SCIENCE DATA SYSTEM DEVELOPMENT PLAN

327-710

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Document Change Record

Issue	Date	Pages	Description of Change
Rev. A	31.3.1999	all	Initial version
Rev. B	31.10.1999	4	Text of point 1) changed
		5	Fig. 1-1 updated: Level 1A/1B included
		6	Chapter 1.2.2: Text changed
		6	Chapter 1.2.2.1: Text completely updated; Figure deleted
		7	Chapter 1.2.2.2: Text completely updated; Figure deleted
		7	Chapter 1.2.2.3: Text updated
		8/9	Text of 1.3.2-3 and 1.3.4-6 changed
		10	Fig. 1-2: Renaming of box: S/W Harmonization UTCSR/GFZ to Architectural S/W Design
		14	Fig 1-6: Renaming of box: S/W Harmonization UTCSR/GFZ to Architectural S/W Design New Sub-Work Packages for this high level WP
		14	Fig 1-6: New Sub-Work Packages for Software Development GFZ defined
		15	Fig 1-9: S/W Requirements Document is changed to Software Description Document
		16	Chapter 1.4.1: Content of Software Description Document respecified; Release dates for PSD &ADD changed.
		17	Chapter 2.1: Text changed
		18,19	Table for Level 1 products separated into level 1A and 1B product tables.
		20	Chapter 2.3: Text changed
		21	Fig. 3-1: Schedule changed for SDS Architectural Design Review and Documents
Rev. C	30.06.2000	7	Chapter 1.2.2: 3rd Paragraph: Clarification of level 2 processing responsibilities
		7	Chapter 1.2.2.1: 1st Paragraph: Statement that identical Software at JPL and GFZ is implemented for level 1 processing.
		8	Chapter 1.2.2.2: 1st Paragraph: Level 2 processing

Issue	Date	Pages	Description of Change
Rev. C	30.6.2000	9	Chapter 1.3.2: Text of point 1 changed
		10	Chapter 1.3.4: Text of point 1 and 4 changed. New point 7 added
		16/17	Chapter 1.4.1: Release dates of documents updated
		18	Chapter 1.5: SRR and SFR review dates moved 3 months behind according to new launch date
		23	Chapter 3: Schedule updated

CHAPTER 1

INTRODUCTION

1.1 PURPOSE

This document defines the basic plan for the Gravity Recovery and Climate Experiment (GRACE) Mission Science Data System (SDS). It describes the data flow and the roles and responsibilities of each SDS component institution. It also lists the documents to be produced by the SDS, and the products to be supported.

1.2 OVERALL SCIENCE DATA SYSTEM ARCHITECTURE AND DATA FLOW

1.2.1 Key aspects of the SDS architecture:

1) The GRACE SDS will be a distributed system. System development, data processing, and archiving will be shared between the Jet Propulsion Laboratory, the University of Texas Center for Space Research, and the GeoForschungsZentrum Potsdam, (GFZ). Section 1.3 describes in detail the breakdown of roles and responsibilities for each component of the SDS.

2) The SDS will be designed to perform gravity processing through Level 2, which corresponds to monthly gravity fields, in spherical harmonics to degree 100, and mean fields over longer times at least twice during the mission, to at least degree 160.

3) The Level 2 occultation products are not supported by the GRACE SDS, but will be processed by other analysis systems. The GRACE SDS will work closely with these systems for solution of common problems. Archiving of level 2 occultation products by the GRACE SDS could be one option for linking the processing systems.

1.2.2 Data Flow

The general science data flow for the GRACE Mission is presented in Figure 1-1, with SDS components shaded.

