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SSALTO

LEVEL 1.0 NAVIGATION DATA PROCESSING

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ABBREVIATIONS

Sigle	Definition
ADA	Algorithms Definition and Accuracy
ADx	Applicable Document x
APID	Application Process Identifier
CCI	Centre de Contrôle Instruments
CLS	Collecte Localisation Satellites
CMA	Centre Multi-missions Altimètre
CNES	Centre National d'Etudes Spatiales
DAD	Dynamic Auxiliary Data
DIODE	Détermination Immédiate d'Orbite par DORIS Embarqué (Navigator)
DORIS	Doppler Orbitography and Radiopositioning Integrated by Satellite
ET	Earth Terminal
FOCC	Flight Operation and Control Center
GPS	Global Positioning System
HKTM	HouseKeeping TeleMetry
TAI	International Atomic Time
ICU	Interface Control Unit
IGDR	Interim Geophysical Data Record
JCCC	Jason Control and Command Center
JPL	Jet Propulsion Laboratory
JSDS	Jason Science Data System
JTCCS	Jason Telemetry Command and Control System
LBR	Low Bit Rate
NASA	National Aeronautics and Space Agency
NRT	Near Real Time
OFL	Off-Line
PDS	Payload Data Segment
PF	Platform
PLTM	PayLoad TeleMetry
POS2	POSEIDON 2
RDx	Reference Document x
SAD	Static Auxiliary Data
SGDR	Sensor Geophysical Data Record
SSALTO	Segment Sol Altimétrie, Orbitographie et Localisation Précise
TBC	To Be Confirmed
TBD	To Be Defined
TM	TeleMetry
TRSR	Turbo Rogue Space Receiver
USO	Ultra-Stable Oscillator
UTC	Universal Time Co-ordinated

APPLICABLE AND REFERENCE DOCUMENTS

Reference	Document title
SMM-SP-M-EA-10600-CN	AD1 Spécifications techniques de besoins du Segment Sol Multi-Missions SSALTO
TP2-SB-J0-100-CNES	AD2 JASON System Requirements
TP2-JS-IF-600-CNES	AD3 Jason Ground System Interfaces
SMM-ST-M-EA-11441-CN	AD4 POS2 level 1.0 Processing.
SMM-ST-M-EA-11454-CN	AD5 Spécifications techniques du traitement sol des télémesures DORIS.
DPP-CI-S/FOCC-EA-10028-ESA	AD6 DORIS/ENVISAT-1 CTDP/FOCC Interface Control Document
PRO-LS-DC-10090-CNES	AD7 PGGS Internal and External Interfaces Specifications.
DPP-CI-052/S-EA-10246-ESA	AD8 DORIS/ENVISAT-1 CTDP/PDS Interface Control Document
In progress	AD9 Spécifications des interfaces internes CCI
SMM-IF-M-EA-20054-CN	AD10 Catalogue des interfaces SSALTO
SMM-IF-M-EA-20055-CN	AD11 Spécifications des interfaces internes SSALTO
SMM-SP-M2-EA-10880-CN	RD1 Algorithm Definition and Accuracy Volume 2: CMA Altimeter Level 1b Processing
SMM-SP-M2-EA-10882-CN	RD2 Algorithm Definition and Accuracy Volume 4: CMA Altimeter Level 2 Processing
DPP-IF-D1/S-EA-10-CN	RD3 Spécification d'interface entre le segment sol DORIS/POSEIDON et l'instrument DORIS/ENVISAT
DJ1-IF-D1/M-EA-590-CN	RD4 Spécification d'interface entre le segment sol DORIS/POSEIDON (SSALTO) et l'instrument DORIS/JASON

TBC AND TBD LIST

TBC/TBD	Paragraph	Brief description
		None

CONTENTS

1. INTRODUCTION

1.1. PURPOSE

This document is aimed at defining the level 1.0 navigation data processing of the DORIS Instrument.

Beginning with SPOT4 that was launch in March 98, DORIS is able to determine in real-time the position of the platform thanks to the DIODE on board software (also called Navigator). This function has been integrated in the DORIS instrument since the second elaboration; all the orbit components, position and velocity, are downlinked at each satellite visibility for the whole mission of ENVISAT and Jason satellite. The raw navigation data of DORIS are then encapsulated in a level 0 format by the satellites ground systems.

