# Earth Observation
# Mission CFI Software

# MISSION SPECIFIC CUSTOMIZATIONS

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# 1 SCOPE

All features and conventions defined and used in the Earth Observation Mission CFI Software are described in the document "Earth Observation Mission CFI Software Conventions" [MCD].

This document covers all CFI SW mission specific customizations that are not described in [MCD], i.e. those features and conventions that are defined and used within specific missions.

# 2 ACRONYMS AND NOMENCLATURE

## 2.1 Acronyms

| | |
|---|---|
| ADM/Aeolus | Atmospheric Dynamics Mission |
| ANX | Ascending Node Crossing |
| AOCS | Attitude and Orbit Control Sub-system |
| CFI | Customer Furnished Item |
| DRS | Data Relay Satellite |
| DORIS | Doppler Orbitography and Radio positioning Integrated by Satellite |
| ERS | European Remote Sensing Satellite |
| ESA | European Space Agency |
| ESTEC | European Space Technology and Research Centre |
| EO | Earth Observation |
| EOCFI | Earth Observation CFI Software |
| GOCE | Gravity Field and Steady-state Ocean Circulation Mission |
| GPS | Global Positioning System |
| METOP | Meteorological Operational Polar Satellite |
| OBT | On-Board Time |
| SBT | Satellite Binary Time |
| SIRAL | Synthetic-Aperture Interferometric Radar Altimeter |
| SMOS | Soil Moisture and Ocean Salinity Mission |
| TAI | International Atomic Time |
| TM | Telemetry |
| UTC | Coordinated Universal Time |

# 3 APPLICABLE AND REFERENCE DOCUMENTS

## 3.1 Applicable Documents

## 3.2 Reference Documents

| | |
|---|---|
| ADM_AGL | AOCS Guidance Laws. AE.RP.ASU.PL.044 |
| CRYO_ATT | CryoSat Star Tracker Data Usage for Attitude Determination. CS-TN-ESA-GS-0300. Issue 1.5. |
| S1_ATT | Sentinel-1: Roll Steering Law. EXPCFI-NOTE-042. Issue 1.2. 10/02/2010 |
| CRYO_SRD | CryoSat System Requirements Document. CS-RS-ESA-SY-0006. Issue 6. |
| DRSENV_ICD | ICD between the DRS and the Envisat-1 System. CD/1945/mad. D/TEL/R. K. Falbe-Hansen. Issue 5. April 1996. |
| KLINKRAD | Semi-Analytical Theory for Precise Single Orbit Predictions of ERS-1. ER-RP-ESA-SY-004. H.K. Klinkrad (ESA/ESTEC/WMM). Issue 1.0. 28/06/87. |
| MCD | Earth Observation Mission CFI Software Conventions Document. EO-MA-DMS-GS-0001. Issue 1.0. 27/10/2009. |
| S2_ATT | Sentinel-2: AOCS Coordinate Systems Document. GS2.TN.ASD.SY.00035. Issue 2 30/09/2010 |

# 4 TIME REFERENCES AND MODELS

## 4.1 Earth Observation CFI Software Time Formats

Table 1 describes the time formats used within specific missions:

*Table 1: Earth Observation time formats*

| Mission Name | Time format | Description | Usage |
|---|---|---|---|
| Cryosat | Transport<br>CryoSat General TM | Three 32-bits integer numbers for days, milliseconds and microseconds | Time values exchange between computers |
| Cryosat | Transport<br>CryoSat SIRAL TM | Four 32-bits integer numbers for days, milliseconds, microseconds and an extra counter of 80 MHz ticks | |
| SMOS | Transport<br>SMOS Transport format | Three 32-bits integer numbers for week number, seconds of the week and fraction of seconds | |
| Envisat | ASCII<br>Envisat | Text string:<br>"dd-mmm-yyyy hh:mm:ss" | Readable output, such as file headers, log messages, ... |
| Envisat | ASCII<br>Envisat with reference | Text string:<br>"RRR=dd-mmm-yyyy hh:mm:ss" | |
| Envisat | ASCII<br>Envisat with microseconds | Text string:<br>"dd-mmm-yyyy hh:mm:ss.uuuuuu" | |
| Envisat | ASCII<br>Envisat with reference and microseconds | Text string:<br>"RRR=dd-mmm-yyyy hh:mm:ss.uuuuuu" | |

