

# Earth Explorer Mission CFI Software

## EXPLORER\_ORBIT SOFTWARE USER MANUAL

**Code:** EE-MA-DMS-GS-0004  
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	<b>Name</b>	<b>Function</b>	<b>Signature</b>
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Issue	Change Description	Date	Approval
1.0	New document	08/11/01	
1.1	<ul style="list-style-type: none"> <li>New <code>xo_orbit_to_time</code>, <code>xo_time_to_orbit</code> and <code>xo_free_osf_records</code> functions.</li> <li><code>xo_cart_extra</code> removal</li> </ul>	23/05/02	
1.2 Draft	<ul style="list-style-type: none"> <li>Cosmetic changes</li> <li>Updated error handling</li> </ul>	19/07/02	
2.0	<ul style="list-style-type: none"> <li>Maintenance release. See change bars.</li> </ul>	29/11/02	
2.1	<ul style="list-style-type: none"> <li>Maintenance release. See change bars.</li> </ul>	13/05/03	
2.2	<ul style="list-style-type: none"> <li>New options for <code>xo_propag_init_file</code> and <code>xo_interpol_init_file</code> functions.</li> <li>Maintenance release. See change bars.</li> </ul>	30/09/03	
2.2.2	<ul style="list-style-type: none"> <li>Option to use a simplified algorithm to initialise using <code>xo_propag_init_def</code></li> <li>Absolute orbit and time since ANX calculated within <code>xo_propag_extra</code> and <code>xo_interpol_extra</code> functions.</li> <li>Nodal period calculated by <code>xo_orbit_info_from_&lt;source&gt;</code> functions</li> <li>Use of enumerations to size extra results arrays</li> </ul>	26/04/04	
3.0	<ul style="list-style-type: none"> <li>New initialisation strategy for orbit calculations, propagation and interpolation.</li> <li>New interfaces</li> </ul>	21/07/04	
3.1	<ul style="list-style-type: none"> <li>Maintenance release</li> </ul>	13/10/04	
3.2	<ul style="list-style-type: none"> <li>Maintenance release</li> </ul>	15/11/04	
3.3	<ul style="list-style-type: none"> <li>Maintenance release</li> <li>New features:               <ul style="list-style-type: none"> <li>Changes for dealing with the new library <code>explorer_datan_handling</code></li> <li>Identifier accessors.</li> <li>Support for ENVISAT ASCII files removed</li> </ul> </li> </ul>	11/07/05	
3.4	<ul style="list-style-type: none"> <li>Maintenance release</li> <li>New features:               <ul style="list-style-type: none"> <li>Orbit file generation functions moved to this library</li> </ul> </li> </ul>	18/11/05	

Issue	Change Description	Date	Approval
3.5	<ul style="list-style-type: none"> <li>• Maintenance release</li> <li>• New features:               <ul style="list-style-type: none"> <li>- time-orbit conversion executable</li> <li>- Support for SWARM and EARTH-CARE</li> </ul> </li> </ul>	26/05/06	
3.6	<ul style="list-style-type: none"> <li>• Maintenance release</li> <li>• New features:               <ul style="list-style-type: none"> <li>- xo_gen_oef</li> <li>- xo_check_osf and xo_check_oef</li> </ul> </li> </ul>	24/11/06	
3.7	<ul style="list-style-type: none"> <li>• Maintenance release</li> <li>• New features:               <ul style="list-style-type: none"> <li>- Function expcfi_check_libs</li> <li>- Library version for MAC OS X on Intel (32 and 64-bits)</li> </ul> </li> </ul>	13/07/06	
3.7.2	<ul style="list-style-type: none"> <li>• Maintenance release</li> <li>• New features:               <ul style="list-style-type: none"> <li>- TLE data for orbit operations and propagation</li> <li>- New executable: gen_oef</li> </ul> </li> </ul>	31/07/08	
3.7.3	<ul style="list-style-type: none"> <li>• Maintenance release</li> </ul>	07/05/10	
3.7.4	<ul style="list-style-type: none"> <li>• Maintenance release</li> </ul>	31/01/11	
3.7.5	<ul style="list-style-type: none"> <li>• Maintenance release</li> </ul>	19/11/13	
3.7.6	<ul style="list-style-type: none"> <li>• Maintenance release</li> </ul>	24/05/19	

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## 1 SCOPE

The EXPLORER\_ORBIT Software User Manual provides a detailed description of usage of the CFI functions included within the EXPLORER\_ORBIT CFI software library.

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## 2 ACRONYMS AND NOMENCLATURE

### 2.1 Acronyms

ANX	Ascending Node Crossing
AOCS	Attitude and Orbit Control Subsystem
CFI	Customer Furnished Item
EF	Earth Fixed reference frame
ESA	European Space Agency
ESTEC	European Space Technology and Research Centre
FOS	Flight Operations Segment
GS	Ground Station
OBT	On-board Binary Time
OSV	Orbit State Vector
SSP	Sub-Satellite Point
SRAR	Satellite Relative Actual Reference
SUM	Software User Manual
TLE	Two Line Elements
TOD	True of Date reference frame
UTC	Universal Time Coordinated
UT1	Universal Time UT1
WGS[84]	World Geodetic System 1984

### 2.2 Nomenclature

CFI	A group of CFI functions, and related software and documentation. that will be distributed by ESA to the users as an independent unit
CFI function	A single function within a CFI that can be called by the user
Library	A software library containing all the CFI functions included within a CFI plus the supporting functions used by those CFI functions (transparently to the user)

---

## 3 APPLICABLE AND REFERENCE DOCUMENTS

### 3.1 Applicable documents

[GEN\_SUM] Earth Explorer Mission CFI Software. General Software User Manual. CS-MA-DMS-GS-0002. Issue 3.7.6. 24/05/2019

### 3.2 Reference documents

[MCD] Earth Explorer Mission CFI Software. Conventions Document. EE-MA-DMS-GS-0001. Issue 3.7.6. 24/05/2019

[MSC] Earth Explorer Mission CFI Software. Conventions Document. EE-MA-DMS-GS-0018. Issue 3.7.6. 24/05/2019.

[F\_H\_SUM] Earth Explorer Mission CFI Software. EXPLORER\_FILE\_HANDLING Software User Manual. EE-MA-DMS-GS-0008. Issue 3.7.6. 24/05/2019

[DAT\_SUM] Earth Explorer Mission CFI Software. EXPLORER\_DATA\_HANDLING Software User Manual. EE-MA-DMS-GS-0007. Issue 3.7.6. 24/05/2019

[LIB\_SUM] Earth Explorer Mission CFI Software. EXPLORER\_LIB Software User Manual. EE-MA-DMS-GS-0003. Issue 3.7.6. 24/05/2019

[FORMATS] Earth Explorer File Format Guidelines. CS-TN-ESA-GS-0148.

---

## 4 INTRODUCTION

### 4.1 Functions Overview

This software library contains:

- CFI functions allowing accurate computation of orbit state vectors, either at ascending node or (by propagation) at any point in the orbit of any Earth Explorer satellite.

The orbit propagation may be performed based on different propagation models. The initial set of models supported are:

- Mean Keplerian model
- Spot model

It includes an interpolator, orbit propagator and several routines used to feed the propagator with either simulated, predicted or restituted initial state vectors.

- CFI functions required to compute the orbit scenario file, used for Earth Explorer mission planning purposes, and several orbit files useful for testing purposes (Predicted Orbit File, Restituted Orbit File, DORIS Navigator Files).

It contains:

- a library of functions which can be called from a main executable program
- a set of executable programs (1 for each function) with the exact same functionality as the functions

The following sections summarize the set of functions in this library:

#### 4.1.1 Orbit Initialisation

Before doing any orbit calculation, the orbit should be initialized using one of the following functions:

- ***xo\_orbit\_init\_def***: this software generates a cartesian state vector around the true ascending node crossings as a function of the date (processing time), the longitude of the ascending node, the satellite Repeat Cycle Length, the mean local solar time and either the drift in mean local solar time or the inclination. For the Spot model, the routine generates the Spot elements.
- ***xo\_orbit\_cart\_init***: This software initializes the orbit using as input a cartesian orbit state vector.
- ***xo\_orbit\_init\_file***: For the Mean Keplerian model, this software reads Cartesian State Vectors. For the Spot model, this routine generates the Spot elements. The following input file types are accepted:
  - Flight Dynamics predicted ascending node state vectors.
  - DORIS Navigator Data
  - FOS Restituted Orbit Files
  - DORIS Preliminary Orbit
  - DORIS Precise Orbit
  - Ascending node state vectors from the Orbit Scenario File
  - State vectors from Spot orbit files.
  - TLE files

In all cases a variable of the type `xo_orbit_id` (*Orbit ID.*) is returned. This variable is a CFI Identifier of the type described in [GEN\_SUM]. This variable keeps internally a list of orbit state vectors that will be used

in further calculations.

### 4.1.2 Orbit Propagation

- ***xo\_propag\_init***: This software initializes the propagation using a cartesian orbit state vector selected from the input Orbit ID.
- ***xo\_propag***: This software is a propagator which allows accurate prediction of osculating Cartesian state vectors for user requested time segments.

### 4.1.3 Orbit Interpolation

- ***xo\_interpol\_init***: This software initializes the interpolation process using the cartesian state vectors selected from the input Orbit ID. The initialization provides ***xo\_interpol*** with a set of orbit state vectors within a margin defined by the user.
- ***xo\_interpol***: This software generates Extended Cartesian State Vectors based on the interpolation of orbit restituted state vector. The user defines the time for which an interpolated state vector has to be generated.

### 4.1.4 Ancillary Results Computation

- ***xo\_propag\_extra***: This software returns ancillary results, i.e. mean and osculating Keplerian orbit state vectors, satellite osculating true latitude, latitude rate and latitude rate-rate, Sun zenith angle and many more.
- ***xo\_interpol\_extra***: This software returns ancillary results, i.e. cartesian orbit state vectors, cartesian orbit state vector acceleration, mean and osculating Keplerian orbit state vectors, satellite osculating true latitude, latitude rate and latitude rate-rate and Sun zenith angle.

### 4.1.5 Time/Orbit Transformation

- ***xo\_time\_to\_orbit***: This software calculates the absolute orbit, number of seconds and number of microseconds since ascending node that corresponds to a given time in processing format.
- ***xo\_orbit\_to\_time***: This software calculates the time, in processing format, that corresponds to a given absolute orbit, number of seconds and number of microseconds since ascending node.

### 4.1.6 Orbit Information Parameters

- ***xo\_orbit\_rel\_from\_abs***: This software calculates the relative orbit, the phase number giving as input an absolute orbit number.
- ***xo\_orbit\_abs\_from\_rel***: This software calculates the absolute orbit number giving as input a relative orbit number and its cycle number.
- ***xo\_orbit\_abs\_from\_phase***: This software calculates the absolute orbit number, the relative orbit, the phase number giving as input a phase number.
- ***xo\_orbit\_info***: This software calculates orbit related parameters providing as input the absolute orbit number.

### 4.1.7 File Generation

- ***xo\_gen\_osf\_create***: generates the orbit scenario file with user provided inputs
- ***xo\_gen\_osf\_append\_orbit\_change***: adds an orbit change to a previously generated OSF
- ***xo\_gen\_osf\_change\_repeat\_cycle***: adds an orbit change for a given target orbit to an existing OSF.

- *xo\_gen\_osf\_add\_drift\_cycle*: adds an orbit change for a requested orbit with a particular ascending node longitude and an orbit for the manoeuvre.
- *xo\_gen\_pof*: generates a Predicted Orbit File from several different reference input files.
- *xo\_gen\_rof* and *xo\_gen\_rof\_prototype*: generates a Restituted Orbit File from several different reference input files.
- *xo\_gen\_oef* generates an orbit event file from an orbit scenario file and a predicted orbit file. Note: Orbit Event File is deprecated, only supported for CRYOSAT mission.
- *xo\_gen\_dnf*: generates a DORIS Navigator File from several different reference input files.
- *xo\_gen\_tle*: generates a TLE file from a Predicted Orbit file.

#### 4.1.8 Clean-up Memory

- *xo\_orbit\_close*: This software frees the memory allocated by the orbit initialization routines. It closes the *xo\_orbit\_id*, so that it cannot be used for further computations.
- *xo\_propag\_close*: This software frees the memory allocated by the *xo\_propag\_init* routine. It closes the *xo\_propag\_id*, so that it cannot be used for further computations.
- *xo\_interpol\_close*: This software frees the memory allocated by the *xo\_interpol\_init* routine. It closes the *xo\_interpol\_id*, so that it cannot be used for further computations.

#### 4.1.9 Check Orbit files

- *xo\_check\_osf*: checks the continuity between the last orbit of an orbital change and the next orbit in an orbit scenario file.
- *xo\_check\_oef*: checks the consistency between the list of the orbital changes and the list of orbit state vectors in an orbit event file. Note: Orbit Event File is deprecated, only supported for CRYOSAT mission.

## 4.2 Orbit Propagation Calling Sequence

A complete propagation sequence consists of:

- A call to any of the initialization routines for orbit, *xo\_orbit\_init\_def*, *xo\_orbit\_init\_file* or *xo\_orbit\_cart\_init*, to generate the internal data necessary for whatever calculation involving orbits.
- A call to the *xo\_propag\_init* function for generate the internal data necessary for the propagation routines.
- An optional call to *xo\_propag\_extra* to calculate any desired ancillary result related to the initializing state vector.
- After initialization, the *xo\_propag* routine should be called to perform the orbit propagation, taking into account the validity times computed during initialization.
- To obtain some ancillary results, the user might call the *xo\_propag\_extra* function.
- At the end of a sequence is mandatory to call *xo\_propag\_close* to free the memory allocated.

The possible propagation sequences of calls allowing to produce an orbit state vector are shown in figure 1.

## 4.3 Orbit Interpolation Calling Sequence

A complete interpolation sequence consists of:

- A call to any of the initialization routines for orbit, *xo\_orbit\_init\_def*, *xo\_orbit\_init\_file* or *xo\_orbit\_cart\_init*, to generate the internal data necessary for whatever calculation involving orbits.
- A call to the *xo\_interpol\_init* routine, to generate the orbit state vector for the interpolation.
- *xo\_interpol* function utilises the data generated during the initialisation to perform the interpolation.
- To obtain extra ancillary results, the user might call the *xo\_interpol\_extra* function.
- At the end of a sequence is mandatory to call *xo\_interpol\_close* to free the memory allocated.

The possible interpolation sequences of calls allowing to produce an orbit state vector are shown in figure 1.

## 4.4 Time/Orbit Transformation and Orbit Information Parameters Calling Sequence

A complete time/orbit transformation and orbit information parameters sequence consists of:

- A call to any of the initialization routines for orbit, *xo\_orbit\_init\_def*, *xo\_orbit\_init\_file* or *xo\_orbit\_cart\_init*, to generate the internal data necessary for whatever calculation involving orbits. Note that time to orbit transformations cannot be computed if the orbit was initialised with *xo\_orbit\_cart\_init*.
- A call to a *time/orbit transformation* or an *orbit information parameters* routine.
- When no more *time/orbit transformations* and *orbit information parameters* routines are going to be used, call to *xo\_orbit\_close* to free the memory allocated.

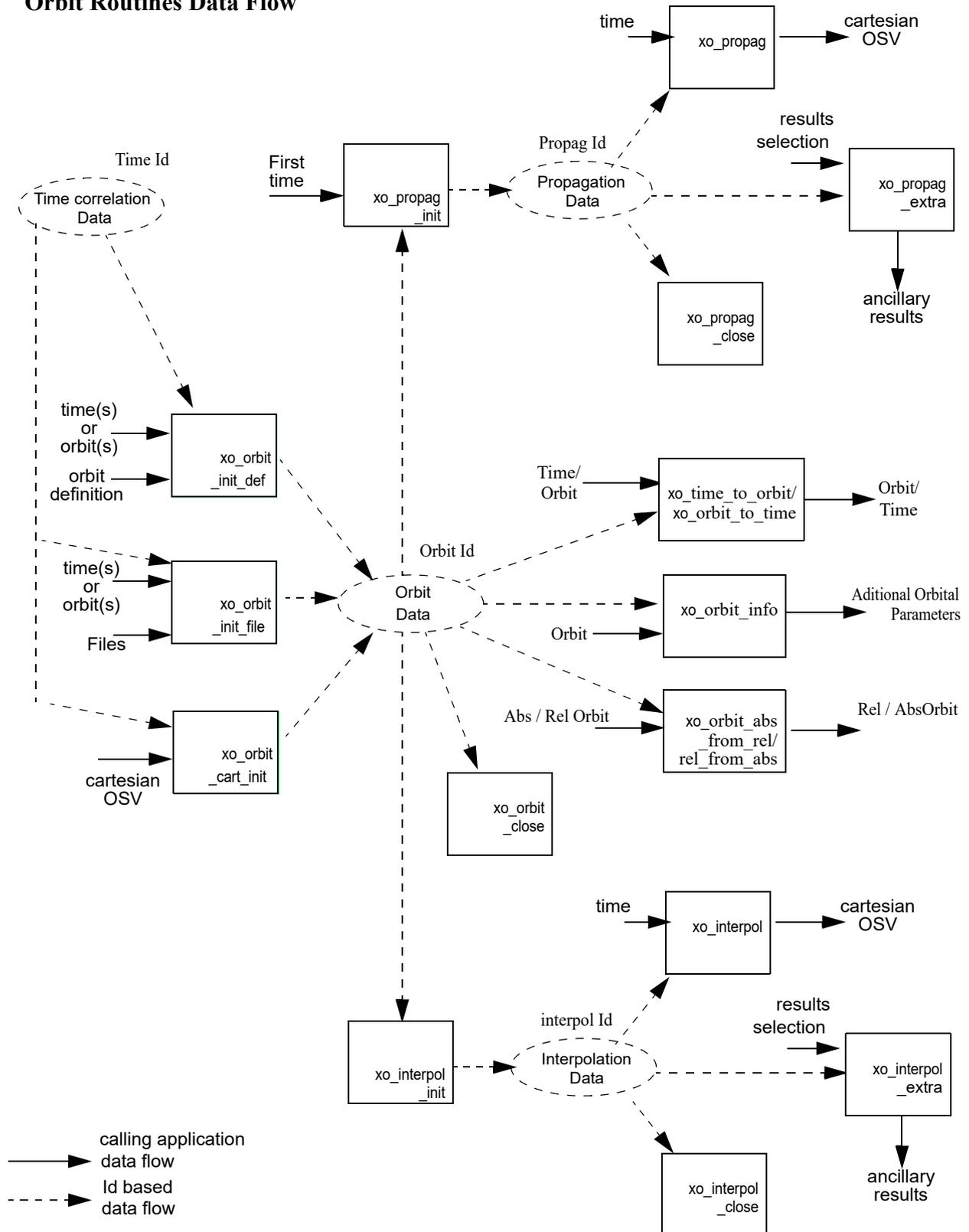
The possible time/orbit transformation and orbit information parameters sequences of calls allowing to produce an orbit state vector are shown in figure 1.

A detailed description of each function is provided in section 7. Please refer also to:

- [MCD] for a detailed description of the time references and formats, reference frames, parameters and models used in this document.
- [GEN\_SUM] for a complete overview of the CFI, and in particular the detailed description of the *Id* concept and the error handling functions.

**Figure 1: Orbit Calling Sequence**

**Orbit Routines Data Flow**



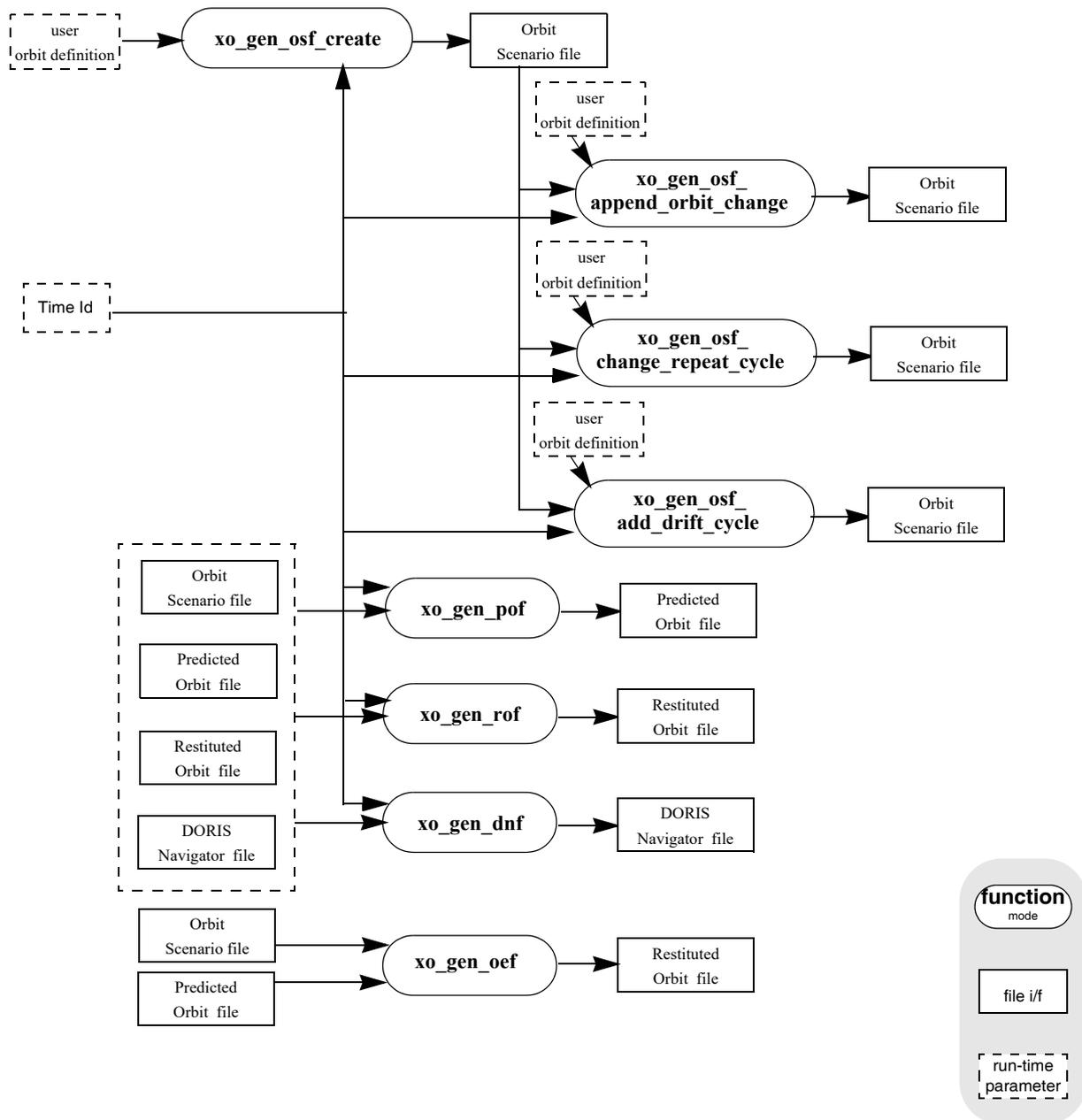
## 4.5 File Generation Calling Sequence

The calling sequence for the file generators consists of:

- One call to a time initialization routine
- One call to the generation routine providing the input parameters. For **xo\_gen\_pof**, **xo\_gen\_rof**, **xo\_gen\_oef** and **xo\_gen\_dnf** a reference orbit file has to be provided as well.

The following figure shows an schema of the calling sequence:

Figure 2: File Generation Calling Sequence



## 5 LIBRARY INSTALLATION

For a detailed description of the installation of any CFI library, please refer to [GEN\_SUM].

Note that example data files are provided with this CFI:

- Orbit files to be used with *xo\_orbit\_init\_file*

These files are orbit file examples.

## 6 LIBRARY USAGE

Note that to use the EXPLORER\_ORBIT software library, the following other CFI software libraries are required:

- EXPLORER\_FILE\_HANDLING (See [F\_H\_SUM]).
- EXPLORER\_DATA\_HANDLING
- EXPLORER\_LIB (See [LIB\_SUM]).

It is also needed to have properly installed in the system the following external GPL library:

- LIBXML2 (see [GEN\_SUM]).

and the POSIX thread library:

- libpthread.so (pthread.lib for WINDOWS)

To use the EXPLORER\_ORBIT software library in a user application, that application must include in its source code:

- `explorer_orbit.h` (for a C application)

To link correctly this application, the user must include in his linking command flags like (assuming `cfi_lib_dir` and `cfi_include_dir` are the directories where respectively all CFI libraries and include files have been installed, see [GEN\_SUM] for installation procedures):

- SOLARIS/LINUX:

```
-Icfi_include_dir -Lcfi_lib_dir
-lexplorer_orbit -lexplorer_lib
-lexplorer_data_handlingexplorer_file_handling
-lxml2 -lpthread
```

- WINDOWS:

```
/I "cfi_include_dir" /libpath:"cfi_lib_dir"
libexplorer_orbit.lib
libexplorer_lib.lib
libexplorer_data_handling.lib
libexplorer_file_handling.lib
libxml2.lib pthread.lib
```

- MacOS:

```
-Icfi_include_dir -Lcfi_lib_dir
-lexplorer_orbit -lexplorer_lib
-lexplorer_data_handling -lexplorer_file_handling
-lpthread
-framework libxml
-framework libiconv
```

All functions described in this document have a name starting with the prefix `xo_`.

To avoid problems in linking a user application with the EXPLORER\_ORBIT software library due to the existence of names multiple defined, the user application should avoid naming any global software item beginning with either the prefix `XO_` or `xo_`.

This is summarized in table 1.

*Table 1: CFI functions included within EXPLORER\_ORBIT library*

Function Name	Enumeration value	long
Main CFI Functions		
xo_orbit_init_def	XO_ORBIT_INIT_DEF_ID	0
xo_orbit_cart_init	XO_ORBIT_CART_INIT_ID	1
xo_orbit_init_file	XO_ORBIT_INIT_FILE_ID	2
xo_orbit_close	XO_ORBIT_CLOSE_ID	3
xo_propag_init	XO_PROPAG_INIT_ID	4
xo_propag	XO_PROPAG_ID	5
xo_propag_extra	XO_PROPAG_EXTRA_ID	6
xo_propag_close	XO_PROPAG_CLOSE_ID	7
xo_interpol_init	XO_INTERPOL_INIT_ID	8
xo_interpol	XO_INTERPOL_ID	9
xo_interpol_extra	XO_INTERPOL_EXTRA_ID	10
xo_interpol_close	XO_INTERPOL_CLOSE_ID	11
xo_orbit_to_time	XO_ORBIT_TO_TIME_ID	12
xo_time_to_orbit	XO_TIME_TO_ORBIT_ID	13
xo_orbit_abs_from_rel	XO_ORBIT_ABS_FROM_REL_ID	14
xo_orbit_rel_from_abs	XO_ORBIT_REL_FROM_ABS_ID	15
xo_orbit_abs_from_phase	XO_ORBIT_ABS_FROM_PHASE_ID	16
xo_orbit_info	XO_ORBIT_INFO_ID	17
xo_osv_to_tle	XO_OSV_TO_TLE_ID	18
xo_run_init	XO_RUN_INIT_ID	19
xo_gen_oef	XO_GEN_OEF_ID	20
xo_gen_osf_create	XO_GEN_OSF_CREATE_ID	21
xo_gen_osf_append_orbit_change	XO_GEN_OSF_APPEND_ORBIT_CHANGE_ID	22
xo_gen_osf_change_repeat_cycle	XO_GEN_OSF_CHANGE_REPEAT_CYCLE_ID	23
xo_gen_osf_add_drift_cycle	XO_GEN_OSF_ADD_DRIFT_CYCLE_ID	24
xo_gen_pof	XO_GEN_POF_ID	25

*Table 1: CFI functions included within EXPLORER\_ORBIT library*

Function Name	Enumeration value	long
xo_gen_rof	XO_GEN_ROF_ID	26
xo_gen_rof_prototype	XO_GEN_ROF_PROTOTYPE_ID	27
xo_gen_dnf	XO_GEN_DNF_ID	28
xo_gen_tle	XO_GEN_TLE_ID	29
xo_check_osf	XO_CHECK_OSF_ID	30
xo_check_oef	XO_CHECK_OEF_ID	31
Error Handling Functions		
xo_verbose	not applicable	
xo_silent		
xo_get_code		
xo_get_msg		
xo_print_msg		

Notes about the table:

- To transform the status vector returned by a CFI function to either a list of error codes or list of error messages, the enumeration value (or the corresponding integer value) described in the table must be used.
- The error handling functions have no enumerated value.
- Orbit Event File is deprecated, only supported for CRYOSAT mission.

## 6.1 Usage hints

Every CFI function has a different length of the Error Vector, used in the calling I/F examples of this SUM and defined at the beginning of the library header file. In order to provide the user with a single value that could be used as Error Vector length for every function, a generic value has been defined (`XO_ERR_VECTOR_MAX_LENGTH`) as the maximum of all the Error Vector lengths. This value can therefore be safely used for every call of functions of this library.

## 6.2 General enumerations

The aim of the current section is to present the enumeration values that can be used rather than integer parameters for some of the input parameters of the EXPLORER\_ORBIT routines, as shown in the table below. The enumerations presented in [GEN\_SUM] are also applicable.

*Table 2: Some enumerations within EXPLORER\_ORBIT library*

Input	Description	Enumeration value	Long
Propagation model	Mean Kepler elements model	XO_PROPAG_MODEL_MEAN_KEPL	0
	SPOT elements model	XO_PROPAG_MODEL_SPOT	1
	TLE model	XO_PROPAG_MODEL_TLE	2
	Auto initialization mode	XO_PROPAG_MODEL_AUTO	10
	Double initialization mode	XO_PROPAG_MODEL_DOUBLE	100
Non Sun-synchronous orbit characterisation	MLST drift	XO_NOSUNSYNC_DRIFT	0
	Inclination	XO_NOSUNSYNC_INCLINATION	1
	Selection of simplified algorithm (additive value)	XO_NOSUNSYNC_USE_SIM_MODEL	10
Time inputs selection	Select the whole file	XO_SEL_FILE	0
	Time	XO_SEL_TIME	1
	Orbit	XO_SEL_ORBIT	2
	Default value	XO_SEL_DEFAULT	3
Orbit_info vector results calculation switch	Orbit_info vector results not calculated	XO_ORBIT_INFO_EXTRA_OFF	0
	Orbit_info vector results calculated	XO_ORBIT_INFO_EXTRA_ON	1
Interpolation model	Default	XO_INTERPOL_MODEL_DEFAULT	0
Orbit Init Model	Unknown mode	XO_ORBIT_INIT_UNKNOWN_MODE	-1
	Automatic detection of file	XO_ORBIT_INIT_AUTO	0
	Orbit Change mode	XO_ORBIT_INIT_ORBIT_CHANGE_MODE	1
	State Vector mode	XO_ORBIT_INIT_STATE_VECTOR_MODE	2
	Orbit Scenario File mode	XO_ORBIT_INIT_OSF_MODE	3
	Predicted Orbit File mode	XO_ORBIT_INIT_POF_MODE	4
	Restituted Orbit File mode	XO_ORBIT_INIT_ROF_MODE	5
	DORIS mode	XO_ORBIT_INIT_DORIS_MODE	5
	POF refined with DORIS mode	XO_ORBIT_INIT_POF_N_DORIS_MODE	7
	OSF part of the OEF mode	XO_ORBIT_INIT_OEF_OSF_MODE	8
	POF part of the OEF mode	XO_ORBIT_INIT_OEF_POF_MODE	9
	TLE file	XO_ORBIT_INIT_TLE_MODE	10
	Maximum value of enumeration	XO_ORBIT_INIT_MAX_VALUE	11
Phase increment	Do not increment phase number at next orbit change	XO_NO_PHASE_INCREMENT	0

*Table 2: Some enumerations within EXPLORER\_ORBIT library*

Input	Description	Enumeration value	Long
	Do increment phase number at next orbit change	XO_PHASE_INCREMENT	1
Orbit change search direction	Search forward	XO_SEARCH_FORWARD	1
	Search backward	XO_SEARCH_BACKWARD	-1
File Type	Orbit Scenario File	XO_REF_FILETYPE_OSF	1
	FOS Predicted Orbit File	XO_REF_FILETYPE_POF	2
	DORIS Navigator File	XO_REF_FILETYPE_DORIS_NAV	3
	FOS Restituted Orbit File	XO_REF_FILETYPE_ROF	4
	DORIS Preliminary Orbit File	XO_REF_FILETYPE_DORIS_PREM	5
	DORIS Precise Orbit File	XO_REF_FILETYPE_DORIS_PREC	6
Precision for ROF and DORIS state vectors times	Default value, non-precise	XO_OSV_PRECISE_NO	1
	Precise location every integer minute	XO_OSV_PRECISE_MINUTE	2
	Precise location every ten seconds	XO_OSV_PRECISE_TEN_SECONDS	3
Number of parameters for Orbit file checking	Number of parameters to check in the functions for checking orbit files	XO_NUM_CHECK_PARAMS	6
TLE generation mode	The requested range of OSV are fitted to one TLE	XO_FIT_TLE	0
	One TLE is generated for every OSV	XO_ONE_TLE_PER_OSV	1

Note: Orbit Event File is deprecated, only supported for CRYOSAT mission

The use of the previous enumeration values could be restricted by the particular usage within the different CFI functions. The actual range to be used is indicated within a dedicated reference named **allowed range**. When there are not restrictions to be mentioned, the allowed range column is populated with the label **complete**.

## 6.3 Data Structures

The aim of the current section is to present the data structures that are used in the EXPLORER\_ORBIT library. The structures are currently used for the CFI Identifiers accessor functions. The following table show the structures with their names and the data that contain:

*Table 3: EXPLORER\_ORBIT structures*

Structure name	Data		
	Variable Name	C type	Description
xo_osv_rec	tai_time	double	TAI time for the state vector
	utc_time	double	UTC time for the state vector
	ut1_time	double	UT1 time for the state vector
	abs_orbit	long	Absolute orbit number
	ref_frame	long	Reference frame of OSV
	pos	double[3]	position of the OSV (x, y, z) components
	vel	double[3]	velocity of the OSV (x, y, z) components
	quality	double	Quality index
xo_anx_extra_info	abs_orbit	long	Absolute orbit number
	tanx	double	ANX time (UT1)
	tnod	double	Nodal period of the orbit
xo_mission_info	abs_orbit	long	Absolute orbit number
	rel_orbit	long	Relative orbit number
	cycle_num	long	Cycle number
	phase_num	long	Phase number
xo_ref_orbit_info	drift_mode	long	Non Sun-synchronous orbit characterisation (see table 2 for possible values)
	inclination	double	Orbit inclination
	rep_cycle	long	Repeat cycle (days)
	cycle_len	long	Cycle length (orbits)
	ANX_long	double	ANX longitude
	mlst	double	MLST for the ANX
	mlst_drift	double	MLST drift

**Table 3: EXPLORER\_ORBIT structures**

Structure name	Data		
	Variable Name	C type	Description
xo_anx_info	anx_tai	double	TAI time for the ANX
	anx_utc	double	UTC time for the ANX
	anx_ut1	double	UT1 time for the ANX
	anx_pos	double[3]	Position vector
	anx_vel	double[3]	Velocity vector
	kepl	double[6]	Keplerian elements
	tnod	double	Nodal period
xo_osf_records	mission_info	xo_mission_info	Orbit numbers
	ref_orbit_info	xo_ref_orbit_info	Orbit Geometry data
	anx_info	xo_anx_info	ANX Data
xo_validity_time	time_ref	long	Time reference
	start	double	Validity star time
	stop	double	Validity stop time
xo_uni_propag	time_ref	long	Time reference in use
	val_time	xo_validity_time	validity propagation time range in UT1 time
	abs_orbit	long	Predicted Absolute orbit
	time_since_anx	double	Time since ANX
	time	double	Predicted time (UT1)
	pos	double[3]	Osculating position vector at pred. time (EF)
	vel	double[3]	Osculating velocity vector at pred. time (EF)
	acc	double[3]	Osculating acceleration vector at pred. time (EF)
x	double[6];	Osculating keplerian elements at pred. time (TOD)	
xo_propag_id_data	double_propag_flag	long	XL_TRUE if the using double propagation
	accu_mode	long	Flag to indicate if using high or low accuracy mode: 1 = low accuracy 2= high accuracy
	propag_osv	xo_uni_propag	Reference data for propagation

*Table 3: EXPLORER\_ORBIT structures*

Structure name	Data		
	Variable Name	C type	Description
xo_interpol_id_data	time_ref	long	Time reference
	time	double	Time for the interpol reference state vector
	abs_orbit	long	Absolute orbit number
	time_since_anx	double	Time since ANX
	pos	double[3]	Position vector
	vel	double[3]	Velocity vector
	acc	double[3]	Acceleration vector
	kep	double[6];	Keplerian elements

## 7 CFI FUNCTIONS DESCRIPTION

The following sections describe each CFI function.

