



USER'S MANUAL

AIR²EO
*ESA Realtime Satellite Orbit
Visualisation & Simulation System*

ESA – ESTEC
January 2011
Version 1.0

Revision Sheet

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|--------------------|-------------|-----------------------------|
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1 - GENERAL INFORMATION

1 GENERAL INFORMATION

1.1 System Overview

The AIR²EO application is intended to assist ESA engineers in the graphical simulation of ESA Earth Observation satellite missions.

The application allows real-time simulation of the satellite position and attitude and 3D display of the satellite model, orbit track, instruments swath activation and ground stations passes. It also includes a database composed of several 3D geometrical models of EO satellites, Earth maps, celestial objects and geographical information layers (points of interest, vector layers, earth grid, and ground stations visibility masks).

The application graphical user interface is composed of a main window displaying the 3D Earth and the satellite(s). Pop-up windows allow to configure and control the simulation interactively.

A typical mission can include several satellites each one driving its dedicated satellite engine. Only one Celestial engine is necessary to drive the Earth rotation, Sun and Moon positions.

The application makes use of the EO CFI version 4.0 simulation libraries to drive the satellite(s) orbital parameters, instruments swath behavior and celestial objects.

1.2 System Requirements

The AIR²EO application version 2.0.38 runs under Windows XP and requires a graphical board NVIDIA GeForce GTX 260.

1.3 Authorized Use Permission

The AIR²EO application has developed in the frame of an ESA contract. The executable code of the application can be distributed freely without any restrictions conditioned to ESA's approval.

1.4 Point of Contact

For additional information and user support, please contact the ESA ESTEC EOP System Support Team:

air2eo@jw.[estec.esa.nl](mailto:air2eo@jw.estec.esa.nl)

1.5 Acronyms and Abbreviations

| | |
|------------------|---|
| AIR ² | Advanced Interactive Real Time Renderer |
| ALT | Altitude |
| ANX | Ascending Node Crossing |
| EOCFI | Earth Observation Customer Furnished Item |
| EO | Earth Observation |
| ESA | European Space Agency |
| ESTEC | European Space Technology and Research Centre |
| GMT | Greenwich Mean Time |
| GS | Ground Station |
| H/W | Hardware |
| I/F | Interface |
| LAT | Latitude |
| LNG | Longitude |
| N/A | None Applicable |
| POI | Point Of Interest |
| POS | Position |
| SMOS | Soil Moisture and Ocean Salinity Satellite |
| UTC | Universal Time Coordinated |

