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GOCE L1B PRODUCTS USER HANDBOOK

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ACRONYMS AND ABBREVIATIONS

AD Applicable Document
ADP Auxiliary Data Provider
ANX Ascending Equator Crossing Node
AO Announcement of Opportunity
AR Acceptance Review
ARF Accelerometer Reference Frame
ATR Algorithm Test Review
CAB Change Appeal Board
CBCP Current Baseline Cost Plan
CCN Contract Change Notice
CDAF Command and Data Acquisition Facility
CDR Critical Design Review
CFI Customer Furnished Item
CMF Calibration and Monitoring Facility
CPF Central Processing Facility
CPR Cycle Per Revolution
CTRS Conventional Terrestrial Reference System
DFACS Drag-Free and Attitude Control System
DPA Data Processing Archive
DPM Detailed Processing Model
DSR Data Set Record
E2E End-to-End Simulator
ECP External Calibration Products
ECSS European Cooperation for Space Standardization
EFRF Earth Fixed Reference Frame
EGG Electrostatic Gravity Gradiometer
EGG-C European GOCE Gravity Consortium
EME2000 Equinox and Mean Equator of J2000.0
EO Earth Observation
EOEP Earth Observation Envelope Programme
EPAR Extended mission Product Acceptance Review
ESA European Space Agency
GOCE Gravity field and steady-state Ocean Circulation Explorer
GPS Global Positioning System
GRF Gradiometer Reference Frame
GS Ground Segment
HPF High level Processing Facility
HW Hardware
ICD Interface Control Document
IERS International Earth Rotation and Reference Systems Service
IGS International GNSS Service
IPF1 Instrument Processing Facility level 1
IRF Inertial Reference Frame
LORF Local Orbital Reference Frame
MBW Measurement BandWidth \
MOP Measurement Operational Phase
MPH Main Product Header
NA Not Applicable
NRT Near-Real Time
OBCP On-Board Control Procedures
OBT On-Board Time
ORR Operational Readiness Review
OSAT On-Site Acceptance Test
PAR Product Acceptance Review
PCD Product Confidence Data
PDD Product Definition Document
PDS Payload Data Segment
PF Processing Facility
POD Precise Orbit Determination
PSD Packet Structure Definition; Power Spectral Density
RD Reference Document
RERF Radial Earth-pointing Reference Frame
RPF Reference Planning Facility
RSS Root-Sum Square
S/C Space-Craft
SCP Secure Copy (remote file copy program)
SDE Software Development Environment
SFTP Secure File Transfer Program
SGG Satellite Gravity Gradiometer
SP Specific Product
SPC Satellite Prime Contractor
SPF Sub-Processing Facility
SPH Specific Product Header
SST Satellite-to-Satellite Tracking
SSTI Satellite-to-Satellite Tracking Instrument
STP Software Test Plan
SVT System Validation Test
UTC Universal Time Coordinated
XML eXtensible Markup Language

TABLE OF CONTENTS

1 INTRODUCTION

1.1 *Purpose*

The purpose of this document is to provide a detailed description of the GOCE Level 1b products generated by Instrument Processing Facility 1 (IPF1) and distributed to GOCE users. The document describes everything required to make use of the Level 1b products for the processing or application and is a self-standing document for what regards Level 1b products user.
For a complete review of GOCE products, please refer also to GOCE Level 2 Data Handbook.

1.2 *Reference Documents*

Document Title	**Identifier**	**[RD-ID]**
Gravity Field and Steady-State Ocean Circulation Mission	ESA-SP-1233 (1)	**[RD- 1]**
GOCE Level 2 Data Handbook	GO-MA-HPF-GS-0110	**[RD- 2]**
GOCE Calibration & Validation Plan for L1b data Products	EOP-SM/1363	**[RD- 3]**
RINEX Modifications to Accommodate Low Earth Orbiter Data - Issue 2.20	IGSMAIL-3281	**[RD- 4]**
NAVSTAR GPS Space Segment / Navigation User Interfaces, Rev. C, Release 004, 12 April 2000	ICD-GPS-200C	**[RD- 5]**
Rummel, Balmino et al. Dedicated gravity field missions, Journal of Geodynamics, N. 33, 2002		**[RD- 6]**
Earth Explorer Ground Segment File Format Standard	PE-TN-ESA-GS-0001	**[RD- 7]**
Torge, W.: Geodesy. 3. ed., de Gruyter, Berlin, 2001.		**[RD- 8]**

1.3 *Acknowledgments*

TBD

2 GOCE USER GUIDE

2.1 Scientific Background

The Earth is a dynamic system constantly undergoing changes. For a better understanding of both surface and deep phenomena which are related to the interior structure of the Earth and its temporal evolution, it is necessary to significantly improve the current models of the Earth's gravitational potential, both in resolution and precision - if not its temporal variations induced by the afore mentioned phenomena.
Thus, the gravity field plays a dual role in Earth sciences.
On the one hand, by comparing the real field with the field of an idealized body (e.g. an ellipsoid in hydrostatic equilibrium) one defines gravity anomalies which characterize deviations from a state of internal equilibrium (that is non-radial density variations), which constitutes one method of sounding our planet's interior. The gravity analysis approach is unique in providing direct information on the density field. A significant part of this information is, at present, provided by seismology, by tomographic analysis, but still suffers from uncertainties due to hypothesis on which such inversions are based. The combination of both types of data (seismic velocities and gravity anomalies) is a powerful tool to get a better picture of the interior and to make progress in the understanding of several phenomena for instance the accumulation of stresses and triggering of earthquakes.
On the other hand, the geoid is used as the reference for defining and measuring the altitudes on the continents but also under the oceans or over the ice caps. The geoid is a particular equipotential surface of the gravity potential (the sum of the gravitational and centrifugal potentials) which may be viewed, in oceanic areas, as the surface of an ocean at rest. The irregularities of the geoid characterize the density field variations in a way similar to the gravity anomalies.
A detailed geoid surface when combined with satellite altimetry yields sea surface topography, the quasi-stationary deviation of the ocean surface from its hypothetical surface of rest. Under the assumption of geostrophic balance, ocean topography can be directly translated into a global map of surface ocean circulation. Thus, ocean surface circulation can become directly measurable.
The fields of application of the gravity analysis approach can be differentiated as follows:

Marine Geoid and its Impact on Ocean Circulation – The absolute value of the ocean dynamic topography requires the determination of the 'hypothetic' ocean at rest, i.e. the marine geoid. This is the basic requirement for modelling ocean circulation and interpreting satellite altimeter data. Unfortunately, current geoid uncertainties and their impact on the absolute dynamic topography are large, particularly at shorter wavelengths less than 2000 km. Given the continuing need to study and predict climate variation and climate change by the combined use of altimetry, global ocean circulation models, and high-quality global in-situ data, it is thus essential to significantly reduce errors in our knowledge of the geoid, in particular, at shorter wavelength. A similar requirement also applies to the growing field of operational oceanography for which radar altimetry is an important data source. This could be achieved once and for all through a single dedicated gravity field mission.

Gravity Field and Solid Earth Processes – Specific issues to be addressed by an accurate and detailed determination of the gravity field includes discrimination between active and passive models of rifting;

identification of anomalous mass which may drive basin subsidence; and determination of the deep density structure beneath the continents and of the mechanical strength of the continental lithosphere.
The GOCE gravity field models are provided in terms of a set of dimensionless coefficients of a spherical harmonic series up to a maximum degree of the gravity potential. These coefficients are the result of the gravity field determination process.
The gravitational potential spherical harmonic series is defined by (see e.g. [RD- 8]):

$$V(r,\theta,\lambda)=\frac{GM}{r}\sum_{n=0}^{N_{\max}}\left(\frac{a}{r}\right)^n\sum_{m=0}^{n}\left(\overline{C}_{nm}\cos m\lambda+\overline{S}_{nm}\sin m\lambda\right)\overline{P}_{nm}(\cos\theta)$$

where:

V	gravitational potential at computation point
GM	gravity constant times total mass of Earth
a	equatorial radius of the Earth ellipsoid
n	degree of spherical harmonic coefficient
N_{max}	maximum degree of spherical harmonic series
m	order of spherical harmonic coefficient
r	radial distance of computation point from geocenter
θ	geocentric co-latitude of computation point
λ	geocentric longitude of computation point
$\overline{P}_{nm}$	normalized associated Legendre functions of degree n and order m
$\overline{C}_{nm}, \overline{S}_{nm}$	coefficients of spherical harmonic series

Understanding of mantle processes, in particular convection patterns, and of post-glacial mass readjustment, will greatly benefit from improved and more detailed knowledge of the Earth's gravity field. Moreover, the accurate and detailed determination of the anomalous gravity field plays a key role in advancing understanding of the dynamics of the continental lithosphere. It is also necessary to identify the contribution of post-glacial rebound to sea level change, and the impact of Solid Earth processes on the global ocean. Further progress in the understanding of these processes and improvement in geopotential models require global determination of the gravity field, at a spatial resolution down to half wavelengths of between 50 and 400 km.

Geodesy – With a high resolution and precise geoid ellipsoidal heights, as provided by GPS, can be directly translated into orthometric (pseudo-levelled) heights, a perspective of high relevance for cartography, mapping, surveying, navigation and exploration. At present, the different orthometric height systems (national datum) differ by the order of decimeters between islands and between islands and continents, over distances of a few 100 km. Between continents these differences may be as large as a metre. Sea level in one part of our planet can therefore not be properly compared with sea level in other parts, nor can changes be precisely separated into sea level rise and vertical land uplift or subsidence respectively. One of the key objectives in geodesy is therefore to improve and unify the different orthometric height systems using high quality gravity field data.

2.2 GOCE Mission Description

The Gravity-field and steady-state Ocean Circulation Experiment (GOCE) is the first Earth Explorer Core Mission selected in the context of ESA's Living Planet Programme. The GOCE satellite, to be launched in 2007, carries onboard a gravity gradiometer and a GPS receiver with the objective of producing high accuracy global measurements of the Earth's static gravity field for being used in a wide range of geophysical applications.

In order to achieve the above scientific objectives two observations concepts are used:

- **Satellite-to-Satellite Tracking (SST)** in high-low (hl) mode is used for the orbit determination and for retrieval of the long-wavelength part of the gravity field. This is accomplished by means of the GPS receiver.
- **Satellite Gravity Gradiometry (SGG)** is employed for the derivation of the medium /short wavelength part of the gravity field.

The techniques of gradiometry and SST are complementary (see Figure 1) in that SST-hl allows derivation of the long and medium wavelength part of the gravity field, while gradiometry is especially sensitive to the short-wavelength part. The point of overlap between the gravity retrieval capabilities of SST-hl and gradiometry begins at around degree and order L = 15, or the equivalent of 1300 km resolution. The SST-hl overlaps the gradiometer capability up to at least L = 60, or the equivalent of 330 km resolution.

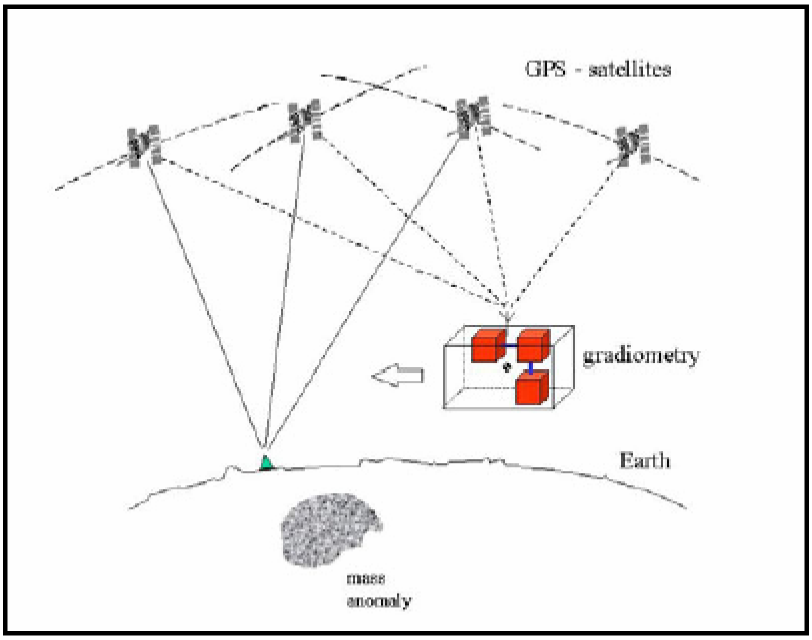

Figure 1 - Schematic illustration of the combined satellite gravity gradiometer (SGG) and satellite-to-satellite (high-low) tracking mission concept

3 GOCE PRODUCTS AND ALGORITHMS

3.1 Introduction

The three basic levels of data products to be produced by the ground segment are briefly described in the following.

3.1.1 Level 0

Level 0 data consists of the time-ordered science and housekeeping raw data produced by the instruments and by the platform. Each of these data streams are needed to produce the Level 1b data products and to check their quality.
Level 0 products include:

- satellite and instrument housekeeping data and ancillary data (such as attitude quaternions measured by the star trackers at 2 Hz)
- output of the 6 accelerometers along their 3 measurement axes at 1 Hz (more precisely at 1/0.999360 Hz)
- SSTI data at 1 Hz

3.1.2 Level 1b

The Level 0 to Level 1b processing carried out by the Instrument Processing Facility (IPF) converts the ordered L0 time series into engineering units and performs calibration, correction and geolocation of data along the orbit.
L1b products include:

- gravity gradients in GRF together with the GRF to Inertial Reference Frame (IRF)
- frame transformation matrices,
- linear accelerations and angular rates and accelerations,
- SST measurements and derived positions and reconstructed satellite orbits in Earth-Fixed Reference Frame (also available in RINEX format),
- attitude and orbit data (position, velocity and time).

3.1.3 Level 2

Level 2 products are generated by the High Level Processing Facility, a distributed system developed and operated by the European GOCE Gravity-Consortium (EGG-C).
Level 2 products include:

- Pre-processed, externally calibrated, and corrected gravity gradients in both Gradiometer Reference Frame and Terrestrial Reference Frame.
- Rapid and precise orbits.
- Gravity field solutions including variance-covariance matrix and derived quantities (geoid heights, gravity anomalies, and geoid slopes).

For a detailed description of the Level 2 Products, please refer to [RD-2].

3.2 Definitions and conventions

3.2.1 REFERENCE FRAMES

The reference frames involved in the Level 0 to Level 1b processing are defined hereafter.

3.2.1.1 Accelerometer Reference Frame (ARF)

This is the reference frame in which the components of the acceleration of the proof mass relative to the cage are measured by the sensor. It is defined in a different way for three accelerometer pairs belonging to the three OAGs, so that the corresponding axes of all the ARFs are nominally aligned when the six accelerometers are installed in the Three-Axis Gradiometer (see Figure 6).
For all accelerometers Ai

- Origin, O_i, located at the centre of the accelerometer A_i.

For the accelerometers A_1, A_4 belonging to OAG1:

- Xi axis parallel to the accelerometer ultra sensitive axis nominally aligned with the OAG1 baseline, positive from the location of A_4 to the location of A_1.
- $Z_{i\ axis} = X_i \times L$, where X_i is the unit vector of the axis X_i and L is unit vector normal to the internal wall of the lower plate of the ULETM cage positive in the opposite direction of the sole plate. Z_i is nominally parallel to the second ultra-sensitive axis of the accelerometer.
- Yi axis parallel to $Z_i \times X_i$, with the same sign of $Z_i \times X_i$. Yi is nominally parallel to the less sensitive axis of the accelerometer.

For the accelerometers A2, A5 belonging to OAG2:

- Y_i axis parallel to the accelerometer ultra sensitive axis nominally aligned with the OAG2 baseline, positive from the location of A_5 to the location of A_2.
- X_i axis = $Y_i \times L$, where Y_i is the unit vector of the axis Y_i and L is unit vector normal to the internal wall of the lower plate of the ULETM cage, positive in the opposite direction of the sole plate. X_i is nominally parallel to the second ultra-sensitive axis of the accelerometer.
- Z_i axis parallel to $X_i \times Y_i$, with the same sign of $X_i \times Y_i$. Z_i is nominally parallel to the less sensitive axis of the accelerometer.

For the accelerometers A_3, A_6 belonging to OAG3:

- Z_i axis parallel to the accelerometer ultra sensitive axis nominally aligned with the OAG3 baseline, positive from the location of A_6 to the location of A_3.

- X_i axis = $L \times Z_i$, where Z_i is the unit vector of the axis Z_i and L is unit vector normal to the internal wall of the lower plate of the ULETM cage, positive in the opposite direction of the sole plate. Xi is nominally parallel to the second ultra-sensitive axis of the accelerometer.
- Y_i axis parallel to $Z_i \times X_i$, with the same sign of $Z_i \times X_i$. Y_i is nominally parallel to the less sensitive axis of the accelerometer.

3.2.1.2 One-Axis Gradiometer Reference Frame (OAGRF)

This is the reference frame in which the components of the gravity gradient tensor are measured by the OAG, and is defined as follows (see Figure 2):

- Origin, O_{1OGR}, located in the mid point of the straight line joining the origin O_4 of ARF_4 to the origin O_1 of ARF_1
- $X1_{OGR}$ axis parallel to the line joining O_4 to O_1, oriented from O_4 to O_1.
- $Y1_{OGR}$ parallel to and with the same versus of the vector $\underline{Y} = \frac{\underline{Y}_1'}{\left|\underline{Y}_1'\right|} + \frac{\underline{Y}_4'}{\left|\underline{Y}_4'\right|}$ where $\underline{Y}_1', \underline{Y}_4'$ are the projections of the vectors Y_1 and Y_4 on the plane perpendicular to X_{1OGR}.
- Z_{1OGR} parallel to $X_{1OGR} \times Y_{1OGR}$, with the same sign of $X_{1OGR} \times Y_{1OGR}$.

