RE-ENGINEERING OF MISSION ANALYSIS SOFTWARE FOR ENVISAT-1

PPF_ORBIT SOFTWARE USER MANUAL

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5.8	• Maintenance release.	15/09/09	
5.9	• Maintenance release.	39/05/11	

Table of Contents

1 SCOPE

The Software User Manual (SUM) of the Envisat-1 mission CFI software is composed of

- a general document describing the sections common to all the CFI software libraries
- a specific document for each of those libraries.

This document is the PPF_ORBIT Software User Manual. It provides a detailed description of the use of the CFI functions included within the PPF_ORBIT CFI software library.

2 ACRONYMS AND NOMENCLATURE

2.1 Acronyms

AOCS	Attitude and Orbit Control System
ANX	Ascending Node Crossing
CFI	Customer Furnished Item
CS	Coordinate System
DRS	Data Relay Satellite
ESA	European Space Agency
ESTEC	European Space Technology and Research Centre
FOS	Flight Operation Segment
GS	Ground Station
H/W	Hardware
I/F	Interface
LOS	Line Of Sight
PPF	Polar Platform
RAM	Random Access Memory
SBT	Satellite Binary Time
SUM	Software User Manual
S/W	Software
UTC	Universal Time Coordinated
UT1	Universal Time UT1
SSP	Sub Satellite Point

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

AD 1 Finalization of the re-engineering of Mission Analysis Software and of the ROP Generation Tool for Envisat: Statement of Work.PO-SW-ESA-SY-1242. ESA/ESTEC/APP. Issue 1.1. 03/10/2001.

AD 2 ESA Software Engineering Standards. ESA PSS-05-0. ESA. Issue 2. February 1991

3.2 Reference documents

RD 1 Envisat-1 Mission CFI Software Description and Interface Definition Document. PO-ID-ESA-SY-00412

RD 2 Envisat-1 Mission CFI Software. Mission Conventions Document. PO-IS-GMV-GS-0561

RD 3 Envisat-1 Mission CFI Software General Software User Manual. PO-IS-DMS-GS-0556

RD 4 Envisat-1 Mission CFI Software PPF_LIB Software User Manual. PO-IS-DMS-GS-0557

RD 5 Envisat-1 Products Specifications. PO-RS-MDA-GS-2009

RD 6 PDS to FOS Interface Specification. PO-ID-CSF-GS-0078

RD 7 Interpol URD, PO-IS-ESA-GS-1158 1.1 September 2001

4 INTRODUCTION

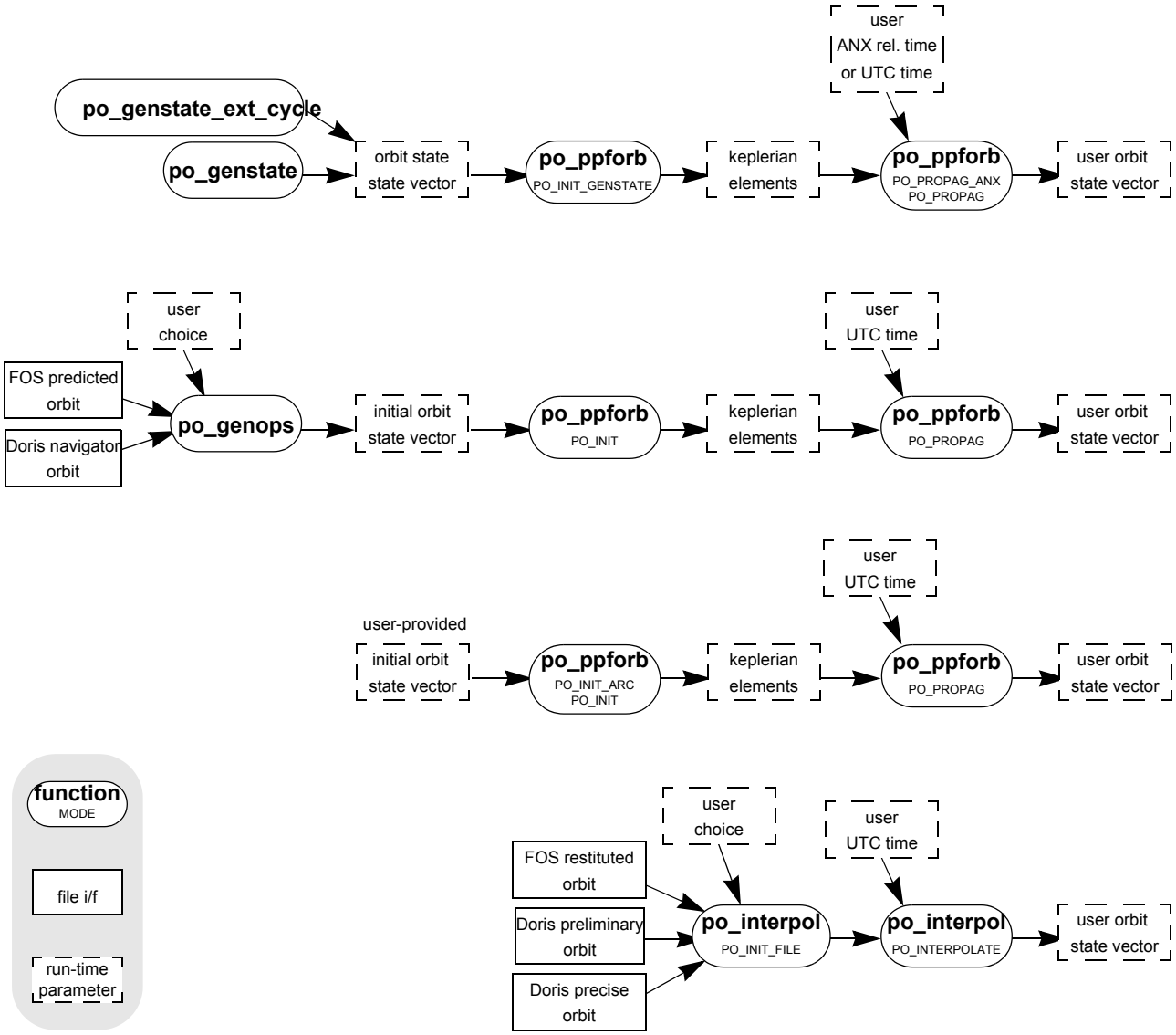
This software library contains all the CFI functions allowing accurate computation of orbit state vectors, either at ascending node or (by propagation) at any point in the Envisat-1 orbit.

It includes the Envisat-1 orbit interpolator, orbit propagator and several routines used to feed the propagator with either simulated, predicted or restituted initial state vectors, i.e. the following CFI functions:

- **po_genstate**: This software is an orbit state vector generator which generates state vectors to perform orbit simulations. It generates a cartesian state vector around the true ascending node crossings in function of the date (processing time), the longitude of the ascending node, the satellite Repeat Cycle Length, and the mean local solar time. It is assumed that there is no MLST drift as it corresponds to a helio-synchronous orbit.

  This state vector can then be fed to the propagator **po_ppforb** in order to initialize the propagation.
- **po_ppforb**: This software is a propagator which allows accurate prediction of osculating Cartesian and Kepler state vectors for user requested time segments, plus the calculation of orbit, and satellite ground track related physical parameters, as well as the direction towards the Sun and the Moon as seen from the satellite position. Input data are specified in an Earth fixed frame.
- **po_genops**: This software generates Envisat-1 Cartesian State Vectors for satellite operations using either Flight Dynamics predicted ascending node state vectors, or the DORIS Navigator Data (extracted in near real time at processing station PDHS). The software function processes and filters the DORIS navigator level 0 data to verify its usability to create a DORIS generated Cartesian State Vector. Otherwise, in case the level 0 DORIS data are too degraded by noise, the software selects the Flight Dynamics predicted Cartesian State vector. The selected state vector can then be fed to the propagator **po_ppforb** in order to initialize the propagation.
- **po_interpol**: This software generates Extended Envisat-1 Cartesian State Vectors based on the interpolation of orbit restituted state vector files (DORIS Preliminary orbit, DORIS precise orbit, FOS restituted orbit), selectable by the user. The user defines the UTC time for which an interpolated state vector has to be generated. There is no need to use the propagator in conjunction with **po_interpol**.
- **po_genstate_ext_cycle**: This software is an orbit state vector generator which generates state vectors to perform orbit simulations. The difference between this function and **po_genstate** is that this function takes into account the possibility of introduccing a drift in the MLST. This drift is not constant, but in order to simplify the satellite planning, the state vector is computed using the orbit at the middle of the cycle as reference. Taking the MLST drift for that reference orbit, any orbit for that cycle will be computed using that drift as a constant.

The possible sequences of calls allowing to produce an orbit state vector are shown in the following data-flow diagram:



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

- RD 2 for a detailed description of the time references and formats, coordinate systems, parameters and models used in this document
- RD 3 for a complete overview of the CFI, and in particular the detailed description of error handling functions

5 LIBRARY INSTALLATION

For a detailed description of the installation of any CFI library, please refer to RD 3.

Notes that example data files are provided with this CFI:

- orbit files to be used with **po_genops**
- orbit files to be used with **po_interpol**

These files are orbit file examples, all relevant for the PDS V1 test reference orbit.

6 LIBRARY USAGE

Note that to use the PPF_ORBIT software library, the following other CFI software libraries are required:

- `PPF_LIB` (version 5.9. See RD 4).

To use the PPF_ORBIT software library in a user application, that application must include in his source code either:

- `ppf_orbit.h` (for a C application)
- `ppf_orbit.inc` (for a Fortran application under SOLARIS/AIX/LINUX/MacOS)
- `ppf_orbit_win.inc` (for a Fortran application under Windows 95/NT)

To link correctly his application, the user must include in his linking command flags like (assuming *cfi_libs_dir* and *cfi_include_dir* are the directories where respectively all CFI libraries and include files have been installed, see RD 3 for installation procedures):

- SOLARIS / AIX

  `-Icfi_include_dir -Lcfi_lib_dir -lppf_orbit -lppf_lib`

- WINDOWS

  `/I "cfi_include_dir" /libpath:"cfi_lib_dir"libppf_orbit.lib libppf_lib.lib`

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

To avoid problems in linking a user application with the `PPF_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 `PO_` or `po_`.