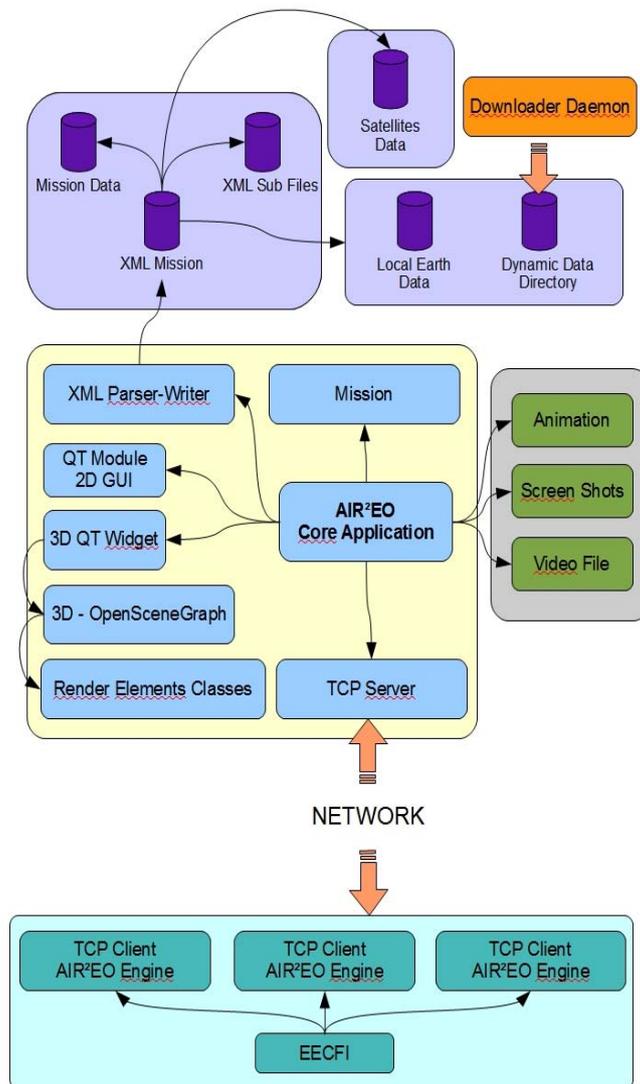
2 - SYSTEM SUMMARY

2 SYSTEM SUMMARY

2.1 System Configuration

The AIR²EO application is contained entirely within a single system (even a single machine). Local text files, databases and other data sources are used by the application during start-up and operation.

The application also supports communication with other machines via the network to receive input data such as simulation data and earth maps.



2.2 User Access Levels

No distinct user access levels are defined since under normal circumstances, AIR²EO activities should be completely transparent to its users.

Standard user should avoid modifying configuration and XML original mission files.

It is recommended to perform a backup of the mission reference files, prior to perform a simulation session.

System maintainers using or modifying AIR²EO database only require access to the AIR²EO/data directory.

3 - GETTING STARTED

3 GETTING STARTED

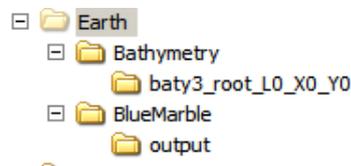
3.1 Installation Procedure

The system is composed of two main software elements: the AIR²EO application (main application and engines) and the Earth 3D database (Blue Marble and Bathymetry). Each component has to be installed separately.

3.1.1 Earth 3D Database

Copy the earth 3D database (46 GB) onto the computer hard drive in a dedicated directory (e.g. "Earth" folder).

The content of the Earth 3D database shall be structured as follow:



3.1.2 AIR²EO Application

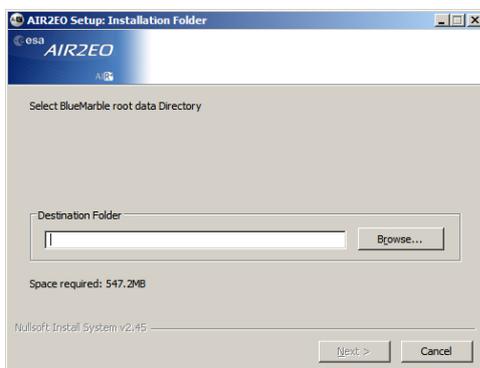
Install the AIR²EO application from the AIR²EO CD onto the computer hard drive. Make sure that the required disk space is available (1 GB).

Note that it is not possible to run the program from the CD.

Follow the on-screen installation instructions.

The standalone installer installs the AIR²EO application and all the associated data except the Earth 3D database.

Although the Earth 3D database needs to be copied manually (as already indicated above), the location of the Blue Marble and Bathymetry databases has to be specified during the installation process.



The Blue Marble destination folder must be identical to the one defined during the earth 3D database installation, i.e. BlueMarble.

Perform the same operation for the destination folder of the Bathymetry database.

3.2 Starting the Application

3.2.1 AIR²EO Main application

Double click on the AIR²EO icon on the user's desktop or via the window start menu.

3.2.2 Satellite Engine

Once the AIR²EO main application is loaded (i.e. appearance of the AIR²EO main window), double click on the SatelliteEngine icon on the user's desktop.

Click on button <Connect to AIR²EO>.

See Section 5.2.1 for further information about how to configure the Satellite Engine.