For OAG2:

- Origin, $O2_{OGR}$, located in the mid point of the straight line joining the origin O_5 of ARF_5 to the origin O_2 of ARF_2.
- Y_{2OGR} axis parallel to the line joining O_5 to O_2, oriented from O_5 to O_2
- Z_{2OGR} parallel to and with the same versus of the vector $\underline{Z} = \frac{\underline{Z}_2'}{\left|\underline{Z}_2'\right|} + \frac{\underline{Z}_5'}{\left|\underline{Z}_5'\right|}$ where $\underline{Z}_2', \underline{Z}_5'$ are the projections of the vectors Z_2 and Z_5 on the plane perpendicular to Y_{2OGR}.
- X_{2OGR} parallel to $Y_{2OGR} \times Z_{2OGR}$, with the same sign of $Y_{2OGR} \times Z_{2OGR}$

For OAG3:

- Origin, O_{3OGR}, located in the mid point of the straight line joining the origin O_6 of ARF_6 to the origin O_3 of ARF_3.
- Z_{3OGR} axis parallel to the line joining O_6 to O_3, oriented from O_6 to O_3
- Y_{3OGR} parallel to and with the same versus of the vector $\underline{Y} = \frac{\underline{Y}_3'}{\left|\underline{Y}_3'\right|} + \frac{\underline{Y}_6'}{\left|\underline{Y}_6'\right|}$ where $\underline{Y}_3', \underline{Y}_6'$ are the projections of the vectors Y_3 and Y_6 on the plane perpendicular to Z_{3OGR}.
- X_{3OGR} parallel to $Y_{3OGR} \times Z_{3OGR}$, with the same sign of $Y_{3OGR} \times Z_{3OGR}$

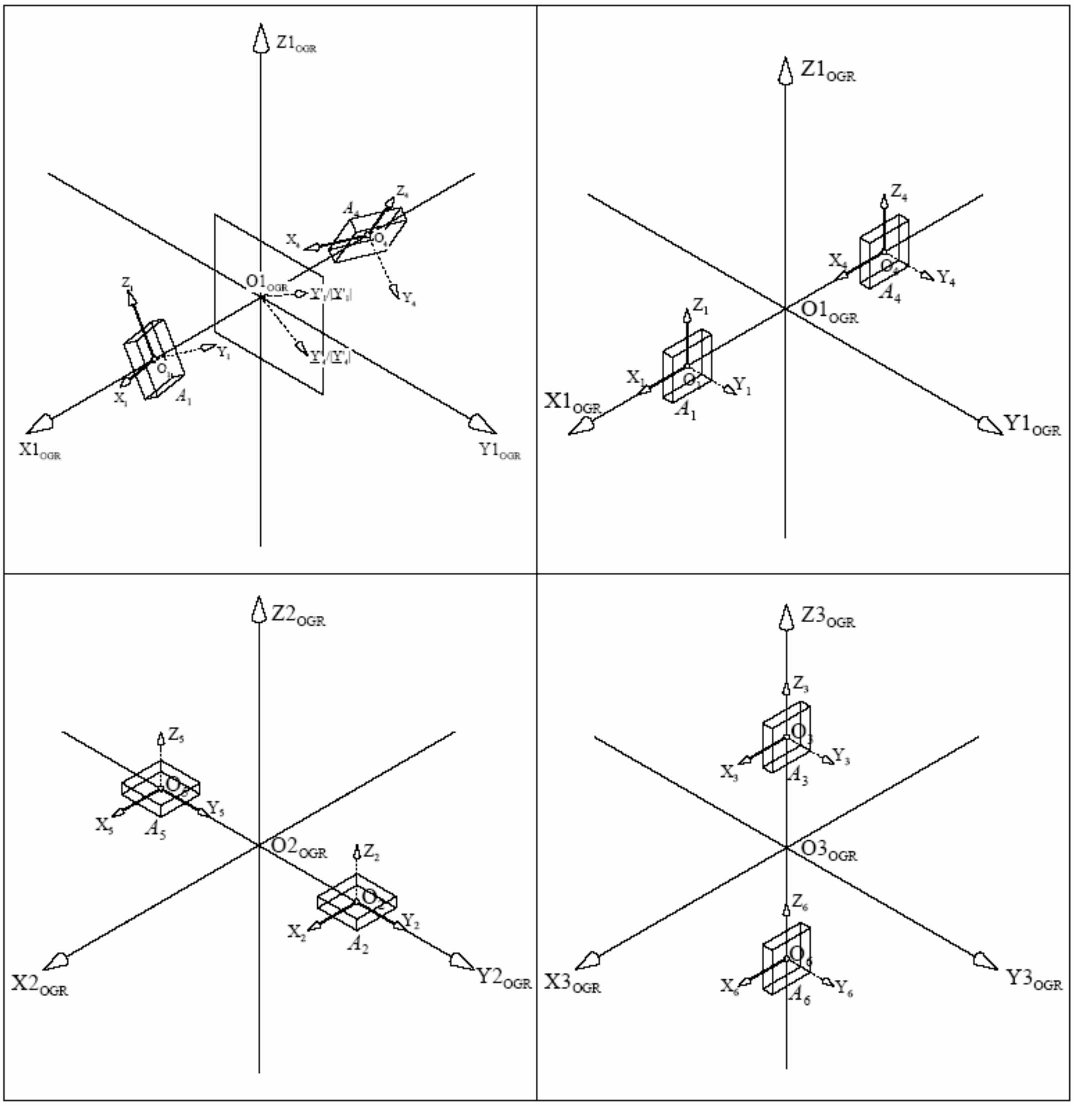

Figure 2 - One-Axis Gradiometer Reference Frame definition for the accelerometer pair A1, A4 (top left) and nominal orientation of the ARF1, ARF4 in the OAGRF1 (top right), of the ARF2, ARF5 in the OAGRF2 (bottom left)and of the ARF3, ARF6 in the OAGRF3 (bottom right)

3.2.1.3 Gradiometer Reference Frame (GRF)

GRF is the coordinate system in which the components of the gravity gradient tensor are measured by GOCE. The GRF represents the Three-Axis Gradiometer common reference for the mutual positioning and alignment of the three One Axis Gradiometers and for the positioning and orientation of the whole instrument with respect to external reference frames (see Figure 3). Nominally the origins of all one-axis gradiometer reference frames (OAGRF) coincide in one intersection point. The corresponding axes of each of the 3 OAGRF's are parallel and point in the same directions. The corresponding 6 accelerometer reference frames (ARF) are parallel and point in the same direction.

3.2.1.4 Inertial Reference Frame (IRF)

The fundamental inertial reference frame of the mission is realized by the J2000 Equatorial Reference Frame (JERF). It is defined as follows (see Figure 3):

- Origin, OJ2000, located at the centre of the Earth.
- XJ2000 axis at the intersection of the mean ecliptic plane with the mean equatorial plane at the date of 01/01/2000 and pointing positively towards the vernal equinox.
- ZJ2000 axis orthogonal to the mean equatorial plane at the date 01/01/2000.
- YJ2000 axis completing a right-handed orthogonal reference frame.

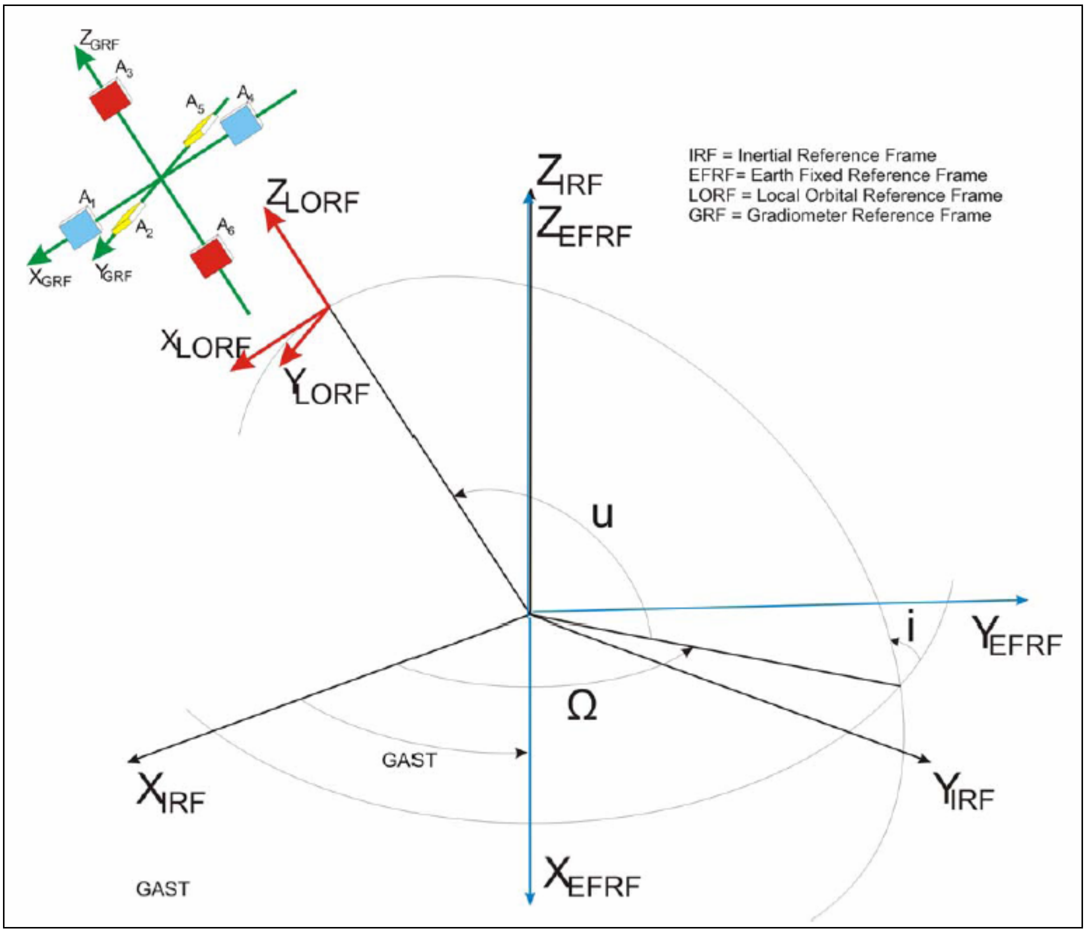

Figure 3 - Definition of fundamental Reference Systems for GOCE

3.2.1.5 Time Reference for GPS

The timing diagram in Figure 4 shows the relations between the different timings involved in the SST receiver.

- *GPS System Time*: this is the GPS System Time reference maintained by the GPS master control station. It is offset from the UTC by an integer number of leap seconds that are periodically kept updated. Conversion between GPS time and UTC may be performed by the receiver using coefficients transmitted by GPS SVs in their navigation message
- *GPS i-th satellite clock*: the GPS satellite clock drifts in time with respect to the time reference and can be corrected at each PVT solution by the receiver, using a set of polynomial coefficients transmitted by the GPS satellite within the navigation message. Polynomial correction is defined by the "Navstar ICD" document **[NAV-ICD]**.
- *Receiver internal clock*: the receiver internal clock drifts with respect to the reference time and can be corrected by the "clock bias" value calculated within the PVT solution. The calculated clock bias accuracy is in the order of 80 nsec with respect to the GPS reference time. The main contributor to this error is from the navigation solution itself
- *Integration Epoch*: this signal is independent for each channel allocated to an SV and once the channel is tracking this signal is synchronous with the C/A code epoch
- *Measurement Epoch*: this signal is internally generated by the receiver (one for all channels) with a period of 20 msec and is maintained synchronous with the receiver PPS.

The GPS week number reference is week #0 starting January 6, 1980. The seconds count begins at the midnight, which begins each Sunday morning. The roll-over of the GPS week (max number 1024) was in August, 1999. The LAGRANGE receiver week, if not differently specified, is evaluated as:

$$\text{internal WN} = \text{actual WN} + 1024$$

where *actual WN* is the WN set by the GPS SVs. GPS time differs from UTC by a variable integral number of seconds.

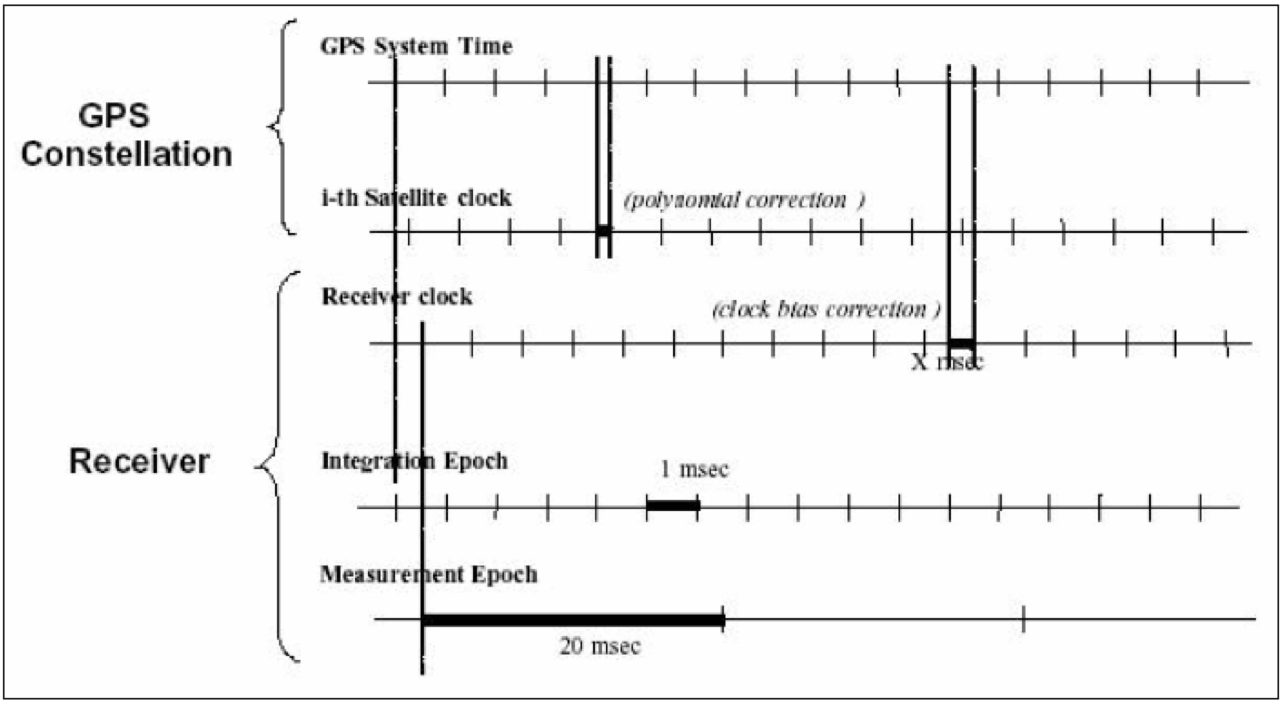

Figure 4- GPS Timing Reference

3.2.2 BASIC MEASUREMENT UNITS

3.2.2.1 GRAVITY (G)

The symbol for the average acceleration produced by gravity at the Earth's surface (sea level) is *g*. The actual acceleration of gravity varies from place to place, depending on latitude, altitude, and local geology. The symbol *g* is often used informally as a unit of acceleration.

3.2.2.2 GALILEO (GAL OR GAL)

The Gal unit is used in making measurements of local variations in the acceleration of gravity g. Variations in the acceleration of Earth's gravity (i.e. gravity anomalies) are typically measured in milligals (mGal). One Gal is approximately 0.0010197g, so a milligal (or mGal) is a very small acceleration, of about 10-6 g (or 10–5 m s-2). The mean Earth gravity is about 981 000 mGal (the well-known 9.81 m/s2), varies from 978,100 mGal to 983,200 mGal from Equator to pole due to the Earth's flattening and rotation. Variations, due to density inhomogeneities, mountain ridges, etc., range from tens to hundreds of milligals. The unit is named after the Italian astronomer and natural philosopher Galileo Galilei, who lived from 1564 until 1642. Galileo proved that all objects at the Earth's surface experience the same gravitational acceleration.

3.2.2.3 EÖTVÖS (E)

The Eötvös unit is used in geophysics to measure the rate of change, or gradient in the acceleration of gravity with horizontal distance. One Eötvös equals 10-7 Gal per metre or 10-4 Gal per kilometer. In proper SI units, the Eötvös unit equals 10-9 per second squared (s-2). The largest component is the vertical gravity gradient, being about 3000 E on Earth (gravity changes by 3.10-6m/s2 per metre of elevation). The horizontal components are approximately half this size; mixed gradients are below 100 E for the normal field. Gravity-gradient anomalies can be much larger and reach 1000 E in mountainous area. This unit is named after the Hungarian physicist Roland von Eötvös who lived from 1848 until 1919.

3.2.2.4 HERTZ (HZ)

Hertz is the SI unit of frequency, equal to one cycle per second. The hertz is used to measure the rates of events that happen periodically in a fixed and definite cycle. Multiples of the hertz are common: the frequencies of radio and television waves are measured in kilohertz (kHz), megahertz (MHz), or even gigahertz (GHz), and the frequencies of light waves in terahertz (THz). The unit is named after the German physicist Heinrich Rudolf Hertz (1857-1894), who proved in 1887 that energy is transmitted through a vacuum by electromagnetic waves.

3.3 Level 1b Products and Algorithms

The GOCE L1b products are:

- The **nominal SST product (file type SST_NOM_1b)**, containing the raw observables from GPS, corrections and orbit solutions. A complete description of this product is in Section 5.3.
- The **SST RINEX product (SST_RIN_1b)**, containing GPS raw measurements in RINEX format (see Section 5.4).
- The **nominal EGG product (EGG_NOM_1b)**, containing the raw measurements from the accelerometer, instrument-calibrated and corrected and the gravity gradients in the instrument reference frame (see Section 5.5).

In the following, the physical justification and the algorithm description for each of these products is detailed.

3.3.1 SATELLITE TO SATELLITE TRACKING INSTRUMENT (SSTI)

3.3.1.1 Physical justification

From the GPS receiver measurements, the orbit trajectory is computed to within ten meters accuracy. As the spacecraft is kept in an almost drag-free mode (at least along track and within an extended measurement bandwidth) the orbit motion is purely gravitational.
The SST technique uses satellites to track other satellites. The GPS receiver sees twelve or more GPS and GLONASS satellites at any time. Their ephemerides are determined very accurately by the large network of ground stations that participate in the International GPS Service (IGS). Taking their orbits and the SSTI GPS measurements, the GOCE orbit can be monitored to cm-precision in L2 processing, without interruption and in three dimensions.

3.3.1.2 Algorithm description

The on-ground processing flow is summarised in Figure 5.
The telemetry packets received from the satellite contain the raw measurements from the GPS Receiver and the orbit solution as computed from the on-board software.
These ordered time series include:

1. 6 (carrier) phase measurements data from 6 GPS satellites at L1;
2. 6 (carrier) phase measurements data from 6 GPS satellites at L2;
3. 6 (C/A code) pseudo-range measurements data from 6 GPS satellites at L1;
4. 6 (P code) pseudo-range measurements data from 6 GPS satellites at L1;
5. 6 (P code) pseudo-range measurements data from 6 GPS satellites at L2;
6. time tag (SSTI data) for the above data;
7. a raw-data-based navigation solution based on the above (code) measurements; the solution will be in the form of a vector containing at least:
   a) three position elements (x, y, z)
   b) three velocity elements $(\dot{x}, \dot{y}, \dot{z})$
   c) one time element, that is the clock bias, that provides the reference to UTC or GPS time

SSTI calibration parameters (inter-frequency and inter-channel biases) are computed) and GPS pseudo-ranges are corrected for inter-channel bias.

Both pseudo-ranges and carrier-phases are checked for outliers. The code measurements are also smoothed using a suitable order polynomial. For quality monitoring, the noise level of the code measurements is estimated from the difference between the unsmoothed observations and the smoothed ones. The filtering and outlier identification is carried out for each receiver channel and each type of observable separately (P1, P2, C/A code measurements and L1, L2 phase measurements).

For computing the satellite position, velocity and time (PVT):

- Both the raw (outliers free) or smoothed pseudo-range measurements can be used
- The light time correction and other relativistic effects are applied
- The effects of the ionosphere are considered, either by use of simultaneous measurements on L1 and L2 or by use IONEX global ionosphere maps.
- The absolute delay of the GOCE GPS receiver is considered
- Antenna offsets for both the GPS satellites and GOCE satellite are considered
- The satellite clock correction is applied
- The GOCE satellite attitude is considered
- GPS Precise orbit positions from IGS are collected and interpolated

Using all the above, the position, velocity and time of the GOCE satellite are derived by using a Least Square Fit algorithm. The solution is computed in the ITRF2000 **[RD- 2]**.

