BiDirectional Scan (BDS) data product when processing a INSTR_PDS file.
 - a) Shall format processed instrument and science data into a 24-hour, time sequenced, data file.
 - b) Shall include all input raw Level 0 instrument and spacecraft data, all converted engineering data, and geolocation information.
 - c) Shall output science data only from data generated within the science mode (fixed and biaxial azimuth modes) and elevation profiles including normal Earth-, short-, and nadir- scan profiles.
 - d) Shall output a BDS data product only if there were no file abort or failure error messages.
 - 1) Shall output all data records that were not packet abort or failure errors.
 - 2) Shall output data records containing warning error messages and include warnings as status flags.
- Note: Solar calibration radiance data is not written to the BDS; this data is contained in the ICCOEF file.
2. Shall output an Instrument Earth-Scan (IES) internal data product when processing a INSTR_PDS file.

- a) Shall format the data into twenty-four 1-hour time along-track sequenced data files.
 - b) Shall include converted radiometric and geolocation data for each footprint record.
 - c) Shall output this data product only from data generated within the science mode (fixed and biaxial azimuth modes) and elevation profiles including normal Earth-, short-, and nadir-scan profiles.
 - d) Shall output IES data products only if there were no file abort or failure error messages.
 - 1) Shall output a data record if there were no associated packet abort or failure error messages.
 - 2) Shall output data records containing warning error messages and include warnings as status flags.
 - e) Shall format an overlap file for the next hour of science data processing.
3. Shall provide the necessary metadata file information for each data product to update the IMS database.

5.2.5.3 Format Report Data - Process 1.5.3

Input Data Flows

Error Messages
 Fault Data
 PPR Data
 QC Validation Data

Output Data Flows

INSTRDIAG
 IPPR

Process Specification (Figure 5-25):

1. Shall output quality control and validation reports for each daily processing run.
 - a) Shall generate instrument, spacecraft, and ephemeris quality control and statistical evaluation reports for each BDS and IES data product.
 - b) Shall generate instrument, spacecraft, and ephemeris quality control, statistical evaluation, and validation reports for quick-look, calibration, and instrument diagnostic processing runs.
 - c) Shall generate daily time series plots of all ephemeris measurements, showing minimum, mean, and maximum values. The following measurements are the minimum data to be plotted:
 - 1) Spacecraft positions and directions.
 - 2) Spacecraft pointing angles and pointing errors.
 - 3) Solar and lunar positions.
 - d) Shall generate a daily quality control report identifying file parameters, file processing errors, and packet dropouts.
 - e) Shall generate a summary report on current state of the instrument for each production run.

- f) Shall generate 24-hour time-series plots for each detector and radiance offsets; report results.
- g) Shall generate reports on all normal and erroneous calibration conditions.
- h) Shall generate error and fault analysis reports.
 - 1) Shall list all abort, failure, or warning error messages and resulting actions taken.
 - 2) Shall correlate all errors with data file; satellite; and packet time, packet count, and APID.

5.2.5.4 Fault Isolation Analysis - Process 1.5.4

Input Data Flows

Error Messages
Trend Results

Output Data Flows

Fault Data

Process Specification (Figure 5-25):

1. Shall perform fault isolation analysis on production run level error warnings and failures.
2. Shall perform fault tree isolation analysis on instrument, ephemeris, and spacecraft ancillary data faults.

Note: This analysis will require fault tree logic that coordinates the digital and analog parameters as well as the spacecraft parameters.

- a) Shall isolate 99% of the digital status and analog parameter edit faults to an instrument module. Instrument modules include the following items:

ACA	- Azimuth Control Assembly
BB	- Blackbody Assembly
DAA	- Data Acquisition Assembly
ECA	- Elevation Control Assembly
ICA	- Instrument Control Assembly
MAM	- Mirror Attenuator Mosaic Assembly
PCA	- Power Converter Assembly
SEA	- Sensor Electronics Assembly
SWICS	- SW Internal Calibration Source Assembly

- b) Shall isolate 95% of the instrument and spacecraft digital status and analog parameters edit faults to a single parameter.
3. Shall report trend and fault analysis results.

Note: It is expected that these requirements will not be met until IPS Release 2.

5.3 Design Goals and Constraints

For this release, the following design goals have been identified.

1. Logically group engineering data by their common conversion algorithms for ease of algorithmic debugging.
2. Take maximum advantage of the available PGS ToolKit tools. Specific areas include geolocation, statistical, and graphical calculations and formats.
3. Take advantage of the HDF's ability to organize data that may allow future data reorganizations as identified in the Implementation Constraints Section.

For this release, the following implementation constraints have been identified and should be considered during the design phase.

1. The accuracy and availability of the TRW instrument measurement list and the data order of engineering data may be subject to change as the instrument is being developed.
2. The downstream CERES-unique Subsystems may dictate a different IES data structure as their design efforts proceed. This may necessitate additional or alternative functional requirement impacts within this Subsystem.
3. Testing of this Subsystem will require data that has been formatted and packetized to look like Level 0 instrument data files and records well before launch.
4. The PGS storage environment calls for using the Hierarchical Data Format (HDF) as the primary storage interface and the ToolKit for library operations. Uncertainty exists as to the level of HDF physical, versus logical, interface implementation in the initial EOSDIS. Consequently, the I/O data structures may be subject to change. Toolkit calls, while highly recommended, may have limited capabilities to support IPS processing. Additional utilities may need to be developed.
5. It has been assumed that the cost of data storage is cheaper than data processing. The processing sequence needs to be logically ordered to minimize production time for erroneous data conditions. The sequences that have been suggested in this document should accommodate this need.

