CRYOSAT-2: TRANSPONDER PASS TOOLS – FILE TRANSFER DOCUMENT

1. INTRODUCTION

This is the File Transfer Document for the executable routines that compute ground-track points for a given set of visibility time windows over a zone or transponder location as well as information associated to the point of closest approach within each pass over a transponder.

1.1 Change History

Issue	Change Description
1.2	First issue of public distribution
1.3	Executable routines compiled using EE CFI v3.7.3 WINDOWS executables added to the package
1.4	MPL_ORBREF file: Use orbit state vectors instead of orbit change parameters Use Cryosat-2 On Board attitude law instead of theoretical Local Normal + Yaw Steering in the satellite/ground minimum distance executables

1.2 Distribution List

Project/Unit	Name	Project/Unit	Name	Project/Unit	Name

2. ARCHIVE CONTENT

The following archive file has been delivered (generated with the zip utility):
EOCFI-FTD-004_1_4.zip

The archive has the following MD5 checksum:
c086aea00011ab83f34abeb5f9a65be4

The archive contains the following files:

```
Transponder_Pass_Routines_v1_4/INPUT/CS_OPER_MPL_ORBPRE_20100517T000000_20100617T000000_0001.EEF
Transponder_Pass_Routines_v1_4/INPUT/SDF_ORBIT.CS
Transponder_Pass_Routines_v1_4/INPUT/input_data_transponder.txt
Transponder_Pass_Routines_v1_4/INPUT/input_data_zone.txt
Transponder_Pass_Routines_v1_4/INPUT/zones.dbf
Transponder_Pass_Routines_v1_4/LINUX/transponder_min_ground_distance
Transponder_Pass_Routines_v1_4/LINUX/transponder_min_satellite_distance
Transponder_Pass_Routines_v1_4/LINUX/zone_intersection_lon_lat
Transponder_Pass_Routines_v1_4/MACINTEL/transponder_min_ground_distance
Transponder_Pass_Routines_v1_4/MACINTEL/transponder_min_satellite_distance
Transponder_Pass_Routines_v1_4/MACINTEL/zone_intersection_lon_lat
Transponder_Pass_Routines_v1_4/OUTPUT/output_data_LLF_CRYOSAT.txt
Transponder_Pass_Routines_v1_4/OUTPUT/output_data_TRANSPONDER_CRYOSAT_min_ground_distance.txt
Transponder_Pass_Routines_v1_4/OUTPUT/output_data_TRANSPONDER_CRYOSAT_min_satellite_distance.txt
Transponder_Pass_Routines_v1_4/README.txt
Transponder_Pass_Routines_v1_4/WINDOWS/transponder_min_ground_distance.exe
Transponder_Pass_Routines_v1_4/WINDOWS/transponder_min_satellite_distance.exe
Transponder_Pass_Routines_v1_4/WINDOWS/zone_intersection_lon_lat.exe
```

3. ARCHIVE CONTENT DESCRIPTION

File	Description
INPUT/ CS_OPER_MPL_ORBPRE_20100517T000000_20100617T000000_0001.EEF	Cryosat-2 Predicted Orbit File example (input)
INPUT/SDF_ORBIT.CS	Cryosat-2 Swath Definition File (input)
INPUT/input_data_transponder.txt	Input configuration file for the executables *transponder_min_ground_distance* *transponder_min_satellite_distance*
INPUT/input_data_zone.txt	Input configuration file for the executable *zone_intersection_lon_lat*
INPUT/zones.dbf	Zone Database File example (input)
LINUX/transponder_min_ground_distance	Executable tools for Linux
LINUX/transponder_min_satellite_distance	
LINUX/zone_intersection_lon_lat	
MACINTEL/transponder_min_ground_distance	Executable tools for Mac Intel
MACINTEL/transponder_min_satellite_distance	
MACINTEL/zone_intersection_lon_lat	
OUTPUT/output_data_LLF_CRYOSAT.txt	Output file generated by the executable *zone_intersection_lon_lat*
OUTPUT/output_data_TRANSPONDER_CRYOSAT_min_ground_distance.txt	Output file generated by the executable *transponder_min_ground_distance*
OUTPUT/output_data_TRANSPONDER_CRYOSAT_min_satellite_distance.txt	Output file generated by the executable *transponder_min_satellite_distance*
README.txt	Quick reference
WINDOWS/transponder_min_ground_distance.exe	Executable tools for Windows
WINDOWS/transponder_min_satellite_distance.exe	
WINDOWS/zone_intersection_lon_lat.exe	

4. INSTALLATION

The archive can be expanded with the command unzip (in Linux/Mac Intel) or with Winzip / 7-zip (in MS Windows).