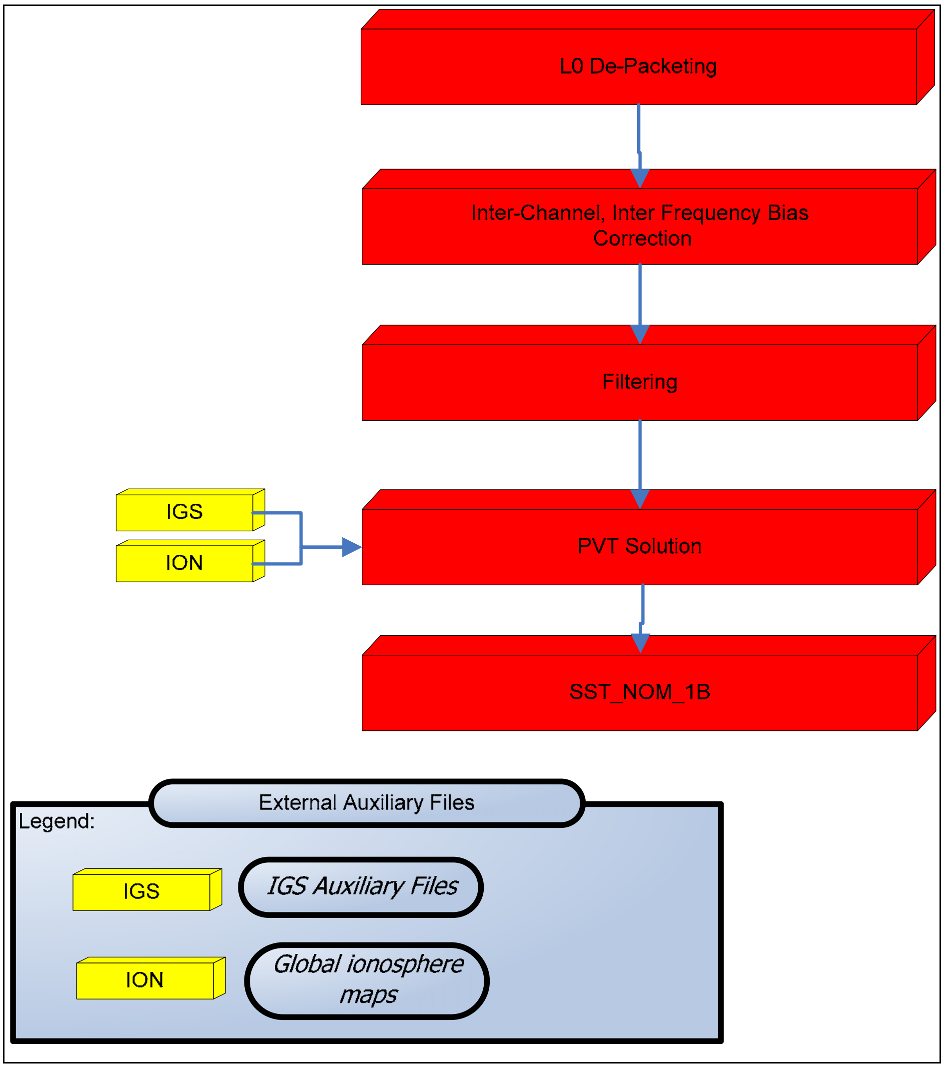

Figure 5- SST_NOM Algorithm overview

3.3.1.3 Products (SST_NOM_1b, SST_RIN_1b)

The **SST_NOM_1b** product is the nominal Level 1b product of the SSTI. It contains:

- Carrier phase and pseudorange measurements from TM packets
- On-board navigator solution
- Inter-frequency bias estimation results
- Carrier phase measurements IFB corrected
- Pseudorange measurements, ICB corrected
- Noise of pseudorange measurements
- Carrier phase measurements, flagged for cycle slips
- Pseudorange corrected for ICB, flagged for outliers
- Smoothed pseudorange

- Solution vector PVT
- GDOP,PDOP,TDOP
- Sigma on PVT elements
- Covariance matrix
- PVT solution sigma and residuals
- Time correlation measurements
- Position and Velocity of the GPS satellites used for the derivation of PVT
- Total number of the outliers in the P1,P2,C/A code and L1,L2 phase measurements

The SST_RIN_1b product **[RD- 4]** contains a subset of SST_NOM_1b data related to processed code and phase observations.

3.3.2 ELECTROSTATIC GRAVITY GRADIOMETER (EGG)

3.3.2.1 Physical justification

The principle of operation of the gradiometer relies on measuring the forces that maintain a 'proof mass' at the centre of a specially engineered 'cage'. Servo-controlled electrostatic suspension provides control of the 'proof mass' in terms of linear and rotational motion. Three pairs of identical accelerometers, which form three 'gradiometer arms', are mounted on the ultra-stable structure as depicted in Figure 6. The difference between accelerations measured by each pair of accelerometers is the basic gradiometric datum, where half the sum is proportional to the externally induced drag acceleration (common mode measurement). The three arms are mounted orthogonally to one another: one aligned with the satellite's trajectory, one perpendicular to the trajectory, and one pointing approximately towards centre of the Earth. The gradiometer baseline of each pair is about 50 cm. The approximate accelerometer precision is $2 \cdot 10^{-12} \frac{m}{s^2} \Big/ \sqrt{Hz}$ along US axis and $1 \cdot 10^{-10} \frac{m}{s^2} \Big/ \sqrt{Hz}$ along LS axis. Each accelerometer is three dimensional with two directions of highest precision and one axis slightly deteriorated. Ideally, the accelerometers of each pair should be perfect twins. Then all linear accelerations acting on the accelerometers would be perfectly removed when taking the difference between the readings of the two along the same axis.

By combining the differential accelerations, it is possible to derive the gravity gradient components as well as the perturbing angular accelerations

In reality, a common mode rejection ratio (CMRR) of 10^{-5} is attained here. The gradiometer will reach a precision of about 1-3 mE/Hz$^{1/2}$ over the measurement bandwidth ($5 \cdot 10^{-3}\,Hz$ - $0.1Hz$). Although the gradiometer is highly accurate, it is not possible to map the complete gravity field at all spatial scales with the same quality. To overcome this limitation the position of the GOCE satellite is tracked by GPS relative to GPS satellites at an altitude of 20 000 km - this procedure is known as satellite-to-satellite tracking. The gradiometer is used to measure high-resolution features of the gravity field whilst GPS is used to obtain low-resolution data.

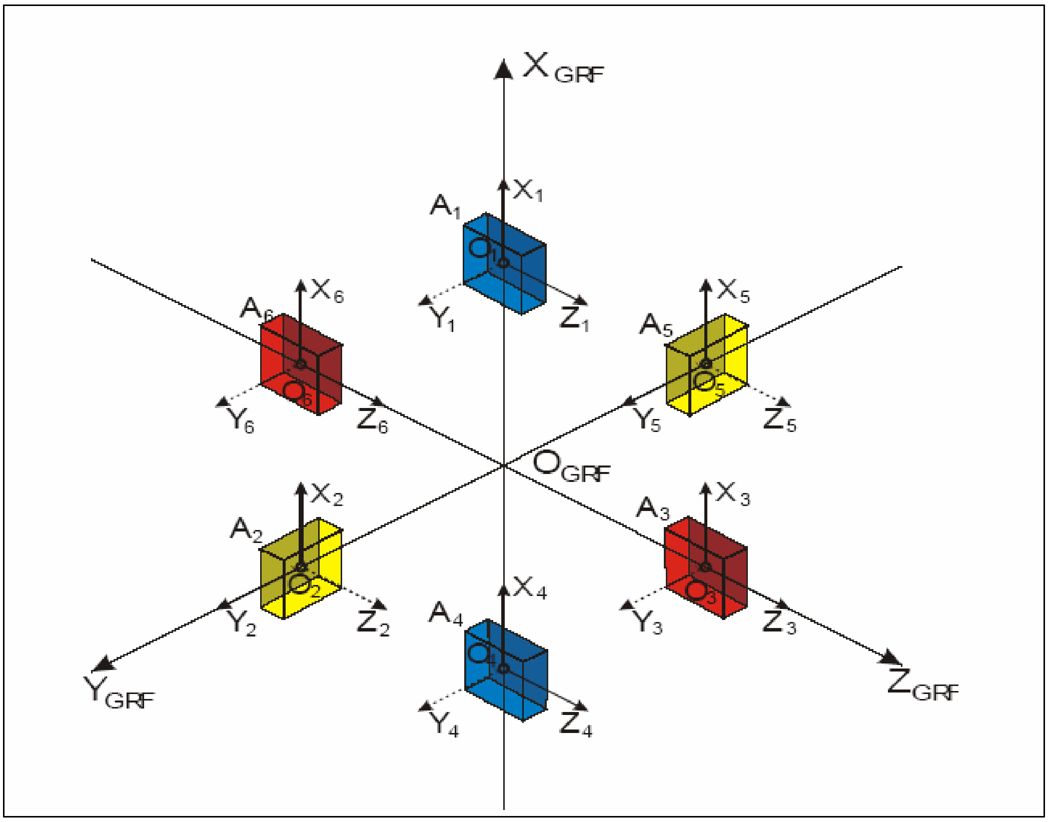

Figure 6- EGG Accelerometers Configuration

From the analytical point of view, gravity gradients are the second order derivatives $\partial^2 V/\partial x_i\, \partial x_j = V_{ij}$ of the gravitational potential V. They form a second-rank tensor with nine components:

$$V_{ij} = \begin{pmatrix} V_{xx} & V_{xy} & V_{xz} \\ V_{yx} & V_{yy} & V_{yz} \\ V_{zx} & V_{zy} & V_{zz} \end{pmatrix} \quad \text{(Eq- 1)}$$

This [3 x 3] matrix must be symmetrical (∇V is a curl-free vector field) and in empty space (density $\rho =$ 0) its trace must be zero (Laplace equation):

$$V_{xx} + V_{yy} + V_{zz} = 0 \qquad \text{(Eq- 2)}$$

Thus, in each point only five of the nine components are independent.
An accelerometer with three axes senses e.g. the acceleration:

$$a_i = -\partial V(0)/\partial x_i - V_{ij}(0)\, dx_j + \Omega_{ik}\, \Omega_{kj}\, dx_j + \dot{\Omega}_{ij}\, dx_j - b_i(0) \qquad \text{(Eq- 3)}$$

where $b_i(0)$ is the sum of all non-gravitational accelerations acting on the satellite along the i-axis at the centre of mass.

In the case of GOCE the gravity gradients are derived from the difference of the measured accelerations f_i along e.g. the i-axis of one couple A and B of the accelerometers, separated by a distance Δx_j along the j-axis of the diamond configuration. Then it is **[RD- 8]:**

$$\frac{a_i(B) - a_i(A)}{\Delta x_j} = \underline{\underline{\Gamma}}_{ij} = -\underline{\underline{V}}_{ij} + \underline{\underline{\Omega}}_{ik}\,\underline{\underline{\Omega}}_{kj} + \dot{\underline{\underline{\Omega}}}_{ij}. \quad \text{(Eq- 4)}$$

It is worth noting that the components V_{ij} are not observable directly but only their combination with two other terms. These two express the effect of centrifugal acceleration ($\Omega\Omega$) and angular acceleration ($\dot{\Omega}$). They are caused by the measurement in a moving frame fixed to the satellite. Closer inspection shows that $\Omega_{ik}\,\Omega_{kj}$ like V_{ij} is symmetric, whereas $\dot{\Omega}_{ij}$ is antisymmetric. It is in detail:

$$\Gamma_{ij} = \begin{pmatrix} V_{xx} - (\omega_y^2 + \omega_z^2) & V_{xy} + \omega_x\omega_y + \dot{\omega}_z & V_{xz} + \omega_z\omega_x - \dot{\omega}_y \\ V_{yx} + \omega_x\omega_y - \dot{\omega}_z & V_{yy} - (\omega_z^2 + \omega_x^2) & V_{yz} + \omega_z\omega_y + \dot{\omega}_x \\ V_{zx} + \omega_z\omega_x + \dot{\omega}_y & V_{zy} + \omega_y\omega_z - \dot{\omega}_x & V_{zz} - (\omega_x^2 + \omega_y^2) \end{pmatrix}$$

Thus, a separation into symmetric and antisymmetric part yields:

$$\frac{1}{2}(\Gamma_{ij} + \Gamma_{ji}) = V_{ij} + \Omega_{ik}\,\Omega_{kj} \quad \text{(Eq- 5)}$$

and:

$$\frac{1}{2}(\Gamma_{ij} - \Gamma_{ji}) = \dot{\Omega}_{ij} \quad \text{(Eq- 6)}$$

In addition, one finds:

$$trace\,\Gamma = \Gamma_{xx} + \Gamma_{yy} + \Gamma_{zz} = -2(\omega_x{}^2 + \omega_y{}^2 + \omega_z{}^2) = -2\omega^2. \quad \text{(Eq- 7)}$$

In the above one should keep in mind that ω_y, the angular velocity about a vector perpendicular to the orbital plane, is much greater than ω_x and ω_y. It represents the once-per-revolution rotation of the Earth pointing satellite: $\omega_y \gg \omega_x, \omega_z$.

By resuming the above considerations:

- Ideally, when differencing the accelerations a_i, all non-gravitational accelerations b_i (0) drop out, as well as the gravitational accelerations $\partial V(0)/\partial x_i$.

- The gravitational gradients cannot be sensed in isolation. They are mixed with centrifugal and angular acceleration terms.

- The angular accelerations can be isolated and, after integration and double integration, be employed for the angular control of the space-craft.

- One time-integration of the angular accelerations yields angular velocities which are used to isolate V_{ij} from $\Omega_{ik}\,\Omega_{kj}$.

- For GOCE, with one axis of each accelerometer weaker than the two others, the arrangement of the six 3-D accelerometers is chosen such as to permit precise determination of ω_y, whereas ω_x and ω_z are not determined as well. Consequently, only V_{xx}, V_{yy}, V_{zz} and V_{xz} can be reproduced with highest precision.

- The sum, i.e. the common mode accelerations $a_i\ (A)$ + $a_i\ (B)$, are a measure of the non-gravitational accelerations

$$a_i(A) + a_i(B) = -2\,b_i(0), \qquad \textit{(Eq- 8)}$$

  if the accelerometers are arranged symmetrically with respect to the centre of mass of the spacecraft, for then $\partial V(0)/\partial x_i \approx$. They are then employed for drag-free control (together with the GPS orbits).

3.3.2.2 Algorithm description

3.3.2.2.1 EGG Processing Description

For deriving the gravity gradients from the EGG accelerometers voltages, the following steps are undertaken:

Voltage to acceleration conversion: The control voltages applied to the eight electrodes surrounding each proof-mass are corrected from noise (gain attenuation and phase delay) and for the non-linearities introduced by transfer function of the digital filter. Then they are transformed in several sets of acceleration figures (linear acceleration and differential acceleration).

Proof Mass Acceleration Retrieval: The common-mode and differential acceleration of each accelerometer pair is transformed respectively into common-mode and differential acceleration of each accelerometer pair by applying the inverse calibration matrices (see Section 3.2.1).
The common-mode and the differential-mode accelerations for the OAG1 (accelerometer pair A_1, A_4), OAG2 (accelerometer pair A_2, A_5) and OAG3 (accelerometer pair A_3, A_6) are obtained as follows in below *(Eq- 9)*:

$$a'_{C,ijX} = \frac{1}{2}\left(a'_{i,X} + a'_{j,X}\right),\ a'_{C,ijY} = \frac{1}{2}\left(a'_{i,Y} + a'_{j,Y}\right),\ a'_{C,ijZ} = \frac{1}{2}\left(a'_{i,Z} + a'_{j,Z}\right),\ \ (\mathrm{ij} = 14{,}25{,}36)$$
$$a'_{d,ijX} = \frac{1}{2}\left(a'_{i,X} - a'_{j,X}\right),\ a'_{d,ijY} = \frac{1}{2}\left(a'_{i,Y} - a'_{j,Y}\right),\ a'_{d,ijZ} = \frac{1}{2}\left(a'_{i,Z} - a'_{j,Z}\right),\ \ (\mathrm{ij} = 14{,}25{,}36)$$

Where: $a_{C,ij,X/y/z}$ are the common mode accelerations (see *Eq-4*), $a_{d,ij,X/y/z}$ are the differential mode accelerations (see *Eq-8*) and $a^{'}_{i/j,X/y/z}$ are the single accelerations for each proof mass (see *Eq-3*).
From the differential-mode accelerations, the three angular accelerations of the Gradiometer (see 5.5.3.1.7) about the X, Y, Z axes of the GRF are obtained as follows in below equation:

$$\dot{\Omega}^{'}_{X} = -\frac{a^{'}_{d,36,Y}}{L_Z} + \frac{a^{'}_{d,25,Z}}{L_Y}, \quad \dot{\Omega}^{'}_{Y} = -\frac{a^{'}_{d,14,Z}}{L_X} + \frac{a^{'}_{d,36,X}}{L_Z}, \quad \dot{\Omega}^{'}_{Z} = -\frac{a^{'}_{d,25,X}}{L_Y} + \frac{a^{'}_{d,14,Y}}{L_X} \qquad (Eq\text{- }10)$$

Angular Rate Reconstruction: This step computes both the inertial angular rates of the Gradiometer in the GRF and the quaternion defining the attitude of the GRF in the IRF (see 5.5.3.1.11).
The fist step is to compute the inertial angular rates (ω_X, ω_Y, ω_Z) of the Gradiometer about the axes of the GRF, from the angular accelerations of the Gradiometer about the axes of the GRF and from the quaternions (q_1, q_2,q_3, q_4). Then, compute the quaternions ($q_{G,1}$, $q_{G,2}$, $q_{G,3}$, $q_{G,4}$) defining the attitude of the GRF in the Inertial Reference Frame.

The angular rate estimate is obtained merging the inertial angular acceleration (obtained from the Gradiometer measurements) and inertial attitude quaternion (measured by the star sensor) decimated at 1 Hz frequency, knowing the time delay ΔTSTR between the two time series.
The angular rate reconstruction process is based on the following considerations:

• Inside the Gradiometer measurement bandwidth (MBW: 5 to 100 mHz) the best available measures come from the Gradiometer itself. The attitude measurements from star tracker are too noisy, to be derived and used. So the angular rate reconstruction is obtained by proper integration of angular accelerations.
• For frequencies significantly below MBW, the gradiometer drifts are too large and the angular rate is obtained by "*derivation*" of the attitude measurements coming from star tracker.
• The equivalent hybridisation frequency is below the MBW and has different values for each axis.
• The star tracker noise must be attenuated in such way to results negligible with respect to Gradiometer noise inside MBW.

Inside bandwidth, the angular rate is reconstructed only by the numerical integration of angular acceleration measures. The attitude measures are used to recovery from angular rate initial value uncertainty, to compensate the effects of EGG low frequency noise, and to delete the drift of the numerical integration of angular accelerations.
These considerations are at the base of the following algorithm:

1. To reconstruct the angular rate uses as much as possible the measure coming from the EGG. These means:
    • to interpolate the acceleration values coming at 1Hz with an interpolator;
    • to solve in a closed form the integral of the interpolated signal in order to obtain the angular rate.
2. To correct the acceleration coming from the EGG using the star-tracker measures below a given frequency (named *hybridization frequency*) where the acceleration obtained deriving two times the attitude information is better than that obtained by EGG

Gravity Gradient Tensor Computation: The GGT computation algorithms will compute the 6 independent components of the GGT in the Gradiometer Reference Frame (GRF), from the calibrated differential-mode accelerations and from the reconstructed inertial angular rates of the Gradiometer about the axes of the GRF. The Figure 7 depicts the algorithm data-flow.
The 6 independent components of the GGT in the GRF are obtained as follows in *(Eq- 11)*:

$$U_{G,XX} = -2\frac{a_{d,14,X}}{L_X} - \omega_Y^2 - \omega_Z^2, U_{G,YY} = -2\frac{a_{d,25,X}}{L_Y} - \omega_X^2 - \omega_Z^2, U_{G,ZZ} = -2\frac{a_{d,36,Z}}{L_Z} - \omega_X^2 - \omega_Y^2$$

and:

$$U_{G,XY} = -\frac{a_{d,25,X}}{L_Y} - \frac{a_{d,14,Y}}{L_X} + \omega_X\omega_Y, U_{G,XZ} = -\frac{a_{d,14,Z}}{L_X} - \frac{a_{d,36,X}}{L_Z} + \omega_X\omega_Z$$

$$U_{G,YZ} = -\frac{a_{d,36,Y}}{L_Z} - \frac{a_{d,25,Z}}{L_Y} + \omega_Y\omega_Z$$

where: $a_{D,ij,X/y/z}$ are the differential mode accelerations (see *Eq-8*) and ω_i the angular rates.

The GGT transformation is implemented by computing the rotation matrix from the GRF to the Inertial Reference Frame from the Gradiometer inertial attitude quaternions. The following Figure 7 shows the GGT Tensor Computation Algorithms overview.

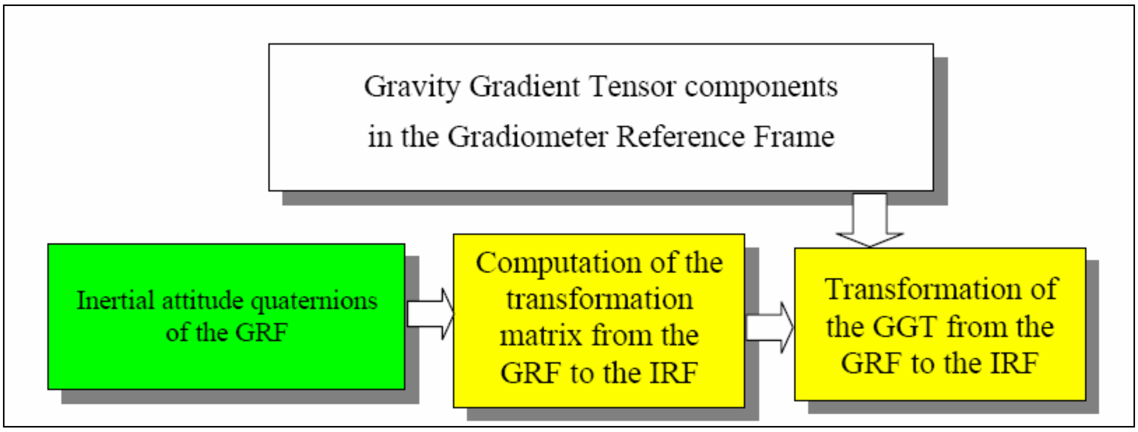

Figure 7- GGT Tensor Computation Algorithm overview

3.3.2.3 Products

The **EGG_NOM_1b** product is the nominal Level 1b product of the Gradiometer. It contains:

- EGG control Voltages
- EGG polarisation Voltages
- Nominal linear and angular accelerations
- Nominal common and differential accelerations

- Corrected Control Voltages
- Calibrated common and differential accelerations
- Calibrated angular accelerations
- Gradiometer angular rates
- Gradiometer inertial attitude quaternions
- Gravity gradient tensor GRF system
- Transformation matrix from GRF to IRF

4 THE GOCE INSTRUMENTS

4.1 EGG

4.1.1 Instrument Description

GOCE will employ a three-axis electrostatic gravity gradiometer (see Figure 8) that will allow gravity gradients to be measured in all spatial directions for the first time. It is designed specifically for determining the stationary gravity field. The measured signal is the difference in gravitational acceleration at the test-mass location inside the spacecraft caused by gravity anomalies from attracting masses of the Earth.