This document describes the requirements of the processing to get level 1.0 navigation data from level 0 data. The main output of this processing, the segment navigator ephemeris, is involved:

- in the production of JASON POS2 level 1.0 Products, inputs of NRT products (OSDR see RD1 and RD2) processed by JSDS and SSALTO,
- in the monitoring of DORIS performed by the CCI in SSALTO,
- in the IGDR processing as a backup orbit (see RD1 and RD2).

The main steps identified in the Level 1.0 navigation data processing are:

- the extraction of raw navigation measurements from PLTM packets (level 0 Navigation Data, from the Operational Science Data from JTCCS for JASON, Navigation Data level 0 product from PDS or HK TM product from FOCC for ENVISAT),
- the generation of the level 1.0 product and of the corresponding segment navigator ephemeris.

These processing steps shall be implemented in each DORIS Ground Segment for ENVISAT and JASON, and so in:

- SSALTO for JASON and ENVISAT processings,
- JSDS, the JPL mission center which produces the JASON NRT products during the routine phase (see AD2 and AD3).

This document is aimed at identifying and describing the main functions of each processing step. It must be considered as the basic input for the detailed requirements of the processing, and not of course as the detailed requirements themselves.

Reception of level 0 data is not detailed here because this function is specific to JSDS or to SSALTO (described in AD5 for SSALTO). The monitoring of DIODE deduced from the navigation data is only performed in SSALTO and is described in AD5.

1.2. ORGANISATION OF THE DOCUMENT

The product tree (see **Figure 1** below) points out the main features of the Level 1.0 navigation data processing (grey cells) and of the corresponding output data (white cells are interfaces).

The interfaces of the processings (input and output data) are defined in section 2.

Extraction of raw navigation measurement is defined in section 3.

Generation of the level 1.0 navigation data product and of the segment navigator ephemeris is defined in section 4.

For each processing, the definition consists of:

- An overview of the overall processing (brief description of the processing and list of functions). Be aware that functions which proceed with data management or quality check, such as for example:
    - To get and prepare input data from space disk,
    - To check input data,
    - To convert units,
    - To manage the processing,

  are generally not detailed in this document, because they are not considered as critical items in the framework of the present processing definition. They will be represented and described more accurately in a document during the processing detailed requirements phase.
- A detailed description of all the functions. For each function, the following items are used:
    - Name,
    - Function description,
    - Applicability,
    - Input data:
        - Product data: data coming from the telemetry
        - Computed data: data issued from a previous algorithm
        - Dynamic auxiliary data: time-varying auxiliary data
        - Static auxiliary data: constant auxiliary data
    - Output data
    - Statement

- Accuracy (if any)
- Comments (if any)
- References (if any)