3.2.3 Celestial Engine

Once the AIR²EO main application is loaded (i.e. appearance of the AIR²EO main window), double click on the CelestialEngine icon on the user's desktop.

Click on button <Connect to AIR²EO>.

3.2.4 Load a Mission

Goto AIR²EO main window menu File > Open

Select a <mission file name>.xml file

Check the appearance of the mission splash screen during loading.

Check the appearance of the 3D scene.

Check that the illumination conditions of the 3D scene (Earth attitude and -Sun position) are active.

3.3 Exit the Application

To exit the AIR²EO application go to menu File > Exit.

The application can also be terminated by typing <ctrl + Q> or by closing AIR²EO main window with the X button.

4 - USING THE APPLICATION

4 USING THE APPLICATION

The typical actions performed to start a simulation session are described hereunder:

4.1 Load a Mission

To load a mission do one of the following:

- Choose the menu item File > Open... or
- recent files Menu File > <number> <mission file name.xml> or

- Select the application toolbar element  (equivalent to Open)

4.2 Define a New Mission

A new mission cannot be defined from scratch. Therefore an existing mission file must be used and customized.

The customization can be performed in two ways:

4.2.1 Via the user interface

All mission parameters can be customised via the user interface, except for the following parameters which can only be edited in main mission.xml file:

```
<Header>
  <Description>Mission SMOS</Description>
  <Author>Silicon Worlds</Author>
  <CreationDate>16/05/2010 10:00:00</CreationDate>
  <LastChangeDate>18/05/2010 11:23:54</LastChangeDate>
  <StartTime>15/05/2010 16:48:00</StartTime>
  <SplashScreen>splash.png</SplashScreen>
  <TimeSpeed>1</TimeSpeed>
</Header>
```

4.2.2 Via the XML file

Off line, edit the <mission.xml> and <mission>/*.xml sub files with a text editor.

Warning – modifying the .xml file may induce errors. The .xml parser does not perform checks on file content consistency.

Save a Mission

To save a mission do one of the following:

- Choose menu item File > Save
- Choose menu item File > Save as or

- Select the application toolbar element  (equivalent to Save) or

- Exit the application  and click Save.

5 - USER INTERFACE DESCRIPTION

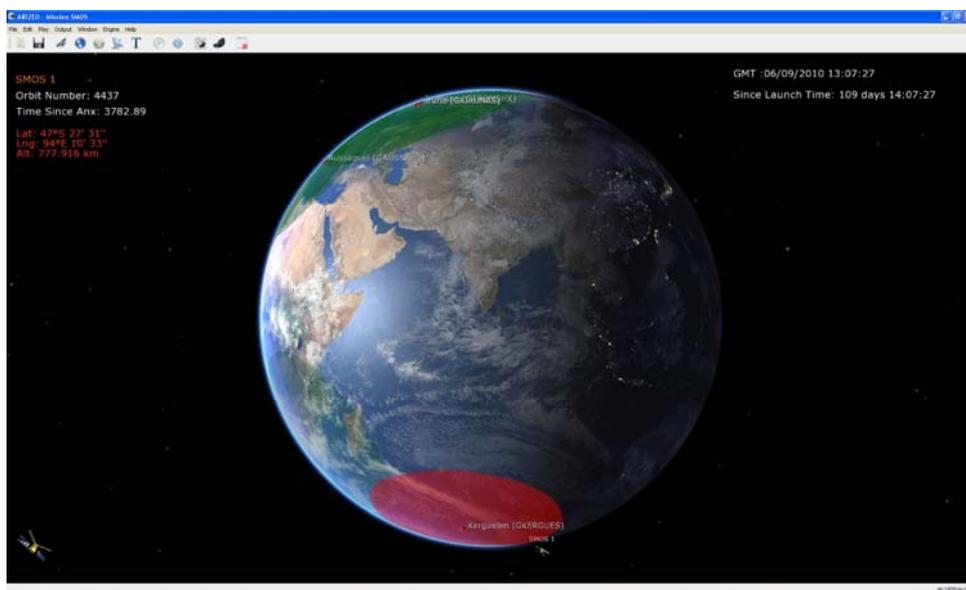
5 USER INTERFACE DESCRIPTION

The AIR²EO work area consists of the main application window with a set of toolboxes, the EO/CFI Satellite Engine control window(s) and the Celestial Engine control window. This - section describes the basics of navigating the work area and the content of the different tool boxes.