5. USAGE

5.1 Executable program *zone_intersection_lon_lat*

For a requested UTC time interval, the executable program *zone_intersection_lon_lat* computes the ground-track longitude and latitude pairs (with a given time step) corresponding to the passes obtained over a zone or transponder location.

5.1.1 Input configuration file description *input_data_zone.txt*

The executable program *zone_intersection_lon_lat* expects as input a configuration file named *input_data_zone.txt*. Note that the configuration file has to be placed in the same folder where the executable routine is located.
The configuration file *input_data_zone.txt* contains the following input parameters (provided in the order in which they have to be supplied):

INPUT PARAMETERS	Definition	Value
Satellite ID	Satellite identifier	CRYOSAT
Predicted or Restituted Orbit Filename	Filename (it may include the path to the file) of the Predicted or Restituted Orbit File	Given by the user
Time Interval Type Flag	Flag to indicate the type of time interval to use for the calculation	0=orbit range 1=UTC time range
Start Orbit or UTC Start Time	Start orbit or UTC start time (in format YYYY-MM-DD_HH:mm:ss.ssssss) of the time interval	Given by the user
Stop Orbit or UTC Stop Time	Stop orbit or UTC stop time (in format YYYY-MM-DD_HH:mm:ss.ssssss) of the time interval	Given by the user
Time Step [s]	Time step (in seconds) for the computation of intermediate points	Given by the user
Swath Definition Filename	Filename (it may include the path to the file) of the swath definition file.	SDF_ORBIT.CS
Zone Database Filename	Filename (it may include the path to the file) of the zone database file.	zones.dbf Two example zones are included.
Zone ID	Zone identifier	Given by the user. It has to match the value of one of the <Zone_Id> tags in Zone Database File.

5.1.2 Output file description *output_data_LLF_CRYOSAT.txt*

The executable program *zone_intersection_lon_lat* generates as output a file *output_data_LLF_CRYOSAT.txt*.
The output file includes comments (starting with the symbol #) describing its contents. Note that it is created in the same folder where the executable routine is located.

5.1.3 Example

5.1.3.1 Input configuration file

The input configuration file and the executable tool have to be contained in the same directory.

An example of input configuration file *input_data_zone.txt*, with UTC start/stop times given as time interval is provided below:

```
CRYOSAT
./AUX_FILES/CS_OPER_MPL_ORBPRE_20100517T000000_20100617T000000_0001.EEF
1
2010-05-21_00:00:00.000000
2010-05-26_00:00:00.000000
```

```
1.0
./AUX_FILES/SDF_ORBIT.CS
./AUX_FILES/zones.dbf
cryosat_transponder
```

An example of input configuration file *input_data_zone.txt*, with orbit start/stop given as time interval is provided below:

```
CRYOSAT
./AUX_FILES/CS_OPER_MPL_ORBPRE_20100517T000000_20100617T000000_0001.EEF
0
616
689
1.0
./AUX_FILES/SDF_ORBIT.CS
./AUX_FILES/zones.dbf
cryosat_transponder
```

In both examples, the Predicted Orbit file, the Swath Definition File and the Zone Database file are contained in a directory AUX_FILES/

5.1.3.2 Running the executable

The executable program can be called in the following way:

