SPT – SATELLITE PASS TOOL – RELEASE NOTES AND USER MANUAL

1. INTRODUCTION

SPT computes the visibility passes of a given satellite within a given time interval from a given ground station. For each pass the maximum elevation is also computed. Data relevant to passes are saved to file. In addition, for each pass and with a given sampling time, SPT computes and saves to file azimuth, elevation and range from ground station to satellite.

The tool can be configured to filter the results (i.e. adjust the start and/or the end time of the pass or fully discard the pass) according to additional constraints (for example, the limited X-BAND beam width, pointing offset and minimal elevation at AOS/LOS in SMOS).

SPT is a tool developed and maintained within the ESTEC EOP System Support Division by the EOCFI Team. For technical support please contact the EOCFI Team at the following e-mail address:

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1.1 Change History

Issue	Prepared by	Change Description
1.0	M. De Bartolomei (EOP-PES)	First Issue
1.1	M. De Bartolomei (EOP-PES)	Added range computation
2.0	M. De Bartolomei (EOP-PES)	Re-engineered to take into account additional requirements.

2. REFERENCES AND DEPENDENCIES

SPT uses the Earth Observation CFI libraries v4.2 (EOCFI), all conventions/terminology used in the rest of this document are according to EOCFI v4.2 documentation:

http://eop-cfi.esa.int/CFI/EO_CFI_DOCS/4.2/C_Libraries/

Please check the above documentation for dependencies to additional libraries (e.g. libxml2) and the main page of the EOP System Support Division Web Server.

http://eop-cfi.esa.int/

3. PACKAGE CONTENT

The following packages are available:

- SPT_MACIN64_v2.0_bin.tar.gz — Binary package for Mac x86 64bit built on MAC OS X 10.5.7 with gcc v4.0.1
- SPT_LINUX64_v2.0_bin.tar.gz — Binary package for Linux x86 64bit built with gcc v4.4.4 and GNU CC library v2.12

3.1 Binary package for Mac x86

It contains the directory SPT_MACIN64_v2.0_bin storing the following files:

- SPT executable for Mac x86:
  `SPT_MACIN64`
- Script to launch the SPT demo:
  `demo_MACIN64.sh`
- Directory **data** with Earth Observation Files:
  - Ground Station Database file:
    `GROUNDSTATIONS.EOF`
  - Generic swath definition file for visibility computations:
    `SDF_ORBIT.EOF`
  - Example of Orbit Scenario Files (OSF):
    For Sentinel-1A:
    `S1A_TEST_MPL_ORBSCT_20110901T175927_99999999T999999_0001.EOF`
    For SMOS:
    `SM_OPER_MPL_ORBSCT_20091102T060001_20251231T000000_310_001_1.EEF`
    (please note that the above OSF are provided as examples only and may not reflect the current mission scenario)
- Directory **cfg** with SPT configuration file examples:
  - Configuration file for Sentinel-1A:
    `S1A.CFG`
  - Configuration file for SMOS:
    `SMOS.CFG`
  - Configuration file for SMOS plus XBAND constraints:
    `SMOS_XBAND.CFG`

3.2 Binary package for Linux x86

It contains the directory SPT_LINUX64_v2.0_bin storing the following files:

- SPT executable for Linux x86:
  `SPT_LINUX64`
- Script to launch the SPT demo:
  `demo_LINUX64.sh`

Earth Observation Files (Ground Station DB / Orbit / Swath) and SPT configuration file examples are the same as per Mac x86 package.

4. INSTALLATION

To extract the package, type from a shell:

```
> tar xvfz <PACKAGE NAME>
```

The directory SPT_MACIN64_v2.0_bin or SPT_LINUX64_v2.0_bin will be created.
The following sections refer to a MACIN installation.

5. RUNNING SPT

From a shell, type:

```
> cd SPT_MACIN64_v2.0_bin
> ./SPT_MACIN64 <configuration file name>
```

e.g.:

```
> ./SPT_MACIN64 cfg/S1A.CFG
```

It is also possible to run a demo (SPT will be executed with all configurations contained in the cfg directory):

```
> ./demo_MACIN64.sh
```

6. CONFIGURATION FILE

6.1 Format

It is an ASCII file.
Lines beginning with '#' are discarded.
Lines are in the format:
<Configuration variable><one or more blanks><'[' character><value><']' character><newline>