5.1 Main Window

The application main window includes a menu bar and a tool bar - at the top of the 3D window display.

The 3D window display is automatically adjusted to the resolution of the user's primary screen. Under Full screen mode (shortcut <ctrl + F>), the Menu and Tool bars are hidden and can be displayed by using the keyboard shortcuts <ctrl + M> and <ctrl + T>.



Main window



Menu and Tool bars

The Tool bar can be detached from the main window and relocated on the user's desktop.



Open – Select and load a mission



Save – overwrite current mission



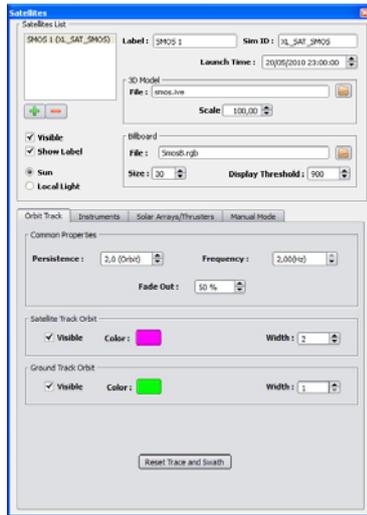
Close – all open tool boxes

All other icons call specific tool boxes. Each tool box appears as a pop up window, which can be relocated on the user's desktop. The description of all the tool boxes is provided in the following -sub-sections.

5.1.1 Satellites



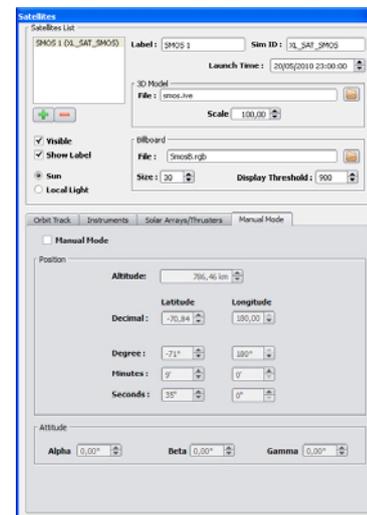
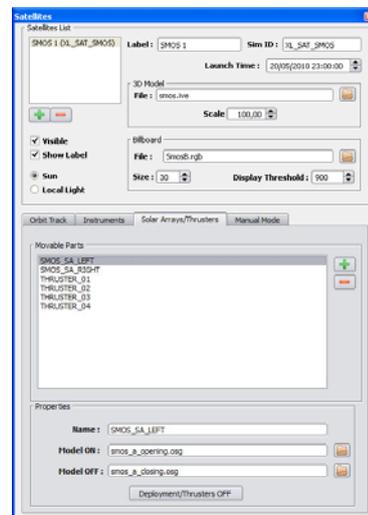
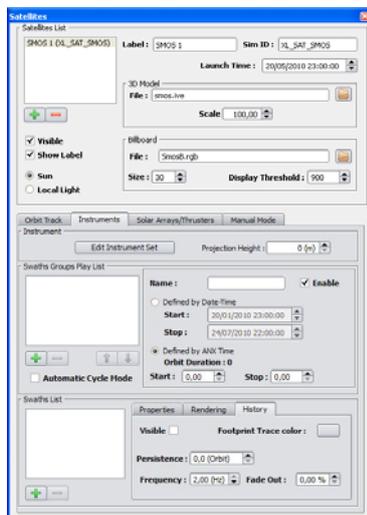
The “Satellites” tool box allows importing and setting up the satellite(s) for a given mission. Graphic attributes definition for the orbit track and the set up of the satellite instruments and movable parts are covered by the tool box.