Input and output parameters of each CFI function are described in tables, where C programming language syntax is used to specify:

- Parameter types (e.g. long, double)
- Array sizes of N elements (e.g. param[N])
- Array element M (e.g. [M])

---

## 7.1 xo\_orbit\_init\_def

### 7.1.1 Overview

The **xo\_orbit\_init\_def** routine generates a Cartesian orbit state vector around the true ascending node crossings. The result is stored and returned through the **xo\_orbit\_id** variable so that can fed other routines involving orbit calculations. The data generated by the **xo\_orbit\_init\_def** function is based on:

- Date (processing time),
- Longitude of the ascending node,
- Satellite Repeat Cycle and Cycle Length
- Mean local solar time at ascending node
- Drift of mean local solar time or the inclination

The user should take into account that **xo\_orbit\_init\_def** only retrieve and stores internal data for one orbit.

The validity start and stop times of the initialization (**val\_time0** and **val\_time1** output parameters) represents the allowed time window for orbit calculations. If the **xo\_orbit\_init\_def** function is called, this time window starts at 01/01/1950 00:00:00 and ends at 31/12/2099 23:59:59.

Before calling this function it is required to initialise the time correlations, using either **xl\_time\_ref\_init** or **xl\_time\_ref\_init\_file** EXPLORER LIB functions (see [LIB\_SUM]).

**Warning:** The algorithm used in this function is only valid for satellites with a finite valid range for the inclination and the semi-major axis of the orbit. In CRYOSAT, for example, as there are no minimum and maximum values defined of these two orbital elements, there are defined provisional ranges of the same size as the ones defined in ENVISAT until new requirements are defined. The nominal values have been taken from the [MCD]. There is not available any other nominal orbital element for any other satellite, so this routine is only valid (at this moment) for both CRYOSAT and ENVISAT.

A complete calling sequence of the orbit calculations procedure is presented in section 4.2.

## 7.1.2 Calling interface

The calling interface of the `xo_orbit_init_def` CFI function is the following (input parameters are underlined):

```
#include <explorer_orbit.h>
{
    long sat_id, propag_model, time_ref, time_init_mode;
    xl_time_id time_id = {NULL};
    xo_orbit_id orbit_id = {NULL};
    long drift_mode, irep, icyc;
    long orbit0, orbit;
    double time0, time, val_time0, val_time1;
    double ascmlst_drift, inclination, rlong, ascmlst;
    long status, ierr[XO_NUM_ERR_ORBIT_INIT_DEF];
    status = xo_orbit_init_def (&sat_id, &time_id,
                               &time_ref, &time0, &orbit0,
                               &drift_mode,
                               &ascmlst_drift, &inclination,
                               &irep, &icyc, &rlong, &ascmlst,
                               &val_time0, &val_time1,
                               &orbit_id, ierr);
}
```

### 7.1.3 Input parameters

The `xo_orbit_init_def` CFI function has the following input parameters:

Table 4: Input parameters of `xo_orbit_init_def` function

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
sat_id	long *	-	Satellite ID	-	Complete
time_id	xl_time_id*	-	Structure that contains the time correlations	-	-
time_ref	long*	-	Time reference ID	-	Complete
time0	double*	-	Reference time	Decimal days (Processing format)	[-18262.0,36524.0]
orbit0	long*	-	Absolute orbit number of the reference orbit	-	>= 0
drift_mode	long*	-	Flag to select between drift in mean local solar time and inclination as input characterization of the reference orbit. <u>Note:</u> When initializing a Sun-synchronous orbit, the selected drift mode must be <code>XO_NOSUNSYNC_DRIFT</code> and the <code>ascmlst_drift</code> parameter must be set to zero.  <u>Note 2:</u> Add <code>XO_NOSUNSYNC_USE_SIM_MODEL</code> to the drift mode to select the simplified model in the algorithm.	-	<code>XO_NOSUNSYNC_DRIFT</code> , <code>XO_NOSUNSYNC_INCLINATION</code> , <code>XO_NOSUNSYNC_DRIFT + XO_NOSUNSYNC_USE_SIM_MODEL</code> , <code>XO_NOSUNSYNC_INCLINATION + XO_NOSUNSYNC_USE_SIM_MODEL</code>
ascmlst_drift	double*	-	If <code>drift_mode = XO_NOSUNSYNC_DRIFT</code> Drift in mean local solar time of the reference orbit: $\cdot MLST[N+1]=MLST[N]+MLSTdrift$ See <code>drift_mode</code> entry in this table.	seconds/day	TBD
inclination	double*	-	If <code>drift_mode = XO_NOSUNSYNC_INCLINATION</code> Inclination of the reference orbit	deg	[0,180]
irep	long *	-	Repeat cycle of the reference orbit The actual repeat cycle is calculated as per definition included in [MCD].	days	> 0
icyc	long *	-	Cycle length of the reference orbit	orbits	> 0

*Table 4: Input parameters of xo\_orbit\_init\_def function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
rlong	double*	-	Geocentric longitude of the [Earth fixed] ascending node (Earth fixed CS)	deg	[0,360)
ascmlst	double*	-	Mean local solar time at ascending node	Decimal hours	[0, 24)

It is possible to use enumeration values rather than integer values for some of the input arguments:

- Satellite ID: `sat_id`. See [GEN\_SUM].
- Time reference ID: `time_ref`. See [GEN\_SUM].
- Time initialisation mode: `time_init_mode`. See [GEN\_SUM].
- Drift mode: `drift_mode`. Current document, section 6.2.

### 7.1.4 Output parameters

The output parameters of the `xo_orbit_init_def` CFI function are:

*Table 5: Output parameters of xo\_orbit\_init\_def function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
<code>xo_orbit_init_def</code>	long	-	Main status flag	-	-1, 0, +1
<code>val_time0</code>	double*	-	Validity start time of the initialization	Decimal days (Processing format)	[-18262.0,36524.0]
<code>val_time1</code>	double*	-	Validity stop time of the initialization	Decimal days (Processing format)	[-18262.0,36524.0]
<code>orbit_id</code>	<code>xo_orbit_id*</code>	-	Structure that contains the orbit initialization.	-	-
<code>ieerr[XO_NUM_ERR_ORBIT_INIT_DEF]</code>	long	all	Status vector	-	-

### 7.1.5 Warnings and errors

Next table lists the possible error messages that can be returned by the `xo_orbit_init_def` CFI function after translating the returned status vector into the equivalent list of error messages by calling the function of the EXPLORER\_ORBIT software library `xo_get_msg` (see [GEN\_SUM]).

This table also indicates the type of message returned, i.e. either a warning (WARN) or an error (ERR), the cause of such a message and the impact on the performed calculation, mainly on the results vector.

The table is completed by the error code and value. These error codes can be obtained translating the status vector returned by the `xo_orbit_init_def` CFI function by calling the function of the EXPLORER\_ORBIT software library `xo_get_code` (see [GEN\_SUM]).

*Table 6: Error messages of xo\_orbit\_init\_def function*

Error type	Error message	Cause and impact	Error code	Error No
ERR	Wrong satellite flag	No calculation performed	XO_CFI_ORBIT_INIT_DEF_SAT_ERR	0
ERR	Wrong input flag: %s	No calculation performed	XO_CFI_ORBIT_INIT_DEF_FLAG_ERR	1
ERR	Could not perform a time transformation	No calculation performed	XO_CFI_ORBIT_INIT_DEF_TIME_CHANGE_ERR	2
ERR	Input out of range: %s	No calculation performed	XO_CFI_PROPAG_INIT_DEF_INPUTS_ERR	3
ERR	An error occurred in the genstate routine	No calculation performed	XO_CFI_PROPAG_INIT_DEF_GENSTATE_ERR	4
ERR	Memory Error	No calculation performed	XO_CFI_ORBIT_INIT_DEF_MEMORY_ERR	5

### **7.1.6 Runtime performances**

The following runtime performance has been measured.

*Table 7: Runtime performances of xo\_orbit\_init\_def function*

Solaris 32-bit. [ms]	Solaris 64 bit. [ms]	Linux 32-bit. [ms]	Linux 64-bit. [ms]
1.232	0.316	0.369	0.127

## 7.2 xo\_orbit\_cart\_init

### 7.2.1 Overview

This software initializes the orbit data using as input a Cartesian orbit state vector.

The validity start and stop times of the initialization (*val\_time0* and *val\_time1* output parameters) represents the allowed time window for orbit calculations. If the **xo\_orbit\_cart\_init** function is called, this time window starts at 01/01/1950 00:00:00 and ends at 31/12/2099 23:59:59.

Before calling this function it is required to initialise the time correlations, using either **xl\_time\_ref\_init** or **xl\_time\_ref\_init\_file** EXPLORER LIB functions (see [LIB\_SUM]).

A complete calling sequence of the orbit calculations procedure is presented in section 4.2.

### 7.2.2 Calling interface

The calling interface of the **xo\_orbit\_cart\_init** CFI function is the following (input parameters are underlined):

```
#include <explorer_orbit.h>
{
    xl_time_id time_id = {NULL};
    xo_orbit_id orbit_id = {NULL};
    long sat_id, time_ref, abs_orbit;
    double time, pos[3], vel[3], val_time0, val_time1;
    long status, ierr[XO_NUM_ERR_ORBIT_CART_INIT];
    status = xo_orbit_cart_init(&sat_id, &time_id,
                               &time_ref, &time,
                               &pos, &vel, &abs_orbit,
                               &val_time0, &val_time1,
                               &orbit_id, ierr);
}
```

### 7.2.3 Input parameters

The `xo_orbit_cart_init` CFI function has the following input parameters:

*Table 8: Input parameters of `xo_orbit_cart_init` function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
sat_id	long *	-	Satellite ID	-	Complete
time_id	xl_time_id*	-	Structure that contains the time correlations	-	-
time_ref	long*	-	Time reference ID	-	Complete
time	double*	-	Reference time	Decimal days (Processing format)	[-18262.0,36524.0]
pos	double[3]	all	Initial osculating position vector (X, Y, Z) (EF reference frame)	m	-
vel	double[3]	all	Initial osculating velocity vector (X, Y, Z) (EF reference frame)	m/s	-
abs_orbit	long*	-	Orbit of the state vector	-	> 0

It is possible to use enumeration values rather than integer values for some of the input arguments:

- Satellite ID: `sat_id`. See [GEN\_SUM].
- Time reference ID: `time_ref`. See [GEN\_SUM].

### 7.2.4 Output parameters

The output parameters of the `xo_orbit_cart_init` CFI function are:

*Table 9: Output parameters of `xo_orbit_cart_init` function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
xo_propag_cart_init	long	-	Main status flag	-	-1, 0, +1
val_time0	double*	-	Validity start time of the initialization	Decimal days (Processing format)	[-18262.0,36524.0]
val_time1	double*	-	Validity stop time of the initialization	Decimal days (Processing format)	[-18262.0,36524.0]
orbit_id	xo_orbit_id*	-	Structure that contains the orbit initialization.	-	-
ier[ <code>XO_NUM_ERR_ORBIT_CART_INIT</code> ]	long	all	Status vector	-	-

### 7.2.5 Warnings and errors

Next table lists the possible error messages that can be returned by the **xo\_orbit\_cart\_init** CFI function after translating the returned status vector into the equivalent list of error messages by calling the function of the EXPLORER\_ORBIT software library **xo\_get\_msg** (see [GEN\_SUM]).

This table also indicates the type of message returned, i.e. either a warning (WARN) or an error (ERR), the cause of such a message and the impact on the performed calculation, mainly on the results vector.

The table is completed by the error code and value. These error codes can be obtained translating the status vector returned by the **xo\_orbit\_cart\_init** CFI function by calling the function of the EXPLORER\_ORBIT software library **xo\_get\_code** (see [GEN\_SUM]).

*Table 10: Error messages of xo\_orbit\_cart\_init function*

Error type	Error message	Cause and impact	Error code	Error No
ERR	Wrong Satellite Id.	No calculation performed	XO_CFI_ORBIT_CART_INIT_SAT_ERR	0
ERR	Wrong input flag	No calculation performed	XO_CFI_ORBIT_CART_INIT_FLAG_ERR	1
ERR	Input Time Id. is not initialized.	No calculation performed	XO_CFI_ORBIT_CART_INIT_TIME_STATUS_ERR	2
ERR	Orbit Id is already initialized.	No calculation performed	XO_CFI_ORBIT_CART_INIT_STATUS_ERR	3
ERR	Time conversion error.	No calculation performed	XO_CFI_ORBIT_CART_INIT_TIME_TRANSFORMING_ERR	4
ERR	Time out of limits.	No calculation performed	XO_CFI_ORBIT_CART_INIT_TIME_RANGE_ERR	5
ERR	Memory allocation error.	No calculation performed	XO_CFI_ORBIT_CART_INIT_MEMORY_ERR	6

### 7.2.6 Runtime performances

The following runtime performance has been measured.

*Table 11: Runtime performances of xo\_orbit\_cart\_init function*

Solaris 32-bit. [ms]	Solaris 64 bit. [ms]	Linux 32-bit. [ms]	Linux 64-bit. [ms]
0.166	0.029	0.039	0.0048

## 7.3 xo\_orbit\_init\_file

### 7.3.1 Overview

The **xo\_orbit\_init\_file** function is used for initializing the orbit calculations using one of these orbit files:

- One or more FOS Predicted ascending node cartesian state vectors file. In case multiple files are used, the files should be time ordered and the gap between them (i.e. time difference between the last vector of nth file and the first vector of the nth+1 file) should be less than two orbital periods.
- One FOS Predicted Orbit File plus a DORIS Navigator unconsolidated level-0 products file.
- One Orbit Scenario File providing orbital changes.
- One or more Orbit Event files. Note: Orbit Event File is deprecated, only supported for CRYOSAT mission
- One or more FOS Restituted orbit files.
- One or more DORIS Navigator files.
- One or more DORIS Predicted files.
- One or more DORIS Preliminary files.
- State vectors from Spot orbit files.
- TLE files. In this case it could be necessary use the function **xl\_set\_tle\_sat\_data** before calling **xo\_orbit\_init\_file**.

The format of these files is described in [FORMATS].

Before calling this function it is required to initialise the time correlations, using either **xl\_time\_ref\_init** or **xl\_time\_ref\_init\_file** EXPLORER LIB functions (see [LIB\_SUM]).

In order to get consistent results, the time correlations defined in the `time_id` shall be identical to those defined in the orbit file. In order to achieve this, the user is strongly recommended to initialize the `time_id` using the same orbit file with the function **xl\_time\_ref\_init\_file**. If time correlations in the `time_id` and the orbit file are not matching, **xo\_orbit\_init\_file** issues a warning and recomputes the times of the orbit file records to make them compatible with the `time_id` correlations. The input parameter `time_ref` is used as base for such re-computation.

For example, if the orbit file is a POF and `time_ref` is UTC, the UTC times are left unchanged but the TAI and UT1 times are recomputed applying to the UTC times the `time_id` correlations.

For Orbit Scenario Files (OSF), the time reference is always UT1 and, in case the time correlation defined in the `time_id` differs from the one defined in the OSF, a warning is issued and, in computations using the orbit file, the time correlation defined in the `time_id` will prevail. For example, in the computation of a state vector at a given UTC time, the input UTC time is converted to UT1 using the time correlation in the `time_id` and not the one in the OSF. Therefore, the user must be aware that, using a `time_id` with a time correlation different from the one defined in the OSF, he is altering the orbit model defined in the OSF and he has to expect results different from those computed by systems that are using the OSF with the correct time correlation (this is often the case of planning systems). In order to avoid this inconsistency, it is always strongly advised to initialize the `time_id` using the same OSF file.

The user can select the time interval to be used from the input file(s) using three different ways:

*Table 12: User requested time range in xo\_orbit\_init\_file*

time_mode (see 7.16.3)	input parameter	requested start time (t_req_start)	requested stop time (t_req_stop)
XL_SEL_TIME	time0 / time1	time0	time1
XL_SEL_ORBIT	orbit0 / orbit1	t <sub>ANX</sub> (orbit0)	t <sub>ANX</sub> (orbit1)
XL_SEL_FILE	-	first state vector in the file(s)	last state vector in the file(s)

The validity start and stop times of the initialization (**val\_time0** and **val\_time1** output parameters) represents the allowed time window for orbit calculation. The following table shows the validity time interval for the different input files:

*Table 13: Validity periods for xo\_orbit\_init\_file*

Input file type	val_time0	val_time1
Orbit file providing Orbit changes	ANX Time of the first orbital change	Infinity
Orbit files providing a list of orbital state vectors	time of the first state vector	Time of the last state vector
TLE files	time of the first TLE	Time of the last TLE + 1day

A complete calling sequence of the orbit calculation procedure is presented in section 4.2

### 7.3.2 Calling interface

The calling interface of the **xo\_orbit\_init\_file** CFI function is the following (input parameters are underlined):

```
#include <explorer_orbit.h>
{
    xl_time_id time_id = {NULL};
    xo_orbit_id orbit_id = {NULL};
    long sat_id;
    long orbit_file_mode;
    long n_files, time_mode;
    long time_ref, orbit0, orbit1;
    char **input_files;
    double time0, time1, val_time0, val_time1;
    long status, ierr[XO_NUM_ERR_ORBIT_INIT_FILE];
}
```

```

status = xo_orbit_init_file (&sat_id, &time_id,
                             &orbit_file_mode, &n_files,
                             input_files,
                             &time_mode, &time_ref,
                             &time0, &time1, &orbit0, &orbit1,
                             &val_time0, &val_time1,
                             &orbit_id, ierr);
    }
    
```

### 7.3.3 Input parameters

The `xo_orbit_init_file` CFI function has the following input parameters:

*Table 14: Input parameters of xo\_orbit\_init\_file function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
sat_id	long *	-	Satellite ID	-	Complete
time_id	xo_time_id*	-	Structure that contains the time correlations	-	-
orbit_file_mode	long*	-	Flag that indicates the type of the input orbit file. <ul style="list-style-type: none"> <li>- There exists the possibility of detecting automatically the type of the files using the value <code>XO_ORBIT_INIT_AUTO</code>.</li> <li>- The Orbit Event files are used as Orbit Scenario files if the <code>AUTO</code> mode is selected. In case they want to be used as Predicted orbit files, the option <code>XO_ORBIT_INIT_OEF_POF_MODE</code> should be chosen.</li> <li>- The <code>AUTO</code> mode cannot be used to detect TLE files.</li> </ul>	-	<code>XO_ORBIT_INIT_AUTO</code> <code>XO_ORBIT_INIT_OSF_MODE</code> <code>XO_ORBIT_INIT_POF_MODE</code> <code>XO_ORBIT_INIT_ROF_MODE</code> <code>XO_ORBIT_INIT_DORIS_MODE</code> <code>XO_ORBIT_INIT_POF_N_DORIS_MODE</code> <code>XO_ORBIT_INIT_OEF_OSF_MODE</code> <code>XO_ORBIT_INIT_OEF_POF_MODE</code> <code>XO_ORBIT_INIT_TLE_MODE</code>
n_files	long	-	Number of input files	-	>=1
input_files	char**	-	Vector of orbit files	-	-
time_init_mode	long*	-	Flag for selecting the time range of the initialisation. For TLE files, the whole file is always selected (this flag and the parameters <code>time0/time1</code> , <code>orbit0/orbit1</code> are dummies)	-	Select either: · <code>XO_SEL_FILE</code> · <code>XO_SEL_ORBIT</code> · <code>XO_SEL_TIME</code>  For DORIS Navigator files, <code>XO_SEL_ORBIT</code> is not allowed

**Table 14: Input parameters of xo\_orbit\_init\_file function**

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
time_ref	long*	-	Time reference ID	-	Complete When using DORIS Navigator files and time_mode is XO_SEL_TIME, only XL_TIME_UTC is allowed.
time0	double*	-	Start time. See section 7.16.1. Used only if: · time_init_mode=XO_SEL_TIME	Decimal days (Processing format)	[-18262.0,36524.0]
time1	double*	-	Stop time. Used only if: · time_init_mode=XO_SEL_TIME	Decimal days (Processing format)	[-18262.0,36524.0]
orbit0	long*	-	Absolute orbit number of the start orbit. Used only if: · time_init_mode=XO_SEL_ORBIT	-	-
orbit1	long*	-	Absolute orbit number of the stop orbit. Used only if: · time_init_mode=XO_SEL_ORBIT	-	-

Note: Orbit Event File is deprecated, only supported for CRYOSAT mission

It is possible to use enumeration values rather than integer values for some of the input arguments:

- Satellite ID: sat\_id. See [GEN\_SUM].
- Orbit init mode: orbit\_init\_mode. Current document, section 6.2.
- Time mode: time\_init\_mode. See [GEN\_SUM].
- Time reference ID: time\_ref. See [GEN\_SUM].

### 7.3.4 Output parameters

The output parameters of the xo\_orbit\_init\_file CFI function are:

**Table 15: Output parameters of xo\_orbit\_init\_file function**

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
xo_orbit_init_file	long	-	Main status flag	-	-1, 0, +1

*Table 15: Output parameters of xo\_orbit\_init\_file function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
val_time0	double*	-	Validity start time of the initialization	Decimal days (Processing format)	see 7.16.1
val_time1	double*	-	Validity stop time of the initialization	Decimal days (Processing format)	see 7.16.1
orbit_id	xo_orbit_id*	-	Structure that contains the orbit initialization data	-	-
ierr[XO_NUMBER_ORBIT_INIT_FILE]	long	all	Status vector	-	-

### 7.3.5 Warnings and errors

Next table lists the possible error messages that can be returned by the **xo\_orbit\_init\_file** CFI function after translating the returned status vector into the equivalent list of error messages by calling the function of the EXPLORER\_ORBIT software library **xo\_get\_msg** (see [GEN\_SUM]).

This table also indicates the type of message returned, i.e. either a warning (WARN) or an error (ERR), the cause of such a message and the impact on the performed calculation, mainly on the results vector.

The table is completed by the error code and value. These error codes can be obtained translating the status vector returned by the **xo\_orbit\_init\_file** CFI function by calling the function of the EXPLORER\_ORBIT software library **xo\_get\_code** (see [GEN\_SUM]).

*Table 16: Error messages of xo\_orbit\_init\_file function*

Error type	Error message	Cause and impact	Error Code	Error No
ERR	Wrong satellite flag.	No calculation performed	XO_CFI_ORBIT_INIT_FILE_SAT_ERR	0
ERR	Wrong input flag.	No calculation performed	XO_CFI_ORBIT_INIT_FILE_FLAG_ERR	1
ERR	The Time Id was not initialized.	No calculation performed	XO_CFI_ORBIT_INIT_FILE_TIME_STATUS_ERR	2
ERR	The Orbit Id is already initialized.	No calculation performed	XO_CFI_ORBIT_INIT_FILE_ORBIT_STATUS_ERR	3
ERR	Memory allocation error.	No calculation performed	XO_CFI_ORBIT_INIT_FILE_MEMORY_ERR	4
ERR	Could not detect input files.	No calculation performed	XO_CFI_ORBIT_INIT_FILE_INPUT_FILES_ERR	5
ERR	Error reading OSF.	No calculation performed	XO_CFI_ORBIT_INIT_FILE_WRONG_OSF_FILE_FORMAT_ERR	6
ERR	Wrong time on input.	No calculation performed	XO_CFI_ORBIT_INIT_FILE_TIME_INPUT_INCORR_ERR	7
ERR	Error while processing DORIS file.	No calculation performed	XO_CFI_ORBIT_INIT_FILE_DORIS_INIT_ERR	8
ERR	Time Conversion Error.	No calculation performed	XO_CFI_ORBIT_INIT_FILE_TIME_CONVERSION_ERR	9
ERR	Error reading input files.	No calculation performed	XO_CFI_ORBIT_INIT_FILE_READ_FILES_ERR	10
ERR	No data read within the input range.	No calculation performed	XO_CFI_ORBIT_INIT_FILE_NO_ENOUGH_DATA_ERR	11
ERR	Error while computing ANX data for the state vectors	No calculation performed	XO_CFI_ORBIT_INIT_FILE_INTERPOL_INIT_ANX_ERR	12

*Table 16: Error messages of xo\_orbit\_init\_file function*

Error type	Error message	Cause and impact	Error Code	Error No
ERR	Error computing the orbit number for every state vector	No calculation performed	XO_CFI_ORBIT_INIT_FILE_CALC_ORBIT_ERR	13
WARN	Warnings while computing ANX data	Calculation performed.	XO_CFI_ORBIT_INIT_FILE_INTERPOL_INIT_ANX_WARN	14
WARN	Warnings during DORIS initialization	Calculation performed.	XO_CFI_ORBIT_INIT_FILE_DORIS_INIT_WARN	15
WARN	Warnings while reading the input file list	Calculation performed.	XO_CFI_ORBIT_INIT_FILE_READ_FILES_WARN	16
WARN	Input time correlations not compatible with input file(s) time correlations	Calculation performed	XO_CFI_ORBIT_INIT_FILE_WRONG_TIME_CORRELATIONS_WARN	17
WARN	Overriding file time correlations	Calculation performed	XO_CFI_ORBIT_INIT_FILE_FILE_TIME_CORR_OVERRIDE_WARN	18
ERR	Error performing time conversion with reference	No calculation performed	XO_CFI_ORBIT_INIT_FILE_TIME_CONVERSION_WITH_REF_ERR	19

### 7.3.6 Runtime performances

The following runtime performances have been measured:

*Table 17: Runtime performances of xo\_orbit\_init\_file function*

Solaris 32-bit. [ms]	Solaris 64 bit. [ms]	Linux 32-bit. [ms]	Linux 64-bit. [ms]
4.434	2.909	2.159	0.437

## 7.4 xo\_orbit\_close

### 7.4.1 Overview

The **xo\_orbit\_close** function is used to free the memory allocated by the other orbit initialization routines, and it must be called after using them.

A complete calling sequence of the propagation procedure is presented in section 4.2.

### 7.4.2 Calling interface

The calling interface of the **xo\_orbit\_close** CFI function is the following (input parameters are underlined>):

```
#include <explorer_orbit.h>
{
    xo_orbit_id orbit_id = {NULL};
    long ierr[XO_NUM_ERR_ORBIT_CLOSE]
    long status;

    status = xo_orbit_close (&orbit_id, ierr);
}
```

### 7.4.3 Input parameters

The **xo\_orbit\_close** CFI function has the following input parameters:

*Table 18: Input parameters of xo\_orbit\_close function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
orbit_id	xo_orbit_id*	-	Structure that contains the orbit initialization	-	-

### 7.4.4 Output parameters

The output parameters of the **xo\_orbit\_close** CFI function are:

*Table 19: Output parameters of xo\_orbit\_close function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
ierr[XO_NUM_ERR_ORBIT_CLOSE]	long	all	Status vector	-	-
xo_orbit_close	long	-	Main status flag	-	-1, 0, +1

### 7.4.5 Warnings and errors

Next table lists the possible error messages that can be returned by the **xo\_orbit\_close** CFI function after translating the returned status vector into the equivalent list of error messages by calling the function of the EXPLORER\_ORBIT software library **xo\_get\_msg** (see [GEN\_SUM]).

This table also indicates the type of message returned, i.e. either a warning (WARN) or an error (ERR), the cause of such a message and the impact on the performed calculation, mainly on the results vector.

The table is completed by the error code and value. These error codes can be obtained translating the status vector returned by the **xo\_orbit\_close** CFI function by calling the function of the EXPLORER\_ORBIT software library **xo\_get\_code** (see [GEN\_SUM]).

*Table 20: Error messages of xo\_orbit\_close function*

Error type	Error message	Cause and impact	Error Code	Error No
ERR	Could not close the Orbit Id.	The Orbit Id. was not closed.	XO_CFI_ORBIT_CLOSE_WRONG_ID_ERR	0

### 7.4.6 Runtime performances

Runtime is smaller than CPU clock and it is not possible to perform loops for measuring it.

## 7.5 xo\_orbit\_get\_osv

### 7.5.1 Overview

The `xo_orbit_get_osv` CFI function returns a data structure containing the list of state vectors used for the initialisation of an `orbit_id`. This function only can be called if the `orbit_id` was initialized with orbital state vectors (i.e., with `xo_orbit_cart_init` or with `xo_orbit_init_file` and a file containing a list of state vectors such as predicted orbit file, a restituted orbit file...)

### 7.5.2 Calling interface

The calling interface of the `xo_orbit_get_osv` CFI function is the following (input parameters are underlined>):

```
#include <explorer_orbit.h>
{
    xo_orbit_id orbit_id;
    long num_rec;
    xo_osv_rec* data;
    long status;
    status = xo_orbit_get_osv(&orbit_id, &num_rec, &data);
}
```

### 7.5.3 Input parameters

The `xo_orbit_get_osv` CFI function has the following input parameters:

*Table 21: Input parameters of xo\_orbit\_get\_osv function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
<code>xo_orbit_id</code>	<code>xo_orbit_id*</code>	-	Structure for orbit initialization	-	-

### 7.5.4 Output parameters

The output parameters of the `xo_orbit_get_osv` CFI function are:

*Table 22: Output parameters of xo\_orbit\_get\_osv function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
<code>xo_orbit_get_osv</code>	long	-	Status flag	-	-
<code>num_rec</code>	long	-	Number of records in the data array	-	-

*Table 22: Output parameters of xo\_orbit\_get\_osv function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
data	xo_osv_rec	all	Dinamic array with the state vectors	-	-

The data structure xo\_osv\_rec can be seen in table 3.

Note: The output *data* array is a pointer, not a static array. The memory for this dynamic array is allocated within the CFI function. So the user will only have to declare that pointer but not to allocate memory for it. However, once the function has returned without error, the user will have the responsibility of freeing the memory when it is not being used any more. For freeing the memory just call to (in a C program):

```
free(data);
```

### **7.5.5 Warnings and errors**

This function does not return any error/warning code. Only the status of the function indicates if the execution was correct or not.

The possible causes of error are:

- The orbit\_id was not initialised.
- The orbit\_id was initialised with orbital changes, instead of state vectors.

### **7.5.6 Runtime performances**

Runtime is smaller than CPU clock and it is not possible to perform loops for measuring it.

## 7.6 xo\_orbit\_set\_osv

### 7.6.1 Overview

The **xo\_orbit\_set\_osv** CFI function changes the list of state vectors used for the initialisation within an `orbit_id`. This function only can be called if the `orbit_id` was initialized with orbital state vectors (i.e., with **xo\_orbit\_cart\_init** or with **xo\_orbit\_init\_file** and a file containing a list of state vectors such as predicted orbit file, a restituted orbit file...)

### 7.6.2 Calling interface

The calling interface of the **xo\_orbit\_set\_osv** CFI function is the following (input parameters are underlined):

```
#include <explorer_orbit.h>
{
    xo_orbit_id orbit_id;
    long num_rec;
    xo_osv_rec* data;
    long status;
    status = xo_orbit_set_osv(&orbit_id, &num_rec, data);
}
```

### 7.6.3 Input parameters

The **xo\_orbit\_set\_osv** CFI function has the following input parameters:

*Table 23: Input parameters of xo\_orbit\_set\_osv function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
orbit_id	xo_orbit_id*	-	Structure for orbit initialization (input / output parameter)	-	-
num_rec	long	-	Number of records in the data array	-	-
data	xo_osv_rec	all	Dinamic array with the state vectors	-	-

### 7.6.4 Output parameters

The output parameters of the **xo\_orbit\_set\_osv** CFI function are:

*Table 24: Output parameters of xo\_orbit\_set\_osv function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
xo_orbit_set_osv	long	-	Status flag	-	-
orbit_id	xo_orbit_id*	-	Structure for orbit initialization (input / output parameter)	-	-

### **7.6.5 Warnings and errors**

This function does not return any error/warning code. Only the status of the function indicates if the execution was correct or not.

The possible causes of error are:

- The orbit\_id was not initialised.
- The orbit\_id was initialised with orbital changes, instead of state vectors.

### **7.6.6 Runtime performances**

Runtime is smaller than CPU clock and it is not possible to perform loops for measuring it.

## 7.7 xo\_orbit\_get\_anx

### 7.7.1 Overview

When initialising an orbit\_id with a list of state vectors that are not in the ANX (restituted orbit file, DORIS Navigator files), the information about the ANX of the orbits of those state vectors are stored in the orbit\_id. The **xo\_orbit\_get\_anx** CFI function allows to retrieve that information.

This function only can be called if the orbit\_id was initialized with orbital state vectors coming from:

- Restituted orbit file
- DORIS Navigator file

### 7.7.2 Calling interface

The calling interface of the **xo\_orbit\_get\_anx** CFI function is the following (input parameters are underlined>):

```
#include <explorer_orbit.h>
{
    xo_orbit_id orbit_id;
    long num_rec;
    xo_anx_extra_info* extra_info;
    long status;
    status = xo_orbit_get_anx(&orbit_id, &num_rec, &extra_info);
}
```

### 7.7.3 Input parameters

The **xo\_orbit\_get\_anx** CFI function has the following input parameters:

*Table 25: Input parameters of xo\_orbit\_get\_anx function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
orbit_id	xo_orbit_id*	-	Structure for orbit initialization	-	-

### 7.7.4 Output parameters

The output parameters of the **xo\_orbit\_get\_anx** CFI function are:

**Table 26: Output parameters of `xo_orbit_get_anx` function**

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
<code>xo_orbit_get_anx</code>	long	-	Status flag	-	-
<code>num_rec</code>	long	-	Number of records in the data array	-	-
<code>extra_info</code>	<code>xo_anx_extra_info</code>	all	Dinamic array with the ANX information	-	-

The data structure `xo_osv_rec` can be seen in table 3.

Note: The output `extra_info` array is a pointer, not a static array. The memory for this dynamic array is allocated within the CFI function. So the user will only have to declare that pointer but not to allocate memory for it. However, once the function has returned without error, the user will have the responsibility of freeing the memory when it is not being used any more. For freeing the memory just call to (in a C program):

```
free(extra_info);
```

### 7.7.5 Warnings and errors

This function does not return any error/warning code. Only the status of the function indicates if the execution was correct or not.

The possible causes of error are:

- The `orbit_id` was not initialised.
- The `orbit_id` was not initialised with the suitable file

### 7.7.6 Runtime performances

Runtime is smaller than CPU clock and it is not possible to perform loops for measuring it.

## 7.8 xo\_orbit\_set\_anx

### 7.8.1 Overview

The `xo_orbit_set_anx` CFI function changes the ANX info that is stored in an `orbit_id` when this orbit id was initialised with a restituted orbit file or a DORIS Navigator file.

### 7.8.2 Calling interface

The calling interface of the `xo_orbit_set_anx` CFI function is the following (input parameters are underlined):

```
#include <explorer_orbit.h>
{
    xo_orbit_id orbit_id;
    long num_rec;
    xo_anx_extra_info* extra_info;
    long status;
    status = xo_orbit_set_anx(&orbit_id, &num_rec, extra_info);
}
```

### 7.8.3 Input parameters

The `xo_orbit_set_anx` CFI function has the following input parameters:

*Table 27: Input parameters of xo\_orbit\_set\_anx function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
orbit_id	xo_orbit_id*	-	Structure for orbit initialization (input / output parameter)	-	-
num_rec	long	-	Number of records in the data array	-	-
extra_info	xo_anx_extra_info	all	Dinamic array with the state vectors	-	-

### 7.8.4 Output parameters

The output parameters of the `xo_orbit_set_anx` CFI function are:

*Table 28: Output parameters of xo\_orbit\_set\_anx function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
xo_orbit_set_anx	long	-	Status flag	-	-
orbit_id	xo_orbit_id*	-	Structure for orbit initialization (input / output parameter)	-	-

### **7.8.5 Warnings and errors**

This function does not return any error/warning code. Only the status of the function indicates if the execution was correct or not.

The possible causes of error are:

- The orbit\_id was not initialised.
- The orbit\_id was initialised with orbital changes, instead of state vectors.

### **7.8.6 Runtime performances**

Runtime is smaller than CPU clock and it is not possible to perform loops for measuring it.

## 7.9 xo\_orbit\_get\_osf\_rec

### 7.9.1 Overview

The `xo_orbit_get_osf_rec` CFI function returns a data structure containing the list of orbital changes used for the initialisation of an orbit\_id. This function only can be called if the orbit\_id was initialized with orbital changes (i.e., with `xo_orbit_init_def` or with `xo_orbit_init_file` and an orbit scenario file)

### 7.9.2 Calling interface

The calling interface of the `xo_orbit_get_osf_rec` CFI function is the following (input parameters are underlined):

```
#include <explorer_orbit.h>
{
    xo_orbit_id orbit_id;
    long num_rec;
    xo_osf_records* data;
    long status;
    status = xo_orbit_get_osf_rec(&orbit_id, &num_rec, &data);
}
```

### 7.9.3 Input parameters

The `xo_orbit_get_osf_rec` CFI function has the following input parameters:

*Table 29: Input parameters of xo\_orbit\_get\_osf\_rec function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
orbit_id	xo_orbit_id*	-	Structure for orbit initialization	-	-

### 7.9.4 Output parameters

The output parameters of the `xo_orbit_get_osf_rec` CFI function are:

*Table 30: Output parameters of xo\_orbit\_get\_osf\_rec function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
xo_orbit_get_osf_rec	long	-	Status flag	-	-
num_rec	long	-	Number of records in the data array	-	-

**Table 30: Output parameters of *xo\_orbit\_get\_osf\_rec* function**

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
data	xo_osf_rec	all	Dinamic array with the orbital changes	-	-

The data structure *xo\_osf\_rec* can be seen in table 3.