To preserve compatibility with the historical CFI function names, it is possible to call the CFI functions described in this document from a user application with or without the `po_` prefix. This does not apply to the error handling functions, which are described in the General SUM (see RD 3).

This is summarized in the table below.

Function Name	Enumeration value	long
Main CFI Functions		
po_genstate genstate	PO_GENSTATE_ID	0
po_genstate_ext_cycle	PO_GENSTATE_EXT_ID	1
po_ppforb ppforb	PO_PPFORB_ID	2
po_genops genops	PO_GENOPS_ID	3
po_interpol interpol	PO_INTERPOL_ID	4
Error Handling Functions		

Function Name	Enumeration value	long
po_verbose	not applicable	
po_silent		
po_vector_code		
po_vector_msg		
po_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

Whenever available **it is strongly recommended to use enumeration values rather than integer values**.

6.1 Usage hints

The runtime performances of the CFI functions `po_genstate`, `po_ppforb` and `po_interpol` are improved if they are called several times with the same UT1 time on input .

However, although the user may not need to call the CFI functions two consecutive times with the same inputs, there are internal functions that are actually called in those conditions, and thus improving the runtime performances of the former.

Thus, the runtime improvement is achieved with any sequence of calls to those CFI functions, not only with a sequence of calls to the same function.

In fact, the UT1 time does not need to keep exactly constant as long as the difference between two consecutive calls lays within the following threshold:

- UT1 time: 0.0864 microsec

7 CFI FUNCTIONS DESCRIPTION

The following sections describe each CFI function.

The calling interfaces are described both for C users and Fortran users.

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])

Fortran users should adapt the tables using Fortran syntax equivalent terms:

- parameter types (e.g. long <=> INTEGER*4, double <=>REAL*8)
- array sizes of N elements (e.g. param[N] <=> param (N))
- array element M (e.g. [M] <=> (M+1))

7.1 po_genstate

7.1.1 Overview

This software is an orbit state vector generator which is to be used in conjunction with the **po_ppforb** orbit propagator function, in order to generate state vectors to perform orbit simulations. It generates a cartesian state vector around the true ascending node crossings in function of:

- the date (processing time),
- the longitude of the ascending node,
- the satellite Repeat Cycle and Cycle Length, and
- the mean local solar time at ascending node

This state vector is fed to the propagator in order to initialize the propagation (i.e. use **po_ppforb** with mode PO_INIT_GENSTATE).

Note: Since version 5.7, The Envisat CFI software has been modified to deal with the new Envisat orbit thought for the Envisat life extension. This new orbit is not a pure helio-synchronous orbit as it has a drift in the MLST. To generate the state vector for such an orbit, a new function has been implemented **po_genstate_ext_cycle** (see section 7.5)

7.1.2 Calling interface

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

```
#include <ppf_orbit.h>
{
      long irep, icyc, iorb0, iorb, ierr[4], status;
      double mjdr[2], rlong, ascmlst, mjdp[2], pos[3], vel[3];

      status = po_genstate(mjdr, &irep, &icyc, &rlong, &ascmlst,
                           &iorb0,&iorb,
                           mjdp, pos, vel, ierr);
}
```

For Fortran programs the declaration and calling procedure is as follows (input parameters are underlined, note that the C preprocessor must be used because of the presence of the #include statement):

```
#include <ppf_orbit.inc>

      INTEGER*4 IREP, ICYC, IORB0, IORB, IERR(4), STATUS
      REAL*8 MJDR(2), RLONG, ASCMLST, MJDP(2), POS(3), VEL(3)

      STATUS = PO_GENSTATE(MJDR, IREP, ICYC, RLONG, ASCMLST,
     &                     IORB0, IORB,
     &                     MJDP, POS, VEL, IERR)
```

7.1.3 Input parameters

The **po_genstate** CFI function has the following input parameters:

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
mjdr[2]	double	[0]	UTC of the reference orbit (UT1 time) Note: only the integer part of the date is required	decimal days (Processing format)	>= -18262 < +36525
		[1]	ΔUT1 of the reference orbit (UT1 time)	s (Processing format)	>= -1.0 <= +1.0
irep	long *	-	Repeat cycle of the reference orbit	days	> 0
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	decimal hours	>= 0 < 24
iorb0	long *	-	Absolute orbit number of the reference orbit	orbits	-
iorb	long *	-	Absolute orbit number of the requested orbit	orbits	-

7.1.4 Output parameters

The output parameters of the **po_genstate** CFI function are:

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
po_genstate	long	-	Main status flag	-	-1, 0, +1
mjdp[2]	double	[0]	UTC of the calculated osculating state vector (UT1 time)	decimal days (Processing format)	>= -18262 < +36525
		[1]	ΔUT1 of the calculated osculating state vector (UT1 time)	s (Processing format)	>= -1.0 <= +1.0

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
pos[3]	double	all	Calculated osculating position vector (X, Y, Z) (Earth fixed CS)	m	-
vel[3]	double	all	Calculated osculating velocity vector (X, Y, Z) (Earth fixed CS)	m/s	-
ierr[4]	long	all	Status vector	-	-

7.1.5 Warnings and errors

Next table lists the possible error messages that can be returned by the **po_genstate** CFI function after translating the returned status vector into the equivalent list of error messages by calling the function of the PPF_ORBIT software library **po_vector_msg** (see RD 3).

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 **po_genstate** CFI function by calling the function of the PPF_ORBIT software library **po_vector_code** (see RD 3).

Error type	Error message	Cause and impact	Error code	Error No
ERR	ANX state vector does not satisfy loose Envisat tolerance requirements.	Output Envisat-1 state vector does not satisfy the loose tolerance requirements. Calculation not performed.	PO_CFI_GENSTATE_FAILED_TESTSTATE_ERR	6
WARN	ANX state vector does not satisfy tight Envisat tolerance requirements	Output Envisat-1 state vector does not satisfy the tight tolerance requirements.	PO_CFI_GENSTATE_FAILED_TESTSTATE_WARN	7
ERR	Repeat Cycle and Cycle Length have common denominator	Repeat cycle and cycle length have common denominator. Calculation not performed.	PO_CFI_GENSTATE_REPEAT_CYCLE_LENGTH_ERR	8
ERR	Wrong UTC on input (out of range)	Not allowed mjdr[0] value Calculation not performed	PO_CFI_INVALID_MDJR_0_ERR	32
ERR	Wrong DUT1 on input (out of range)	Not allowed mjdr[1] value Calculation not performed	PO_CFI_INVALID_MDJR_1_ERR	33
ERR	Wrong Repeat Cycle on input (out of range)	Not allowed irep value Calculation not performed	PO_CFI_INVALID_IREP_ERR	34
ERR	Wrong Cycle Length on input (out of range)	Not allowed icyc value Calculation not performed	PO_CFI_INVALID_ICYC_ERR	35
ERR	Wrong MLST on input (out of range)	Not allowed ascmlst value Calculation not performed	PO_CFI_INVALID_MLST_ERR	36

7.1.6 Runtime performances

The following runtime performance has been measured.

Ultra Sparc [ms]
2.358

7.2 po_ppforb

7.2.1 Overview

This software is a propagator which allows accurate prediction of osculating Cartesian and Kepler state vectors for user requested time segments, plus the calculation of orbit, and satellite ground track related physical parameters, as well as the direction towards the Sun and the Moon as seen from the satellite position. Input data are specified in an Earth fixed frame.

The detailed functions of the Orbit Propagator are:

- For propagation over complete orbits:
  - 1. Accurate prediction of osculating Orbit State Vectors in the Earth-fixed rotating coordinate system and osculating Kepler states in the Quasi-Inertial geocentric coordinate system of the True system of date, for user requested relative or absolute times which must fall within plus/minus two orbital periods of the reference node crossing epoch. This node crossing epoch is being obtained by the initialization using an osculating Orbit State Vector in the Earth-fixed rotating coordinate system at, or near (+/- 5 deg) true node, as provided by the FOCC.
  - 2. Calculation of orbit, altitude and ground track related quantities as well as the direction to Sun and Moon as seen from the S/C position, along the whole orbit.
- For propagation over short restituted orbit arcs:
  - 1. Accurate prediction of osculating Orbit State Vectors in the Earth-fixed rotating coordinate system and osculating Kepler states in the Quasi-Inertial geocentric coordinate system of the True system of date, for user requested absolute times which must fall within plus/minus 3 minutes of a restituted Orbit State Vector epoch. Now the constraint for the initialization using an Orbit State Vector at or near true ascending node is not applicable. The restituted Orbit State Vector is an osculating Cartesian State Vector in the Earth-fixed rotating coordinate system, as provided by the FOCC.
  - 2. Calculation of orbit, altitude and ground track related quantities as well as the direction to Sun and Moon as seen from the S/C position, along this arc.

A proper sequence of Orbit Propagator calls consist of:

- one initialization call
- a number of propagation calls

7.2.2 Calling interface

The calling interface of the **po_ppforb** CFI function is the following:

```
#include <ppf_orbit.h>
{
       long mode, ierr[4], status;
       double mjdr[2], xm[6], mjdp[2], x[6], pos[3], vel[3], acc[3];
       double res[54];

       status = po_ppforb(&mode, mjdr, xm, mjdp, x,
                          pos, vel, acc, res, ierr);
}
```

For Fortran programs the declaration and calling procedure is as follows (note that the C preprocessor must be used because of the presence of the #include statement):

```
#include <ppf_orbit.inc>

       INTEGER*4 MODE, IERR(4), STATUS
       REAL*8 MJDR(2), XM(6), MJDP(2), X(6), POS(3), VEL(3), ACC(3)
       REAL*8 RES(54)

       STATUS = PO_PPFORB(MODE, MJDR, XM, MJDP, X,
      &                   POS, VEL, ACC, RES, IERR)
```

CAUTION: Note that for historical reasons, some parameters are both input and output parameters. So please read very carefully the following sections.