- From Linux/Mac shell

```
./zone_intersection_lon_lat
```

- From Windows command prompt window

```
zone_intersection_lon_lat.exe
```

The executable program shows the following messages:

```
Input data set by the user:
Satellite: CRYOSAT
Orbit Fie: ./CS_OPER_MPL_ORBPRE_20100517T000000_20100617T000000_0001.EEF
Start Time: 2010-05-21_00:00:00.000000
Stop  Time: 2010-05-26_00:00:00.000000
Time  Step: 1.000000 <s>
SDF filename: SDF_ORBIT.CS
Zone filename: zones.dbf
Zone ID: cryosat_transponder
Output Filename: output_data_LLF_CRYOSAT.txt


TIME INITIALIZATION: POF



ORBIT INITIALIZATION: POF



CALCULATION OF ZONE INTERSECTION TIME SEGMENTS


Inputs:
   Start/Stop Absolute Orbit: 615 / 688
Outputs:
   Number of segments: 2
   Segments: Start (Orbit, seconds, microseconds) -- Stop (Orbit, seconds, microseconds)
             ( 654, 1676, 561347) -- ( 654, 1678, 205201)
             ( 675, 1292, 201369) -- ( 675, 1293, 950184)
```

```
CALCULATION OF INTERMEDIATE POINTS, VISIBILITY SEGMENT #0

Inputs:
   Requested Orbit, Second, Microsecond: 654 1676 561347
Outputs:
   Pt #0:   long = 15.342649, lat = 78.283221

Inputs:
   Requested Orbit, Second, Microsecond: 654 1677 561347
Outputs:
   Pt #0:   long = 15.287218, lat = 78.223715


CALCULATION OF INTERMEDIATE POINTS, VISIBILITY SEGMENT #1

Inputs:
   Requested Orbit, Second, Microsecond: 675 1292 201375
Outputs:
   Pt #0:   long = 15.486052, lat = 78.180188

Inputs:
   Requested Orbit, Second, Microsecond: 675 1293 201375
Outputs:
   Pt #0:   long = 15.431006, lat = 78.239673


Output file created successfully in output_data_LLF_CRYOSAT.txt
```

5.1.3.3 *Output file*

The output file *output_data_LLF_CRYOSAT.txt* is created:

```
    # Generated with executable tool zone_intersection_lon_lat v1.4
    # Data_Block
    # Instrument: ORBIT
    # Predicted orbit file: ./CS_OPER_MPL_ORBPRE_20100517T000000_20100617T000000_0001.EEF
    # 1 Number of visibility segments | Number of points per instantaneous swath
    2 1
    # 2 Index of visibility segment | Orbit number start | Seconds since ANX start | UTC time start |
{Longitude [deg] Latitude [deg],..} |  Orbit number stop | Seconds since ANX stop  | UTC time stop |
{Longitude [deg] Latitude [deg],...}
    0 654 +1676.561347 20100523_152406165470 +015.342649 +078.283221 654 +1678.205201
20100523_152407809324 +015.251820 +078.185396
    # 3 Time step [s] | Number of intermediate points in visibility segment
    +001.000000 3
    # 4 Index of intermediate point | Orbit number | Seconds since ANX | UTC time | {Longitude [deg]
Latitude [deg],..}
    0 654 +1676.561347 20100523_152406165470 +015.342649 +078.283221
    1 654 +1677.561347 20100523_152407165470 +015.287218 +078.223715
    2 654 +1678.205201 20100523_152407809324 +015.251820 +078.185396
    # 2 Index of visibility segment | Orbit number start | Seconds since ANX start | UTC time start |
{Longitude [deg] Latitude [deg],..} |  Orbit number stop | Seconds since ANX stop  | UTC time stop |
{Longitude [deg] Latitude [deg],...}
    1 675 +1292.201369 20100525_020122355763 +015.486053 +078.180187 675 +1293.950184
20100525_020124104577 +015.389426 +078.284210
    # 3 Time step [s] | Number of intermediate points in visibility segment
    +001.000000 3
    # 4 Index of intermediate point | Orbit number | Seconds since ANX | UTC time | {Longitude [deg]
Latitude [deg],..}
    0 675 +1292.201375 20100525_020122355763 +015.486052 +078.180188
    1 675 +1293.201375 20100525_020123355763 +015.431006 +078.239673
    2 675 +1293.950184 20100525_020124104577 +015.389426 +078.284210
    # End Data_Block
```

5.2 Executable program *transponder_min_satellite_distance*

For a requested UTC time interval, the executable program *transponder_min_satellite_distance* computes
- the time of closest approach from satellite to transponder (in orbit relative time and UTC)
- the minimum distance between the satellite and the transponder
- the incidence angle of the line of sight with the ellipsoid normal at the time of closest approach
- the longitude and latitude of the sub-satellite point at the time of closest approach

corresponding to the passes obtained over a transponder location.