Note: The output *data* array is a pointer, not a static array. The memory for this dynamic array is allocated within the CFI function. So the user will only have to declare that pointer but not to allocate memory for it. However, once the function has returned without error, the user will have the responsibility of freeing the memory when it is not being used any more. For freeing the memory just call to (in a C program):

```
free(data);
```

### 7.9.5 Warnings and errors

This function does not return any error/warning code. Only the status of the function indicates if the execution was correct or not.

The possible causes of error are:

- The *orbit\_id* was not initialised.
- The *orbit\_id* was not initialised with orbital changes.

### 7.9.6 Runtime performances

The following runtime performances have been estimated.

**Table 31: Runtime performances of *xo\_orbit\_get\_osf\_rec* function**

Solaris 32-bit. [ms]	Solaris 64 bit. [ms]	Linux 32-bit. [ms]	Linux 64-bit. [ms]
0.0018	0.0008	0.0016	0.0002

## 7.10 xo\_orbit\_set\_osf\_rec

### 7.10.1 Overview

The `xo_orbit_set_osf_rec` CFI function changes the list of orbital changes used for the initialisation within an `orbit_id`. This function only can be called if the `orbit_id` was initialized with `xo_orbit_init_def` or with `xo_orbit_init_file` and an orbit scenario file.

### 7.10.2 Calling interface

The calling interface of the `xo_orbit_set_osf_rec` CFI function is the following (input parameters are underlined):

```
#include <explorer_orbit.h>
{
    xo_orbit_id orbit_id;
    long num_rec;
    xo_osv_rec* data;
    long status;
    status = xo_orbit_set_osf_rec(&orbit_id, &num_rec, data);
}
```

### 7.10.3 Input parameters

The `xo_orbit_set_osf_rec` CFI function has the following input parameters:

*Table 32: Input parameters of xo\_orbit\_set\_osf\_rec function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
orbit_id	xo_orbit_id*	-	Structure for orbit initialization (input / output parameter)	-	-
num_rec	long	-	Number of records in the data array	-	-
data	xo_osf_rec	all	Dinamic array with the orbital changes	-	-

### 7.10.4 Output parameters

The output parameters of the `xo_orbit_set_osf_rec` CFI function are:

*Table 33: Output parameters of xo\_orbit\_set\_osf\_rec function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
xo_orbit_set_osf_rec	long	-	Status flag	-	-
orbit_id	xo_orbit_id*	-	Structure for orbit initialization (input / output parameter)	-	-

### 7.10.5 Warnings and errors

This function does not return any error/warning code. Only the status of the function indicates if the execution was correct or not.

The possible causes of error are:

- The orbit\_id was not initialised.
- The orbit\_id was not initialised with orbital changes.

### 7.10.6 Runtime performances

The following runtime performances have been estimated.

*Table 34: Runtime performances of xo\_orbit\_set\_osf\_rec function*

Solaris 32-bit. [ms]	Solaris 64 bit. [ms]	Linux 32-bit. [ms]	Linux 64-bit. [ms]
0.0048	0.0018	0.0016	0.0002

## 7.11 xo\_orbit\_get\_val\_time

### 7.11.1 Overview

The `xo_orbit_get_val_time` CFI function returns the validity period of an `orbit_id`.

### 7.11.2 Calling interface

The calling interface of the `xo_orbit_get_val_time` CFI function is the following (input parameters are underlined):

```
#include <explorer_orbit.h>
{
    xo_orbit_id orbit_id;
    xo_validity_time val_time;
    long status;
    status = xo_orbit_get_val_time(&orbit_id, &val_time);
}
```

### 7.11.3 Input parameters

The `xo_orbit_get_val_time` CFI function has the following input parameters:

*Table 35: Input parameters of xo\_orbit\_get\_val\_time function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
orbit_id	xo_orbit_id*	-	Structure for orbit initialization	-	-

### 7.11.4 Output parameters

The output parameters of the `xo_orbit_get_val_time` CFI function are:

*Table 36: Output parameters of xo\_orbit\_get\_val\_time function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
xo_orbit_get_val_time	long	-	Status flag	-	-
val_time	xo_validity_time	-	Validity Time structure	-	-

The data structure `xo_validity_time` can be seen in table 3.

### ***7.11.5 Warnings and errors***

This function does not return any error/warning code. Only the status of the function indicates if the execution was correct or not.

The possible causes of error are:

- The orbit\_id was not initialised.

### ***7.11.6 Runtime performances***

The following runtime performances have been estimated: runtime is smaller than CPU clock and it is not possible to perform loops for measuring it.

## 7.12 xo\_orbit\_set\_val\_time

### 7.12.1 Overview

The **xo\_orbit\_set\_val\_time** CFI function changes the validity period of an `orbit_id`.

### 7.12.2 Calling interface

The calling interface of the **xo\_orbit\_set\_val\_time** CFI function is the following (input parameters are underlined):

```
#include <explorer_orbit.h>
{
    xo_orbit_id orbit_id;
    xo_validity_time val_time;
    long status;
    status = xo_orbit_set_val_time(&orbit_id, &val_time);
}
```

### 7.12.3 Input parameters

The **xo\_orbit\_set\_val\_time** CFI function has the following input parameters:

*Table 37: Input parameters of xo\_orbit\_set\_val\_time function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
orbit_id	xo_orbit_id*	-	Structure for orbit initialization (input / output parameter)	-	-
val_time	xo_validity_time	-	Validity Time structure	-	-

### 7.12.4 Output parameters

The output parameters of the **xo\_orbit\_set\_val\_time** CFI function are:

*Table 38: Output parameters of xo\_orbit\_set\_val\_time function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
xo_orbit_set_val_time	long	-	Status flag	-	-
orbit_id	xo_orbit_id*	-	Structure for orbit initialization (input / output parameter)	-	-

### 7.12.5 Warnings and errors

This function does not return any error/warning code. Only the status of the function indicates if the execution was correct or not.

The possible causes of error are:

- The orbit\_id was not initialised.

### 7.12.6 Runtime performances

The following runtime performances have been estimated.

*Table 39: Runtime performances of xo\_orbit\_set\_val\_time function*

Solaris 32-bit. [ms]	Solaris 64 bit. [ms]	Linux 32-bit. [ms]	Linux 64-bit. [ms]
0.0002	0.0002	0	0

---

## 7.13 xo\_run\_init

### 7.13.1 Overview

The **xo\_run\_init** CFI function adds to the *run Id* the *orbit id*, and, optionally, the *propag Id* or the *interpol Id*.

It is not possible to assign the same *run Id* to both a *propag Id* and an *interpol Id*.

### 7.13.2 Calling interface

The calling interface of the **xo\_run\_init** CFI function is the following:

```
#include <explorer_orbit.h>
{
    long run_id;
    xo_orbit_id orbit_id = {NULL};
    xo_propag_id propag_id = {NULL};
    xo_interpol_id interpol_id = {NULL};
    long ierr[XO_NUM_ERR_RUN_INIT], status;
    status = xo_run_init (&run_id, &orbit_id,
                        &propag_id, &interpol_id,
                        ierr);
}
```

### 7.13.3 Input parameters

The `xo_run_init` CFI function has the following input parameters:

*Table 40: Input parameters of xo\_run\_init function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
run_id	long *	-	Run ID	-	>=0
orbit_id	xo_orbit_id*	-	Structure that contains the orbit data	-	-
propag_id	xo_propag_id*	-	Structure that contains the propagator data	-	-
interpol_id	xo_interpol_id*	-	Structure that contains the interpolator data	-	-

### 7.13.4 Output parameters

The output parameters of the `xo_run_init` CFI function are:

*Table 41: Output parameters of xo\_run\_init function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
xo_run_init	long	-	Status flag	-	-
run_id	long *	-	Run ID	-	>=0
ierr	long	-	Error vector	-	-

### 7.13.5 Warnings and errors

Next table lists the possible error messages that can be returned by the `xo_run_init` CFI function after translating the returned extended status flag into the equivalent list of error messages by calling the function of the EXPLORER\_ORBIT software library `xo_get_msg` (see [GEN\_SUM]).

This table also indicates the type of message returned, i.e. either a warning (WARN) or an error (ERR), the cause of such a message and the impact on the performed calculation.

The table is completed by the error code and value. These error codes can be obtained translating the extended status flag returned by the `xo_run_init` function by calling the function of the EXPLORER\_ORBIT software library `xo_get_code` (see [GEN\_SUM])

*Table 42: Error messages of xo\_run\_init function*

Error type	Error message	Cause and impact	Error code	Error No
ERR	Inputs Id no initialized or incompatible.	No calculation performed	XO_CFI_RUN_INIT_STATUS_ERR	0
ERR	Memory allocation error.	No calculation performed	XO_CFI_RUN_INIT_MEMORY_ERR	1
ERR	Input Ids incompatible with the run_id.	No calculation performed	XO_CFI_RUN_INIT_INCONSISTENCY_ERR	2

### **7.13.6 Runtime performances**

The following runtime performances have been estimated: runtime is smaller than CPU clock and it is not possible to perform loops for measuring it.

## 7.14 xo\_run\_get\_ids

### 7.14.1 Overview

The **xo\_run\_get\_ids** CFI function returns the *ids* being used..

### 7.14.2 Calling interface

The calling interface of the **xo\_run\_get\_ids** CFI function is the following:

```
#include <explorer_orbit.h>
{
    long run_id;
    xo_orbit_id orbit_id = {NULL};
    xo_propag_id propag_id = {NULL};
    xo_interpol_id interpol_id = {NULL};
    xo_run_get_ids (&run_id,
                  &orbit_id,
                  &propag_id,
                  &interpol_id);
}
```

### 7.14.3 Input parameters

The `xo_run_get_ids` CFI function has the following input parameters:

*Table 43: Input parameters of `xo_run_get_ids` function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
run_id	long *	-	Run ID	-	>=0

### 7.14.4 Output parameters

The output parameters of the `xo_run_get_ids` CFI function are:

*Table 44: Output parameters of `xo_run_get_ids` function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
<code>xo_run_get_ids</code>	void	-	-	-	-
orbit_id	xo_orbit_id*	-	Structure that contains the orbit data	-	-
propag_id	xo_propag_id*	-	Structure that contains the propagator data	-	-
interpol_id	xo_interpol_id*	-	Structure that contains the interpolator data	-	-

### 7.14.5 Warnings and errors

TBW

### 7.14.6 Runtime performances

The following runtime performances have been estimated: runtime is smaller than CPU clock and it is not possible to perform loops for measuring it.

## 7.15 xo\_run\_close

### 7.15.1 Overview

The **xo\_run\_close** CFI function cleans up any memory allocation performed by the initialization functions.

### 7.15.2 Calling interface

The calling interface of the **xo\_run\_close** CFI function is the following:

```
#include <explorer_orbit.h>
{
    long run_id;
    xo_run_close (&run_id);
}
```

### 7.15.3 Input parameters

The `xo_run_close` CFI function has the following input parameters:

*Table 45: Input parameters of xo\_run\_close function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
run_id	long *	-	Run ID	-	>=0

### 7.15.4 Output parameters

The output parameters of the `xo_run_close` CFI function are:

*Table 46: Output parameters of xo\_run\_close function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
xo_run_close	void	-	-	-	-

### 7.15.5 Warnings and errors

TBW

### 7.15.6 Runtime performances

The following runtime performances have been estimated: runtime is smaller than CPU clock and it is not possible to perform loops for measuring it.

## 7.16 xo\_propag\_init

### 7.16.1 Overview

The **xo\_propag\_init** function is to be used on the ground segment near real time processing chains. This software is used in conjunction with the appropriate propagation initialization routine to initialize the orbit propagator with the necessary internal data.

The propagation initialization routine called depends on the propagation model used (indicated by an input parameter).

Before calling this function it is required to initialise the orbit with one of the following modes (orbit modes):

- XO\_ORBIT\_INIT\_ORBIT\_CHANGE\_MODE
- XO\_ORBIT\_INIT\_STATE\_VECTOR\_MODE
- XO\_ORBIT\_INIT\_OSF\_MODE
- XO\_ORBIT\_INIT\_POF\_MODE
- XO\_ORBIT\_INIT\_POF\_N\_DORIS\_MODE
- XO\_ORBIT\_INIT\_OEF\_POF\_MODE
- XO\_ORBIT\_INIT\_OEF\_OSF\_MODE
- XO\_ORBIT\_INIT\_TLE\_MODE

Note: Orbit Event File is deprecated, only supported for CRYOSAT mission

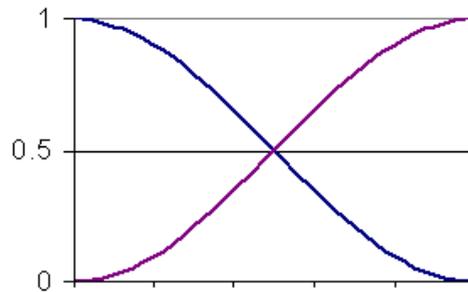
Additionally, it is possible to initialize the propagation with the auto and/or double mode described below. These modes cannot be used with any of the orbit modes above. The following table shows the possible combinations:

Orbit mode	Auto Mode allowed	Double Mode allowed
XO_ORBIT_INIT_ORBIT_CHANGE_MODE	Yes	Yes
XO_ORBIT_INIT_STATE_VECTOR_MODE	No	No
XO_ORBIT_INIT_OSF_MODE	Yes	Yes
XO_ORBIT_INIT_POF_MODE	Yes	Yes
XO_ORBIT_INIT_POF_N_DORIS_MODE	No	No
XO_ORBIT_INIT_OEF_POF_MODE	Yes	Yes
XO_ORBIT_INIT_OEF_OSF_MODE	Yes	Yes
XO_ORBIT_INIT_TLE_MODE	Yes	No

- **Auto mode:** This mode allows to propagate the space craft along the complete initialization range. In the normal **Mean Keplerian** model, the validity range is limited to  $\pm 2$  orbits. In the **Auto** model, the software automatically re-initialize, transparently to the user, for the closer ANX to the propagation time.
- **Double mode:** the two ANX covering the propagation time are used. When calling **xo\_propag**, the propagation is performed from each of the ANX and then a weighted average is done. The weight function is :

$$\cos^2\left(\frac{\pi}{2} \cdot \frac{\Delta t}{T}\right)$$

where  $\Delta t = t - t_{\text{ANX}}$  and T is the nodal period of the orbit.



**Figure 3: Weight Function for Double Propagation Model**

This propagation method removes any discontinuity that may arise when changing the state vector around the true ascending node crossing used to propagate.

The propagation is initialized using an orbital state vector at an ANX. This ANX is chosen in the following way:

- The user have two options:
  - introduce an specific time or orbit ( $= t_0$ )
  - ask for a default value. In that case the seleteted time ( $t_0$ ) is the half value of the time of first state vector ( $t_{\text{start}}$ ) within the input orbit\_id plus the time of the last state vector( $t_{\text{stop}}$ )
- The ANX used in the initialization depends on the propagation model parameter:
  - **Mean Kepler mode:** ANX of the orbit closer to the  $t_0$  time (within the  $t_{\text{start}} / t_{\text{stop}}$  range)
  - **Mean Kepler + Double mode:** the closer two ANX covering the  $t_0$ . If  $t_0$  is less than the  $t_{\text{start}}$ , only the first ANX (ANX at  $t_{\text{start}}$ ) will be chosen and double propagation will no be performed. In the same way, if  $t_0$  is greater than  $t_{\text{stop}}$ , only the last ANX (ANX at  $t_{\text{stop}}$ ) will be chosen and double propagation will not be performed.
  - **Mean Kepler + Auto mode:** the first ANX read from the file(s).
  - **Mean Kepler + Auto + Double mode:** the two firsts ANX read from the file. If  $t_0$  is less than  $t_{\text{start}}$ , only the first ANX (ANX at  $t_{\text{start}}$ ) will be chosen and double propagation will no be performed. In the same way, if  $t_0$  is greater than  $t_{\text{stop}}$  (ANX at  $t_{\text{stop}}$ ), only the last ANX will be chosen and double propagation will no be performed.

The validity start and stop times of the initialization (**val\_time0** and **val\_time1** output parameters) represents the allowed time window for propagation. The following table shows the validity time interval for the different propagation models. The horizontal line represents the part of the file(s) read ( $t_{\text{start}}$  to  $t_{\text{stop}}$ ), while the tick marks are the ANX times. Square brackets represent the validity period for propagation. When using the auto model, the propagation is re-initialized when the time jumps out of the region in brackets. The red arrow(s) represent the chosen ANX depending on the  $t_0$  value.

**Table 47: Validity Time Intervals for Propagation**

Propag model	$t_0$ value	Validity time interval
Mean Kepler	$t_{start} < t_0 < t_{stop}$	[ANX - 2 orbits, ANX + 2 orbits] 
	$t_0 < t_{start}$	[ANX - 2 orbits, ANX + 2 orbits] 
	$t_0 > t_{stop}$	[ANX - 2 orbits, ANX + 2 orbits] 
Mean Kepler + Auto Mode	$t_{start} < t_0 < t_{stop}$	[ $t_{start} - 2$ orbits, $t_{stop} + 2$ orbits]; (ANX - 1/2 orbit, ANX + 1/2 orbit) 
	$t_0 < t_{start}$	[ $t_{start} - 2$ orbits, $t_{stop} + 2$ orbits]; (ANX - 2 orbits, ANX + 1/2 orbit) 
	$t_0 > t_{stop}$	[ $t_{start} - 2$ orbits, $t_{stop} + 2$ orbits]; (ANX - 1/2 orbit, ANX + 2 orbits) 
Mean Kepler + Double Mode	$t_{start} < t_0 < t_{stop}$	[ANX, ANX + 1 orbit] 
	$t_0 < t_{start}$	[ANX - 2 orbits, ANX] 
	$t_0 > t_{stop}$	[ANX, ANX + 2 orbits] 
Mean Kepler + Auto + Double Mode	$t_{start} < t_0 < t_{stop}$	[ $t_{start} - 2$ orbits, $t_{stop} + 2$ orbits]; (ANX, ANX + 1 orbit) 
	$t_0 < t_{start}$	[ $t_{start} - 2$ orbits, $t_{stop} + 2$ orbits]; (ANX - 2 orbits, ANX) 
	$t_0 > t_{stop}$	[ $t_{start} - 2$ orbits, $t_{stop} + 2$ orbits]; (ANX, ANX + 2 orbits) 

Summing up, with a file it is possible to propag to times that are  $\pm 2$  orbits out of the validity time interval of the file.

Note that this schema is not valid in case that the orbit was initialised with `XO_ORBIT_INIT_TLE_MODE`. With this mode, the propagation interval is the selected TLE minus/plus one day. The selected TLE is the nearest one to the requested time.

A complete calling sequence of the propagation procedure is presented in section 4.2.

### 7.16.2 Calling interface

The calling interface of the `xo_propag_init` CFI function is the following (input parameters are underlined):

```
#include <explorer_orbit.h>
{
    xo_orbit_id *orbit_id = {NULL};
    xo_propag_id *propag_id = {NULL};
    long propag_model, time_mode;
    long time_ref, orbit;
    double time, val_time0, val_time1;
    long status, ierr[XO_NUM_ERR_PROPAG_INIT];

    status = xo_propag_init (&orbit_id, &propag_model,
                            &time_mode, &time_ref,
                            &time, &orbit,
                            &val_time0, &val_time1,
                            &propag_id, ierr);
}
```

### 7.16.3 Input parameters

The `xo_propag_init` CFI function has the following input parameters:

*Table 48: Input parameters of `xo_propag_init` function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
orbit_id	xo_orbit_id*	-	Structure that containing the orbit initialization	-	-
propag_model	long*	-	Propagation model ID	-	Complete

**Table 48: Input parameters of *xo\_propag\_init* function**

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
time_mode	long*	-	Flag for selecting the time for which the function selects the ANX used to initialize the propagator.	-	Select either: · XO_SEL_ORBIT · XO_SEL_TIME · XO_SEL_DEFAULT
time_ref	long*	-	Time reference ID	-	Complete
time	double*	-	Start time. See section 7.16.1. Used only if: · <i>time_init_mode=XO_SEL_TIME</i>	Decimal days (Processing format)	[-18262.0,36524.0]
orbit0	long*	-	Absolute orbit number of the start orbit. Used only if: · <i>time_init_mode=XO_SEL_ORBIT</i>	-	-

It is possible to use enumeration values rather than integer values for some of the input arguments:

- Propagation model ID: *propag\_model*. Current document, section 6.2.
- Time mode: *time\_init\_mode*. See [GEN\_SUM].
- Time reference ID: *time\_ref*. See [GEN\_SUM].

### 7.16.4 Output parameters

The output parameters of the **xo\_propag\_init** CFI function are:

**Table 49: Output parameters of *xo\_propag\_init* function**

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
<i>xo_propag_init</i>	long	-	Main status flag	-	-1, 0, +1
<i>val_time0</i>	double*	-	Validity start time of the initialization	Decimal days (Processing format)	see 7.16.1
<i>val_time1</i>	double*	-	Validity stop time of the initialization	Decimal days (Processing format)	see 7.16.1
<i>propag_id</i>	<i>xo_propag_id*</i>	-	Structure that containing the propagation data	-	-
<i>ierr[XO_NUM_ERR_PROPAG_INIT]</i>	long	all	Status vector	-	-

### 7.16.5 Warnings and errors

Next table lists the possible error messages that can be returned by the **xo\_propag\_init** CFI function after translating the returned status vector into the equivalent list of error messages by calling the function of the EXPLORER\_ORBIT software library **xo\_get\_msg** (see [GEN\_SUM]).

This table also indicates the type of message returned, i.e. either a warning (WARN) or an error (ERR), the cause of such a message and the impact on the performed calculation, mainly on the results vector.

The table is completed by the error code and value. These error codes can be obtained translating the status vector returned by the **xo\_propag\_init** CFI function by calling the function of the EXPLORER\_ORBIT software library **xo\_get\_code** (see [GEN\_SUM]).

*Table 50: Error messages of xo\_propag\_init function*

Error type	Error message	Cause and impact	Error Code	Error No
ERR	Wrong input flag	No calculation performed	XO_CFI_PROPAG_INIT_FLAG_ERR	0
ERR	Auto and/or double model for propagation are incompatible with the input Orbit Id. model	No calculation performed	XO_CFI_PROPAG_INIT_MODEL_INCONSISTENCY_ERR	1
ERR	Orbit Id was not initialized	No calculation performed	XO_CFI_PROPAG_INIT_ORBIT_STATUS_ERR	2
ERR	Error closing input Propag Id. for re-initializing	No calculation performed	XO_CFI_PROPAG_INIT_CLOSE_ERR	3
ERR	Memory allocation error	No calculation performed	XO_CFI_PROPAG_INIT_MEMORY_ERR	4
ERR	Could not initialise	No calculation performed	XO_CFI_PROPAG_INIT_CART_INIT_ERR	5
ERR	Error computing reference state vector	No calculation performed	XO_CFI_PROPAG_INIT_GET_OS_V_ERR	6
ERR	Error making a time transformation.	No calculation performed	XO_CFI_PROPAG_INIT_TIME_TRANSFORMATION_ERR	7
WARN	Propagation allowed out of the file boundaries. Propagation could not reach the desired accuracy.	Calculation performed. Warning raised when using <b>AUTO</b> and/or <b>DOUBLE</b> propagation model and trying to initialize out of the file validity interval.	XO_CFI_PROPAG_INIT_INACCURACY_PROP_WARN	8

### 7.16.6 Runtime performances

The following runtime performances have been measured:

*Table 51: Runtime performances of xo\_propag\_init function*

<b>Solaris 32-bit. [ms]</b>	<b>Solaris 64 bit. [ms]</b>	<b>Linux 32-bit. [ms]</b>	<b>Linux 64-bit. [ms]</b>
2.239	0.634	0.733	0.235

## 7.17 xo\_propag\_spot\_init

TBW

---

## 7.18 xo\_propag

### 7.18.1 Overview

This routine simulates orbit propagations over complete orbits, performing an accurate prediction of oscillating Cartesian state vectors for user requested times, which must fall within the validity time interval calculated by the initialization routines.

For the orbit propagation, the user may choose between different propagation models, although for the time being, the initial set of models supported are:

- **Mean Kepler elements model** (which is the current model). It implies the use of a formulation for the time rates of change for the different mean Kepler elements as functions of a given initial set of mean Kepler elements. Using the above time rates of change, the mean orbital elements can be propagated forward or backward in time by extrapolating the individual time slopes of the superimposed secular and long-periodic perturbations functions. As the long periodic variations have typically periods on the order of months, a near-linear time slope for prediction intervals of many orbits is warranted.
- **TLE model**. This model propagates the state vector using the NORAD “two line elements” (TLE) and the SGP4 propagation theory. This theory was designed for near Earth Satellites (nodal period less than 225 minutes). The SGP4 theory uses an Earth gravitational field through zonal terms J2, J3 and J4 and a power density function for the atmospheric model (assuming a non-rotating spherical model).
- **Spot elements model** (still TBD). This model is based upon the usage of an extended orbit state vector (originally used for SPOT satellites and currently for MetOp). The calculation of the orbit state vector is made by fitting them using a predicted or restituted orbit file.

The propagation model is set as an input parameter for the initialization routines, and the **xo\_propag** routine utilizes that model transparently for the user.

For a general description of the initialization routines and how to use them in conjunction to the **xo\_propag** function, see section 4.2.

---

### 7.18.2 Calling interface

The calling interface of the **xo\_propag** CFI function is the following (input parameters are underlined):

```
#include <explorer_orbit.h>
{
    xo_propag_id propag_id = {NULL};
    long mode, time_ref;
    double time, pos_out[3], vel_out[3], acc_out[3];
    long status, ierr[XO_NUM_ERR_PROPAG];

    status = xo_propag (&propag_id, &mode, &time_ref, &time,
                       pos_out, vel_out, acc_out, ierr);

    /* Or, using the run_id */
    long run_id;

    status = xo_propag_run (&run_id, &mode, &time_ref, &time,
                           pos_out, vel_out, acc_out, ierr);
}
```

### 7.18.3 Input parameters

The `xo_propag` CFI function has the following input parameters:

*Table 52: Input parameters of `xo_propag` function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
<code>propag_id</code>	<code>xo_propag_id*</code>	-	Structure that contains the propagator data	-	-
<code>mode</code>	<code>long *</code>	-	Propagation mode. (TBD in Spot model).	-	<ul style="list-style-type: none"> <li><code>XO_PROPAG_MODEL_MEAN_KEPL</code></li> <li><code>XO_PROPAG_MODEL_SPOT</code></li> <li><code>XO_PROPAG_MODEL_TLE</code></li> </ul>
<code>time_ref</code>	<code>long*</code>	-	Time reference ID	-	Complete
<code>time</code>	<code>double*</code>	-	Reference time	Decimal days (Processing format)	[-18262.0,36524.0]

It is possible to use enumeration values rather than integer values for some of the input arguments:

- Time reference ID: `time_ref`. See [GEN\_SUM].

### 7.18.4 Output parameters

The output parameters of the `xo_propag` CFI function are:

*Table 53: Output parameters of `xo_propag` function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
<code>xo_propag</code>	<code>long</code>	-	Main status flag	-	-1, 0, +1
<code>pos_out[3]</code>	<code>double</code>	all	Osculating position vector at predicted time (Earth fixed CS)	m	-
<code>vel_out[3]</code>	<code>double</code>	all	Osculating velocity vector at predicted time (Earth fixed CS)	m/s	-
<code>acc_out[3]</code>	<code>double</code>	all	Osculating acceleration vector at predicted time (Earth fixed CS)	m/s <sup>2</sup>	-
<code>ierr[XO_NUM_ERR_PROPAG]</code>	<code>long</code>	all	Status vector	-	-

### 7.18.5 Warnings and errors

Next table lists the possible error messages that can be returned by the **xo\_propag** CFI function after translating the returned status vector into the equivalent list of error messages by calling the function of the EXPLORER\_ORBIT software library **xo\_get\_msg** (see [GEN\_SUM]).

This table also indicates the type of message returned, i.e. either a warning (WARN) or an error (ERR), the cause of such a message and the impact on the performed calculation, mainly on the results vector.

The table is completed by the error code and value. These error codes can be obtained translating the status vector returned by the **xo\_propag** CFI function by calling the function of the EXPLORER\_ORBIT software library **xo\_get\_code** (see [GEN\_SUM]).

*Table 54: Error messages of xo\_propag function*

Error type	Error message	Cause and impact	Error Code	Error No
ERR	Wrong input flag	No calculation performed	XO_CFI_PROPAG_FLAG_ERR	0
ERR	The internal data were not initialized	No calculation performed	XO_CFI_PROPAG_NOT_INTERNAL_DATA_ERR	1
ERR	An error occurred in the Mean Keplerian OSV routine	No calculation performed	XO_CFI_PROPAG_MKO_ERR	2
ERR	An error occurred in the TLE propagation routine	No calculation performed	XO_CFI_PROPAG_TLE_ERR	3

### 7.18.6 Runtime performances

The following runtime performances have been measured:

*Table 55: Runtime performances of xo\_propag function*

Solaris 32-bit. [ms]	Solaris 64 bit. [ms]	Linux 32-bit. [ms]	Linux 64-bit. [ms]
0.299	0.073	0.090	0.021

## 7.19 xo\_propag\_extra

### 7.19.1 Overview

This software returns ancillary results derived from an orbit state vector obtained from the orbit propagation routines (stored within the *orbit Id*). This state vector depends on which is the last function called:

- when calling to **xo\_propag\_extra** after initialising **xo\_propag\_init** with the *orbit Id* from **xo\_orbit\_cart\_init**, the Cartesian orbit state vector used to calculate the ancillary results is the one given as input in the initialization routine.
- when calling after initialising **xo\_propag\_init** with the *orbit Id* from **xo\_orbit\_init\_def**, the Cartesian orbit state vector is the one generated internally at the requested ANX in the initialization routine.
- when calling after initialising **xo\_propag\_init** with the *orbit Id* from **xo\_orbit\_init\_file**, the Cartesian orbit state vector is the one generated internally by the routine around the ANX (in Mean Keplerian model; in Spot model is not defined yet).
- when calling after **xo\_propag**, the Cartesian orbit state vector is the one predicted at the requested time in the propagation routine.

A description of the ancillary results may be found in the section 7.19.5.

A complete calling sequence of the propagation procedure is presented in section 4.2.

### 7.19.2 Calling interface

The calling interface of the **xo\_propag\_extra** CFI function is the following:

```
#include <explorer_orbit.h>
{
    xo_propag_id propag_id = {NULL};
    long extra_choice;
    double model_out[XO_PROPAG_EXTRA_NUM_DEP_ELEMENTS],
           extra_out[XO_PROPAG_EXTRA_NUM_INDEP_ELEMENTS];
    long status, ierr[XO_NUM_ERR_PROPAG_EXTRA];

    status = xo_propag_extra (&propag_id, &extra_choice,
                             model_out, extra_out, ierr);

    /* Or, using the run_id */
    long run_id;

    status = xo_propag_extra_run (&run_id, &extra_choice,
                                  model_out, extra_out, ierr);
}
```

### 7.19.3 Input parameters

The `xo_propag_extra` CFI function has the following input parameters:

*Table 56: Input parameters of `xo_propag_extra`*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
propag_id	xo_propag_id*	-	Structure that contains the propagator data	-	-
extra_choice	long *	-	Flag to allow an ancillary results choice	-	[0, 4095]

It is possible to use enumeration values rather than integer values for some of the input arguments:

- Flag to select ancillary results: `extra_choice`. See tables below:

*Table 57: Enumeration values of `extra_choice` input flag*

Model independant	Description	Long
XO_PROPAG_EXTRA_NO_RESULTS	No extra results	0
XO_PROPAG_EXTRA_GEOLOCATION	Geolocation results	1
XO_PROPAG_EXTRA_GEOLOCATION_D	Geolocation rate results	2
XO_PROPAG_EXTRA_GEOLOCATION_2D	Geolocation rate-rate results	4
XO_PROPAG_EXTRA_GEOLOCATION_EXTRA	Geolocation extra results	8
XO_PROPAG_EXTRA_EARTH_FIXED_D	Earth fixed velocity results	16
XO_PROPAG_EXTRA_EARTH_FIXED_2D	Earth fixed acceleration results	32
XO_PROPAG_EXTRA_SUN	Sun results	64
XO_PROPAG_EXTRA_MOON	Moon results	128
XO_PROPAG_EXTRA_OSCULATING_KEPLER	Osculating keplerian elements	256
XO_PROPAG_EXTRA_INERTIAL_AUX	Inertial auxiliary results	512
Model dependant (Mean Keplerian model)	Description	Long
XO_PROPAG_EXTRA_DEP_ANX_TIMING	ANX timing results	1024
XO_PROPAG_EXTRA_DEP_MEAN_KEPLER	Mean keplerian elements	2048

To calculate all results there is an extra enumeration value, defined as the addition of all the enumeration result values:

Enumeration value	Description	Long
XO_PROPAG_EXTRA_ALL_RESULTS	All results	4095

The elements calculated in each case are shown in section 7.6.5. It is possible to select the calculation of different sets of output parameters, or to make any combination of them by adding the results enumeration desired. In order to calculate some elements it might be necessary to calculate elements which have not been explicitly requested. The function identifies internally all the dependencies and those elements are also returned in the result vectors.

### 7.19.4 Output parameters

The output parameters of the `xo_propag_extra` CFI function are:

*Table 58: Output parameters of xo\_propag\_extra*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
<code>xo_propag_extra</code>	long	-	Main status flag	-	-1, 0, +1
<code>model_out[XO_PROPAG_EXTRA_NUM_DEP_ELEMENTS]</code>	double	all	Vector of model-dependent parameters	-	-
<code>extra_out[XO_PROPAG_EXTRA_NUM_INDEP_ELEMENTS]</code>	double	all	Vector of model-independent parameters. It depends upon extra-choice	-	-
<code>ierr[XO_NUM_ERR_PROPAG_EXTRA]</code>	long	all	Status vector	-	-

### 7.19.5 Results vectors

The model-dependent parameters vector for the **Mean Keplerian propagation model** is (note that there is an enumeration associated to the elements of the results vectors) in table 59:

*Table 59: Ancillary results vector. Model-dependent parameters*

Result parameter	Set	Description (Reference)	Unit (Format)	Allowed Range
[0] XO_PROPAG_EXTRA_DEP_NODAL_PERIOD	ANX Timing	Nodal period	s	$\geq 0$
[1] XO_PROPAG_EXTRA_DEP.UTC_CURRENT_ANX		Time of current ANX	decimal days (Processing format)	-
[2] XO_PROPAG_EXTRA_DEP_ORBIT_NUMBER	Positi on in orbit <sup>a</sup>	Absolute Orbit Number		$> 0$
[3] XO_PROPAG_EXTRA_DEP_SEC_SINCE_ANX		Time since ANX	s	$\geq 0$ < Nodal Period
[4:9] XO_PROPAG_EXTRA_DEP_MEAN_KEPL_A XO_PROPAG_EXTRA_DEP_MEAN_KEPL_E XO_PROPAG_EXTRA_DEP_MEAN_KEPL_I XO_PROPAG_EXTRA_DEP_MEAN_KEPL_RA XO_PROPAG_EXTRA_DEP_MEAN_KEPL_W XO_PROPAG_EXTRA_DEP_MEAN_KEPL_M	Mean Kepler	Mean Kepler ele- ments of the propa- gated OSV (True of Date)	-	-

a. These parameters are calculated only when initialising with `xo_orbit_init_file` and `xo_orbit_init_def`

The model-dependent parameters vector for the **Spot propagation model** is TBD.