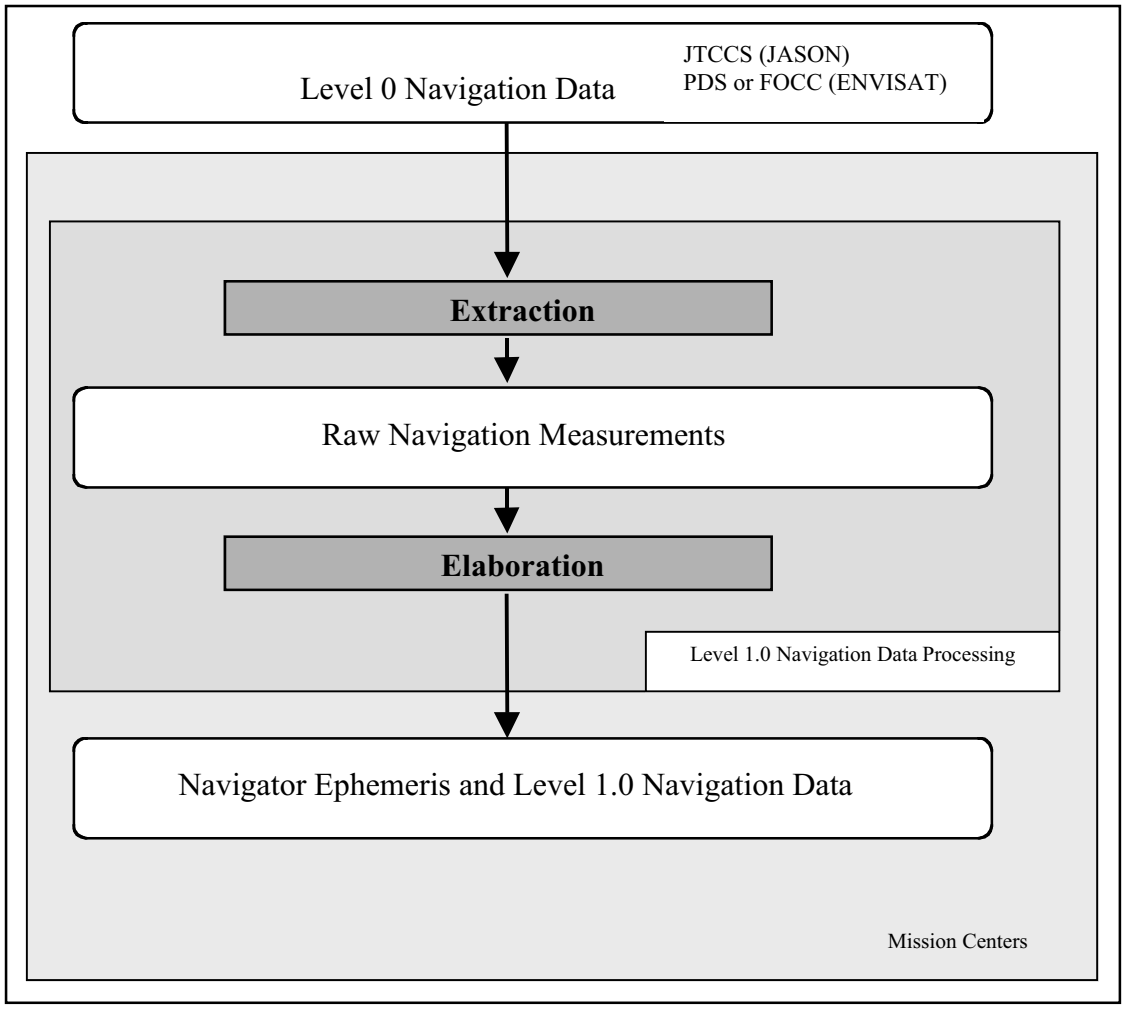

Figure 1: Product tree (Level 1.0 navigation data processing)

1.3. SCOPE

All the functions of the Level 1.0 navigation data processing are applicable to the CNES mission Center (SSALTO) and to the JPL mission Center (JSDS).

2. INPUT AND OUTPUT DATA

Inputs and outputs exchanged between sub-systems of the french mission center SSALTO, are described in AD10 and AD11.

Specific inputs or outputs used during the level 1.0 navigation data processing are described in AD9, to be written during the detailed requirements phase.

2.1. INPUT DATA

Two types of input data may be identified:

- Level 0 Navigation Data source packets, which correspond to raw data produced by the DORIS instrument and encapsulated by ground segments;
- Auxiliary data, which are dynamic or static:
    - Dynamic auxiliary data (DAD) are time-varying data,
    - Static auxiliary data (SAD) are constant data.

2.1.1. LEVEL 0 NAVIGATION DATA

Raw data are generated by DORIS every 10 seconds, and delivered in 16 bits serial words by the platform in frames or sources packets (see RD3 and RD4).

Note that for both JASON and ENVISAT, positions that are part of navigation data are also given within the DORIS scientific housekeeping telemetry (see RD3 and RD4).

2.1.1.1. ENVISAT Level 0 Navigation Data

Navigation Data are delivered nominally in LBR source packets and in ICUHK frames for backup. LBR source packets are received by the PDS stations (Kiruna, Sweden and Frascati, Italy). The PDS is the nominal producer of navigation level 0 products. FOCC receives the ICUHK frames to generate Housekeeping Telemetry Data, source of level 0 navigation data as a backup.

For the description of AD8 (resp. AD6) and AD5, and RD3.