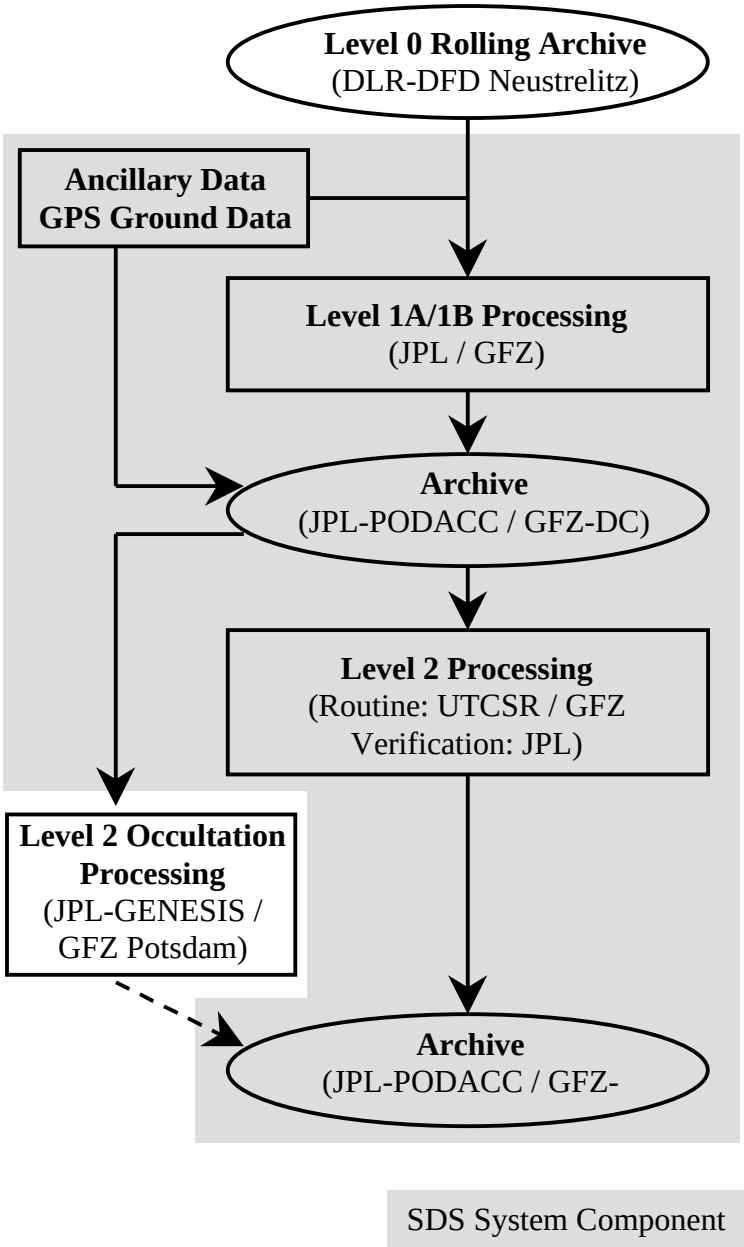

Figure 1-1: GRACE Science Data Flow

The GRACE science data are defined at four levels. The SDS processing starts at Level-0 data, which is the result of data reception and decommutation by the Mission Operations System (MOS), and ends at Level-2, which include the estimates for models for the time variable and mean components of the Earth's gravity field. Intermediate Level-1A and Level-1B are also defined. At each level, ancillary data products from outside the GRACE project are also defined, which are used in the processing of the GRACE science data.

The processing activities from Level-0 to Level-1B are collectively called Level-1 Processing, and the activities from Level-1B to Level-2 as Level-2 Processing. The Level-1 processing is primarily the responsibility of JPL and GFZ. Level-2 processing is shared between UTCSR, GFZ and JPL with different responsibilities. While UTCSR is primarily responsible for level 2 products generation, GFZ will support Software development and products verification. Common standards and interfaces are implemented in both Software packages. JPL will provide in addition from case to case independent verification products.

An overview of data products in each Level is given in Chapter 2, with the detailed definitions in the Product Specification Document. At each level, several ancillary data products are also used in data processing. Relevant GRACE science and ancillary data at each level are acquired and exchanged as necessary by the component institutions of the SDS. The final Level-2 products as well as the verified Level-1B products are delivered to the scientific community.

1.2.2.1 Processing From Level-0 to Level-1

The task of processing various Level-0 into Level-1B products is to be performed by the SDS analysis center at JPL, with backup capability at GFZ, where the identical Software will run. Level-1 processing consists of different steps and interfaces, depending on the product type and application. The Level-0 data will be retrieved by the JPL and GFZ analysis centers within 24 hours of decommutation at the Level-0 rolling archive at the DLR-DFD-NZ. Ancillary data necessary for these tasks, including GPS ground network data, Earth orientation parameters, etc., will be retrieved by the JPL and GFZ analysis centers.

The Level-1 products will be assembled as specified in Table 2-5 in the SMRD (327-200) (and repeated in Chapter 2 below), and made available to all SDS analysis centers through the respective SDS archives at JPL and GFZ, within 5 days of availability at DLR/DFD-NZ.

1.2.2.2 Processing From Level-1 to Level-2

The task of processing Level-1B and related ancillary data into Level-2 products is carried out primarily by UTCSR with GFZ support in a close cooperation. A selected subset of processing is carried out by JPL for additional verification purposes. Ancillary geophysical data and models, for example atmospheric pressure fields, will be acquired and processed appropriately by each analysis center.

The Level-2 data will be assembled as specified in Table 2-6 in the SMRD (327-200), and repeated in Chapter 2 below. The results of this processing will be placed in the respective SDS archives at JPL and GFZ within 60 days of Level-1 data availability.

During the Operational Phase of the mission, the final Level-2 and verified Level-1B data will be made available for release to the scientific community by the PI and the co-PI.

1.2.2.3 Instrument Calibration Maneuver Analysis

The CG Offset Calibrations and the KBR Boresight-to-SCA Alignment Calibration will be computed by the SDS as the result of orbital maneuvers and subsequent data analysis by the analysis center at JPL. The bias and scale estimates for the accelerometer will be obtained by the Level-2 processing centers in conjunction with the Level-2 processing.