The “Label” is used as the satellite name displayed in the 2D / 3D window. The “Sim ID” is used by the EO CFI satellite engine and *must be consistent with the satellite ID enumeration values provided in the EO CFI documentation.*

The 3D Model is the geometrical representation of the satellite to be selected from the database and is loaded in the 3D scene.

The billboard is a 2D image representing the satellite used in the 2D scene and in the 3D scene depending on the camera distance (i.e. Display Threshold setting).



After selecting a satellite the user can define a list of instruments by pressing the <Edit Instrument Set> button. A swath list can be attached to each instrument. Each swath is driven by the EO CFI engine via the swath <file name>. The file name used must be presented in the sub directory SDF (ENGINES/SIM/<sat name>/SDF).

After having defined the swaths, the user can establish a group of swaths to be active. A <Swaths Groups Play List> can be established, with an active time period defined either by a Start Stop Date Time period or by a duration within the orbit.

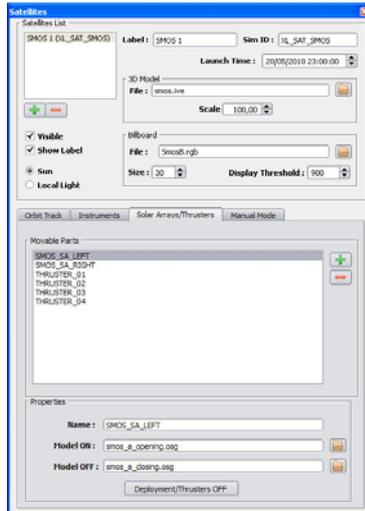
The swath <Status> can either be:

Not Initialized –

- EOCFI Satellite Engine error
- EOCFI Satellite Engine not running
- Swath Filename not found

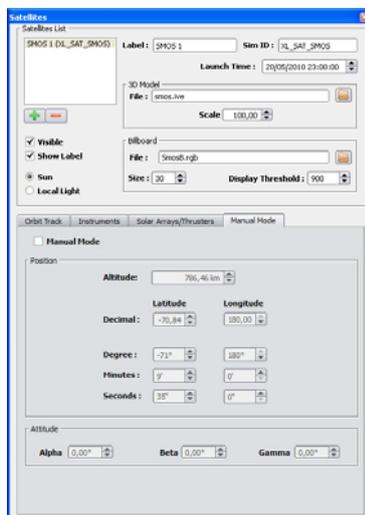
Valid – driven by EOCFI Satellite Engine

To avoid geometrical co penetration between the swaths and the earth model, the user can adjust the swaths projection height over the earth (distance in meters from the earth surface).



Movable parts are defined as animated 3D geometrical objects (e.g. solar panel, antenna, thruster plume) which can be driven by a dedicated predefined animation sequence (.ani file).

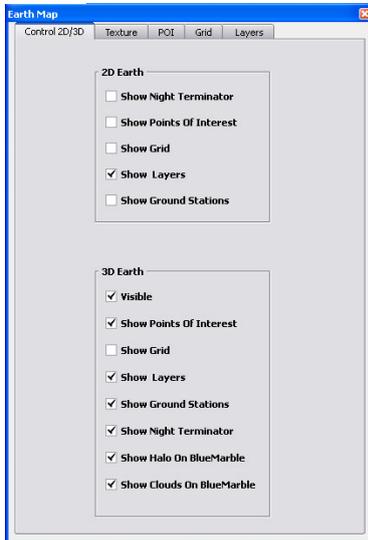
The user must first declare a moveable part by its identification <name> identical to the one used in the .ani file. Then the corresponding 3D geometrical objects (.osg file) are linked to the animation.