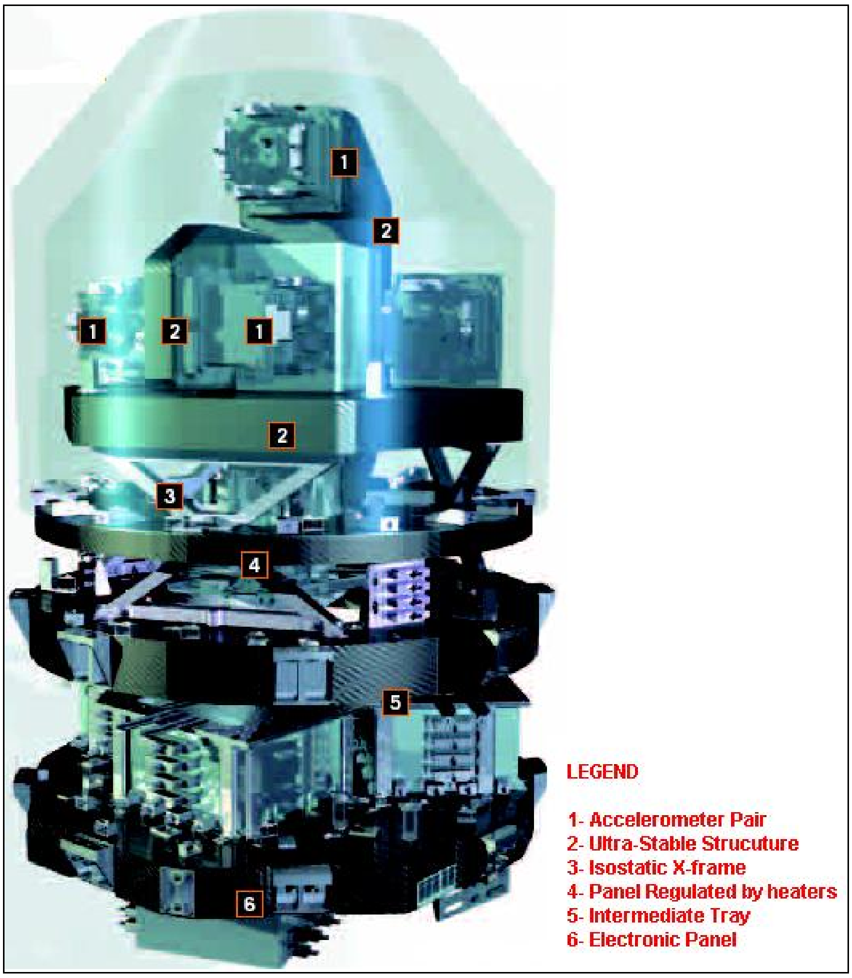

Figure 8 EGG Instrument excluding harness

4.1.2 INSTRUMENT CHARACTERISTICS AND PERFORMANCE

The three gradiometer arms are mounted orthogonally to one another one aligned with the satellite's trajectory, one perpendicular to the trajectory, and one pointing approximately towards centre of the Earth. The gradiometer baseline of each pair is about 50 cm.

The approximate accelerometer precision is $2 \cdot 10^{-12} \frac{m}{s^2} \Big/ \sqrt{Hz}$ along US axis and $1 \cdot 10^{-10} \frac{m}{s^2} \Big/ \sqrt{Hz}$ along LS axis. Each accelerometer is three dimensional with two directions of highest precision and one axis slightly deteriorated. Ideally, the accelerometers of each pair should be perfect twins.

The gradiometric performance is not only a function of the gradiometer but of the whole satellite and the environment, so the gradiometric budget includes all satellite and Level 0 to Level 1b processing errors. The specified GOCE gravimetric mission goal is to provide, after Level 0 and Level 1a/1b ground processing data that conform to the so-called 'trace' requirement. The trace (see *Eq.7*), or residual Earth gravity gradient tensor (GGT) measurement error should not exceed a pre-specified residual level within the measurement bandwidth (MBW = 5 mHz to 100 mHz) in the gradiometer reference frame (GRF) (for definition of the GRF refer to Section 3.2.1). The following Table 1 lists the EEG Instrument characteristics (see http://www.esa.int/esaLP/ESAHTK1VMOC_LPgoce_0.html).

Payload: Gravity gradiometry	
	Three-axis diagonal gradiometer based on three pairs of electrostatic servo-controlled accelerometers
Design Measurement Bandwidth (MBW)	$5 * 10^{-3}$ to 10-1 Hz.
Approximate Baseline length	0.5 m
Sensitivity (detection noise)	
Measurement bandwidth	< US axis precision approx. 2E-12m/s^2/sqrt(Hz); LS axis spec 1E-10 m/s^2/sqrt(Hz)
Extended bandwidth (10-5 to 1 Hz)	< US axis precision approx. 2E-12m/s^2/sqrt(Hz); LS axis spec 1E-10 m/s^2/sqrt(Hz)
Proof-mass positioning error	$6 * 10^{-8}$ m Hz-1/2
Absolute / relative scale factors	10^{-3} / 10-5
Absolute / relative misalignment	10^{-3} rad / 10-5 rad

Table 1 – EGG Instrument Characteristics

4.2 SST

4.2.1 INSTRUMENT DESCRIPTION

The principle of Satellite-to-Satellite Tracking provides knowledge of the precise (geodetic quality) position of the spacecraft measured relative to a constellation of reference satellites such as the US GPS system. This information is used to extract gravity information through orbit perturbation analysis. The technical specifications for the Receiver are:

- Multi-channel receiver with codeless tracking capability
- Dual frequency for compensation of ionospheric delays

4.2.2 INSTRUMENT CHARACTERISTICS AND PERFORMANCE

Reconstruction of the gravity field from the effect it has on the satellite trajectory requires the precise orbit determination (POD) from the 1 Hz satellite to satellite tracking instrument (SSTI) data. Orbit determination by the HPF is undertaken in two steps. First, the reference trajectory of the GOCE spacecraft, or Rapid Science Orbit (RSO) is determined using reduced dynamic (RD) and kinematic (KI) techniques, as part of the Quick-look (QL) processing within the HPF, and shall be accurate to a few decimeters. The GPS data, together with this reference orbit, will then subsequently be used in both reduced dynamic and kinematic techniques to determine the precise science orbit (PSO) with errors reduced to centimetre level.
Kinematic PO D does not need as input the non-conservative forces on the spacecraft, thus the achievable accuracy in the determination of the position of the satellite COM depends mainly on the following contributions:

- SSTI measurement noise
- SSTI ground station coordinates error
- SSTI ephemeris error
- Troposphere correction error
- Phase centre location error of the GPS antenna
- The error in the location of the spacecraft COM relative to the GPS antenna

For dynamic POD, errors on the measurement of the non-conservative linear accelerations of the satellite COM, and in the knowledge of the gravity field, must be added to the above list. The performance specifications for the SSTI measurements are:

- Carrier phase noise on L1 less than 0.001m
- Carrier phase noise on L2 less than 0.001m in the absence of anti-spoofing and less than 0.0049m in presence of anti-spoofing.
- C/A code pseudo-range noise on L1 less than 0.5m
- P(Y)-code pseudo-range noise on L1 and L2 less than 0.25m (in absence of antispoofing).

The requirement is 1.5 m in presence of anti-spoofing. The expected multi-path effect (due to signal reflection off the satellite structure prior to arrival at the GPS antenna) is less than 0.004 m, while the contribution of multi-path to the code error is expected to be lower than 0.15 m (RD3). All these requirements are applicable to GPS satellites above 15^o elevation, as seen by the GOCE spacecraft.

5 GOCE PRODUCTS FORMATS

5.1 Naming conventions

The name of the SST_NOM_1b and EGG_NOM_1b products follows the naming convention:

```
012345678901234567890123456789012345678901234567890123 4
GO_CCCC_TTTTTTTTTT_yyyymmdd_hhmmss_YYYYMMDD_HHMMSS_vvvv
```

where:

- GO is the Mission ID indicating "GOCE" (fixed string)
- CCCC is the File Class. Allowed values are:
  1. **OPER** for "Operational" files.
  2. **CONS** for consolidated files.
  3. **RPRO** for reprocessed files.
- TTTTTTTTTT is the File Type (10-characters)
- yyyymmdd_hhmmss is the start of the time interval covered by the file. It corresponds to the start of the retrieval time window specified in the request.
- YYYYMMDD_HHMMSS is the end of the time interval covered by the file. It corresponds to the end of the retrieval time window specified in the request.
- vvvv is the file version number. It starts from 0001 and increases by 1 every time a new version of the same file is generated.

The GPS Rinex file follows a different convention, which is compliant with the RINEX naming convention (see [RD-4])

```
012345678901
GOCEdddf.yyO
```

Where:

- ddd = day in year
- f = relative orbit number of the day
- yy = year
- O = file type, fixed, set to observation

5.2 General structure of GOCE L1b Products

The Level-1b files produced by the IPF subsystem are ASCII files structured following the Earth Explorer Standard. Each level-1 product is composed of:

- Earth Explorer Header
- Data Block

The Earth Explorer Header is composed of a Fixed Header plus a Variable Header containing:

- a Main Product Header (MPH)
- a Specific Product Header (SPH) which includes Data Set Descriptors for Reference external input files and Measurement Data of the Product

The Data Block contains meaningful instrument's data organized in Measurement Data Set (MDS).
The Figure 9 represents the general structure of an L1b product.

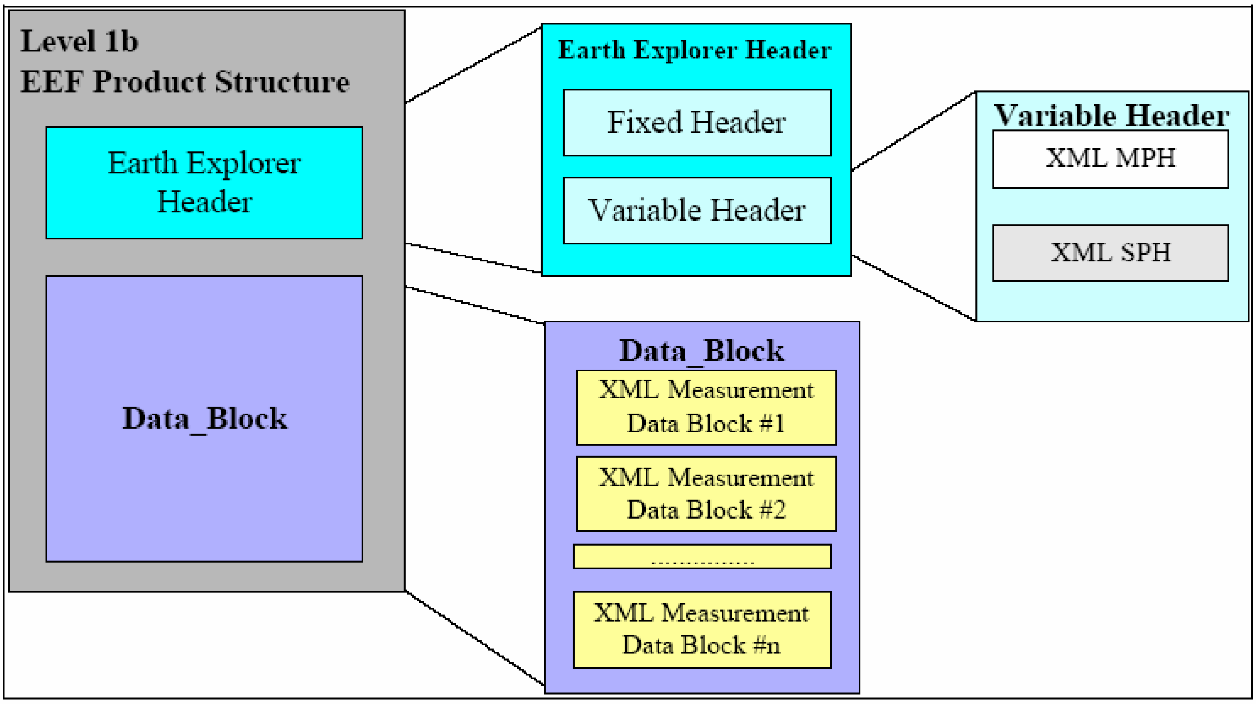

Figure 9 - - L1-b Files Structure

5.2.1 PRODUCT HEADER

5.2.1.1 Fixed Header (Standard GOCE Header)

The Standard GOCE Header is completely ASCII and based on XML syntax and conventions proposed in **[RD- 7]**.
The fixed header fields are specified in the following table. Note that the **format** string notation is:

`%[+][width][.precision]type`

Where '+' Forces to precede the result with a sign (+ or -) if signed type. (by default only - (minus) is printed), and type is one of the following:

d	*Signed decimal integer*

ud	Signed decimal integer (unsigned)
f	Decimal floating point
uf	Decimal floating point (unsigned)
c	Character
s	String of characters
uc	Unsigned Character

Field #	Description	Units	Format
#1	**File_Name**	Tag	
	Product File Name without the extension		55uc
#2	**File_Description**	Tag	
	This field shall contain a description of file product.		
#3	**Notes**	Tag	
	This field shall be always empty		
#4	**Mission**	Tag	
	This field shall be always GOCE		4uc
#5	**File_Class**	Tag	
	This field is part of the File Name and indicates the type of processing. Possible values are: OPER (for Routine Operations) TEST (for Test product) REPR (for Reprocessed product) CONS (for Consolidated product) LTA_ (for Long Term Archive product)		%s
#6	**File_Type**	Tag	
	This field is part of the File Name and shall correspond to one of the Product ID listed in Section 5.1		10uc
#7	**Validity_Period**	Tag	
#7.1	**Validity_Start**	Tag	
	This field correspond to: o Start Time of the nominal L1B product, in UTC format, referred to the predicted ANX time (this time is computed using the Earth Explorer library) o For the Calibration product, is the Start Time of the calibration activity o For the Auxiliary Level1b Product is the Start Time of the Auxiliary Level0		UTC=yyyy-mm-ddThh:mm:ss
#7.2	**Validity_Stop**	Tag	
	This field correspond to: o Stop Time of the nominal L1B product, in UTC format, referred to the predicted ANX+1 time (this time is computed using the Earth Explorer library) o For the Calibration product, is the Stop Time of the calibration activity o For the Auxiliary Level1b Product is the Stopt Time of the Auxiliary Level0		UTC=yyyy-mm-ddThh:mm:ss

#8	**File_Version**	Tag	
	This field is version number of the generation of the product. It shall start from 0001 and increased by one anytime the same product shall be regenerated		%4d
#9	**Source**	Tag	
#9.1	**System**	Tag	
	Name of the Ground Segment component creating the product. It shall be always set as: PDS		3uc
#9.2	**Creator**	Tag	
	Name of the Ground Segment tool creating the product. It shall be set as: IPF1		12uc
#9.3	**Creator_Version**	Tag	
	This field gives the version of the creator tool as **VV.rr**;		5uc
#9.4	**Creation_Date**	Tag	
	This field gives the UTC date of the generation of the file		UTC=yyyy-mm-ddThh:mm:ss

Table 2 Level 1b Fixed Haeder

5.2.1.2 Variable Header (Product Header)

5.2.1.3 XML Main Product Header (XML MPH)

Field #	Description	Units	Format
#01	**Product**	tag	
	Product File Name		See Section 5.1
#02	**Proc_Stage**	tag	
	Processing stage code: T = Test O = Operation R = Reprocessing C = Consolidation		%c
#03	**Ref_Doc**	tag	
	Reference Document describing the product		23*uc
#04	**Acquisition_Station**	tag	
	Acquisition Station ID		20*uc
#05	**Proc_Center**	tag	
	Processing Center ID code		PDS
#06	**Proc_Time**	tag	
	Processing Time (Product Generation Time)	UTC	UTC=yyyy-mm-ddThh:mm:ss.uuuuuu
#07	**Software_Ver**	tag	
	Processor name, up to 8 characters, and software version number followed by trailer blanks if any.		14*uc ProcessorName/V

			V.rr
#08	**Sensing_Start**	tag	
	UTC start time of data sensing. This is the UTC start time of the first measured record in the L1b product. This time is computed from the GPS time of the first measured record in the product For the Auxiliary File this time is the Start Time of the first record contained into the Auxiliary Level0 product		UTC=yyyy-mm-ddThh:mm:ss.uuuuuu
#09	**Sensing_Stop**	tag	
	UTC stop time of data sensing. This is the UTC stop time of the last measured record in the L1b product. This time is computed from the GPS time of the first measured record in the product For the Auxiliary File this time is the Stop Time of the last record contained into the Auxiliary Level0 product		UTC=yyyy-mm-ddThh:mm:ss.uuuuuu
#10	**Phase**	tag	
	Phase Code: phase letter (A, B, …) For GOCE always set to X		%c
#11	**Cycle**	tag	
	Cycle number. If not used set to 0000		%04d
#12	**Rel_Orbit**	tag	
	Relative Orbit Number at sensing start time. If not used set to 000000		%06d
#13	**Abs_Orbit**	tag	
	Absolute Orbit Number at sensing start time. If not used set to 000000		%06d
#14	**State_Vector_Time**	tag	
	UTC state vector time It is filled properly in case of usage of FOS Predicted Orbit information otherwise it shall be empty	UTC	UTC=yyyy-mm-ddThh:mm:ss.uuuuuu
#15	**X_Position**	tag	
	unit	m	
	X position in Earth Fixed Reference It is filled properly in case of usage of FOS Predicted Orbit information otherwise it shall be set to +0000000.000	m	%+012.3f
#16	**Y_Position**	tag	
	unit	m	
	Y position in Earth Fixed Reference It is filled properly in case of usage of FOS Predicted Orbit information otherwise it shall be set to +0000000.000	m	%+012.3f
#17	**Z_Position**	tag	
	unit	m	
	Z position in Earth Fixed Reference It is filled properly in case of usage of FOS Predicted Orbit information otherwise it shall be set to +0000000.000		%+012.3f
#18	**X_Velocity**	tag	
	unit	m/s	
	X velocity in Earth Fixed Reference It is filled properly in case of usage of FOS Predicted Orbit	m/s	%+012.6f

	information otherwise it shall be set to +0000.000000		
#19	**Y_Velocity**	tag	
	unit	m/s	
	Y velocity in Earth Fixed Reference It is filled properly in case of usage of FOS Predicted Orbit information otherwise it shall be set to +0000.000000		%+012.6f
#20	**Z_Velocity**	tag	
	unit	m/s	
	Z velocity in Earth Fixed Reference It is filled properly in case of usage of FOS Predicted Orbit information otherwise it shall be set to +0000.000000		%+012.6f
#21	**Vector_Source**	tag	
	Source of Orbit State Vector Record. It shall be set to FP (FOS Predicted) in case of usage of FOS Predicted Orbit information otherwise it shall be empty		2*uc
#22	**Product_Err**	tag	
	Product Error Flag set to 1 if errors have been reported in the product otherwise 0		%d
#23	**Tot_Size**	tag	
	Unit	bytes	
	Total size of the product		%021d
#24	**SPH_Size**	tag	
	Unit	bytes	
	Length of the SPH		%+011d
#25	**Num_DSD**	tag	
	Number of all Data Set Descriptors.		%+011d
#26	**DSD_Size**	tag	
	unit	bytes	
	Length of each DSD. For GOCE this field **must be empty**		%+011d
#27	**Num_Data_Sets**	tag	
	Number of attached Data Sets (note that not all the DSDs have a DS attached)		%+011d
#28	**CRC**	tag	
	Cyclic Redundancy Code computed as overall value of all records of the Measurement Data Set. If not computed it shall be set to -00001		%+06d

Table 3: XML MPH Description

5.2.1.4 XML Specific Product Header (SPH)

The Specific Product (SP) Header is an ASCII header. The SPH structure is as follows.