5.4 Resource Utilization

An estimate of the utilization of resources necessary to process the Level 0 CERES instrument data into Level 1b data products is based on ERBE scanner Telemetry, Ephemeris, and Merge production runs on a Sun Sparc2 workstation using FORTRAN software. The combined ERBE numbers are approximated below and are based on processing 24 hours of data:

User time	= 3300 CPU seconds
System time	= 200 CPU seconds
Total time	= 3500 CPU seconds
Memory usage	= 3 MBytes
System I/O requests:	
Input Service	= 3000

Output	= 1000
Page Faults:	
Non I/O	= 90000
I/O	= 4500
Context Switches:	
Voluntary (wait)	= 13000
Involuntary	= 75000
Memory Swap-outs	= 0
Exceptions/Interrupts	= 0
Socket I/O:	
Messages sent	= 0
Messages received	= 0

CERES processing resources are estimated to require a factor of 4X the above numbers for all except those numbers that are currently 0. This increase assumes a factor of 3X for the increase in data and an additional 1X for Ada overhead requirements. Memory swaps, exceptions/interrupts, and socket I/O for the CERES system using Ada can not be determined until the software development phase.

References

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3. Instrument Processing Subsystem Algorithm Theoretical Basis Document, Version 1.1, April, 1994.
4. CERES Instrument Operations Manual, November, 1993.
5. CCSDS Packet Telemetry Blue Book, CCSDS 102.0-B-2, January, 1987.
6. CCSDS Time Code Formats, Blue Book, CCSDS 301.0-B-1, January, 1987.
7. In-Flight Measurement Analysis, DRL-64, Rev. B December 7,1993. Updated handout delivered at the CERES Software Seminar, LaRC, April 5, 1994.
8. CERES Standard Parameter Abbreviations, December 3, 1993.
9. EOSDIS Core System (ECS) Requirements Specifications, August, 1993.
10. ECS Operations Concept Document for the ECS Project, August, 1993.
11. PGS Toolkit Requirements Specification for the ECS Project, October, 1993.

Abbreviations, Acronyms, and Symbols

ACA	Azimuth Control Assembly
ACCTG	Accounting (Information)
ADC	Analog to Digital Converter
ANC	Ancillary
ANL	Analog
APID	APplication IDentifier
ATBD	Algorithm Theoretical Basis Document
ATT	Attitude
AUX	Auxiliary
BB	Blackbody
BDS	BiDirectional Scan
CAL	Calibration
CCSDS	Consultative Committee for Space Data Systems
CERES	Clouds and the Earth's Radiant Energy System
CNT	Counts
CPU	Computer Processing Unit
CO ₂	Carbon Dioxide
DAA	Data Acquisition Assembly
DAC	Digital to Analog Converter
DADS	Data Archival and Distribution System
DAP	Data Acquisition Processor
DET	Detectors
DIAG	Diagnostic
DIG	Digital
DMS	Data Management System
DMT	Data Management Team
DRL	Deliverable Requirements List
ECA	Elevation Control Assembly
ECI	Earth Centered Inertial
ECS	EOSDIS Core System
EGMOD	Earth Geode Model
ENGG	Engineering
EOS	Earth Observing System
EOS-AM	EOS Morning Crossing (Ascending) Mission
EOS-PM	EOS Afternoon Crossing (Descending) Mission
EOSDIS	Earth Observing System Data and Information System
EPH	Ephemeris
ERBE	Earth Radiation Budget Experiment
FLT	Fault
FM	Flight Model
FORTTRAN	FORmula TRANslation
FOV	Field-Of-View
FTM	Flight Test Model

HDF	Hierarchical Data Format (storage)
HDR	Header
ICA	Instrument Control Assembly
ICCOEF	Instrument Calibration Coefficients
ICP	Instrument Control Processor
IENGCOEF	Instrument ENGINEERING Coefficients
IES	Instrument Earth Scan
IMS	Information Management System
INP	Input
INSTR	Instrument
IPS	Instrument Processing (Subsystem)
IPFCOEF	Instrument Platform Coefficients
IPPR	Instrument Production Processing Reports
IRCOEF	Instrument Radiance Coefficients
ITREND	Instrument Trends (Validation support)
IUSER	Instrument User (Parameter Inputs)
L0	Level 0
LW	Longwave
MAM	Mirror Attenuator Mosaic
MEM	Memory
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
OP	Operation
PARAM	Parameter
PCA	Power Converter Assembly
PDS	Production Data Set
PFM	Proto-Flight Model
PGE	Product Generation Executive
PGS	Product Generation System
PPR	Production Processing Reports
PROM	Programmable Read Only Memory
PSF	Point Spread Function
QA	Quality Assurance
QC	Quality Control
QLKD	Quick-look Data
RAD	Radiance
RAM	Random Access Memory
RES	Results
ROM	Read Only Memory
SC	Spacecraft
SCI	Science
SEA	Sensor Electronics Assembly
SPS	Solar Presence Sensor
SPSEN	Spectral Sensitivity
SRD	Software Requirements Document
SW	Shortwave

SWICS	ShortWave Internal Calibration Source
TBD	To Be Determined
TEMP	Temperature
TOT	Total
TMP	Temporary
TOA	Top-Of-Atmosphere
TDRSS	Tracking and Data Relay Satellite System
TRMM	Tropical Rainfall Measuring Mission
W _n	Window
ZEN	Zenith