## 4.2 Earth Observation CFI Software On-board times

### 4.2.1 Envisat On-board clock ticks

*Table 2: On-board clock ticks*

| Time reference and format | Description | Usage |
|---|---|---|
| Satellite Binary Time (SBT) | 32-bits integer number:<br>· Count of 256 Hz clock ticks | Processing of satellite binary |
| On Board Time (OBT) | 32-bits integer numbers:<br>· obtm = most significant bits<br>· obtl = least significant bits | Processing of instrument on-board time |

The Satellite Binary Time (SBT) is a 32 bits counter, incremented by 1 at a frequency of about 256Hz (defined as the step-length $PER_0$). It varies from **00000000** (Hexadecimal) to **FFFFFFFF** (Hexadecimal), the next value being again **00000000** (Hexadecimal) and so on. This reset of the counter after **FFFFFFFF** (Hexadecimal) is called the **wrap-around**.

The On Board Time (OBT) is a generic term to represent any of the instrument counters, used to date their source packets. Most instruments use a 32 bits counter synchronized with the SBT. Some instruments use a 40 or 43 bits counter, where the 32 most significant bits are synchronized with the SBT (i.e. they use a more precise clock).

Figure 1 shows the relationship between SBT and OBT.

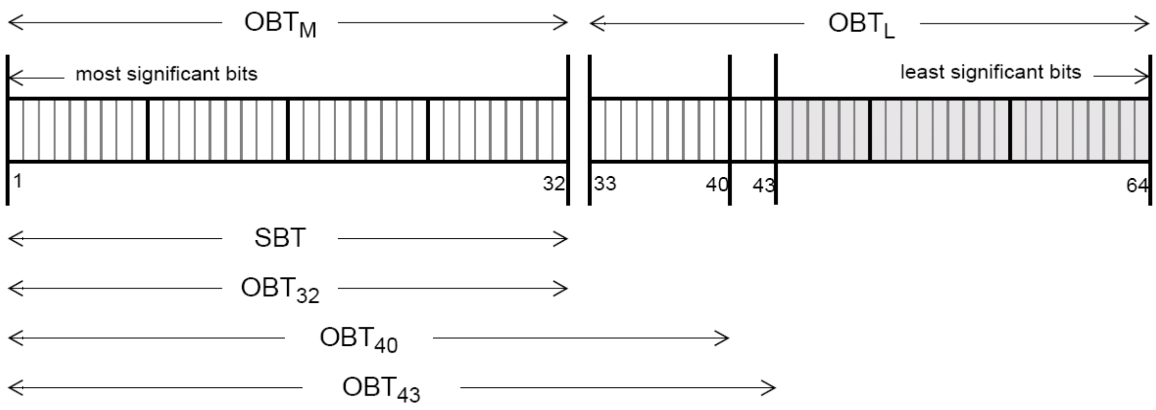


***Figure 1: SBT and OBT relationship***

### 4.2.2 TAI time

If DORIS is used to perform the orbit determination, the satellite will work with TAI time reference using dedicated transport formats (Telemetry formats).[1]

### 4.2.3 CryoSat SIRAL extra counter

The main payload of CryoSat is the Synthetic-Aperture Interferometric Radar Altimeter (SIRAL). The way the SIRAL instrument performs the on-board datation of each TM packet is the following:

Every time SIRAL receives the 1 Hz PPS signal (Pulse-Per-Second) from the central computer, it reads and sets in its memory the first 3 time parameters (days / milliseconds / microseconds). These won't change until the next PPS tick.

At the same time, it resets the fourth time parameter (extra counter) to 0, and starts counting ticks of the internal 80MHz clock in it. Each tick of the 80 MHz clock is 12.5 nanoseconds. The extra counter actually has a lower resolution, it actually counts a multiple (165) of the 80 MHz. This results in a counter resolution of 165 * 12.5 nanoseconds = 2.0625 microseconds.