6.2 Example

This is the file S1A.CFG contained also in the package.

```
# Configuration file for SPT
SATELLITE_ID                  [SAT_SENTINEL_1A]
ORBIT_FILENAME                [data/S1A_TEST_MPL_ORBSCT_20110901T175927_99999999T999999_0001.EOF]
SWATH_FILENAME                [data/SDF_ORBIT.EOF]
STATION_ID                    [GKIRUNBX]
SESSION_NAME                  [SESSION_S1A_GKIRUNBX]
START_TIME                    [2013-07-07_00:00:00.000000]
STOP_TIME                     [2013-07-08_00:00:00.000000]
STATION_DB_FILENAME           [data/GROUNDSTATIONS.EOF]
VISIBILITY_MASK               [XV_AOS_LOS]
AOS_ELEVATION                 [0.0]
LOS_ELEVATION                 [0.0]
SAMPLING_PERIOD               [1.0]
FILTER                        [NO_FILTER]
```

6.3 Configuration Variables Description

Configuration variable	Value
SATELLITE_ID	The Satellite identifier. Accepted values are: **SAT_ADM** **SAT_CRYOSAT** **SAT_EARTHCARE**

	SAT_ENVISAT **SAT_GOCE** **SAT_SEOSAT** **SAT_SMOS** **SAT_SENTINEL_1A** **SAT_SENTINEL_1B** **SAT_SENTINEL_1C** **SAT_SENTINEL_2A** **SAT_SENTINEL_2B** **SAT_SENTINEL_2C** **SAT_SENTINEL_3A** **SAT_SENTINEL_3B** **SAT_SENTINEL_3C** **SAT_SWARM_A** **SAT_SWARM_B** **SAT_SWARM_C**
ORBIT_FILENAME	Name of orbit file with full or relative path. SPT accepts files that are valid EOCFI orbit files suitable for propagation (for example Orbit Scenario Files and Orbit Predicted Files) or interpolation (for example Restituted Orbit Files).
SWATH_FILENAME	Name of swath definition file with full or relative path. **Please note that, to ensure correct operations of SPT, the file SDF_ORBIT.EOF provided in the package shall be used and shall not be modified.**
STATION_DB_FILENAME	Name of Ground Station Database file with full or relative path. SPT accepts files that are valid EOCFI Ground Station Database files.
STATION_ID	Ground Station Identifier. As in Ground Station Database (e.g. <Station_id>GSMVIL_X</Station_id>)
SESSION_NAME	Arbitrary name to be used to run separated tests and keep outputs isolated (see also next sections).
START_TIME	start time of search interval (UTC)
STOP_TIME	stop time of search interval (UTC)
VISIBILITY_MASK	Visibility mask to be applied. Valid values are (see EOCFI documentation): **AOS_LOS** : only use AOS/LOS **PHYSICAL** : only use physical mask **COMBINE** : combine the two above **FROM_FILE** : from Ground Station DB
AOS_ELEVATION	Minimum elevation for AOS (in deg).
LOS_ELEVATION	Maximum elevation for LOS (in deg).
SAMPLING_PERIOD	Sampling period (in sec) to be used in the calculation of expanded data. See next section for a description of expanded data.
FILTER	Additional constraint to be applied. Valid values are: **NO_FILTER** : no constraint applied **SMOS_XBAND_FILTER** : SMOS XBAND constraint applied

7. SPT OUTPUT

A directory is created to store the output files. The directory has the same name as the SESSION_NAME in the configuration file (i.e. in the example above).

Inside this directory the following files are created:

7.1 PASSES.CSV

It is a file with comma separated values plus header, it can be opened with MS Excel.
It contains a list of the pass found in the given time interval.
Start/end time of the pass are calculated taking into account AOS/LOS minimum elevations and visibility mask (as defined in the configuration file) and no additional constraint.

7.1.1 Header

```
SEG,     DATE BGN,   TIME BGN, ORBIT BGN,  SECS BGN, MSECS BGN,     DATE END,   TIME END, ORBIT END,
SECS END, MSECS END,  DURATION,   AZIMUTH BGN,      MAX ELEV
```

7.1.2 Row example

```
0, 07/07/2013, 02:22:03,    9835,    1520,     528309, 07/07/2013, 02:31:43,    9835,    2101,
326695  580.798,        19.082,      7.439
```

…

7.1.3 Fields description

Field	Description
SEG	The pass identifier starting from 0.
DATE BGN, TIME BGN, ORBIT BGN, SECS BGN, MSECS BGN	Date, Time, Orbit Number, Seconds/Microsecs after ANX. They are referring to the start time of the pass.
DATE END, TIME END, ORBIT END, SECS END, MSECS END	Date, Time, Orbit Number, Seconds/Microsecs after ANX. They are referring to the end time of the pass.
DURATION	Duration of the pass in seconds.
AZIMUTH BGN	Azimuth at pass start time in deg.
MAX ELEV	Maximum elevation within the pass in deg.