The results of these calibrations will be reported back to the appropriate SDS archive within 60 days of the maneuver. Interfaces with the MOS will be established to ensure a rapid feedback, to enable the MOS to carry out the CG Trim maneuver.

1.3 ROLES AND RESPONSIBILITIES BY SDS COMPONENT INSTITUTION

Below we summarize the specific roles and responsibilities of each of the SDS component institutions in the data flow outlined above. Figures 1-2 to 1-6 provide this information in the form of a work breakdown chart.

1.3.1 ROLE AND RESPONSIBILITY OF DLR/DFD-NZ

The Level-0 rolling archive at DLR/DFD-NZ is responsible for

1. Decommutation of satellite downlink data

2. Making these data available within 24 hours of acquisition

1.3.2 ROLE AND RESPONSIBILITY OF UTCSR

As an SDS Science Analysis Center, the roles of UTCSR include

1. Primary processing of GRACE data from Level-1 to Level-2 with upgraded MSODP Software Implementation of common UTCSR/GFZ standards and set up of interfaces to GFZ Software.

2. Acquisition and processing of the necessary ancillary data for obtaining Level-2 products from Level-1 data.

3. Archiving and distribution of the Level-2 data to the SDS archive within 60 days of acquisition of Level-1 data.

1.3.3 ROLE AND RESPONSIBILITY OF JPL

As an SDS Science Analysis Center, the roles of JPL include

1. Preliminary orbit computation necessary for Level-0 to Level-1 processing.

2. Processing of KBR, SCA, and ACC data from Level-0 to Level-1.

3. Acquisition and processing of the necessary ancillary data for obtaining Level-1 products from Level-0 data.

4. Archiving and distribution of the Level-1 data to SDS analysis centers within 5 days of acquisition of Level-0 data.

5. Verification of Level-2 data products through selected independent gravity field computation and comparison with UTCSR and GFZ.

6. Analysis, archiving and reportage of the results of the accelerometer CG offset calibration, the KBR/SCA alignment, and ACC/SCA alignment maneuvers.

1.3.4 ROLE AND RESPONSIBILITY OF GFZ

As an SDS Science Analysis Center, the roles of GFZ include

1. Backup capability for processing of GRACE data from Level-0 to Level-1 by implementation of JPL Software at GFZ.

2. Acquisition and processing of the necessary ancillary data for obtaining Level-1 products from Level-0 data.

3. Archiving and distribution of the Level-1 data to SDS analysis centers within 5 days of acquisition of Level-0 data.

4. Support of UTCSR in processing of GRACE data from Level-1 to Level-2. Upgrade of EPOS Software and implementation of common standards. Setup of interfaces between both Software systems.

5. Acquisition and processing of the necessary ancillary data for obtaining Level-2 products from Level-1 data.

6. Archiving and distribution of the Level-2 data to the SDS archive within 60 days of acquisition of Level-1 data

7. Processing of atmospheric and oceanic time variable gravity input for de-aliasing GRACE data (part of Level-1 processing).