5.2.1 Input configuration file description *input_data_transponder.txt*

The executable program *transponder_min_satellite_distance* expects as input a configuration file named *input_data_transponder.txt*. Note that the configuration file has to be placed in the same folder where the executable routine is located.
The configuration file *input_data_transponder.txt* contains the following input parameters (provided in the order in which they have to be supplied):

INPUT PARAMETERS	Definition	Value
Satellite ID	Satellite identifier	CRYOSAT
Predicted or Restituted Orbit Filename	Filename (it may include the path to the file) of the Predicted or Restituted Orbit File	Given by the user
Time Interval Type Flag	Flag to indicate the type of time interval to use for the calculation	0=orbit range 1=UTC time range
Start Orbit or UTC Start Time	Start orbit or UTC start time (in format YYYY-MM-DD_HH:mm:ss.ssssss) of the time interval	Given by the user
Stop Orbit or UTC Stop Time	Stop orbit or UTC stop time (in format YYYY-MM-DD_HH:mm:ss.ssssss) of the time interval	Given by the user
Time Step [s]	Time step (in seconds) used to compute the minimum distance	0.001
Swath Definition Filename	Filename (it may include the path to the file) of the swath definition file.	SDF_ORBIT.CS
Transponder Longitude [deg]	Transponder geocentric longitude (in degrees)	Given by the user For the Svalbard Transponder: +015.393777
Transponder Latitude [deg]	Transponder geodetic latitude (in degrees)	Given by the user For the Svalbard Transponder: +078.230514
Transponder Diameter [m]	Diameter of a circular zone with center the transponder location (in meters)	Given by the user 15000.0
Transponder Altitude [m]	Transponder geodetic altitude (in meters)	Given by the user For the Svalbard Transponder:

		487.96

5.2.2 Output file description *output_data_TRANSPONDER_CRYOSAT_min_satellite_distance.txt*

The executable program *transponder_min_satellite_distance* generates as output a file *output_data_TRANSPONDER_CRYOSAT_min_satellite_distance.txt*.
The output file includes comments (starting with the symbol #) describing its contents. Note that it is created in the same folder where the executable routine is located.

5.2.3 Example

5.2.3.1 Input configuration file

The input configuration file and the executable tool have to be contained in the same directory.

An example of input configuration file *input_data_transponder.txt*, with UTC start/stop times given as time interval is provided below:

```
CRYOSAT
./AUX_FILES/CS_OPER_MPL_ORBPRE_20100517T000000_20100617T000000_0001.EEF
1
2010-05-21_00:00:00.000000
2010-05-26_00:00:00.000000
0.001
./AUX_FILES/SDF_ORBIT.CS
+015.393777
+078.230514
15000.0
487.96
```

An example of input configuration file *input_data_transponder.txt*, with orbit start/stop given as time interval is provided below:

```
CRYOSAT
./AUX_FILES/CS_OPER_MPL_ORBPRE_20100517T000000_20100617T000000_0001.EEF
0
616
689
0.001
./AUX_FILES/SDF_ORBIT.CS
+015.393777
+078.230514
15000.0
487.96
```

In both examples, the Predicted Orbit file and the Swath Definition File are contained in a directory AUX_FILES/

5.2.3.2 Running the executable

The executable program can be called in the following way:

- From Linux/Mac shell

```
./transponder_min_satellite_distance
```

- From Windows command prompt window

```
transponder_min_satellite_distance.exe
```