7.2.3 Input parameters

The *mode* parameter is used to select the appropriate INITIALISATION and PROPAGATION mode. It is the combination of two values. A **mandatory** value, determining the initialisation or propagation mode to be used, and an **optional** value which is added to the former and is used to select the output parameters to be calculated.

```
mode = <init/prop mode(mandatory)> + <results mode value(optional)>
```

The next table shows the allowed initialisation and propagation values:

Initialization (I) mode ⇒ Propagation (P) mode	Initial state vector (Reference)	Propagation mode (see RD 2)	Maximum propagation time
I = -2 ⇒ P = 2	Near centre of the local orbital arc (Earth fixed CS)	Longitude independent	± 3 min wrt the initial orbit state vector
I = -1 ⇒ P = 1 / 2	Within ± 5 deg of [Earth fixed] ascending node (Earth fixed CS)	Longitude independent	± two nodal periods wrt the true [Earth fixed] ascending node
I = 0 ⇒ P = 2	Within ± 5 deg of true [Earth fixed] ascending node (Earth fixed CS)	Longitude dependent	± two nodal periods wrt the true [Earth fixed] ascending node

It is also possible to use enumeration values rather than integer values for some of the input arguments, as shown in the table below

Input	Description	Enumeration value	long
mode	Initialization mode	PO_INIT_ARC	-2
		PO_INIT_GENSTATE	-1
		PO_INIT	0
	Propagation mode	PO_PROPAG_ANX	1
		PO_PROPAG	2

In addition, when results are required, it is possible to select individually the calculation of different sets of output parameters, or to make any combination of them by adding the results mode value to the mode value. If no value is added **all** the elements of the result vector will be calculated while if PO_NO_RESULTS is added none of them will be calculated. The different values of the results mode are shown below:

Description	Enumeration value	long
Optional value to be added to the mode value, in order to avoid producing the optional results vector (and therefore improve runtime performance of the function)	PO_NO_RESULTS	100
Set of basic results without derivatives	PO_PPFORB_RES_BAS	1000
Set of basic results with first derivatives	PO_PPFORB_RES_BAS_D	2000
Set of basic results with second derivatives	PO_PPFORB_RES_BAS_2D	4000
Set of auxiliary results without derivatives	PO_PPFORB_RES_AUX	10000
Set of auxiliar results with first derivatives	PO_PPFORB_RES_AUX_D	20000
Set of auxiliary results with second derivatives	PO_PPFORB_RES_AUX_2D	40000

The elements calculated in each case are shown in 7.2.5.

Some examples of the feasible combinations are shown below:

```
mode = PO_INIT_ARC + PO_PPFORB_RES_BAS + PO_PPFORB_RES_BAS_D
     = -2 + 1000 + 2000 = 2998
mode = PO_PROPAG + PO_PPFORB_RES_BAS + PO_PPFORB_RES_AUX
     = 2 + 1000 + 10000 = 11002
mode = PO_PROPAG_ANX + PO_PPFORB_RES_BAS + PO_PPFORB_RES_BAS_D +
       PO_PPFORB_RES_AUX + PO_PPFORB_RES_AUX_D +
       PO_PPFORB_RES_AUX_2D
     = 1 + 1000 + 2000 + 10000 + 20000 + 40000 = 73001
mode = PO_PROPAG + PO_NO_RESULTS = 2 + 100 = 102
```

In order to calculate some elements it might be neccesary to calculate elements which have not been explicitly requested (e.g. if the derivative of a parameter is requested, the parameter itself will also be calculated). The function identifies internally all the dependencies and those elements are also returned in the result vector.

The **po_ppforb** CFI function has the following input parameters in initialisation modes:

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
mode	long *		Initialization mode		-2, -1, 0 98, 99, 100, etc.

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
mjdp[2]	double	[0]	UTC of the initial osculating state vector (UT1 time)	decimal days (Processing format)	>= -18262 < +36525
		[1]	ΔUT1 of the initial osculating state vector (UT1 time)	s (Processing format)	>= -1.0 <= +1.0
pos[3]	double	all	Initial osculating position vector (X, Y, Z) (Earth fixed CS)	m	-
vel[3]	double	all	Initial osculating velocity vector (X, Y, Z) (Earth fixed CS)	m/s	-

The **po_ppforb** CFI function has the following input parameters in propagation modes:

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
mode	long *	-	Propagation mode	-	1, 2 101, 102, etc.
mjdr[2]	double	[0]	UTC of the true [Earth-fixed] ascending node (UT1 time)	decimal days (Processing format)	>= -18262 < +36525
		[1]	ΔUT1 of the true [Earth-fixed] ascending node (UT1 time)	s (Processing format)	>= -1.0 <= +1.0
xm[6]	double	all	Mean Kepler elements at the true [Earth-fixed] ascending node (True of Date CS)	-	-
		[0]	Semi-major axis	m	> 0
		[1]	Eccentricity		>= 0 < 1
		[2]	Inclination	deg	>= 0 <= 180
		[3]	Right ascension of the ascending node	deg	>= 0 < 360
		[4]	Argument of perigee	deg	>= 0 < 360
		[5]	Mean anomaly	deg	>= 0 < 360
mjdp[2]	double	[0]	In mode = 1 ΔT: prediction time relative to the true [Earth fixed] ascending node (UTC time) In mode = 2 ΔT: UTC prediction time (UTC time)	 s decimal days (Processing format)	-
		[1]	DUMMY. The used ΔUT1 is the one taken in po_ppforb in initialisation mode.	-	-

7.2.4 Output parameters

The output parameters of the **po_ppforb** CFI function are in initialisation modes:

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
po_ppforb	long	-	Main status flag	-	-1, 0, +1
mjdr[2]	double	[0]	UTC of the true [Earth fixed] ascending node (UT1 time)	decimal days (Processing format)	>= -18262 < +36525
		[1]	ΔUT1of the true [Earth fixed] ascending node (UT1 time)	s (Processing format)	>= -1.0 <= +1.0
xm[6]	double	all	Mean Kepler elements at the true [Earth fixed] ascending node. (True of Date CS)	-	-
		[0]	Semi-major axis	m	> 0
		[1]	Eccentricity	-	>= 0 < 1
		[2]	Inclination	deg	>= 0 <= 180
		[3]	Right ascension of the ascending node	deg	>= 0 < 360
		[4]	Argument of perigee	deg	>= 0 < 360
		[5]	Mean anomaly	deg	>= 0 < 360
x[6]	double	all	Osculating Kepler elements of the initial state vector (True of Date CS)	-	-
acc[3]	double	all	Osculating acceleration vector of the initial state vector (Earth fixed CS)	m/s^2	-
res[54]	double	all	Optional results vector corresponding to the initial state vector In mode = -2 / -1 / 0 the results vector is calculated. In mode = 98 / 99 / 100 the results vector is NOT calculated, i.e. all parameters are set to 0. The other modes calculate only a fraction of the result vector, see 7.2.5.	-	-
ierr[4]	long	all	Status vector	-	-

The output parameters of the **po_ppforb** CFI function in propagation modes are:

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
po_ppforb	long	-	Main status flag	-	-1, 0, +1
mjdp[2]	double	[0]	UTC at predicted time (UT1 time)	decimal days (Processing format)	>= -18262 < +36525
		[1]	ΔUT1 at predicted time (UT1 time)	s (Processing format)	>= -1.0 <= +1.0
x[6]	double	all	Osculating Kepler elements at predicted time. (True of Date CS)	-	-
pos[3]	double	all	Osculating position vector at predicted time (Earth fixed CS)	m	-
vel[3]	double	all	Osculating velocity vector at predicted time (Earth fixed CS)	m/s	-
acc[3]	double	all	Osculating acceleration vector at predicted time (Earth fixed CS)	m/s^2	-
res[54]	double	all	Optional results vector corresponding to the predicted state vector In mode = 1 / 2 the results vector is calculated. In mode = 101 / 102 the results vector is NOT calculated, i.e. all its parameters are set to zero. The other modes calculate only a fraction of the result vector, see 7.2.5.	-	-
ierr[4]	long	all	Status vector	-	-

7.2.5 Optional results vector

The optional results vector contains many additional parameters which can be optionally calculated by the **po_ppforb** function (see input mode parameter). It contains:

(note that there is also an enumeration associated to the elements of the result vector).

Result parameter (res element)	Set	Description (Reference)	Unit (Format)	Allowed Range
[0] PO_PPFORB_RES_ORBIT_RAD	AUX	Orbit radius (True of Date CS)	m	>= 0
[1] PO_PPFORB_RES_RADIAL_ORB_VEL	AUX	Radial orbit velocity component (True of Date CS)	m/s	-
[2] PO_PPFORB_RES_TRANS_ORB_VEL	AUX	Transversal orbit velocity component (True of Date CS)	m/s	-
[3] PO_PPFORB_RES_ORB_VEL_MAG	AUX	Orbit velocity magnitude (True of Date CS)	m/s	>= 0
[4] PO_PPFORB_RES_RA_SAT	AUX	Right ascension of the satellite (True of Date CS)	deg	>= 0 < 360
[5] PO_PPFORB_RES_DEC_SAT	AUX	Declination of the satellite (True of Date CS)	deg	>= -90 <= +90
[6] PO_PPFORB_RES_EARTH_ROTATION_ANGLE	AUX	Earth rotation angle [H]	deg	>= 0 < 360
[7] PO_PPFORB_RES_GEOC_LONG	BAS	Geocentric longitude of satellite and SSP (Earth fixed CS)	deg	>= 0 < 360
[8] PO_PPFORB_RES_GEOD_LAT	BAS	Geodetic latitude of satellite and SSP (Earth fixed CS)	deg	>= -90 <= +90
[9] PO_PPFORB_RES_GEOC_LAT	BAS	Geocentric latitude of the SSP (Earth fixed CS)	deg	>= -90 <= +90
[10] PO_PPFORB_RES_SAT_ASPECT_ANGLE	BAS	Satellite centred aspect angle (Earth fixed CS)	deg	>= 0 <= 180
[11] PO_PPFORB_RES_GEOC_ASPECT_ANGLE	BAS	Geocentric aspect angle (Earth fixed CS)	deg	>= 0 <= 180
[12] PO_PPFORB_RES_SSP_ASPECT_ANGLE	BAS	SSP centred aspect angle (Earth fixed CS)	deg	>= 0 <= 180
[13] PO_PPFORB_RES_GEOC_DISTANCE_OF_SSP	BAS	Geocentric distance of the SSP (Earth fixed CS)	m	>= 0