Field #	Description	Units	Format

#1	**SPH_Descriptor**	tag	
	ASCII string describing the product		28*uc Product ID Specific Header See Product ID in 5.2.1.4
#2	**Start _GPS_Time**	tag	
	GPS time of the first record in the Main MDS of the product Note: The time is represented as follow: 10 digits for seconds, 9 digits for nanoseconds separated by '.'	[s][ns]	%20.9uf
#3	**Stop_ GPS_Time**	tag	
	GPS time of the last record in in the Main MDS of the product Note: The time is represented as follow: 10 digits for seconds, 9 digits for nanoseconds separated by '.'	[s][ns]	%20.9uf
#4	**Abs_Orbit_Start**	tag	
	Absolute Orbit Number at Product Start Time		%06d
#5	**Rel_Time_Asc_Node_Start**	tag	
	unit	s	
	Relative time since crossing ascending node time relative to start time of data sensing	s	%011.6f
#6	**Abs_Orbit_Stop**	tag	
	Absolute Orbit Number at Product Stop Time		%06d
#7	**Rel_Time_Asc_Node_Stop**	tag	
	unit	s	
	Relative time since crossing ascending node time relative to stop time of data sensing		%011.6f
#8	**Equator_Cross_Time_Start**	tag	
	unit	[s][ns]	
	Time of Equator crossing at the ascending node of the sensing start time (GPS time) Note: The time is represented as follow: 10 digits for seconds, 9 digits for nanoseconds separated by '.'		%20.9uf
#9	**Equator_Cross_Time_Stop**	tag	
	unit	[s][ns]	
	Time of Equator crossing at the ascending node of the sensing stop time (GPS time) Note: The time is represented as follow: 10 digits for seconds, 9 digits for nanoseconds separated by '.'		%20.9uf
#10	**Equator_Cross_Long**	tag	

	unit	10-6degE	
	Longitude of Equator Crossing at the ascending node of the sensing start time (positive East, 0 = Greenwich) referred to WGS84		%+011d
#11	**Ascending_Flag**	tag	
	Orbit Orientation at the sensing start time A= Ascending D= Descending		uc
#12	**Start_Lat**	tag	
	unit	10-6degN	
	WGS84 latitude of the first record in the Main MDS (positive north)		%+011d
#13	**Start_Long**	tag	
	unit	10-6degE	
	WGS84 longitude of the first record in the Main MDS (positive East, 0 = Greenwich)		%+011d
#14	**Stop_Lat**	tag	
	unit	10-6degN	
	WGS84 latitude of the last record in the Main MDS (positive north)		%+011d
#15	**Stop_Long**	tag	
	unit	10-6degE	
	WGS84 longitude of the last record in the Main MDS (positive East, 0 = Greenwich)		%+011d
#16	**L0_Proc_Flag**	tag	
	Processing errors significance flag (1 or 0). 1 if the percentage of instrument packets free of processing errors is less than the acceptable threshold		uc
#17	**L0_Processing_Quality**	tag	
	unit	10-2%	
	Percentage of quality checks successfully passed during the SP processing (max allowed +10000)		%+06d
#18	**L0_Proc_Thresh**	tag	
	unit	10-2%	
	Minimum acceptable percentage of quality threshold that must be passed during SP processing (max allowed +10000)	[10-2 %]	%+06d
#19	**L0_Gaps_Flag**	tag	
	Gaps significance flag (1 or 0). 1 if gaps (either caused by extraction or alignment failures) were detected during the SP processing		%d
#20	**L0_Gaps_Num**	tag	

	Number of gaps detected during the SP processing (no gaps indicated as +0000000)		%+08d
#21	**Op_Mode**	tag	
	Operative Mode:		15*uc
#22	**L1b_Prod_Status**	tag	
	Complete/Incomplete Product Completion Flag (0 or 1). 1 if the Product is incomplete		%d
#23	**L1b_Proc_Flag**	tag	
	Processing errors significance flag (1 or 0). 1 if the percentage of Data Set Record (DSR) free of processing errors is less than the acceptable threshold		%d
#24	**L1b_Processing_Quality**	tag	
	unit	10-2%	
	Percentage of quality checks successfully passed during Level 1B processing (max allowed +10000)		%+06d
#25	**L1b_Proc_Thresh**	tag	
	unit	10-2%	
	Minimum acceptable percentage of quality threshold that must be passed during Level 1B processing (max allowed +10000)		%+06d
#26	**List_Of_K2Accelorometers**	tag	
	Counter		
#26.1	**K2Accelerometer**	tag	
#26.1.1	**Accel_Id**	tag	
	Identifier of the accelerometer under calibration Possible value 1÷6		%d
#26.1.2	**Axis**	tag	
	Axis under calibration Possible value : X,Y,Z		uc

Table 4: XML Specific Product Header description

The DSD Section contains information on Reference files and on Measurement Data Sets of the product. The ‘Summary Quality of DSR’ is filled only for the Measurement Data Sets. The general structure of a DSD is shown in Table 5

Field ID	Description	Units	Format
Field #	**List_of_DSDs**	tag	
27	**List_of_DSDs**	tag	
27.1	**DSD**		
27.1.1	**Data_Set_Name**	tag	
	Name describing the Data Set		28*uc
27.1.2	**Data_Set_Type**	tag	

	Type of Data Set. It can be: M = Measurement R = Reference		uc
27.1.3	**Filename**	tag	
	Name of the Reference File. Used if DS_TYPE is set to R.. The file name shall be without the extension		62*uc
27.1.4	**Num_DSR**	tag	
	Number of Data Set Records		%+011d
27.1.5	**MDS_Proc_Thresh** Minimum acceptable percentage of quality threshold that must be passed during the processing of the MDS	tag	%+06d
27.1.6	**Perc_Good_Record** Percentage of good record passed during the processing of the MDS	tag	%+06d

Table 5: Generic DSD Description

A variable number of DSDs will compose the SPH. Variability in fact depends most on the number of measurement data sets included into the Level 1b. For convenience Measurement DSDs (1 or more) appear first in the list, followed by the Reference DSDs.
For the Reference DSDs the possible Data_Set_Name are hereafter listed. For a given Data_Set_Name one or more Reference DSDs may be in the final layout of the DSD if more than one file was used to generate the product. Identification of the specific file will be possible through the field #N.3 FILENAME.

Data_Set_Name for Reference DSD (R)	
CONSTANTS_FILES	Constants File
PROC_CONFIG_PARAMS_FILE	Processor Configuration Parameters File
Level_0_file	EGG/SST/DFC/STR Attitude Error (GRF_LOR) LEVEL 0 nominal/Calibration File from which the product was created
SST_Level_1b_File	SSTI Nominal Level 1b File
SST_Auxiliary_L1b_file	SSTI Auxiliary File
Star_Tracker_L1b_file	Star Tracker Level 1b File
AUX_Level_0_File	Auxiliary Nominal Level0 File
Auxiliary_OBT_UTC_Correlation_file	Auxiliary OBT-UTC Time correlation File
EGG_Single_shaking_L1b_file	EGG proof-mass shaking Level0 Product
Inverse_Calibration_Matrix_file	EGG Inverse Calibration Level 1B File
EGG_Auxiliary_Database_file	EGG Auxiliary Database file
SST_Auxiliary_Database_file	SST Auxiliary Database file
Auxiliary_Calibration_K2_file	Auxiliary Quadratic factor file
Auxiliary_Predicted_Orbit_file	Auxiliary Predicted Orbit file
DFACS_L1b_file	DFCAS 1Hz Level1B File

Inter_channel_bias_calibration_file	ICB Level1b File
IONEX_file	Global Ionosphere Maps File
Antenna_Off_Sets_file	Antenna Off-sets of GPS Satellite
IGS_GPS_Precise_Orbits_Clocks_file	GPS Satellites positions and cloks given as IGS Rapid Orbits (sampling interval 15 minutes)
EGG_Monotoring_File	Moniroring Level1b
IGS_Station_Satellite_Clocks_file	Station and Satellite clocks (sampling interval 5 minutes)
IGS_ Satellite_Navigation_file	GPS Navigation messages

Table 6: Data Set Names for Reference DSDs

5.3 SST_NOM_1b

5.3.1 NAMING CONVENTION

The name of the L1b products follows the naming convention described in Section 5.1.

5.3.2 PRODUCT PACKAGING

The SST_NOM_1b product is distributed on a single physical file (extension EEF), tarred and gzipped. That is, the extension of the files delivered to users is .TGZ.

5.3.3 PRODUCT STRUCTURE

The high-level structure of this product is described in Section 5.2. The detailed description of the data block is described in the following paragraph.

5.3.3.1 Data Block

The Data Block contains the following data organized in Measurement Data Sets (see Figure 10). The following table reports all MDSs contained in the SST_NOM_1b product:

MDS Name	Description of contents
SST_RNG_1i	Carrier phase and pseudorange measurements from TM packets
SST_NAV_1i	On-board navigator solution
SST_IFB_1i	Inter-frequency bias estimation results
SST_CPM_1i	Carrier phase measurements IFB corrected
SST_PRM_1i	Pseudorange measurements, ICB corrected
SST_CPN_1i	Noise of pseudorange measurements
SST_CPF_1i	Carrier phase measurements, flagged for cycle slips (

SST_PRF_1i	Pseudorange corrected for ICB, flagged for outliers
SST_SRG_1i	Smoothed pseudorange
SST_POS_1i	Solution vector PVT
SST_GPT_1i	GDOP,PDOP,TDOP
SST_SIG_1i	Sigma on PVT elements
SST_COV_1i	Covariance matrix
SST_SRS_1i	PVT solution sigma and residuals
SST_TCT_1i	Time correlation measurements
SST_GPS_1i	Position and Velocity of the GPS satellites used for the derivation of PVT
SST_OUT_1i	Total number of the outliers in the P1,P2,C/A code and L1,L2 phase measurement

Table 7 – SST_NOM_1b product Measurement Data Set

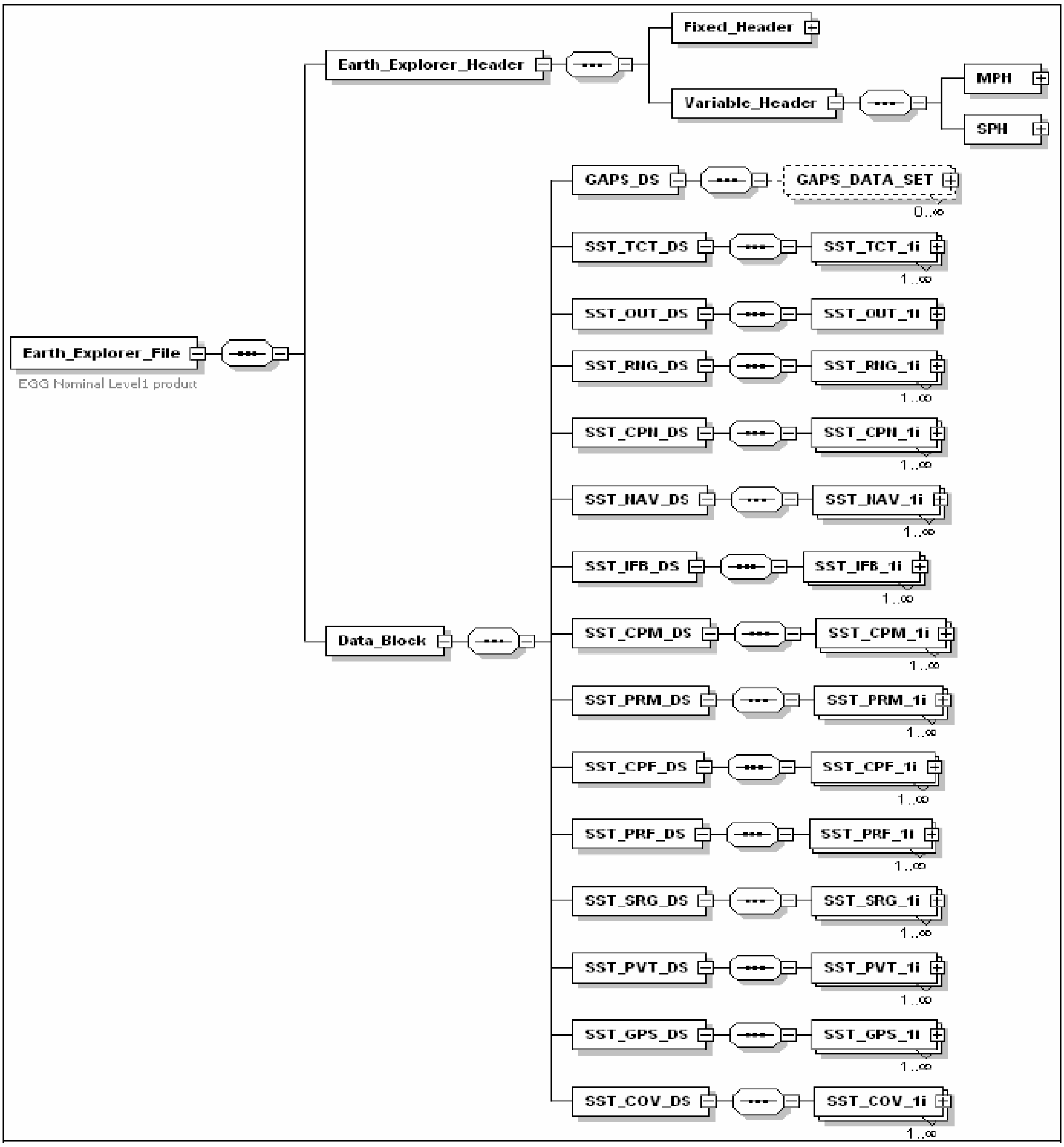

Figure 10- SST_NOM_1b Product XML Structure

5.3.3.1.1 GAPS Data Set

The GAPS Data Set contains the start and stop time of detected gaps. For Gaps that occur across the ANX, as in the picture below, the start time of the first gap will coincide with the ANX time (i.e. equal to the Start

Time of the product), for the gap across the ANX+1 the stop of the gap will be the ANX +1 time (i.e. equal to the Stop Time of the product).
The format is detailed in the following table.

Field	Description	Units	Type/Format
	GAPS DATA MDS (GAPS_DATA_SET)		
#1	**Missing_Line**	tag	
	Number of Missing lines for the first detected gaps Value from 1 to N		Int %3d
#2	**Start_Time**	tag	
	GPS Time of the last measured packet before the gap. In case the gap starts exactly at the ANX the gap start time is the ANXtime Note. The time is represented as follow: 10 digits for seconds, 9 digits for nanoseconds separated by '.'	[s][ns]	Int[2] %20.9uf
#3	**Stop_Time**	tag	
	GPS Time of the first measured packet after the gap. In case the gap stop exactly at the ANX+1 the gap stop time is the ANX+1 time. *Note:*The time is represented as follow: 10 digits for seconds, 9 digits for nanoseconds separated by '.'	[s][ns]	Int[2] %20.9uf
	Fields 1 from 3 are repeated for each detected gaps		

Table 8- SST *GAPS DATA MDS*

5.3.3.1.2 Time correlation Table MDS Record (SST_TCT_1i)

This MDS contains the OBT from the SST Level 0, the difference between receiver GPS time and OBT, GPS Time and a flag indicating how the TT_GPS is computed.
The detailed description of data records is reported in following table.

Field #	Description	Units	Type/Format
Time Correlation Table MDS (SST_TCT_1i)			
#1	**Tt_Obt**	tag	
	Time Tag in LOBT from the GOCE GPS receiver. Note: The time is represented as follow: 10 digits for seconds, 9 digits for nanoseconds separated by '.'	[s][ns]	Int[2] %20.9uf
#2	**Tt_Rx_GPS**	tag	
	Time Tag in GPS time as supplied by the GOCE GPS eceiver. This time has to be corrected for the receiver clock error derived during the PVT solution to get GPS system time. Note: The time is represented as follow: 10 digits for seconds, 9 digits for nanoseconds separated by '.'	[s][ns]	%20.9uf
#3	**Dif_Obt_GPS**	tag	
	Difference between OBT and GPS system time. To determine the difference, This difference is corrected with the estimated clock error of the PT solution to get the correct offset between OBT and GPS system time Note: The time is represented as follow: 10 digits for seconds, 9 digits for nanoseconds separated by '.'	[s][ns]	%20.9uf
#4	**Tt_GPS**	tag	
	Time Tag in GPS system time. This time is computed after PVT solution determination Note: The time is represented as follow: 10 digits for seconds, 9 digits for nanoseconds separated by '.'	[s][ns]	%20.9uf
#5	**UTC_Corr**	tag	
	UTC Time corrected for leap seconds	[s]	Double %20.9uf
#6	**Flag_Origin_GPS**	tag	
	Flag indicating the origin of Tt_GPS (This time is tagged in the [SST-DPM] document as Tt_GPS) GPS system time: 1 = from PVT solution 2 = from Navigation solution (RECV_CLKB_NAV) 3 = from AUX_0UTC 4 = no correction applied		%d
	Fields 1 ÷ 5 are repeated for all the measurements in the product		

Table 9- SST *Time Correlation Table MDS*

5.3.3.1.3 Outliers MDS Record (SST_OUT _1i)

This MDS contains the total number of outliers in the P1, P2, C/A code measurements and the L1, L2 phase measurements. The detailed description of data records is reported in following table.

Field #	Description	Units	Type/Format
Outliers (SST_OUT_1i)			
#1	**Enum_Cs_L1**	tag	
	Counter for the number of cycle slips in the phase measurements on L1 for current product		Int %5d
#2	**Enum_Cs_L2**	tag	
	Counter for the number of cycle slips in the phase measurements on L2 for current product		Int %5d
#3	**Enum_Ol_C_A**	tag	
	Counter for the number of outliers in the C/A Code for current product		Int %5d
#4	**Enum_Ol_P1**	tag	
	Counter for the number of outliers in the P Code on L1 for current product		Int %5d
#5	**Enum_Ol_P2**	tag	
	Counter for the number of outliers in the P Code on L2 for current product		Int %5d

Table 10- SST *Outliers MDS*

5.3.3.1.4 Carrier Phase and Pseudorange measurements MDS Record (SST_RNG _1i)

This MDS contains the phase and pseudorange measurements data from the GPS visible satellites obtained from the de-packing and sorting algorithm applied to the Level 0 product
The detailed description of data records is reported in following table.