2.1.1.2. JASON Level 0 Navigation Data

One Earth Terminal of the Jason ET Network (see AD2) receives all the APID as PLTM frames during the satellite visibility. This set of frames is called a segment of data and is sent to JTCCS. Then, JTCCS processes these frames into JTCCS packets (see AD3) for each APID.

For our purpose, these APID are gathered in two main sets:

- the Operational Science Data (including the Navigation Data)
- the Raw Science Data whose priority is lower in terms of downlink operations, since Operational Science Data is used for NRT processing.

The Operational Science Data is composed of (see AD2):

- Level 0 Navigation Data Source Packets,

- Level 0 Time-Tag Data processed by DORIS,
- Level 0 POS2 source packets for NRT processing,
- Level 0 JMR source packets.

The Raw Science Data is composed of set of science source packets from DORIS and POS2 and TRSR. Processing of these raw science data is described in AD4 for POS2, in AD5 for DORIS. They are independent of Level 1.0 navigation data processing.

For the description of the level 0 navigation data from the JTCCS, see AD3 and AD7, and RD4.

2.1.2. AUXILIARY DATA

- Dynamic auxiliary data

Specific dynamic auxiliary data consist of the last time-tag of previous processed data (used to detect lack of telemetry), defined in AD9.

- Static auxiliary data

Static auxiliary data consist of constant processing parameters such as:

- Thresholds to check quality, defined in AD9,
- UTC-TAI Differences, defined in AD11,
- polynomial transfer functions, defined in AD9,
- decommutation tables described in the Satellite Database from JCCC (see AD3) or the FOCC (see AD6) and defined in AD9.

2.2. OUTPUT DATA

2.2.1. LIST OF OUTPUTS

The outputs are the Level 1.0 Navigation Data Product and the segment navigator ephemeris.

A report file, as defined in AD9, mainly contains:

- statistics: number of valid data, number of error data, number of redundant data, etc.
- product characteristics: mission id, data time window, etc.

2.2.2. MAIN CHARACTERITICS OF LEVEL 1.0 NAVIGATION DATA PRODUCT

Level 1.0 navigation data product contains all the on-board information, delivered by DORIS at 0.1 Hz and completed by level 1.0 processing with quality flags (see AD11). It is the input for the generation of segment navigator ephemeris and is also used for investigations.

This output is a level 1.0 product and therefore:

- corresponds to a segment of data without redundant information,
- is chronologically ordered,
- data are in physical values,
- TAI time is used,
- All parameters have been checked and quality flags are set.

2.2.3. MAIN CHARACTERITICS OF SEGMENT NAVIGATOR EPHEMERIS

For a segment of acquisition or for a full day, the segment navigator ephemeris is composed of position and velocity vectors of the platform given every TAI minute.

A segment navigator ephemeris is used in level 1.0 POS2 processing (see AD4) and OFL production (see RD2), as a backup orbit data. It is defined in AD11.

2.3. SUMMARY OF THE INTERFACES

The interfaces of the level 1.0 navigation data processing are summed up in **Figure 2**.