The model-dependent parameters vector for the **TLE propagation model** is (note that there is an enumeration associated to the elements of the results vectors) in table 60:

*Table 60: Ancillary results vector. Model-dependent parameters*

Result parameter	Set	Description (Reference)	Unit (Format)	Allowed Range
[0] XO_PROPAG_EXTRA_DEP_NODAL_PERIOD	Not used <sup>a</sup>	-	-	-
[1] XO_PROPAG_EXTRA_DEP.UTC_CURRENT_ANX		-	-	-
[2] XO_PROPAG_EXTRA_DEP_ORBIT_NUMBER	Positi on in orbit	Absolute Orbit Number		$> 0$
[3] XO_PROPAG_EXTRA_DEP_SEC_SINCE_ANX		Time since ANX	s	$\geq 0$ < Nodal Period

**Table 60: Ancillary results vector. Model-dependent parameters**

[4:9] XO_PROPAG_EXTRA_DEP_MEAN_KEPL_A XO_PROPAG_EXTRA_DEP_MEAN_KEPL_E XO_PROPAG_EXTRA_DEP_MEAN_KEPL_I XO_PROPAG_EXTRA_DEP_MEAN_KEPL_RA XO_PROPAG_EXTRA_DEP_MEAN_KEPL_W XO_PROPAG_EXTRA_DEP_MEAN_KEPL_M	Not used <sup>a</sup>	-	-	-
--	-----------------------	---	---	---

a. These parameters can be computed by calling the CFI function `xo_orbit_info` for the current absolute orbit

The model-independent parameters vector is (note that there is an enumeration associated to the elements of the results vectors) in table 61:

**Table 61: Ancillary results vector. Model-independent parameters**

Result parameter (res element)	Set	Description (Reference)	Unit (Format)	Allowed Range
[0] XO_PROPAG_EXTRA_GEOC_LONG	Geolocation	Geocentric longitude of satellite and SSP (EF frame)	deg	>= 0 < 360
[1] XO_PROPAG_EXTRA_GEOD_LAT		Geodetic latitude of satellite and SSP (EF frame)	deg	>= -90 <= +90
[2] XO_PROPAG_EXTRA_GEOD_ALT		Geodetic altitude of the satellite (EF frame)	m	-
[3] XO_PROPAG_EXTRA_GEOC_LONG_D	Geolocation rate	Geocentric longitude rate of satellite and SSP (EF frame)	deg/s	-
[4] XO_PROPAG_EXTRA_GEOD_LAT_D		Geodetic latitude rate of satellite and SSP (EF frame)	deg/s	-
[5] XO_PROPAG_EXTRA_GEOD_ALT_D		Geodetic altitude rate of the satellite (EF frame)	m/s	-
[6] XO_PROPAG_EXTRA_GEOC_LONG_2D	Geolocation rate rate	Geocentric longitude rate-rate of satellite and SSP (EF frame)	deg/s <sup>2</sup>	-
[7] XO_PROPAG_EXTRA_GEOD_LAT_2D		Geodetic latitude rate-rate of satellite and SSP (EF frame)	deg/s <sup>2</sup>	-
[8] XO_PROPAG_EXTRA_GEOD_ALT_2D		Geodetic altitude rate-rate of the satellite (EF frame)	m/s <sup>2</sup>	-
[9] XO_PROPAG_EXTRA_RAD_CUR_PARALLEL_MERIDIAN	Geolocation extra	Radius of curvature parallel to meridian at the SSP (EF frame)	m	>= 0
[10] XO_PROPAG_EXTRA_RAD_CUR_ORTHOMERIDIAN		Radius of curvature orthogonal to meridian at the SSP (EF frame)	m	>= 0
[11] XO_PROPAG_EXTRA_RAD_CUR_ALONG_GROUNDTRACK		Radius of curvature along groundtrack at the SSP (EF frame)	m	>= 0

**Table 61: Ancillary results vector. Model-independent parameters**

Result parameter (res element)	Set	Description (Reference)	Unit (Format)	Allowed Range
[12] XO_PROPAG_EXTRA_NORTH_VEL	Earth-fixed velocity	Northward component of the velocity relative to the Earth of the SSP (Topocentric frame)	m/s	-
[13] XO_PROPAG_EXTRA_EAST_VEL		Eastward component of the velocity relative to the Earth of the SSP (Topocentric frame)	m/s	-
[14] XO_PROPAG_EXTRA_MAG_VEL		Magnitude of the velocity relative to the Earth of the SSP (Topocentric frame)	m/s	$\geq 0$
[15] XO_PROPAG_EXTRA_AZ_VEL		Azimuth of the velocity relative to the Earth of the SSP (Topocentric frame)	deg	$\geq 0$ < 360
[16] XO_PROPAG_EXTRA_NORTH_ACC	Earth-fixed acceleration	Northward component of the acceleration relative to the Earth of the SSP (Topocentric frame)	m/s <sup>2</sup>	-
[17] XO_PROPAG_EXTRA_EAST_ACC		Eastward component of the acceleration relative to the Earth of the SSP (Topocentric frame)	m/s <sup>2</sup>	-
[18] XO_PROPAG_EXTRA_GROUNDTRACK_TANG_ACC		Groundtrack tangential component of the acceleration relative to the Earth of the SSP (Topocentric frame)	m/s <sup>2</sup>	-
[19] XO_PROPAG_EXTRA_AZ_ACC		Azimuth of the acceleration relative to the Earth of the SSP (Topocentric frame)	deg	$\geq 0$ < 360

*Table 61: Ancillary results vector. Model-independent parameters*

Result parameter (res element)	Set	Description (Reference)	Unit (Format)	Allowed Range
[20] XO_PROPAG_EXTRA_SAT_ECLIPSE_FLAG	Sun	Satellite eclipse flag  0 = No 1 = Yes		0, 1
[21] XO_PROPAG_EXTRA_SZA		Sun Zenith Angle	deg	$\geq 0$ $< 180$
[22] XO_PROPAG_EXTRA_MLST		Mean local solar time at the SSP	decimal hour	$\geq 0$ $< 24$
[23] XO_PROPAG_EXTRA_TLST		True local solar time at the SSP	decimal hour	$\geq 0$ $< 24$
[24] XO_PROPAG_EXTRA_TRUE_SUN_RA		True Sun's (centre) right ascension (TOD frame)	deg	$\geq 0$ $< 360$
[25] XO_PROPAG_EXTRA_TRUE_SUN_DEC		True Sun's (centre) declination (TOD frame)	deg	$\geq -90$ $\leq +90$
[26] XO_PROPAG_EXTRA_TRUE_SUN_SEMI_DIAM		True Sun's semi-diameter	deg	$\geq 0$
[27] XO_PROPAG_EXTRA_MOON_RA	Moon	Moon's (centre) right ascension (TOD frame)	deg	$\geq 0$ $< 360$
[28] XO_PROPAG_EXTRA_MOON_DEC		Moon's (centre) declination (TOD frame)	deg	$\geq -90$ $\leq +90$
[29] XO_PROPAG_EXTRA_MOON_SEMI_DIAM		Moon's semi-diameter	deg	$\geq 0$
[30] XO_PROPAG_EXTRA_MOON_AREA_LIT		Area of Moon lit by Sun		$\geq 0$ $\leq 1$
[31:36] XO_PROPAG_EXTRA_OSC_KEPL_A XO_PROPAG_EXTRA_OSC_KEPL_E XO_PROPAG_EXTRA_OSC_KEPL_I XO_PROPAG_EXTRA_OSC_KEPL_RA XO_PROPAG_EXTRA_OSC_KEPL_W XO_PROPAG_EXTRA_OSC_KEPL_M	Osculating Kepler	Osculating Keplerian elements of the OSV (TOD frame)		

**Table 61: Ancillary results vector. Model-independent parameters**

Result parameter (res element)	Set	Description (Reference)	Unit (Format)	Allowed Range
[37] XO_PROPAG_EXTRA_ORBIT_RAD	Inertial Aux	Orbit radius (TOD frame)	m	>= 0
[38] XO_PROPAG_EXTRA_RADIAL_ORB_VEL		Radial orbit velocity component (TOD frame)	m/s	-
[39] XO_PROPAG_EXTRA_TRANS_ORB_VEL		Transversal orbit velocity component (TOD frame)	m/s	-
[40] XO_PROPAG_EXTRA_ORB_VEL_MAG		Orbit velocity magnitude (TOD frame)	m/s	>= 0
[41] XO_PROPAG_EXTRA_RA_SAT		Right ascension of the satellite (TOD frame)	deg	>= 0 < 360
[42] XO_PROPAG_EXTRA_DEC_SAT		Declination of the satellite (TOD frame)	deg	>= -90 <= +90
[43] XO_PROPAG_EXTRA_EARTH_ROTATION_ANGLE		Earth rotation angle [H]	deg	>= 0 < 360
[44] XO_PROPAG_EXTRA_RA_SAT_D		Right ascension rate of the satellite (TOD frame)	deg/s	-
[45] XO_PROPAG_EXTRA_RA_SAT_2D		Right ascension rate-rate of the satellite (TOD frame)	deg/s <sup>2</sup>	-
[46] XO_PROPAG_EXTRA_OSC_TRUE_LAT		Satellite osculating true latitude (TOD frame)	deg	>= 0 < 360
[47] XO_PROPAG_EXTRA_OSC_TRUE_LAT_D		Satellite osculating true latitude rate (TOD frame)	deg/s	-
[48] XO_PROPAG_EXTRA_OSC_TRUE_LAT_2D		Satellite osculating true latitude rate-rate (TOD frame)	deg/s <sup>2</sup>	-

### 7.19.6 Warnings and errors

Next table lists the possible error messages that can be returned by the **xo\_propag\_extra** CFI function after translating the returned status vector into the equivalent list of error messages by calling the function of the EXPLORER\_ORBIT software library **xo\_get\_msg** (see [GEN\_SUM]).

This table also indicates the type of message returned, i.e. either a warning (WARN) or an error (ERR), the cause of such a message and the impact on the performed calculation, mainly on the results vector.

The table is completed by the error code and value. These error codes can be obtained translating the status vector returned by the **xo\_propag\_extra** CFI function by calling the function of the EXPLORER\_ORBIT software library **xo\_get\_code** (see [GEN\_SUM]).

*Table 62: Error messages of xo\_propag\_extra function*

Error type	Error message	Cause and impact	Error Code	Error No
ERR	The internal data were not initialized	No calculation performed	XO_CFI_PROPAG_EXTR A_NOT_INTERNAL_DA TA_ERR	0
ERR	Could not create extra results	No calculation performed	XO_CFI_PROPAG_EXTR A_RESULTS_ERR	1

### 7.19.7 Runtime performances

The following runtime performances have been measured:

*Table 63: Runtime performances of xo\_propag\_extra function*

<b>Solaris 32-bit. [ms]</b>	<b>Solaris 64 bit. [ms]</b>	<b>Linux 32-bit. [ms]</b>	<b>Linux 64-bit. [ms]</b>
0.090	0.14	0.019	0.0026

## 7.20 xo\_propag\_close

### 7.20.1 Overview

The **xo\_propag\_close** function is used to free the memory allocated by the other propagation routines, and it must be called after using them.

A complete calling sequence of the propagation procedure is presented in section 4.2.

### 7.20.2 Calling interface

The calling interface of the **xo\_propag\_close** CFI function is the following (input parameters are underlined):

```
#include <explorer_orbit.h>
{
    xo_propag_id propag_id = {NULL};
    long status;
    long ierr[XO_NUM_ERR_PROPAG_CLOSE];

    status = xo_propag_close (&propag_id, ierr)
}
```

### 7.20.3 Input parameters

The `xo_propag_close` CFI function has the following input parameters:

*Table 64: Input parameters of `xo_propag_close` function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
<code>propag_id</code>	<code>xo_propag_id*</code>	-	Structure that contains the propagator data	-	-

### 7.20.4 Output parameters

The output parameters of the `xo_propag_close` CFI function are:

*Table 65: Output parameters of `xo_propag_close` function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
<code>xo_propag_close</code>	<code>long</code>	-	Main status flag	-	-1, 0, +1
<code>ierr[XO_NUM_ERR_PROPAG_CLOSE]</code>	<code>long</code>	all	Status vector	-	-

### 7.20.5 Warnings and errors

Next table lists the possible error messages that can be returned by the `xo_propag_close` CFI function after translating the returned status vector into the equivalent list of error messages by calling the function of the EXPLORER\_ORBIT software library `xo_get_msg` (see [GEN\_SUM]).

This table also indicates the type of message returned, i.e. either a warning (WARN) or an error (ERR), the cause of such a message and the impact on the performed calculation, mainly on the results vector.

The table is completed by the error code and value. These error codes can be obtained translating the status vector returned by the `xo_propag_close` CFI function by calling the function of the EXPLORER\_ORBIT software library `xo_get_code` (see [GEN\_SUM]).

*Table 66: Error messages of `xo_propag_close` function*

Error type	Error message	Cause and impact	Error Code	Error No
ERR	Wrong Propag Id. It was not initialized or it is in use	The Propag Id. was not closed.	XO_CFI_PROPAG_CLOSE_WRONG_ID_ERR, ERR, NO_PAR	0

### ***7.20.6 Runtime performances***

The following runtime performances have been measured: runtime is smaller than CPU clock and it is not possible to perform loops for measuring it.

## 7.21 xo\_propag\_get\_id\_data

### 7.21.1 Overview

The `xo_propag_get_id_data` CFI function returns the data used for the propagation from the `propag_id`.

### 7.21.2 Calling interface

The calling interface of the `xo_propag_get_id_data` CFI function is the following (input parameters are underlined>):

```
#include <explorer_orbit.h>
{
    xo_propag_id propag_id;
    xo_propag_id_data data;
    long status;
    status = xo_propag_get_id_data(&propag_id, &data);
}
```

### 7.21.3 Input parameters

The `xo_propag_get_id_data` CFI function has the following input parameters:

*Table 67: Input parameters of xo\_propag\_get\_id\_data function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
propag_id	xo_propag_id*	-	Structure for propagation initialization	-	-

### 7.21.4 Output parameters

The output parameters of the `xo_propag_get_id_data` CFI function are:

*Table 68: Output parameters of xo\_propag\_get\_id\_data function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
xo_propag_get_id_data	long	-	Status flag	-	-
data	xo_propag_id_data	-	Propagation data structure	-	-

The data structure `xo_propag_id_data` can be seen in table 3.

### 7.21.5 Warnings and errors

This function does not return any error/warning code. Only the status of the function indicates if the execution was correct or not.

The possible causes of error are:

- The `propag_id` was not initialised.

### 7.21.6 Runtime performances

The following runtime performances have been estimated.

*Table 69: Runtime performances of `xo_propag_get_id_data` function*

Solaris 32-bit. [ms]	Solaris 64 bit. [ms]	Linux 32-bit. [ms]	Linux 64-bit. [ms]
0.0002	0.000	0.0002	0.000

## 7.22 xo\_interpol\_init

### 7.22.1 Overview

The **xo\_interpol\_init** initializes the interpolation process, i. e., it produces internal data to be used by the **xo\_interpol** function to perform the interpolation. The internal data consists of Cartesian orbit state vectors extracted from the *orbit\_id*, and validity times giving the allowed time window for interpolation.

Before calling this function it is required to initialise the orbit with one of the following modes:

- XO\_ORBIT\_INIT\_ROF\_MODE
- XO\_ORBIT\_INIT\_DORIS\_MODE

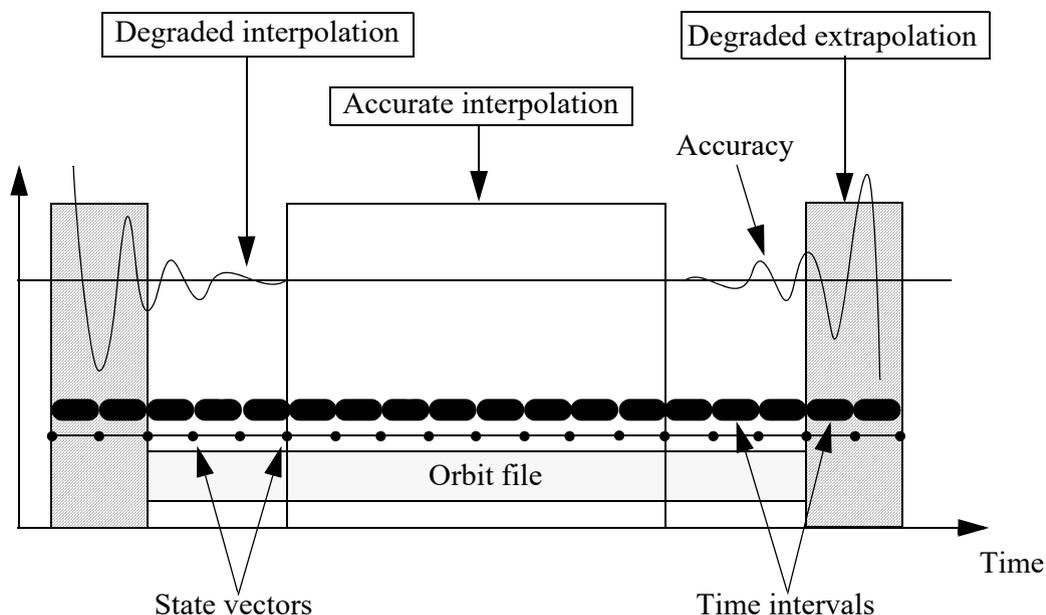
The validity start and stop times of the initialization (*val\_time0* and *val\_time1* output parameters) represents the allowed time window for interpolation.

**CAUTION:** The interpolation is highly accurate (1 mm. accuracy TBC) when it is performed between 4 input file(s) time intervals after start of file(s) and before end of file(s), but it degrades (up to a few cm. TBC) until 1 or 2 time intervals (TBD) before start of file(s) and after end of file(s). figure 4 provides a graphical explanation.

The **xo\_interpol** function allows to extrapolate, that is, compute results for the 1 or 2 (TBC) intervals before start of the input file(s) and after end of the input file. Anyway, as seen above in the caution statement, extrapolation is not recommended. In this case, the extrapolation window is NOT included in the valid time interval.

When the interpolation is in “degraded” mode, that is, when extrapolation is used, or when there is less than four orbit state vectors available in the input file before or after the requested time, **xo\_interpol** function will issue different warnings messages indicating that a degraded interpolation or extrapolation is performed. If the requested time is out the allowed extrapolation range, the function will return an error message.

A complete calling sequence of the interpolation procedure is presented in section 4.3.



**Figure 4: Performances of the interpolation algorithm**

### 7.22.2 Calling interface

The calling interface of the **xo\_interpol\_init** CFI function is the following (input parameters are underlined):

```
#include <explorer_orbit.h>
{
    xo_orbit_id *orbit_id = {NULL};
    xo_interpol_id *interpol_id = {NULL};
    long interpol_model;
    long time_ref;
    double val_time0, val_time1;
    long status, ierr[XO_NUM_ERR_INTERPOL_INIT];

    status = xo_interpol_init (&orbit_id, &interpol_model,
                              &time_ref,
                              &val_time0, &val_time1,
                              &interpol_id, ierr);
}
```

### 7.22.3 Input parameters

The `xo_interpol_init` CFI function has the following input parameters:

*Table 70: Input parameters of xo\_interpol\_init function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
orbit_id	xo_orbit_id*	-	Structure that containing the orbit initialization	-	-
interpol_model	long*	-	Interpolation model ID	-	Complete
time_ref	long*	-	Time reference ID used in the output validity period	-	Complete

It is possible to use enumeration values rather than integer values for some of the input arguments:

- Interpolation model ID: `interpol_model`. Current document, section 6.2.
- Time reference ID: `time_ref`. See [GEN\_SUM].

### 7.22.4 Output parameters

The output parameters of the `xo_interpol_init` CFI function are:

*Table 71: Output parameters of xo\_interpol\_init function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
<code>xo_interpol_init_file</code>	long	-	Main status flag	-	-1, 0, +1
<code>val_time0</code>	double*	-	Validity start time of the initialization	Decimal days (Processing format)	[-18262.0,36524.0]
<code>val_time1</code>	double*	-	Validity stop time of the initialization	Decimal days (Processing format)	[-18262.0,36524.0]
<code>interpol_id</code>	xo_interpol_id*	-	Structure that containing the interpolation data	-	-
<code>ierr[XO_NUM_ERR_INTERPOL_INIT]</code>	long	all	Status vector	-	-

### 7.22.5 Warnings and errors

Next table lists the possible error messages that can be returned by the **xo\_interpol\_init** CFI function after translating the returned status vector into the equivalent list of error messages by calling the function of the EXPLORER\_ORBIT software library **xo\_get\_msg** (see [GEN\_SUM]).

This table also indicates the type of message returned, i.e. either a warning (WARN) or an error (ERR), the cause of such a message and the impact on the performed calculation, mainly on the results vector.

The table is completed by the error code and value. These error codes can be obtained translating the status vector returned by the **xo\_interpol\_init** CFI function by calling the function of the EXPLORER\_ORBIT software library **xo\_get\_code** (see [GEN\_SUM]).

*Table 72: Error messages of xo\_interpol\_init function*

Error type	Error message	Cause and impact	Error Code	Error No
ERR	Memory allocation error.	No calculation performed	XO_CFI_INTERPOL_INIT_MEMORY_ERR	0
ERR	Orbit Id. is not initialized	No calculation performed	XO_CFI_INTERPOL_INIT_ORBIT_STATUS_ERR	1
ERR	Wrong input orbit Id.	No calculation performed	XO_CFI_INTERPOL_INIT_ORBIT_ID_ERR	2
ERR	Interpol Id is already initialized.	No calculation performed	XO_CFI_INTERPOL_INIT_STATUS_ERR	3
ERR	ANX state vector does not satisfy loose Earth Explorer tolerance requirements.	No calculation performed	XO_CFI_INTERPOL_INIT_LOOSE_TOL_ERR	4
ERR	Problem calculating the Earth Explorer acceleration.	No calculation performed	XO_CFI_INTERPOL_INIT_ACCELERATION_ERR	5
ERR	Error changing time format or reference	No calculation performed	XO_CFI_INTERPOL_INIT_TIME_CORRELATION_ERR	6
WARN	ANX state vector does not satisfy tight Earth Explorer tolerance requirements.	Calculation performed	XO_CFI_INTERPOL_INIT_TIGHT_TOL_WARN	7

### 7.22.6 Runtime performances

The following runtime performances have been measured:

*Table 73: Runtime performances of xo\_interpol\_init function*

Solaris 32-bit. [ms]	Solaris 64 bit. [ms]	Linux 32-bit. [ms]	Linux 64-bit. [ms]
0.383	0.0.095	0.117	0.022

## 7.23 xo\_interpol

### 7.23.1 Overview

The **xo\_interpol** function is used to compute a Cartesian state vector at a requested time, using the internal data generated by the **xo\_interpol\_init\_file** routine.

To complete the description of the **xo\_interpol** function see comments in section 7.22.1.

A complete calling sequence of the interpolation procedure is presented in section 4.3.

### 7.23.2 Calling interface

The calling interface of the **xo\_interpol** CFI function is the following (input parameters are underlined):

```
#include <explorer_orbit.h>
{
    xo_interpol_id interpol_id = {NULL};
    long model, time_ref;
    double time, pos_out[3], vel_out[3], acc_out[3];
    long status, ierr[XO_NUM_ERR_INTERPOL];

    status =xo_interpol(&interpol_id, &model, &time_ref, &time,
                       pos_out, vel_out, acc_out, ierr);

    /* Or, using the run_id */
    long run_id;

    status =xo_interpol_run(&run_id, &model, &time_ref, &time,
                           pos_out, vel_out, acc_out, ierr);
}
```

### 7.23.3 Input parameters

The `xo_interpol` CFI function has the following input parameters:

*Table 74: Input parameters of xo\_interpol function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
interpol_id	xo_interpol_id*	-	Structure that contains the interpolator data	-	-
model	long *	-	Interpolation model	-	Complete
time_ref	long*	-	Time reference ID	-	Complete
time	double*	-	Reference time	Decimal days (Processing format)	[-18262.0,36524.0]

It is possible to use enumeration values rather than integer values for some of the input arguments:

- Interpolation model: model. Current document, section 6.2.
- Time reference ID: time\_ref. See [GEN\_SUM].

### 7.23.4 Output parameters

The output parameters of the `xo_interpol` CFI function are:

*Table 75: Output parameters of xo\_interpol function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
xo_propag	long	-	Main status flag	-	-1, 0, +1
pos_out[3]	double	all	Osculating position vector at interpolated time (EF reference frame)	m	-
vel_out[3]	double	all	Osculating velocity vector at interpolated time (EF reference frame)	m/s	-
acc_out[3]	double	all	Osculating acceleration vector at interpolated time (EF reference frame)	m/s <sup>2</sup>	-
ierr[XO_NUM_ERR_IN_TERPOL]	long	all	Status vector	-	-

### 7.23.5 Warnings and errors

Next table lists the possible error messages that can be returned by the **xo\_interpol** CFI function after translating the returned status vector into the equivalent list of error messages by calling the function of the EXPLORER\_ORBIT software library **xo\_get\_msg** (see [GEN\_SUM]).

This table also indicates the type of message returned, i.e. either a warning (WARN) or an error (ERR), the cause of such a message and the impact on the performed calculation, mainly on the results vector.

The table is completed by the error code and value. These error codes can be obtained translating the status vector returned by the **xo\_interpol** CFI function by calling the function of the EXPLORER\_ORBIT software library **xo\_get\_code** (see [GEN\_SUM]).

*Table 76: Error messages of xo\_interpol function*

Error type	Error message	Cause and impact	Error Code	Error No
ERR	Wrong input flag	No calculation performed	XO_CFI_INTERPOL_FLAG_ERR	0
ERR	Error changing time format or reference	No calculation performed	XO_CFI_INTERPOL_TIME_CORRELATION_ERR	1
ERR	Input time is out of range.	No calculation performed	XO_CFI_INTERPOL_WRONG_TIME2_ERR	2
ERR	The data base has not been previously initialised.	No calculation performed	XO_CFI_INTERPOL_NOT_INITIALISED_ERR	3
ERR	The requested date is out of the data base.	No calculation performed	XO_CFI_INTERPOL_TIME_OUT_OF_DB_ERR	4
ERR	Fatal error in XO_Interpol	No calculation performed	XO_CFI_INTERPOL_FATAL_ERROR_INTERPOL_ERR	5
ERR	State vector does not satisfy loose Earth Explorer tolerance requirements	No calculation performed	XO_CFI_INTERPOL_LOOSE_TOL_ERR	6
ERR	Problem calculating the Earth Explorer acceleration	No calculation performed	XO_CFI_INTERPOL_ACCELERATION_ERR	7
WARN	State vector does not satisfy tight Earth Explorer tolerance requirements	Calculation performed	XO_CFI_INTERPOL_TIGHT_TOL_WARN	8
WARN	Warning error in XO_Interpol	Calculation performed	XO_CFI_INTERPOL_FATAL_ERROR_INTERPOL_WARN	9
WARN	Time out of range. Computing State Vector with extrapolation algorithm	Calculation performed using an extrapolation algorithm. The results could not reach the desired accuracy.	XO_CFI_INTERPOL_EXTRAPOL_WARN	10
WARN	Less than four Orbit State Vectors to interpolate	Calculation performed Interpolation could not reach the desired accuracy	XO_CFI_INTERPOL_FEW_OSV_WARN	11

### 7.23.6 Runtime performances

The following runtime performances have been measured:

*Table 77: Runtime performances of xo\_interpol function*

<b>Solaris 32-bit. [ms]</b>	<b>Solaris 64 bit. [ms]</b>	<b>Linux 32-bit. [ms]</b>	<b>Linux 64-bit. [ms]</b>
0.0064	0.0014	0.002	0.0004

## 7.24 xo\_interpol\_extra

### 7.24.1 Overview

This software returns ancillary results derived from an orbit interpolation using the `xo_interpol` function. The ancillary results are similar to the ones produced by the `xo_propag_extra` routine.

Note that `xo_interpol_extra` should be called after `xo_interpol`. In case of calling `xo_interpol_extra` after `xo_interpol_init`, the ancillary results are computed for the first vector stored in the `xo_orbit_id` structure used for the interpol initialization (since `xo_interpol_init` does not have as input a requested time)

A complete calling sequence of the interpolation procedure is presented in section 4.3.

### 7.24.2 Calling interface

The calling interface of the `xo_interpol_extra` CFI function is the following:

```
#include <explorer_orbit.h>
{
    xo_interpol_id interpol_id = {NULL};
    long extra_choice;
    double model_out[XO_INTERPOL_EXTRA_NUM_DEP_ELEMENTS],
           extra_out[XO_INTERPOL_EXTRA_NUM_INDEP_ELEMENTS];
    long status, ierr[XO_NUM_ERR_INTERPOL_EXTRA];

    status = xo_interpol_extra (&interpol_id,&extra_choice,
                               model_out, extra_out, ierr);

    /* Or, using the run_id */
    long run_id;

    status = xo_interpol_extra_run (&run_id,&extra_choice,
                                    model_out, extra_out, ierr);
}
```

### 7.24.3 Input parameters

The `xo_interpol_extra` CFI function has the following input parameters:

*Table 78: Input parameters of `xo_interpol_extra` function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
<code>interpol_id</code>	<code>xo_interpol_id*</code>	-	Structure that contains the interpolator data	-	-
<code>extra_choice</code>	<code>long *</code>	-	Flag to allow an ancillary results choice	-	[0, 2047]

It is possible to use enumeration values rather than integer values for some of the input arguments:

- Flag to select ancillary results: `extra_choice`. See tables below:

*Table 79: Enumeration values of `extra_choice` input flag*

Model independant	Description	Long
<code>XO_INTERPOL_EXTRA_NO_RESULTS</code>	No extra results	0
<code>XO_INTERPOL_EXTRA_GEOLOCATION</code>	Geolocation results	1
<code>XO_INTERPOL_EXTRA_GEOLOCATION_D</code>	Geolocation rate results	2
<code>XO_INTERPOL_EXTRA_GEOLOCATION_2D</code>	Geolocation rate-rate results	4
<code>XO_INTERPOL_EXTRA_GEOLOCATION_EXTRA</code>	Geolocation extra results	8
<code>XO_INTERPOL_EXTRA_EARTH_FIXED_D</code>	Earth fixed velocity results	16
<code>XO_INTERPOL_EXTRA_EARTH_FIXED_2D</code>	Earth fixed acceleration results	32
<code>XO_INTERPOL_EXTRA_SUN</code>	Sun results	64
<code>XO_INTERPOL_EXTRA_MOON</code>	Moon results	128
<code>XO_INTERPOL_EXTRA_OSCULATING_KEPLER</code>	Osculating keplerian elements	256
<code>XO_INTERPOL_EXTRA_INERTIAL_AUX</code>	Inertial auxiliary results	512
Model dependant (Mean Keplerian model)	Description	Long
<code>XO_INTERPOL_EXTRA_DEP_ANX_TIMING</code>	ANX timing results	1024

To calculate all results there is an extra enumeration value, defined as the addition of all the enumeration result values:

Enumeration value	Description	Long
<code>XO_INTERPOL_EXTRA_ALL_RESULTS</code>	All results	2047

The elements calculated in each case are shown in sections 7.6.5 and 7.10.5. It is possible to select the calculation of different sets of output parameters, or to make any combination of them by adding the results enumeration desired. In order to calculate some elements it might be necessary to calculate elements which have not been explicitly requested. The function identifies internally all the dependencies and those elements are also returned in the result vectors.

### 7.24.4 Output parameters

The output parameters of the `xo_interpol_extra` CFI function are:

*Table 80: Output parameters of xo\_interpol\_extra function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
<code>xo_interpol_extra</code>	long	-	Main status flag	-	-1, 0, +1
<code>model_out[XO_INTERPOL_EXTRA_NUM_DEP_ELEMENTS]</code>	double	all	Vector of model-dependant parameters	-	-
<code>extra_out[XO_INTERPOL_EXTRA_NUM_INDEP_ELEMENTS]</code>	double	all	Vector of model-independant parameters	-	-
<code>rierr[XO_NUM_ERR_INTERPOL_EXTRA]</code>	long	all	Status vector	-	-

### 7.24.5 Results vectors

The model-dependant parameters vector for the **default interpolation model** is (note that there is an enumeration associated to the elements of the results vectors) in the following table:

*Table 81: Ancillary results vector. Model-dependent parameters*

Result parameter (res element)	Set	Description (Reference)	Unit (Format)	Allowed Range
[0] <code>XO_INTERPOL_EXTRA_DEP_NODAL_PERIOD</code>	ANX Timing	Nodal period	s	$\geq 0$
[1] <code>XO_INTERPOL_EXTRA_DEP_UTC_CURRENT_ANX</code>		UTC of current ANX	decimal days (Processing format)	-
[2] <code>XO_INTERPOL_EXTRA_DEP_ORBIT_NUMBER</code>	Position in orbit	Absolute Orbit Number		$> 0$
[3] <code>XO_INTERPOL_EXTRA_DEP_SEC_SINCE_ANX</code>		Time since ANX	s	$\geq 0$ $<$ Nodal Period

The model-independant results vectors are the same as the `xo_propag_extra` model-independant results vectors (see 7.19.5). The enumeration names are the same, changing PROPAG with INTERPOL (e.g. `XO_INTERPOL_EXTRA_ORBIT_RAD`).

### 7.24.6 Warnings and errors

Next table lists the possible error messages that can be returned by the **xo\_interpol\_extra** CFI function after translating the returned status vector into the equivalent list of error messages by calling the function of the EXPLORER\_ORBIT software library **xo\_get\_msg** (see [GEN\_SUM]).

This table also indicates the type of message returned, i.e. either a warning (WARN) or an error (ERR), the cause of such a message and the impact on the performed calculation, mainly on the results vector.

The table is completed by the error code and value. These error codes can be obtained translating the status vector returned by the **xo\_interpol\_extra** CFI function by calling the function of the EXPLORER\_ORBIT software library **xo\_get\_code** (see [GEN\_SUM]).

*Table 82: Error messages of xo\_interpol\_extra function*

Error type	Error message	Cause and impact	Error Code	Error No
ERR	Interpol Id. was not initialized	No calculation performed	XO_CFI_INTERPOL_EXTRA_ID_STATUS_ERR	0
ERR	Wrong input Interpol Id.	No calculation performed	XO_CFI_INTERPOL_EXTRA_FLAG_ERR	1
ERR	Could not perform a time transformation	No calculation performed	XO_CFI_INTERPOL_EXTRA_TIME_ERR	2
ERR	Could not calculate extra results	No calculation performed	XO_CFI_INTERPOL_EXTRA_RESULTS_ERR	3

### 7.24.7 Runtime performances

The following runtime performances have been measured:

*Table 83: Runtime performances of xo\_interpol\_extra function*

Solaris 32-bit. [ms]	Solaris 64 bit. [ms]	Linux 32-bit. [ms]	Linux 64-bit. [ms]
0.0068	0.0014	0.002	0.0002

## 7.25 xo\_interpol\_close

### 7.25.1 Overview

The **xo\_interpol\_close** function is used to free the memory allocated by the other orbit interpolation routines, and it must be called after using them.

A complete calling sequence of the interpolation procedure is presented in section 4.3.

### 7.25.2 Calling interface

The calling interface of the **xo\_interpol\_close** CFI function is the following (input parameters are underlined):

```
#include <explorer_orbit.h>
{
    xo_interpol_id interpol_id = {NULL};
    long status, ierr[XO_NUM_ERR_INTERPOL_CLOSE];

    status = xo_interpol_close (&interpol_id, ierr)
}
```

### 7.25.3 Input parameters

The `xo_interpol_close` CFI function has the following input parameters:

*Table 84: Input parameters of `xo_interpol_close` function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
<code>interpol_id</code>	<code>xo_interpol_id*</code>	-	Structure that contains the interpolator data	-	-

### 7.25.4 Output parameters

The output parameters of the `xo_interpol_close` CFI function are:

*Table 85: Output parameters of `xo_interpol_close` function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
<code>xo_interpol_close</code>	<code>long</code>	-	Main status flag	-	-1, 0, +1
<code>ierr[XO_NUM_ERR_INTERPOL_CLOSE]</code>	<code>long</code>	all	Status vector	-	-

### 7.25.5 Warnings and errors

Next table lists the possible error messages that can be returned by the `xo_interpol_close` CFI function after translating the returned status vector into the equivalent list of error messages by calling the function of the EXPLORER\_ORBIT software library `xo_get_msg` (see [GEN\_SUM]).

This table also indicates the type of message returned, i.e. either a warning (WARN) or an error (ERR), the cause of such a message and the impact on the performed calculation, mainly on the results vector.

The table is completed by the error code and value. These error codes can be obtained translating the status vector returned by the `xo_interpol_close` CFI function by calling the function of the EXPLORER\_ORBIT software library `xo_get_code` (see [GEN\_SUM]).

*Table 86: Error messages of `xo_interpol_close` function*

Error type	Error message	Cause and impact	Error Code	Error No
ERR	Wrong Interpol Id. It was not initialized or it is in use.	The Interpol Id. was not closed.	XO_CFI_INTERPOL_CLOSE_WRONG_ID_ERR	0

### 7.25.6 Runtime performances

The following runtime performances have been measured: runtime is smaller than CPU clock and it is not possible to perform loops for measuring it.

## 7.26 xo\_interpol\_get\_id\_data

### 7.26.1 Overview

The `xo_interpol_get_id_data` CFI function returns the data used for the interpolation from the `interpol_id`.

### 7.26.2 Calling interface

The calling interface of the `xo_interpol_get_id_data` CFI function is the following (input parameters are underlined>):

```
#include <explorer_orbit.h>
{
    xo_interpol_id interpol_id;
    xo_interpol_id_data data;
    long status;
    status = xo_interpol_get_id_data(&interpol_id, &data);
}
```

### 7.26.3 Input parameters

The `xo_interpol_get_id_data` CFI function has the following input parameters:

*Table 87: Input parameters of xo\_interpol\_get\_id\_data function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
interpol_id	xo_interpol_id*	-	Structure for interolation initialization	-	-

### 7.26.4 Output parameters

The output parameters of the `xo_interpol_get_id_data` CFI function are:

*Table 88: Output parameters of xo\_interpol\_get\_id\_data function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
xo_interpol_get_id_data	long	-	Status flag	-	-
data	xo_interpol_id_data	-	Interpolation data structure	-	-

The data structure `xo_interpol_id_data` can be seen in table 3.

### 7.26.5 Warnings and errors

This function does not return any error/warning code. Only the status of the function indicates if the execution was correct or not.

The possible causes of error are:

- The `interpol_id` was not initialised.

### 7.26.6 Runtime performances

The following runtime performances have been estimated.