Result parameter (res element)	Set	Description (Reference)	Unit (Format)	Allowed Range
[14] PO_PPFORB_RES_RAD_CUR_PARALLEL_MERIDIAN	AUX	Radius of curvature parallel to meridian at the SSP (Earth fixed CS)	m	>= 0
[15] PO_PPFORB_RES_RAD_CUR_ORTHO_MERIDIAN	AUX	Radius of curvature orthogonal to meridian at the SSP (Earth fixed CS)	m	>= 0
[16] PO_PPFORB_RES_RAD_CUR_ALONG_GROUNDTRACK	BAS	Radius of curvature along groundtrack at the SSP (Earth fixed CS)	m	>= 0
[17] PO_PPFORB_RES_MSLT	BAS	Mean local solar time at the SSP	decimal hour	>= 0 < 24
[18] PO_PPFORB_RES_TLST	BAS	True local solar time at the SSP	decimal hour	>= 0 < 24
[19] PO_PPFORB_RES_TRUE_SUN_RA	AUX	True Sun's (centre) right ascension (True of Date CS)	deg	>= 0 < 360
[20] PO_PPFORB_RES_TRUE_SUN_DEC	AUX	True Sun's (centre) declination (True of Date CS)	deg	>= -90 <= +90
[21] PO_PPFORB_RES_TRUE_SUN_SEMI_DIAM	AUX	True Sun's semi-diameter	deg	>= 0
[22] PO_PPFORB_RES_MOON_RA	AUX	Moon's (centre) right ascension (True of Date CS)	deg	>= 0 < 360
[23] PO_PPFORB_RES_MOON_DEC	AUX	Moon's (centre) declination (True of Date CS)	deg	>= -90 <= +90
[24] PO_PPFORB_RES_MOON_SEMI_DIAM	AUX	Moon's semi-diameter	deg	>= 0
[25] PO_PPFORB_RES_MOON_AREA_LIT	AUX	Area of Moon lit by Sun		>= 0 <= 1
[26] PO_PPFORB_RES_SAT_ECLIPSE_FLAG	BAS	Satellite eclipse flag 0 = No 1 = Yes		0, 1
[27] PO_PPFORB_RES_GEOD_ALT	BAS	Geodetic altitude of the satellite (Earth fixed CS)	m	-
[28] PO_PPFORB_RES_GEOD_LAT_D	BAS_D	Geodetic latitude rate of satellite and SSP (Earth fixed CS)	deg/s	-
[29] PO_PPFORB_RES_GEOC_LAT_D	BAS_D	Geocentric latitude rate of the SSP (Earth fixed CS)	deg/s	-

Result parameter (res element)	Set	Description (Reference)	Unit (Format)	Allowed Range
[30] PO_PPFORB_RES_GEOC_LONG_D	BAS_D	Geocentric longitude rate of satellite and SSP (Earth fixed CS)	deg/s	-
[31] PO_PPFORB_RES_RA_SAT_D	AUX_D	Right ascension rate of the satellite (True of Date CS)	deg/s	-
[32] PO_PPFORB_RES_GEOC_DISTANCE_OF_SSP_D	BAS_D	Geocentric distance rate of the SSP (Earth fixed CS)	m/s	-
[33] PO_PPFORB_RES_RAD_CUR_PARALLEL_MERIDIAN_D	AUX_D	Radius of curvature parallel to meridian rate at the SSP (Earth fixed CS)	m/s	-
[34] PO_PPFORB_RES_RAD_CUR_ORTHO_MERIDIAN_D	AUX_D	Radius of curvature orthogonal to meridian rate at the SSP (Earth fixed CS)	m/s	-
[35] PO_PPFORB_RES_GEOD_ALT_D	BAS_D	Geodetic altitude rate of the satellite (Earth fixed CS)	m/s	-
[36] PO_PPFORB_RES_NORTH_VEL	BAS_D	Northward component of the velocity relative to the Earth of the SSP (Topocentric CS)	m/s	-
[37] PO_PPFORB_RES_EAST_VEL	BAS_D	Eastward component of the velocity relative to the Earth of the SSP (Topocentric CS)	m/s	-
[38] PO_PPFORB_RES_MAG_VEL	BAS_D	Magnitude of the velocity relative to the Earth of the SSP (Topocentric CS)	m/s	>= 0
[39] PO_PPFORB_RES_AZ_VEL	BAS_D	Azimuth of the velocity relative to the Earth of the SSP (Topocentric CS)	deg	>= 0 < 360
[40] PO_PPFORB_RES_GEOD_LAT_2D	BAS_2D	Geodetic latitude rate-rate of satellite and SSP (Earth fixed CS)	deg/s^2	-
[41] PO_PPFORB_RES_GEOC_LAT_2D	BAS_2D	Geocentric latitude rate-rate of the SSP (Earth fixed CS)	deg/s^2	-
[42] PO_PPFORB_RES_GEOC_LONG_2D	BAS_2D	Geocentric longitude rate-rate of satellite and SSP (Earth fixed CS)	deg/s^2	-
[43] PO_PPFORB_RES_RA_SAT_2D	AUX_2D	Right ascension rate-rate of the satellite (True of Date CS)	deg/s^2	-
[44] PO_PPFORB_RES_GEOC_DISTANCE_OF_SSP_2D	BAS_2D	Geocentric distance rate-rate of the SSP (Earth fixed CS)	m/s^2	-

Result parameter (res element)	Set	Description (Reference)	Unit (Format)	Allowed Range
[45] PO_PPFORB_RES_RAD_CUR_PARALLEL_MERIDIAN_2D	AUX_2D	Radius of curvature parallel to meridian rate-rate at the SSP (Earth fixed CS)	m/s^2	-
[46] PO_PPFORB_RES_RAD_CUR_ORTHO_MERIDIAN_2D	AUX_2D	Radius of curvature orthogonal to meridian rate-rate at the SSP (Earth fixed CS)	m/s^2	-
[47] PO_PPFORB_RES_GEOD_ALT_2D	BAS_2D	Geodetic altitude rate-rate of the satellite (Earth fixed CS)	m/s^2	-
[48] PO_PPFORB_RES_NORTH_ACC	BAS_2D	Northward component of the acceleration relative to the Earth of the SSP (Topocentric CS)	m/s^2	-
[49] PO_PPFORB_RES_EAST_ACC	BAS_2D	Eastward component of the acceleration relative to the Earth of the SSP (Topocentric CS)	m/s^2	-
[50] PO_PPFORB_RES_GROUNDTRACK_TANG_ACC	BAS_2D	Groundtrack tangential component of the acceleration relative to the Earth of the SSP (Topocentric CS)	m/s^2	-
[51] PO_PPFORB_RES_AZ_ACC	BAS_2D	Azimuth of the acceleration relative to the Earth of the SSP (Topocentric CS)	deg	>= 0 < 360
[52] PO_PPFORB_RES_NODAL_PERIOD	With any of them	Nodal period	s	>= 0
[53] PO_PPFORB_RES_UTC_NEXT_ANX	With any of them	UTC of next ascending node (UTC time)	decimal days (Processing format)	-

7.2.6 Warnings and errors

Next table lists the possible error messages that can be returned by the **po_ppforb** CFI function after translating the returned status vector into the equivalent list of error messages by calling the function of the PPF_ORBIT software library **po_vector_msg** (see RD 3).

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 **po_ppforb** CFI function by calling the function of the PPF_ORBIT software library **po_vector_code** (see RD 3).

Error type	Error message	Cause and impact	Error code	Error No
ERR	Initial state vector does not satisfy loose Envisat tolerance requirements	Initial Envisat-1 state vector does not satisfy the loose tolerance requirements. Calculation not performed	PO_CFI_PPFORB_INIT_INVALID_PPF_SV_ERR	0
ERR	ANX state vector does not satisfy loose Envisat tolerance requirements	ANX state vector does not meet loose tolerance requirements. Calculation not performed	PO_CFI_PPFORB_INIT_INVALID_ANX_SOL_ERR	2
WARN	Initial state vector too far from ascending node	Initial state vector too far from ascending node. Degraded accuracy of the ANX state vector.	PO_CFI_PPFORB_INIT_INIT_TOO_FAR_WARN	4
WARN	Initial state vector does not satisfy tight tolerance requirements	Initial Envisat-1 state vector does not satisfy the tight tolerance requirements.	PO_CFI_PPFORB_INIT_INVALID_PPF_SV_WARN	6
WARN	ANX state vector does not satisfy tight Envisat tolerance requirements	ANX state vector does not meet tight tolerance requirements.	PO_CFI_PPFORB_INIT_INVALID_ANX_SOL_WARN	7
ERR	Propagated state vector does not satisfy loose Envisat tolerance requirements.	Propagated Envisat-1 state vector does not satisfy the loose tolerance requirements. Calculation not performed	PO_CFI_PPFORB_PRED_INVALID_PROP_SV_ERR	33
WARN	Propagated state vector does not satisfy tight Envisat tolerance requirements.	Propagated Envisat-1 state vector does not satisfy the tight tolerance requirements.	PO_CFI_PPFORB_PRED_INVALID_PROP_SV_WARN	34
ERR	Wrong selected mode on input (not allowed mode)	Not allowed mode value Calculation not performed	PO_CFI_PPFORB_NOT_VALID_MODE_ERR	96
ERR	Wrong selected mode on input (initialization not performed yet)	po_ppforb needs to be initialized before propagated Calculation not performed	PO_CFI_PPFORB_NOT_INITIALIZED_ERR	97
ERR	Wrong UTC on input (out of range)	Not allowed UTC value Calculation not performed.	PO_CFI_PPFORB_INITIAL_VALUE_ERROR_MJDP_TJDP_ERR	98

Error type	Error message	Cause and impact	Error code	Error No
ERR	Wrong DUT1 on input (out of range)	Not allowed DUT1 value Calculation not performed.	PO_CFI_PPFORB_INITIAL_VALUE_ERROR_MJDP_TJDP_2_ERR	99
WARN	Requested propagation time too long	Requested propagation time too long. Degraded accuracy of the propagated state vector. Important note: if po_ppforb is initialized with PO_INIT of PO_INIT_ARC then if the propagation time exceeds its allowed range the propagation may be invalid	PO_CFI_PPFORB_PRED_EXC_MAX_TIME_WARN	100
WARN	Wrong DUT1 on output (out of range)	Not allowed DUT1 value	PO_CFI_PPFORB_OUTPUT_DUT1_WARN	101

7.2.7 Runtime performances

The following runtime performances have been measured.

mode	Ultra Sparc [ms]
-2	7.282
-1	7.288
0	7.263
1	2.757
2	2.114
98	5.113
99	5.391
100	5.204
101	0.579
102	0.444
1000	4.849
1002	1.604
10000	4.906
10002	2.087

7.3 po_interpol

7.3.1 Overview

The **po_interpol** function is used by the Envisat-1 ground segment off-line processing chains to compute an Envisat-1 Cartesian state vector and its associated parameters (e.g. geolocation parameters) at a requested time, using either (selectable by the user):

- Doris Precise Orbit product file(s)
- Doris Preliminary Orbit product file(s)
- FOS Restituted Orbit file(s)
- Doris Navigator File

The format of these files is described in RD 5. A different file format for the Restituted Orbit file, described in RD 6, is also supported.

