GUIDELINES FOR THE SPECIFICATION OF GROUND PROCESSING ALGORITHMS

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ENVISAT-1 GROUND SEGMENT

Document Change Record

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0		03.03.95	Draft of document
1		23.03.95	First issue of document

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Abbreviations

ADD	Architectural Design Document
CFI	Customer Furnished Items
CRR	Computation Resources Requirements Document
DDD	Detailed Design Document
DPM	Detailed Processing Model Document
I/O DD	Input / Output Data Definition Document
PDL	Parameter Data List
PDS	ENVISAT Payload Data Segment
SRD	Software Requirements Document
SUM	Software User's Manual
TDD / TPD	Test Definition / Test Procedures Document
TDS	Test Data Sets

1.0 Purpose of Document

The current document defines general standards to be followed during the initial development phases of processing software for the **ENVISAT Payload Data Segment (PDS)**. The main activities during the different development steps are outlined and the documentation to be delivered at different stages is specified.

2.0 Introduction

The definition of the instrument processing software for the routine on ground processing of payload data is a key activity in the overall definition and implementation of the ENVISAT Ground Segment. Due to the high data rates produced by most instruments, the large flexibility of measurement modes and the complexity of the processing steps to transform the raw data into engineering quantities and geophysical products, a detailed knowledge of the algorithms involved is critical for the overall design and sizing of the Ground Segment. Therefore, during the definition of algorithms and in the software prototyping phase, activities have to be arranged such that critical parameters of individual processor modules, in particular throughput, I / O interfaces and computing power requirements, are derived accurately at an early stage.

This document specifies the approach to be followed for the generation of the relevant documentation, development of a supporting prototype code and generation of the test data sets required as input for the PDS development contract. This documentation, supported by test data and prototype code, shall be sufficient to allow the PDS contractor to implement the required PDS operational processing software.

3.0 Reference Documents

[RD1] ESA PSS-05-0, Issue 2, **ESA Software Engineering Standards**

[RD2] PO-TN-ESA-GS-0195, ver. 1.0, **ENVISAT PDS Orbit-Visibility-Time CFE Functional Specifications**

4.0 Development Phases

A two phases approach is considered for the processing software development:

4.1 Detailed Definition Phase

The first phase, in the following called **"Detailed Definition Phase"**, serves to perform a critical review and, if necessary, a detailed re-formulation of the processor performance requirements that were defined in previous phases. In addition, a first (and possibly incomplete) logical model shall be established and a list of ancillary and external data (i.e., all data not included in the payload data stream) shall be generated. From the logical model and the knowledge on typical measurement scenarios / calibration cycles first estimates on the throughput of input / output data shall be provided.

From the performance requirements and the logical structure discussed in the above steps, a list of critical elements shall be produced. This list shall define the necessary specific studies to be performed in parallel with the **Phase 2**, to secure the complete processing algorithm definition.

Phase 2 shall include the prototyping of the algorithms, the generation of test data and the provision of all relevant documentation to be delivered to the PDS consortium to produce the final operational software.

At completion of the **Detailed Definition Phase** the following documents shall be delivered:

- **A technical note on Ground Processing Performance Requirements**
- **A technical note on Input / Output Data Definition**
- **A technical note on Detailed Processing Model / Parameter Data List**
- **A technical note on Computation Resources Requirements**
- **A list of High Priority Studies**
- **A Development Plan for the Prototyping Phase**

The purpose and contents of these documents is described in the **sections 4.1.1** through **4.1.6**.

4.1.1 Ground Processing Performance Requirements

This note shall provide an updated list of requirements on the Ground Processor. It shall reflect the actual requirements imposed by data products definition, product availability scenarios and requirements on external data sources (external calibration, meteorology or climatology tables, etc.). The actual instrument development status, including recent and expected late design changes, shall be considered.

4.1.2 Input / Output Data Definition

This document should provide a complete list of input / output data as required or generated by the processor. In particular detailed formats for the ancillary input data (especially instrument characterization data), all types of calibration data and possible external data shall be given.

4.1.3 Detailed Processing Model / Parameter Data List

This document shall describe the basic logical processing model based on current knowledge. The model shall take into account all results from scientific and industrial studies performed in earlier phases. A top-down decomposition of the processor model into the basic functional elements shall be given and different hierarchy levels shall be established. The basic physical models shall be discussed and all underlying equations shall be given.