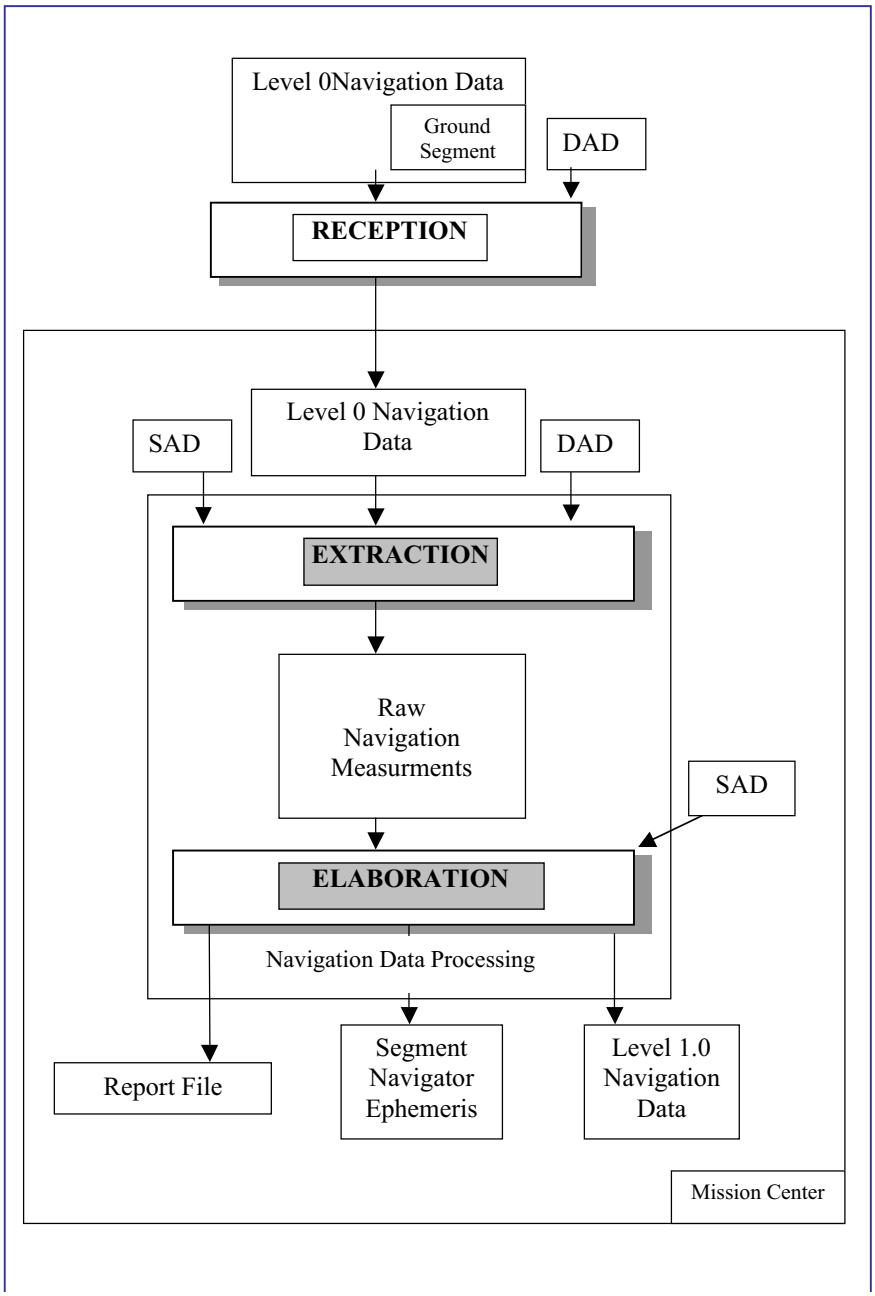

Figure 2: Interfaces of the Level 1.0 navigation data processing

3. "EXTRACTION" PROCESSING

The goal of this processing is to extract the raw navigation measurement from the level 0 navigation data, i.e. to transform level 0 navigation data whose format is specific to each satellite ground system into a common raw navigation measurement SSALTO format, whatever the satellite.

3.1. PROCESSING OVERVIEW

3.1.1. BRIEF DESCRIPTION

Once data are collected by the Reception processing, the Extraction processing extracts raw navigation measurements from level 0 navigation data source packets and removes extra information added by the satellite ground systems.

The Extraction processing has to detect lacks of TM. The relevant time information used to perform this detection is the platform time, i.e. GPS-UTC creation time, given in the JTCCS PLTM packets for JASON, and on-board time, converted in UTC by FOCC or PDS for ENVISAT.

For Jason, data are chronologically ordered in each JTCCS PLTM packet due to the protocol of exchange between the instruments and the satellite platform. Moreover, there is no overlap between data segments thanks to the organisation of the dump of the platform memory. If JTCCS detects a lack of telemetry after a downlink, then telemetry is not delivered to the others components of the Jason ground segment. A second dump of the PF memory is performed and checked before delivery of the whole downlinked telemetry.

For ENVISAT, raw data are collected by the Interface Control Unit and delivered to the platform in LBR or HK source packets. The DORIS data acquisition frequency by ICU is different from the DORIS data generation frequency, and there is no synchronisation. In this case, the Extraction processing has to concatenate raw navigation measurement given in two different telemetry source packets.