1 Not applicable to ENVISAT

From then on, at each TM packet production (which is about every 46 ms), SIRAL dates using the "frozen" first 3 parameters, plus the counter of 2 microsec ticks in the fourth parameter.

The actual date of the packet can be calculated by adding up all four parameters (with the appropriate scaling for each, of course), as for any other format.

At the next PPS, the same sequence starts.

It has to be remarked that these TM transport formats use vectors of long integers in the CFI (according to CFI standard). This, however, does not match the TM packet time contents, in which byte efficiency is important. For example, days are on 16-bits, milli-seconds on 32-bits, micro-seconds on 16-bits, and the extra counter on 16-bits.

This does not allow users to simply copy the sequence of bytes into memory and point the time vector to it, they will have to read each time component and set it into a long integer (and vice-versa for users producing test data).

### 4.2.4 SMOS On-board time

SMOS will manage two time sources:

- OBET: This value is derived by a HW counter 48 bits wide which is increased at a frequency of 65536 KHz, starting in 0 after power-on.
- UTC provided by Proteus each second.

The following tables shows the format for the OBET and the UTC-Proteus times:

***Table 3: SMOS OBET time***

| **P-Field** | | | | **T-Field** | |
|---|---|---|---|---|---|
| Extension Flag | Time Code identification | Details Bits for the information on the code | | Coarse Time | Fine Time Note |
| 1 bit | 3 bits | 4 bits | | 32 bits | 24 bits |
| 0 | 110 | 01 | 10 | (Seconds from epoch) | (2-24 seconds) |
| 1 byte | | | | 4 bytes | 3 bytes |

***Table 4: UTC Proteus time format***

| **Week Number** | **Unused** | **H3** | **Second of Week** | **Fraction of Seconds** |
|---|---|---|---|---|
| 12 bits | 3 bits | 1 bit | 32 bits | 16 bits |
| | 000 | | (Seconds from epoch) | (2-16 seconds) |
| 2 bytes | | | 4 bytes | 2 bytes |

Where “Week Number” is weeks elapsed since January 6-12, 1980. This week is numbered (0). LSB=1 Week.

H3 represents the time source from which the payload is synchronised to the platform.

### 4.2.5 Aeolus On-board Time

The OBT format for Aeolus is given in CCSDS Unsegmented time code (CUC), that is defined as: the time from a defined epoch in seconds coded on 4 octets and sub-seconds coded on 2 octets.

According to this the time is:

$$\text{Time} = C_0 * 256^3 + C_1 * 256^2 + C_2 * 256 + C_3 + F_0 * 256^{-1} + F_1 * 256^{-2}.$$

OBT is set to GPS Time such that the UTC zero time-point reference of OBT is the same as that of GPS, i.e. midnight on the night of January 5 1980 / morning of January 6 1980. At this UTC zero time-point reference there had been19 leap seconds applied.

Therefore, the conversion from OBT (in CUC) to UTC is:

$$\text{UTC} = (\text{CUCseconds} + \text{CUCsub-seconds} * 256\text{-}2) - \text{GPST} + \text{UTC}_0$$

Where:

CUCseconds is the 4 most significant octets of OBT ($C_0$ to $C_3$)

CUCsub-seconds is the 2 least significant octets of OBT ($F_0$ to $F_1$)

GPST is the number of leap seconds between UTC and GPS Time (see section 3.2);

$\text{UTC}_0$: UTC time at 06-01-1980 00:00:00.000000

### 4.2.6 GOCE On-board Time

The OBT for GOCE is provided by telemetry as two parameters, the coarse OBT in 32 bits and the fine OBT in 16 bits. The OBT time is therefore OBT = (Coarse OBT) + (Fine OBT)/$2^{16}$.