For each of the first 3 types of Orbit file above, one or more files can be used by **po_interpol** to cope with processing of products which span a time interval covered by more than a single Orbit file. Only one Doris Navigator can be processed.

The four sources of data above are listed by decreasing order of orbital precision achieved. In normal processing, the **po_interpol** software will use the most precise source available at the time of processing. Optionally, usage of a specific type of file can be enforced.

In order to avoid reading the source file(s) at each call, **po_interpol** has 2 modes of operation:

- INITIALISATION, which reads the appropriate file(s) and sets up internal data; it is performed only once. The output state vector and associated results corresponds to the instant of time just after (or equal) to the initialization start UTC time contained in the input file (time, position and velocity are extracted from this input data file).
- INTERPOLATION, which ignores the source file(s) and uses the internal data to produce the requested Cartesian state vector; it´s to be performed as often as needed for a given processing session. The output state vector is located exactly at the requested UTC time (time, position and velocity are interpolated).

It is the responsibility of the software calling **po_interpol** to prepare the input files, i.e. to ensure that files relevant for the processing being performed are available. See RD 5 for a description of the files.

CAUTION: Note that to guarantee correct interpolation, the file(s) made available must cover the time span of the product being processed, PLUS 4 minutes before and 4 minutes after. This will avoid degradation of the interpolation at the edges of the product time interval.

Extrapolation is allowed when using Doris Navigator files, but the start (stop) times should not be earlier (later) than 60 seconds before the first (after the last) osv in the Navigator Product. In this case, the extrapolation window is NOT included in the valid time interval.

Figure 1 provides a graphical explanation.

In order to guarantee continuous and correct interpolation over the whole processing session, the initialisation call must useas inputs the intended start UTC time and end UTC time of the Envisat-1 product to be processed off-line. This allows **po_interpol** to select not only the most precise source available, but also the source file(s) which spans the needed time interval.

The time interval defined by this start and end UTC times is limited to one day. The maximum number of lines read from the input file(s) within this period is also limited to 2000.

Note that if the time interval does not contain any ANX **po_interpol** calculates next ANX time (res[53]) and the nodal period (res[52]) of the orbit propagating with **po_ppforb** low-level functions and returns a warning. In order to guarantee correct interpolation for above parameters, a time interval longer than one orbit must be used if possible.

The process calling **po_interpol** is responsible for identifying the number and names of input file(s) required. This must be deducted from the time interval of the product to be processed off-line and from the available Orbit files.

The output format of the data generated by **po_interpol** at the required time is identical to the output format of the **po_ppforb** software.

A proper sequence of **po_interpol** calls consist of:

- initialization call (mode PO_INIT_FILE)
- subsequent interpolation calls (mode PO_INTERPOLATE)

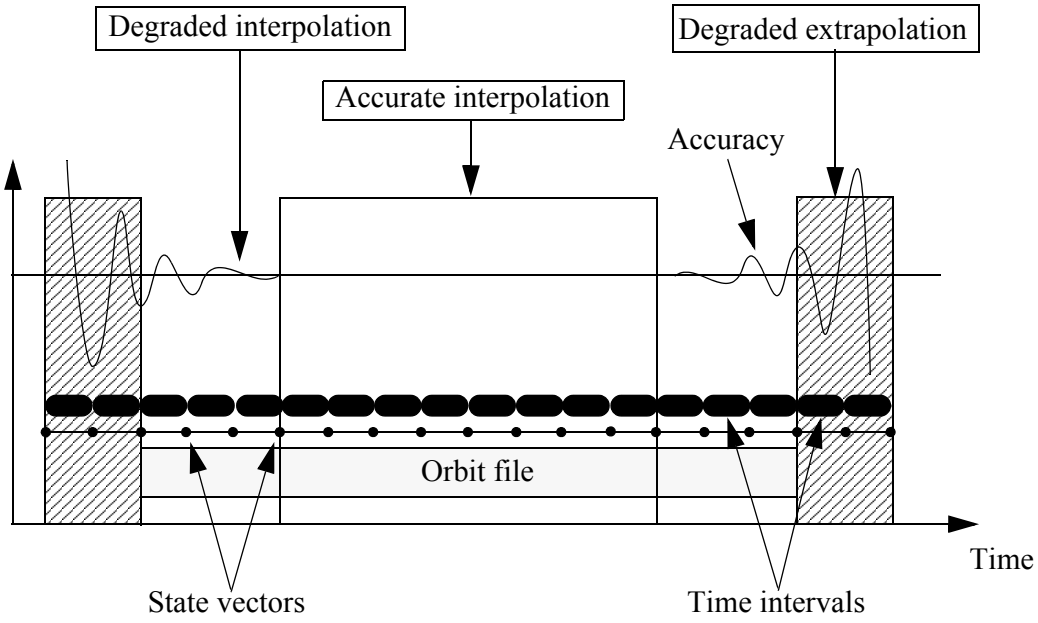


Figure 1: Performances of the interpolation algorithm

7.3.2 Calling interface

The calling interface of the **po_interpol** CFI function is the following (input parameters are underlined[1]):

```
#include <ppf_orbit.h>
{
      long mode, choice, ndc, ndp, ner, selected, ierr[10], status;
      double mjdr0, mjdr1, mjdp[2], x[6], pos[3], vel[3],acc[3],
             res[54];
      char **doris_precise_file, **doris_prelim_file;
      char **esoc_rest_file;

      status = po_interpol(&mode,&choice,
                           &ndc, doris_precise_file,
                           &ndp, doris_prelim_file,
                           &ner, esoc_rest_file,
                           &mjdr0, &mjdr1,
                           mjdp, x, pos, vel, acc,
                           &selected, res, ierr);
}
```

For Fortran programs the declaration and calling procedure is as follows (input parameters are underlined, note that the C preprocessor must be used because of the presence of the #include statement):

```
#include <ppf_orbit.inc>

       INTEGER*4 MODE, CHOICE, NDC, NDP, NER, SELECTED,
     &           IERR(10), STATUS
       REAL*8 MJDR0, MJDR1, MJDP(2), X(6), POS(3), VEL(3), ACC(3),
     &RES(54)
       CHARACTER*LENGTH_NAME DORIS_PRECISE_FILE(NUM_FILES)
       CHARACTER*LENGTH_NAME DORIS_PRELIM_FILE(NUM_FILES)
       CHARACTER*LENGTH_NAME ESOC_REST_FILE(NUM_FILES)

       STATUS = PO_INTERPOL(MODE, CHOICE,
     &                      NDC, DORIS_PRECISE_FILE,
     &                      NDP, DORIS_PRELIM_FILE,
     &                      NER, ESOC_REST_FILE,
     &                      MJDR0, MJDR1,
```

1. Number of files, filenames and choice are not used in Interpolation mode (mode 2 or 102)

```
     &                          MJDP, X, POS, VEL, ACC,
     &                          SELECTED, RES, IERR)
```

Note that NUM_FILES must be set to the number of input files of that type, i.e. NDC, NDP or NER, with a maximum value of 16, whereas LENGTH_NAME must be set to the maximum string length of the filenames of that type (maximum possible value of 200). All strings in FORTRAN must end in "\0" (for compatibility with C programs).

7.3.3 Input parameters

The **po_interpol** CFI function has the following input parameters in initialisation mode:

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
mode	long *		Initialization mode		0
choice	long *		Switch to select the file 0 = automatic selection 1 = Doris Precise Orbit 2 = Doris Preliminary Orbit 3 = FOS Restituted Orbit 4 = Doris Navigator		0, 1, 2, 3, 4
ndc	long *		Number of Doris Precise Orbit files on input		>= 0 <= 16[a]
doris_precise_file	char **	all	Filenames of the Doris Precise Orbit files Files must be time-ordered Or Filename of Doris Navigator File	-	-
ndp	long *		Number of Doris Preliminary Orbit files on input		>= 0 <= 16[a]
doris_prelim_file	char **	all	Filenames of the Doris Preliminary Orbit files Files must be time-ordered	-	-
ner	long *		Number of FOS Restituted Orbit files on input	-	>= 0 <= 16[a]
esoc_rest_file	char **	all	Filenames of the FOS Restituted Orbit files Files must be time-ordered	-	-
mjdr0	double *		UTC associated with the start time of the Envisat-1 product to be processed	decimal days (MJD2000)	>= -18262.0 < +36525.0
mjdr1	double *		UTC associated with the end time of the Envisat-1 product to be processed	decimal days (MJD2000)	>= -18262.0 < +36525.0

a. This max number of orbit files must be according to the dimension of the array in the main program.