Some of the functions may be critical for the overall performance of the model so that a detailed check on their suitability should be performed before they can be accepted in the logical model. In such a case the affected equations shall be coded using suitable mathematical tools (e.g., MathCAD) and tested on the basis of realistic test data. For uncritical functions this type of **low level verification** is not necessary and they can immediately be adopted for the design of the software prototype (**Phase 2**).

An important part of the document is the **Parameter Data List (PDL)** that compiles a complete set of physical constants, parameters and variables used in the model. In particular, all data ranges, data types, step sizes for discretized quantities and initial values shall be defined. If necessary references to the instrument characterization data base shall be included. The **PDL** may form an appendix to the technical note or could be handled as a separate document.

4.1.4 Computation Resources Requirements

Based on the information compiled in the **I / O Data Definition (I/O DD)** documents and on the **Detailed Processing Model (DPM)** first estimates on computing resources requirements shall be given. The estimate shall be based on a detailed inspection of the basic mathematical equations, the information given in the **PDL** and on the logical model indicating the approximate number of execution of a certain function per time interval. Only the basic operations such as integer / floating point addition/multiplication shall be analyzed. No operations such as I / O transfers or possible parallel execution of steps shall be considered at this stage.

4.1.5 List of High Priority Studies

Following a critical analysis of the information compiled in the above documents, a list of critical elements or unsolved problems shall be generated. From this list a plan for dedicated high priority studies shall be established. For each study the type (engineering / basic scientific problem), the estimated effort and the time sequence in which the tasks should be performed shall be identified.

The impact of each study on the above identified documents (especially **4.1.3** and **4.1.4**) shall be precisely identified:

- module(s) affected,
- impacts of the possible change (complexity, run time, etc.),
- possibility to use study results via look-up tables (study results insensitive to the processing algorithm software code).

4.1.6 Prototype Development Plan

This document shall define the activities to be performed during the second phase of the project, based on the information collected in the documents under sections **4.1.1 - 4.1.5**. With reference to the list of required **High Priority Studies,** possible industrial or scientific teams shall be identified and the budgets to be allocated for the studies shall be estimated. A realistic schedule for the delivery of the prototype code, test / reference data bases (see below) and the complete set of final documentation shall be given. The basic milestones and the list of deliverable items are discussed below.

4.2 Prototype Design Phase

The second phase aimes at the generation of the final set of documentation that will be forwarded to industry to form the basic input for the coding of the operational Ground Processing software. In parallel to the generation of the documentation a detailed software prototype shall be produced that will be used to verify the approach chosen and the functionality of the overall processing chain on the basis of realistic input test data. Moreover, in its final version, it will be used to generate reference output data needed to verify the correct implementation and functioning of the operational Ground Processor software. In parallel with the prototype coding a set of technical notes shall be generated to document the software development in sufficient detail, allowing to trace the changes in the processing model and in the architecture introduced during the **Prototype Design Phase**. The naming of these technical notes follows partly the conventions introduced in [RD1] to indicate certain similarities to elements in the **Software Life Cycle Model** of the **ESA Software Engineering Standards**.

The basis for the prototyping phase is the set of documents produced in the **Detailed Definition Phase**. The information included in these documents is used, in a first step, to establish the **Software Requirements Document (SRD)** which shall provide a complete set of requirements for the software prototype covering functional (arising from the results of **Phase 1**) and additional, implementation-specific requirements imposed by the hardware and software environment in which the prototype will have to be operated.

In parallel a detailed plan for performing the **High Priority Studies** identified in the proposal (**section 4.1.6**) shall be established. The schedule for the availability of the study results shall be taken into account when establishing the software prototype development plan. In particular, it will permit to identify the impact of these study results to the phasing of software prototype releases and the documents related to the prototype (see below) and to the processing model (**I/O DD**, **DPM/PDL** and **Computation Resources Requirements**) to be updated accordingly.

The steps to be performed during the **Prototype Design Phase** are as follows:

1. In an initial step, a Software Requirements Document (**SRD**) shall be generated to compile a full set of requirements for the prototype, describing the needs of functionality, performance, selected hardware and software environment, interfaces to input / output data and operational conditions (user interaction, access to processing results, ...) under which the prototype will have to be used. A proposed list of contents for the **SRD** is given in **Appendix 1**.