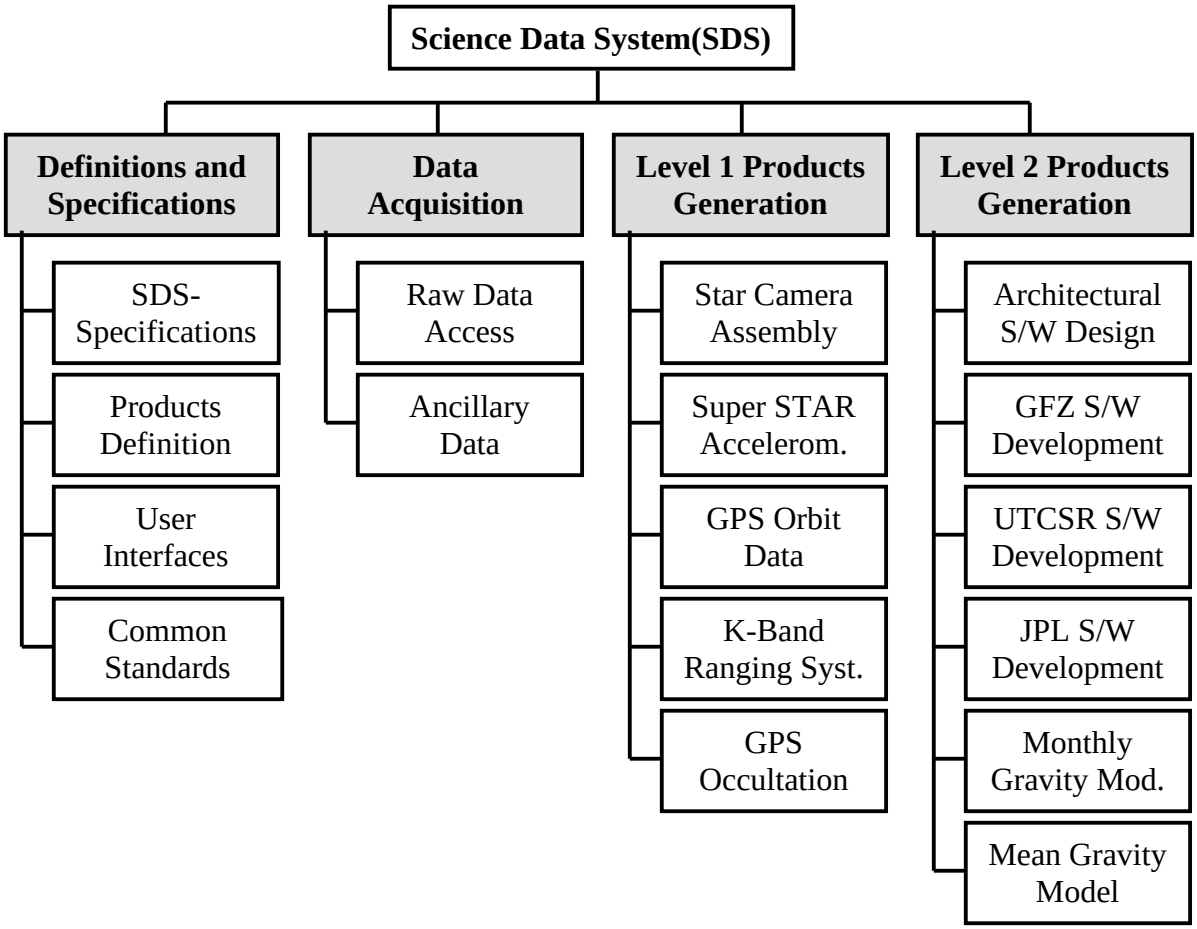

Figure 1-2: High level work breakdown structure

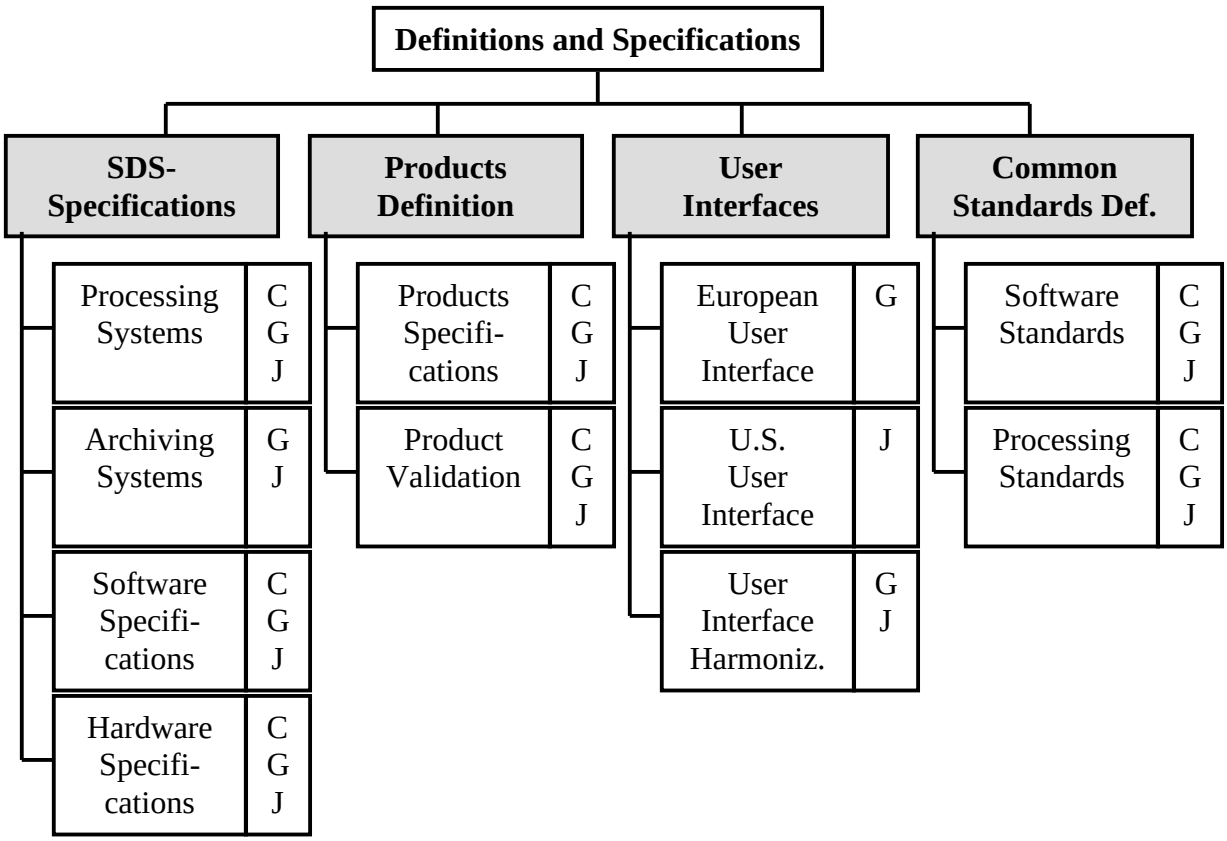

Figure 1-3: Definitions and specifications work breakdown structure and responsibilities (C=UTCSR, G=GFZ, J=JPL)