*Table 89: Runtime performances of `xo_interpol_get_id_data` function*

Solaris 32-bit. [ms]	Solaris 64 bit. [ms]	Linux 32-bit. [ms]	Linux 64-bit. [ms]
0.0002	0.000	0.0002	0.000

---

## 7.27 xo\_orbit\_to\_time

### 7.27.1 Overview

The **xo\_orbit\_to\_time** function converts an orbit-relative time into processing time.

### 7.27.2 Calling sequence of xo\_orbit\_to\_time:

For C programs, the call to **xo\_orbit\_to\_time** is (input parameters are underlined):

```
#include <explorer_orbit.h>
{
    xo_orbit_id    orbit_id = {NULL};
    long time_ref;
    long orbit, second, microsec;
    long status, ierr[XO_NUM_ERR_ORBIT_TO_TIME];
    double time;

    status = xo_orbit_to_time (&uorbit_id,
                              &uorbit, &usecond, &umicrosec, &utime_ref,
                              &time, ierr);

    /* Or, using the run_id */
    long run_id;

    status = xo_orbit_to_time_run (&run_id,
                                   &uorbit, &usecond, &umicrosec,
                                   &utime_ref,
                                   &time, ierr);
}
```

### 7.27.3 Input parameters

Table 90: Input parameters for *xo\_orbit\_to\_time*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
orbit_id	xo_orbit_id*	-	Structure that contains the orbit data	-	-
orbit	long*		Absolute orbit number		> 0
second	long*		Seconds since ascending node	s	>= 0 <orbital period
microsec	long*		Micro seconds within second	μs	0 =< =< 999999
time_ref	long*		Time reference ID	-	Complete

### 7.27.4 Output parameters

Table 91: Output parameters for *xo\_orbit\_to\_time*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
xo_orbit_to_time	long		Main status flag		-1, 0, 1
time	double*		Resulting time	Dedimal days (processing format)	[-18262.0, +36519.0]
ierr[XO_NUM_ERR_ORBIT_TO_TIME]	long		Error status flags		

### 7.27.5 Warnings and errors

Next table lists the possible error messages that can be returned by the **xo\_orbit\_to\_time** CFI function after translating the returned status vector into the equivalent list of error messages by calling the function of the EXPLORER\_ORBIT software library **xo\_get\_msg** (see [GEN\_SUM]).

This table also indicates the type of message returned, i.e. either a warning (WARN) or an error (ERR), the cause of such a message and the impact on the performed calculation, mainly on the results vector.

The table is completed by the error code and value. These error codes can be obtained translating the status vector returned by the **xo\_orbit\_to\_time** CFI function by calling the function of the EXPLORER\_ORBIT software library **xo\_get\_code** (see [GEN\_SUM]).

*Table 92: Error messages of xo\_orbit\_to\_time function*

Error type	Error message	Cause and impact	Error Code	Error No
ERR	Wrong input flag	Computation not performed	XO_CFI_ORBIT_TO_TIME_FLAG_ERR	0
ERR	Input incorrect: negative orbit number	Computation not performed	XO_CFI_ORBIT_TO_TIME_ORB_NUM_1ST_ERR	1
ERR	Orbit Id. is not initialised.	Computation not performed	XO_CFI_ORBIT_TO_TIME_ORBIT_STATUS_ERR	2
ERR	Seconds and microseconds greater than nodal period	Computation not performed	XO_CFI_ORBIT_TO_TIME_SEC_MICROSEC_ERR	3
ERR	Requested orbit less than the first orbital change	Computation not performed	XO_CFI_ORBIT_TO_TIME_ORB_ERR	4
ERR	Input incorrect: negative number of seconds	Computation not performed	XO_CFI_ORBIT_TO_TIME_SEC_ERR	5
ERR	Input incorrect: number of microseconds out of range	Computation not performed	XO_CFI_ORBIT_TO_TIME_MICROSEC_ERR	6
ERR	Error computing time.	Computation not performed	XO_CFI_ORBIT_TO_TIME_COMPUTE_ERR	7
ERR	Could not make a time transformation	Computation not performed	XO_CFI_ORBIT_TO_TIME_TIME_CHANGE_ERR	8

### 7.27.6 Runtime performances

The following runtime performances have been measured:

*Table 93: Runtime performances of xo\_orbit\_to\_time function*

Solaris 32-bit. [ms]	Solaris 64 bit. [ms]	Linux 32-bit. [ms]	Linux 64-bit. [ms]
0.073	0.012	0.016	0.0022

### 7.27.7 Executable Program

The conversion from orbit to time described before can be carried out by the `orbit_to_time` executable program as follows:

```
orbit_to_time-sat satellite_name
    -file Orbit file
    -tref time_ref
    -orb orbit
    -anx anx_time (seconds)
    [ -v ]
    [ -xl_v ]
    [ -xo_v ]
    [ -help ]
    [ -show ]
    { (-tai TAI_time -gps GPS_time -utc UTC_time -ut1 UT1_time) |
      (-tmod time_model -tfile time_file -trid time_reference
        {(-tm0 time0 -tm1 time1) | (-orb0 orbit0 -orb1 orbit1) } ) }
```

Note that:

- Order of parameters does not matter.
- Bracketed parameters are not mandatory.
- Options between curly brackets and separated by a vertical bar are mutually exclusive.
- [ `-xl_v` ] option for EXPLORER\_LIB Verbose mode.
- [ `-xo_v` ] option for EXPLORER\_ORBIT Verbose mode.
- [ `-v` ] option for Verbose mode for all libraries (default is Silent).
- [ `-show` ] displays the inputs of the function and the results.
- Possible values for `satellite_name`: ERS1, ERS2, ENVISAT, METOP1, METOP2, METOP3, CRYOSAT, ADM, GOCE, SMOS, TERRASAR, EARTHCARE, SWARM\_A, SWARM\_B, SWARM\_C, SENTINEL\_1A, SENTINEL\_1B, SENTINEL\_2, SENTINEL\_3, SEOSAT, GENERIC

- 
- Possible values for *time\_model*: USER, NONE, IERS\_B\_PREDICTED, IERS\_B\_RESTITUTED, FOS\_PREDICTED, FOS\_RESTITUTED, DORIS\_PRELIMINARY, DORIS\_PRECISE, DORIS\_NAVIGATOR.
  - Possible values for *time\_ref* and *time\_reference*: UNDEF, TAI, UTC, UT1, GPS.
  - Data for initialising the time references are needed only when using an Orbit Scenario file. For other files the data is optional. In that case, if the initialization parameters are not provided, the time correlations are initialised with the input orbit file.

The inputs needed for time initialization are provided in the last three lines of parameters. Note that only one set of parameters should be introduced:

- TAI, GPS, UTC and UT1 input times (as in `xl_time_ref_init`)
- A file with time reference data, the time mode, the time reference name and a time range (as in `xl_time_ref_init_file`)

Example:

```
orbit_to_time -sat CRYOSAT -file EARTH_EXPLORER_FPO -tref UTC  
-orb 1001 -anx 0.0 -show -v
```

## 7.28 *xo\_time\_to\_orbit*

### 7.28.1 *Overview*

The **xo\_time\_to\_orbit** function converts an orbit-relative time into processing time.

### 7.28.2 *Calling sequence of xo\_time\_to\_orbit*

For C programs, the call to **xo\_time\_to\_orbit** is (input parameters are underlined):

```
#include <explorer_orbit.h>
{
    xo_orbit_id    orbit_id = {NULL};
    long time_ref;
    long orbit, second, microsec;
    long status, ierr[XO_NUM_ERR_ORBIT_TO_TIME];
    double time;

    status = xo_time_to_orbit ( &orbit_id,
                               &time_ref, &time,
                               &orbit, &second, &microsec,
                               ierr);

    /* Or, using the run_id */
    long run_id;

    status = xo_time_to_orbit_run ( &run_id,
                                   &time_ref, &time,
                                   &orbit, &second, &microsec,
                                   ierr);
}
```

### 7.28.3 Input parameters

Table 94: Input parameters for *xo\_time\_to\_orbit* function

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
orbit_id	xo_orbit_id*	-	Structure that contains the orbit data	-	-
time_ref	long*		Time reference ID	-	Complete
time	double*		Requested time	Dedimal days (processing format)	[-18262.0, +36519.0]

### 7.28.4 Output parameters

Table 95: Output parameters for *xo\_time\_to\_orbit*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
xo_time_to_orbit	long		Main status flag		-1, 0, 1
orbit	long*		Absolute orbit number		> 0
second	long*		Seconds since ascending node	s	>= 0 <orbital period
microsec	long*		Micro seconds within second	μs	0 =<=< 999999
ierr[XO_NUM_ERR_TIME_TO_ORBIT]	long		Error status flags		

### 7.28.5 Warnings and errors

Next table lists the possible error messages that can be returned by the **xo\_time\_to\_orbit** CFI function after translating the returned status vector into the equivalent list of error messages by calling the function of the EXPLORER\_ORBIT software library **xo\_get\_msg** (see [GEN\_SUM]).

This table also indicates the type of message returned, i.e. either a warning (WARN) or an error (ERR), the cause of such a message and the impact on the performed calculation, mainly on the results vector.

The table is completed by the error code and value. These error codes can be obtained translating the status vector returned by the **xo\_time\_to\_orbit** CFI function by calling the function of the EXPLORER\_ORBIT software library **xo\_get\_code** (see [GEN\_SUM]).

*Table 96: Error messages of xo\_time\_to\_orbit function*

Error type	Error message	Cause and impact	Error Code	Error No
ERR	Wrong input flag	Computation not performed	XO_CFI_TIME_TO_ORBIT_FLAG_ERR	0
ERR	Orbit Id. was not initialized.	Computation not performed	XO_CFI_TIME_TO_ORBIT_ORBIT_STATUS_ERR	1
ERR	Input incorrect: time out of range.	Computation not performed	XO_CFI_TIME_TO_ORBIT_TIME_ERR	2
ERR	Input time smaller than the first ANX time.	Computation not performed	XO_CFI_TIME_TO_ORBIT_BEFORE_RANGE_ERR	3
ERR	Could not compute the orbit number.	Computation not performed	XO_CFI_TIME_TO_ORBIT_COMPUTE_ERR	4
ERR	The current orbit initialization does not allow to compute the time.	Computation not performed	XO_CFI_TIME_TO_ORBIT_WRONG_ORBIT_MODE_ERR	5
WARN	Input time before first orbit.	Computation performed	XO_CFI_TIME_TO_ORBIT_TIME_BEFORE_RANGE_WARN	6
WARN	Input time after first orbit.	Computation performed	XO_CFI_TIME_TO_ORBIT_TIME_AFTER_RANGE_WARN	7
WARN	Orbit number computed with warnings.	Computation performed	XO_CFI_TIME_TO_ORBIT_COMPUTE_WARN	8

### 7.28.6 Runtime performances

The following runtime performances have been measured:

*Table 97: Runtime performances of `xo_time_to_orbit` function*

Solaris 32-bit. [ms]	Solaris 64 bit. [ms]	Linux 32-bit. [ms]	Linux 64-bit. [ms]
0.397	0.171	0.288	0.058

### 7.28.7 Executable Program

The conversion from time to orbit described before can be carried out by the `time_to_orbit` executable program as follows:

```
time_to_orbit-sat satellite_name
    -file Orbit file
    -tref time_ref
    {-time time (days) | -atime time (CCSDSA format)}
    [-v ]
    [-xl_v ]
    [-xo_v ]
    [-help ]
    [-show]
    {(-tai TAI_time -gps GPS_time -utc UTC_time -ut1 UT1_time) |
    (-tmod time_model -tfile time_file -trid time_reference
    {(-tm0 time0 -tm1 time1) | (-orb0 orbit0 -orb1 orbit1) } ) }
```

Note that:

- Order of parameters does not matter.
- Bracketed parameters are not mandatory.
- Options between curly brackets and separated by a vertical bar are mutually exclusive.
- [ `-xl_v` ] option for EXPLORER\_LIB Verbose mode.
- [ `-xo_v` ] option for EXPLORER\_ORBIT Verbose mode.
- [ `-v` ] option for Verbose mode for all libraries (default is Silent).
- [ `-show` ] displays the inputs of the function and the results.
- Possible values for `satellite_name`: ERS1, ERS2, ENVISAT, METOP1, METOP2, METOP3, CRYOSAT, ADM, GOCE, SMOS, TERRASAR, EARTHCARE, SWARM\_A, SWARM\_B, SWARM\_C, SENTINEL\_1A, SENTINEL\_1B, SENTINEL\_2, SENTINEL\_3, SEOSAT, GENERIC.
- Possible values for `time_model`: USER, NONE, IERS\_B\_PREDICTED, IERS\_B\_RESTITUTED, FOS\_PREDICTED, FOS\_RESTITUTED, DORIS\_PRELIMINARY, DORIS\_PRECISE, DORIS\_NAVIGATOR.
- Possible values for `time_ref` and `time_reference`: UNDEF, TAI, UTC, UT1, GPS.

- Data for initialising the time references are needed only when using an Orbit Scenario file. For other files the data are optional. In that case, if the initialization parameters are not provided, the time correlations are initialised with the input orbit file

The inputs needed for time initialization are provided in the last three lines of parameters. Note that only one set of parameters should be introduced:

- TAI, GPS, UTC and UT1 input times (as in `xl_time_ref_init`)
- A file with time reference data, the time mode, the time reference name and a time range (as in `xl_time_ref_init_file`)

Example:

```
time_to_orbit -sat CRYOSAT -file EARTH_EXPLORER_FPO -tref UTC  
-time -2010.108657407 -show -v
```

## 7.29 xo\_orbit\_info

### 7.29.1 Overview

The **xo\_orbit\_info** function retrieves from the orbit initialisation, information related with a certain orbit (specified by means of absolute orbit number).

### 7.29.2 Calling sequence of xo\_orbit\_info

For C programs, the call to **xo\_orbit\_info** is (input parameters are underlined, some may be input or output depending on the calling mode):

```
#include <explorer_orbit.h>
{
    xo_orbit_id    orbit_id = {NULL};
    long          abs_orbit;
    long          ierr[XO_NUM_ERR_ORBIT_INFO], status;
    double        result_vector[XO_ORBIT_INFO_EXTRA_NUM_ELEMENTS];

    status = xo_orbit_info (&orbit_id,
                          &abs_orbit,
                          result_vector, ierr);

    /* Or, using the run_id */
    long run_id;

    status = xo_orbit_info_run (&run_id,
                              &abs_orbit,
                              result_vector, ierr);
}
```

### 7.29.3 Input parameters

*Table 98: Input parameters for xo\_orbit\_info*

<b>C name</b>	<b>C type</b>	<b>Array Element</b>	<b>Description (Reference)</b>	<b>Unit (Format)</b>	<b>Allowed Range</b>
orbit_id	xo_orbit_id*	-	Structure that contains the orbit data.	-	-
abs_orbit	long *		Absolute orbit number		within orbit_id range

## 7.29.4 Output parameters

Table 99: Output parameters for *xo\_orbit\_info*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
xo_orbit_info	long	-	Main status flag		-1, 0, 1
result_vector [XO_ORBIT_INFO_EXTRA_NUM_ELEMENTS]	double	[0]: XO_ORBIT_INFO_EXTRA_REPEAT_CYCLE	repeat_cycle <sup>a</sup>	days	>0
		[1]:XO_ORBIT_INFO_EXTRA_CYCLE_LENGTH	cycle_length <sup>a</sup>	orbits	>0
		[2]:XO_ORBIT_INFO_EXTRA_MLST_DRIFT	MLST drift <sup>a</sup>	s/day	
		[3]:XO_ORBIT_INFO_EXTRA_MLST	MLST <sup>b</sup>	hours	>0 <24
		[4]:XO_ORBIT_INFO_EXTRA_ANX_LONG	phasing	deg	>0 <360
		[5]:XO_ORBIT_INFO_EXTRA_UTC_ANX	UTC time at ascending node	days (processing format)	
		[6]:XO_ORBIT_INFO_EXTRA_POS_X, [7]:XO_ORBIT_INFO_EXTRA_POS_Y, [8]:XO_ORBIT_INFO_EXTRA_POS_Z,	position at ANX	m	
		[9]:XO_ORBIT_INFO_EXTRA_VEL_X [10]:XO_ORBIT_INFO_EXTRA_VEL_Y [11]:XO_ORBIT_INFO_EXTRA_VEL_Z	velocity at ANX	m/s	
		[12]: XO_ORBIT_INFO_EXTRA_MEAN_KEPL_A [13]: XO_ORBIT_INFO_EXTRA_MEAN_KEPL_E [14]: XO_ORBIT_INFO_EXTRA_MEAN_KEPL_I [15]: XO_ORBIT_INFO_EXTRA_MEAN_KEPL_RA [16]: XO_ORBIT_INFO_EXTRA_MEAN_KEPL_W [17]: XO_ORBIT_INFO_EXTRA_MEAN_KEPL_M	mean keplerian elements at ANX		
		[18]: XO_ORBIT_INFO_EXTRA_OSC_KEPL_A [19]: XO_ORBIT_INFO_EXTRA_OSC_KEPL_E [20]: XO_ORBIT_INFO_EXTRA_OSC_KEPL_I [21]: XO_ORBIT_INFO_EXTRA_OSC_KEPL_RA [22]: XO_ORBIT_INFO_EXTRA_OSC_KEPL_W [23]: XO_ORBIT_INFO_EXTRA_OSC_KEPL_M	osculating keplerian elements at ANX		
[24]: XO_ORBIT_INFO_EXTRA_NODAL_PERIOD	Nodal period	s			
ieerr[XO_ORBIT_INFO_FROM_ABS]	long	all	Error status flags		

a. This parameter is only computed if the input orbit\_id was computed either with an Orbit Sceanrio file using xo\_orbit\_init\_file or with xo\_orbit\_init\_def

b. This parameter is not computed if the input orbit\_id was computed using a Restituted Orbit file or a DORIS file

### 7.29.5 Warnings and errors

Next table lists the possible error messages that can be returned by the **xo\_orbit\_info** CFI function after translating the returned status vector into the equivalent list of error messages by calling the function of the EXPLORER\_ORBIT software library **xo\_get\_msg** (see [GEN\_SUM]).

This table also indicates the type of message returned, i.e. either a warning (WARN) or an error (ERR), the cause of such a message and the impact on the performed calculation, mainly on the results vector.

The table is completed by the error code and value. These error codes can be obtained translating the status vector returned by the **pv\_utcanx** CFI function by calling the function of the EXPLORER\_ORBIT software library **xo\_get\_code** (see [GEN\_SUM]).

*Table 100: Error messages of xo\_orbit\_info function*

Error type	Error message	Cause and impact	Error Code	Error No
ERR	Orbit Id. No initialised.	Computation not performed	XO_CFI_ORBIT_INFO_ORBIT_INIT_ERR	0
ERR	Orbit out of initialised limits.	Computation not performed	XO_CFI_ORBIT_INFO_OUT_OF_LIMITS_ERR	1
ERR	Could not compute extra results	Computation not performed	XO_CFI_ORBIT_INFO_RESULTS_ERR	2

### 7.29.6 Runtime performances

The following runtime performances have been measured:

*Table 101: Runtime performances of xo\_orbit\_info function*

Solaris 32-bit. [ms]	Solaris 64 bit. [ms]	Linux 32-bit. [ms]	Linux 64-bit. [ms]
1.362	0.337	0.4200	0.155

## 7.30 xo\_orbit\_rel\_from\_abs

### 7.30.1 Overview

The `xo_orbit_rel_from_abs` function retrieves from an Orbit Scenario File (previously initialised through the `orbit Id`) the relative orbit corresponding to a given absolute orbit number.

### 7.30.2 Calling sequence of `xo_orbit_rel_from_abs`

For C programs, the call to `xo_orbit_rel_from_abs` is (input parameters are underlined, some may be input or output depending on the calling mode):

```
#include <explorer_orbit.h>
{
    xo_orbit_id    orbit_id = {NULL};
    long          abs_orbit, rel_orbit, cycle, phase;
    long          ierr[XO_NUM_ERR_ORBIT_REL_FROM_ABS], status;

    status = xo_orbit_rel_from_abs (&uorbit_id,
                                   &uabs_orbit,
                                   &urel_orbit, &ucycle,
                                   &uphase, ierr);

    /* Or, using the run_id */
    long run_id;
    status = xo_orbit_rel_from_abs_run (&run_id,
                                       &uabs_orbit,
                                       &urel_orbit, &ucycle,
                                       &uphase, ierr);
}
```

### 7.30.3 Input parameters

Table 102: Input parameters for *xo\_orbit\_rel\_from\_abs*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
orbit_id	xo_orbit_id*	-	Structure that contains the orbit data	-	-
abs_orbit	long *		Absolute orbit number		within orbit_id range

### 7.30.4 Output parameters

Table 103: Output parameters for *xo\_orbit\_rel\_from\_abs*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
xo_orbit_rel_from_abs	long		Main status flag,		-1, 0, 1
rel_orbit	long *		Relative orbit number		
cycle	long *		Cycle number		
phase	long *		Phase number		
ierr[XO_ORBIT_REL_FROM_ABS]	long	all	Error status flags		

### 7.30.5 Warnings and errors

Next table lists the possible error messages that can be returned by the `xo_orbit_rel_from_abs` CFI function after translating the returned status vector into the equivalent list of error messages by calling the function of the EXPLORER\_ORBIT software library `xo_get_msg` (see [GEN\_SUM]).

This table also indicates the type of message returned, i.e. either a warning (WARN) or an error (ERR), the cause of such a message and the impact on the performed calculation, mainly on the results vector.

The table is completed by the error code and value. These error codes can be obtained translating the status vector returned by the `pv_utcanx` CFI function by calling the function of the EXPLORER\_ORBIT software library `xo_get_code` (see [GEN\_SUM]).

*Table 104: Error messages of `xo_orbit_rel_from_abs` function*

Error type	Error message	Cause and impact	Error Code	Error No
ERR	Orbit Id. is not initialised.	Computation not performed	XO_CFI_ORBIT_REL_FROM_ABS_ORBIT_INIT_ERR	0
ERR	The relative orbit could not be computed with the current orbit initialization.	Computation not performed	XO_CFI_ORBIT_REL_FROM_ABS_ORBIT_WRONG_MODE_ERR	1
ERR	Wrong input orbit number	Computation not performed	XO_CFI_ORBIT_REL_FROM_ABS_WRONG_ORBIT	2

### 7.30.6 Runtime performances

The following runtime performances have been measured:

*Table 105: Runtime performances of `xo_orbit_rel_from_abs` function*

Solaris 32-bit. [ms]	Solaris 64 bit. [ms]	Linux 32-bit. [ms]	Linux 64-bit. [ms]
0.0094	0.0018	0.002	0.0002

## 7.31 **xo\_orbit\_abs\_from\_rel**

### 7.31.1 *Overview*

The **xo\_orbit\_abs\_from\_rel** function retrieves from an Orbit Scenario File (previously initialised through the *orbit Id*) the absolute orbit corresponding to a given relative orbit number and cycle.

### 7.31.2 *Calling sequence of xo\_orbit\_abs\_from\_rel*

For C programs, the call to **xo\_orbit\_abs\_from\_rel** is (input parameters are underlined, some may be input or output depending on the calling mode):

```
#include <explorer_orbit.h>
{
    xo_orbit_id    orbit_id = {NULL};
    long          abs_orbit, rel_orbit, cycle, phase;
    long          ierr[XO_NUM_ERR_ORBIT_ABS_FROM_REL], status;

    status = xo_orbit_abs_from_rel (&orbit_id,
                                   &rel_orbit, &cycle,
                                   &abs_orbit, &phase, ierr);

    /* Or, using the run_id */
    long run_id;

    status = xo_orbit_abs_from_rel_run (&run_id,
                                       &rel_orbit, &cycle,
                                       &abs_orbit, &phase, ierr);
}
```

### 7.31.3 Input parameters

Table 106: Input parameters for *xo\_orbit\_abs\_from\_rel*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
orbit_id	xo_orbit_id*	-	Structure that contains the orbit data	-	-
rel_orbit	long *		Relative orbit number		
cycle	long *		Cycle number		

### 7.31.4 Output parameters

Table 107: Output parameters for *xo\_orbit\_abs\_from\_rel*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
xo_orbit_abs_from_rel	long		Main status flag,		-1, 0, 1
abs_orbit	long *		Absolute orbit number		within orbit_id range
phase	long *		Phase number		
ierr[XO_ORBIT_ABS_FROM_REL]	long	all	Error status flags		

### 7.31.5 Warnings and errors

Next table lists the possible error messages that can be returned by the `xo_orbit_abs_from_rel` CFI function after translating the returned status vector into the equivalent list of error messages by calling the function of the EXPLORER\_ORBIT software library `xo_get_msg` (see [GEN\_SUM]).

This table also indicates the type of message returned, i.e. either a warning (WARN) or an error (ERR), the cause of such a message and the impact on the performed calculation, mainly on the results vector.

The table is completed by the error code and value. These error codes can be obtained translating the status vector returned by the `pv_utcanx` CFI function by calling the function of the EXPLORER\_ORBIT software library `xo_get_code` (see [GEN\_SUM]).

*Table 108: Error messages of `xo_orbit_abs_from_rel` function*

Error type	Error message	Cause and impact	Error Code	Error No
ERR	Orbit Id. is not initialised.	Computation not performed	XO_CFI_ORBIT_ABS_FROM_REL_ORBIT_INIT_ERROR	0
ERR	The orbit numbers could not be computed with the current orbit initialization.	Computation not performed	XO_CFI_ORBIT_ABS_FROM_REL_ORBIT_WRONG_MODE_ERROR	1
ERR	Wrong input relative orbit and/or cycle.	Computation not performed	XO_CFI_ORBIT_ABS_FROM_REL_INPUT_PARAMETER_ERROR	2

### 7.31.6 Runtime performances

The following runtime performances have been measured:

*Table 109: Runtime performances of `xo_orbit_abs_from_rel` function*

Solaris 32-bit. [ms]	Solaris 64 bit. [ms]	Linux 32-bit. [ms]	Linux 64-bit. [ms]
0.0098	0.0016	0.0022	0.0002

---

## 7.32 xo\_orbit\_abs\_from\_phase

### 7.32.1 Overview

The `xo_orbit_abs_from_phase` function retrieves from an Orbit Scenario File (previously initialised through the `orbit Id`) the absolute orbit corresponding to a given phase.

### 7.32.2 Calling sequence of `xo_orbit_abs_from_phase`

For C programs, the call to `xo_orbit_abs_from_phase` is (input parameters are underlined, some may be input or output depending on the calling mode):

```
#include <explorer_orbit.h>
{
    xo_orbit_id    orbit_id = {NULL};
    long           abs_orbit, rel_orbit, cycle, phase;
    long           ierr[XO_NUM_ERR_ORBIT_ABS_FROM_REL], status;

    status = xo_orbit_abs_from_phase (&orbit_id,
                                     &phase,
                                     &abs_orbit,
                                     &rel_orbit, &cycle,
                                     ierr);

    /* Or, using the run_id */
    long run_id;
    status = xo_orbit_abs_from_phase_run (&run_id,
                                          &phase,
                                          &abs_orbit,
                                          &rel_orbit, &cycle,
                                          ierr);
}
```

### 7.32.3 Input parameters

Table 110: Input parameters for *xo\_orbit\_abs\_from\_phase*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
orbit_id	xo_orbit_id*	-	Structure that contains the orbit data	-	-
phase	long *		Phase number		

### 7.32.4 Output parameters

Table 111: Output parameters for *xo\_orbit\_abs\_from\_phase*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
xo_orbit_abs_from_phase	long		Main status flag,		-1, 0, 1
abs_orbit	long *		Absolute orbit number		within orbit_id range
rel_orbit	long *		Relative orbit number		
cycle	long *		Cycle number		
ierr[XO_ORBIT_ABS_FROM_PHASE]	long	all	Error status flags		

### 7.32.5 Warnings and errors

Next table lists the possible error messages that can be returned by the `xo_orbit_abs_from_phase` CFI function after translating the returned status vector into the equivalent list of error messages by calling the function of the EXPLORER\_ORBIT software library `xo_get_msg` (see [GEN\_SUM]).

This table also indicates the type of message returned, i.e. either a warning (WARN) or an error (ERR), the cause of such a message and the impact on the performed calculation, mainly on the results vector.

The table is completed by the error code and value. These error codes can be obtained translating the status vector returned by the `pv_utcanx` CFI function by calling the function of the EXPLORER\_ORBIT software library `xo_get_code` (see [GEN\_SUM]).

*Table 112: Error messages of `xo_orbit_abs_from_phase` function*

Error type	Error message	Cause and impact	Error Code	Error No
ERR	Orbit Id. is not initialised.	Computation not performed	XO_CFI_ORBIT_ABS_FROM_PHASE_ORBIT_INIT_ERR	0
ERR	The orbit numbers could not be computed with the current orbit initialization.	Computation not performed	XO_CFI_ORBIT_ABS_FROM_PHASE_ORBIT_WRONG_MODE_ERR	1
ERR	Wrong input phase number.	Computation not performed	XO_CFI_ORBIT_ABS_FROM_PHASE_INPUT_PARAMETER_ERR	2

### 7.32.6 Runtime performances

The following runtime performances have been measured:

*Table 113: Runtime performances of `xo_orbit_abs_from_phase` function*

Solaris 32-bit. [ms]	Solaris 64 bit. [ms]	Linux 32-bit. [ms]	Linux 64-bit. [ms]
0.01	0.0016	0.002	0.0004

## 7.33 xo\_osv\_to\_tle

### 7.33.1 Overview

The `xo_osv_to_tle` function generates a TLE by fitting the set of orbit state vectors stored in the `orbit_id`. This set of OSVs are selected from the input `orbit_id` for the orbit/time requested range. Note that it is possible to convert only one OSV if:

- the requested time range only contains an OSV.
- the start orbit equal to the stop orbit.

Note: Currently, only one OSV can be converted to TLE. In case of introducing a time/orbit range, the first OSV in that range is selected for the conversion.

### 7.33.2 Calling sequence of `xo_osv_to_tle`

For C programs, the call to `xo_osv_to_tle` is (input parameters are underlined, some may be input or output depending on the calling mode):

```
#include <explorer_orbit.h>
{
    xo_orbit_id    orbit_id = {NULL};
    xd_tle_rec     tle_rec;
    long           time_mode, time_ref, orbit0, orbit1;
    double         time0, time1;
    long           ierr[XO_NUM_ERR_OSV_TO_TLE], status;

    status = xo_osv_to_tle (&orbit_id,
                           &time_mode, &time_ref,
                           &time0, &time1,
                           &orbit0, &orbit1,
                           /* outputs */
                           &tle_rec,
                           ierr);
}
```

### 7.33.3 Input parameters

Table 114: Input parameters for *xo\_osv\_to\_tle*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
orbit_id	xo_orbit_id*	-	Structure that contains the orbit data	-	-
time_mode	long	-	time/orbit selection mode. For the XL_SEL_DEFAULT mode, the whole range of orbits stored in the orbit_id is selected	-	XO_SEL_TIME XO_SEL_ORBIT XO_SEL_DEFAULT
time_ref	long	-	time reference (only used if time_mode is XO_SEL_TIME)	-	Complete
time0	double	-	Start time	days	Start validity time for the orbit_id
time1	double	-	Output time	days	Stop validity time for the orbit_id
orbit0	long	-	Start orbit	-	First orbit stored in the orbit_id
orbit1	long	-	Stop orbit	-	Last orbit stored in the orbit_id

It is possible to use enumeration values rather than integer values for some of the input arguments:

- time\_mode: See [LIB\_SUM], section 6.2 (Time Initialization)
- time\_ref: See [LIB\_SUM], section 6.2 (Time reference).

### 7.33.4 Output parameters

Table 115: Output parameters for *xo\_osv\_to\_tle*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
xo_osv_to_tle	long	-	Main status flag	-	-1, 0, 1
tle_rec	xd_tle_rec	-	TLE record data	-	-
ierr	long	all	error array	-	-

### 7.33.5 Warnings and errors

Next table lists the possible error messages that can be returned by the `xo_osv_to_tle` CFI function after translating the returned status vector into the equivalent list of error messages by calling the function of the EXPLORER\_ORBIT software library `xo_get_msg` (see [GEN\_SUM]).

This table also indicates the type of message returned, i.e. either a warning (WARN) or an error (ERR), the cause of such a message and the impact on the performed calculation, mainly on the results vector.

The table is completed by the error code and value. These error codes can be obtained translating the status vector returned by calling the function of the EXPLORER\_ORBIT software library `xo_get_code` (see [GEN\_SUM]).

*Table 116: Error messages of `xo_osv_to_tle` function*

Error type	Error message	Cause and impact	Error Code	Error No
ERR	Input orbit_id is initialised with an incorrect model	Computation not performed	XO_CFI_OSV_TO_TLE_WRONG_FILE_MODEL_ERR	0
ERR	The input time/orbit interval is not correct	Computation not performed	XO_CFI_OSV_TO_TLE_WRONG_INPUT_INTERVAL_ERR	1
ERR	Error in a time transformation	Computation not performed	XO_CFI_OSV_TO_TLE_TIME_TRANS_ERR	2
ERR	Incorrect input time mode	Computation not performed	XO_CFI_OSV_TO_TLE_WRONG_TIME_MODEL_ERR	3
ERR	Could not change from EFCS to TEME CS	Computation not performed	XO_CFI_OSV_TO_TLE_CHANGE_CS_ERR	4
ERR	Could not get keplerian elements for absolute orbit	Computation not performed	XO_CFI_OSV_TO_TLE_CART_TO_KEPLER_ERR	5

### 7.33.6 Runtime performances

The following runtime performances have been measured:

*Table 117: Runtime performances of `xo_osv_to_tle` function*

Solaris 32-bit. [ms]	Solaris 64 bit. [ms]	Linux 32-bit. [ms]	Linux 64-bit. [ms]
TBD	TBD	TBD	TBD

## 7.34 xo\_gen\_osf\_create

### 7.34.1 Overview

The **xo\_gen\_osf\_create** CFI function creates a reference Orbit Scenario File (OSF) with one orbit change data structure using only user inputs in the calling interface. This data structure characterizes the reference orbit by means of the following parameters:

- Absolute orbit number
- Relative orbit number
- Cycle number
- Phase number
- Repeat cycle (days)
- Cycle length (orbits)
- Ascending crossing node longitude
- Mean local solar time of the ascending crossing node
- Mean local solar time drift (seconds per day)
- Time of the ascending crossing node (TAI, UTC and UT1)

### 7.34.2 Calling interface

The calling interface of the **xo\_gen\_osf\_create** CFI function is the following (input parameters are underlined):

```
#include <explorer_orbit.h>
{
    long sat_id;
    xl_time_id time_id = {NULL};
    long abs_orbit_number, cycle_number, phase_number,
        repeat_cycle, cycle_length, drift_mode, version_number;
    double anx_long, inclination, mlst_drift, mlst, date;
    char output_dir[XD_MAX_STR], output_filename[XD_MAX_STR];
    char *file_class, *fh_system;
    long status, ierr[XO_ERR_VECTOR_MAX_LENGTH];
    status = xo_gen_osf_create (&sat_id, &time_id, &abs_orbit_number,
        &cycle_number, &phase_number,
        &repeat_cycle, &cycle_length,
        &anx_long, &drift_mode,
        &inclination, &mlst_drift,
        &mlst, &date,
        &output_dir, &output_filename,
        &file_class, &version_number,
        &fh_system,
        ierr);
}
```

```
/* Or, using the run_id */  
long run_id;  
  
status = xo_gen_osf_create_run (&run_id, &abs orbit number,  
                                &cycle number, &phase number,  
                                &repeat cycle, &cycle length,  
                                &anx long, &drift mode,  
                                &inclination, &mlst drift,  
                                &mlst, &date,  
                                output dir, output filename,  
                                file class, &version number,  
                                fh system,  
                                ierr);  
}
```

### 7.34.3 Input parameters

The `xo_gen_osf_create` CFI function has the following input parameters:

*Table 118: Input parameters of `xo_gen_osf_create` function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
sat_id	long *	-	Satellite ID	-	Complete
time_id	xl_time_id*	-	Structure that contains the time correlations.	-	-
abs_orbit_number	long*	-	Orbit number in OSF first orbit change	-	>= 1
cycle_number	long*	-	Cycle number in OSF first orbit change	-	>= 1
phase_number	long*	-	Phase number in OSF first orbit change	-	>= 1
repeat_cycle	long*	-	Repeat cycle of the reference orbit	days	>= 1
cycle_length	long*	-	Cycle length of the reference orbit	orbits	>= 14
anx_long	double*	-	Reference orbit ascending node crossing longitude	deg	[-180, 180]
drift_mode	long*	-	Flag to select between drift in mean local solar time and inclination as input characterization of the reference orbit	-	[0,1]
inclination	double*	-	If <i>drift_mode</i> = <i>XO_NOSUNSYNC_INCLINATION</i> Inclination of the reference orbit	deg	[0,180]
mlst_drift	double*	-	If <i>drift_mode</i> = <i>XO_NOSUNSYNC_DRIFT</i> Drift in mean local solar time of the reference orbit: · $MLST[N+1]=MLST[N]+MLST-drift$	seconds/day	TBD
mlst	double*	-	Mean local solar time at ascending node	decimal hours	[0,24)
date	double*	-	ANX date	decimal days	-
output_dir	char*	-	Directory where the resulting OSF is written (if empty (i.e. ""), the current directory is used)	-	-

*Table 118: Input parameters of xo\_gen\_osf\_create function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
output_filename	char*	-	Output OSF name  if empty (i.e. ""), the software will generate the filename according to file name specification presented in [FORMATS]. In such case, the generated name is returned in this variable	-	-
file_class	char*	-	File class for output Orbit file	-	-
version_number	long*	-	Version number of output Orbit file	-	>= 1
fh_system	char*	-	System field of the output Orbit file fixed header	-	-

It is possible to use enumeration values rather than integer values for some of the input arguments:

- Satellite ID: sat\_id.
- Drift mode: mlst\_drift.