The **po_interpol** CFI function has the following input parameters in interpolation mode:

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
mode	long *	-	Interpolation mode: 2 = the results vector is calculated 102 = the results vector is NOT calculated	-	2, 102
mjdr0	double *	-	Requested UTC time	decimal days (MJD2000)	>= -18262 < +36525
mjdr1	double *	-	DUMMY	-	-

It is also possible to use enumeration values rather than integer values for all input flags:

Input	Description	Enumeration value	long
mode	Execution mode	PO_INIT_FILE	0
		PO_INTERPOLATE	2
		PO_INTERPOLATE + PO_NO_RESULTS	102
	Optional value to be added to the mode value, in order to avoid producing the optional results vector (and therefore improve performance of the function) See above mode values for usage.	PO_NO_RESULTS	100
choice	Switch to select the source file (only used in initialisation)	PO_AUTO_SELECT	0
		PO_ONLY_DORIS_PRECISE	1
		PO_ONLY_DORIS_PRELIMINARY	2
		PO_ONLY_ESOC_RESTITUTED	3
		PO_ONLY_DORIS_NAVIGATOR	4

In addition, when results are required, it is possible to select individually the calculation of different sets of output parameters, or to make any combination of them by adding the results mode value to the mode value. The different values of the results mode are shown below:

Description	Enumeration value	long
Set of basic results without derivatives	PO_INTERPOL_RES_BAS	1000

Description	Enumeration value	long
Set of basic results with first derivatives	PO_INTERPOL_RES_BAS_D	2000
Set of basic results with second derivatives	PO_INTERPOL_RES_BAS_2D	4000
Set of auxiliary results without derivatives	PO_INTERPOL_RES_AUX	10000
Set of auxiliar results with first derivatives	PO_INTERPOL_RES_AUX_D	20000
Set of auxiliary results with second derivatives	PO_INTERPOL_RES_AUX_2D	40000

The elements calculated in each case are shown in 7.2.5.

Some examples of the feasible combinations are shown below:

```
mode = PO_INIT_FILE + PO_INTERPOL_RES_BAS + PO_INTERPOL_RES_BAS_D
     = 0 + 1000 + 2000 = 3000
mode = PO_INTERPOLATE + PO_INTERPOL_RES_BAS + PO_INTERPOL_RES_AUX
     = 2 + 1000 + 10000 = 11002
mode = PO_INTERPOLATE + PO_INTERPOL_RES_BAS +
       PO_INTERPOL_RES_BAS_D + PO_INTERPOL_RES_AUX +
       PO_INTERPOL_RES_AUX_D + PO_INTERPOL_RES_AUX_2D
     = 2 + 1000 + 2000 + 10000 + 20000 + 40000 = 73002
```

In order to calculate some elements it might be neccesary to calculate elements which have not been explicitly requested (e.g. if the derivative of a parameter es requested, the parameter itself will also be calculated). The function identifies internally all the dependencies and those elements are also returned in the result vector.

7.3.4 Output parameters

The output parameters of the **po_interpol** CFI function in initialisation mode are:

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
po_interpol	long	-	Main status flag	-	-1, 0, +1
selected	long *	-	Selected file: -1 = none 1 = Doris Precise Orbit 2 = Doris Preliminary Orbit 3 = FOS Restituted Orbit 4 = Doris Navigator	-	-1, 1, 2, 3, 4
mjdp[2]	double	[0]	UTC of the state vector. This time is extracted from the input data file and it is just after (or equal) the requested start time (mjdr0)	decimal days (Processing format)	>= -18262 < +36525
		[1]	ΔUT1of the state vector (it is extracted from the input data file) set to 0 for Doris Navigator	s (Processing format)	>= -1.0 <= +1.0
x[6]	double	all	Osculating Kepler elements of the state vector (True of Date CS)	-	-
		[0]	Semi-major axis	m	> 0.0
		[1]	Eccentricity	-	>= 0 < 1
		[2]	Inclination	deg	>= 0 <= 180
		[3]	Right ascension of the ascend-ing node	deg	>= 0 < 360
		[4]	Argument of perigee	deg	>= 0 < 360
		[5]	Mean anomaly	deg	>= 0 < 360
pos[3]	double	all	Osculating position vector of the state vector (Earth fixed CS) This position vector is extracted from the input data file and it cor-responds to the output UTC time (mjdp[0])	m	-

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
vel[3]	double	all	Osculating velocity vector of the state vector (Earth fixed CS) This velocity vector is extracted from the input data file and it corresponds to the output UTC time (mjdp[0])	m/s	-
acc[3]	double	all	Osculating acceleration vector of the state vector (Earth fixed CS)	m/s^2	-
res[54]	double	all	Optional results vector associated with the state vector	-	-
ierr[10]	long	all	Status vector	-	-

The output parameters of the **po_interpol** CFI function in interpolation mode are:

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
po_interpol	long	-	Main status flag	-	-1, 0, +1
selected	long *	-	Selected file (from initialization mode): -1 = none 1 = Doris Precise Orbit 2 = Doris Preliminary Orbit 3 = FOS Restituted Orbit 4 = Doris Navigator	-	-1, 1, 2, 3, 4
mjdp[2]	double	[0]	UTC of the state vector (it is mjdr0)	decimal days (Processing format)	>= -18262 < +36525
		[1]	ΔUT1of the state vector (it is constant and equals to ΔUT1 from intialization)	s (Processing format)	>= -1.0 <= +1.0
x[6]	double	all	Osculating Kepler elements of the state vector (True of Date CS)	-	-
		[0]	Semi-major axis	m	> 0.0
		[1]	Eccentricity	-	>= 0 < 1
		[2]	Inclination	deg	>= 0 <= 180
		[3]	Right ascension of the ascend-ing node	deg	>= 0 < 360
		[4]	Argument of perigee	deg	>= 0 < 360
		[5]	Mean anomaly	deg	>= 0 < 360
pos[3]	double	all	Osculating position vector of the state vector (Earth fixed CS)	m	-
vel[3]	double	all	Osculating velocity vector of the state vector (Earth fixed CS)	m/s	-
acc[3]	double	all	Osculating acceleration vector of the state vector (Earth fixed CS)	m/s^2	-
res[54]	double	all	Optional results vector associ-ated with the state vector	-	-
ierr[10]	long	all	Status vector	-	-

It is also possible to use enumeration values rather than integer values for all output flags:

Input	Description	Enumeration value	long
selected	Selected file	PO_NONE	-1
		PO_DORIS_PRECISE	1
		PO_DORIS_PRELIMINARY	2
		PO_ESOC_RESTITUTED	3
		PO_DORIS_NAVIGATOR	4

7.3.5 Optional results vector

The results vector is exactly the same as the **po_ppforb** optional results vector (see 7.2.5).
The enumeration names are the same, changing PPFORB with INTERPOL (e.g. PO_INTERPOL_RES_ORBIT_RAD).

7.3.6 Warnings and errors

Next table lists the possible error messages that can be returned by the **po_interpol** CFI function after translating the returned status vector into the equivalent list of error messages by calling the function of the PPF_ORBIT software library **po_vector_msg** (see RD 3).

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 **po_interpol** CFI function by calling the function of the PPF_ORBIT software library **po_vector_code** (see RD 3).

Error type	Error message	Cause and impact	Error Code	Error No
ERR	Wrong choice on input (out of range)	Not allowed choice value. Calculation not performed.	PO_CFI_INTERPOL_BADCHOICE_ERR	160
ERR	Input file can not be opened	Input file can not be open. Calculation not performed.	PO_CFI_INTERPOL_OPENFILE_ERR	161
ERR	Requested data file not specified.	Requested data file not specified. Calculation not performed.	PO_CFI_INTERPOL_NOT_SPEC_DF_ERR	162
ERR	Can´t find state vectors in data file.	Can´t find state vectors in data file. Calculation not performed.	PO_CFI_INTERPOL_FIND_ERR	163
ERR	Error attempting to decode input data file	Input data file can not be decoded. Calculation not performed.	PO_CFI_INTERPOL_DECODE_ERR	165
ERR	Input data files do not cover user requested period	Data files do not cover the requested period.	PO_CFI_INTERPOL_PERIOD_ERR	166
ERR	Input time interval larger than one day.	Initialization time interval must be less than one day. Calculation not performed.	PO_CFI_INTERPOL_TIME_INTERVAL_ERR	167
ERR	End of Interpol data base reached.	The maximum size of the internal data base has been exceeded. The input file(s) have more than 2000 lines within the input time interval. Calculation not performed.	PO_CFI_INTERPOL_DBASE_FILLED_ERR	168
ERR	Wrong time on input (out of range)	Not allowed time value. (Time must lie between -18262 and +36525) Calculation not performed.	PO_CFI_INTERPOL_TIME_RANGE_ERR	224
ERR	Number of input files must be >=0	Not allowed number of input files. Calculation not performed.	PO_CFI_INTERPOL_NUMBER_IF_ERR	225
ERR	Wrong mode on input (out of range)	Not allowed mode value. Calculation not performed.	PO_CFI_INTERPOL_MODE_ERR	226

Error type	Error message	Cause and impact	Error Code	Error No
ERR	Initialization was not performed successfully	Initialization failed. Calculation not performed.	PO_CFI_INTERPOL_INIT_DATA_BASE_ERR	227
ERR	The requested date is outside the initialized time range.	Requested data is outside the initialized time range. Calculation not performed.	PO_CFI_INTERPOL_MJDR0_ERR	228
ERR	Envisat state vector does not satisfy loose tolerance requirements.	Envisat-1 state vector does not satisfy the loose tolerance requirements.	PO_CFI_INTERPOL_PL_TESTSTATE_PPF_ERR	229
ERR	No convergence to get ANX.	Iterative proccess does not reach the accuracy in the determination of ascending node crossing. Calculation not performed	PO_CFI_INTERPOL_NO_CONV_ERR	197
ERR	Wrong time on input (start time after end time)	Not allowed start time after end time. Calculation not performed	PO_CFI_INTERPOL_TIME_WINDOW_ERR	231
ERR	Input data files do not have the minimum number of state vectors to interpolate (10)	Input data files have less tha 10 lines. Calculation not performed	PO_CFI_INTERPOL_DBASEFEW_RECS__ERR	169
WARN	Envisat state vector does not satisfy tight tolerance requirements.	Envisat-1 state vector does not satisfy the tight tolerance requirements.	PO_CFI_INTERPOL PL_TESTSTATE_PPF_WARN	232
WARN	Wrong DUT1 on output (out of range)	Not allowed DUT1 value	PO_CFI_INTERPOL_OUTPUT_DUT1_WARN	238
WARN	No ANX found in the interval.	The user time interval does not contain any ascending node crossing.	PO_CFI_INTERPOL_NO_ANX_FOUND	202

Several error numbers have changed, while the error names have not. The proper way to identify error codes is then by using the error name.