The conversion form a given OBT to UTC is given by:

$$\text{UTC0} = (\text{Coarse UTC0}) + (\text{Fine UTC0})/2^{16}$$

$$\text{OBT0} = (\text{Coarse OBT0}) + (\text{Fine OBT0})/2^{16}$$

$$\text{UTC} = \text{Gradient}*(\text{OBT}-\text{OBT0}) + \text{Offset} + \text{UTC0}$$

The result is the number of seconds from 1st of Januay 2000 at 00:00:00.000000, without counting the leap seconds (i.e. to convert into a calendar date and time, one has to assume that all days have 86400 seconds).

# 5 ORBIT CONSISTENCY CHECKS

The EO CFI software will check that the orbit supplied as input complies with a set of tolerances on the main osculating Kepler elements.

Two categories of tolerance requirements will be checked:

- Tight requirements
- Loose requirements

If the tight tolerance requirements are not satisfied, but the loose ones are, then a warning will be returned by the CFI software. If even the loose tolerance requirements are not satisfied, then an error will be returned.

These consistency checks are mission specific.

Table 5 and Table 6 list, for each supported mission, the loose and tight requirements:

*Table 5: Loose tolerance requirements*

| Mission Name | Semi-major axis (m) | | Eccentricity | | Inclination (deg) | |
|---|---|---|---|---|---|---|
| | A min | A max | E min | E max | I min | Imax |
| ERS1 | 7000000 | 7300000 | 0 | 0.1 | 98 | 99 |
| ERS2 | 7000000 | 7300000 | 0 | 0.1 | 98 | 99 |
| Envisat | 7000000 | 7300000 | 0 | 0.1 | 98 | 99 |
| METOP1 | 7000000 | 7300000 | 0 | 0.1 | 97 | 100 |
| METOP2 | 7000000 | 7300000 | 0 | 0.1 | 97 | 100 |
| METOP3 | 7000000 | 7300000 | 0 | 0.1 | 97 | 100 |
| CryoSat | 1000000 | 10000000 | 0 | 0.5 | 60 | 120 |
| Aeolus | 6680000 | 6860000 | 0 | 0.1 | 95.7 | 98.3 |
| GOCE | 1000000 | 10000000 | 0 | 0.5 | 60 | 120 |
| SMOS | 7040000 | 7220000 | 0 | 0.1 | 97.1 | 99.7 |
| TerraSAR | 6915000 | 7095000 | 0 | 0.1 | 96.6 | 99.2 |
| EarthCARE | 6720000 | 6830000 | 0 | 0.5 | 96.62 | 97.43 |
| SwarmA | 6500000 | 6975000 | 0 | 0.5 | 85 | 89 |
| SwarmB | 6500000 | 6975000 | 0 | 0.5 | 85 | 89 |
| SwarmC | 6500000 | 6975000 | 0 | 0.5 | 85 | 89 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Sentinel1A** | 7000000 | 7140000 | 0 | 0.5 | 97.7 | 98.7 |
| **Sentinel1B** | 7000000 | 7140000 | 0 | 0.5 | 97.7 | 98.7 |
| **Sentinel2** | 7120000 | 7210000 | 0 | 0.5 | 98.16 | 98.98 |
| **Sentinel3** | 7100000 | 7250000 | 0 | 0.5 | 98.22 | 99.04 |
| **SEOSAT** | 7000000 | 7090000 | 0 | 0.5 | 97.68 | 98.49 |
| **Sentinel1C** | 7000000 | 7140000 | 0 | 0.5 | 97.7 | 98.7 |
| **Sentinel2A** | 7120000 | 7210000 | 0 | 0.5 | 98.16 | 98.98 |
| **Sentinel2B** | 7120000 | 7210000 | 0 | 0.5 | 98.16 | 98.98 |
| **Sentinel2C** | 7120000 | 7210000 | 0 | 0.5 | 98.16 | 98.98 |
| **Sentinel3A** | 7100000 | 7250000 | 0 | 0.5 | 98.22 | 99.04 |
| **Sentinel3B** | 7100000 | 7250000 | 0 | 0.5 | 98.22 | 99.04 |
| **Sentinel3C** | 7100000 | 7250000 | 0 | 0.5 | 98.22 | 99.04 |
| **JasonCSA** | 7660000 | 7760000 | 0 | 0.5 | 65.62 | 66.45 |
| **JasonCSB** | 7660000 | 7760000 | 0 | 0.5 | 65.62 | 66.45 |
| **MetOpSGA1** | 7140000 | 7240000 | 0 | 0.5 | 98.29 | 99.11 |
| **MetOpSGA2** | 7140000 | 7240000 | 0 | 0.5 | 98.29 | 99.11 |
| **MetOpSGA3** | 7140000 | 7240000 | 0 | 0.5 | 98.29 | 99.11 |
| **MetOpSGB1** | 7140000 | 7240000 | 0 | 0.5 | 98.29 | 99.11 |
| **MetOpSGB2** | 7140000 | 7240000 | 0 | 0.5 | 98.29 | 99.11 |
| **MetOpSGB3** | 7140000 | 7240000 | 0 | 0.5 | 98.29 | 99.11 |
| **Sentinel5P** | 7150000 | 7250000 | 0 | 0.5 | 98.34 | 99.15 |
| **Generic satellite** | 1000000 | 10000000 | 0 | 0.5 | 60 | 120 |
| **Generic Geostationary satellite** | 30000000 | 50000000 | 0 | 0.9 | -20 | 20 |
| **MTG** | 30000000 | 50000000 | 0 | 0.9 | -20 | 20 |
| **Generic Medium Earth Orbit satellite** | 1000000 | 40000000 | 0 | 1 | 0 | 180 |