This CFI can generate Orbit Scenario Files for both sun-synchronous orbits and quasi-sun-synchronous orbits.

Use drift\_mode=XO\_NOSUNSYNC\_DRIFT and mlst\_drift = 0.0 for a sun-synchronous orbit.

Use any other combination for the general case of quasi-sun-synchronous orbit.

### 7.34.4 Output parameters

The output parameters of the xo\_gen\_osf\_create CFI function are:

*Table 119: Output parameters of xo\_gen\_osf\_create function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
output_filename	char*	-	Name for output file. <u>This is only an output parameter when it is empty</u> (i.e. ""); see description of this parameter in table 118)	-	-
ierr[XO_ERR_VECTOR_MAX_LENGTH]	long	all	Status vector	-	-

### 7.34.5 Warnings and errors

Next table lists the possible error messages that can be returned by the **xo\_gen\_osf\_create** CFI function after translating the returned status vector into the equivalent list of error messages by calling the function of the EXPLORER\_ORBIT software library **xo\_get\_msg** (see [GEN\_SUM]).

This table also indicates the type of message returned, i.e. either a warning (WARN) or an error (ERR), the cause of such a message and the impact on the performed calculation, mainly on the results vector.

The table is completed by the error code and value. These error codes can be obtained translating the status vector returned by the **xo\_gen\_osf\_create** CFI function by calling the function of the EXPLORER\_ORBIT software library **xo\_get\_code** (see [GEN\_SUM]).

*Table 120: Error messages of xo\_gen\_osf\_create function*

Error type	Error message	Cause and impact	Error code	Error No
ERR	Wrong input values	Wrong value of one or more of the following input parameters: abs_orbit_number, cycle_number, phase_number, repeat_cycle, cycle_length, mlst  Computation not performed	XO_CFI_GEN_OSF_CREATE_INPUTS_ERR	0
ERR	Time ID is not initialized	Time correlations were not initialized. Computation not performed	XO_CFI_GEN_OSF_CREATE_TIME_INIT_ERR	1
ERR	Memory allocation error	Memory allocation error for the orbit change data structure  Computation not performed	XO_CFI_GEN_OSF_CREATE_ALLOC_ERR	2
ERR	Wrong drift mode	Wrong drift mode flag value for characterization of non-sun.synchronous orbits  Computation not performed	XO_CFI_GEN_OSF_CREATE_DRIFT_MODE_ERR	3
ERR	Error calculating MLST drift	Error calculating MLST drift from inclination  Computation not performed	XO_CFI_GEN_OSF_CREATE_DRIFT_CALC_ERR	4
ERR	Error calculating UTC of ANX	Error calculating the UTC time of the orbit ascending node  Computation not performed	XO_CFI_GEN_OSF_CREATE_UTC_CALC_ERR	5

*Table 120: Error messages of xo\_gen\_osf\_create function*

Error type	Error message	Cause and impact	Error code	Error No
ERR	Error calculating TAI of ANX	Error calculating the TAI time of the orbit ascending node Computation not performed	XO_CFI_GEN_OSF_CREATE_TAI_CALC_ERR	6
ERR	Error calculating UT1 of ANX	Error calculating the UT1 time of the orbit ascending node Computation not performed	XO_CFI_GEN_OSF_CREATE_UT1_CALC_ERR	7
ERR	Error calculating the Fixed Header data	Error getting the data for the Fixed Header. Computation not performed	XO_CFI_GEN_OSF_CREATE_GET_FH_ERR	8
ERR	Error writing file to disk	Error writing the data structure to a file on disk Computation not performed	XO_CFI_GEN_OSF_CREATE_WRITE_ERR	9

### **7.34.6 Runtime performances**

The following runtime performance has been measured.

*Table 121: Runtime performances of xo\_gen\_osf\_create function*

Solaris 32-bit. [ms]	Solaris 64 bit. [ms]	Linux 32-bit. [ms]	Linux 64-bit. [ms]
9.8	6.9	7.6	5.6

### 7.34.7 Executable Program

The **gen\_osf\_create** executable program can be called from a Unix shell as:

```
gen_osf_create  -sat satellite_name
                -orbit abs_orbit_number
                -cyc cycle_number
                -pha phase_number
                -repcyc repeat_cycle (days)
                -cyclen cycle_length (orbits)
                -anx anx_long (deg)
                {-mlstdr mlst_drift|-inc inclination}
                -mlst mlst (decimal hours)
                -date anx_date
                [-dir dir_name] (current directory by default)
                [-osf name of the orbit scenario file] (default: name generated automatically)
                [-flcl file_class] (empty string by default)
                [-vers version] (version = 1 by default)
                [-fhsys fh_system] (empty string by default)
                [ -v ]
                [ -xl_v ]
                [ -xo_v ]
                [ -help ]
                [ -show ]
                {(-tai TAI_time -gps GPS_time -utc UTC_time -ut1 UT1_time) |
                (-tmod time_model -tfile time_reference_data file -trid time_reference
                {(-tm0 time 0 -tm1 time 1) | (-orb0 orbit 0 -orb1 orbit 1) } )}
```

Note that:

- Order of parameters does not matter.
- Bracketed parameters are not mandatory.
- Options between curly brackets and separated by a vertical bar are mutually exclusive.
- [ **-xl\_v** ] option for EXPLORER\_LIB Verbose mode.
- [ **-xo\_v** ] option for EXPLORER\_ORBIT Verbose mode.
- [ **-v** ] option for Verbose mode for all libraries (default is Silent)for all libraries (default is Silent).
- [ **-show** ] displays the inputs of the function and the results.
- Possible values for *satellite\_name*: ERS1, ERS2, ENVISAT, METOP1, METOP2, METOP3, CRYOSAT, ADM, GOCE, SMOS, TERRASAR, EARTHCARE, SWARM\_A, SWARM\_B, SWARM\_C, SENTINEL\_1A, SENTINEL\_1B, SENTINEL\_2, SENTINEL\_3, SEOSAT, GENERIC.

- 
- Possible values for *time\_model*: USER, NONE, IERS\_B\_PREDICTED, IERS\_B\_RESTITUTED, FOS\_PREDICTED, FOS\_RESTITUTED, DORIS\_PRELIMINARY, DORIS\_PRECISE, DORIS\_NAVIGATOR.
  - Possible values for *time\_reference*: UNDEF, TAI, UTC, UT1, GPS.
  - The last three lines of parameters are used to initialize the time references. In order to do this, only one set of parameters should be introduced:
    - TAI, GPS, UTC and UT1 input times
    - A file with time reference data, the time mode, the time reference name and the time range

Example:

```
gen_osf_create -sat CRYOSAT -orbit 1 -cyc 1 -pha 1 -repcyc 2
               -cyclen 29 -inc 92 -mlst 21 -date 790 -anx 130
               -dir ./gen_osf -osf mpl_orb_sc_at_302
               -tai -1100.1 -utc -1100.099595
               -utl -1100.0995914352 -gps -1100.0997801
```

## 7.35 xo\_gen\_osf\_append\_orbit\_change

### 7.35.1 Overview

The `xo_gen_osf_append_orbit_change` CFI function appends an orbit change to an existing reference Orbit Scenario File (OSF). The user must provide in the calling interface the name of the existing OSF, the parameters describing the new orbit change and the output file name where the old OSF with the appended orbit change will be written. No output file is generated if the resulting orbit is discontinuous in terms of ascending node longitude, mean local solar time.

### 7.35.2 Calling interface

The calling interface of the `xo_gen_osf_append_orbit_change` CFI function is the following (input parameters are underlined):

```
#include <explorer_orbit.h>
{
    long sat_id;
    xl_time_id time_id = {NULL};
    long abs_orbit_number,  repeat_cycle, cycle_length,
        drift_mode, phase_increment, version_number;
    double anx_long, inclination, mlst_drift, mlst;
    char input_filename[XD_MAX_STR],
        output_dir[XD_MAX_STR], output_filename[XD_MAX_STR];
    char *file_class, *fh_system;
    long status, ierr[XO_ERR_VECTOR_MAX_LENGTH];
    status = xo_gen_osf_append_orbit_change (&sat_id, &time_id,
        &input_filename, &abs_orbit_number,
        &repeat_cycle, &cycle_length,
        &anx_long, &drift_mode,
        &inclination, &mlst_drift,
        &mlst, &phase_increment,
        output_dir, output_filename,
        file_class, &version_number,
        fh_system,
        ierr);

    /* Or, using the run_id */
    long run_id;

    status = xo_gen_osf_append_orbit_change_run (&run_id,
        &input_filename, &abs_orbit_number,
        &repeat_cycle, &cycle_length,
        &anx_long, &drift_mode,
```

```
        &inclination, &mlst drift,  
        &mlst, &phase increment,  
        output dir, output filename,  
        file class, &version number,  
        fh system,  
        ierr);  
}
```

### 7.35.3 Input parameters

The `xo_gen_osf_append_orbit_change` CFI function has the following input parameters:

*Table 122: Input parameters of `xo_gen_osf_append_orbit_change` function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
sat_id	long *	-	Satellite ID	-	Complete
time_id	xl_time_id*	-	Structure that contains the time correlations.	-	-
input_filename	char*	-	Input OSF to which the orbit change is appended		
abs_orbit_number	long*	-	Absolute orbit number of the new orbit change	-	> abs orbit number in input OSF last orbit change
repeat_cycle	long*	-	Repeat cycle of the new reference orbit	days	>= 1
cycle_length	long*	-	Cycle length of the new reference orbit	orbits	>= 14
anx_long	double*	-	Requested orbit ascending node crossing longitude	deg	[-180, 180]
drift_mode	long*	-	Flag to select between drift in mean local solar time and inclination as input characterization of the reference orbit	-	[0,1]
inclination	double*	-	If <code>drift_mode = XO_NOSUNSYNC_INCLINATION</code> Inclination of the reference orbit	deg	[0,180]
mlst_drift	double*	-	If <code>drift_mode = XO_NOSUNSYNC_DRIFT</code> Drift in mean local solar time of the reference orbit: · $MLST[N+1]=MLST[N]+MLST-drift$	seconds/day	TBD
mlst	double*	-	Mean local solar time at ascending node	decimal hours	[0,24)
phase_increment	long*	-	If 1 then $phase [N+1] = phase [N] + 1$ If 0 then $phase [N+1] = phase [N]$	-	[0, 1]
output_dir	char*	-	Directory where the resulting OSF is written (if empty (i.e. ""), the current directory is used)	-	-

*Table 122: Input parameters of xo\_gen\_osf\_append\_orbit\_change function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
output_filename	char*	-	Output OSF name  if empty (i.e. ""), the software will generate the filename according to file name specification presented in [FORMATS]. In such case, the generated name is returned in this variable	-	-
file_class	char*	-	File class for output Orbit file	-	-
version_number	long*	-	Version number of output Orbit file	-	>= 1
fh_system	char*	-	System field of the output Orbit file fixed header	-	-

It is possible to use enumeration values rather than integer values for some of the input arguments:

- Satellite ID: sat\_id. See [GEN\_SUM].
- Drift mode: mlst\_drift.
- Phase increment.

This CFI can append orbit changes for both sun-synchronous orbits and quasi-sun-synchronous orbits. Use drift\_mode=XO\_NOSUNSYNC\_DRIFT and mlst\_drift = 0.0 for a sun-synchronous orbit. Use any other combination for the general case of quasi-sun-synchronous orbit.

### 7.35.4 Output parameters

The output parameters of the xo\_gen\_osf\_append\_orbit\_change CFI function are:

*Table 123: Output parameters of xo\_gen\_osf\_append\_orbit\_change function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
output_filename	char*	-	Name for output file. <u>This is only an output parameter when it is empty</u> (i.e. ""); see description of this parameter in table 122)	-	-
ierr[XO_ERR_VECTOR_MAX_LENGTH]	long	all	Status vector	-	-

### 7.35.5 Warnings and errors

Next table lists the possible error messages that can be returned by the **xo\_gen\_osf\_append\_orbit\_change** CFI function after translating the returned status vector into the equivalent list of error messages by calling the function of the EXPLORER\_ORBIT software library **xo\_get\_msg** (see [GEN\_SUM]).

This table also indicates the type of message returned, i.e. either a warning (WARN) or an error (ERR), the cause of such a message and the impact on the performed calculation, mainly on the results vector.

The table is completed by the error code and value. These error codes can be obtained translating the status vector returned by the **xo\_gen\_osf\_append\_orbit\_change** CFI function by calling the function of the EXPLORER\_ORBIT software library **xo\_get\_code** (see [GEN\_SUM]).

*Table 124: Error messages of xo\_gen\_osf\_append\_orbit\_change function*

Error type	Error message	Cause and impact	Error code	Error No
ERR	Wrong input values	Wrong value of one or more of the following input parameters: abs_orbit_number, repeat_cycle, cycle_length, mlst, phase_increment  Computation not performed	XO_CFI_GEN_OSF_APPEND_INPUTS_ERR	0
ERR	Time ID is not initialized	Time correlations were not initialized. Computation not performed	XO_CFI_GEN_OSF_APPEND_TIME_INIT_ERR	1
ERR	Cannot read input OSF	Computation not performed	XO_CFI_GEN_OSF_APPEND_READ_IN_OSF_ERR	2
ERR	ANX long jump larger than allowed	Requested ANX long leads to an orbit discontinuity	XO_CFI_GEN_OSF_APPEND_ANX_LONG_ERR	3
ERR	MLST jump larger than allowed	Requested MLST leads to an orbit discontinuity	XO_CFI_GEN_OSF_APPEND_MLST_ERR	4
ERR	Wrong drift mode	Wrong drift mode flag value for characterization of non-sun.synchronous orbits  Computation not performed	XO_CFI_GEN_OSF_APPEND_DRIFT_MODE_ERR	5
ERR	Error calculating MLST drift	Error calculating MLST drift from inclination  Computation not performed	XO_CFI_GEN_OSF_APPEND_DRIFT_CALC_ERR	6
ERR	Error calculating UTC of ANX	Error calculating the UTC time of the orbit ascending node  Computation not performed	XO_CFI_GEN_OSF_APPEND_UTC_CALC_ERR	7

*Table 124: Error messages of xo\_gen\_osf\_append\_orbit\_change function*

Error type	Error message	Cause and impact	Error code	Error No
ERR	Error calculating TAI of ANX	Error calculating the TAI time of the orbit ascending node Computation not performed	XO_CFI_GEN_OSF_APPE ND_TAI_CALC_ERR	8
ERR	Error calculating UT1 of ANX	Error calculating the UT1 time of the orbit ascending node Computation not performed	XO_CFI_GEN_OSF_APPE ND_UT1_CALC_ERR	9
ERR	Memory allocation error	Computation not performed	XO_CFI_GEN_OSF_APPE ND_ALLOC_ERR	10
ERR	Error calculating the Fixed Header data	Computation not performed	XO_CFI_GEN_OSF_APPE ND_GET_FH_ERR	11
ERR	Error writing file to disk	Error writing the data structure to a file on disk Computation not performed	XO_CFI_GEN_OSF_APPE ND_WRITE_ERR	12

### 7.35.6 Runtime performances

The following runtime performance has been measured.

*Table 125: Runtime performances of xo\_gen\_osf\_append\_orbit\_change function*

Solaris 32-bit. [ms]	Solaris 64 bit. [ms]	Linux 32-bit. [ms]	Linux 64-bit. [ms]
14.5	8.8	11.2	6

### 7.35.7 Executable Program

The `gen_osf_append_orbit_change` executable program can be called from a Unix shell as:

```
gen_osf_append_orbit_change-sat satellite_name
      -inosf input_filename
      -orbit abs_orbit_number
      -repcyc repeat_cycle(days)
      -cyclen cycle_length(orbits)
      -anx anx_long(deg)
      { -mlstdr mlst_drift | -inc inclination }
      -mlst mlst
      [-phinc]
      [-dir output_dir] (current directory by default)
      [-osf output_filename] (default: name generated automatically)
      [-file file_class] (empty string by default)
      [-vers version] (version = 1 by default)
      [-fhsys fh_system] (empty string by default)
      [-v ]
      [-xl_v ]
      [-xo_v ]
      [-help ]
      [-show]
      { (-tai TAI_time -gps GPS_time -utc UTC_time -ut1 UT1_time) |
        (-tmod time_model -tfile time_file -trid time_reference
          {(-tm0 time0 -tm1 time1) | (-orb0 orbit0 -orb1 orbit1) } ) }
```

Note that:

- Order of parameters does not matter.
- Bracketed parameters are not mandatory.
- Options between curly brackets and separated by a vertical bar are mutually exclusive.
- `[-phinc]` option for `phase_increment`. Default value for `phase_increment` is `xo_NO_PHASE_INCREMENT`. When the option is written, `phase_increment` is `xo_PHASE_INCREMENT`.
- `[-xl_v ]` option for `EXPLORER_LIB` Verbose mode.
- `[-xo_v ]` option for `EXPLORER_ORBIT` Verbose mode.
- `[-v ]` option for Verbose mode for all libraries (default is Silent).
- `[-show ]` displays the inputs of the function and the results.

- Possible values for *satellite\_name*: ERS1, ERS2, ENVISAT, METOP1, METOP2, METOP3, CRYOSAT, ADM, GOCE, SMOS, TERRASAR, EARTHCARE, SWARM\_A, SWARM\_B, SWARM\_C, SENTINEL\_1A, SENTINEL\_1B, SENTINEL\_2, SENTINEL\_3, SEOSAT, GENERIC.
- Possible values for *time\_model*: USER, NONE, IERS\_B\_PREDICTED, IERS\_B\_RESTITUTED, FOS\_PREDICTED, FOS\_RESTITUTED, DORIS\_PRELIMINARY, DORIS\_PRECISE, DORIS\_NAVIGATOR.
- Possible values for *time\_reference*: UNDEF, TAI, UTC, UT1, GPS.
- The last three lines of parameters are used to initialize the time references. In order to do this, only one set of parameters should be introduced:
  - TAI, GPS, UTC and UT1 input times (as in *xl\_time\_ref\_init*)
  - A file with time reference data, the time mode, the time reference name and a time range (as in *xl\_time\_ref\_init\_file*)

Example:

```
gen_osf_append_orbit_change -sat CRYOSAT
-inosf CS_TEST_MPL_ORBREF_20020301T122001_99999999T999999_0001.EEF
-orbit 30 -repcyc 366 -cyclen 5344 -anx 129.9986 -mlst 20.90083
-inc 92 -dir ./gen_osf -osf mpl_orb_sc_at_303
-tai -1100.1 -utc -1100.099595
-ut1 -1100.0995914352 -gps -1100.0997801
```

## 7.36 xo\_gen\_osf\_change\_repeat\_cycle

### 7.36.1 Overview

Given a reference orbit from an existing OSF and a new target orbit (repeat cycle, cycle length, ascending node longitude and inclination or mean local solar time drift), the **xo\_gen\_osf\_change\_repeat\_cycle** CFI function finds an optimum orbit change such that the target orbit can be reached from the found orbit change. This function will write a new OSF with the found orbit change appended to the content of the old OSF.

### 7.36.2 Calling interface

The calling interface of the **xo\_gen\_osf\_change\_repeat\_cycle** CFI function is the following (input parameters are underlined):

```
#include <explorer_orbit.h>
{
    long sat_id;
    xl_time_id time_id = {NULL};
    long abs_orbit_number, search_direction, repeat_cycle,
        cycle_length, drift_mode, phase_increment, version_number;
    double anx_long, inclination, mlst_drift;
    char input_filename[XD_MAX_STR],
        output_dir[XD_MAX_STR], output_filename[XD_MAX_STR];
    char *file_class, *fh_system;
    long status, ierr[XO_ERR_VECTOR_MAX_LENGTH];
    status = xo_gen_osf_change_repeat_cycle (&sat_id, &time_id,
        &input_filename, &abs_orbit_number,
        &search_direction,
        &repeat_cycle, &cycle_length,
        &anx_long, &drift_mode,
        &inclination, &mlst_drift,
        &phase_increment,
        output_dir, output_filename,
        file_class, &version_number,
        fh_system,
        ierr);

    /* Or, using the run_id */
    long run_id;

    status = xo_gen_osf_change_repeat_cycle_run (&run_id,
        &input_filename, &abs_orbit_number,
        &search_direction,
```

```
        &repeat cycle, &cycle length,  
        &anx long, &drift mode,  
        &inclination, &mlst drift,  
        &phase increment,  
        output dir, output filename,  
        file class, &version number,  
        fh system,  
        ierr);  
}
```

### 7.36.3 Input parameters

The `xo_gen_osf_change_repeat_cycle` CFI function has the following input parameters:

Table 126: Input parameters of `xo_gen_osf_change_repeat_cycle` function

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
sat_id	long *	-	Satellite ID	-	Complete
time_id	xl_time_id*	-	Structure that contains the time correlations.	-	-
input_filename	char*	-	Input OSF to which the orbit change is appended		
abs_orbit_number	long*	-	Absolute orbit number from which the optimum transition search starts	-	> abs orbit number in input OSF last orbit change
search_direction	long*	-	Search for optimum transition after or before abs_orbit_number		{-1, 1}
repeat_cycle	long*	-	Repeat cycle of the new reference orbit	days	>= 1
cycle_length	long*	-	Cycle length of the new reference orbit	orbits	>= 14
anx_long	double*	-	Target orbit ascending node crossing longitude	deg	[-180, 180]
drift_mode	long*	-	Flag to select between drift in mean local solar time and inclination as input characterization of the reference orbit	-	[0,1]
inclination	double*	-	If <i>drift_mode</i> = <i>XO_NOSUNSYNC_INCLINATION</i> Inclination of the reference orbit	deg	[0,180]
mlst_drift	double*	-	If <i>drift_mode</i> = <i>XO_NOSUNSYNC_DRIFT</i> Drift in mean local solar time of the reference orbit: · MLST[N+1]=MLST[N]+MLST-drift	seconds/day	TBD
phase_increment	long*	-	If 1 then phase [N+1] = phase [N] + 1 If 0 then phase [N+1] = phase [N]	-	[0, 1]
output_dir	char*	-	Directory where the resulting OSF is written (if NULL, the current directory is used)	-	-

*Table 126: Input parameters of xo\_gen\_osf\_change\_repeat\_cycle function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
output_filename	char*	-	Output OSF name  if empty (i.e. ""), the software will generate the filename according to file name specification presented in [FORMATS]. In such case, the generated name is returned in this variable	-	-
file_class	char*	-	File class for output Orbit file	-	-
version_number	long*	-	Version number of output Orbit file	-	>= 1
fh_system	char*	-	System field of the output Orbit file fixed header	-	-

It is possible to use enumeration values rather than integer values for some of the input arguments:

- Satellite ID: sat\_id.
- Search direction.
- Drift mode: mlst\_drift.
- Phase increment.

This CFI can append orbit changes for both sun-synchronous orbits and quasi-sun-synchronous orbits.

Use drift\_mode=XO\_NOSUNSYNC\_DRIFT and mlst\_drift = 0.0 for a sun-synchronous orbit.

Use any other combination for the general case of quasi-sun-synchronous orbit.

### 7.36.4 Output parameters

The output parameters of the xo\_gen\_osf\_change\_repeat\_cycle CFI function are:

*Table 127: Output parameters of xo\_gen\_osf\_change\_repeat\_cycle function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
output_filename	char*	-	Name for output file. This is only an output parameter when it is empty (i.e. ""); see description of this parameter in table 126)	-	-
ierr[XO_ERR_VECTOR_MAX_LENGTH]	long	all	Status vector	-	-

### 7.36.5 Warnings and errors

Next table lists the possible error messages that can be returned by the **xo\_gen\_osf\_change\_repeat\_cycle** CFI function after translating the returned status vector into the equivalent list of error messages by calling the function of the EXPLORER\_ORBIT software library **xo\_get\_msg** (see [GEN\_SUM]).

This table also indicates the type of message returned, i.e. either a warning (WARN) or an error (ERR), the cause of such a message and the impact on the performed calculation, mainly on the results vector.

The table is completed by the error code and value. These error codes can be obtained translating the status vector returned by the **xo\_gen\_osf\_change\_repeat\_cycle** CFI function by calling the function of the EXPLORER\_ORBIT software library **xo\_get\_code** (see [GEN\_SUM]).

*Table 128: Error messages of xo\_gen\_osf\_change\_repeat\_cycle function*

Error type	Error message	Cause and impact	Error code	Error No
ERR	Wrong input values	Wrong value of one or more of the following input parameters: abs_orbit_number, search_direction, repeat_cycle, cycle_length, phase_increment  Computation not performed	XO_CFI_GEN_OSF_CHANGE_INPUTS_ERR	0
ERR	Time ID is not initialized	Computation not performed	XO_CFI_GEN_OSF_CHANGE_TIME_INIT_ERR	1
ERR	Cannot read input OSF	Computation not performed	XO_CFI_GEN_OSF_CHANGE_READ_IN_OSF_ERR	2
ERR	Wrong drift mode	Wrong drift mode flag value for characterization of non-sun.synchronous orbits  Computation not performed	XO_CFI_GEN_OSF_CHANGE_DRIFT_MODE_ERR	3
ERR	Error calculating MLST drift	Error calculating MLST drift from inclination  Computation not performed	XO_CFI_GEN_OSF_CHANGE_DRIFT_CALC_ERR	4
ERR	No transition found	No optimum transition found keeping orbit continuity  Computation not performed	XO_CFI_GEN_OSF_CHANGE_NO_TRANSITION_ERR	5
ERR	Error calculating UTC of ANX	Error calculating the UTC time of the orbit ascending node  Computation not performed	XO_CFI_GEN_OSF_CHANGE_UTC_CALC_ERR	6

*Table 128: Error messages of xo\_gen\_osf\_change\_repeat\_cycle function*

Error type	Error message	Cause and impact	Error code	Error No
ERR	Error calculating TAI of ANX	Error calculating the TAI time of the orbit ascending node Computation not performed	XO_CFI_GEN_OSF_CHANGE_TAI_CALC_ERR	7
ERR	Error calculating UT1 of ANX	Error calculating the UT1 time of the orbit ascending node Computation not performed	XO_CFI_GEN_OSF_CHANGE_UT1_CALC_ERR	8
ERR	Memory allocation error	Computation not performed	XO_CFI_GEN_OSF_CHANGE_ALLOC_ERR	9
ERR	Error calculating the Fixed Header data	Computation not performed	XO_CFI_GEN_OSF_CHANGE_GET_FH_ERR	10
ERR	Error writing file to disk	Error writing the data structure to a file on disk Computation not performed	XO_CFI_GEN_OSF_CHANGE_WRITE_ERR	11

### 7.36.6 Runtime performances

The following runtime performance has been measured.

*Table 129: Runtime performances of xo\_gen\_osf\_change\_repeat\_cycle function*

Solaris 32-bit. [ms]	Solaris 64 bit. [ms]	Linux 32-bit. [ms]	Linux 64-bit. [ms]
24.0	11.2	13.6	6.7

### 7.36.7 Executable Program

The `gen_osf_change_repeat_cycle` executable program can be called from a Unix shell as:

```
gen_osf_change_repeat_cycle -sat satellite_name
                               -inosf input_filename
                               -orbit abs_orbit_number
                               [-back]
                               -repcyc repeat_cycle(days)
                               -cyclen cycle_length(orbits)
                               -anx anx_long(deg)
                               { -mlstdr mlst_drift | -inc inclination }
                               [-phinc]
                               [-dir output_dir] (current directory by default)
                               [-osf output_filename] (default: name generated automatically)
                               [-flel file_class] (empty string by default)
                               [-vers version] (version = 1 by default)
                               [-fhsys fh_system] (empty string by default)
                               [-v ]
                               [-xl_v ]
                               [-xo_v ]
                               [-help ]
                               [-show]
                               { (-tai TAI_time -gps GPS_time -utc UTC_time -ut1 UT1_time) |
```

(-tmod time\_model -tfile time\_file -trid time\_reference  
 {(-tm0 time0 -tm1 time1) | (-orb0 orbit0 -orb1 orbit1) } ) }

Note that:

- Order of parameters does not matter.
- Bracketed parameters are not mandatory.
- Options between curly brackets and separated by a vertical bar are mutually exclusive.
- [ **-back** ] option for search\_direction. Default value is xo\_SEARCH\_FORWARD. When the option is written, search\_direction value is xo\_SEARCH\_BACKWARD.
- [ **-phinc** ] option for phase\_increment. Default value is xo\_NO\_PHASE\_INCREMENT. When the option is written, phase\_increment value is xo\_PHASE\_INCREMENT.
- [ **-xl\_v** ] option for EXPLORER\_LIB Verbose mode.
- [ **-xo\_v** ] option for EXPLORER\_ORBIT Verbose mode.
- [ **-v** ] option for Verbose mode for all libraries (default is Silent).
- [ **-show** ] displays the inputs of the function and the results.

- Possible values for *satellite\_name*: ERS1, ERS2, ENVISAT, METOP1, METOP2, METOP3, CRYOSAT, ADM, GOCE, SMOS, TERRASAR, EARTHCARE, SWARM\_A, SWARM\_B, SWARM\_C, SENTINEL\_1A, SENTINEL\_1B, SENTINEL\_2, SENTINEL\_3, SEOSAT, GENERIC.
- Possible values for *time\_model*: USER, NONE, IERS\_B\_PREDICTED, IERS\_B\_RESTITUTED, FOS\_PREDICTED, FOS\_RESTITUTED, DORIS\_PRELIMINARY, DORIS\_PRECISE, DORIS\_NAVIGATOR.
- Possible values for *time\_reference*: UNDEF, TAI, UTC, UT1, GPS.
- The last three lines of parameters are used to initialize the time references. In order to do this, only one set of parameters should be introduced:
  - TAI, GPS, UTC and UT1 input times (as in *xl\_time\_ref\_init*)
  - A file with time reference data, the time mode, the time reference name and a time range (as in *xl\_time\_ref\_init\_file*)

Example:

```
gen_osf_change_repeat_cycle -sat CRYOSAT
-inosf CS_TEST_MPL_ORBREF_20020301T122001_99999999T999999_0001.EEF
-orbit 400 -repcyc 369 -cyclen 5344 -anx 286.524398 -inc 92
-dir ./gen_osf -osf mpl_orb_sc_at_304
-tai -1100.1 -utc -1100.099595
-ut1 -1100.0995914352 -gps -1100.0997801
```

## 7.37 xo\_gen\_osf\_add\_drift\_cycle

### 7.37.1 Overview

Given a reference orbit from an existing OSF, a new requested orbit with a particular ascending node longitude and an orbit for the manoeuvre, the **xo\_gen\_osf\_add\_drift\_cycle** CFI function fits a repeat cycle/cycle length between the manoeuvre orbit (drift start) and the requested orbit (drift stop) such that the longitude of the ascending node at the drift stop orbit be the one requested.

The drift orbit is constrained by a maximum altitude difference with respect to the reference orbit.

Furthermore, if the reference orbit is sun-synchronous, the drift orbit shall also be sun-synchronous; but if the reference orbit is not sun-synchronous, the drift orbit shall keep the inclination constant.

This CFI appends two orbit changes to the existing OSF:

- The first one for the drift manoeuvre
- The second one for restoring the old reference orbit characteristics at the requested ascending node longitude

### 7.37.2 .Calling interface

The calling interface of the **xo\_gen\_osf\_add\_drift\_cycle** CFI function is the following (input parameters are underlined):

```
#include <explorer_orbit.h>
{
    long sat_id;
    xl_time_id time_id = {NULL};
    long drift_start_orbit, drift_stop_orbit,
        phase_inc_start, phase_inc_stop, version_number;
    double drift_stop_anx_long, max_altitude_change;
    char input_filename[XD_MAX_STR],
        output_dir[XD_MAX_STR], output_filename[XD_MAX_STR];
    char *file_class, *fh_system;
    long status, ierr[XO_ERR_VECTOR_MAX_LENGTH];
    status = xo_gen_osf_add_drift_cycle (&sat id, &time id,
                                        &input filename,
                                        &drift start orbit,
                                        &drift stop orbit,
                                        &drift stop anx long,
                                        &max altitude change,
                                        &phase inc start, &phase inc stop,
                                        output dir, output filename,
                                        file class, &version number,
                                        fh system,
                                        ierr);
}
```

---

```
/* Or, using the run_id */  
long run_id;  
  
status = xo_gen_osf_add_drift_cycle_run (&run_id,  
                                         &input filename,  
                                         &drift start orbit,  
                                         &drift stop orbit,  
                                         &drift stop anx long,  
                                         &max altitude change,  
                                         &phase inc start, &phase inc stop,  
                                         output dir, output filename,  
                                         file class, &version number,  
                                         fh system,  
                                         ierr);  
}
```

### 7.37.3 Input parameters

The `xo_gen_osf_add_drift_cycle` CFI function has the following input parameters:

*Table 130: Input parameters of `xo_gen_osf_add_drift_cycle` function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
sat_id	long *	-	Satellite ID	-	Complete
time_id	xl_time_id*	-	Structure that contains the time correlations.	-	-
input_filename	char*	-	Input OSF to which the orbit changes are appended	-	-
drift_start_orbit	long*	-	Absolute orbit number at the drift start	-	> abs orbit number in input OSF last orbit change
drift_stop_orbit	long*	-	Absolute orbit number at the drift stop	-	> drift_start_orbit
drift_stop_anx_long	double*	-	Drift stop orbit ascending node crossing longitude	deg	[-180, 180]
max_altitude_change	double*	-	Maximum variation in altitude between the reference orbit and the drift orbit	m	-
phase_inc_start	long*	-	Phase increment at drift start If 1 then phase [N+1] = phase [N] + 1 If 0 then phase [N+1] = phase [N]	-	[0, 1]
phase_inc_stop	long*	-	Phase increment at drift stop If 1 then phase [N+1] = phase [N] + 1 If 0 then phase [N+1] = phase [N]	-	[0, 1]
output_dir	char*	-	Directory where the resulting OSF is written (if empty (i.e. ""), the current directory is used)	-	-
output_filename	char*	-	Output OSF name  if empty (i.e. ""), the software will generate the filename according to file name specification presented in [FORMATS]. In such case, the generated name is returned in this variable	-	-
file_class	char*	-	File class for output Orbit file	-	-
version_number	long*	-	Version number of output Orbit file	-	>= 1
fh_system	char*	-	System field of the output Orbit file fixed header	-	-

It is possible to use enumeration values rather than integer values for some of the input arguments:

- Satellite ID: `sat_id`.
- Search direction.
- Drift mode: `mlst_drift`.
- Phase increment.

### 7.37.4 Output parameters

The output parameters of the `xo_gen_osf_add_drift_cycle` CFI function are:

*Table 131: Output parameters of `xo_gen_osf_add_drift_cycle` function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
<code>output_filename</code>	<code>char*</code>	-	Name for output file. This is only an output parameter when it is empty (i.e. ""); see description of this parameter in table 130)	-	-
<code>ierr[XO_ERR_VECTOR_MAX_LENGTH]</code>	<code>long</code>	all	Status vector	-	-

### 7.37.5 Warnings and errors

Next table lists the possible error messages that can be returned by the `xo_gen_osf_add_drift_cycle` CFI function after translating the returned status vector into the equivalent list of error messages by calling the function of the EXPLORER\_ORBIT software library `xo_get_msg` (see [GEN\_SUM]).

This table also indicates the type of message returned, i.e. either a warning (WARN) or an error (ERR), the cause of such a message and the impact on the performed calculation, mainly on the results vector.

The table is completed by the error code and value. These error codes can be obtained translating the status vector returned by the `xo_gen_osf_add_drift_cycle` CFI function by calling the function of the EXPLORER\_ORBIT software library `xo_get_code` (see [GEN\_SUM]).