Additionally, some new ones appear with respect to previous versions of the document.

Note that:

- if several input files of the same type are given, they must be time-ordered, no error or warning is returned if they are not.
- except for the identification of the file format (FOS or PDS), the type of file is not checked, make sure that you provide files of the appropriate type

7.3.7 Runtime performances

The following runtime performances have been measured.

mode	choice	Ultra Sparc [ms]
0	0	31.891
0	1	30.878
0	2	45.723
0	3	67.153
2	-	3.905
102	-	0.714
1000	0	28.096
1002	-	2.095

7.4 po_genops

7.4.1 Overview

The **po_genops** function is used by the Envisat-1 ground segment near real time processing chains to compute a Cartesian state vector at (or near) true ascending node, using either:

- the DORIS Navigator unconsolidated level-0 products (i.e. produced in near-real-time in the PDHS, according to the acquired downlink instrument data segment)
- the FOS Predicted ascending node cartesian state vectors.

It is the responsibility of the software calling **po_genops** to prepare the input files, i.e. to ensure that files relevant for the processing being performed are available.

The format of these files is described in RD 5. A different file format for the Predicted Orbit file, described in RD 6, is also supported.

The output format of the data generated by **po_genops** is compatible with the input of **po_ppforb**. It is either:

- a single Cartesian State Vector at ascending node (if valid DORIS Navigator data on input)
- a single Cartesian State Vector near (plus or minus 5 degrees in latitude) the ascending node, copied from the FOS Predicted Orbit File (if no valid DORIS Navigator data on input)

po_genops allows to specify a subset of the DORIS file (e.g. in order to avoid a satellite manoeuvre).

The **po_genops** function processes and filters the DORIS navigator level 0 data to verify its usability to create a DORIS generated Cartesian State Vector at true ascending node. Otherwise, in case the unconsolidated level-0 DORIS data are too degraded by noise or in case the difference between the FOS predicted Cartesian State Vector and the DORIS generated Cartesian State Vector is too large, the **po_genops** function selects the FOS predicted Cartesian State Vector which is near true ascending node.

The internal noise is estimated by calculating the root-mean-square (RMS) of the difference between the DORIS generated cartesian state vector with the original DORIS Navigator data.

The cartesian state vector output by **po_genops** must be fed to the orbit propagator **po_ppforb** in order to initialize the propagation (using PO_INIT mode of **po_ppforb**). So, a proper sequence of **po_genops** in conjunction with **po_ppforb** call consists of:

- call to **po_genops**
- call to **po_ppforb** initialization, longitude dependent mode (**po_ppforb** mode PO_INIT)
- successive calls to **po_ppforb** for state vector propagation using absolute times (**po_ppforb** mode PO_PROPAG)

7.4.2 Calling interface

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

```
#include <ppf_orbit.h>
{
       long mode, choice, selected, ierr[10], status;
       double mjd0, mjd1, mjdp[2], pos[3], vel[3], res[32];
       char *doris_nav_file, *esoc_pred_file;

       status = po_genops(&mode, &choice,
                          esoc_pred_file, doris_nav_file,
                          &mjd0, &mjd1,
                          mjdp, pos, vel,
                          &selected, res, ierr);
}
```

For Fortran programs the declaration and calling procedure is as follows (input parameters are underlined, note that the C preprocessor must be used because of the presence of the #include statement):

```
#include <ppf_orbit.inc>

       INTEGER*4 MODE, CHOICE, SELECTED, IERR(10), STATUS
       REAL*8 MJD0, MJD1, MJDP(2), POS(3), VEL(3), RES(32)
       CHARACTER*LENGTH_NAME DORIS_NAV_FILE, ESOC_PRED_FILE

       STATUS = PO_GENOPS(MODE, CHOICE,
      &                   ESOC_PRED_FILE, DORIS_NAV_FILE,
      &                   MJD0, MJD1,
      &                   MJDP, POS, VEL,
      &                   SELECTED, RES, IERR)
```

Note that `LENGTH_NAME` must be set to the string length of the filename of each type. All strings in FORTRAN must end in "\0" (for compatibility with C programs).

7.4.3 Input parameters

The **po_genops** CFI function has the following input parameters:

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
mode	long *	-	Operation mode 0 = use all records in the Doris Navigator unconsolidated level-0 product 1 = use records in the Doris Navigator unconsolidated level-0 product between mjdr0 and mjdr1	-	0, 1
choice	long *	-	Switch to select the file 0 = automatic selection 1 = Doris Navigator 2 = FOS Predicted Orbit	-	0, 1, 2
esoc_pred_file	char *	all	Filename of the FOS Predicted Orbit file	-	-
doris_nav_file	char *	all	Filename of the Doris Navigator unconsolidated level-0 product file	-	-
mjdr0	double *	-	In mode = 0 UTC associated with the start time of the Envisat-1 product to be processed In mode = 1 UTC of the start time of the sub set of records of the Doris file to be used	decimal days (MJD2000)	>= -18262.0 < +36525.0
mjdr1	double *		In mode = 0 UTC associated with the end time of the Envisat-1 product to be processed In mode = 1 UTC of the end time of the sub set of records of the Doris file to be used	decimal days (MJD2000)	>= -18262.0 < +36525.0

It is also possible to use enumeration values rather than integer values for all input flags:

Input	Description	Enumeration value	long
mode	Operation mode	PO_ALL_REC	0
		PO_USER_REC	1
choice	Switch to select the source file (only used in initialisation)	PO_AUTO_FILE	0
		PO_ONLY_DORIS_FILE	1
		PO_ONLY_ESOC_FILE	2

7.4.4 Output parameters

The output parameters of the **po_genops** CFI function are:

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
po_genops	long	-	Main status flag	-	-1, 0, +1
selected	long *	-	Selected file: -1 = none 1 = Doris Navigator 2 = FOS Predicted Orbit	-	-1, 1, 2
mjdp[2]	double	[0]	UTC of the state vector (UT1 time)	decimal days (Processing format)	>= -18262 < +36525
		[1]	ΔUT1of the state vector (UT1 time)	s (Processing format)	>= -1.0 <= +1.0
pos[3]	double	all	Osculating position vector of the state vector (Earth fixed CS)	m	-
vel[3]	double	all	Osculating velocity vector of the state vector (Earth fixed CS)	m/s	-
res[32]	double	all	RESERVED	-	-
ierr[10]	long	all	Status vector	-	-

7.4.5 Warnings and errors

Next table lists the possible error messages that can be returned by the **po_genops** CFI function after translating the returned status vector into the equivalent list of error messages by calling the function of the PPF_ORBIT software library **po_vector_msg** (see RD 3).

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 **po_genops** CFI function by calling the function of the PPF_ORBIT software library **po_vector_code** (see RD 3).

Error type	Error message	Cause and impact	Error Code	Error No
WARN	Too much noise in DORIS data	DORIS data are too noisy, and cannot be used. FOS state vector returned	PO_CFI_GENOPS_RMS_SOL_ERR	133
WARN	Too much data filtered	DORIS filtering not finished. FOS state vector returned	PO_CFI_GENOPS_DATA_FILT_ERR	134
WARN	Some data rejected because they are too far from ANX	DORIS data more than two orbits away from selected state vector Some data rejected.	PO_CFI_GENOPS_FAR_FROM_ANX_WARN	135
ERR	Wrong mode on input (out of range)	Not allowed mode value. Calculation not performed.	PO_CFI_GENOPS_HL_MODE_INCORR_ERR	160
ERR	Returned DORIS state vector is not correct.	DORIS result is not correct (only if choice = PO_ONLY_DORIS_FILE)	PO_CFI_GENOPS_HL_DORIS_INCORR_ERR	161
ERR	There is no valid FOS data	No FOS data available. Calculation not performed.	PO_CFI_GENOPS_HL_NO_ESOC_DATA_ERR	162
ERR	ANX state vector does not satisfy loose Envisat tolerance requirements	Output Envisat-1 state vector does not satisfy the loose tolerance requirements.	PO_CFI_GENOPS_HL_TEST_STATE_ERR	163
WARN	ANX state vector does not satisfy tight Envisat tolerance requirements	Output Envisat-1 state vector does not satisfy the tight tolerance requirements.	PO_CFI_GENOPS_HL_TEST_STATE_WARN	172
ERR	Wrong choice on input (out of range)	Not allowed choice value. Calculation not performed.	PO_CFI_GENOPS_HL_CHOICE_INCORR_ERR	164
ERR	Wrong time on input (out of range)	Not allowed input time value. Calculation not performed.	PO_CFI_GENOPS_HL_TIME_INPUT_INCORR_ERR	165
ERR	Input files cannot be opened	No input files. Calculation not performed.	PO_CFI_GENOPS_HL_INPUT_FILES_ERR	166

Error type	Error message	Cause and impact	Error Code	Error No
WARN	Error while reading DORIS binary file	DORIS file incorrect or impossibility to manage DORIS data. FOS state vector returned. Note: this event is in fact a warning and so the status returned by po_genops is +1 and a valid output is produced (the FOS state vector). However, the message and error code suggest that it is an error.	PO_CFI_GENOPS_HL_BIN_FILE_ERR	168
ERR	There is no data available.	Bad DORIS and FOS data. Calculation not performed.	PO_CFI_GENOPS_HL_DATA_INCORR_ERR	169
WARN	Wrong mode on input (out of range). Trying to use FOS data.	Not allowed mode value. A result still can be returned if choice is not PO_ONLY_DORIS_FILE	PO_GENOPS_MODE_CHOICE_WARN	173
WARN	There is no DORIS data available	No DORIS file. A result still can be returned if choice is not PO_ONLY_DORIS_FILE	PO_GENOPS_NO_DORIS_WARN	174
WARN	Difference between FOS and DORIS state vector is too large.	DORIS data cannot be trusted. FOS state vector returned	PO_GENOPS_BEST_ESOC_WARN	175
WARN	Wrong DUT1 on output (out of range)	Not allowed DUT1 value	PO_CFI_GENOPS_OUTPUT_DUT1_WARN	177