The user can position and orientate manually the satellite in the 3D scene.

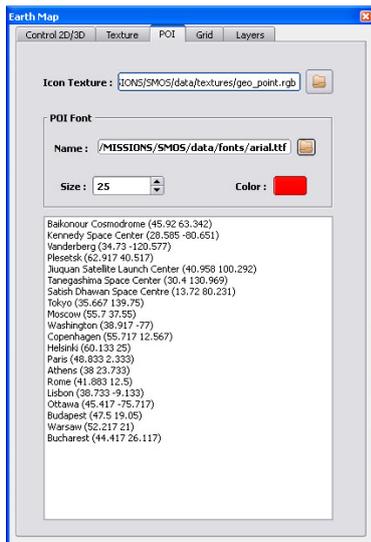
Under Manual Mode, the satellite is static and cannot be driven by the EOCFI Satellite Engine.

5.1.2 Earth

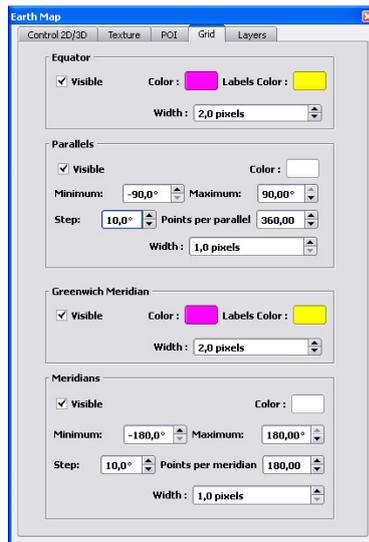


The “Earth” tool box allows importing and activating the various earth graphical attributes (earth map texture, points of interest, grid and layers).

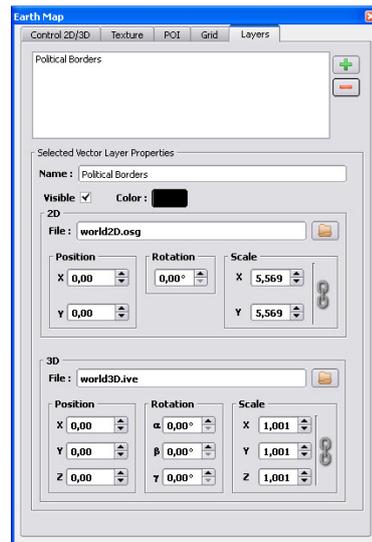
Earth attribute display can be controlled manually and independently for the 2D and the 3D earth.



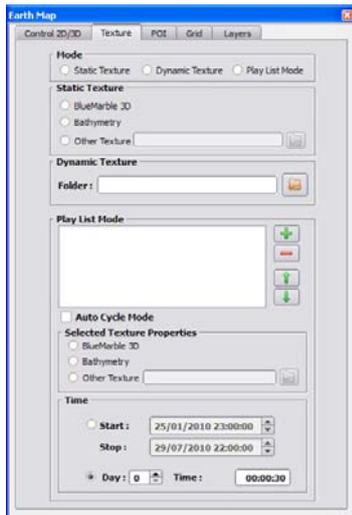
POI – A predefined POI list is part of the application. *The POI list cannot be edited from the tool box (see section 6.1).* The POI icon and font can be changed.



Grid - A grid, representing the parallels and meridians can be overlaid on the 2D and 3D earth. The graphical attributes and grid spacing can be adjusted.



Layers - Vector layer can be imported and overlaid on the 2D and 3D earth. The file formats accepted are either .osg or .ive. *The suitable projection required is under the user's responsibility (flat or spherical).*



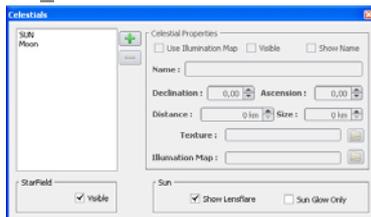
3 different modes to display earth textures are available:

Static Texture - A define texture is manually selected and loaded.