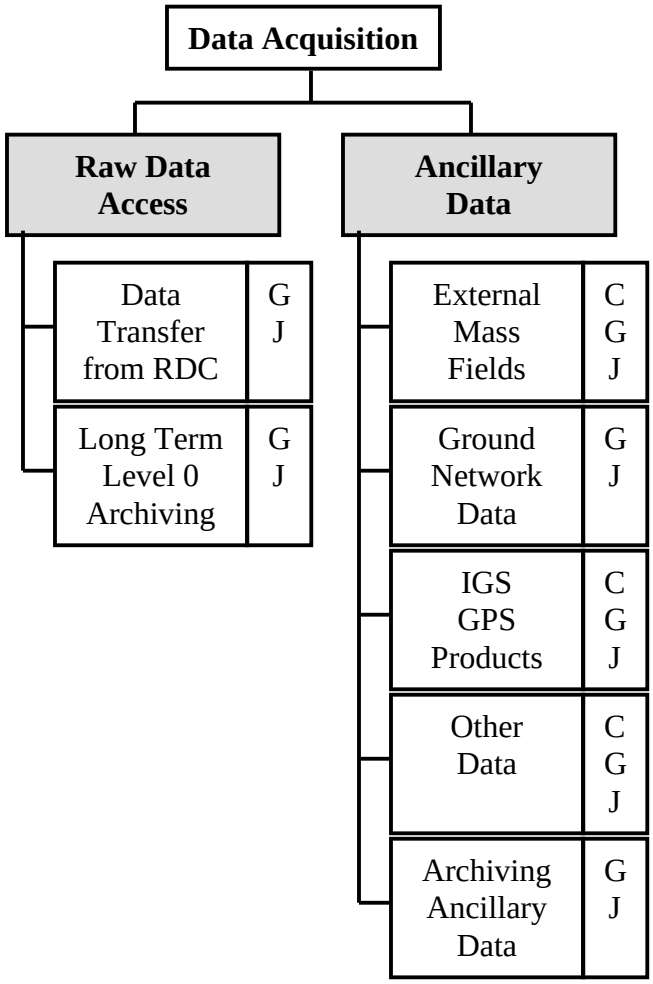

Figure 1-4: Data acquisition work breakdown structure and responsibilities
(C=UTCSR, G=GFZ, J=JPL)

