# 6. Interface Definition

The planner is realized as a C++ standalone application to be called via command-line.

The call will have two arguments and that will be the input-file names, defined as described in the following sections.

The following is an exemplary call:

```
FlySmart_Planner_v0_01.exe  AircraftFileName.txt  WayPointsFileName.txt
```

The output will consist of a single file containing all the necessary spline information.

## 6.1. Input Files Structures

### 6.1.1. Aircraft File Structure

The Aircraft input file will be a space-separated value ASCII file located in the same directory as the executable of the planner.

The filename will contain the word "Aircraft" followed by the aircraft type, e.g.:

```
Aircraft_DA42.txt
```

The file will consists of several lines illustrating the aircraft limitations to be respected during the planning process, as described in the following table:

| Line | Units | Guard | Description |
|---|---|---|---|
| 1 | rad/s | Psi_Dot | Desired turn rate |
| 2 | rad | Phi_Max | Maximum bank angle |
| 3 | m/s | RoC | Desired Rate of Climb in cruise |
| 4 | m/s | RoD | Desired Rate of Descent in cruise |
| 5 | %g | Max_Load | Maximum vertical load |
| 6 | m | Lat_Dist | Maximum lateral deviation |
| 7 | m | Ceiling | Ceiling Height |
| 8 | m/s | VMin_UP | Minimum Cruise speed |
| 9 | m/s | VMax_UP | Maximum Cruise speed |
| 10 | m | Range | (residual) Flight range |
| 11 | m | TO_Dist | Minimum Take-Off Runway Length (worst case scenario) |
| 12 | m | LDG_Dist | Minimum Landing Runway Length (worst case scenario) |

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| Line | Units | Guard | Description |
|---|---|---|---|
| 13 | m | Flare_H | Flare Height |
| 14 | m | TO_H | Minimum height to reach with TO Climb. |
| 15 | m | LDG_H | Minimum height above ground from which to initiate descent. |
| 16 | m/s | TO_RoC | TO Rate of Climb |
| 17 | m/s | APP_RoD | Approach Rate of Descent (positive) |
| 18 | m/s | V_R | Velocity to be reached before rollout |
| 19 | m/s | V_Climb | Velocity to be maintained during TO Climb |
| 20 | m/s | V_APP | Velocity with which begin the descent |
| 21 | m/s | V_Flare | Velocity to be maintained at Flare execution |
| 22 | s | CFG_Time | Upper limit for the time needed to change the configuration of the aircraft |

All the values listed will be always preceded with their sign and written in the scientific format with 15 digits after the comma and 3 digits for the exponent.

Each line will be in the format:

%Guard% %Value%

The guard is case-sensitive. The following is a partial exemplary file. Please note that the gray numbers indicate the line number and are not actual part of the file.

```
1 Psi_Dot +1.047197551196598e-001
2 Phi_Max +5.235987755982988e-001
3 RoC +2.726646259971647e+000
4 RoD -1.235987755982988e+000
5 Max_Load +1.250000000000000e+000
6 Lat_Dist +5.000000000000000e+000
7 Ceiling +1.000000000000000e+004
8 VMin_UP +4.500000000000000e+001
```

### 6.1.2. WayPoint File Structure

The WayPoints input file will be a space-separated value ASCII file located in the same directory as the executable of the planner.

The filename will contain the word "WayPoints" followed by the 2-digit mission number, e.g.:

WayPoints_05.txt

Each line will respect the following format:

| Value Name | Format | Description |
|---|---|---|
| Phase of Flight | Integer | The index of the phase of flight to which the waypoint is to be assigned. It shall follow the following convention:<br>• 0: Pre-flight taxiing<br>• 1: Take-off<br>• 2: Cruise<br>• 3: Holding<br>• 4: Landing<br>• 5: Post-flight taxiing |
| WayPoint ID | Integer | Incremental index of the waypoint. Each phase of flight will start with its own Waypoint "0" |
| Horizontal Type | Integer | It describes how the waypoint should be treated during horizontal planning. It shall follow the following convention:<br>• 0: GoNear<br>• 1: GoThrough<br>• 2: GoTo<br>• 3: GoAround |
| 4D Type | Binary | It describes whether the waypoint is part of a time or velocity-priority phase of flight according to the following convention:<br>• 0: Time<br>• 1: Velocity |
| Latitude | Scientific | In degrees, preceded by the sign, 15 digits after the comma and 3 digits for the exponent. In the range $[-80Â°, +84Â°]$ |
| Longitude | Scientific | In degrees, preceded by the sign, 15 digits after the comma and 3 digits for the exponent. In the range $[-180Â°, +180Â°]$ |
| Height | Scientific | In meters, preceded by the sign, 15 digits after the comma and 3 digits for the exponent. 0 is the sea level. |
| 4D Coordinate | Scientific | If time, in seconds since last month change. If velocity, in meters per second. Preceded by the sign, 15 digits after the comma and 3 digits for the exponent. |
| Desired Heading | Scientific | If Horizontal type == 2 this specifies which heading is to be mantained at the location described. Otherwise it should be equal to 0. Preceded by the sign, 15 digits after the comma and 3 digits for the exponent. |

The following are line examples:

```
2 0 1 1 +1.123456789012345e+001 +1.123456789012345e+001 +6.000000000000000e+003
...     +5.500000000000000e+001 +0.000000000000000e+000
2 1 1 1 +1.123456789012345e+001 +1.123456789012400e+001 +6.000000000000000e+003
...     +5.500000000000000e+001 +0.000000000000000e+000
```

## 6.2. Output File Structure

The output file will be a space-separated value ASCII file located in the same directory as the executable of the planner.

The filename will contain the word "Splines" followed by the 2-digit mission number and a 4-digit number indicating the total number of splines, e.g.:

Splines_05_0025.txt

The first line will contain a list of the indexes of the first splines of each phase of flight (e.g. spline 2000 for the cruise). If a phase has not been planned (taxiing phases of take-off), the number will either be 0 or the index of the last spline:

0 0 0 9 16 25

Each subsequent line of the file will contain all data describing a spline and it will respect the following format:

| Value Name | Format | Description |
|---|---|---|
| Spline ID | Integer | It will be in the format $XYYY$ where $X$ will indicate the phase of flight to which the spline belongs according to the following convention:<br>• 0: Pre-flight taxiing<br>• 1: Take-off<br>• 2: Cruise<br>• 3: Holding<br>• 4: Landing<br>• 5: Post-flight taxiing<br>$YYY$ is instead the incremental index of the spline. Each phase of flight will start with its own Spline "000" |
| 4D Type | Binary | It describes whether the spline is part of a time or velocity-priority phase of flight according to the following convention:<br>• 0: Time<br>• 1: Velocity |
| UTMLong | Integer | Specifies the UTM longitude origin for the coordinates of the spline divided by 3 since the possible longitudes are all multiples of 3Â°, with the Greenwich meridian being equal to 180Â°. It is a value in the interval $[0, 119]$. |
| Area | Integer | Indicates how many million meters lays the spline origin from the south pole (it is thus a value defined in the interval $[0, 19]$, with 10 being immediately north of the equator). See App. A |

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| Value Name | Format | Description |
|---|---|---|
| Exit Condition | Integer | Determines which condition to apply in order to check the end of the spline<br>• 0: Spline Coefficient [default]<br>• 1: Velocity larger than indicated value<br>• 2: Velocity smaller than indicated value<br>• 3: Height larger than indicated value<br>• 4: Height smaller than indicated value |
| Exit Value | Scientific | Units according to the variable specified by the previous index. Preceded by the sign, 15 digits after the comma and 3 digits for the exponent. It is equal to 0.0 if "Exit Condition" is 0 |
| Spline Length | Scientific | In meters, preceded by the sign, 15 digits after the comma and 3 digits for the exponent. |
| Coefficients | Scientific | The 16 coefficients, each preceded by the sign, 15 digits after the comma and 3 digits for the exponent. Following the naming convention of Eq. (1.1), first the spatial coefficients in the following order: $a_0^x\ a_1^x\ a_1^x\ a_3^x\ a_0^y\ a_1^y\ a_1^y\ a_3^y\ a_0^z\ a_1^z\ a_1^z\ a_3^z$ followed by the coefficients of the 4th dimension in analogous order. |

The following is a line example:

2001 1 62 15 0
... +0.000000000000000e+000 +1.123456789012345e+006 +1.123456789012345e+000
... +1.123456789012345e+001 +1.123456789012345e+002 +1.123456789012345e+003
... +1.123456789012345e+000 +1.123456789012345e+001 +1.123456789012345e+002
... +1.123456789012345e+003 +1.123456789012345e+000 +1.123456789012345e+001
... +1.123456789012345e+002 +1.123456789012345e+003 +1.123456789012345e+000
... +1.123456789012345e+001 +1.123456789012345e+002 +1.123456789012345e+003

## 6.3. Return Value

If the planning is succesful, the planner will return a value of "0" and the output file will have been created and will contain all the necessary information.

Should a problem have occourred, the return value will describe it according to the following table:

| Value | Description |
|---|---|
| Call Errors | |
| 1 | The planner has been called with not enough call arguments. |
| 2 | The planner has been called with too many call arguments. |
| 3 | The Aircraft filename is not correct. |
| 4 | The WayPoints filename is not correct. |

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| Value | Description |
|---|---|
| | Input Values Errors |
| 10 | The selected takeoff runway has insufficient length. |
| 11 | The selected landing runway has insufficient length. |
| 30 | Flight range beyond aircraft capabilities. |
| 4y | Incomplete Mission: not enough waypoints for phase of flight y. |
| 5y | Improper Mission: too many waypoints for phase of flight y. |
| 60 | Holding Pattern must have velocity as 4th dimension. |
| 61 | Holding pattern WPs must have same velocity. |
| 62 | Holding pattern WPs must have same height. |
| 63 | Holding pattern WPs are too close. |
| 64 | Holding pattern WPs must be "GoAround". |
| 65 | Holding pattern is not at the same height as last Cruise WP. |
| 70 | Take Off climb is too short. |
| 71 | Approach descent is too short. |
| | Files Errors |
| 1000 | The given aircraft file was not found/could not be accessed. |
| 2xxx | The given aircraft file is not correctly formatted at line xxx. |
| 3000 | The given waypoint file was not found/could not be accessed. |
| 4xxx | The given waypoint file is not correctly formatted at line xxx. |
| 5000 | The designated output file could not be created. |
| | WayPoints Errors |
| 8xxx | The geodetic distance between Cruise waypoint xxx and xxx+1 is not sufficient to perform a UTM zone switch. |
| 9xxx | The longitude distance between Cruise waypoint xxx and xxx+1 is not sufficient to perform a UTM zone switch. |
| 1yxxx | Waypoint xxx in phase of flight y is above specified height ceiling. |
| 2yxxx | Climb/descent too steep after waypoint xxx in phase of flight y. |
| 3yxxx | Not enough horizontal space to perform "S" maneuver at waypoint xxx in phase of flight y. |
| 4yxxx | Not enough vertical space to perform change of altitude maneuver after waypoint xxx in phase of flight y. |
| 5yxxx | Waypoint xxx in phase of flight y has inconsistent 4th dimension type. |
| 6yxxx | Excessive velocity required at waypoint xxx in phase of flight y. |
| 7yxxx | Insufficient velocity required at waypoint xxx in phase of flight y. |

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| Value | Description |
|---|---|
| 8yxxx | Insufficient time interval after waypoint xxx in phase of flight y. |
| 9yxxx | Excessive time interval after waypoint xxx in phase of flight y. |
| 10yxxx | Waypoint xxx in phase of flight y is too near to the North Pole. |
| 11yxxx | Waypoint xxx in phase of flight y is too near to the South Pole. |
| Internal Errors | |
| 12yxxx | Cannot Match Velocity at waypoint xxx in phase of flight y. |
| 200000 | Too many splines have been generated. |

Please note that in addition to the standard flight phases, an internal phase "6" is used by the planner to indicate all intercept splines (See Chap. 5).