Field	Description	Units	Type/Format
Carrier Phase & Pseudo-Range Measurements (SST_RNG_1i)			
#1	**Tt_GPS**	tag	
	Time Tag in GPS system time. This time is computed after PVT solution determination. Note: The time is represented as follow: 10 digits for seconds, 9 digits for nanoseconds separated by '.'	[s][ns]	Int[2] %20.9uf
#2	**N_Sv**	tag	
	Number of observed GPS satellites		Int %2d
#3	**Sv_Identifier**	tag	
	PRN-number of the observed satellites, the sequence of PRNs shall be consistent with the sequence of CHANNEL_ID so that the satellite with SV_IDENTIFIER[1] Is tracked on CHANNEL_ID[1]. Array of integer value, size = N_Sv. The values are separated by blank character		Int[N_Sv] %2d
#4	**Channel_Id**	Tag	
	Receiver channel numbers of the tracked satellites (Bits 5 to 2 of the Channel_ID field of the science telemetry) Array of integer values, size = N_SV. The values are separated by blank character		Int[N_Sv] %2d
#5	**Recv_Sig_Stat**	tag	
	Signal status of the corresponding receiver channel.		
#5.1	**TS0**	tag	
	L1 Code lock Set to 1 when L1CA code DLL is locked Array of integer value, size = N_Sv. The values are separated by blank character		Int[N_Sv] %d
#5.2	**TS1**	tag	
	L1 Carrier lock Set to 1 when L1CA carrier PLL is locked Array of integer value, size = N_Sv. The values are separated by blank character		Int[N_Sv] %d
#5.3	**TS2**	tag	
	Data Bit lock Set to 1 when data bit intervals have been located Array of integer value, size = N_Sv. The values are separated by blank character		Int[N_Sv] %d

#5.4	**TS3**	tag	
	L1 signal lock Set to 1 when L1 P code loop is locked Array of integer value, size = N_Sv. The values are separated by blank character		Int[N_Sv] %d
#5.5	**TS4**	tag	
	L2 signal lock Set to 1 when L2 Code and Carrier loops are locked Array of integer value, size = N_SV. The values are separated by blank character		Int[N_Sv] %d
#6	**Car_Phase**	tag	
	Phase measurement for all the satellite in visibility.	Cycles	Double[N_Sv] %17.6f
#6.1	**L1**	tag	
	Phase measurement at L1 for all the satellites in vsibility Array of double value, size = N_Sv. The values are separated by blank character		Double[N_Sv] %17.6f
#6.2	**L2**	tag	
	Phase measurement at L2 for all the satellites in visibility Array of double value, size = N_SV. The values are separated by blank character		Double[N_Sv] %17.6f
#7	**Pseudo_Range**	tag	
	Pseudorange	m	
#7.1	**CA**	tag	
	Pseudo-range C/A code at L1 for all the satellites in visibility. Array of double value, size = N_Sv. The values are separated by blank character		Double[N_Sv] %17.6f
#7.2	**L1**	tag	
	Pseudorange P code at L1 for all the satellites in visibility. Array of double value, size = N_Sv. The values are separated by blank character		Double[N_Sv] %17.6f
#7.3	**L2**	tag	
	Pseudorange P code at L2 for all the satellites in visibility. Array of double value, size = N_Sv. The values are separated by blank character		Double[N_Sv] %17.6f
#8	**Synch_Pulse**	tag	

	Status of sinch pulse This value reprents the status of Synch Pulse extracted by the SST_NOM_0_		Int %3d
#9	**Channel_Stat**	tag	
	Channel Status Array of integer value, size = N_Sv. The values are separated by blank character This array contains the values stored into the Channel_status (one byte) extracted by the Level 0 product, for each satellite in visibility.		Int[N_Sv] %3d
#10	**Inst_Dopp**	tag	
	Instantaneous Doppler measurements Array of double value, size = N_Sv. The values are separated by blank character	Hz	Double[N_Sv] %17.6f
#11	**Sig_Stat_Full**	tag	
	Total content of the signal status byte from the SST_NOM_0. It is used in the CMF for monitoring Array of integer value, size = N_Sv. The values are separated by blank character This array contains the values stored into the Signal status (one byte) as extracted by the Level 0 product, for each satellite in visibility.		Int[N_Sv] %3d
#12	**Channel_Id_Full**	tag	
	Total content of the channel id byte from the SST_NOM_0. It is used in the CMF for monitoring Array of integer value, size = N_Sv. The values are separated by blank character		Int[N_Sv] %3d

Table 11- SST *Carrier Phase & Pseudo-Range Measurements*

5.3.3.1.5 Noise measurement MDS Record (SST_CPN_1i

This MDS contains the noise of carrier phase and pseudorange measurements for the L1 and L2 and C/A channel. The detailed description of data records is reported in following table.

Field **#**	**Description**	**Units**	**Type/Format**
Code/Phase Noise (SST_CPN_1i)			
#1	**Tt_GPS**		

	Time Tag in GPS system time. This time is computed after PVT solution determination. Note: The time is represented as follow: 10 digits for seconds, 9 digits for nanoseconds separated by '.'	[s][ns]	Int[2] %20.9uf
#2	**N_Sv**	tag	
	Number of GPS satellites on visibility		Int %2d
#3	**Sv_Identifier**	tag	
	PRN-number of the observed satellites, the order shall be consistent with the receiver channels, so that the first satellite with SV_IDENTIFIER[1] is tracked on receiver channel 1, satellite with SV_IDENTIFIER[2] on channel 2 and so on. Array of integer values, size =N_Sv The values are separated by blank character.		Int[N_Sv] %2d
#4	**Noise_Prm**	tag	
	Noise on Pseudo-Range-Measurements for all the GPS satellites in visibility	m	
#4.1	**CA**	tag	
	Noise of the C/A-Code Pseudo-Range-Measurements for the N_Sv GPS satellites Array of double values, size =N_Sv The values are separated by blank character		Double[N_Sv] %17.6f
#4.2	**L1**	tag	
	Noise of the Pseudo-Range Measurements (P-Code) for all GPS satellites at L1. Array of double values, size =N_Sv The values are separated by blank character		Double[N_Sv] %17.6f
#4.3	**L2**	tag	
	Noise of the Pseudo-Range Measurements (P-Code) for all the first GPS satellites at L2 Array of double values, size =N_Sv The values are separated by blank character		Double[N_Sv] %17.6f

Table 12- SST *Code/Phase Noise MDS*

5.3.3.1.6 Navigator data MDS Record (SST_NAV_1i)

This MDS contains the on-board navigation solution data. The detailed description of data records is reported in following table.

Field #	Description	Units	Type/Format
Navigation Solution data (SST_NAV_1i)			
#1	**Tt_GPS**	tag	
	Time Tag in GPS system time. This time is computed after PVT solution determination. Note: The time is represented as follow: 10 digits for seconds, 9 digits for nanoseconds separated by '.'	[s][ns]	Int[2] %20.9uf
#2	**Recv_Sol_Type**	tag	
	Solution type: 0=SPS 1=NKF		%c
#3	**Pos_Nav**	tag	
	Position of the GOCE satellite based on the raw-data navigation solution OR the Kalman filtered navigation solution of the Receiver		
#3.1	**X**	tag	
	X position element	m	Double %+17.6f
#3.2	**Y**	tag	
	Y position element	m	Double %+17.6f
#3.3	**Z**	tag	
	Z position element	m	Double %+17.6f
#4	**Vel_Nav**	tag	

	Velocity of the GOCE satellite based on the raw-data navigation solution OR the Kalman-filtered navigation solution of the Receiver		
#4.1	**X**	tag	
	X velocity element	m/s	Double %+17.6f
#4.2	**Y**	tag	
	X velocity element	m/s	Double %+17.6f
#4.3	**Z**	tag	
	Z velocity element	m/s	Double %+17.6f
#5	**Recv_Clkb_Nav**	tag	
	Clock bias of the GOCE GPS receiver with respect to GPS time, derived within the on-bard navigation solution	m	Double %+17.6f

Table 13- SST *Navigation Solution data MDS*

5.3.3.1.7 Inter-Freq. Bias estimation results MDS Record (SST_IFB_1i)

This MDS contains the Inter-frequency bias as a function of the temperature. The detailed description of data records is reported in following table.

Field	Description	Units	Type/Format
Inter Frequency Bias estimation (SST_IFB_1i)			
#1	**Tt_GPS**	tag	
	Time Tag in GPS system time. This time is computed after PVT solution determination. Note: The time is represented as follow: 10 digits for seconds, 9 digits for nanoseconds separated by '.'	[s][ns]	Int[2] %20.9uf
#2	**Ifb_Corr**	tag	
	IFB correction as applied to the L2 phase measurements	Cycles	Double %20.9uf

Table 14- SST *Inter Frequency Bias estimation*

5.3.3.1.8 Carrier Phase Measur., Inter-Freq. Bias Corrected MDS Record (SST_CPM _1i)

This MDS contains the carrier phase measurements corrected for inter-frequency bias. The detailed description of data records is reported in following table.

Field #	Description	Units	Type/Format
Carrier Phase IFB Corrected (SST_CPM_1i)			
#1	**Tt_GPS**	tag	
	Time Tag in GPS system time. This time is computed after PVT solution determination. Note: The time is represented as follow: 10 digits for seconds, 9 digits for nanoseconds separated by '.'	[s][ns]	Int[2] %20.9uf
#2	**N_Sv**	tag	
	Number of satellites in visibility		Int %2d
#3	**Sv_Identifier**	tag	
	PRN-number of the observed satellites, the sequence of PRNs shall be consistent with the sequence of CHANNEL_ID so that The satellite with SV_IDENTIFIER[1] Is tracked on CHANNEL_ID[1] Array of integer values, size =N_Sv The values are separated by blank character		Int[N_Sv] %2d
#4	**Channel_Id**	tag	
	Receiver channel numbers of the tracked satellites (Bits 5 to 2 of the Channel_ID field of the science telemetry) Array of integer values, size = N_SV. The values are separated by blank character.		Int[N_Sv] %2d
#5	**Recv_Sig_Stat**	tag	

	Signal status of the corresponding receiver channel		
#5.1	**TS0**	tag	
	L1 Code lock Set to 1 when L1CA code DLL is locked Array of double values, size =N_SV The values are separated by blank character		Int[N_Sv] %d
#5.2	**TS1**	tag	
	L1 Carrier lock Set to 1 when L1CA carrier PLL is locked Array of double values, size =N_Sv The values are separated by blank character		Int[N_Sv] %d
#5.3	**TS2**	tag	
	Data Bit lock Set to 1 when data bit intervals have been located Array of double values, size =N_Sv The values are separated by blank character		Int[N_Sv] %d
#5.4	**TS3**	tag	
	L1 signal lock Set to 1 when L1 P code loop is locked Array of double values, size =N_Sv The values are separated by blank character		Int[N_Sv] %d
#5.5	**TS4**	tag	

	L2 signal lock Set to 1 when L2 Code and Carrier loops are locked Array of double values, size =N_Sv The values are separated by blank character		Int[N_Sv] %d
#6	**Corr_Phase**	tag	
	Carrier Phase measurement corrected for inter-frequency bias for all the satellites on visibility	Cycles	
#6.1	**L1**	tag	
	Corrected Carrier Phase measurement at L1 for all the satellites in visibility Array of double values, size= N_Sv. The values are separated by blank character		Double[N_Sv] %17.6f
#6.2	**L2**	tag	
	Carrier Phase measurement at L2 corrected for inter-channel bias for all the satellites on visibility. Array of double values, size= N_Sv. The values are separated by blank character		Double[N_Sv] %17.6f

Table 15- ***Carrier Phase IFB Corrected***

5.3.3.1.9 Pseudorange Measur., Inter Channel Bias Corrected MDS Record (SST_PRM _1i)

This MDS collect the pseudorange values corrected by ICB. The detailed description of data records is reported in following table.

Field **#**	**Description**	**Units**	**Type/Format**
Pseudo-Range measurements, Inter Channel Bias Corrected (SST_PRM_1i)			
#1	**Tt_GPS**	tag	

	Time Tag in GPS system time. This time is computed after PVT solution determination. Note: The time is represented as follow: 10 digits for seconds, 9 digits for nanoseconds separated by '.'	[s][ns]	Int[2] %20.9uf
#2	**N_Sv**	tag	
	Number of satellites in visibility		Int %2d
#3	**Sv_Identifier**	tag	
	PRN-number of the observed satellites, the sequence of PRNs shall be consistent with the sequence of CHANNEL_ID so that The satellite with SV_IDENTIFIER[1] Is tracked on CHANNEL_ID[1] Array of integer value, size = N_Sv. Values are separated by blank character		Int[N_Sv] %2d
#4	**Channel_Id**	tag	
	Receiver channel numbers of the tracked satellites (Bits 5 to 2 of the Channel_ID field of the science telemetry) Array of integer values, size = N_Sv Values are separated by blank character		Int[N_Sv] %2d
#5	**Recv_Sig_Stat**	tag	
	Signal status of the corresponding receiver channel for all the satellites in visibility		
#5.1	**TS0**	tag	
	L1 Code lock Set to 1 when L1CA code DLL is locked Array of integer values, size = N_Sv Values are separated by blank character		Int[N_Sv] %d

#5.2	**TS1**	tag	
	L1 Carrier lock Set to 1 when L1CA carrier PLL is locked Array of integer values, size = N_Sv Values are separated by blank character		Int[N_Sv] %d
#5.3	**TS2**	tag	
	Data Bit lock Set to 1 when data bit intervals have been located Array of integer values, size = N_Sv Values are separated by blank character		Int[N_Sv] %d
#5.4	**TS3**	tag	
	L1 signal lock Set to 1 when L1 P code loop is locked Array of integer values, size = N_Sv Values are separated by blank character		Int[N_Sv] %d
#5.5	**TS4**	tag	
	L2 signal lock Set to 1 when L2 Code and Carrier loops are locked Array of integer values, size = N_Sv Values are separated by blank character		Int[N_Sv] %d
#6	**Corr_Pseudo_Range**	tag	
	Pseudorane measurement corrected for inter-channel bias for all the Satellites in visibility	m	
#6.1	**CA**	tag	

	C/A code Pseudorange measurement corrected for inter-channel bias Array of double values, size = N_Sv Values are separated by blank character		Double[N_Sv] %+17.6f
#6.2	**L1**	tag	
	Pseudorane measurement on L1 corrected for inter-channel bias Array of double values, size = N_Sv Values are separated by blank character		Double[N_Sv] %+17.6f
#6.3	**L2**	tag	
	Pseudorange measurement on L2 corrected for inter-channel bias. Array of double values, size = N_Sv Values are separated by blank character		Double[N_Sv] %+17.6f

Table 16- SST Pseudo-Range measurements, Inter Channel Bias Corrected

5.3.3.1.10 Carrier Phase measurement flagged for cycle slips MDS Record (SST_CPF _1i)

This MDS contains the values of the carrier phase measurements corrected for inter-frequency bias flagged for occurrence of cycle slips.
The detailed description of data records is reported in following table.

Field	Description	Units	Format
Carrier Phase measurements flagged for cycle slips (SST_CPF _1i)			
#1	**Tt_GPS**	tag	
	Time Tag in GPS receiver time (is the time related to CPM_CORR_L1, CPM_CORR_L2 measurements) Note: The time is represented as follow: 10 digits for seconds, 9 digits for nanoseconds separated by '.'	[s][ns]	Int[2] %20.9uf
#2	**N_Sv**	tag	
	Number of observed GPS satellites		%2d
#3	**Sv_Identifier**	tag	

	PRN-number of the observed satellites, the sequence of PRNs shall be consistent with the sequence of CHANNEL_ID so that The satellite with SV_IDENTIFIER[1] Is tracked on CHANNEL_ID[1] Array of integer value, size = N_Sv Values are separated by blank character		Int[N_Sv] %2d
#4	**Channel_Id**	tag	
	Receiver channel numbers of the tracked satellites (Bits 5 to 2 of the Channel_ID field of the science telemetry) Array of integer value, size = N_Sv Values are separated by blank character		Int[N_Sv] %2d
#5	**Corr_Phase**	tag	
	Carrier Phase measurement IFB corrected	Cycles	
#5.1	**L1**	tag	
	Carrier Phase Measurements from all GPS satellites at L1, corrected for inter-frequency bias. Array of double values, size = N_Sv Values are separated by blank character		Double[N_Sv] %+17.6f
#5.2	**L2**	tag	
	Carrier Phase Measurements from all GPS satellites at L2, corrected for inter-frequency bias Array of double values, size = N_Sv Values are separated by blank character		Double[N_Sv] %+17.6f
#6	**Flag**	tag	
	Flag for cycle slip occurred on L1/L2, set to 1 if measurement at considered epoch is identified as an outlier otherwise set to 0.		
#6.1	**L1**	tag	
	Flag for cycle slip occurred on L1. Array of integer values, size = N_Sv Values are separated by blank character		Int[N_Sv] %d

#6.2	**L2**	tag	
	Flag for cycle slip occurred on L2. Array of integer values, size = N_Sv Values are separated by blank character		Int[N_Sv] %d

Table 17- SST *Carrier Phase measurements flagged for cycle slips MDS*

5.3.3.1.11 Pseudorange measurement flagged for outliers MDS Record (SST_PRF _1i)

This MDS is generated after the filtering and outliers function. It contains the values of pseudorange flagged for outliers.
The detailed description of data records is reported in following table.

Field #	Description	Units	Type/Format
Smoothed pseudorange measurements (SST_PRF _1i)			
#1	**Tt_GPS**	tag	
	Time Tag in GPS receiver time (is the time related to PRM_CORR_C_A, PRM_L1, PRM_L2 measurements) Note: The time is represented as follow: 10 digits for seconds, 9 digits for nanoseconds separated by '.'	[s][ns]	Int[2] %20.9uf
#2	**N_Sv**	tag	
	Number of observed GPS satellites		Int %2d
#3	**Sv_Identifier**	tag	
	PRN-number of the observed satellites, the sequence of PRNs shall be consistent with the sequence of CHANNEL_ID so that The satellite with SV_IDENTIFIER[1] Is tracked on CHANNEL_ID[1] Array of integer values, size = N_Sv Values are separated by blank character		Int[N_Sv] %2d
#4	**Channel_Id**	tag	

	Receiver channel numbers of the tracked satellites (Bits 5 to 2 of the Channel_ID field of the science telemetry) Array of integer values, size = N_Sv Values are separated by blank character		Int[N_Sv] %2d
#5	**Corr_Pseudo_Range**	tag	
	Pseudo-Range-Measurements from the all GPS satellites, corrected for the inter-channel bias	m	
#5.1	**CA**	tag	
	C/A-Code Pseudo-Range Measurements at L1 corrected for the inter-channel bias. Array of double values, size = N_Sv Values are separated by blank character		Double[N_Sv] %+17.6f
#5.2	**L1**	tag	
	Pseudo-Range Measurements (P-Code) from all GPS satellites at L1, corrected for the inter-channel bias Array of double values, size = N_Sv Values are separated by blank character		Double[N_Sv] %+17.6f
#5.3	**L2**	tag	
	Smoothed Pseudo-Range Measurements (P-Code) from all GPS satellites at L2, corrected for the inter-channel bias Array of double values, size = N_Sv Values are separated by blank character		Double[N_Sv] %17.6f
#6	**Flag**	tag	
	Flag for outlier for all GPS satellietes		
#6.1	**CA**	tag	
	Flag for outlier in P code on C/A code, set to 1 if measurements at considered epoch are identified as an outlier otherwise set to 0. Array of integer values, size=N_Sv Values are separated by blank character		Int[N_Sv] %d
#6.2	**L1**	tag	

	Flag for outlier in P code on L1, set to 1 if measurements at considered epoch are identified as an outlier otherwise set to 0. Array of integer values, size=N_Sv Values are separated by blank character		Int[N_Sv] %d
#6.3	**L2**	tag	
	Flag for outlier in P code on L2, set to 1 if measurements at considered epoch are identified as an outlier otherwise set to 0. Array of integer values, size=N_Sv Values are separated by blank character		Int[N_Sv] %d

Table 18-SST *Smoothed pseudorange measurements MDS*

5.3.3.1.12 Smoothed Pseudorange MDS Record (SST_SRG _1i)

This MDS is generated after the filtering and outliers function. It contains the values of the smoothed pseudorange.
The detailed description of data records is reported in following table.