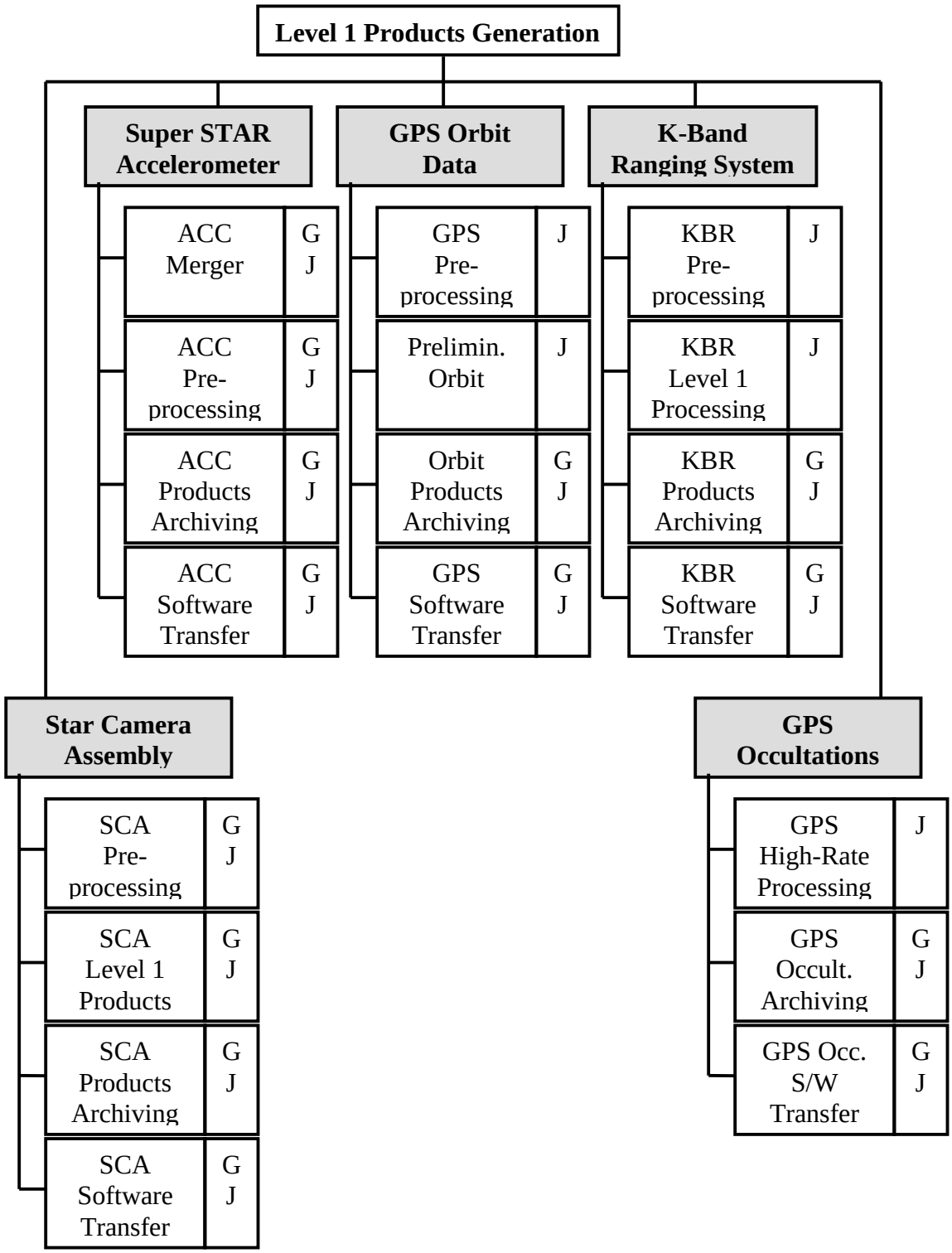

Figure 1-5: Level 1 products generation work breakdown structure and responsibilities (C=UTCSR, G=GFZ, J=JPL)

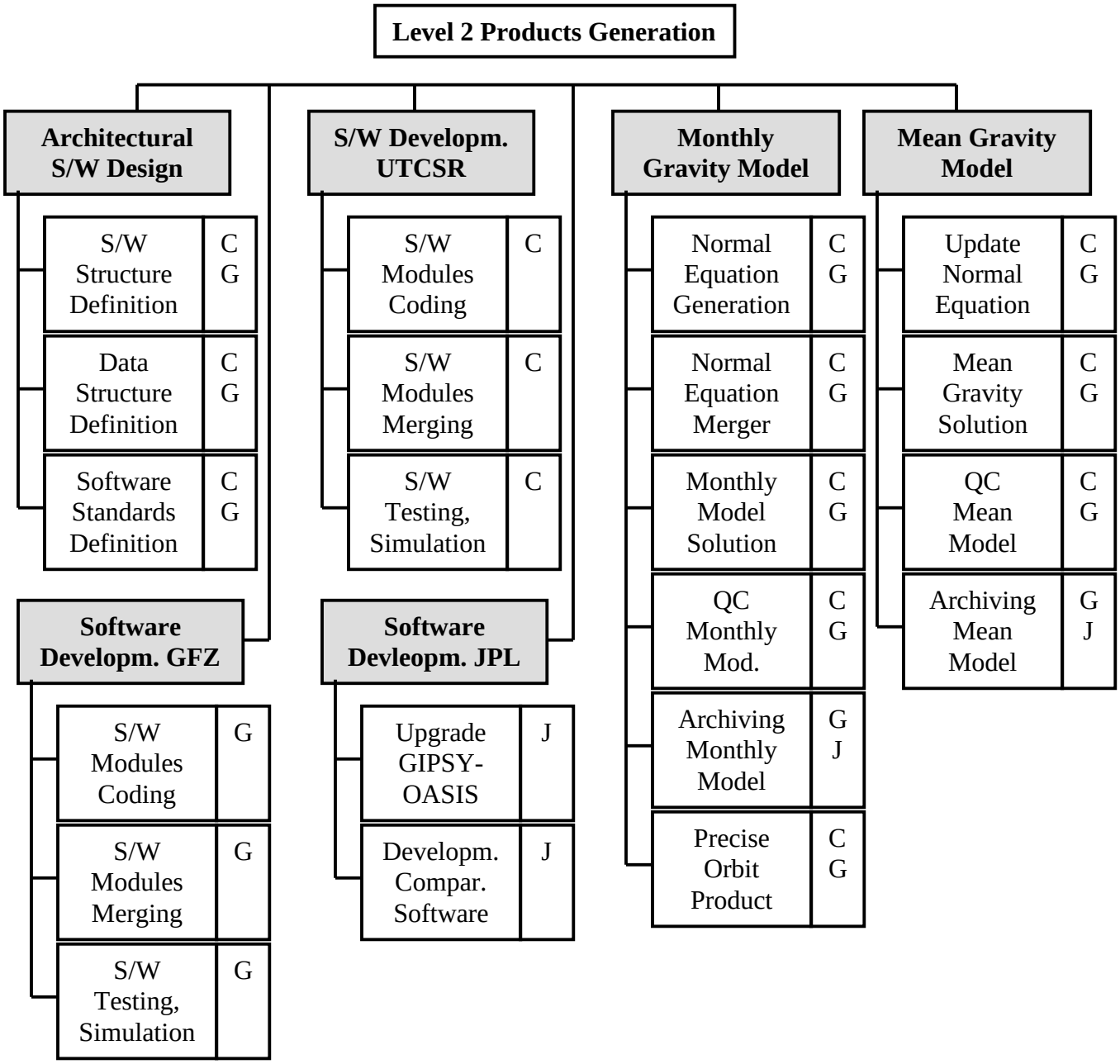

Figure 1-6: Level 2 products generation work breakdown structure and responsibilities (C=UTCSR, G=GFZ, J=JPL)