The executable program shows the following messages:

```
Input data set by the user:
Satellite: CRYOSAT
Orbit Fie: ./CS_OPER_MPL_ORBPRE_20100517T000000_20100617T000000_0001.EEF
Start Time: 2010-05-21_00:00:00.000000
Stop  Time: 2010-05-26_00:00:00.000000
Time  Step: 0.001000 <s>
SDF filename: SDF_ORBIT.CS
Transponder Longitude: 15.393777 <deg>
Transponder Latitude: 78.230514 <deg>
Transponder Diameter: 15000.000000< m>
Transponder Altitude: 487.960000< m>
Output Filename: output_data_TRANSPONDER_CRYOSAT_min_satellite_distance.txt


TIME INITIALIZATION: POF



ORBIT INITIALIZATION: POF



CALCULATION OF ZONE INTERSECTION TIME SEGMENTS


Inputs:
   Start/Stop Absolute Orbit: 615 / 688
Outputs:
   Number of segments: 2
   Segments: Start (Orbit, seconds, microseconds) -- Stop (Orbit, seconds, microseconds)
             ( 654, 1676, 325462) -- ( 654, 1678, 441896)
             ( 675, 1291, 978227) -- ( 675, 1294, 173398)


CALCULATION OF MINIMUM DISTANCE, VISIBILITY SEGMENT #0



CALCULATION OF MINIMUM DISTANCE, VISIBILITY SEGMENT #1



Output file created successfully in output_data_TRANSPONDER_CRYOSAT_min_satellite_distance.txt
```

5.2.3.3 *Output file*

The output file *output_data_TRANSPONDER_CRYOSAT_min_satellite_distance.txt* is created:

```
# Generated with executable tool transponder_min_satellite_distance v1.4
# Data_Block
# Instrument: ORBIT
# Predicted orbit file: ./CS_OPER_MPL_ORBPRE_20100517T000000_20100617T000000_0001.EEF
# Transponder location: LON =+015.393777 [deg] LAT =+078.230514 [deg] ALT=+0487.960000 [m]
# Transponder diameter: 15000.000000 [m]
# 300 Number of visibility segments
2
# 301 Index of visibility segment | Orbit number start | Seconds since ANX start | UTC time start
|  Orbit number stop | Seconds since ANX stop  | UTC time stop
0 654 +1676.325462 20100523_152405929585 654 +1678.441896 20100523_152408046019
# 302 Minimum distance from satellite to transponder
# 303 Orbit number | Seconds since ANX | UTC time | Minimum distance [m] | LOS incidence angle
(measured from local normal) [deg] | SSP Longitude [deg] | SSP Latitude [deg]
654 +1677.520478 20100523_152407124601 +00721433.822799 +000.214100 +015.289606 +078.226167
```

```
    # 301 Index of visibility segment | Orbit number start | Seconds since ANX start | UTC time start
|  Orbit number stop | Seconds since ANX stop  | UTC time stop
    1 675 +1291.978227 20100525_020122132621 675 +1294.173398 20100525_020124327791
    # 302 Minimum distance from satellite to transponder
    # 303 Orbit number | Seconds since ANX | UTC time | Minimum distance [m] | LOS incidence angle
(measured from local normal) [deg] | SSP Longitude [deg] | SSP Latitude [deg]
    675 +1293.087248 20100525_020123241636 +00723032.293449 +000.090153 +015.437006 +078.232969
    # End Data_Block
```

5.3 Executable program *transponder_min_ground_distance*

For a requested UTC time interval, the executable program *transponder_min_ground_distance* computes
- the time of closest approach from ground-track to transponder (in orbit relative time and UTC)
- the minimum distance between the ground-track and the transponder
- the incidence angle of the line of sight with the ellipsoid normal at the time of closest approach
- the longitude and latitude of the ground-track point of closest approach

corresponding to the passes obtained over a transponder location.

5.3.1 Input configuration file description *input_data_transponder.txt*

The executable program *transponder_min_ground_distance* expects as input a configuration file named *input_data_transponder.txt*. Note that the configuration file has to be placed in the same folder where the executable routine is located.
The configuration file *input_data_transponder.txt* has been already described in Section 5.2.1.