2. Based on the output of **Phase 1** and on the **SRD** an **Architectural Design Document** (**ADD**) for the software prototype shall be generated. This document shall reflect a suitable implementation of the Logical Model of the processor for a specific hardware and software environment (see **section 6.0**). The breakdown of the main functional elements into different hierarchy levels and the control and data flow between the individual components shall be described. The **ADD** shall describe a complete physical model of the processor for the

selected environment and describe the relations between the functions in the **DPM** and the corresponding modules/subroutines in the physical model in a transparent way such that any modifications in the **DPM** can be immediately reflected in the **ADD**.

3. Once the architectural design has been established, the processing model can be implemented in a prototype code. The detailed mapping of the elements of the processing model on software modules and subroutines shall be described in the **Detailed Design Document (DDD)**. In addition, a **Software User's Manual (SUM)** shall be produced which describes the basic instructions needed to operate the software (set-up of runs, selections of operational modes, I / O data handling etc.).

   The correct performance of the prototype software should be verified using a set of realistic test data.

4. An important task in the prototype design is the implementation of new results from parallel activities, in particular from the **High Priority Studies**, on critical processing aspects. The results shall be implemented and tested in an update of the prototype and be reflected in the **ADD, DDD** and, if necessary, in the **SUM.**

5. The prototype results shall be used to consolidate and update the processing model documentation produced in **Phase 1**.

The basic approach adopted for the development of the software prototype and for the algorithms definition is illustrated in **Figure 1**.