1.4 SCIENCE DATA SYSTEM DOCUMENTATION PLAN

Due to resource restrictions, the GRACE Science Data System (SDS) plans streamlined documentation with respect to historical flight mission software engineering standards. The tree in Figure 1-7 lists the documents that will define and document the SDS for the GRACE project.

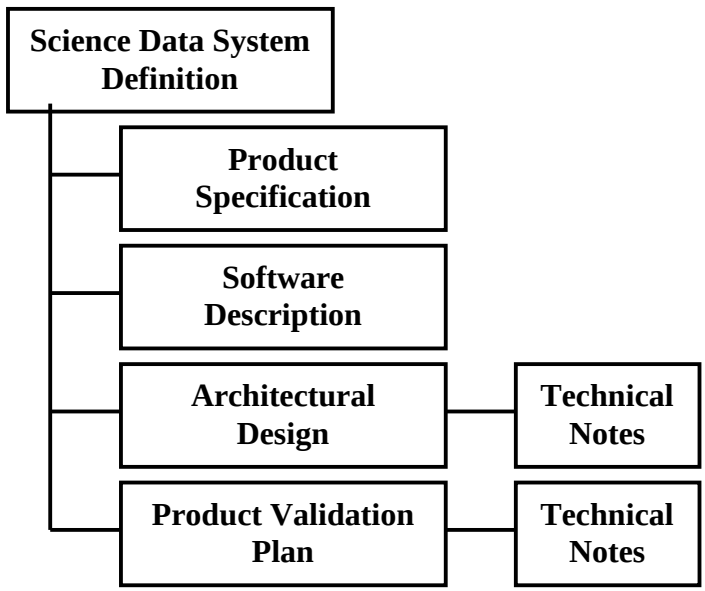

Figure 1-7: GRACE SDS Document Tree

1.4.1 Content of Planned SDS Documents:

Science Data System Development Plan (327-710, this document)

- Definition of roles and responsibilities
- System Definition
- Data and product list
- Schedule and milestones for SDS
- Release A: March 31, 1999
- Release B: October 30, 1999
- Release C: this issue

Product Specification Document (327-720)
- Product definition (content, data rates, latencies)
- Input description and interfaces
- Algorithm description
- Format description
- Draft release: Fourth quarter of 1999

Software Description Document (327-730)
- Subsytem and interface description
- Functional, Performance, Operational, Resource requirements
- Software User Manual
- Planned release: First quarter of 2001

Architectural Design Document (327-740)
- System Design
- Data object description
- Component design
- Draft release: Third quarter of 2000

Product Validation Plan (327-750)
- Validation procedures
- Validation data sets
- Planned release: Second quarter of 2001

Specific technical descriptions will be provided in technical notes, which are supporting the architectural design document and product validation plan. These technical notes will provide details regarding specific algorithms for product processing or validation, and decisions to produce such notes will be made on a case by case basis during the SDS implementation phase.

1.5 GRACE SCIENCE DATA SYSTEM REVIEWS

The GRACE SDS will undergo 4 reviews:

1) The Architecture Design Review (ADR) – a peer review to assess the overall design of the SDS. Scheduled for fall 1999.

2) Implementation Mid-Term Review (IMR) – an internal project review to assess the status and schedule of SDS implementation. Scheduled for fourth quarter of 2000.

3) SDS Readiness Review (SRR) – A final pre-launch review of the SDS by the component institutions. Scheduled 3 months prior to launch, which would nominally place it in the third quarter of 2001.

4) SDS Functionality Review (SFR) – a review of the performance of the SDS by the major SDS component institutions and GRACE science team. Scheduled for 3 months after GRACE launch, which would nominally place it in the third or first quarter of 2002.

CHAPTER 2

GRACE SDS PRODUCT LIST

Ancillary data products are not included in the GRACE SDS product list, but are described in relevant lower level documents.

2.1 LEVEL 0 DATA

The Level-0 data records contain raw, unprocessed telemetry data that has been decommutated by DLR/DFD_NZ.