*Table 132: Error messages of `xo_gen_osf_add_drift_cycle` function*

Error type	Error message	Cause and impact	Error code	Error No
ERR	Wrong input values	Wrong value of one or more of the following input parameters: <code>drift_start_orbit</code> , <code>drift_stop_orbit</code> , <code>phase_inc_start</code> , <code>phase_inc_stop</code> ,  Computation not performed	<code>XO_CFI_GEN_OSF_DRIFT_INPUTS_ERR</code>	0

*Table 132: Error messages of xo\_gen\_osf\_add\_drift\_cycle function*

<b>Error type</b>	<b>Error message</b>	<b>Cause and impact</b>	<b>Error code</b>	<b>Error No</b>
ERR	Time ID is not initialized	Computation not performed	XO_CFI_GEN_OSF_DRIFT_TIME_INIT_ERR	1
ERR	Cannot read input OSF	Computation not performed	XO_CFI_GEN_OSF_DRIFT_READ_IN_OSF_ERR	2
ERR	No drift orbit necessary	Computation not performed	XO_CFI_GEN_OSF_DRIFT_NO_ADD_ERR	3
ERR	Error calculating inclination	Error calculating inclination for a no sun-synchronous orbit in order to keep inclination constant during the drift phase  Computation not performed	XO_CFI_GEN_OSF_DRIFT_INCL_CALC_ERR	4
ERR	No drift orbit found	No drift orbit has been found that matches the drift start and stop ANX longitude  Computation not performed	XO_CFI_GEN_OSF_DRIFT_NOT_FOUND_ERR	5
ERR	Error calculating UTC of ANX	Error calculating the UTC time of the orbit ascending node  Computation not performed	XO_CFI_GEN_OSF_DRIFT_UTC_CALC_ERR	6
ERR	Error calculating TAI of ANX	Error calculating the TAI time of the orbit ascending node  Computation not performed	XO_CFI_GEN_OSF_DRIFT_TAI_CALC_ERR	7
ERR	Error calculating UT1 of ANX	Error calculating the UT1 time of the orbit ascending node  Computation not performed	XO_CFI_GEN_OSF_DRIFT_UT1_CALC_ERR	8
ERR	Memory allocation error	Computation not performed	XO_GEN_OSF_DRIFT_ALL_OC_ERR	
ERR	Error calculating the Fixed Header data	Computation not performed	XO_GEN_OSF_DRIFT_GET_FH_ERR	
ERR	Error writing file to disk	Error writing the data structure to a file on disk  Computation not performed	XO_CFI_GEN_OSF_DRIFT_WRITE_ERR	9

### 7.37.6 Runtime performances

The following runtime performance has been measured.

*Table 133: Runtime performances of xo\_gen\_osf\_add\_drift\_cycle function*

Solaris 32-bit. [ms]	Solaris 64 bit. [ms]	Linux 32-bit. [ms]	Linux 64-bit. [ms]
38.1	15.3	19.0	8.7

### 7.37.7 Executable Program

The `gen_osf_add_drift_cycle` executable program can be called from a Unix shell as:

```
gen_osf_add_drift_cycle -sat satellite_name
                        -inosf input_filename
                        -drorb0 drift_start_orbit
                        -drorb1 drift_stop_orbit
                        -anx drift_stop_anx_long (deg)
                        -alt max_altitude_change (m)
                        [-phinc0]
                        [-phinc1]
                        [-dir output_dir] (current directory by default)
                        [-osf output_filename] (default: name generated automatically)
                        [-flel file_class] (empty string by default)
                        [-vers version] (version = 1 by default)
                        [-fhsys fh_system] (empty string by default)
                        [-v ]
                        [-xl_v ]
                        [-xo_v ]
                        [-help ]
                        [-show]
                        { (-tai TAI_time -gps GPS_time -utc UTC_time -ut1 UT1_time) |
```

```
      (-tmod time_model -tfile time_file -trid time_reference
        { (-tm0 time0 -tm1 time1) | (-orb0 orbit0 -orb1 orbit1) } })
```

Note that:

- Order of parameters does not matter.
- Bracketed parameters are not mandatory.
- Options between curly brackets and separated by a vertical bar are mutually exclusive.
- `[-phinc0]` option for `phase_inc_start`. Default value is `xo_NO_PHASE_INCREMENT`. When the option is written, `phase_inc_start` value is `xo_PHASE_INCREMENT`.
- `[-phinc1]` option for `phase_inc_stop`. Default value is `xo_NO_PHASE_INCREMENT`. When the option is written, `phase_inc_stop` value is `xo_PHASE_INCREMENT`.
- `[-xl_v]` option for `EXPLORER_LIB` Verbose mode.
- `[-xo_v]` option for `EXPLORER_ORBIT` Verbose mode.
- `[-v]` option for Verbose mode for all libraries (default is Silent).
- `[-show]` displays the inputs of the function and the results.
- Possible values for `satellite_name`: ERS1, ERS2, ENVISAT, METOP1, METOP2, METOP3, CRYOSAT, ADM, GOCE, SMOS, TERRASAR, EARTHCARE, SWARM\_A, SWARM\_B, SWARM\_C, SENTINEL\_1A, SENTINEL\_1B, SENTINEL\_2, SENTINEL\_3, SEOSAT, GENERIC.

- 
- Possible values for *time\_model*: USER, NONE, IERS\_B\_PREDICTED, IERS\_B\_RESTITUTED, FOS\_PREDICTED, FOS\_RESTITUTED, DORIS\_PRELIMINARY, DORIS\_PRECISE, DORIS\_NAVIGATOR.
  - Possible values for *time\_reference*: UNDEF, TAI, UTC, UT1, GPS.
  - The last three lines of parameters are used to initialize the time references. In order to do this, only one set of parameters should be introduced:
    - TAI, GPS, UTC and UT1 input times (as in `xl_time_ref_init`)
    - A file with time reference data, the time mode, the time reference name and a time range (as in `xl_time_ref_init_file`)

Example:

```
gen_osf_add_drift_cycle -sat CRYOSAT
-inosf CS_TEST_MPL_ORBREF_20020301T122001_999999999T9999999_0001.EEF
-drorb0 30 -drorb1 2702 -anx 310 -alt 15000 -dir ./gen_osf
-osf mpl_orb_sc_at_305
-tai -1100.1 -utc -1100.099595 -ut1 -1100.0995914352 -gps -1100.0997801
```

## 7.38 xo\_gen\_rof

### 7.38.1 Overview

The **xo\_gen\_rof** CFI function creates a Restituted Orbit File (ROF) using as input one of the following reference file types:

- Orbit Scenario File
- FOS Predicted Orbit File
- DORIS Navigator File
- FOS Restituted Orbit File
- DORIS Preliminary Orbit File
- DORIS Precise Orbit FileTime of the ascending crossing node (TAI, UTC and UT1)

The accepted output file types are:

- FOS Restituted Orbit File
- DORIS Preliminary Orbit File
- DORIS Precise Orbit FileTime

The time interval between consecutive OSVs can be selected by the user by means of a parameter in the calling interface. A flag for precise location of OSVs at “integer intervals” (e.g. every exact minute) is also available. If the reference file and the Restituted Orbit File contain OSVs at the same time, these OSVs will be identical.

Note: when using an OSF or Predicted Orbit file, the maximum time interval within the output Restituted orbit file is limited to 2 orbital periods before and after the middle point of the user requested time range.

### 7.38.2 Calling interface

The calling interface of the **xo\_gen\_rof** CFI function is the following (input parameters are underlined):

```
#include <explorer_orbit.h>
{
    long sat_id;
    xl_time_id time_id = {NULL};
    long    time_init, time_ref, start_orbit, stop_orbit,
           ref_filetype, rof_filetype, osv_precise, version_number;
    double start_time, stop_time, osv_interval;
    char    reference_file[XD_MAX_STR], output_dir[XD_MAX_STR],
           rof_filename[XD_MAX_STR];
    char    *file_class, *fh_system;
    long    status, ierr[XO_ERR_VECTOR_MAX_LENGTH];
    status = xo_gen_rof(&sat_id, &time_id, &time_init,
                       &time_ref, &start_time, &stop_time,
                       &start_orbit, &stop_orbit,
                       &osv_interval, &osv_precise,
```

---

```
        &ref filetype, reference file,  
        &rof filetype, output dir, rof filename,  
        file class, &version number, fh system,  
        /* output */  
        ierr);  
  
/* Or, using the run_id */  
long run_id;  
  
status = xo_gen_rof_run(&run_id, &time init, &time ref,  
                        &start time, &stop time,  
                        &start orbit, &stop orbit,  
                        &osv interval, &osv precise,  
                        &ref filetype, reference file,  
                        &rof filetype, output dir, rof filename,  
                        file class, &version number, fh system,  
                        /* output */  
                        ierr);  
}
```

### 7.38.3 Input parameters

The `xo_gen_rof` CFI function has the following input parameters:

*Table 134: Input parameters of `xo_gen_rof` function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
<code>sat_id</code>	long *	-	Satellite ID	-	Complete
<code>time_id</code>	xl_time_id*	-	Structure that contains the time correlations. NOTE: This parameter is optional. If the <code>time_id</code> is not initialised, the algorithm will use the time correlations from the input reference file.	-	-
<code>time_init</code>	long*	-	Flag for selecting the time range of the initialisation.	-	Select either: · <code>XO_SEL_ORBIT</code> · <code>XO_SEL_TIME</code>
<code>time_ref</code>	long*	-	Time reference ID (see note in the <code>ref_filetype</code> field)	-	Select either: · <code>XO_TIME_TAI</code> · <code>XO_TIME_UTC</code> · <code>XO_TIME_UT1</code>
<code>start_time</code>	double*	-	Processing time corresponding to the beginning of the required interval	Decimal days, MJD2000	[-18262.0,36524.0]
<code>stop_time</code>	double*	-	Processing time corresponding to the end of the required interval	Decimal days, MJD2000	[-18262.0,36524.0]
<code>start_orbit</code>	long*	-	Orbit number corresponding to the beginning of the required interval	orbits	>= 1
<code>stop_orbit</code>	long*	-	Orbit number corresponding to the end of the required interval	orbits	>= 1
<code>osv_interval</code>	double*	-	Interval between consecutive state vector. This parameter should be coherent with the <code>osv_precise</code> flag (see below). If <code>osv_precise</code> is set to: <ul style="list-style-type: none"> <li>· <code>xo_OSV_PRECISE_MINUTE</code>: <code>osv</code> will be forced to be a multiple of 60 seconds.</li> <li>· <code>xo_OSV_PRECISE_TEN_SECONDS</code>: <code>osv</code> will be forced to be a multiple of 10 seconds.</li> </ul>	secs	>=0
<code>osv_precise</code>	long*	-	Flag to indicate if state vectors should be placed at exact time locations	-	Complete

*Table 134: Input parameters of xo\_gen\_rof function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
ref_filetype	long*	-	File type of the input reference file. (Note: When generating a ROF file from a DORIS NAVIGATOR file, the input times should be expressed in UTC)	-	Complete
reference_filename	char*	-	Reference File name	-	
rof_filetype	long*	-	File type of the output reference file	-	xo_REF_FILETYPE_ROF xo_REF_FILETYPE_DORIS_PREM xo_REF_FILETYPE_DORIS_PREC
output_dir	char*	-	Directory where the resulting ROF is written (if NULL, the current directory is used)	-	-
rof_filename	char*	-	Output ROF name  if empty (i.e. ""), the software will generate the filename according to file name specification presented in [FORMATS]. In such case, the generated name is returned in this variable	-	-
file_class	char*	-	File class for output Restituted file	-	-
version_number	long*	-	Version number of output Restituted file	-	>= 1
fh_system	char*	-	System field of the output Restituted file fixed header	-	-

It is possible to use enumeration values rather than integer values for some of the input arguments:

- Satellite ID: sat\_id.
- Time initialisation: time\_init.
- Time reference: time\_ref.
- OSV precise: osv\_precise. See this SUM.
- File type: ref\_filetype and rof\_filetype. See this SUM.

### 7.38.4 Output parameters

The output parameters of the `xo_gen_rof` CFI function are:

*Table 135: Output parameters of xo\_gen\_rof function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
rof_filename	char*	-	Name for the output file. <u>This is only an output parameter when it is empty</u> (i.e. ""; see description of this parameter in table 134)	-	-
ier[ <code>XO_ERR_VECTOR_MAX_LENGTH</code> ]	long	all	Status vector	-	-

### 7.38.5 Warnings and errors

Next table lists the possible error messages that can be returned by the `xo_gen_rof` CFI function after translating the returned status vector into the equivalent list of error messages by calling the function of the EXPLORER\_ORBIT software library `xo_get_msg` (see [GEN\_SUM]).

This table also indicates the type of message returned, i.e. either a warning (WARN) or an error (ERR), the cause of such a message and the impact on the performed calculation, mainly on the results vector.

The table is completed by the error code and value. These error codes can be obtained translating the status vector returned by the `xo_gen_rof` CFI function by calling the function of the EXPLORER\_ORBIT software library `xo_get_code` (see [GEN\_SUM]).

*Table 136: Error messages of xo\_gen\_rof function*

Error type	Error message	Cause and impact	Error code	Error No
ERR	Wrong satellite flag	Computation not performed	<code>XO_CFI_GEN_ROF_WRONG_SAT_ID_ERR</code>	0
ERR	Wrong input flag	Computation not performed	<code>XO_CFI_GEN_ROF_WRONG_FLAG_ERR</code>	1
ERR	Time ID is not initialized	Computation not performed	<code>XO_CFI_GEN_ROF_TIME_ID_INIT_ERR</code>	2
ERR	Could not initialise the time reference	Computation not performed	<code>XO_CFI_GEN_ROF_TIME_ID_INITIALIZATION_ERR</code>	3
ERR	Cannot initialise orbit ID	Computation not performed	<code>XO_CFI_GEN_ROF_ORBIT_INIT_FILE_ERR</code>	4
ERR	Cannot initialise the propagator	Computation not performed	<code>XO_CFI_GEN_ROF_PROPAG_INIT_ERR</code>	5
ERR	Could not perform a time <-> orbit transformation	Computation not performed	<code>XO_CFI_GEN_ROF_TIME_ORBIT_ERR</code>	6

*Table 136: Error messages of xo\_gen\_rof function*

Error type	Error message	Cause and impact	Error code	Error No
ERR	Cannot initialise interpolation	Computation not performed	XO_CFI_GEN_ROF_INTERPOL_INIT_ERR	7
ERR	Cannot calculate state vector	Computation not performed	XO_CFI_GEN_ROF_CALCULATING_STATE_VECTOR_ERR	8
ERR	Cannot convert time to processing format	Computation not performed	XO_CFI_GEN_ROF_TIME_ERR	9
ERR	Cannot convert time from processing to external	Computation not performed	XO_CFI_GEN_ROF_TIME_TO_EXTERNAL_ERR	10
ERR	Cannot write ROF file to disk	Computation not performed	XO_CFI_GEN_ROF_WRITE_ERR	11
ERR	Error freeing memory	Computation not performed	XO_CFI_GEN_ROF_CLOSE_ERR	12
ERR	Memory allocation error	Computation not performed	XO_CFI_GEN_ROF_MEMORY_ERR	13
ERR	Error getting fixed header	Computation not performed	XO_CFI_GEN_ROF_GET_FIXED_HEADER_ERR	14
ERR	OSV interval is not compatible with OSV Precise flag. The OSV Interval will be set to %f seconds.	Computation performed with a different value for the osv_interval	XO_CFI_GEN_ROF_WRONG_INTERVAL_WARN	15
ERR	Time reference ID is not allowed	Computation not performed	XO_CFI_GEN_ROF_TIME_ID_NOT_ALLOWED_ERR	16

### 7.38.6 Runtime performances

The following runtime performance has been measured.

*Table 137: Runtime performances of xo\_gen\_rof function*

Solaris 32-bit. [ms]	Solaris 64 bit. [ms]	Linux 32-bit. [ms]	Linux 64-bit. [ms]
522.6	213.9	252.7	75.9

### 7.38.7 Executable Program

The **gen\_rof** executable program can be called from a Unix shell as:

```
gen_rof  -sat satellite_name
         -tref time_ref
         { -tstart start_time -tstop stop_time (decimal days) |
           -tastart start_time -tastop stop_time (CCSDSA format) |
           -ostart start_orbit -ostop stop_orbit (orbits) }
         -osvint osv_interval
         [-osvpre]
         -reftyp ref_file_type
         -ref reference_file
         -roftyp rof_file_type
         [-dir output_dir] (current directory by default)
         [-rof output_filename] (default: name generated automatically)
         [-flcl file_class] (empty string by default)
         [-vers version] (version= 1 by default)
         [-fhsys fh_system] (empty string by default)
         [-v ]
         [-xl_v ]
         [-xo_v ]
         [-help ]
         [-show]
         [ (-tai TAI_time -gps GPS_time -utc UTC_time -ut1 UT1_time) |
           (-tmod time_model -tfile time_file -trid time_reference
            {(-tm0 time0 -tm1 time1) | (-orb0 orbit0 -orb1 orbit1) } ) ]
```

Note that:

- Order of parameters does not matter.
- Bracketed parameters are not mandatory.
- Options between curly brackets and separated by a vertical bar are mutually exclusive.
- [ **-osvpre** ] option for osv\_precise. Default value is xo\_OSV\_PRECISE\_NO. When the option is written, osv\_precise value is xo\_OSV\_PRECISE\_MINUTE.
- [ **-xl\_v** ] option for EXPLORER\_LIB Verbose mode.
- [ **-xo\_v** ] option for EXPLORER\_ORBIT Verbose mode.
- [ **-v** ] option for Verbose mode for all libraries (default is Silent).
- [ **-show** ] displays the inputs of the function and the results.

- Possible values for *satellite\_name*: ERS1, ERS2, ENVISAT, METOP1, METOP2, METOP3, CRYOSAT, ADM, GOCE, SMOS, TERRASAR, EARTHCARE, SWARM\_A, SWARM\_B, SWARM\_C, SENTINEL\_1A, SENTINEL\_1B, SENTINEL\_2, SENTINEL\_3, SEOSAT, GENERIC.
- Possible values for *time\_model*: USER, NONE, IERS\_B\_PREDICTED, IERS\_B\_RESTITUTED, FOS\_PREDICTED, FOS\_RESTITUTED, DORIS\_PRELIMINARY, DORIS\_PRECISE, DORIS\_NAVIGATOR.
- Possible values for *ref\_file\_type*: OSF, POF, DORISNAV, ROF, DORISPREM, DORISPREC.
- Possible values for *rof\_file\_type*: ROF, DORISPREM, DORISPREC.
- Possible values for *time\_ref* and *time\_reference*: UNDEF, TAI, UTC, UT1.
- Time references need to be initialized only when using OSF as the type of the input reference file. The inputs needed for this issue are provided in the last three lines of parameters. Note that only one set of parameters should be introduced:
  - TAI, GPS, UTC and UT1 input times (as in *xl\_time\_ref\_init*)
  - A file with time reference data, the time mode, the time reference name and a time range (as in *xl\_time\_ref\_init\_file*)

Example:

```
gen_rof  -sat CRYOSAT -tref TAI -ostart 1000 -ostop 1001
        -osvint 300 -reftyp OSF
        -ref CS_TEST_MPL_ORBREF_20020301T122001_99999999T9999999_0001.EEF
        -roftyp ROF -dir ./gen_rof/ -rof orb_res_file_at_306
        -tmod FOS_PREDICTED -tfile ./data/test.fpo -trid TAI
        -tm0 0 -tm1 10000
```

## 7.39 xo\_gen\_rof\_prototype

### 7.39.1 Overview

The **xo\_gen\_rof\_prototype** CFI function creates a Restituted Orbit File (ROF) using the following input parameters:

- Date (processing time) and orbit
- Longitude of the ascending node,
- Satellite Repeat Cycle and Cycle Length
- Mean local solar time at ascending node
- Drift of mean local solar time or the inclination

The time interval between consecutive OSVs can be selected by the user by means of a parameter in the calling interface.

### 7.39.2 Calling interface

The calling interface of the **xo\_gen\_rof\_prototype** CFI function is the following (input parameters are underlined):

```
#include <explorer_orbit.h>
{
    long sat_id;
    xl_time_id time_id = {NULL};
    long propag_model, time_ref, time_init_mode;
    long orbit0, drift_mode, irep, icyc, start_orbit, stop_orbit;
    double time0, start_time, stop_orbit, osv_interval;
    double ascmlst_drift, inclination, rlong, ascmlst;
    char  output_dir[XD_MAX_STR], rof_filename[XD_MAX_STR];
    char  *file_class, *fh_system;
    long status, ierr[XO_ERR_VECTOR_MAX_LENGTH], version_number;
    status = xo_gen_rof_prototype (&sat_id, &time_id,
                                   &propag_model, &time_ref,
                                   &time0, &orbit0, &time_init_mode,
                                   &start_time, &start_orbit,
                                   &stop_time, &stop_orbit,
                                   &drift_mode,
                                   &ascmlst_drift, &inclination,
                                   &irep, &icyc, &rlong, &ascmlst,
                                   &osv_interval,
                                   output_dir, rof_filename,
                                   file_class, &version_number,
                                   fh_system,
                                   /* output */
                                   ierr);
}
```

---

```
/* Or, using the run_id */  
long run_id;  
  
status = xo_gen_rof_prototype_run (&run_id,  
                                   &propag model, &time ref,  
                                   &time0, &orbit0, &time init mode,  
                                   &start time, &start orbit  
                                   &stop time, &stop orbit,  
                                   &drift mode,  
                                   &ascmlst drift, &inclination,  
                                   &irep, &icyc, &rlong, &ascmlst,  
                                   &osv interval  
                                   output dir, rof filename,  
                                   file class, &version number,  
                                   fh system,  
                                   /* output */  
                                   ierr);  
}
```

### 7.39.3 Input parameters

The `xo_gen_rof_prototype` CFI function has the following input parameters:

*Table 138: Input parameters of `xo_gen_rof_prototype` function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
sat_id	long *	-	Satellite ID	-	Complete
time_id	xl_time_id*	-	Structure that contains the time correlations.	-	-
propag_model	long*	-	Propagation model ID	-	Complete
time_ref	long*	-	Time reference ID	-	Complete
time0	double*	-	Reference time	Decimal days (Processing format)	[-18262.0,36524.0]
orbit0	long*	-	Absolute orbit number of the reference orbit	-	>= 0
time_init_mode	long*	-	Flag for selecting the time range of the initialisation.	-	Select either: · XO_SEL_ORBIT · XO_SEL_TIME
start_time	double*	-	Processing time corresponding to the beginning of the required interval	Decimal days, MJD2000	[-18262.0,36524.0]
start_orbit	long*	-	Orbit number corresponding to the beginning of the required interval	orbits	>= 1
stop_time	double*	-	Processing time corresponding to the end of the required interval	Decimal days, MJD2000	[-18262.0,36524.0]
stop_orbit	long*	-	Orbit number corresponding to the end of the required interval	orbits	>= 1
drift_mode	long*	-	Flag to select between drift in mean local solar time and inclination as input characterization of the reference orbit	-	Complete
ascmlst_drift	double*	-	If <code>drift_mode = XO_NOSUNSYNC_MLST</code> Drift in mean local solar time of the reference orbit	seconds/day	TBD
inclination	double*	-	If <code>drift_mode = XO_NOSUNSYNC_INCLINATION</code> Inclination of the reference orbit	deg	[0,180]
irep	long *	-	Repeat cycle of the reference orbit The actual repeat cycle is calculated as per definition included in [MCD].	days	> 0

*Table 138: Input parameters of xo\_gen\_rof\_prototype function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
icyc	long *	-	Cycle length of the reference orbit	orbits	> 0
rlong	double*	-	Geocentric longitude of the [Earth fixed] ascending node (Earth fixed CS)	deg	[0,360)
ascmlst	double*	-	Mean local solar time at ascending node	hours	[0, 24)
osv_interval	double*	-	Interval between consecutive state vector	secs	>=0
output_dir	char*	-	Directory where the resulting ROF is written (if NULL, the current directory is used)	-	-
rof_filename	char*	-	Output ROF name  if empty (i.e. ""), the software will generate the filename according to file name specification presented in [FORMATS]. In such case, the generated name is returned in this variable	-	-
file_class	char*	-	File class for output Restituted file	-	-
version_number	long*	-	Version number of output Restituted file	-	>= 1
fh_system	char*	-	System field of the output Restituted file fixed header	-	-

It is possible to use enumeration values rather than integer values for some of the input arguments:

- Satellite ID: sat\_id.
- Time initialisation: time\_init.
- Time reference: time\_ref.
- Drift Mode: drift\_mode.

### 7.39.4 Output parameters

The output parameters of the `xo_gen_rof_prototype` CFI function are:

*Table 139: Output parameters of xo\_gen\_rof\_prototype function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
rof_filename	char*	-	Name for the output file. <u>This is only an output parameter when it is empty</u> (i.e. “”; see description of this parameter in table 138)	-	-
ier[ <code>XO_ERR_VECTOR_MAX_LENGTH</code> ]	long	all	Status vector	-	-

### 7.39.5 Warnings and errors

Next table lists the possible error messages that can be returned by the `xo_gen_rof_prototype` CFI function after translating the returned status vector into the equivalent list of error messages by calling the function of the EXPLORER\_ORBIT software library `xo_get_msg` (see [GEN\_SUM]).

This table also indicates the type of message returned, i.e. either a warning (WARN) or an error (ERR), the cause of such a message and the impact on the performed calculation, mainly on the results vector.

The table is completed by the error code and value. These error codes can be obtained translating the status vector returned by the `xo_gen_rof_prototype` CFI function by calling the function of the EXPLORER\_ORBIT software library `xo_get_code` (see [GEN\_SUM]).

*Table 140: Error messages of xo\_gen\_rof\_prototype function*

Error type	Error message	Cause and impact	Error code	Error No
ERR	Wrong satellite flag	Computation not performed	<code>XO_CFI_GEN_ROF_PROTOTYPE_WRONG_SAT_ID_ERR</code>	0
ERR	Time ID is not initialized	Computation not performed	<code>XO_CFI_GEN_ROF_PROTOTYPE_TIME_ID_ERR</code>	1
ERR	Wrong input flag	Computation not performed	<code>XO_CFI_GEN_ROF_PROTOTYPE_WRONG_FLAG_ERR</code>	2
ERR	Cannot initialise propagator	Computation not performed	<code>XO_CFI_GEN_ROF_PROTOTYPE_PROPAG_INIT_DEF_ERR</code>	3
ERR	Cannot calculate state vector	Computation not performed	<code>XO_CFI_GEN_ROF_PROTOTYPE_CALCULATING_STATE_VECTOR_ERR</code>	3
ERR	Cannot convert time in processing reference	Computation not performed	<code>XO_CFI_GEN_ROF_PROTOTYPE_TIME_ERR</code>	5

*Table 140: Error messages of xo\_gen\_rof\_prototype function*

Error type	Error message	Cause and impact	Error code	Error No
ERR	Cannot convert time from processing to external	Computation not performed	XO_CFI_GEN_ROF_PROTOTYPE_TIME_TO_EXTERNAL_ERR	6
ERR	Error freeing memory	Computation not performed	XO_CFI_GEN_ROF_PROTOTYPE_CLOSE_ERR	7
ERR	Error creating the fixed header	Computation not performed	XO_CFI_GEN_ROF_PROTOTYPE_GET_FH_ERR	8
ERR	Memory allocation error	Computation not performed	XO_CFI_GEN_ROF_PROTOTYPE_MEMORY_ERR	9
ERR	Cannot write ROF XML file	Computation not performed	XO_CFI_GEN_ROF_PROTOTYPE_WRITE_ERR	10

### 7.39.6 Runtime performances

The following runtime performance has been measured.

*Table 141: Runtime performances of xo\_gen\_rof\_prototype function*

Solaris 32-bit. [ms]	Solaris 64 bit. [ms]	Linux 32-bit. [ms]	Linux 64-bit. [ms]
TDB	TDB	TDB	TDB

## 7.40 xo\_gen\_pof

### 7.40.1 Overview

The **xo\_gen\_pof** CFI function creates a Predicted Orbit File (POF) with one state vector per orbit using as input one of the following reference file types:

- Orbit Scenario File
- FOS Predicted Orbit File
- DORIS Navigator File
- FOS Restituted Orbit File
- DORIS Preliminary Orbit File
- DORIS Precise Orbit FileTime of the ascending crossing node (TAI, UTC and UT1)

The location of the state vector within the orbit can be selected by the user by means of a parameter in the calling interface. If the reference file and the Predicted Orbit File contain OSVs at the same time, these OSVs will be identical.

### 7.40.2 Calling interface

The calling interface of the **xo\_gen\_pof** CFI function is the following (input parameters are underlined):

```
#include <explorer_orbit.h>
{
    long    sat_id;
    xl_time_id time_id = {NULL};
    long    time_init, time_ref, start_orbit, stop_orbit,
           ref_filetype, pof_filetype, version_number;
    double start_time, stop_time, osv_location;
    char    reference_file[XD_MAX_STR], output_dir[XD_MAX_STR],
           pof_filename[XD_MAX_STR];
    char    *file_class, *fh_system;
    long    status, ierr[XO_ERR_VECTOR_MAX_LENGTH];
    status = xo_gen_pof(&sat_id, &time_id,
                       &time_init, &time_ref,
                       &start_time, &stop_time,
                       &start_orbit, &stop_orbit, &osv_location,
                       &ref_filetype, reference_file,
                       &pof_filetype, output_dir, pof_filename,
                       file_class, &version_number, fh_system,
                       /* output */
                       ierr);
}
```

```
/* Or, using the run_id */  
long run_id;  
status = xo_gen_pof_run(&run_id,  
                        &time init, &time ref,  
                        &start time, &stop time,  
                        &start orbit, &stop orbit, &osv location,  
                        &ref filetype, reference file,  
                        &pof filetype, output dir, pof filename,  
                        file class, &version number, fh system,  
                        /* output */  
                        ierr);  
}
```

### 7.40.3 Input parameters

The `xo_gen_pof` CFI function has the following input parameters:

*Table 142: Input parameters of `xo_gen_pof` function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
<code>sat_id</code>	long *	-	Satellite ID	-	Complete
<code>time_id</code>	xl_time_id*	-	Structure that contains the time correlations. NOTE: This parameter is optional. If the <code>time_id</code> is not initialised, the algorithm will use the time correlations from the input reference file.	-	-
<code>time_init</code>	long*	-	Flag for selecting the time range of the initialisation.	-	Select either: · <code>XO_SEL_ORBIT</code> · <code>XO_SEL_TIME</code>
<code>time_ref</code>	long*	-	Time reference ID. (See note in the <code>ref_filetype</code> field)	-	Select either: · <code>XO_TIME_TAI</code> · <code>XO_TIME_UTC</code> · <code>XO_TIME_UT1</code>
<code>start_time</code>	double*	-	Processing time corresponding to the beginning of the required interval	Decimal days, MJD2000	[-18262.0,36524.0]
<code>stop_time</code>	double*	-	Processing time corresponding to the end of the required interval	Decimal days, MJD2000	[-18262.0,36524.0]
<code>start_orbit</code>	long*	-	Orbit number corresponding to the beginning of the required interval	orbits	>= 1
<code>stop_orbit</code>	long*	-	Orbit number corresponding to the end of the required interval	orbits	>= 1
<code>osv_location</code>	double*	-	Location of the state vector within the orbit	secs	>=0 < 1 nodal period
<code>ref_filetype</code>	long*	-	File type of the input reference file. (Note: When generating a POF file from a DORIS NAVIGATOR file, the input times should be expressed in UTC)	-	Complete
<code>reference_filename</code>	char*	-	Reference File name	-	
<code>pof_filetype</code>	long*	-	File type of the output reference file	-	<code>XO_REF_FILETYPE_POF</code>
<code>output_dir</code>	char*	-	Directory where the resulting POF is written (if NULL, the current directory is used)	-	-

*Table 142: Input parameters of xo\_gen\_pof function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
pof_filename	char*	-	Output POF name  if empty (i.e. ""), the software will generate the filename according to file name specification presented in [FORMATS]. In such case, the generated name is returned in this variable	-	-
file_class	char*	-	File class for output Predicted file	-	-
version_number	long*	-	Version number of output Predicted file	-	>= 1
fh_system	char*	-	System field of the output Predicted file fixed header	-	-

It is possible to use enumeration values rather than integer values for some of the input arguments:

- Satellite ID: sat\_id.
- Time initialisation: time\_init.
- Time reference: time\_ref.
- File type: ref\_filetype and pof\_filetype. See section 6.2 in this SUM.

### 7.40.4 Output parameters

The output parameters of the **xo\_gen\_pof** CFI function are:

*Table 143: Output parameters of xo\_gen\_pof function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
pof_filename	char*	-	Name for the output file. <u>This is only an output parameter when it is empty</u> (i.e. ""); see description of this parameter in table 142)	-	-
ierr[XO_ERR_VECTOR_MAX_LENGTH]	long	all	Status vector	-	-

### 7.40.5 Warnings and errors

Next table lists the possible error messages that can be returned by the **xo\_gen\_pof** CFI function after translating the returned status vector into the equivalent list of error messages by calling the function of the EXPLORER\_ORBIT software library **xo\_get\_msg** (see [GEN\_SUM]).

This table also indicates the type of message returned, i.e. either a warning (WARN) or an error (ERR), the cause of such a message and the impact on the performed calculation, mainly on the results vector.

The table is completed by the error code and value. These error codes can be obtained translating the status vector returned by the **xo\_gen\_pof** CFI function by calling the function of the EXPLORER\_ORBIT software library **xo\_get\_code** (see [GEN\_SUM]).

*Table 144: Error messages of xo\_gen\_pof function*

Error type	Error message	Cause and impact	Error code	Error No
ERR	Wrong satellite flag	Computation not performed	XO_CFI_GEN_POF_WRONG_SAT_ID_ERR	0
ERR	Wrong input flag	Computation not performed	XO_CFI_GEN_POF_WRONG_FLAG_ERR	1
ERR	Time ID is not initialized	Computation not performed	XO_CFI_GEN_POF_TIME_INIT_ERR	2
ERR	Could not initialise the time reference	Computation not performed	XO_CFI_GEN_POF_TIME_INITIALIZATION_ERR	3
ERR	Cannot initialise orbit	Computation not performed	XO_CFI_GEN_POF_ORBIT_INIT_FILE_ERR	4
ERR	Cannot initialise propagation	Computation not performed	XO_CFI_GEN_POF_PROPAG_INIT_ERR	5
ERR	Cannot initialise interpolation	Computation not performed	XO_CFI_GEN_POF_INTERPOL_INIT_ERR	6
ERR	Wrong interpol initialisation	Computation not performed	XO_CFI_GEN_POF_INTERPOL1_ERR	7
ERR	Cannot calculate state vector	Computation not performed	XO_CFI_GEN_POF_CALCULATING_STATE_VECTOR_ERR	8
ERR	Error freeing memory	Computation not performed	XO_CFI_GEN_POF_CLOSE_ERR	9
ERR	Time transformation error	Computation not performed	XO_CFI_GEN_POF_TIME_TRANS_ERR	10
ERR	Memory allocation error	Computation not performed	XO_CFI_GEN_POF_MEMORY_ERR	11
ERR	Error creating the fixed header	Computation not performed	XO_CFI_GEN_POF_GET_FH_ERR	12
ERR	Error writing POF file to disk	Computation not performed	XO_CFI_GEN_POF_WRITE_ERR	13
ERR	Time reference ID is not allowed	Computation not performed	XO_CFI_GEN_POF_TIME_ID_NOT_ALLOWED_ERR	14

### 7.40.6 Runtime performances

The following runtime performance has been measured.

*Table 145: Runtime performances of xo\_gen\_pof function*

<b>Solaris 32-bit. [ms]</b>	<b>Solaris 64 bit. [ms]</b>	<b>Linux 32-bit. [ms]</b>	<b>Linux 64-bit. [ms]</b>
70.5	26.2	32.1	11.5

### 7.40.7 Executable Program

The **gen\_pof** executable program can be called from a Unix shell as:

```
gen_pof  -sat satellite_name
         -tref time_ref
         { -tstart start_time -tstop stop_time (decimal days) |
           -tastart start_time -tastop stop_time (CCSDSA format) |
           -ostart start_orbit -ostop stop_orbit (orbits) }
         -osvloc osv_location (secs)
         -reftyp ref_file_type
         -ref reference_file
         -poftyp pof_file_type
         [-dir output_dir] (current directory by default)
         [-pof output_filename] (default: name generated automatically)
         [-file file_class] (empty string by default)
         [-vers version] (version = 1 by default)
         [-fhsys fh_system] (empty string by default)
         [-v ]
         [-xl_v ]
         [-xo_v ]
         [-help ]
         [-show]
         [ (-tai TAI_time -gps GPS_time -utc UTC_time -ut1 UT1_time) |
           (-tmod time_model -tfile time_file -trid time_reference
            {(-tm0 time0 -tm1 time1) | (-orb0 orbit0 -orb1 orbit1) } ) ]
```

Note that:

- Order of parameters does not matter.
- Bracketed parameters are not mandatory.
- Options between curly brackets and separated by a vertical bar are mutually exclusive.
- [ **-xl\_v** ] option for EXPLORER\_LIB Verbose mode.
- [ **-xo\_v** ] option for EXPLORER\_ORBIT Verbose mode.
- [ **-v** ] option for Verbose mode for all libraries (default is Silent).
- [ **-show** ] displays the inputs of the function and the results.
- Possible values for *satellite\_name*: ERS1, ERS2, ENVISAT, METOP1, METOP2, METOP3, CRYOSAT, ADM, GOCE, SMOS, TERRASAR, EARTHCARE, SWARM\_A, SWARM\_B, SWARM\_C, SENTINEL\_1A, SENTINEL\_1B, SENTINEL\_2, SENTINEL\_3, SEOSAT, GENERIC.