Field	Description	Units	Type/Format
Smoothed pseudorange measurements (SST_SRG _1i)			
#1	**Tt_GPS**	tag	
	Time Tag in GPS system time Note: The time is represented as follow: 10 digits for seconds, 9 digits for nanoseconds separated by '.'	[s][ns]	Int[2] %20.9uf
#2	**N_Sv**	tag	
	Number of observed GPS satellites		Int %2d
#3	**Sv_Identifier**	tag	
	PRN-number of the observed satellites, the sequence of PRNs shall be consistent with the sequence of CHANNEL_ID so that The satellite with SV_IDENTIFIER[1] Is tracked on CHANNEL_ID[1] Array of integer values, size = N_Sv Values are separated by blank character		Int[N_Sv] %2d
#4	**Channel_Id**	tag	

	Receiver channel numbers of the tracked satellites (Bits 5 to 2 of the Channel_ID field of the science telemetry) Array of integer values, size = N_SV Values are separated by blank character		Int[N_Sv] %2d
#5	**Sm_Pseudo_Range**	tag	
	Smoothed Pseudo-Range Measurements from all GPS satellite, corrected for the inter-channel bias	m	
#5.1	**CA**	tag	
	Smoothed C/A-Code Pseudo-Range-Measurements at L1 from all GPS satellite, corrected for the inter-channel bias Array of double values, size = N_Sv Values are separated by blank character		Double[N_Sv] %17.6f
#5.2	**L1**	tag	
	Smoothed Pseudo-Range Measurements (P-Code) from first GPS satellite at L1, corrected for the inter-channel bias Array of double values, size = N_Sv Values are separated by blank character		Double[N_Sv] %17.6f
#5.3	**L2**	tag	
	Smoothed Pseudo-Range Measurements (P-Code) from first GPS satellites at L2, corrected for the inter-channel bias Array of double values, size = N_Sv Values are separated by blank character		Double[N_Sv] %17.6f
#6	**Flag**	tag	
	Flag for outlier for all GPS satellietes		
#6.1	**CA**	tag	
	Flag for outlier in P code on C/A code, set to 1 if measurements at considered epoch are identified as an outlier otherwise set to 0. Array of integer values, size=N_Sv Values are separated by blank character		Int[N_Sv] %d
#6.2	**L1**	tag	

	Flag for outlier in P code on L1, set to 1 if measurements at considered epoch are identified as an outlier otherwise set to 0. Array of integer values, size=N_Sv Values are separated by blank character		Int[N_Sv] %d
#6.3	**L2**	tag	
	Flag for outlier in P code on L2, set to 1 if measurements at considered epoch are identified as an outlier otherwise set to 0. Array of integer values, size=N_Sv Values are separated by blank character		Int[N_Sv] %d

Table 19- SST *SRG MDS*

5.3.3.1.13 Solution vector PVT, MDS Record (SST_POS_1i, SST_SRS_1i, SST_SIG_1i and SST_GPT_1i)

This MDS contains the PVT solution in ITRF2000, the sigma on the PT solution, the Residuals and the GDOP,PDOP and TDOP values. The SST_POS_1i , SST_SRS_1i , SST_SIG_1i, and SST GPT_1i are grouped in one MDS record SST_PVT_1i.
The detailed description of data records is reported in following table.

Field **#**	**Description**	**Units**	**Type/Format**
SST_PVT_1i *PVT solution ,sigma & GDOP-PDOP-TDOP(SST_POS _1i,SST_SRS_1i,SST_SIG_1i and SST_GPT_1i)*			
#1	**Tt_GPS**	tag	
	Time Tag in GPS system time. This time is computed after PVT solution determination Note: The time is represented as follow: 10 digits for seconds, 9 digits for nanoseconds separated by '.'	[s][ns]	Int[2] %20.9uf
#2	**UTC_Corr**	tag	
	UTC Time corrected for leap second	s	Double %20.9uf
#3	**N_Sv**	tag	
	Number of tracked GPS Satellites		Int %2d
#4	**Iono_Type**	tag	

	Type of ionospheric correction applied to the measured pseudorange 1 – if P-code on L1 and L2 are available 2 - if P-code on L1 is available and IONEX data has been used for correction 3 – if only C/A code is available and IONEX data has been used for the correction Array of integer values, size = N_Sv Values are separated by blank character		Int[N_Sv] %1d
#5	**SST_Pos**	tag	
	Position of GOCE satellite, output of the least-squares adjustment and receiver clock error. Array of double values, size = 4 [X,Y,Z] Values are separated by blank character		
#5.1	**Position**	tag	
	Position of GOCE satellite, output of the least-squares adjustment	m	Double[3] %+17.6f
#5.2	**Rec_ Clock_Err**	tag	
	Receiver clock error output of the least-squares adjustment	s	Double %+17.6f
#6	**SST_Vel**	tag	
	Velocity of GOCE satellite, output of the least-squares adjustment Array of double values, size =3 [X,Y,Z] Values are separated by blank character	m/s	Double[3] %+17.6f
#7	**Sigma_P**	tag	

	Sigma on Position solution Array of double values, size =3 [X,Y,Z] Values are separated by blank character	m	Double[3] %+17.6f
#8	**Sigma_V**	tag	
	Sigma on Velocity solution Array of double values, size =3 [X,Y,Z] Values are separated by blank character	m/s	Double[3] %+17.6f
#9	**Sigma_T**	tag	
	Sigma on clock error solution	s	Double %+17.6f
#10	**Sol_Sigma_Pt**	tag	
	Sigma for PT Solution		Double %+17.6f
#11	**Res_Sol_Pt**	tag	
	Solution Residuals, containing the residuals of all satellite Pseudoranges from the PT Ssolution Array of double valus, size = N_Sv Values are separated by blank character	m	Double[N_Sv] %+17.6f
#12	**Sol_Sigma_V**	tag	Double %+17.6f
	Sigma for Velocity solution		
#13	**Res_Sol_V**	tag	
	Solution Residuals containing the residuals to M_PV Positions from the Velocity solution	m	
#13.1	**X**	tag	
	Array of double values, size = MPV Values are separated by blank character		Double[MPV] %17.6f

#13.2	**Y** Array of double values, size = MPV Values are separated by blank character		Double[MPV] %17.6f
#13.3	**Z** Array of double values, size = MPV Values are separated by blank character		Double[MPV] %17.6f
#14	**G-P-TDOP**	tag	
	GDOP – PDOP – TDOP value Array of double, size = 3 Values are separated by blank character		Double[3] %+17.6f

Table 20- *SST_PVT_1i MDS*

5.3.3.1.14 GPS MDS Record (SST_GPS_1i)

This MDS contains the position and velocity of the tracked GPS satellites used for the derivation of PVT solution. The table below details the MDS format.

Field #	**Description**	**Units**	**Type/Format**
	GPS measurements (SST_GPS_1i)		
#1	**Tt_GPS**	tag	
	GPS system Time. Note: The time is represented as follow: 10 digits for seconds, 9 digits for nanoseconds separated by '.'	[s][ns]	Int[2] %20.9uf
#2	**N_Sv**	tag	
	Number of tracked GPS Satellites		Int %2d
#3	**Sv_Identifier**	tag	

	PRN-number of the observed satellite, the order shall be consistent with the receiver channels, so that the first satellite with SV_IDENTIFIER[1] is tracked on receiver channel 1, satellite with SV_IDENTIFIER[2] on channel 2 and so on. Array of integer values, size = N_Sv Values are separated by blank character		Int[N_Sv] %2d
#4	**Channel_Id**	tag	
	Receiver channel numbers of the tracked satellites Array of integer values, size = N_Sv Values are separated by blank character		Int[N_Sv] %2d
#5	**Pos_GPS**	tag	
	Position of the tracked GPS satellites	m	
#5.1	**X**	tag	
	X element Array of double values, size = N_Sv Values are separated by blank character		Double[N_Sv] %+17.6f
#5.2	**Y**	tag	
	Y element Array of double values, size = N_Sv Values are separated by blank character		Double[N_Sv] %+17.6f
#5.3	**Z**	tag	
	Z element Array of double values, size = N_Sv Values are separated by blank character		Double[N_Sv] %+17.6f
#6	**Vel_GPS**	tag	

	Velocity of the GPS satellite, needed for the consideration of the Sagnac effect.	m/s	
#6.1	**X**	tag	
	X velocity element Array of double values, size = N_Sv Values are separated by blank character		Double[N_Sv] %+17.6f
#6.2	**Y**	tag	
	Y velocity element Array of double values, size = N_Sv Values are separated by blank character		Double[N_Sv] %+17.6f
#6.3	**Z**	tag	
	Z velocity element Array of double values, size = N_Sv Values are separated by blank character		Double[N_Sv] %+17.6f

Table 21- SST *GPS measurement MDS*

5.3.3.1.15 Covariance Matrix MDS Record (SST_COV_1i)

This MDS contains Covariance Matrix of the Position and Time solution [4X4], the Covariance Matrix for the Velocity solution [3X3]. The format is specified in the following table.

Field **#**	**Description**	**Units**	**Type/Format**
Covariance Matrix measurements (SST_COV_1i)			
#1	**Tt_GPS**	tag	
	Time Tag in GPS system time. This time is computed after PVT solution determination. Note: The time is represented as follow: 10 digits for seconds, 9 digits for nanoseconds separated by '.'	[s][ns]	Int[2] %20.9uf

#2	**UTC_Corr**	tag	
	UTC time corrected for leap seconds	s	Double %20.9uf
#3	**SST_Cov_Pt**	tag	
#3.1	**Row1**	tag	
	4 elements of the first row of the covariance position/time matrix Values are separated by blank character		Double[4] %+17.6f
#3.2	**Row2**	tag	
	4 elements of the second row of the covariance position/time matrix Values are separated by blank character		Double[4] %+17.6f
#3.3	**Row3**	tag	
	4 elements of the third row of the covariance position/time matrix Values are separated by blank character		Double[4] %+17.6f
#3.4	**Row4**	tag	
	4 elements of the fourth row of the covariance position/time matrix Values are separated by blank character		Double[4] %+17.6f
#4	**SST_Cov_V**	tag	
#4.1	**Row1**	tag	
	3 elements of the first row of the covariance velocity matrix Values are separated by blank character		Double[3] %+17.6f
#4.2	**Row2**	tag	
	3 elements of the second row of the covariance velocity matrix Values are separated by blank character		Double[3] %+17.6f
#4.3	**Row3**	tag	
	3 elements of the second row of the covariance velocity matrix Values are separated by blank character		Double[3] %+17.6f

Table 22- SST *Covariance Matrix measurements MDS*

5.4 SST_RIN_1B

The RINEX product is a subset of the data of the Level 1b product contained in SST_NOM_1b, relating to code and phase observations.

5.4.1 NAMING CONVENTION

The name of the L1b products follows the naming convention described in Section 5.1.

5.4.2 PRODUCT PACKAGING

The RINEX product is distributed on two separate physical files: a header file (extension .HDR) and a data block file (extension .DBL). The 'HDR' file contains the Fixed Header and the Variable Header as detailed in Sections 5.2, 5.2.1.2. The 'DBL' file is completely compliant with the RINEX specification.

5.4.3 PRODUCT STRUCTURE

The high-level structure of this product is described in Section 5.2. The detailed description of the data block is described in the following paragraph.

5.4.3.1 Header

The general format of the RINEX is defined in [RINEX-LEO]. Using the terminology defined in [RINEX-LEO], the header fields are populated as follows:

Field Name	Description	Units/Value
Rinex Version	File format version	2.20
TYPE	File type fixed	OBSERVATION
SATELLITE SYSTEM	Satellite system, fixed	GPS
PCM	Processor name and version	SST_L1NOM_P
RUN BY	Processing centre ID code, fixed	PDS
DATE	Product generation time	
MARKER NAME	Mission ID	GOCE
MARKER TYPE	Receiver location	SPACEBORN
OBSERVER	Acquisition station	KIRUNA
AGENCY	Agency	ESA
RECEIVER NUMBER	RECEIVER NUMBER	MAIN
RECEIVER TYPE	RECEIVER TYPE	LABEN
RECEIVER VERSION	RECEIVER VERSION	2.0.9
ANTENNA NUMBER	ANT_ID_GOCE, identify. Of GOCE antennae	0-2-4
ANTENNA TYPE	Antenna type	RYMSA
ANTENNA DELTA X/Y/Z	ANT_PC_GOCE the antenna phase centre offset	[m]
ANTENNA B.SIGHT XYZ	Boresight	[m]

INTERVAL	Interval between records	1.000s
WAVELENGTH FACT L1/2	Wavelength factor used for all frequencies	1 1
TYPES OF OBSERV	Number and specification of the observables in the main part of the rinex file	6 L1 L2 C1 P1 P2 S1 S2 CH
TIME OF FIRST OBS	GPS time stamp of first observation	GPS

Table 23- RINEX Products Header Structure

5.4.3.2 Data Block

For each epoch, the RINEX file contains the following records:

Field Name	Description	Units/Value
EPOCH	GPS receiver time stamp	GPS
EVENT FLAG	Not used	0
NUMBER OF GPS	Number of observed GPS	
PRN	List of PRN	
RECEIVER CLOCK OFFSET	Receiver clock offset from the onboard navigation solution	[s]
L1	Phase on L1 corrected from inter-freq. bias	[cycles]
L1LLI	Loss of lock identificator for L1 LLI=1 if cycle slip detected	
L2	Phase on L2 corrected from inter-freq. bias	[cycles]
L2LLI	Loss of lock identificator for L2 LLI=1 if cycle slip detected	
C1	C/A code measurements corrected from Inter-channel bias	[m]
P1	P1 code measurements corrected from Inter-channel bias	[m]
P2	P2 code measurements corrected from Inter-channel bias	[m]
S1	SNR ON L1	
S2	SNR ON L2	
CH	Channel number	

Table 24- RINEX Products Data Block Structure

5.5 EGG_NOM_1B

5.5.1 NAMING CONVENTION

The name of the L1b products follows the naming convention described in Section 5.1.

5.5.2 PRODUCT PACKAGING

The SST_NOM_1b product is distributed on a single physical file (extension EEF), tarred and gzipped. That is, the extension of the files delivered to users is .TGZ

5.5.3 PRODUCT STRUCTURE

The high-level structure of this product is described in Sections 0, 5.2 and 5.2.1.2. The detailed description of the data block follows.

5.5.3.1 Data Block

The Data Block contains the following data organized in Measurement Data Set (see Figure 11)

MDS Name	Description of contents
EGG_CTR_1i	EGG control Voltages
EGG_POL_1i	EGG polarisation Voltages
EGG_NLA_1i	Nominal linear and angular accelerations
EGG_NCD_1i	Nominal common and differential accelerations
EGG_NGA_1i	Nominal gradiometer angular accelerations
EGG_CCV_1i	Corrected Control Voltages
EGG_CCD_1i	Calibrated common and differential accelerations
EGG_CGA_1i	Calibrated angular accelerations
EGG_GAR_1i	Gradiometer angular rates
EGG_IAQ_1i	Gradiometer inertial attitude quaternions
EGG_GGT_1i	Gravity gradient tensor GRF system
EGG_GIM_1i	Transformation matrix from GRF to IRF

Table 25 - EGG_NOM_1b product Measurement Data Sets

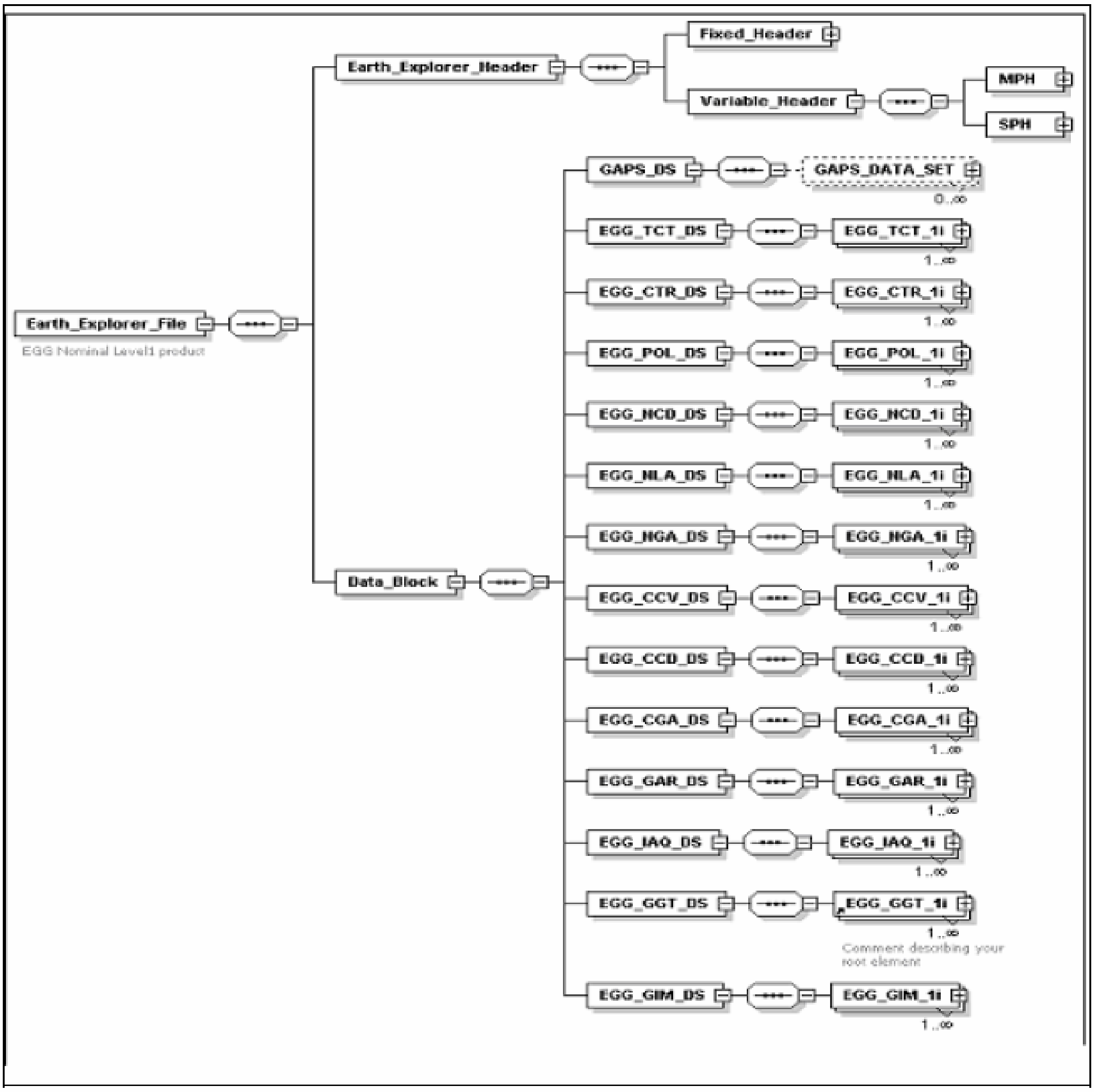

Figure 11- EGG_NOM_1b XML File Structure

5.5.3.1.1 GAPS Data Set

See section 5.3.3.1.1 for format description.

5.5.3.1.2 Time correlation Table MDS Record (EGG_TCT_1i)

This MDS contains the EGG On-board time, the GPS time, difference between GPS time and OBT, and the flag indicating how the Tt_GPS is computed derived from the SST_TCT_1i.
The detailed description of data records is reported in the following table*:*

Field	Description	Units	Type/Format
Time Correlation Table MDS (EGG_TCT _1i)			
#1	**Tt_EGG_Obt**	tag	
	OBT Time tag in GPS system time Note: The time is represented as follow: 10 digits for seconds, 9 digits for nanoseconds separated by '.'	[s][ns]	Int[2] %20.9uf
#2	**Tt_GPS**	tag	
	Computed Time in GPS system time. Note: The time is represented as follow: 10 digits for seconds, 9 digits for nanoseconds separated by '.'	[s][ns]	Int[2] %20.9uf
#3	**Dif_EGG_Obt_GPS**	tag	
	Difference between EGG OBT and GPS system time, derived through linear interpolation from SST_TCT_1i. Note: The time is represented as follow: 10 digits for seconds, 9 digits for nanoseconds separated by '.'	[s][ns]	Int[2] %20.9uf
#4	**UTC_Corr**	tag	
	UTC Time corrected for leap seconds, extracted from AUX_OUTC	[s]	Double %20.9uf
#5	**Flag_Origin_GPS**	tag	
	Flag indicating the origin of Tt_GPS derived from SST_TCT_1i of SSTI nominal product. 1 = from PVT solution 2 = from Navigation solution (RECV_CLKB_NAV) 3 = from AUX_0UTC 4 = no correction applied		%1d

Table 26- EGG *Time Correlation Table MDS*

5.5.3.1.3 EGG Control Voltages MDS Record (EGG_CTR_1i)

This MDS contains the time series of proof mass control voltages applied to the eight pairs surrounding the proof mass of the accelerometer A_i (i=1÷6) and two flags, the Detector health status (DHS_i) and Detector saturation status (DSS_i).
The format is detailed in the following table.