Thus, the Extraction processing does not check the chronology of level 0 navigation data and instrument time-tag. It processes data in the same order as their reception.

3.1.2. LIST OF FUNCTIONS

The list of the functions of the Extraction processing is given in **Figure 3**.

FUNCTION
TO DETECT LACKS OF TELEMETRY
TO EXTRACT RAW NAVIGATION MEASUREMENTS FROM SATELLITE GROUND SYSTEM SOURCE PACKETS

Figure 3: Functions of the Extraction processing

3.2. FUNCTIONS

A detailed description of the functions of the Extraction processing is given in this section.

3.2.1. TO DETECT LACKS OF TELEMETRY

Function

This function detects lacks of telemetry by checking the on-board UTC time of data sources packets given by the satellite ground segment.

Applicability

ENVISAT and JASON

Input data

- Product data:
    - current data source packet
    - previous data source packet
- Computed data: None
- Dynamic auxiliary data: None
- Static auxiliary data:
    - Extraction processing configuration file defining the acceptable telemetry time gap and the processing configuration.

Output data

- Continuity check status
- Duration gap

Statement

This function checks that there is no more than the acceptable duration lack between two consecutive level 0 data source packets (test of the UTC on-board time difference between the current packet and the previous packet, relative to the acceptable telemetry gap). If a continuity default is detected, this function returns a significant status of the continuity check and the value of the duration gap.

Accuracy: /

Comments: level 0 navigation data are chronologically ordered with the UTC on-board time.

References: /

3.2.2. TO EXTRACT RAW NAVIGATION MEASUREMENTS FROM SATELLITE GROUND SYSTEM SOURCE PACKETS

Function

This function extracts the instrument raw navigation measurements (defined in RD3 and RD4) from the level 0 navigation data source packets delivered by the satellite ground system (see AD6, AD7, AD8).

Applicability

ENVISAT and JASON

Input data

- Product data:
    - Satellite ground system source packets
- Computed data: None
- Dynamic auxiliary data: None
- Static auxiliary data: None

Output data

- Raw navigation measurements (defined in AD9)

Statement

This function generates raw navigation measurements from level 0 navigation data source packets by removing the headers found in the satellite ground system interfaces.

For ENVISAT only, each new level 0 navigation data source packet is concatenated with the end of the previous (if an incomplete raw navigation measurement was given in the previous source packet). Then it splits the level 0 navigation data into complete raw navigation measurements. If any, the last incomplete raw navigation measurement is memorised to try to complete it with the next level 0 navigation data source packets.

Accuracy: /

Comments: One source packet contains one raw navigation measurement for JASON, several for ENVISAT.

References: /

4. "GENERATION " PROCESSING

4.1. PROCESSING OVERVIEW

The level 1.0 navigation data product is generated from the extracted raw navigation measurements, for each data segment:

- a level 1.0 navigation product,
- a navigator ephemeris product deduced from level 1.0 navigation product.

The navigator ephemeris product is created for each data segment for OFL production, as a back-up orbit.

4.1.1. BRIEF DESCRIPTION

A brief overview of the main functions of the Generation processing is given in this section. A detailed description is provided in section 4.2.

The generation of level 1.0 Navigation data product uses many functions identical to or derived from functions already described in AD4 (function and statement parts):

- To extract a parameter,
- To apply a transfer function,
- To convert UTC Time in TAI.

The other function (To check for redundant/default information) is very similar to function of the “Level 1.0 DORIS Time-tag data Processing”.

The order of the description of the functions respects their chronology.

4.1.2. LIST OF FUNCTIONS

The list of the functions of the Generation of level 1.0 navigation data processing is given in **Figure 4**.

FUNCTION
TO EXTRACT A PARAMETER
TO APPLY A TRANSFER FUNCTION
TO CONVERT UTC TIME- IN TAI
TO CHECK FOR REDUNDANT/DEFAULT INFORMATION
TO CHECK THE ON-BOARD PRECISION ESTIMATOR

TO GENERATE SEGMENT NAVIGATOR EPHEMERIS

Figure 4: Functions of the level 1.0 Navigation Data Generation processing

4.2. FUNCTIONS

A detailed description of the functions of the Level 1.0 Navigation Data Generation processing is given in this section.