*Table 6: Tight tolerance requirements*

| Mission Name | Semi-major axis (m) | | Eccentricity | | Inclination (deg) | |
|---|---|---|---|---|---|---|
| | A min | A max | E min | E max | I min | Imax |
| **ERS1** | 7118050 | 7194056 | 0 | 0.507 | 98.4475 | 98.6226 |
| **ERS2** | 7118050 | 7194056 | 0 | 0.507 | 98.4475 | 98.6226 |
| **Envisat** | 7118050 | 7194056 | 0 | 0.007 | 98.4475 | 98.6226 |
| **METOP1** | 7154298 | 7230343 | 0 | 0.007 | 98.5613 | 98.8165 |
| **METOP2** | 7154298 | 7230343 | 0 | 0.007 | 98.5613 | 98.8165 |
| **METOP3** | 7154298 | 7230343 | 0 | 0.007 | 98.5613 | 98.8165 |
| **CryoSat** | 1000000 | 10000000 | 0 | 0.5 | 60 | 120 |
| **Aeolus** | 6730000 | 6810000 | 0 | 0.007 | 96.7 | 97.3 |
| **GOCE** | 6500000 | 6700000 | 0 | 0.5 | 96 | 97 |
| **SMOS** | 7090000 | 7170000 | 0 | 0.007 | 98.1 | 98.7 |
| **TerraSAR** | 6965000 | 7045000 | 0 | 0.007 | 97.6 | 98.2 |
| **EarthCARE** | 6750000 | 6790000 | 0 | 0.007 | 96.72 | 97.33 |
| **SwarmA** | 6500000 | 6925000 | 0 | 0.007 | 85.85 | 88.15 |
| **SwarmB** | 6550000 | 6925000 | 0 | 0.007 | 85.85 | 88.15 |
| **SwarmC** | 6550000 | 6925000 | 0 | 0.007 | 85.85 | 88.15 |
| **Sentinel1A** | 7035000 | 7105000 | 0 | 0.007 | 97.8 | 98.6 |
| **Sentinel1B** | 7035000 | 7105000 | 0 | 0.007 | 97.8 | 98.6 |
| **Sentinel2** | 7140000 | 7190000 | 0 | 0.007 | 98.26 | 98.88 |
| **Sentinel3** | 7130000 | 7210000 | 0 | 0.007 | 98.32 | 98.94 |
| **SEOSAT** | 7016000 | 7076000 | 0 | 0.007 | 97.78 | 98.39 |
| **Sentinel1C** | 7035000 | 7105000 | 0 | 0.007 | 97.8 | 98.6 |
| **Sentinel2A** | 7140000 | 7190000 | 0 | 0.007 | 98.26 | 98.88 |
| **Sentinel2B** | 7140000 | 7190000 | 0 | 0.007 | 98.26 | 98.88 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Sentinel2C** | 7140000 | 7190000 | 0 | 0.007 | 98.26 | 98.88 |
| **Sentinel3A** | 7130000 | 7210000 | 0 | 0.007 | 98.32 | 98.94 |
| **Sentinel3B** | 7130000 | 7210000 | 0 | 0.007 | 98.32 | 98.94 |
| **Sentinel3C** | 7130000 | 7210000 | 0 | 0.007 | 98.32 | 98.94 |
| **JasonCSA** | 7670000 | 7750000 | 0 | 0.007 | 65.72 | 66.35 |
| **JasonCSB** | 7670000 | 7750000 | 0 | 0.007 | 65.72 | 66.35 |
| **MetOpSGA1** | 7150000 | 7230000 | 0 | 0.007 | 98.39 | 99.01 |
| **MetOpSGA2** | 7150000 | 7230000 | 0 | 0.007 | 98.39 | 99.01 |
| **MetOpSGA3** | 7150000 | 7230000 | 0 | 0.007 | 98.39 | 99.01 |
| **MetOpSGB1** | 7150000 | 7230000 | 0 | 0.007 | 98.39 | 99.01 |
| **MetOpSGB2** | 7150000 | 7230000 | 0 | 0.007 | 98.39 | 99.01 |
| **MetOpSGB3** | 7150000 | 7230000 | 0 | 0.007 | 98.39 | 99.01 |
| **Sentinel5P** | 7160000 | 7240000 | 0 | 0.007 | 98.44 | 99.05 |
| **Generic satellite** | 1000000 | 10000000 | 0 | 0.5 | 60 | 120 |
| **Generic Geostationary satellite** | 42000000 | 43000000 | 0 | 0.1 | -0.1 | 0.1 |
| **MTG** | 42000000 | 43000000 | 0 | 0.1 | -0.1 | 0.1 |
| **Generic Medium Earth Orbit satellite** | 1000000 | 30000000 | 0 | 1 | 0 | 180 |