Field	Description	Units	Type/Format
EGG Control Voltages MDS record (EGG_CTR_1i)			
#1	**Tt_GPS**	tag	
	Time in GPS system time Note: The time is represented as follow: 10 digits for seconds, 9 digits for nanoseconds separated by '.'	[s][ns]	Int[2] %20.9uf
#2	**Proof_Mass_Contr_Voltages**	tag	
	Proof Mass Control Voltages for all accelerometers	V	
#2.1	**X1**	tag	
	Control voltages Vx1 applied to the X1 electrode of all the accelerometer Array of double value, size = 6. The values are separated by blank character		Double[6] %±15.8e
#2.2	**X2**	tag	
	Control voltages Vx2 applied to the X2 electrode of all the accelerometer Array of double value, size = 6. The values are separated by blank character		Double[6] %±15.8e
#2.3	**X3**	tag	
	Control voltages Vx3 applied to the X3 electrode of all the accelerometer Array of double value, size = 6. The values are separated by blank character		Double[6] %±15.8e
#2.4	**X4**	tag	
	Control voltages Vx4 applied to the X4 electrode of all the accelerometer Array of double value, size = 6. The values are separated by blank character		Double[6] %±15.8e
#2.5	**Y1**	tag	
	Control voltages Vy1 applied to the Y1 electrode of all the accelerometer Array of double value, size = 6. The values are separated by blank character		Double[6] %±15.8e

#2.6	**Y2**	tag	
	Control voltages Vy2 applied to the Y2 electrode of all the accelerometer Array of double value, size = 6. The values are separated by blank character		Double[6] %±15.8e
#2.7	**Z1**	tag	
	Control voltages Vz1 applied to the Z1 electrode of all the accelerometer Array of double value, size = 6. The values are separated by blank character		Double[6] %±15.8e
#2.8	**Z2**	tag	
	Control voltages Vz2 applied to the Z2 electrode of all the accelerometer Array of double value, size = 6. The values are separated by blank character		Double[6] %±15.8e
#3	**DHS**	tag	
	Detector Healt Status given for all the accelerometer Array of integer value, size = 6. The values are separated by blank character		Int[6] %d
#4	**DSS**	tag	
	Detector Saturation Status given for all the accelerometer Array of integer value, size = 6. The values are separated by blank character		Int[6] %d
#5	**Flag_Ctr_Fail**	tag	
	Flag that indicates the failure of a readout-branch of a accelerometer		
#5.1	**X1**	tag	
	X1 electrode of all the accelerometer Array of integer value, size = 6. The values are separated by blank character		Int[6] %d
#5.2	**X2**	tag	
	X2 electrode of all the accelerometer Array of integer value, size = 6. The values are separated by blank character		Int[6] %d
#5.3	**X3**	tag	

	X3 electrode of all the accelerometer Array of integer value, size = 6. The values are separated by blank character		Int[6] %d
#5.4	**X4**	tag	
	X4 electrode of all the accelerometer Array of double value, size = 6. The values are separated by blank character		Int[6] %d
#5.5	**Y1**	tag	
	Y1 electrode of all the accelerometer Array of integer value, size = 6. The values are separated by blank character		Int[6] %d
#5.6	**Y2**	tag	
	Y2 electrode of all the accelerometer Array of integer value, size = 6. The values are separated by blank character		Int[6] %d
#5.7	**Z1**	tag	
	Z1 electrode of all the accelerometer Array of integer value, size = 6. The values are separated by blank character		Int[6] %d
#5.8	**Z2**	tag	
	Z2 electrode of all the accelerometer Array of integer value, size = 6. The values are separated by blank character		Int[6] %d
#6	**Flag_Acc_Fail**	tag	
	Flag that indicates the failure of an accelerometer Array of integer value, size = 6. The values are separated by blank character		Int[6] %d
#7	**K2_Status_Flag**	tag	
	Calibration K2 Status Always set to 0		Int

Table 27- ***EGG Control Voltages MDS***

5.5.3.1.4 EGG Polarization Voltages MDS Record (EGG_POL_1i)

This MDS contains the time series of proof mass polarization and detection voltages applied to the proof masses the Accelerometers belonging respectively to the OAG1 (A_1, A_4), OAG2 (A_2, A_5) and the OAG3 (A_3, A_6).
The format is described in the following table.

Field#	Description	Units	Format
EGG Polarization Voltages MDS record (EGG_POL_1i)			
#1	**Tt_GPS**	tag	
	Time in GPS system time Note:The time is represented as follow: 10 digits for seconds, 9 digits for nanoseconds separated by '.'	[s][ns]	Int[2] %20.9uf
#2	**Acc_Det_Voltages**	tag	
	Proof Mass Detection Voltages	V	
#2.1	**Pm_Dv**	tag	
	Proof Mass Detection Voltages Array of double value, size = 6. The values are separated by blank character		Double[6] %+15.8e
#3	**Acc_Pol_Voltages**	tag	
	Proof Mass Polarization Voltages	V	
#3.1	**Pm_Pv**	tag	
	Proof Mass Polarization Voltages Array of double value, size = 6. The values are separated by blank character		Double[6] %+15.8e

Table 28- *EGG Polarization Voltages MDS*

5.5.3.1.5 Nominal Common & Differential Accelerations MDS Record (EGG_NCD_1i)

This MDS contains the common-mode accelerations and the differential-mode accelerations of the accelerometers pairs A_i,A_j (i, j=14,25,36). The structure of this MDS record is described in the following table:

Field	Description	Units	Format
	Nominal Common & Differential Acceleration MDS record (EGG_NCD_1i)		
#1	**Tt_GPS**	tag	
	Time in GPS system time Note: The time is represented as follow: 10 digits for seconds, 9 digits for nanoseconds separated by '.'	[s][ns]	Int[2] %20.9uf
#2	**Acc_Ncm**	tag	
	Unit	m/s^2	
	Nominal Common Acceleration component for each accelerometer pair and each degree of freedom		
#2.1	**X**	tag	
	Vector of Pair_1_4, Pair_2_5 and Pair_3_6 along X axis Array of double value, size = 3. The values are separated by blank character		Double[3] %+15.8e
#2.2	**Y**	tag	
	Vector of Pair_1_4, Pair_2_5 and Pair_3_6 along Y axis Array of double value, size = 3. The values are separated by blank character		Double[3] %+15.8e
#2.3	**Z**	tag	
	Vector of Pair_1_4, Pair_2_5 and Pair_3_6 along Z axis Array of double value, size = 3. The values are separated by blank character		Double[3] %+15.8e
#3	**Acc_Ndm**	tag	
	Nominal differential mode acceleration for each accelerometer pair and each degree of freedom	m/s^2	
#3.1	**X**	tag	
	Vector of Pair_1_4, Pair_2_5 and Pair_3_6 along X axis Array of double value, size = 3. The values are separated by blank character		Double[3] %+15.8e
#3.2	**Y**	tag	

	Vector of Pair_1_4, Pair_2_5 and Pair_3_6 along Y axis Array of double value, size = 3. The values are separated by blank character		Double[3] %+15.8e
#3.3	**Z**	tag	
	Vector of Pair_1_4, Pair_2_5 and Pair_3_6 along Z axis Array of double value, size = 3. The values are separated by blank character		Double[3] %+15.8e

Table 29- ***Nominal Common & Differential Acceleration MDS***

5.5.3.1.6 Nominal Linear & Angular Accelerations MDS Record (EGG_NLA_1i)

This MDS contains for each accelerometer A_i (i=1 ÷6) the three linear acceleration in the ARF. The format of this MDS record is described in the following table:

Field	Description	Units	Format
Nominal Linear & Angular Acceleration MDS record (EGG_NLA_1i)			
#1	**Tt_GPS**	tag	
	Time in GPS system time Note: The time is represented as follow: 10 digits for seconds, 9 digits for nanoseconds separated by '.'	[s][ns]	Int[2] %20.9uf
#2	**Acc_Nl**	Tag	
	Nominal Linear Acceleration for each accelerometer and each degree of freedom in the ARF	m/s^2	
#2.1	**X**	Tag	
	Linear Acceleration X component for all accelerometers Array of double value, size = 6. The values are separated by blank character		Double[6] %+15.8e
#2.2	**Y**	Tag	
	Linear Acceleration Y component for all accelerometers Array of double value, size = 6. The values are separated by blank character		Double[6] %+15.8e

#2.3	**Z**	Tag	
	Linear Acceleration Z component for all accelerometers Array of double value, size = 6. The values are separated by blank character		Double[6] %+15.8e
#3	**Acc_Na**	tag	
	Nominal Angular Acceleration for each accelerometer and each degree of freedom in the ARF	rad/s^2	
#3.1	**X**	tag	
	Angular Acceleration X component for all accelerometers Array of double value, size = 6. The values are separated by blank character		Double[6] %+15.8e
#3.2	**Y**	tag	
	Angular Acceleration X component for all accelerometers Array of double value, size = 6. The values are separated by blank character		Double[6] %+15.8e
#3.3	**Z**	tag	
	Angular Acceleration X component for all accelerometers Array of double value, size = 6. The values are separated by blank character		Double[6] %+15.8e
#4	**Acc_Rec**	tag	
	Accelerations per degree of freedom (three linear and three angular components) and per accelerometer. The values are derived through the recombination of the corrected accelerations of the electrodes, given in AESRF system	m/s^2	
#4.1	**A1**	**tag**	
	Six values for accelerometer 1		**Double[6]** %+15.8e

#4.2	**A2**	**tag**	
	Six values for accelerometer 2		**Double[6]** %+15.8e
#4.3	**A3**	**tag**	
	Six values for accelerometer 3		**Double[6]** %+15.8e
#4.4	**A4**	**tag**	
	Six values for accelerometer 4		**Double[6]** %+15.8e
#4.5	**A5**	**tag**	
	Six values for accelerometer 5	**tag**	**Double[6]** %+15.8e
#4.6	**A6**	**tag**	
	Six values for accelerometer 6		**Double[6]** %+15.8e

Table 30- ***Nominal Linear & Angular Acceleration MDS***

5.5.3.1.7 Nominal Gradiometer Angular Accelerations MDS Record (EGG_NGA_1i)

This MDS contains the nominal gradiometer angular accelerations. The detailed description of data records is reported in following table.

Field	Description	Units	Type/Format
Nominal Gradiometer Angular Acceleration (EGG_NGA_1i)			
#1	**Tt_GPS**	tag	
	Time in GPS system time Note: The time is represented as follow: 10 digits for seconds, 9 digits for nanoseconds separated by '.'	[s][ns]	Int[2] %20.9uf
#2	**Grad_Ang_Acc**	tag	
	Nominal Gradiometer Angular acceleration	rad/s²	
#2.1	**N_Gaa**	tag	

	Nominal Gradiometer angular acceleration X, Y and Z components Array of double value, size = 3. The values are separated by blank character		Double[3] %±15.8e

Table 31- *Nominal Gradiometer Angular Acceleration MDS*

5.5.3.1.8 Corrected Control Voltages MDS Record (EGG_CCV_1i)

This MDS contains the corrected control voltages for phase delay and gain attenuation for each accelerometer A_i (i=1 ÷6).
The format is described in the following table.

Field #	Description	Units	Type/Format
Corrected Control Voltages (EGG_CCV_1i)			
#1	**Tt_GPS**	tag	
	Time in GPS system time Note: The time is represented as follow: 10 digits for seconds, 9 digits for nanoseconds separated by '.'	[s][ns]	Int[2] %20.9uf
#2	**V_Corr**	Tag	
	Corrected Control Voltages for each accelerometer and for each electrodes.	V	
#2.1	**X1**	Tag	
	Electrodes X1 for all accelerometers Array of double value, size = 6. The values are separated by blank character		Double[6] %±15.8e
#2.2	**X2**	Tag	
	Electrodes X2 for all accelerometers Array of double value, size = 6. The values are separated by blank character		Double[6] %±15.8e
#2.3	**X3**	Tag	
	Electrodes X3 for all accelerometers Array of double value, size = 6. The values are separated by blank character		Double[6] %±15.8e

#2.4	**X4**	Tag	
	Electrodes X4 for all accelerometers Array of double value, size = 6. The values are separated by blank character		Double[6] %±15.8e
#2.5	**Y1**	Tag	
	Electrodes Y1 for all accelerometers Array of double value, size = 6. The values are separated by blank character		Double[6] %±15.8e
#2.6	**Y2**	Tag	
	Electrodes Y2 for all accelerometers Array of double value, size = 6. The values are separated by blank character		Double[6] %±15.8e
#2.7	**Z1**	Tag	
	Electrodes Z1 for all accelerometers Array of double value, size = 6. The values are separated by blank character		Double[6] %±15.8e
#2.8	**Z2**	Tag	
	Electrodes Z2 for all accelerometers Array of double value, size = 6. The values are separated by blank character		Double[6] %±15.8e

Table 32- ***Corrected Control Voltages MDS***

5.5.3.1.9 Calibrated Common and Differential Accelerations MDS Record (EGG_CCD_1i)

This MDS contains the calibrated common and differential accelerations of the accelerometers pairs A_i,A_j (i, j=14,25,36).
The format of this data set is detailed in below table.

Field	Description	Units	Type/Format
Calibrated Common & Differential Acceleration MDS record (EGG_CCD_1i)			
#1	**Tt_GPS**	tag	
	Time in GPS system time Note: The time is represented as follow: 10 digits for seconds, 9 digits for nanoseconds separated by '.'	[s][ns]	Int[2] %20.9uf
#2	**Acc_Ccm**	tag	
	Calibration Common Acceleration component for each accelerometer pair and each degree of freedom	m/s^2	
#2.1	**X**	tag	
	Vector of Pair_1_4, Pair_2_5 and Pair_3_6 along X axis Array of double value, size = 3. The values are separated by blank character		Double[3] %±15.8e
#2.2	**Y**	tag	
	Vector of Pair_1_4, Pair_2_5 and Pair_3_6 along Y axis Array of double value, size = 3.		Double[3] %±15.8e
#2.3	**Z**	tag	
	Vector of Pair_1_4, Pair_2_5 and Pair_3_6 along Z axis Array of double value, size = 3		Double[3] %±15.8e
#3	**Acc_Cdm**	tag	
	Calibrated differential mode acceleration for each accelerometer pair and each degree of freedom	m/s^2	
#3.1	**X**	tag	
	Vector of Pair_1_4, Pair_2_5 and Pair_3_6 along X axis Array of double value, size = 3		Double[3] %±15.8e
#3.2	**Y**	tag	
	Vector of Pair_1_4, Pair_2_5 and Pair_3_6 along Y axis Array of double value, size = 3.		Double[3] %±15.8e
#3.3	**Z**	tag	

	Vector of Pair_1_4, Pair_2_5 and Pair_3_6 along Z axis Array of double value, size = 3.		Double[3] %±15.8e

Table 33- ***Calibrated Common & Differential Acceleration MDS***

5.5.3.1.10 Calibrated Angular Accelerations MDS Record (EGG_CGA_1i)

This MDS contains the calibrated angular accelerations of the gradiometer about the axes of the GRF. The format of this data set is detailed in below table.

Field	Description	Units	Type/Format
Calibrated Gradiometer Angular Acceleration (EGG_CGA_1i)			
#1	**Tt_GPS**	tag	
	Time in GPS system time Note: The time is represented as follow: 10 digits for seconds, 9 digits for nanoseconds separated by '.'	[s][ns]	Int[2] %20.9uf
#2	**Cal_Grad_Ang_Acc**	tag	
	Calibrated Gradiometer Angular acceleration	rad/s²	
#2.1	**CGA**	tag	
	Calibrated Gradiometer Angular acceleration X, Y and Zcomponents Array of double value, size = 3. The values are separated by blank character		Double[3] %+15.8e

Table 34- ***Calibrated Gradiometer Angular Acceleration MDS***

5.5.3.1.11 Gradiometer Angular Rates MDS Record (EGG_GAR_1i)

This MDS contains the three components of the corrected estimated angular rate at epoch time '*i*'. The format of this data set is detailed in below table.

Field #	Description	Units	Type/Format
Gradiometer Angular Rates (EGG_GAR_1i)			
#1	**Tt_GPS**	tag	
	Time in GPS system time Note: The time is represented as follow: 10 digits for seconds, 9 digits for nanoseconds separated by '.'	[s][ns]	Int[2] %20.9uf
#2	**Corr_Est_Ang_Rate**	tag	
	Corrected estimated Inertial Angular rate relative at epoch i	rad/s	
#2.1	**Iar_Est**	tag	
	Angular Rate X, Y and Z components Array of double value, size = 3. The values are separated by blank character		Double[3] %±15.8e

Table 35- *Gradiometer Angular Rates MDS*

5.5.3.1.12 Gradiometer Inertial Attitude Quaternions MDS Record (EGG_IAQ_1i)

This MDS contains the Corrected quaternions synchronous with the gradiometer.
The following table details the MDS structure:

Field #	Description	Units	Type/Format
Corrected Quaternions (EGG_IAQ_1i)			
#1	**Tt_GPS**	tag	
	Time in GPS system time Note:The time is represented as follow: 10 digits for seconds, 9 digits for nanoseconds separated by '.'	[s][ns]	Int[2] %20.9uf
#2	**Corr_Quat**	tag	
	Corrected quaternion synchronous with the gradiometer measurements		
#2.1	**Q_Grad**	tag	

	Array of double value, size = 4. The values are separated by blank character		Double[4] %±15.8e

Table 36- *Corrected Quaternions MDS*

5.5.3.1.13 Gravity Gradient Tensor in the GRF MDS Record (EGG_GGT_1i)

This MDS contains six independent components of the gravity gradient tensor in the Gradiometer Reference Frame (GRF).
The detailed description of data records is reported in following table.

Field #	**Description**	**Units**	**Type/Format**
Gravity Gradient Tensor in GRF (EGG_GGT_1i)			
#1	**Tt_GPS**	tag	
	Time in GPS system time Note:The time is represented as follow: 10 digits for seconds, 9 digits for nanoseconds separated by '.'	[s][ns]	Int[2] %20.9uf
#2	**Gravity_Grad_Tensor**	tag	
	Gravity gradient tensor	$1/s^2$	
#2.1	**U_G**	tag	
	Gravity gradient tensor (XX, YY , ZZ, XY, XZ, YZ) components Array of double value, size = 6. The values are separated by blank character		Double[6] %+15.8e
#3	**Qual_Flag**	tag	
#3.1	**Flag**	tag	

	Quality Flag on Proof Mass Control Voltages **Qual_Flag_Ctr**. Quality Flag on Acceleration for DFACS **Qual_Flag_Dfc** Quality Flag on Proof Mass Polarization Voltages **Qual_Flag_Pv** Quality Flag on Proof Mass Detectection Voltages with threshold **Qual_Flag_Dv** Quality Flag coming from the check on the Nominal Angular Acceleration and Nominal Gradiometer Angular Acceleration **Qual_Flag_Acc_Nga** Quality Flag on Nominal Angular Acceleration **Qual_Flag_Na** Quality Flag coming from the check on Nominal Common Accelerations with threshold. **Qual_Flag_Dfc_Ncm** Quality Flag coming from the check on Nominal Common Accelerations with threshold **Qual_Flag_Acc_Ncm** Quality Flag on Trace_GGT with threshold **Qual_Flag_Ggt** (These flags are computed into the monitoring function) Values: 0 – if quality test passed 1 – if quality test failed Array of integer value, size = 9. The values are separated by blank character		Int[9] %d

Table 37- ***Gravity Gradient Tensor in GRF MDS***

5.5.3.1.14 Transformation Matrix GRF->IRF MDS Record (EGG_GIM_1i)

This MDS contains nine elements of the transformation matrix from the GRF to IRF. The detailed description of data records is reported in following table.

Field #	Description	Units	Type/Format
Transformation Matrix GRF->IRF (EGG_GIM_1i)			
#1	**Tt_GPS**	tag	
	Time in GPS system time Note:The time is represented as follow: 10 digits for seconds, 9 digits for nanoseconds separated by '.'	[s][ns]	Int[2] %20.9uf
#2	**R_GRF_IRF**	tag	
	Rotation Matrix from GRF to IRF		
#2.3	**Row1**		
	First row of transformation matrix GRF to IRF Array of double value, size = 3. The values are separated by blank character		Double[3] %+15.8e
#2.4	**Row2**	tag	
	Second row of transformation matrix GRF to IRF Array of double value, size = 3. The values are separated by blank character		Double[3] %+15.8e
#2.5	**Row3**	tag	
	Third row of transformation matrix GRF to IRF Array of double value, size = 3. The values are separated by blank character		Double[3] %+15.8e

Table 38- ***Transformation Matrix GRF->IRF MDS***

6 REFERENCES

TBD