5.3.2 Output file description *output_data_TRANSPONDER_CRYOSAT_min_ground_distance.txt*

The executable program *transponder_min_ground_distance* generates as output a file *output_data_TRANSPONDER_CRYOSAT_min_ground_distance.txt*.
The output file includes comments (starting with the symbol #) describing its contents. Note that it is created in the same folder where the executable routine is located.

5.3.3 Example

5.3.3.1 Input configuration file

The input configuration file and the executable tool have to be contained in the same directory.

Examples of input configuration files *input_data_transponder.txt* are already given in Section 5.2.3.1

5.3.3.2 Running the executable

The executable program can be called in the following way:

- From Linux/Mac shell

```
./transponder_min_ground_distance
```

- From Windows command prompt window

```
transponder_min_ground_distance.exe
```

The executable program shows the following messages:

```
Input data set by the user:
Satellite: CRYOSAT
Orbit Fie: ./CS_OPER_MPL_ORBPRE_20100517T000000_20100617T000000_0001.EEF
Start Time: 2010-05-21_00:00:00.000000
```

```
Stop  Time: 2010-05-26_00:00:00.000000
Time  Step: 0.001000 <s>
SDF filename: SDF_ORBIT.CS
Transponder Longitude: 15.393777 <deg>
Transponder Latitude: 78.230514 <deg>
Transponder Diameter: 15000.000000< m>
Output Filename: output_data_TRANSPONDER_CRYOSAT_min_ground_distance.txt


TIME INITIALIZATION: POF


ORBIT INITIALIZATION: POF


CALCULATION OF ZONE INTERSECTION TIME SEGMENTS


Inputs:
   Start/Stop Absolute Orbit: 615 / 688
Outputs:
   Number of segments: 2
   Segments: Start (Orbit, seconds, microseconds) -- Stop (Orbit, seconds, microseconds)
             ( 654, 1676, 325462) -- ( 654, 1678, 441896)
             ( 675, 1291, 978227) -- ( 675, 1294, 173398)


CALCULATION OF MINIMUM DISTANCE, VISIBILITY SEGMENT #0


CALCULATION OF MINIMUM DISTANCE, VISIBILITY SEGMENT #1


Output file created successfully in output_data_TRANSPONDER_CRYOSAT_min_ground_distance.txt
```

5.3.3.3 *Output file*

The output file *output_data_TRANSPONDER_CRYOSAT_min_ground_distance.txt* is created:

```
# Generated with executable tool transponder_min_ground_distance v1.4
# Data_Block
# Instrument: ORBIT
# Predicted orbit file: ./CS_OPER_MPL_ORBPRE_20100517T000000_20100617T000000_0001.EEF
# Transponder location: LON =+015.393777 [deg] LAT =+078.230514 [deg]
# Transponder diameter: 15000.000000 [m]
# 400 Number of visibility segments
2
# 401 Index of visibility segment | Orbit number start | Seconds since ANX start | UTC time start |
Orbit number stop | Seconds since ANX stop  | UTC time stop
0 654 +1676.325462 20100523_152405929585 654 +1678.441896 20100523_152408046019
# 402 Minimum distance from ground-track to transponder
# 403 Orbit number | Seconds since ANX | UTC time | Minimum distance [m] | LOS incidence angle
(measured from local normal) [deg] | SSP Longitude [deg] | SSP Latitude [deg]
654 +1677.384476 20100523_152406988599 +00002240.719549 +000.197900 +015.297125 +078.234260
# 401 Index of visibility segment | Orbit number start | Seconds since ANX start | UTC time start |
Orbit number stop | Seconds since ANX stop  | UTC time stop
1 675 +1291.978227 20100525_020122132621 675 +1294.173398 20100525_020124327791
# 402 Minimum distance from ground-track to transponder
# 403 Orbit number | Seconds since ANX | UTC time | Minimum distance [m] | LOS incidence angle
(measured from local normal) [deg] | SSP Longitude [deg] | SSP Latitude [deg]
675 +1293.074248 20100525_020123228636 +00001018.506120 +000.089776 +015.437725 +078.232196
# End Data_Block
```