4.2.1. TO EXTRACT A PARAMETER

Function

See AD4.

Applicability

ENVISAT and JASON

Input data

- Product data:
    - Raw navigation measurement (see RD3 and RD4 for the content of source packets).
- Computed data: None
- Static auxiliary data: Decommutation tables.

Output data

- Raw parameter.

Statement

See AD4.

Accuracy None

Comments This function is called for all the parameters of raw navigation measurement.

References None

4.2.2. TO APPLY A TRANSFER FUNCTION

Function

See AD4.

Applicability

ENVISAT and JASON

Input data

- Product data: None
- Computed data: Raw Parameter, output from “To Extract a Parameter”.
- Static auxiliary data: polynomial transfer functions.

Output data

- Parameter in physical value.

Statement

See AD4.

Accuracy None

Comments This function is called for all the parameters of raw navigation measurement.

References None

4.2.3. TO CONVERT UTC TIME IN TAI

Function

See AD4.

Applicability

ENVISAT and JASON

Input data

- Product data:
    - UTC on-board creation time of each raw navigation measurement (see AD8, AD6, RD4).
- Computed data: None.
- Static auxiliary data: UTC/TAI time differences.

Output data

- TAI creation Time of each raw navigation measurement.

Statement

Adds the appropriate UTC/TAI difference to convert the UTC creation time into the TAI creation Time.

Accuracy None.

Comments This function is called for each raw navigation measurement.

For Jason , the UTC time is the time provided by the platform GPS.

For ENVISAT, the UTC time is the time derived by the ICU from the platform time

References None

4.2.4. TO CHECK FOR REDUNDANT/DEFAULT INFORMATION

Function

This function detects and deletes redundant or default information in the raw navigation measurement.

Applicability

ENVISAT and JASON

Input data

- Product data: Raw navigation measurement
- Computed data: None
- Static auxiliary data: None.

Output data

- On-board navigation measurements.

Statement

In case of DORIS/ENVISAT instrument

If (DORIS TAI Time and position and velocity) of one raw navigation measurement is equal to 'FFFF'H, then measurement is deleted

If (DORIS TAI Time and position and velocity) of one raw navigation measurement is equal to default value 0, then the quality flag is set to "Default ".

Else

For Envisat only,
If a raw navigation measurement is received more than once *(several occurrences at one DORIS TAI time)*,

If all its occurrences (different by the creation time) are equal *(same position and velocity at the same DORIS TAI Time)*, then

the data corresponding to the oldest creation time of the navigation data is selected, its quality flag is set to "valid".
The other data are identified as "redundant" and are deleted.

Else a quality flag is set to "non-valid" for each occurrence.

When selected, data is registered by creation time chronology.

Accuracy None

Comments The On-board navigation measurements is the result of the four functions described above.

References None

4.2.5. TO CHECK THE ON-BOARD PRECISION ESTIMATOR

Function

This function checks the value of the on-board precision estimator of the on-board navigation measurements.

Applicability

ENVISAT and JASON.

Input data

- Product data: On-board navigation measurements.
- Computed data: None.
- Static auxiliary data: Threshold of the on-board precision estimator.

Output data

Quality flag

Level 1.0 Navigation Data (see AD11).

Statement

This function checks the on-board precision estimator. If its value exceeds a threshold (static but that may be changed), the quality flag is set to “non-valid”, else to “valid”.

A report file reporting characteristics of the level 1.0 navigation data product is generated.

Accuracy None

Comments None

References None

4.2.6. TO GENERATE SEGMENT NAVIGATOR EPHEMERIS

Function

This function generates a segment navigator ephemeris by selecting, from Level 1.0 Navigation Data, position and velocity vectors computed by DIODE at every TAI minute.

Applicability

ENVISAT and JASON.

Input data

- Product data: Level 1.0 Navigation Data
- Computed data: None
- Static auxiliary data: see AD9.

Output data

- Segment Navigator Ephemeris (see AD11).

Statement

This function selects position and velocity vectors at every TAI minute and generates an ephemeris with a SSALTO common format.

Accuracy None

Comments None

References None