Note: if SPT is configured to take into account additional constraint (FILTER is different from NO_FILTER), then AZIMUTH BGN and MAX ELEV are set both to 0.0 in case that the pass is fully discarded due to such constraint (see next section).

7.2 FILTERED_PASSES.CSV

If SPT is configured to take into account additional constraints (FILTER is different from NO_FILTER), then FILTERED_PASSES.CSV is generated.
FILTERED_PASSES.CSV takes into account both AOS/LOS elevation, visibility mask and additional constraints.
The format is similar to the one of PASSES.CSV, with additional fields depending on the type of filter, as described in the tables below:

FILTER = SMOS_XBAND_FILTER Passes are calculated considering also X-BAND beam width limitation and pointing offset. The satellite here is considered in range (not in range) if the angle between antenna and direction satellite-ground station is less than (greater than) 65.0 deg.	
Additional Field	**Description**
XBAND MIN	Minimum value of angle between X-BAND antenna and direction to Ground Station within the pass in deg.
XBAND MAX	Maximum value of angle between X-BAND antenna and direction to Ground Station within the pass in deg.

FILTERED_PASSES.CSV may differ from PASSES.CSV in one of the following conditions:

1. A pass in PASSES.CSV is not present in FILTERED_PASSES.CSV: the pass has been discarded since, considering the additional constraints, there is no visibility;
2. Start time in PASSES.CSV is shifted forwards in FILTERED_PASSES.CSV: the pass start time has been shifted forwards since, considering the additional constraints, there is no visibility in a time interval at the beginning of the pass.
3. End time in PASSES.CSV is shifted backwards in FILTERED_PASSES.CSV: similar as condition 2.;
4. condition 2. and 3. at the same time.

Other quantities (DURATION, AZIMUTH BGN, MAX ELEV are adjusted consequently to the new interval.

7.3 PASS_XXXX.CSV

One file for each pass is generated in the format PASS_XXXX.CSV, being XXXX the pass identifier (i.e. PASS_0000.CSV, PASS_0001.CSV, ...).

Each row of the file contains satellite azimuth and elevation, antenna range at a given time within the pass. The sampling period is configurable with the SAMPLING_PERIOD variable.

7.3.1 Example

```
      DATE,      TIME,    ORBIT,      SEC,       MSEC,   AZIMUTH, ELEVATION,     RANGE
07/07/2013, 05:37:37,     9837,     1406,     156027,    21.086,     0.000, 3091.243
07/07/2013, 05:37:38,     9837,     1407,     156027,    21.097,     0.061, 3084.438
07/07/2013, 05:37:39,     9837,     1408,     156027,    21.108,     0.123, 3077.634
…
```

7.3.2 Fields description

Field	Description
DATE, TIME, ORBIT, SECS, MSECS	They are referring to a given time within the pass (SECS and MSECS are seconds and microseconds after orbit begins).
AZIMUTH, ELEVATION	Azimuth, Elevation of the satellite at the given time in deg.
RANGE	Distance from Ground Station to Satellite, in Km.

When SPT is configured to take into account additional constraints (FILTER is different from NO_FILTER):

- If Pass with identifier NNNN is discarded, then the file PASS_NNNN is not generated.
- The following additional fields are also written in the file depending on the enabled filter:

FILTER = SMOS_XBAND_FILTER Passes are calculated considering also X-BAND beam width limitation and pointing offset. The satellite here is considered in range (not in range) if the angle between antenna and direction satellite-ground station is less than (greater than) 65.0 deg.	
Field	**Description**
XBAND ANG	Value of angle between X-BAND antenna and direction to Ground Station at the given time in deg.

8. EXECUTION LOG

SPT logs on standard outputs event (marked with [INFO]) and errors (marked with [ERR]) taking place during execution.
The following is an example of execution log of a pass computation with a filter enabled, it shows that passes 0, 5, 6, 11 are discarded and start and end times of passes 1 and 10 are adjusted:

```
[ INFO ]
```

```
[ INFO ] ********************************************************
[ INFO ] ************** Satellite Pass Tool v2.0 **************
[ INFO ]
[ INFO ] Target      : [ x86_64 Darwin 9.8.0 ]
[ INFO ] Build date  : [ Oct 21 2011 14:36:32 ]
[ INFO ] gcc version : [ 4.0.1 ]
[ INFO ]
[ INFO ] [./SPT_MACIN64] Started using configuration file [cfg/SMOS_XBAND.CFG]
[ INFO ] --------------- Configuration parameters -------------------
[ INFO ] SATELLITE_ID:           [SAT_SMOS]
[ INFO ] START_TIME:             [2013-07-07_00:00:00.000000]
[ INFO ] STOP_TIME:              [2013-07-09_00:00:00.000000]
[ INFO ] ORBIT_FILENAME:         [data/SM_OPER_MPL_ORBSCT_20091102T060001_20251231T000000_310_001_1.EEF]
[ INFO ] SWATH_FILENAME:         [data/SDF_ORBIT.EOF]
[ INFO ] STATION_DB_FILENAME:    [data/GROUNDSTATIONS.EOF]
[ INFO ] STATION_ID:             [GSMVIL_X]
[ INFO ] SESSION_NAME:           [SESSION_SMOS_XBAND_GSMVIL_X]
[ INFO ] AOS_ELEVATION:          [  0.000]
[ INFO ] LOS_ELEVATION:          [  0.000]
[ INFO ] SAMPLING_PERIOD:        [  1.000]
[ INFO ] VISIBILITY_MASK:        [AOS_LOS]
[ INFO ] FILTER:                 [SMOS_XBAND_FILTER]
[ INFO ] ------------------------------------------------------------
[ INFO ]
[ INFO ] Ground Station position: (LONG LAT ALT) = (    356.050000      40.440000     650.452000)
[ INFO ] Ground Station position:       EF       = (4850105.865997 -334899.487441 4115713.244570)
[ INFO ]
[ INFO ] Computing Passes
[ INFO ] Completed - Number of Passes found: [0012]
[ INFO ]
[ INFO ] Directory [SESSION_SMOS_XBAND_GSMVIL_X] created
[ INFO ] Current Working Directory is [/Users/test/SPT_MACIN64_v2.0_bin/SESSION_SMOS_XBAND_GSMVIL_X]
[ INFO ]
[ INFO ] Expanding pass [#0000]
[ INFO ] Pass [#0000] discarded
[ INFO ]
[ INFO ]
[ INFO ] Expanding pass [#0001]
[ INFO ] Transition XBAND OUT_RANGE -> IN_RANGE
[ INFO ] Transition XBAND IN_RANGE  -> OUT_RANGE
[ INFO ] AOS adjusted forwards  of [ 110.000s]
[ INFO ] LOS adjusted backwards of [  89.919s]
[ INFO ] Pass [#0001] data written to file [PASS_0001.CSV]
[ INFO ]
[ INFO ]
[ INFO ] Expanding pass [#0002]
[ INFO ] Pass [#0002] data written to file [PASS_0002.CSV]
[ INFO ]
[ INFO ]
[ INFO ] Expanding pass [#0003]
[ INFO ] Pass [#0003] data written to file [PASS_0003.CSV]
[ INFO ]
[ INFO ]
[ INFO ] Expanding pass [#0004]
[ INFO ] Pass [#0004] data written to file [PASS_0004.CSV]
[ INFO ]
[ INFO ]
[ INFO ] Expanding pass [#0005]
[ INFO ] Pass [#0005] discarded
[ INFO ]
[ INFO ]
[ INFO ] Expanding pass [#0006]
[ INFO ] Pass [#0006] discarded
[ INFO ]
[ INFO ]
[ INFO ] Expanding pass [#0007]
[ INFO ] Pass [#0007] data written to file [PASS_0007.CSV]
[ INFO ]
[ INFO ]
[ INFO ] Expanding pass [#0008]
[ INFO ] Pass [#0008] data written to file [PASS_0008.CSV]
[ INFO ]
[ INFO ]
[ INFO ] Expanding pass [#0009]
[ INFO ] Pass [#0009] data written to file [PASS_0009.CSV]
[ INFO ]
[ INFO ]
[ INFO ] Expanding pass [#0010]
[ INFO ] Transition XBAND OUT_RANGE -> IN_RANGE
[ INFO ] Transition XBAND IN_RANGE  -> OUT_RANGE
[ INFO ] AOS adjusted forwards  of [ 118.000s]
[ INFO ] LOS adjusted backwards of [ 126.140s]
[ INFO ] Pass [#0010] data written to file [PASS_0010.CSV]
[ INFO ]
[ INFO ]
[ INFO ] Expanding pass [#0011]
[ INFO ] Pass [#0011] discarded
[ INFO ]
[ INFO ] pass list data written to file [PASSES.CSV]
[ INFO ] Filtered pass list data written to file [FILTERED_PASSES.CSV]
[ INFO ]
[ INFO ] ********** Computation completed succesfully **********
[ INFO ] ********************************************************
[ INFO ]
```

SPT execution log example