7.4.6 Runtime performances

The following runtime performances have been measured:

mode	Ultra Sparc [msec]
0	10488.708 (one orbit data)

The above times depend strongly on the number of iterations performed and the amount of data taken into account. When no calculations on DORIS data is made (e.g, choice =PO_ONLY_ESOC_FILE), the runtime is:

choice	Ultra Sparc [ms]
2	19.922

7.5 po_genstate_ext_cycle

7.5.1 Overview

This software is an orbit state vector generator which is to be used in conjunction with the **po_ppforb** orbit propagator function, in order to generate state vectors to perform orbit simulations. This function has been implemented in order to plan the Envisat mission for its extended life and it is a generalization of the previous function **po_genstate** (see section 7.1)

The cartesian state vector is generated around the true ascending node crossings in function of:

- the date (processing time),
- the longitude of the ascending node,
- the satellite Repeat Cycle and Cycle Length, and
- the mean local solar time at ascending node
- the mean local solar time drifting parameters. These parameters are used to compute the terms of the formula that models the MLST evolution:

$$\begin{aligned} MLST_{ANX} = {} & MLST_{ref} + L(t - t_{ref}) + Q(t - t_{ref})^2 + \ldots \\ & SH_1 \sin\left(\frac{2\pi}{T_1}(t - t_{ref}^{harm1})\right) + CH_1 \cos\left(\frac{2\pi}{T_1}(t - t_{ref}^{harm1})\right) + \ldots \\ & SH_2 \sin\left(\frac{4\pi}{T_2}(t - t_{ref}^{harm2})\right) + CH_2 \cos\left(\frac{4\pi}{T_2}(t - t_{ref}^{harm2})\right) \end{aligned}$$

In order to simplify the planning of the mission, the function assumes a constant MLST drift along one cycle. This MLST drift is computed with the input drifting parameters for the orbit at the middle of the cycle to which the requested orbit belongs.

This state vector is fed to the propagator in order to initialize the propagation (i.e. use **po_ppforb** with mode PO_INIT_GENSTATE).

7.5.2 Calling interface

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

```
#include <ppf_orbit.h>
{
      long irep, icyc, iorb0, irel0, iorb, ierr[4], status;
      double mlst_linear, mlst_quadratic;
      double mlst_harm1[4], mlst_harm2[4];
      double mjdr[2], rlong, ascmlst, mjdp[2], pos[3], vel[3];

      status = po_genstate_ext_cycle(mjdr, &irep, &icyc,
                                     &rlong, &ascmlst,
                                     &mlst_linear, &mlst_quadratic,
                                     mlst_harm1, mlst_harm2,
                                     &iorb0, &irel0, &iorb,
                                     mjdp, pos, vel, ierr);
}
```

For Fortran programs the declaration and calling procedure is as follows (input parameters are underlined, note that the C preprocessor must be used because of the presence of the #include statement):

```
#include <ppf_orbit.inc>

      INTEGER*4 IREP, ICYC, IORB0, IREL0, IORB, IERR(4), STATUS
      REAL*8 MLST_LINEAR, MLST_QUADRATIC
      REAL*8 MLST_HARM1(4), MLST_HARM2(4)
      REAL*8 MJDR(2), RLONG, ASCMLST, MJDP(2), POS(3), VEL(3)

      STATUS = PO_GENSTATE_EXT_CYCLE(MJDR, IREP, ICYC,
      &                              RLONG, ASCMLST,
      &                              MLST_LINEAR, MLST_QUADRATIC,
      &                              MLST_HARM1, MLST_HARM2,
      &                              IORB0, IREL0, IORB,
      &                              MJDP, POS, VEL, IERR)
```

7.5.3 Input parameters

The **po_genstate_ext_cycle** CFI function has the following input parameters:

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
mjdr[2]	double	[0]	UTC of the reference orbit (UT1 time) Note: only the integer part of the date is required	decimal days (Processing format)	>= -18262 < +36525
		[1]	ΔUT1 of the reference orbit (UT1 time)	s (Processing format)	>= -1.0 <= +1.0
irep	long *	-	Repeat cycle of the reference orbit	days	> 0
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	decimal hours	>= 0 < 24
mlst_linear	double *	-	Mean local solar time 1st derivative (linear term)	sec / year	
mlst_quadratic	double *	-	Mean local solar time 2nd derivative (quadratic term)	sec / year^2	
mlst_harm1	double [4]	0	Reference date of the first harmonic	decimal days (Processing format)	
		1	Period	days	(0.0, 365.25]
		2	Amplitude of the sine coeficcient	sec	
		3	Amplitude of the cosine coeficcient	sec	
mlst_harm2	double [4]	0	Reference date of the second harmonic	decimal days (Processing format)	
		1	Period	days	(0.0, 365.25]
		2	Amplitude of the sine coeficcient	sec	
		3	Amplitude of the cosine coeficcient	sec	
iorb0	long *	-	Absolute orbit number of the reference orbit	orbits	-
irel0	long *	-	Relative orbit number of the reference orbit	orbits	-

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
iorb	long *	-	Absolute orbit number of the requested orbit	orbits	-

7.5.4 Output parameters

The output parameters of the **po_genstate_ext_cycle** CFI function are:

C name	C type	Array Element	Description (Reference)	Unit (Format)	Allowed Range
po_genstate_ext_cycle	long	-	Main status flag	-	-1, 0, +1
mjdp[2]	double	[0]	UTC of the calculated osculating state vector (UT1 time)	decimal days (Processing format)	>= -18262 < +36525
		[1]	ΔUT1 of the calculated osculating state vector (UT1 time)	s (Processing format)	>= -1.0 <= +1.0
pos[3]	double	all	Calculated osculating position vector (X, Y, Z) (Earth fixed CS)	m	-
vel[3]	double	all	Calculated osculating velocity vector (X, Y, Z) (Earth fixed CS)	m/s	-
ierr[4]	long	all	Status vector	-	-

7.5.5 Warnings and errors

Next table lists the possible error messages that can be returned by the **po_genstate_ext_cycle** CFI function after translating the returned status vector into the equivalent list of error messages by calling the function of the PPF_ORBIT software library **po_vector_msg** (see RD 3).

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 **po_genstate_ext_cycle** CFI function by calling the function of the PPF_ORBIT software library **po_vector_code** (see RD 3).

Error type	Error message	Cause and impact	Error code	Error No
WARN	Internal computation warning #1	Calculation performed.	PO_CFI_GENSTATE_EXT_CANT_CONVERGE_1_WARN	0
WARN	Internal computation warning #2	Calculation performed.	PO_CFI_GENSTATE_EXT_CANT_CONVERGE_2_WARN	1
WARN	Internal computation warning # 3	Calculation performed.	PO_CFI_GENSTATE_EXT_CANT_CONVERGE_3_WARN	2
WARN	Internal computation warning # 4	Calculation performed	PO_CFI_GENSTATE_EXT_SINGULAR_MATRIX_WARN	3
WARN	Internal computation warning # 5	Calculation performed	PO_CFI_GENSTATE_EXT_COMPUTATION_WARN	4
ERR	Internal computation error # 1	Calculation performed	PO_CFI_GENSTATE_EXT_COMPUTATION_ERR	5
ERR	ANX state vector does not satisfy loose Envisat tolerance requirements	Output Envisat-1 state vector does not satisfy the loose tolerance requirements. Calculation not performed	PO_CFI_GENSTATE_EXT_FAILED_TESTSTATE_ERR	6
WARN	ANX state vector does not satisfy tight Envisat tolerance requirements	Output Envisat-1 state vector does not satisfy the tight tolerance requirements. Calculation performed	PO_CFI_GENSTATE_EXT_FAILED_TESTSTATE_WARN	7
ERR	Repeat Cycle and Cycle Length have common denominator	Calculation not performed	PO_CFI_GENSTATE_EXT_REPEAT_CYCLE_LENGTH_ERR	8
ERR	Wrong UTC on input (out of range	Calculation not performed	PO_CFI_GENSTATE_EXT_INVALID_MDJR_0_ERR	9
ERR	Wrong DUT1 on input (out of range	Calculation not performed	PO_CFI_GENSTATE_EXT_INVALID_MDJR_1_ERR	10
ERR	Wrong Repeat Cycle on input (out of range)	Calculation not performed	PO_CFI_GENSTATE_EXT_INVALID_IREP_ERR	11
ERR	Wrong Cycle Length on input (out of range)	Calculation not performed	PO_CFI_GENSTATE_EXT_INVALID_ICYC_ERR	12

Error type	Error message	Cause and impact	Error code	Error No
ERR	Wrong MLST on input (out of range)	Calculation not performed	PO_CFI_GENSTATE_EXT_INVALID_MLST_ERR	13
ERR	Wrong amplitude on input MLST harmonic terms (out of range)	Calculation not performed	PO_CFI_GENSTATE_EXT_INVALID_HARM_AMP_ERR	14
ERR	Wrong period on input MLST harmonic terms (cannot be zero)	Calculation not performed	PO_CFI_GENSTATE_EXT_INVALID_HARM_PERIOD_ERR	15

7.5.6 Runtime performances

The following runtime performance has been measured.

Ultra Sparc [ms]
TBD

8 LIBRARY PRECAUTIONS

The following precautions shall be taken into account when using PPF_ORBIT software library:

- When a message like

PPF_ORBIT >>> ERROR in *po_function*: Internal computation error # *n*
or
PPF_ORBIT >>> WARNING in *po_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.

- There is a limitation of 1500 in the number of DORIS state vectors that *po_genops* can handle.

If more DORIS state vectors than this value are intended to read, the program returns an error message.

9 KNOWN PROBLEMS

The following precautions shall be taken into account when using the CFI software libraries:

CFI library	Problem	Work around solution
po_interpol	If po_interpol initialization time window is within the first 60 minutes of the orbit file, result element number 52 (next ANX time) can be wrong.	Ensure that initialization time window ends after the first 60 minutes in the orbit file.