# 6 PROPAGATION MODES

## 6.1 Envisat Operational mode

The effect of the latitude and longitude dependent geoid anomalies up to degree and order 36 (GEM-10B), as well as the effect of a medium air drag (MSIS'77) and luni-solar perturbations, have been modeled in the form of second order correction terms to the satellite position and velocity components (radial, along track, and across track).

These correction terms are function of the longitude of the true ascending node in the Earth fixed reference frame, and of the true latitude of the propagated state vector using the longitude independent mode, expressed in the True of Date reference frame.

This mode is based on the equations derived in KLINKRAD reference.

# 7 ATTITUDE MODES

The Attitude modes supported in the EO CFI SW are described in [MCD].

The following are mission specific attitude modes that are implemented and supported in the EO CFI:

*Table 7: Attitude modes*

| Mission Name | Attitude Law | Reference documentation |
|---|---|---|
| Envisat | Envisat attitude law | TBD |
| Cryosat | Cryosat attitude law | CRYO_ATT |
| ADM-Aeolus | ADM-Aeolus attitude law | ADM_AGL |
| Sentinel 1 | Sentinel 1 attitude law | S1_ATT |
| Sentinel 2 | Sentinel 2 attitude law | S2_ATT |

## 7.1 Sentinel-1 attitude law

The Sentinel-1 attitude is defined by the Roll Steering Law described in the document S1_ATT.