Dynamic Texture - The application automatically checks for a new texture in a defined folder and load it.

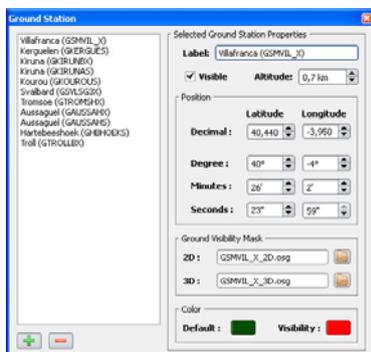
Play List - The user can define a list of textures to be displayed for a given time period or duration.

5.1.3 Celestials



The Sun and Moon celestial objects are mandatory and cannot be deleted. The user can define a new celestial object, which will be displayed as a billboard using a texture and an illumination map. The new celestial object can be positioned at a defined distance with respect to the earth reference.

5.1.4 Ground Stations



A list of ESA pre-defined Ground Stations are part of the database. The user can add a new GS in the list or delete any GS from the list.

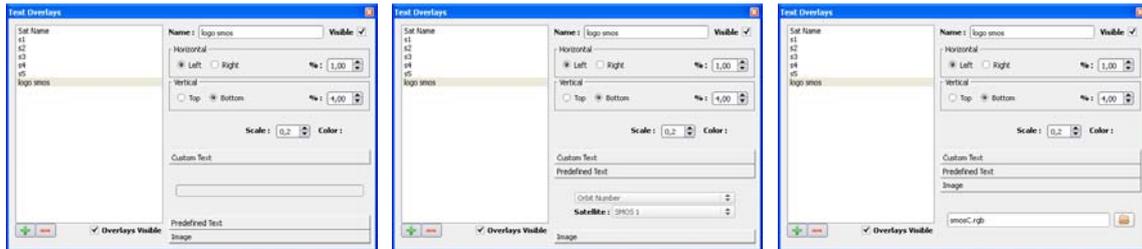
Warning - The position parameters are only applicable to the GS label. The Ground Visibility Mask position is defined within the mask data, which is a 3D model already projected.

5.1.5 Text Overlays



2D text and image can be overlaid on the main window display. The position, the size and the color are user defined. 3 types of overlay can be selected:

- Custom Text* – any alpha numerical character
- Predefined Text* – list of predefined dynamic text string (e.g. orbit number)
- Image* – any image (e.g. logo)



5.1.6 Time Control



The user can play / pause the simulation session.

By adjusting the <Time Factor> the user can accelerate the simulation.

The <Update> is the simulation data request rate from AIR²EO main application to the EO/CFI satellite engine(s). The <Update> value sets the upper limit for the <Orbit Track Frequency> and the <Swath List History Frequency> defined in the satellite tool box.

The <Start Time> date can be manually set or forced to the user's computer <System Time>. The user must press the <Apply Start Time> button to pass the data to the current simulation session.

5.1.7 Status



| Engine | Object | Status | Pos | Altitude | Swath | Message |
|-----------------|-----------|--------|-----|----------|-------|--------------|
| EOCFI_ENGINE_V1 | S-MORS 1 | ● | ● | ● | ● | Disconnected |
| EOCFI_ENGINE_V1 | S-MORS 1 | ● | ● | ● | ● | Connected |
| EOI_ENGINE_V1 | Celestial | ● | ● | ● | ● | Connected |

The link and the parameters exchange status between the AIR²EO main application and the engines are displayed in the "Status" tool box.