Measurement	Sample Rate	Time Interval
K-Band Phase Data	10 Hz	Continuous
GPS Data (Orbit Det.)	1 Hz	Continuous
GPS Data (Occultation)	50 Hz	Brief intervals; < 200 /day
Accelerometer	10 Hz	Continuous
SCA Quaternions	1 Hz	Continuous
GPS Data (Ionosphere)	TBD	TBD
Housekeeping Data	All	Continuous

2.2 LEVEL 1 DATA

The Level-1 data products include the calibrated and verified satellite-to-satellite line of sight biased range and its derivatives, along with the GPS tracking data and initial ephemerides for the GRACE satellites. These data will be made available to the scientific community no later than 60 days following receipt of the Level 0 data. Level 1 data products are splitted into two different processing levels, namely Level 1A and Level 1B. Level 1A data products are non-destructive with respect to Level 0 products, but sensor calibration factors are applied to convert the binary encoded measurements to engineering units. Level 1B data products are correctly time tagged and the data sample rate is reduced from the high rate data of previous levels.

Level 1A Data

Measurement	Product	Sample Rate
K-Band Ranging	K and Ka frequency integrated carrier phase	0.1 s
GPS RO-Measurements	SNR + Phases	50 Hz
GPS Orbit Data	SNR + Phases	1-0.1 s
Acceleration	Linear & Angular Accelerations	0.1s
SCA Quaternions	Orientation of SCA axes relative to inertial frame	0.5 s - 5 s

Level 1B Data

Measurement	Product	Sample Rate
K-Band Ranging	Biased Range & Derivatives	5 s
Laser Ranges to satellite	Groundsite-GRACE distance (2-way)	5 s
Satellite Position & Velocity		5s
Acceleration	Non-grav. linear accelerations	5s
Spacecraft Attitude	S/C and ACC attitude	5s

2.3 LEVEL 2 DATA

The Level-2 data include the orbits for the GRACE spacecraft, estimates of spherical harmonic coefficients for the Earth gravitational potential, and excess path delay/refractivities from the occultation data.

Measurement	Product	Sample Rate
Geopotential Field	Spherical Harmonic Coefficients	30 days or longer
Satellite Position & Velocity	Cartesian	5 s
Excess Delay/Refractivity *	Profiles	<50hz
Temperature/Water vapor *	Profiles	< 50Hz

* to be created by companion data systems and not the responsibility of the GRACE SDS.

CHAPTER 3

SDS SCHEDULE AND MILESTONES

3.1 The GRACE SDS schedule referenced throughout the document is presented in Figure 3-1.

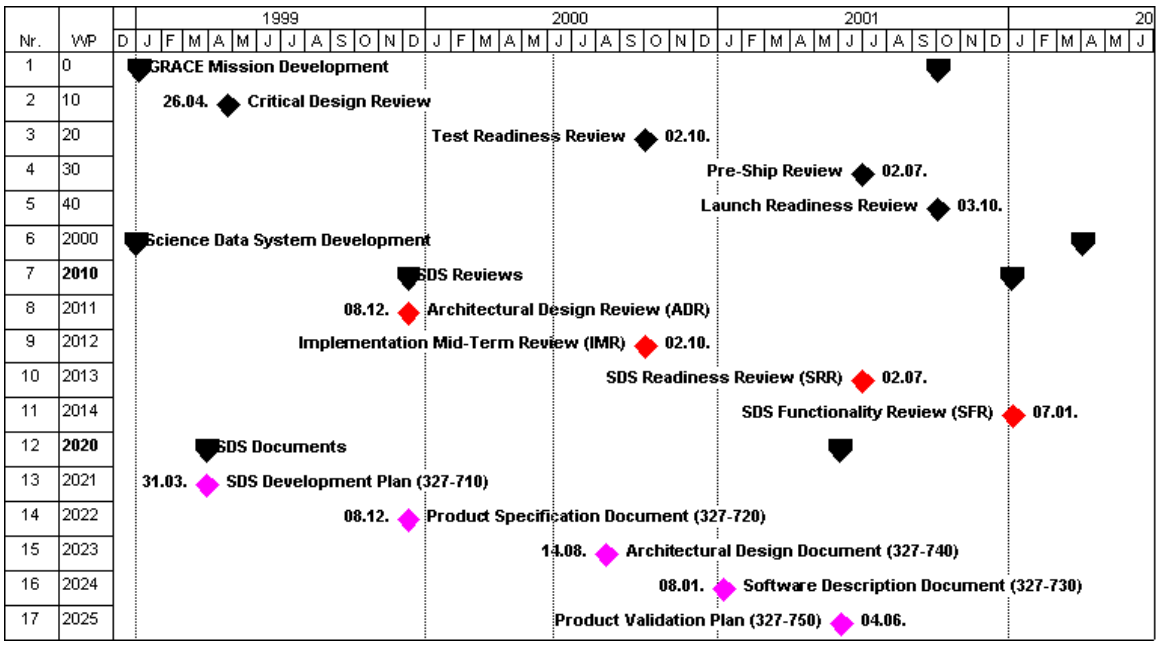

Figure 3-1: SDS Reviews and Documents