The law for the roll steering is:

$$\theta_{offNadir} = \theta_{ref} - \alpha_{roll}(H - H_{ref})$$

where the parameters are:

*Table 8: Definition of Sentinel-1 roll steering law*

| Parameter | Description | Value | Units |
|---|---|---|---|
| $\Theta_{offNadir}$ | Antenna bore sight off nadir angle as function of altitude | | |
| $\Theta_{ref}$ | Antenna bore sight off nadir angle at reference altitude | 29.450 | deg |
| $\alpha_{roll}$ | Roll steering sensitivity versus altitude | 0.05660 | deg/km |
| H | Actual satellite altitude | | |
| $H_{ref}$ | Reference altitude | 711.700 | km |

The actual altitude of the satellite is approximated by the following function:

$$H(t) = h_0 + \sum_{n=1}^{N} h_n \cdot \sin(n \cdot \omega_{orb} \cdot (t - t_{ANX}) + \phi_n)$$

where

*Table 9: Sentinel-1 numerical values describing altitude versus time by a series of four terms*

| Parameter | Description | Value | Units |
|---|---|---|---|
| $t_{ANX}$ | Time of ascending node crossing | | |
| $\omega_{orb}$ | Orbital frequency | $\omega_{orb} = 2\pi / T_{orb}$ | |
| $h_0$ | | 707714.8*a) | m |
| $h_1$ | | 8351.5*a) | m |
| $h_2$ | | 8947.0*a) | m |
| $h_3$ | | 23.32*a) | m |
| $h_4$ | | 11.74*a) | m |
| $\varphi_1$ | | 3.1495*a) | rad |
| $\varphi_2$ | | -1.5655*a) | rad |
| $\varphi_3$ | | -3.1297*a) | rad |
| $\varphi_4$ | | 4.7222*a) | rad |
| $T_{orb}$ | 12 days / 175 orbits | 5924.57*a) | sec |

*a) These values may have to be recalculated, depending on actual orbit data

# 8 DRS-ARTEMIS ORBIT

The EOCFI allows for Envisat the visibility computation of the DRS-Artemis Satellite:

## 8.1 DRS-Artemis Orbit Definition

The initial DRS space segment comprises the Artemis Satellite located in the GEO orbit over Europe (16.4° E). Artemis was launched the 12th of July 2001 reaching its operational orbit in xxxxx and is planned to be moved to 59º E when the first DRSS is launched (DRSENV_ICD reference).

The orbit of the DRS is known on ground to an accuracy corresponding to the following errors ± 20.0 Km along track, ± 15.0 Km across track and ± 15.0 Km radial. These accuracies are achieved for a 24 hour prediction and are achieved when UT is the time reference (DRSENV_ICD reference)

Due to launch failure the North-South station keeping is not operationally implemented. The inclination drift has not been modeled in the EO CFI Software. However it has been modelled in the Envisat CFI Software.

The CFI software will check the compliance of the DRS orbit supplied on input with a set of requirements on the main osculating Kepler elements:

*Table 10: DRS orbit tolerance requirements*

| Osculating Kepler element | Tight tolerance | Loose tolerance |
|---|---|---|
| Semi-major axis | 42000 / 43000 Km | 30000 / 50000 Km |
| Eccentricity | 0.0 / 0.1 | 0.0 / 0.9 |
| Inclination | - 0.1 / + 0.1 deg | - 1.0 / + 1.0 deg |

If the tight tolerance requirements are not satisfied, but the loose ones are, then a warning will be returned by the CFI software.

If even the loose requirements are not satisfied, then an error will be returned.

## 8.2 DRS-Artemis Orbit Propagation Model

The 24-hour prediction of DRS will be available in equinoctial elements at a given epoch valid for certain validity period, and assuming that the user will propagate this state vector, within the validity period using the following algorithm:

$$a = a_{initial}$$

$$e_x = (e_x)_{initial}$$

$$e_y = (e_y)_{initial}$$

$$i_x = (i_x)_{initial}$$

$$i_y = (i_y)_{initial}$$

$\lambda = \lambda_{initial} + (t - t_{initial})\ d\lambda_{initial}\ dt$

$d\lambda_{initial}\ dt = (\mu/a^3)^{1/2}$

$\mu = 3{,}9860044\ 10^5\ km^3/s^2$

where $a_{initial}$, $(e_x)_{initial}$, $(e_y)_{initial}$ , $(i_x)_{initial}$ , $(i_y)_{initial}$ and $\lambda_{initial}$ are the equinoctial elements at $t_{initial}$.