- Possible values for *time\_model*: USER, NONE, IERS\_B\_PREDICTED, IERS\_B\_RESTITUTED, FOS\_PREDICTED, FOS\_RESTITUTED, DORIS\_PRELIMINARY, DORIS\_PRECISE, DORIS\_NAVIGATOR.
- Possible values for *ref\_file\_type* and *pof\_file\_type*: OSF, POF, DORISNAV, ROF, DORISPREM, DORISPREC.
- Possible values for *time\_ref* and *time\_reference*: UNDEF, TAI, UTC, UT1.
- Time references need to be initialized only when using OSF as the type of the input reference file. The inputs needed for this issue are provided in the last three lines of parameters. Note that only one set of parameters should be introduced:
  - TAI, GPS, UTC and UT1 input times (as in *xl\_time\_ref\_init*)
  - A file with time reference data, the time mode, the time reference name and a time range (as in *xl\_time\_ref\_init\_file*)

Example:

```
gen_pof -sat CRYOSAT -tref TAI -ostart 13 -ostop 14 -osvloc 0 -reftyp OSF
        -ref CS_TEST_MPL_ORBREF_20020301T122001_99999999T999999_0001.EEF
        -poftyp POF -dir ./gen_pof/ -pof orb_pre_file_at_307
        -tai -1100.1 -utc -1100.099595 -ut1 -1100.0995914352
        -gps -1100.0997801
```

## 7.41 xo\_gen\_oef

### 7.41.1 Overview

The `xo_gen_oef` CFI function creates an Orbit Event by merging an Orbit Scenario file (OSF) and a Predicted Orbit File.

Orbit Event File is deprecated and is supported only for Cryosat mission.

### 7.41.2 Calling interface

The calling interface of the `xo_gen_oef` CFI function is the following (input parameters are underlined):

```
#include <explorer_orbit.h>
{
    char    oef[XD_MAX_STR], osf[XD_MAX_STR],
           pof[XD_MAX_STR];
    char    *file_class, *fh_system;
    long    version_number;
    long    status, ierr[XO_NUM_ERR_GEN_OEF];
    status = xo_gen_oef(&oef, &osf, &pof,
                       file class, &version number, fh system,
                       /* output */
                       ierr);
}
```

### 7.41.3 Input parameters

The `xo_gen_oef` CFI function has the following input parameters:

*Table 146: Input parameters of xo\_gen\_oef function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
oef	char[]	-	Output OEF name. If empty (i.e. ""), the software will generate the filename according to file name specification presented in [FORMATS]. In such case, the generated name is returned in this variable	-	-
osf	char*	-	Orbit Scenario File name	-	-
pof	char*	-	Predicted Orbit File name	-	-
file_class	char*	-	File class for output file (dummy in the current version)	-	-
version_number	long*	-	Version number of output file (dummy in the current version)	-	>= 1

*Table 146: Input parameters of xo\_gen\_oef function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
fh_system	char*	-	System field of the output file fixed header (dummy in the current version)	-	-

### 7.41.4 Output parameters

The output parameters of the `xo_gen_oef` CFI function are:

*Table 147: Output parameters of xo\_gen\_oef function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
xo_gen_oef	long	-	Main status flag	-	-1, 0, +1
oef	char*	-	Name for the output file. <u>This is only an output parameter when it is empty</u> (i.e. ""; see description of this parameter in table 146)	-	-
ierr[]	long	all	Status vector	-	-

### 7.41.5 Warnings and errors

Next table lists the possible error messages that can be returned by the `xo_gen_oef` CFI function after translating the returned status vector into the equivalent list of error messages by calling the function of the EXPLORER\_ORBIT software library `xo_get_msg` (see [GEN\_SUM]).

This table also indicates the type of message returned, i.e. either a warning (WARN) or an error (ERR), the cause of such a message and the impact on the performed calculation, mainly on the results vector.

The table is completed by the error code and value. These error codes can be obtained translating the status vector returned by the `xo_gen_oef` CFI function by calling the function of the EXPLORER\_ORBIT software library `xo_get_code` (see [GEN\_SUM]).

*Table 148: Error messages of xo\_gen\_dnf function*

Error type	Error message	Cause and impact	Error code	Error No
ERR	Could not open output file for writing	Computation not performed	XO_CFI_GEN_OEF_OPEN_FILE_ERR	0
ERR	Could not copy the Orbit Scenario file	Computation not performed	XO_CFI_GEN_OEF_COPY_FILE_ERR	1
ERR	Could not copy "List_of_OSVs" in the output file	Computation not performed	XO_CFI_GEN_OEF_COPY_NODE_ERR	2

*Table 148: Error messages of xo\_gen\_dnf function*

Error type	Error message	Cause and impact	Error code	Error No
ERR	Could not close output file	Computation not performed	XO_CFI_GEN_OEF_CLOSE_ERR	3
ERR	Error reading the fixed header from the Orbit Scenario file	Computation not performed	XO_CFI_GEN_OEF_READ_OSF_ERR	4
ERR	Error reading the fixed header from the Predicted Orbit file	Computation not performed	XO_CFI_GEN_OEF_READ_POF_ERR	5
ERR	Could not write the Orbit Event file	Computation not performed	XO_CFI_GEN_OEF_WRITE_ERR	6
ERR	Could not get the current time	Computation not performed	XO_CFI_GEN_OEF_CURRENT_TIME_ERR	7
WARN	Cannot write schema in the file	Computation performed. The output file does not contain the schema reference in the root tag	XO_CFI_GEN_OEF_SET_SCHEMA_WARN	8

### 7.41.6 Runtime performances

The following runtime performance has been measured.

*Table 149: Runtime performances of xo\_gen\_oef function*

Solaris 32-bit. [ms]	Solaris 64 bit. [ms]	Linux 32-bit. [ms]	Linux 64-bit. [ms]
42.3	22.2	25.3	10.9

### 7.41.7 Executable Program

The `gen_oef` executable program can be called from a Unix shell as:

```
gen_oef -osf name of the orbit scenario file
        -pof
        [-oef] (default: name generated automatically)
        [-flcl file_class] (empty string by default)
        [-vers version] (version = 1 by default)
        [-fhsys fh_system] (empty string by default)
        [-v ]
        [-xd_v ]
        [-xl_v ]
        [-xo_v ]
        [-help ]
        [-show ]
```

Note that:

- Order of parameters does not matter.
- Bracketed parameters are not mandatory.
- Options between curly brackets and separated by a vertical bar are mutually exclusive.
- `[-xl_v ]` option for EXPLORER\_LIB Verbose mode.
- `[-xo_v ]` option for EXPLORER\_ORBIT Verbose mode.
- `[-v ]` option for Verbose mode for all libraries (default is Silent).
- `[-show ]` displays the inputs of the function and the results.

Example:

```
gen_oef -osf ./input_osf.xml -pof ./input_pof.xml
        -flcl OPER -vers 0 -show -v
```

## 7.42 xo\_gen\_dnf

### 7.42.1 Overview

The **xo\_gen\_dnf** CFI function creates a DORIS Navigator File using as input one of the following reference file types:

- Orbit Scenario File
- FOS Predicted Orbit File
- FOS Restituted Orbit File
- DORIS Navigator File
- DORIS Preliminary Orbit File
- DORIS Precise Orbit FileTime of the ascending crossing node (TAI, UTC and UT1)

The accepted output file types are:

- FOS Restituted Orbit File
- DORIS Preliminary Orbit File
- DORIS Precise Orbit FileTime

The time interval between consecutive OSVs can be selected by the user by means of a parameter in the calling interface. A flag for precise location of OSVs at “integer intervals” (e.g. every exact minute or every ten seconds ) is also available. If the reference file and the DORIS Navigator File contain OSVs at the same time, these OSVs will be identical.

An optional control file can be introduced to correct the state vectors. This file contains the corrections for position and velocity in the along, across and radial directions. The format of this file is shown in [DAT\_SUM].

Note: when using an OSF or Predicted Orbit file, the maximum time interval within the output Doris Navigator file is limited to 2 orbital periods before and after the middle point of the user requested time range.

### 7.42.2 Calling interface

The calling interface of the **xo\_gen\_dnf** CFI function is the following (input parameters are underlined>):

```
#include <explorer_orbit.h>
{
    long    sat_id;
    xl_time_id time_id = {NULL};
    long    time_init, time_ref, start_orbit, stop_orbit,
           ref_filetype, dnf_filetype, osv_precise, version_number;
    double start_time, stop_time, osv_interval;
    char    reference_file[XD_MAX_STR], output_dir[XD_MAX_STR],
           dnf_filename[XD_MAX_STR], ctrl_file[XD_MAX_STR];
    char    *file_class, *fh_system;
    long    status, ierr[XO_ERR_VECTOR_MAX_LENGTH];
}
```

---

```
status = xo_gen_dnf(&sat_id, &time_id,  
                  &time_init, &time_ref,  
                  &start_time, &stop_time,  
                  &start_orbit, &stop_orbit,  
                  &osv_interval, &osv_precise,  
                  &ref_filetype, reference_file, ctrl_file,  
                  &dnf_filetype, output_dir, dnf_filename,  
                  file_class, &version_number, fh_system,  
                  /* output */  
                  ierr);  
  
/* Or, using the run_id */  
long run_id;  
  
status = xo_gen_dnf_run(&run_id,  
                      &time_init, &time_ref,  
                      &start_time, &stop_time,  
                      &start_orbit, &stop_orbit,  
                      &osv_interval, &osv_precise,  
                      &ref_filetype, reference_file, ctrl_file,  
                      &dnf_filetype, output_dir, dnf_filename,  
                      file_class, &version_number, fh_system,  
                      /* output */  
                      ierr);  
}
```

### 7.42.3 Input parameters

The `xo_gen_dnf` CFI function has the following input parameters:

*Table 150: Input parameters of `xo_gen_dnf` function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
sat_id	long *	-	Satellite ID	-	Complete
time_id	xl_time_id*	-	Structure that contains the time correlations. NOTE: This parameter is optional. If the time_id is not initialised, the algorithm will use the time correlations from the input reference file.	-	-
time_init	long*	-	Flag for selecting the time range of the initialisation.	-	Select either: · XO_SEL_ORBIT · XO_SEL_TIME
time_ref	long*	-	Time reference ID (see note in the ref_filetype field)	-	Complete
start_time	double*	-	Processing time corresponding to the beginning of the required interval	Decimal days, MJD2000	[-18262.0,36524.0]
stop_time	double*	-	Processing time corresponding to the end of the required interval	Decimal days, MJD2000	[-18262.0,36524.0]
start_orbit	long*	-	Orbit number corresponding to the beginning of the required interval	orbits	>= 1
stop_orbit	long*	-	Orbit number corresponding to the end of the required interval	orbits	>= 1
osv_interval	double*	-	Interval between consecutive state vector. This parameter should be coherent with the osv_precise flag (see below). If osv_precise is set to: <ul style="list-style-type: none"> <li>· <code>xo_OSV_PRECISE_MINUTE</code>: osv will be forced to be a multiple of 60 seconds.</li> <li>· <code>xo_OSV_PRECISE_TEN_SECONDS</code>: osv will be forced to be a multiple of 10 seconds.</li> </ul>	secs	>=0
osv_precise	long*	-	Flag to indicate if state vectors should be placed at exact time locations	-	Complete

*Table 150: Input parameters of xo\_gen\_dnf function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
ref_filetype	long*	-	File type of the input reference file. (Note: When generating a DNF file from another DORIS NAVIGATOR file, the input times should be expressed in UTC)	-	Complete
reference_filename	char*	-	Reference File name	-	
ctrl_file	char*	-	Control File in xml format. This file contains the corrections for position and velocity in the along, across and radial directions together with the position accuracy(see [DAT_SUM].) If empty string (“”), no corrections will be performed and the accuracy (quality index in the DNF)will be set to 1.	-	
dnf_filetype	long*	-	File type of the output DORIS Navigator file	-	xo_REF_FILETYPE_DORIS_NAV
output_dir	char*	-	Directory where the resulting DNF is written (if NULL, the current directory is used)	-	-
dnf_filename	char*	-	Output DNF name  if empty (i.e. “”), the software will generate the filename according to file name specification presented in [FORMATS]. In such case, the generated name is returned in this variable	-	-
file_class	char*	-	File class for output file (dummy in the current version)	-	-
version_number	long*	-	Version number of output file (dummy in the current version)	-	>= 1
fh_system	char*	-	System field of the output file fixed header (dummy in the current version)	-	-

It is possible to use enumeration values rather than integer values for some of the input arguments:

- Satellite ID: sat\_id.
- Time initialisation: time\_init.
- Time reference: time\_ref.
- OSV precise: osv\_precise. See this SUM.
- File type: ref\_filetype and rof\_filetype. See this SUM.

### 7.42.4 Output parameters

The output parameters of the `xo_gen_dnf` CFI function are:

*Table 151: Output parameters of xo\_gen\_dnf function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
dnf_filename	char*	-	Name for the output file. <u>This is only an output parameter when it is empty</u> (i.e. ""; see description of this parameter in table 150)	-	-
ierr[XO_ERR_VECTOR_MAX_LENGTH]	long	all	Status vector	-	-

### 7.42.5 Warnings and errors

Next table lists the possible error messages that can be returned by the **xo\_gen\_dnf** CFI function after translating the returned status vector into the equivalent list of error messages by calling the function of the EXPLORER\_ORBIT software library **xo\_get\_msg** (see [GEN\_SUM]).

This table also indicates the type of message returned, i.e. either a warning (WARN) or an error (ERR), the cause of such a message and the impact on the performed calculation, mainly on the results vector.

The table is completed by the error code and value. These error codes can be obtained translating the status vector returned by the **xo\_gen\_dnf** CFI function by calling the function of the EXPLORER\_ORBIT software library **xo\_get\_code** (see [GEN\_SUM]).

*Table 152: Error messages of xo\_gen\_dnf function*

Error type	Error message	Cause and impact	Error code	Error No
ERR	Wrong satellite flag	Computation not performed	XO_CFI_GEN_DNF_WRONG_SAT_ID_ERR	0
ERR	Wrong input flag	Computation not performed	XO_CFI_GEN_DNF_WRONG_FLAG_ERR	1
ERR	Time ID is not initialized	Computation not performed	XO_CFI_GEN_DNF_TIME_ID_INIT_ERR	2
ERR	Could not initialise the time reference	Computation not performed	XO_CFI_GEN_DNF_TIME_ID_INITIALIZATION_ERR	3
ERR	Cannot initialise orbit ID	Computation not performed	XO_CFI_GEN_DNF_ORBIT_INIT_FILE_ERR	4
ERR	Cannot initialise the propagator	Computation not performed	XO_CFI_GEN_DNF_PROPAG_INIT_ERR	5
ERR	Cannot initialise interpolation	Computation not performed	XO_CFI_GEN_DNF_INTERPOL_INIT_ERR	6
ERR	Could not perform a time <-> orbit transformation	Computation not performed	XO_CFI_GEN_DNF_TIME_ORBIT_ERR	7
ERR	Error in a time transformation function	Computation not performed	XO_CFI_GEN_DNF_TIME_ERR	8
ERR	Memory allocation error	Computation not performed	XO_CFI_GEN_DNF_MEMORY_ERR	9
ERR	Cannot calculate state vector	Computation not performed	XO_CFI_GEN_DNF_CALCULATING_STATE_VECTOR_ERR	10
ERR	Error reading the Control File	Computation not performed	XO_CFI_GEN_DNF_READ_CONTROL_FILE_ERR	11
ERR	Cannot correct state vector	Computation not performed	XO_CFI_GEN_DNF_CORRECT_OSV_ERR	12
ERR	Error changing state vector from EF to J2000	Computation not performed	XO_CFI_GEN_DNF_CHANGE_COORD_ERR	13
ERR	Error creating the DORIS header	Computation not performed	XO_CFI_GEN_DNF_COMPUTE_HEADER_ERR	14

*Table 152: Error messages of xo\_gen\_dnf function*

Error type	Error message	Cause and impact	Error code	Error No
ERR	Error freeing memory	Computation not performed	XO_CFI_GEN_DNF_CLOSE_ERR	15
ERR	Cannot write DORIS Data Block file	Computation not performed	XO_CFI_GEN_DNF_WRITE_FILE_ERR	16
WARN	OSV interval is not compatible with OSV Precise flag. The OSV Interval will be set to %f seconds.	Computation performed with a different value for the osv_interval	XO_CFI_GEN_DNF_WRONG_INTERVAL_WARN	17

### 7.42.6 Runtime performances

The following runtime performance has been measured.

*Table 153: Runtime performances of xo\_gen\_dnf function*

Solaris 32-bit. [ms]	Solaris 64 bit. [ms]	Linux 32-bit. [ms]	Linux 64-bit. [ms]
4246.0	1895.0	1936.0	353.0

### 7.42.7 Executable Program

The **gen\_dnf** executable program can be called from a Unix shell as:

```
gen_dnf  -sat satellite_name
         -tref time_ref
         { -tstart start_time -tstop stop_time (decimal days) |
           -tastart start_time -tastop stop_time (CCSDSA format) |
           -ostart start_orbit -ostop stop_orbit (orbits) }
         -osvint osv_interval
         [-osvpre]
         -reftyp ref_file_type
         -ref reference_file
         [-ctrl control_file]
         [-dir output_dir] (current directory by default)
         [-dnf output_filename] (default: name generated automatically)
         [-fcl file_class] (empty string by default)
         [-vers version] (version = 1 by default)
         [-fhsys fh_system] (empty string by default)
         [-v ]
         [-xl_v ]
         [-xo_v ]
         [-help ]
         [-show]
         [ (-tai TAI_time -gps GPS_time -utc UTC_time -ut1 UT1_time) |
         (-tmod time_model -tfile time_file -trid time_reference
         {(-tm0 time0 -tm1 time1) | (-orb0 orbit0 -orb1 orbit1) } ) ]
```

Note that:

- Order of parameters does not matter.
- Bracketed parameters are not mandatory.
- Options between curly brackets and separated by a vertical bar are mutually exclusive.
- [ **-osvpre** ] option for osv\_precise. Default value is xo\_OSV\_PRECISE\_NO. When the option is written, osv\_precise value is xo\_OSV\_PRECISE\_MINUTE.
- [ **-xl\_v** ] option for EXPLORER\_LIB Verbose mode.
- [ **-xo\_v** ] option for EXPLORER\_ORBIT Verbose mode.
- [ **-v** ] option for Verbose mode for all libraries (default is Silent).
- [ **-show** ] displays the inputs of the function and the results.

- Possible values for *satellite\_name*: ERS1, ERS2, ENVISAT, METOP1, METOP2, METOP3, CRYOSAT, ADM, GOCE, SMOS, TERRASAR, EARTHCARE, SWARM\_A, SWARM\_B, SWARM\_C, SENTINEL\_1A, SENTINEL\_1B, SENTINEL\_2, SENTINEL\_3, SEOSAT, GENERIC.
- Possible values for *time\_model*: USER, NONE, IERS\_B\_PREDICTED, IERS\_B\_RESTITUTED, FOS\_PREDICTED, FOS\_RESTITUTED, DORIS\_PRELIMINARY, DORIS\_PRECISE, DORIS\_NAVIGATOR.
- Possible values for *ref\_file\_type*: OSF, POF, DORISNAV, ROF, DORISPREM, DORISPREC.
- Possible values for *time\_ref* and *time\_reference*: UNDEF, TAI, UTC, UT1, GPS.
- Time references need to be initialized only when using OSF as the type of the input reference file. The inputs needed for this issue are provided in the last three lines of parameters. Note that only one set of parameters should be introduced:
  - TAI, GPS, UTC and UT1 input times (as in *xl\_time\_ref\_init*)
  - A file with time reference data, the time mode, the time reference name and a time range (as in *xl\_time\_ref\_init\_file*)

Example:

```
gen_dnf -sat CRYOSAT -tref UTC -tstart 0.99650462962963
-tstop 01386574074708 -osvint 20 -reftyp ROF
-ref EARTH_EXPLORER_FRO_TO_DORIS_2000
-ctrl CONTROL_FILE.xml -dir ./gen_dnf/ -dnf doris_nav_at_308
-tai 0.000000 -utc -4.0509259e-4 -ut1 -4.1435185185e-4 -gps 2.1991e-4
-show
```

---

## 7.43 xo\_gen\_tle

### 7.43.1 Overview

The **xo\_gen\_tle** CFI function creates TLE File using as input a Predicted Orbit File. It is possible to select the way in which the TLE are generated:

- Generate a TLE per OSV in the orbit file (XO\_ONE\_TLE\_PER\_OSV).
- Find the best TLE which fits to the OSVs in the orbit file (XO\_FIT\_TLE).

### 7.43.2 Calling interface

The calling interface of the **xo\_gen\_tle** CFI function is the following (input parameters are underlined>):

```
#include <explorer_orbit.h>
{
    long    sat_id;
    xl_time_id time_id = {NULL};
    long    fit_mode, time_mode, time_ref, start_orbit, stop_orbit;
    double  start_time, stop_time;
    char    reference_file[XD_MAX_STR], tle_filename[XD_MAX_STR];
    long    status, ierr[XO_ERR_VECTOR_MAX_LENGTH];

    status = xo_gen_tle (&sat_id, &fit_mode,
                        &time_mode, &time_ref,
                        &start_time, &stop_time,
                        &start_orbit, &stop_orbit,
                        reference_file, tle_filename,
                        ierr);
}
```

### 7.43.3 Input parameters

The `xo_gen_tle` CFI function has the following input parameters:

*Table 154: Input parameters of `xo_gen_tle` function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
sat_id	long *	-	Satellite ID	-	Complete
fit_mode	long*	-	fitting mode	-	Complete
time_mode	long*	-	Flag for selecting the time range of the initialisation.	-	Select either: • XO_SEL_ORBIT • XO_SEL_TIME • XO_SEL_DEFAULT
time_ref	long*	-	Time reference for the input start_time and stop_time	-	Complete
start_time	double*	-	Processing time corresponding to the beginning of the required interval	Decimal days, MJD2000	[-18262.0,36524.0]
stop_time	double*	-	Processing time corresponding to the end of the required interval	Decimal days, MJD2000	[-18262.0,36524.0]
start_orbit	long*	-	Orbit number corresponding to the beginning of the required interval	orbits	>= 1
stop_orbit	long*	-	Orbit number corresponding to the end of the required interval	orbits	>= 1
reference_file	char*	-	Reference File name	-	-

It is possible to use enumeration values rather than integer values for some of the input arguments:

- Fitting mode: `fit_mode`. See this SUM.
- Satellite ID: `sat_id`.
- Time initialisation: `time_mode`.
- Time reference: `time_ref`.

### 7.43.4 Output parameters

The output parameters of the `xo_gen_tle` CFI function are:

*Table 155: Output parameters of xo\_gen\_tle function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
tle_filename	char*	-	Name for the output file.	-	-
ierr[XO_ERR_VECTOR_MAX_LENGTH]	long	all	Status vector	-	-

### 7.43.5 Warnings and errors

Next table lists the possible error messages that can be returned by the **xo\_gen\_tle** CFI function after translating the returned status vector into the equivalent list of error messages by calling the function of the EXPLORER\_ORBIT software library **xo\_get\_msg** (see [GEN\_SUM]).

This table also indicates the type of message returned, i.e. either a warning (WARN) or an error (ERR), the cause of such a message and the impact on the performed calculation, mainly on the results vector.

The table is completed by the error code and value. These error codes can be obtained translating the status vector returned by the **xo\_gen\_tle** CFI function by calling the function of the EXPLORER\_ORBIT software library **xo\_get\_code** (see [GEN\_SUM]).

*Table 156: Error messages of xo\_gen\_tle function*

Error type	Error message	Cause and impact	Error code	Error No
ERR	Wrong satellite ID.	Computation not performed	XO_CFI_GEN_TLE_WRONG_SAT_ID_ERR	0
ERR	Wrong input time reference	Computation not performed	XO_CFI_GEN_TLE_WRONG_FLAG_ERR	1
ERR	Wrong input fitting mode	Computation not performed	XO_CFI_GEN_TLE_WRONG_FIT_MODE_ERR	2
ERR	Could not initialise the time correlations from input file: %s	Computation not performed	XO_CFI_GEN_TLE_TIME_INITIALIZATION_ERR	3
ERR	Could not initialise the orbit data from input file: %s	Computation not performed	XO_CFI_GEN_TLE_ORBIT_INIT_FILE_ERR	4
ERR	Memory allocation error	Computation not performed	XO_CFI_GEN_TLE_MEMORY_ERR	5
ERR	Could not generate the TLE for orbit %ld	Computation not performed	XO_CFI_GEN_TLE_OSV_TO_TLE_ERR	6
ERR	Could not close an ID	Computation not performed	XO_CFI_GEN_TLE_CLOSE_ERR	7
ERR	Could not write output file to disk	Computation not performed	XO_CFI_GEN_TLE_WRITE_FILE_ERR	8

### 7.43.6 Runtime performances

The following runtime performance has been measured.

*Table 157: Runtime performances of xo\_gen\_tle function*

Solaris 32-bit. [ms]	Solaris 64 bit. [ms]	Linux 32-bit. [ms]	Linux 64-bit. [ms]
TBD	TBD	TBD	TBD

## 7.44 xo\_check\_osf

### 7.44.1 Overview

The `xo_check_osf` CFI function checks the continuity of the orbital parameters at the transition from one orbital change and the next one in an Orbit Scenario file.

### 7.44.2 Calling interface

The calling interface of the `xo_check_osf` CFI function is the following (input parameters are underlined):

```
#include <explorer_orbit.h>
{
    long    sat_id;
    xl_time_id time_id = {NULL};
    char    *osf_file;
    long    transition_number;
    double  threshold[XO_NUM_CHECK_PARAMS],
           diffs[XO_NUM_CHECK_PARAMS];
    long    status, ierr[XO_ERR_VECTOR_MAX_LENGTH];
    status = xo_check_osf(&sat_id, &time_id,
                        osf_file, &transition_number,
                        threshold,
                        /* output */
                        diffs, ierr);

    /* Or, using the run_id */
    long    run_id;

    status = xo_check_osf_run(&run_id,
                            osf_file, &transition_number,
                            threshold,
                            /* output */
                            diffs, ierr);
}
```

### 7.44.3 Input parameters

The `xo_check_osf` CFI function has the following input parameters:

*Table 158: Input parameters of `xo_check_osf` function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
sat_id	long *	-	Satellite ID	-	Complete
time_id	xl_time_id*	-	Structure that contains the time correlations.	-	-
osf_file	char*	-	Orbit Scenario file to be checked	-	-
transition_number	long*	-	Nuber of the transition to be checked. If 0, the last transition is checked	-	>1 <=Number of transicions
threshold	double [XO_NUM_CHECK_PARAMS]	0	Threshold for the time at ANX	s	>0
		1	Threshold for the ANX longitude	deg	
		2	Threshold for the MLST	s	
		3	Threshold for the osculating semi-axis major	m	
		4	Threshold for the osculating inclination	deg	
		5	Threshold for the nodal period	s	

### 7.44.4 Output parameters

The output parameters of the `xo_check_osf` CFI function are:

*Table 159: Output parameters of `xo_check_osf` function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
xo_check_osf	long	-	Status	-	-1, 0, 1
diffs	double [XO_NUM_CHECK_PARAMS]	0	Difference for the time at ANX	s	>0
		1	Difference for the ANX longitude	deg	
		2	Difference for the MLST	s	
		3	Difference for the osculating semi-axis major	m	
		4	Difference for the osculating inclination	deg	
		5	Difference for the nodal period	s	
ierr	long*	all	Status vector	-	

### 7.44.5 Warnings and errors

Next table lists the possible error messages that can be returned by the **xo\_check\_osf** CFI function after translating the returned status vector into the equivalent list of error messages by calling the function of the EXPLORER\_ORBIT software library **xo\_get\_msg** (see [GEN\_SUM]).

This table also indicates the type of message returned, i.e. either a warning (WARN) or an error (ERR), the cause of such a message and the impact on the performed calculation, mainly on the results vector.

The table is completed by the error code and value. These error codes can be obtained translating the status vector returned by the **xo\_check\_osf** CFI function by calling the function of the EXPLORER\_ORBIT software library **xo\_get\_code** (see [GEN\_SUM]).

*Table 160: Error messages of xo\_ckeck\_osf function*

Error type	Error message	Cause and impact	Error code	Error No
ERR	Time correlations are not initialized	Computation not performed	XO_CFI_CHECK_OSF_TIME_INIT_ERR	0
ERR	Error reading the Orbit Scenario file	Computation not performed	XO_CFI_CHECK_OSF_OSF_READ_ERR	1
ERR	Wrong transition number	Computation not performed	XO_CFI_CHECK_OSF_WRONG_TRANSITION_ERR	2
ERR	Couldn't initialize the orbit	Computation not performed	XO_CFI_CHECK_OSF_ORBIT_INIT_ERR	3
ERR	Error in xo_orbit_info	Computation not performed	XO_CFI_CHECK_OSF_ORBIT_INFO_ERR	4
WARN	UTC at ANX exceeds the input threshold	Computation performed	XO_CFI_CHECK_OSF_UTC_WARN	5
WARN	ANX Longitude exceeds the input threshold	Computation performed	XO_CFI_CHECK_OSF_ANX_LONG_WARN	6
WARN	MLST exceeds the input threshold	Computation performed	XO_CFI_CHECK_OSF_MLST_WARN	7
WARN	Osculating semi-major axis exceeds the input threshold	Computation performed	XO_CFI_CHECK_OSF_OSC_A_WARN	8
WARN	Osculating inclination exceeds the input threshold	Computation performed	XO_CFI_CHECK_OSF_OSC_I_WARN	9
WARN	Nodal period exceeds the input threshold	Computation performed	XO_CFI_CHECK_OSF_TNOD_WARN	10

### 7.44.6 Runtime performances

The following runtime performance has been measured.

*Table 161: Runtime performances of xo\_check\_osf function*

Solaris 32-bit. [ms]	Solaris 64 bit. [ms]	Linux 32-bit. [ms]	Linux 64-bit. [ms]
5.66	2.12	3.45	0.73

## 7.45 xo\_check\_oef

### 7.45.1 Overview

The `xo_check_oef` CFI function checks the consistency between the list of orbital changes and the list of state vectors in an Orbit Event file.

Note: Orbit Event File is deprecated, only supported for CRYOSAT mission

### 7.45.2 Calling interface

The calling interface of the `xo_check_oef` CFI function is the following (input parameters are underlined):

```
#include <explorer_orbit.h>
{
    long    sat_id;
    xl_time_id time_id = {NULL};
    char    *oef_file;
    long    time_mode, time_ref;
    double  start_time, stop_time;
    long    start_orbit, stop_orbit;
    double  threshold[XO_NUM_CHECK_PARAMS],
            max_diffs[XO_NUM_CHECK_PARAMS],
            rms[XO_NUM_CHECK_PARAMS];
    long    status, ierr[XO_ERR_VECTOR_MAX_LENGTH];
    status = xo_check_oef(&sat_id, &time_id,
                        &time_mode, &time_ref,
                        &start_time, &stop_time,
                        &start_orbit, &stop_orbit,
                        oef_file, threshold,
                        /* output */
                        max_diffs, rms, ierr);

    /* Or, using the run_id */
    long    run_id;
    status = xo_check_oef_run(&run_id,
                            time_mode, &time_ref,
                            &start_time, &stop_time,
                            &start_orbit, &stop_orbit,
                            oef_file, threshold,
                            /* output */
                            max_diffs, rms, ierr);
}
```

### 7.45.3 Input parameters

The `xo_check_oef` CFI function has the following input parameters:

*Table 162: Input parameters of `xo_check_oef` function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
sat_id	long *	-	Satellite ID	-	Complete
time_id	xl_time_id*	-	Structure that contains the time correlations.	-	-
time_mode	long*	-	Flag for the input time range selection: whole file, time or orbits	-	XO_SEL_FILE, XO_SEL_TIME, XO_SEL_ORBIT
time_ref	long*	-	Time reference for the <code>start_time</code> and <code>stop_time</code> input parameters (only needed if <code>time_mode</code> is <code>XO_SEL_TIME</code> )	-	Complete
start_time	double*	-	Start time for the time range to be checked (only needed if <code>time_mode</code> is <code>XO_SEL_TIME</code> )	days	[-18262.0, 36524.0]
stop_time	double*	-	Stop time for the time range to be checked (only needed if <code>time_mode</code> is <code>XO_SEL_TIME</code> )	days	[-18262.0, 36524.0]
start_orbit	long*	-	Start orbit for the orbit range to be checked (only needed if <code>time_mode</code> is <code>XO_SEL_ORBIT</code> )	-	file range
stop_orbit	long*	-	Stop orbit for the orbit range to be checked (only needed if <code>time_mode</code> is <code>XO_SEL_ORBIT</code> )	-	file range
oef_file	char*	-	Orbit Event file to be checked	-	-
threshold	double [XO_NUM_CHECK_PARAMS]	0	Threshold for the time at ANX	s	>0
		1	Threshold for the ANX longitude	deg	
		2	Threshold for the MLST	s	
		3	Threshold for the osculating semi-axis major	m	
		4	Threshold for the osculating inclination	deg	
		5	Threshold for the nodal period	s	

It is possible to use enumeration values rather than integer values for some of the input arguments:

- Satellite ID: `sat_id`.
- Time inputs selection: `time_mode`
- Time reference: `time_ref`.

### 7.45.4 Output parameters

The output parameters of the `xo_check_oef` CFI function are:

*Table 163: Output parameters of xo\_check\_oef function*

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
<code>xo_check_oef</code>	long	-	Status	-	-1, 0, 1
<code>max_diffs</code>	double [XO_NUM_CHECK_PARAMS]	All	The following parameters are computed using the list of orbital changes and the list of state vectors. The maximum value of these differences for the requested interval are returned in this array.	-	>0
		0	Time at ANX	s	
		1	ANX longitude	deg	
		2	MLST	s	
		3	Osculating semi-axis major	m	
		4	Osculating inclination	deg	
<code>rms</code>	double [XO_NUM_CHECK_PARAMS]	All	The following parameters are computed using the list of orbital changes and the list of state vectors. The standard deviation of these differences for the requested interval are returned in this array.	-	>0
		1	ANX longitude	deg	
		2	MLST	s	
		3	Osculating semi-axis major	m	
		4	Osculating inclination	deg	
		5	Nodal period	s	
<code>ierr</code>	long*	all	Status vector	-	

### 7.45.5 Warnings and errors

Next table lists the possible error messages that can be returned by the `xo_check_oef` CFI function after translating the returned status vector into the equivalent list of error messages by calling the function of the EXPLORER\_ORBIT software library `xo_get_msg` (see [GEN\_SUM]).

This table also indicates the type of message returned, i.e. either a warning (WARN) or an error (ERR), the cause of such a message and the impact on the performed calculation, mainly on the results vector.

The table is completed by the error code and value. These error codes can be obtained translating the status vector returned by the `xo_check_oef` CFI function by calling the function of the EXPLORER\_ORBIT software library `xo_get_code` (see [GEN\_SUM]).

*Table 164: Error messages of xo\_ckeck\_oef function*

Error type	Error message	Cause and impact	Error code	Error No
ERR	Error in xo_orbit_info	Computation not performed	XO_CFI_CHECK_OEF_ORBIT_INIT_ERR	0
ERR	Couldn't initialize the orbit	Computation not performed	XO_CFI_CHECK_OEF_ORBIT_INFO_ERR	1
ERR	Memory allocation error	Computation not performed	XO_CFI_CHECK_OEF_MEM_ERR	2
WARN	UTC at ANX exceeds the input threshold	Computation performed	XO_CFI_CHECK_OEF_UTC_WARN	3
WARN	ANX Longitude exceeds the input threshold	Computation performed	XO_CFI_CHECK_OEF_ANX_LONG_WARN	4
WARN	MLST exceeds the input threshold	Computation performed	XO_CHECK_OEF_MLST_WARN	5
WARN	Osculating semi-major axis exceeds the input threshold	Computation performed	XO_CFI_CHECK_OEF_OSC_A_WARN	6
WARN	Osculating inclination exceeds the input threshold	Computation performed	XO_CFI_CHECK_OEF_OSC_I_WARN	7
WARN	Nodal period exceeds the input threshold	Computation performed	XO_CFI_CHECK_OEF_TNOD_WARN	8

### 7.45.6 Runtime performances

The following runtime performance has been measured.

*Table 165: Runtime performances of xo\_check\_oef function*

Solaris 32-bit. [ms]	Solaris 64 bit. [ms]	Linux 32-bit. [ms]	Linux 64-bit. [ms]
62.6	20.6	26.6	6.0

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## 8 LIBRARY PRECAUTIONS

The following precautions shall be taken into account when using EXPLORER\_ORBIT software library:

- When a message like

EXPLORER\_ORBIT >>> ERROR in *xo\_function*: Internal computation error # *n*

or

EXPLORER\_ORBIT >>> WARNING in *xo\_function*: Internal computation warning # *n*

appears, run the program in *verbose* mode for a complete description of warnings and errors, and call for maintenance if necessary.

## 9 KNOWN PROBLEMS

The following precautions shall be taken into account when using the CFI software libraries:

*Table 166: Known problems*

CFI library	Problem	Work around solution
Spot model	Functionality is not currently available	-
xo_propag_spot_init	Functionality is not currently available	-
xo_interpol	Extrapolation is only allowed for Doris Navigation Files and ROF files	-
All	No Fortran version of the library exists	-