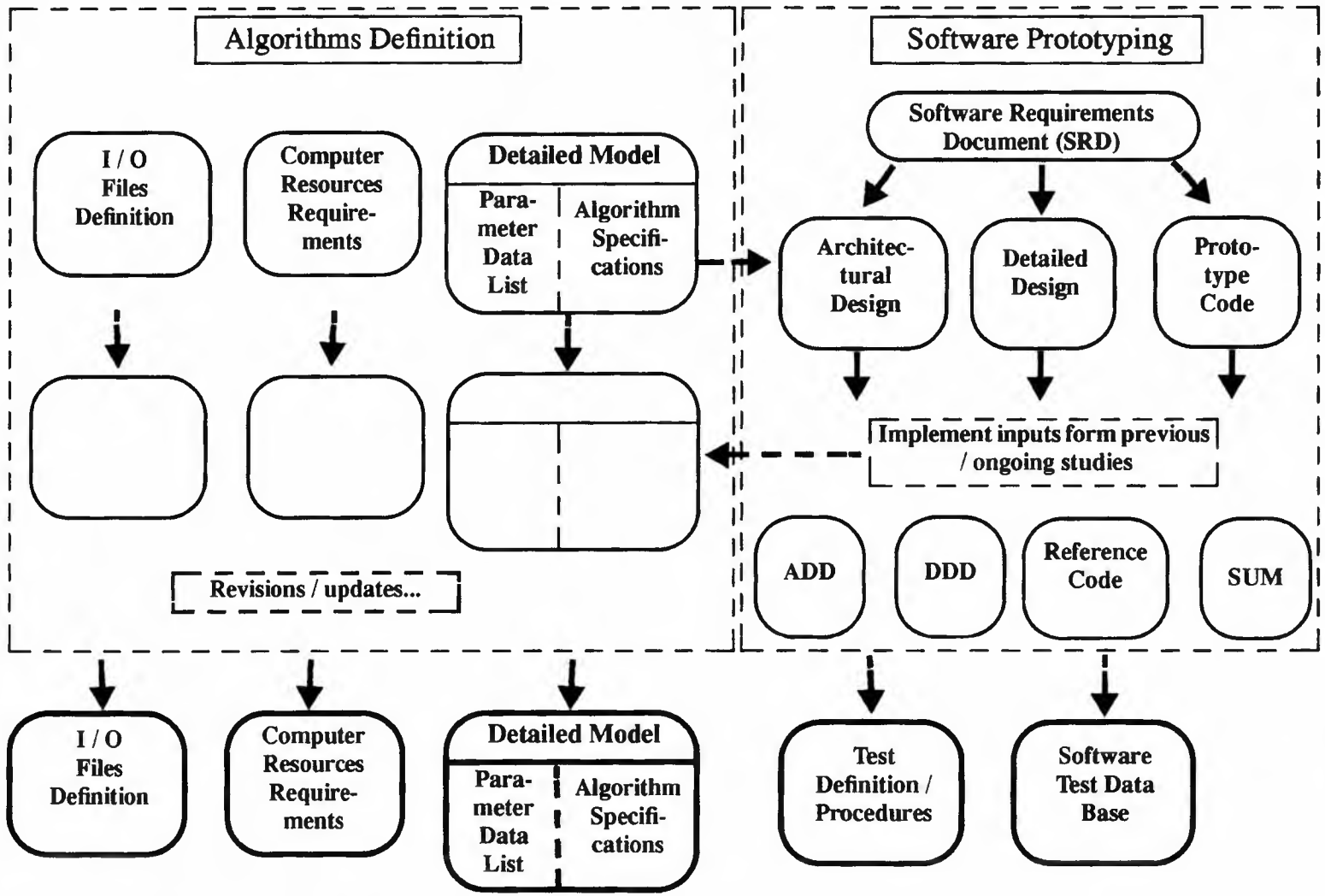

Figure 1. Approach for **Stage 2**, the **Prototype Design Phase**. The items required as input for designing the final operational code are shown as solid boxes.

4.3 Final Documentation on Algorithms Specifications

The previous section describes the development of a consolidated logical model of the processor in which a detailed software prototype is produced to verify the proper functioning of the overall processor model under "realistic" conditions and to test new algorithms for critical functions that are analyzed in parallel, dedicated studies. Taking into account the feedback from the prototype software and the related analyses, a good knowledge on behaviour and overall performance of the ground processor will be achieved. It will permit iterating and finalizing the documents **Input / Output Data Definition, Detailed Processing Model / Parameter Data List** and **Computation Resources Requirements.** In particular, the elements of the **Detailed Processing Model** and the parameters, data types / ranges as defined in the **Parameter Data List** will be defined in sufficient detail to allow the final operational software to be designed. The final set of documents will be handed over to the PDS contractor for implementation of the corresponding operational processing chain.

4.4 The Test Data Sets

Once the iterative process is finalized the prototype code will be renamed into **Reference Code** and used to generate reference **Test Data Sets (TDS)**. The **TDS** shall contain sets of input data and expected processor output data for typical measurement scenarios. These data will be used as a reference for verification of the final operational software. The test data shall be based on actual instrument characterization data taking into account late changes in instrument design and performance. Also the actual baseline scenarios for different measurement modes and calibration cycles shall be considered. The setup parameters of the prototype software, software version, instrument characterization and simulation data, measurement submode, target data and all other input data if relevant for the generation of the reference output data shall be listed and included in the **TDS**. The detailed definition of the **TDS** may vary significantly for different ENVISAT instruments and is therefore not discussed here.

4.5 The Test Definition / Procedures Document

The **Test Definition / Procedures Document (TDD / TPD)** shall describe the detailed test program to be followed to verify the proper implementation of the Detailed Processing Model of the final operational software. The verification is based on a number of simulated processing runs under pre-defined conditions and the comparison of the results with expected output data included in the **TDS**. All the steps, starting from the preparation of input data, through the setting up of the processing modes and the handling of the processor output data up to the extraction of the reference data from the **TDS** shall be described in detail. The criteria to be applied for declaring the test successful shall be defined. A proposed list of contents of the **TDD / TPD** is given in the **Appendix**.

4.6 Documents on Input / Output Data Definition, Computation Resources Requirements and Detailed Processing Model Document / Parameter Data List

The documents on **Input / Output Data Definition, Computation Resources Requirements** and **Detailed Processing Model Document / Parameter Data List** are produced on the basis of the latest issues of the documents described in **sections 4.1.2 - 4.1.4**. These documents will undergo a final, critical revision and the general structure and list of contents will be modified according to the **Appendix**.

5.0 Deliverable Items

In the final stage of the **Prototype Design Phase** the following items shall be produced:

- **An Input / Output Data Definition Document (I/O DD)**
- **A Detailed Processing Model Document / Parameter Data List (DPM / PDL)**
- **A Computation Resources Requirements Document (CRR)**
- **A Test Definition / Procedures Document (TDD / TPD)**
- **A Test Data Sets (TDS)**

6.0 Operational Environment for the Prototype Software

The software prototype shall be designed for implementation on a **SUN SPARCstation** running a **SOLARIS 2.x** operating system. The software shall be written in **ANSI C** programming language (e.g., using the **SPARCompiler C 3.0**). The system shall support **FORTRAN 77** software (CFI modules as specified in [RD2]) using the **SPARCompiler FORTRAN 3.0**.

Appendix

SRD table of contents:

I/O DD table of contents:

CRR table of contents:

DPM / PDL table of contents:

TDD / TPD table of contents: