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MEGARA Control System. User Manual.
Fiber MOS Positioning Tool

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Acronyms:

CB	Configuration Block
CBS	Configuration Block Set
DDS	Disjoint Disperse Subsets
EA	Exclusion Area
FMPT	Fiber MOS Positioning Tool
FMAT	Fiber MOS Assignment Tool
FMOSA	Fiber MOS Assignment file
GFCCS	GTC Folded-Cassegrain Coordinate System
MCS	MEGARA Control System
PPA	Pair of Positions Angles
PP	Positioning Program
DP	Depositioning Program
SP	Sky Point
SPM	Security Perimetral Margin
S/W	Software
TBD	To Be Defined

Change Control

Issue	Date	Section	Page	Change description
1.A	26/01/15	All	All	New Issue
1.B	23/06/15	3	9	Description on how to get the help of the tool changed.
		4	9	Description of the input file for the FMPT rewritten.
		5	11	Description of the output files from the FMPT rewritten.
		6	14	Description of the new functionalities of the FMPT rewritten.
1.C	21/02/16	-	7-8	Index updated.
		All	All	Corrected use of abbreviation S/W.
		1	9	Implemented functionality for generate parking program.
		All	All	Version number updated to 3.0.7.
		2	10	Execute 'ldconfig' at the end of installation.
		2	10	Installation tested in Ubuntu 14.04.4
		2	10	Application functioning in Solaris 10.
		3	10	Output command help updated.
		4	11-12	Corrected description of format file FMOSA.
		5	13	Modified example of FMOSA file.
		5.1	13	Modified description of content of log file.
		5.2	13	PP and DP are stored in a single file jointly the content of FMOSA input file.
		5.2	14-15	Modified description of format of the output file.
		5.3	15	Modified description of file 'outputs-from-<inputfile>'.
		6.1	16	Generating a pair (PP, DP) is generated a file called 'PPDPandFMOSA-from-<inputfile>'.
		6.2	16-17	Motion program for recovery now is called parking program instead depositioning program. Furthermore has been described the syntax of the function for generate pairs (PP, DP).
		6.3	17	Described the syntax of the function for generate parking programs.

1.D	09/08/16	All	All	Strings changed: “<inputfile>” → “<inputfilename>” “<inputfile>.log” → “fmpt_saa.log” “PPDPandFMOSA” → “outputs” “outputs” →”other_outputs” “FMOSA file” → “file type FMOSA” “3.0.6” → “3.3.4” “3.0.7” → “3.3.4”
		3	10-11	Updated output of command $ fmpt_saa help
		4	11	Added phrase: “These parameters are ignored by the FMPT.”
		5.1	13-14	Updated content of log file ‘fmpt_saa.log’.
		5.3	17	Updated content of file ‘other_outputs...txt’.
		6.1	18	Changed strings: generatePPDP → generatePairPPDP_offline <path> → <path_FMOSA>
				Replaced figure due to error:
		7.1.2	20	Figure 1 (error in labels P0 and P1).
		7.1.3	21	Figure 2 (error in label P3).
				Updated content of files of the FMM instance:
		7.6	23	Instance.txt
		7.7	24	ExclusionArea<Id>/Contour_.txt
		7.8	24	ExclusionArea<Id>/Instance.txt
		7.9	24	RoboticPositioner<Id>/Contour____.txt
		7.10	24	RoboticPositioner<Id>/Contour_.txt
		7.11	24	RoboticPositioner<Id>/F1.txt
		7.12	25	RoboticPositioner<Id>/F2.txt
		7.13	25	RoboticPositioner<Id>/Instance.txt
1.E	16/01/16	All	All	The document has been updated to reply the comments in LAR-INT-007 to LAR-INT-011
1.F	22/06/17	4	13	Added field “Angle (deg)” to file type FMOSA.
		4	15	Example type FMOSA updated.
		6.2	21	Function “generateParkProg_online” return structure outputs instead ParkProg.
		6.3	22	Function “generatePPDP_online” return structure outputs instead PP and DP.
		7.11	26	Redefined F1 for SB1 = 194086.302.
		7.13	27	Removed SB1 and SB2 from ‘Instance.txt’. String changed: “S2” → “S0”.
		All	All	String changed: “3.3.4” → “4.8.0”.
		7.6-7.13	27-29	Updated content of files of the FMM instance.

1.G	31/08/17	2 4	11 13	Description of the installation process has been completed Description about the output format has been updated

Reference Documents

Nº	Document Name	Code
R.1	MEGARA CS. Fiber MOS Assignment Tool (FMAT). User Manual	TEC/MEG/174
R.2	FMPT/FMAT tools compatibility report.	TEC/MEG/184

Reference Documents (GTC codes)

Nº	Document Name	Code
R.1	MEGARA CS. Fiber MOS Assignment Tool (FMAT). User Manual	N/A
R.2	FMPT/FMAT tools compatibility report.	N/A

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1. INTRODUCTION

This document contains the User Manual of the MEGARA Fiber MOS Positioning Tool (FMPT). The manual allows the user to install the FMPT in his computer and to understand the FMPT functionality.

The S/W to configure the Fiber MOS has been split in two tools: Fiber MOS Assignment Tool (FMAT) [R.1] and Fiber MOS Positioning Tool (FMPT). The FMAT allows the user to prepare a Configuration Block Set (CBS) composed by several Configuration Blocks for the MEGARA MOS mode by assisting the user in the assignment of their sources to the different in-use robotic positioners of the MEGARA MOS (up to 92 positioners). Each file containing the information of a particular Configuration Block will be the input for the Fiber MOS Positioning Tool. This tool computes the sequence of movements that will be commanded before starting the exposure for reaching the source positions (positioning program, PP) as well as the sequence of movements that will be commanded after the exposure is finished for coming back to the parking position (depositioning program, DP). The Fiber MOS Positioning Tool also allows to compute a depositioning program to come back from an anomalous situation (during the observation) receiving, in this case, as input the current positions of the robotic positioners that are not at the parking position.

This manual describes only the installation and use of the FMPT, which is composed by the FMPT library, containing all necessary functionalities, and the application FMPT SAA, which uses the dynamic library ‘libfmpt.so’. The functionalities of the FMPT will be the following:

1. The GRANTECAN staff will use the FMPT as a standalone tool to generate pairs (PP, DP) for the Configuration Blocks of a CBS generated and previously validated by the FMAT. The FMPT also includes the validation of the source assignments to ensure there is no risk of collisions between the RPs.
2. MEGARA Control System (MCS) will make use of some FMPT functionalities to:
   - Generate a depositioning program to come back from an anomalous situation (during the observation) knowing the disabled RPs and the positions of all RPs.
   - Regenerate the pair (PP, DP) from the information about the positions of the disabled RPs. The rest of the RPs are in parking positions after executing the depositioning program previously computed.

2. HOW TO INSTALL THE FMPT

The process to install this S/W can be found in the file INSTALL. The process is summarized below:

1. Decompress tar file 'megara-fmpt-4.8.0.tar.gz' (or .xz).
2. Change to directory './megara-fmpt-4.8.0'.
3. Execute './configure; make;' to configure and build this package.

4. Grant superuser privileges to have access to '/usr/local/...'.
5. Execute 'make install' (as superuser) to install the library and the application.
6. Execute 'ldconfig' (as superuser) to update the linkage with the libraries in case of Linux systems.

Both dynamic and static libraries will be installed in the usual directories of the operative system, according to the user distribution and version.

As an example, in Ubuntu 14.04.4 and Fedora 20:

- Static and dynamic libraries will be installed in '/usr/local/lib';
- The executable file fmpt_saa will be installed in '/usr/local/bin';
- The instance of the Fiber MOS Model will be installed in:

  '/usr/local/share/megara-fmpt/Models/MEGARA_FiberMOSModel_Instance';
- The sample input files will be installed in: '/usr/local/bin/share/megara-fmpt/Samples'.

These paths can vary depending on the operating system and distribution where this package is installed. In this document the mentioned paths assume that the installation has been done in Ubuntu 14.04.4.

The current version of the FMPT allows installation in Linux systems.

In particular, the installation of this SW in the GCS has required the following steps:

$ ssh orm-vgcs5

$ exit # (to compile outside the GCS environment)

$ bash

$ cd /home/ldap-users/megara/megara-fmpt

$./configure JSON_CFLAGS="-I/opt/gcs/ext/jsoncpp_0.6.0/include/" JSON_LIBS="-L/opt/gcs/ext/jsoncpp_0.6.0/lib/linux/ -ljsoncpp" --prefix=/work/megara/ --libdir=/work/megara/lib/linux

$ make -j

$ make install

The user can obtain help about the arguments of the FMPT SAA by typing:

```
$ fmpt_saa help
```

3. INPUTS OF THE FMPT SAA

In the following sections we describe in detail the input and output files of the FMPT SAA. In the Appendix of this document, the files that constitute the instance of the Fiber MOS Model, which is the major defining parameter for the program, are described.

For each Configuration Block the user needs to execute the FMPT to generate the positioning and depositioning programs (PP and DP). The input file for the FMPT is the Fiber MOS Assignment file (FMOSA) generated by the Fiber-MOS Assignment Tool (FMAT). This file must be uploaded by the astronomer during the Phase-2. The structure and contents of this input file are described in detail in the FMAT Manual (see [R1]).

The FMPT reads from this input file the values of the properties (Pid, X, Y) for each assigned RP and also the Priority and Enabled column information. These properties represent a Projection Point allocated to the RP whose identifier matches with this particular Id.

Below follows an example of a FMOSA file:

```
# MEGARA file for block 0
# Generated with FMAT version: 3.0.3
# Properties file version: 1
# Date of generation  2017-04-25T14:43:53Z
# Id| Ra          | Dec         | Pos
@@SOB@@
0|275,140267|-24,849013|33,293693
@@EOB@@
#      Name          |    RA    |    Dec   | Mag |     Type        |Pr|Bid|Pid| X(mm)     | Y(mm)    | Angle(deg) | Enabled| Comment
@@SOS@@
s:96                 |275.149975|-24.832343|21.81|SOURCE             |10|0   |1   |5.300288  |55.689377 |154.0841  |1|
                     |275.176729|-24.835645|     |UNKNOWN            |  |    |2   |-60.300000|87.036000 |0.0000    |0|
                     |275.151770|-24.820775|     |UNKNOWN            |  |    |3   |20.100000 |87.036000 |0.0000    |0|
                     |275.170488|-24.831928|     |UNKNOWN            |  |    |4   |-40.200000|87.036000 |0.0000    |0|
                     |275.145531|-24.817056|     |UNKNOWN            |  |    |5   |40.200000 |87.036000 |0.0000    |0|
                     |275.164248|-24.828210|     |UNKNOWN            |  |    |6   |-20.100000|87.036000 |0.0000    |0|
                     |275.139292|-24.813338|     |UNKNOWN            |  |    |7   |60.300000 |87.036000 |0.0000    |0|
                     |275.182543|-24.846125|     |UNKNOWN            |  |    |8   |-90.450000|69.628000 |0.0000    |0|
                     |275.151341|-24.827538|     |UNKNOWN            |  |    |9   |10.050000 |69.628000 |0.0000    |0|
                     |275.176302|-24.842408|     |UNKNOWN            |  |    |10  |-70.350000|69.628000 |0.0000    |0|
                     |275.145102|-24.823820|     |UNKNOWN            |  |    |11  |30.150000 |69.628000 |0.0000    |0|
                     |275.170061|-24.838691|     |UNKNOWN            |  |    |12  |-50.250000|69.628000 |0.0000    |0|
                     |275.138863|-24.820101|     |UNKNOWN            |  |    |13  |50.250000 |69.628000 |0.0000    |0|
                     |275.163821|-24.834974|     |UNKNOWN            |  |    |14  |-30.150000|69.628000 |0.0000    |0|
                     |275.132625|-24.816382|     |UNKNOWN            |  |    |15  |70.350000 |69.628000 |0.0000    |0|
                     |275.157581|-24.831256|     |UNKNOWN            |  |    |16  |-10.050000|69.628000 |0.0000    |0|
                     |275.126387|-24.812663|     |UNKNOWN            |  |    |17  |90.450000 |69.628000 |0.0000    |0|
                     |275.175875|-24.849172|     |UNKNOWN            |  |    |18  |-80.400000|52.221000 |0.0000    |0|
s:1698               |275.142130|-24.832133|23.99|SOURCE             |10|0   |19  |23.300493 |44.615473 |68.2914   |1|
                     |275.169634|-24.845454|     |UNKNOWN            |  |    |20  |-60.300000|52.221000 |0.0000    |0|
                     |275.138434|-24.826864|     |UNKNOWN            |  |    |21  |40.200000 |52.221000 |0.0000    |0|
                     |275.163393|-24.841737|     |UNKNOWN            |  |    |22  |-40.200000|52.221000 |0.0000    |0|
                     |275.132196|-24.823145|     |UNKNOWN            |  |    |23  |60.300000 |52.221000 |0.0000    |0|
                     |275.157153|-24.838019|     |UNKNOWN            |  |    |24  |-20.100000|52.221000 |0.0000    |0|
                     |275.125957|-24.819426|     |UNKNOWN            |  |    |25  |80.400000 |52.221000 |0.0000    |0|
                     |275.175448|-24.855935|     |UNKNOWN            |  |    |26  |-90.450000|34.814000 |0.0000    |0|
                     |275.144245|-24.837346|     |UNKNOWN            |  |    |27  |10.050000 |34.814000 |0.0000    |0|
                     |275.169206|-24.852217|     |UNKNOWN            |  |    |28  |-70.350000|34.814000 |0.0000    |0|
                     |275.138005|-24.833627|     |UNKNOWN            |  |    |29  |30.150000 |34.814000 |0.0000    |0|
                     |275.162965|-24.848500|     |UNKNOWN            |  |    |30  |-50.250000|34.814000 |0.0000    |0|
                     |275.131766|-24.829908|     |UNKNOWN            |  |    |31  |50.250000 |34.814000 |0.0000    |0|
                     |275.156725|-24.844782|     |UNKNOWN            |  |    |32  |-30.150000|34.814000 |0.0000    |0|
                     |275.125528|-24.826189|     |UNKNOWN            |  |    |33  |70.350000 |34.814000 |0.0000    |0|
                     |275.150485|-24.841064|     |UNKNOWN            |  |    |34  |-10.050000|34.814000 |0.0000    |0|
                     |275.119289|-24.822470|     |UNKNOWN            |  |    |35  |90.450000 |34.814000 |0.0000    |0|
                     |275.168779|-24.858981|     |UNKNOWN            |  |    |36  |-80.400000|17.407000 |0.0000    |0|
                     |275.137576|-24.840390|     |UNKNOWN            |  |    |37  |20.100000 |17.407000 |0.0000    |0|
                     |275.162538|-24.855263|     |UNKNOWN            |  |    |38  |-60.300000|17.407000 |0.0000    |0|
                     |275.131337|-24.836671|     |UNKNOWN            |  |    |39  |40.200000 |17.407000 |0.0000    |0|
                     |275.156297|-24.851545|     |UNKNOWN            |  |    |40  |-40.200000|17.407000 |0.0000    |0|
                     |275.125098|-24.832952|     |UNKNOWN            |  |    |41  |60.300000 |17.407000 |0.0000    |0|
                     |275.150056|-24.847827|     |UNKNOWN            |  |    |42  |-20.100000|17.407000 |0.0000    |0|
```

4. OUTPUTS OF THE FMPT SAA

After generating a pair (PP, DP) the output files from the FMPT, located at the working directory, would be the following:

4.1 Log file

This file, named fmpt_saa.`log`, contains the same output written in the terminal when the application is executed:

4.2 File containing the pair (PP, DP)

This file, named **PairPPDP`_outputs_from_<inputfilename>.json`**, contains three blocks of data: A general section, a section containing information related to the input FMOSA file ("assignments"), and a section containing information related to the final configurations of the RPs ("robot").

The general section contains the following fields:

- @schema: http://guaix.fis.ucm.es/megara/robot-schema.json: contains an URL describing the format of this file.

- @version: format version of the output .json file.

- title: The title of the sequence (limited to 70 characters), from the FMOSA file

- description: A text containing information on the sequence, from the FMOSA file

- uuid: The uuid identifying the sequence

The "assignments" section contains the all the relevant information contained in the FMOSA file: title, description, creation_date, fmat_version, fmat_properties (version of the FMAT configuration file), number of observing blocks, observing block identifier (bid), coordinates and position angle of the field.

Example:

```
"assignments" : {
       "bid" : 0,
       "coordinates" : {
          "Dec" : 12.1693270,
          "RA" : 322.4921360,
          "position_angle" : 360.0
       },
       "creation_date" : "2017-08-23T18:23:59Z",
       "description" : "s36s64s81s28s26",
       "fmat_properties" : 1,
       "fmat_version" : "3.1.0",
       "nblocks" : 1,
        "title" : "M15"
```

In addition, there is a "targets" subsection where the information (included in the FMOSA file) for each target assigned to each RP of the Fiber-MOS is detailed:

- RA, Dec: celestial coordinates of the center of the RP

- comment on the RP or the object to be observed

- X, Y: cartesian coordinates in the focal plane of the center of the RP

- enabled: whether the RP is enabled or disabled

- magnitude of the assigned object if any

- name: Name of the assigned object if any

- position angle of the arm of the RP with respect to the horizontal

- priority of the assigned object if any

- rpid: robotic positioner identifier

- type: "UNKNOWN" when the RP is not assigned and "REFERENCE" or "SOURCE" when it is assigned to an object

Example:

```
"targets" : [
         {
            "Dec" : 12.18540,
            "RA" : 322.4895750,
            "comment" : "foo comment",
            "coordinate_x" : 7.433730,
            "coordinate_y" : 47.7413620,
            "enabled" : true,
            "magnitude" : 15.320,
            "name" : "1745948426813304960",
            "position_angle" : 105.73930,
            "priority" : 0,
            "rpid" : 1,
            "type" : "SOURCE"
         },
```

Finally, the "robot" section contains the following information:

- creation_date: date of generation of the PPDP or Parking program

- fmat_filename:_name of the FMOSA file used as input for the FMPT

- fmpt_instance_version: version of the FMPT instance used to generate the PPDP or Parking program

- fmpt_version: version of the FMPT used to generate the PPDP or Parking program

- type: type of sequence PPDP or Parking program

Example:

```
  "robot" : {
      "creation_date" : "2017-08-23T22:05:13Z",
      "fmat_filename" : "megara-cb0.meg",
      "fmpt_instance_version" : "1",
      "fmpt_version" : "4.8.0",
       "type" : "PPDP",
```

Inside this section description of the trajectories of the RPs during the positioning/depositioning sequences are included with the following schemas: the motion programs are composed of a list of groups containing each the simultaneous displacements of several non-adjacent RPs. The groups are separated by "[]" in the json file. Each group contains the following information of the corresponding RPs:

- rpid: the RP identifier

- r1, r2: the absolute final positions of the R1 and R2 rotors (in engine steps)

Example:

```
    "sequences" : {
          "depositioning" : {
             "program" : [
                [
                   {
                      "r1" : 162361,
                      "r2" : 0,
                      "rpid" : 1
                   },
……
{
                      "r1" : 0,
                      "r2" : 0,
                      "rpid" : 92
                   }
                ]
             ],
          },
          "positioning" : {
             "program" : [
                [
                   {
                      "r1" : 162361,
                      "r2" : 0,
                      "rpid" : 1
….
{
                      "r1" : 100656,
                      "r2" : -5303,
                      "rpid" : 92
                   }
```

5. EXECUTION OF THE FMPT

5.1 Generating a pair (PP, DP)

The GRANTECAN staff will make use the FMPT as a stand-alone tool to generate pairs (PP, DP) for the Configuration Blocks of a CBS generated, and previously validated by the FMAT.

Although the compatibility of both tools, FMPT and FMAT has been checked in [R.2], the FMPT also includes a validation to ensure there is no risk of collisions between the RPs. In those cases when the FMPT detects RPs with risk of collision the output.json file is not generated and instead a warning message about the presence of collisions of RPs is written in the terminal.

The syntax for the PP and DP generation is as follows:

```
$ fmpt_saa generatePairPPDP_offline <path_FMOSA>
```

`<path_FMOSA>`: is the absolute or relative path to FMOSA file.

Setting parameters:

There is a directory containing the Fiber MOS Model Instance in the path: `/usr/local/share/megara-fmpt/Models`.

This parameter file is loaded by default from the directory 'MEGARA_FiberMOSModel_Instance'.

Inputs:

File `<path_FMOSA>`[1] contains a table with the projection points and their allocations to RPs.

The following output files will be saved in the same directory where the program is executed: `fmpt_saa.log` and `PairPPDP_outputs_from_<filename>.json`.

[1] This file is the output of the FMAT whose name is 'megara-cb0.meg' or similar (cb1, cb2, etc.).

5.2 Generating a parking program

It could be the case that during the execution of a motion program, a RP fails and some of the rest of RPs are out of their parking positions. In this situation, the failed RP and the six adjacent to this one, must be disabled (using the FiberMOS CS panel by the support astronomer) and MCS will recover the original positions of the non-failed RPs using the FMPT functionality to generate a parking program as described in this section.

To generate the parking program, the FMPT needs as input the list of the disabled RPs and the list of the current positions of all the RPs to compute the parking program. This information will be provided by MCS as arguments when this function is called. The syntax to execute this functionality in MCS is the following:

```
bool generateParkingProgram_online(OutputsParkProg& outputs,
    TFiberMOSModel& FMM,
    const vector<double>& p_1s, const vector<double>& p___3s,
    const vector<int>& Ids);
```

Where:

- outputs: the structure containing the parking program to be generated, and all information for their execution.
- FMM: is the Fiber MOS Model.
- (p_1s, p___3s): are the starting positions (in steps), of all RPs in the FMM.
- Ids: is the list of identifiers of the RPs to be disabled.

This function is internally documented in the file ‘MotionProgramGenerator.h’ (provided with the release 4.8.0 of the FMPT).

5.3 Regenerate a pair (PP, DP)

When the pair (PP, DP) of a particular CB is going to be executed by MCS, a malfunction or anomaly related with the rotors of the RPs could happen. This could be the case before or during the execution of the RP movement programs.

It is recommendable to execute the FMPT (to compute positioning and depositioning programs) just before the corresponding observing run. This is to avoid situations where there are sources assigned to RPs which are temporarily non-available and were considered as available at the moment of creating the PP and DP programs.

It could be the case that during the execution of a movement program, a RP fails and some of the rest of RPs are out of their parking positions. In this situation, the failed RP is disabled and MCS will recover the original positions of the non-failed RPs using the FMPT functionality to generate a parking program as described in last section.

As the RP that has failed could be disabled in an insecure position the pair PP and DP computed for that configuration block is not valid because its execution could produce collisions. To follow with the observing run, MCS would call the FMPT functionality to regenerate the pair (PP, DP), calling the function whose syntax is briefly described below:

```
bool generatePairPPDP_online(OutputsPairPPDP& outputs,
    TFiberMOSModel& FMM,
    const vector<double>& p_1s, const vector<double>& p___3s,
    const vector<int>& Ids);
```

Where:

- outputs: the structure containing the pair to be generated, and all information for their execution.
- FMM: the Fiber MOS Model.
- (p_1s, p___3s): are the initial positions in steps, of all RPs in the FMM.
- Ids: is the list of identifiers of the RPs to be disabled.

This function is similar to the function to generate the original pair, but including the parameters (p_1s, p___3s) and Ids.

This function is internally documented in the file 'MotionProgramGenerator.h' (provided with the release 4.8.0 of the FMPT).

6. APPENDIX: INSTANCE OF THE FIBER MOS MODEL

6.1 FMPT coordinate systems

The Fiber MOS Positioning Tool (FMPT) uses internally four different coordinate systems, which are described in the following subsections.

6.1.1 FMPT S0 coordinate system

The FMPT S0 coordinate system coincides with the Fiber MOS focal frame coordinate system.

The Fiber MOS focal frame coordinate system is defined as follows:

- The origin is in the center of the frame.
- The Z-axis runs in direction of the Z-axis of the GFCCS against the incoming light.
- The Y-axis runs in direction of the Y-axis of the GFCCS, positive sense of Y-axis going away from the base plate.
- The X-axis forms a right handed system with the two previous.

The Fiber MOS focal frame shall be used to define the position of the each positioner and, therefore, locate the origin of each individual Fiber MOS positioner coordinate system.

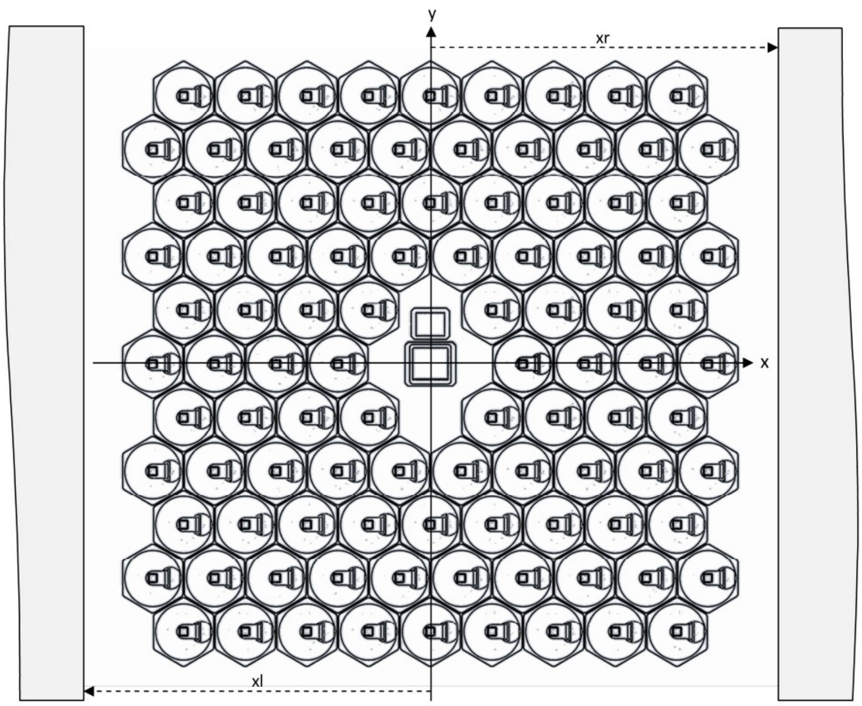

Figure 1: *FMPT S0 coordinate system.*

6.1.2 FMPT S1 coordinate system

The FMPT S1 coordinate system is defined as follows:

- This is dextrorotatory.
- The origin of the system is at the center of rotation 1.
- The x-axis is oriented passing through rotation 1 and rotation 2 centers.

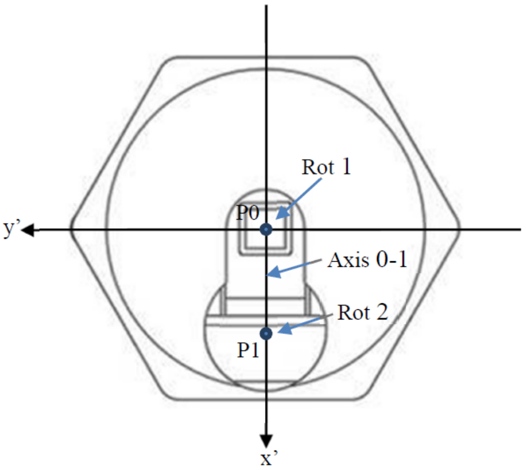

Figure 2: *FMPT S1 coordinate system*

6.1.3 FMPT S2 coordinate system

The FMPT S2 coordinate system is defined as follows:

- This is dextrorotatory.
- The origin of the system is at the center of rotation 2.
- The x-axis is orientated in such way that it works as symmetrical axis to the arm's contour.

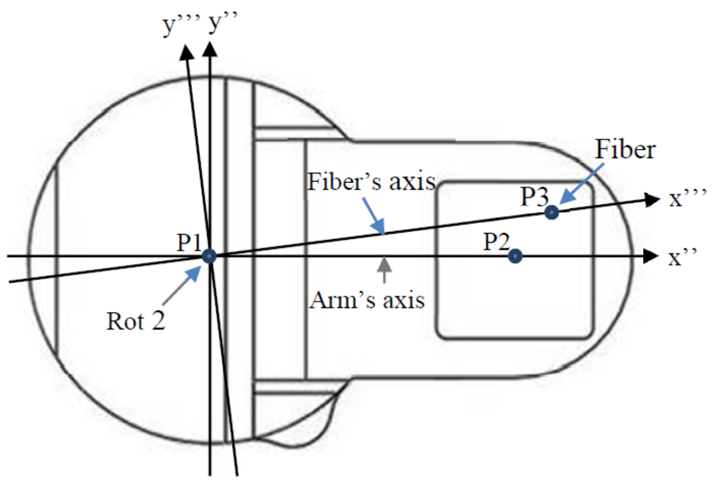

Figure 3: *FMPT S2 and S3 coordinate systems*

6.1.4 FMPT S3 coordinate system

The FMPT S3 coordinate system is defined as follows:

- This is dextrorotatory.
- The origin of the system is at the center of rotation 2.
- The x-axis is orientated in such way that passes through rotation 1 and the center of the fiber minibundle.

6.2 Set of files composing the instance of the Fiber MOS Model

The instance of the Fiber MOS Model is composed by a directory containing the following sets of data:

- **RP Origins Table (RoboticPositionerOriginsTable.txt)**: containing a table to indicate the position and orientation of each RP in the Fiber MOS Model, containing the following fields: (Id, x0, y0, thetaS1).
- **EA Origins Table (ExclusionAreaOriginsTable.txt)**: containing a table to indicate the position and orientation of each exclusion area (EA) in the Fiber MOS Model, containing the following fields: (Id, x0, y0, thetaS1).
- **RP Map (InstanceMap.txt)**: containing a matrix to transform each point (x, y) given in Cartesian coordinates in S0, in a list of identifiers of RPs {Id} in whose observing domain could be the point (x, y).
- **Fiber MOS Additional Properties (Instance.txt)**: containing the additional properties of the Fiber MOS Model instance. In particular, the version of the complete Fiber-MOS instance is indicated in this file. Should the Fiber-MOS instance changed for any reason, we recommend to record a copy of the current version and to update the number version of the new instance in this file.
- **A subdirectory for each RP (RoboticPositioner<n>) containing the following text files**:
    - **RP Arm Contour____**: containing a list of segments and arcs to describe the template of the contour of the RP Arm, in S4 (in mm).
    - **RP Frontier Contour_**: containing a list of segments and arcs to describe the template of the contour of the RP Frontier, in S1 (in mm).
    - **RP F1**: containing the compression function of the quantifier of rot 1 of the RP (in step/rad). Shall be defined in a domain that contains rot 1 domain [theta_1min, theta_1max].
    - **RP F2**: containing the compression function of the quantifier of rot 2 of the RP in (step/rad). Shall be defined in a domain that contains rot 2 domain [theta___3min, theta___3max].

- **RP Additional Properties (Instance.txt)**: containing the additional properties of the RP Model instance. Only in case a RP is permanently disabled the status property should be `Disabled = True` for the corresponding robotic positioner.

- **A subdirectory for the EA containing the following text files**:
  - **EA Barrier Contour_**: containing a list of segments and arcs to describe the template of the contour of the EA Barrier, in S1 (in mm).
  - **EA Additional Properties**: containing the additional properties of the EA Model instance.

Each set of these sets of data is stored in a file. These files are stored in the directory of the instance and are root proprietary, because the user usually shall not modify the instance.

The names of these files and the default values of the data are shown below, with comments added to facilitate understanding.

6.3 Fiber MOS Model - RP Origins Table (RoboticPositionerOriginsTable.txt)

```
# A table for indicate the position and orientation of each RP (Robotic Positioner):
#     Id: identifier of the RP (a nonnegative integer number)
#     x0: abscissa of the point P0 of the RP in S0 (in mm)
#     y0: ordinate of the point P0 of the RP in S0 (in mm)
#     theta01: orientation of S1 in S0 (in rad)

Id     x0     y0     theta01
1      -0.045259375   52.2962875    0.0137000127470387
2      -60.4789828125 87.1743703125 0.00511258188666815
…      …      …      …
100    80.4   -87.035553    0
```

6.4 Fiber MOS Model - EA Origins Table (ExclusionAreaOriginsTable.txt)

```
# A table for indicate the position and orientation of each EA (Exclusion Area):
#     Id: identifier of the EA (a nonnegative integer number)
#     x0: abscissa of the point P0 of the EA in S0 (in mm)
#     y0: ordinate of the point P0 of the EA in S0 (in mm)
#     theta01: orientation of S1 in S0 (in rad)

Id     x0     y0     theta01
1      0      0      0
```

6.5 Fiber MOS Model - RP Map (InstanceMap.txt)

```
# A matrix to transform each point (x, y) given in Cartesian coordinates in S0,
# in a list of identifiers of RPs {Id} in whose observing domain could be the
point (x, y):

xmin = -102.055               # lower limit in x-axis of the matrix of cells (in
mm)
xmax = 102.055                # upper limit in x-axis of the matrix of cells (in
mm)
ymin = -98.640553             # lower limit in y-axis of the matrix of cells (in
mm)
ymax = 98.640553              # upper limit in y-axis of the matrix of cells (in
mm)
```

```
I = 49                          # number of rows of the cell matrix
J = 50                          # number of columns of the cell matrix

# Cells[i][j]: list of RPs whose observing domain is in the square cell (i, j)
Cells[0][0] = {}
Cells[0][1] = {}
…
Cells[1][0] = {}
Cells[1][1] = {}
…
Cells[50][49] = {}
Cells[50][50] = {}
```

6.6 Fiber MOS Model - Instance properties (Instance.txt)

```
# Instance properties of the FMM (Fiber MOS Model):

Tolerances:                 # Tolerances of the Fiber MOS:
    PAem = 0                    # orientation error margin of the system S0 (in rad)
    Pem = 0                     # pointing error margin of the system S0 (in mm)
```

6.7 EA - Barrier Contour_ (ExclusionArea1/Countour_.txt)

```
# A list of segments (Pa, Pb) and arcs (Pa, Pb, Pc, R) to describe
# the template of EA.Barrier.Contour_, in S1 (in mm):


({-14, -9.75}, {-14, 7.877})
({-14, 7.877}, {-9.5, 11.629})
({-9.5, 11.629}, {-9.5, 23.2})
({-9.5, 23.2}, {9.5, 23.2})
({9.5, 23.2}, {9.5, 11.629})
({9.5, 11.629}, {14, 7.877})
({14, 7.877}, {14, -9.75})
({14, -9.75}, {-14, -9.75})
```

6.8 EA - Instance properties (ExclusionArea<Id>/Instance.txt)

```
# Instance properties of the EA (Exclusion Area):

Tolerances:                     # Tolerance properties of the EA:
    Eo = 0                          # error margin in theta_ orientation (in rad)
    Ep = 0.499                       # error margin in P0 position (in mm)
```

6.9 RP - Arm Contour____ (RoboticPositioner<Id>/Contour____.txt)

```
# A list of segments (Pa, Pb) and arcs (Pa, Pb, Pc) for describe
# the template of RP.Actuator.Arm.Contour____ in S4 (in mm):

({0.807111, 2.35}, {5.807111, 2.35})
({5.807111, 2.35}, {5.807111, -2.35}, {5.807111, 0}, 2.35)
({5.807111, -2.35}, {0.807111, -2.35})
({0.807111, -2.35}, {0.807111, 2.35})
```

6.10 RP - Barrier Contour_ (RoboticPositioner<Id>/Contour_.txt)

```
# A list of segments (Pa, Pb) and arcs (Pa, Pb, Pc, R) to describe
# the template of the RP.Barrier.Contour_, in S1 (in mm):

({13.955, 0}, {-13.955, 0}, {0, 0}, 13.955)
({-13.955, 0}, {13.955, 0}, {0, 0}, 13.955)
```

6.11 RP – Rotor 1 compression function (RoboticPositioner<Id>/F1.txt)

```
# The compression-function of the quantifier of rot 1 of the RP in step/rad.
# Must be defined almost in the rot 1 domain [theta_1min, theta_1max]:
#     theta_1: position of rot 1 (in rad)
#     p_1: position of rot 1 (in step)

-6.28318530717959   -194086.302
0                   0
6.28318530717959    194086.302
12.5663706143592    388172.604
```

6.12 RP – Rotor 2 compression function (RoboticPositioner<Id>/F2.txt)

```
# The compression-function of the quantifier of rot 2 of the RP in step/rad.
# Must be defined in the rot 2 domain [theta___3min, theta___3max]:
#     theta___3: position of rot 2 (in rad)
#     p___3: position of rot 2 (in step)

-6.28318530717959   -30720
0                   0
6.28318530717959    30720
12.5663706143592    61440
```

6.13 RP - Instance properties (RoboticPositioner<Id>/Instance.txt)

```
# Instance properties of the RP (Robotic Positioner):

ActuatorInstance:               # Instance properties of the RP.Actuator (sizing, orientation and others):
    L01 = 5.9930890625              # distance between P0 and P1 (in mm)
    theta_1min = -0.043633231       # position angleâ€™s lower limit of the axis 0-1 respect S1 (in rad)
    theta_1max = 6.326818538        # position angleâ€™s upper limit of the axis 0-1 respect S1 (in rad)
    theta_1 = 0                     # position angle of axis 0-1 respect S1 (in rad)
    theta_O3o = 3.1489737525635     # orientation of S3 respect S1 when theta_1 = 0 (in rad)

    ArmInstance:                    # Instance properties of the RP.Actuator.Arm (siz., ori. and quant.):
        L12 = 5.8025                    # distance between P1 and P2 (in mm)
        L13 = 5.9437703125              # distance between P1 and P3 (in mm)
        theta__O3 = 0                   # orientation of S3 respect S2 (in rad)
        R3 = 0.75                       # radio of representative circle of the microlens (in mm)
        theta___3min = -0.043633231     # position angleâ€™s lower limit of axis 1-3 respect S3 (in rad)
        theta___3max = 3.185225885      # position angleâ€™s upper limit of axis 1-3 respect S3 (in rad)
        theta___3 = 0                   # position angle of axis 1-3 respect S3 (in rad)

    SPMmin = 0.005                  # SPM minimum: is the SPM due to the minimum jump during gen. (in mm)
    SPMsim = 0.00893643794946       # SPM of simulation: is the max. deviation in the rad. traj. (in mm)
    PAkd = Pre                      # position angles knowledge degree [Pre | App | Unk]

CMFInstance:                    # Instance properties of the RP.CMF:
    SF1.vmaxabs = 3                 # absolute maximum velocity of rot 1 when MFT = mftSquare (in step/ms)
    SF2.vmaxabs = 0.945             # absolute maximum velocity of rot 2 when MFT = mftSquare (in step/ms)
    RF1.vmaxabs = 3                 # absolute maximum velocity of rot 1 when MFT = mftRamp (in step/ms)
    RF2.vmaxabs = 0.945             # absolute maximum velocity of rot 2 when MFT = mftRamp (in step/ms)
    RF1.amaxabs = 4294.967295       # absolute maximum accel. of rot 1 when MFT = mftRamp (in step/ms^2)
    RF2.amaxabs = 4294.967295       # absolute maximum accel. of rot 2 when MFT = mftRamp (in step/ms^2)
    MFM = Square                    # motion function type [Square | Ramp]
    SSM = Free                      # square synchronous mode [Free, Tmin, MaxTmin]
    RSM = Free                      # ramp synchronous mode [Free | Tmin | MaxTmin | Tv | MaxTv]
    Id1 = 0                         # CAN identifier of the rot 1 controller (a nonneg. integer number)
    Id2 = 0                         # CAN identifier of the rot 2 controller (a nonneg. integer number)

Tolerances:                     # Tolerances of the RP:
    Eo = 0.000872665                # error margin in theta_ orientation (in rad)
    Ep = 0.1                        # error margin in P0 position (in mm)
    Tstop = 0                       # margin time from last pos. stored in memory, to stop. rotors (in ms)
    Tshiff = 1                      # margin time to shift of all rotors of RPs in Fiber MOS (in ms)
    SPMadd = 0.32                   # SPM additional: is a component of SPM added once (in mm)

Status:                         # Qualitative status of the RP:
    Disabled = False                # disabling status [False | True]
    FaultProbability = 0            # probability of fault status (a real number in [0, 1])
    FaultType = Unk                 # type of fault [Unk | Sta | Dyn]
```

Note that SPM values depend on (SPMmin, SPMsim, Tshiff, SMPadd) and the value assigned to the SPM is a function of (PAkd, Purpose). The calculus of SPM is a complex process which is described in the file:

‘megara-fmpt-4.8.0/data/Manuals/calculus_of_SPM.txt’