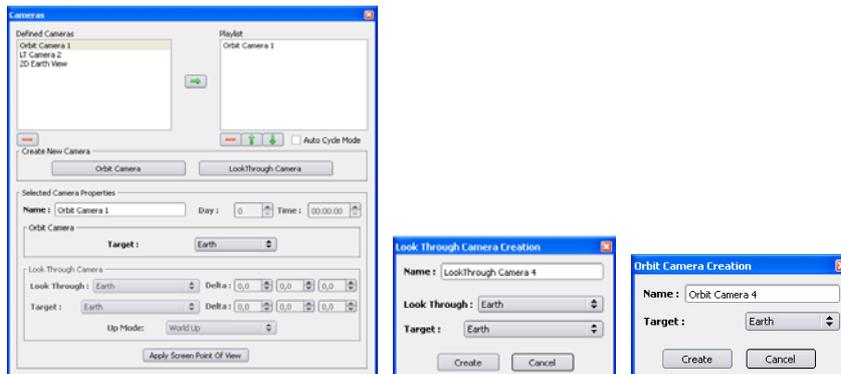
5.1.8 Camera Animation



During a simulation session, the user can record the current camera path at any time.

The user playback any saved camera animation. During the playback the user can interact with any simulation parameters except for the cameras settings.

5.1.9 Cameras



3 types of camera can be selected:

Orbit Camera – an attached camera moving freely around its defined <target>. The distance can be adjusted by using the right mouse button

LookThrough Camera – an attached camera to a defined <target> looking through a defined <Look Through> object. The distance can be adjusted by using the right mouse button. The camera can be off set using the <Delta> parameters.

2D Earth View – a predefined camera used for the 2D display mode. This camera is fixed and cannot be modified.

The procedure to define a new camera is as follow:

- select a camera type <Orbit Camera> or <LookThrough Camera>
- adjust the corresponding parameters
- use the mouse to modify the camera position and orientation (if applicable)
- apply the current camera parameters changes by pressing the <Apply Screen Point of View> button.

The parameters of an existing camera can be modified applying the procedure as described above.

5.1.10 Keyboard Shortcut

Keyboard shortcuts are included in the application. Type <H> on keyboard to display the shortcut function as overlay on the main window.

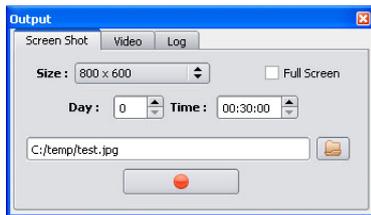
The keyboard shortcut functions are:

| | |
|-------------|--------------------------------------|
| <ctrl + F > | Toggle Full Screen / Window Mode |
| <ctrl + M > | Toggle Menu Visibility |
| <ctrl + Q > | Exit AIR ² EO application |
| <ctrl + T > | Toggle Tool Bar visibility |
| <S> | Show graphic statistics |
| <H> | Display keyboard shortcut functions. |

5.1.11 Recording

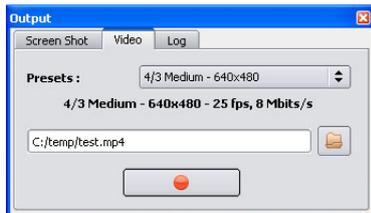
The application allows to record / output data for data analysis and distribution. The user can define the recording settings by editing the <OutputConfig.xml> configuration file. Preset settings have been defined.

5.1.11.1 Fixed image



Automatically captured snapshots of the main window display can be triggered at a given rate. The maximum resolution supported is 1920 x 1080. The image file formats supported are: jpg, bmp, png, tga.

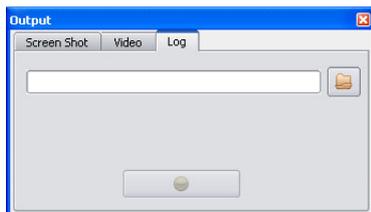
5.1.11.2 Video sequence



Video sequences of the main window display can be recorded in different predefined video formats described in the <OutputConfig.xml> configuration file.

The video resolution may have an impact on the application performances and on disk storage capability. The maximum video resolution supported is 1280 x 720 (HD Ready).

5.1.11.3 Log file



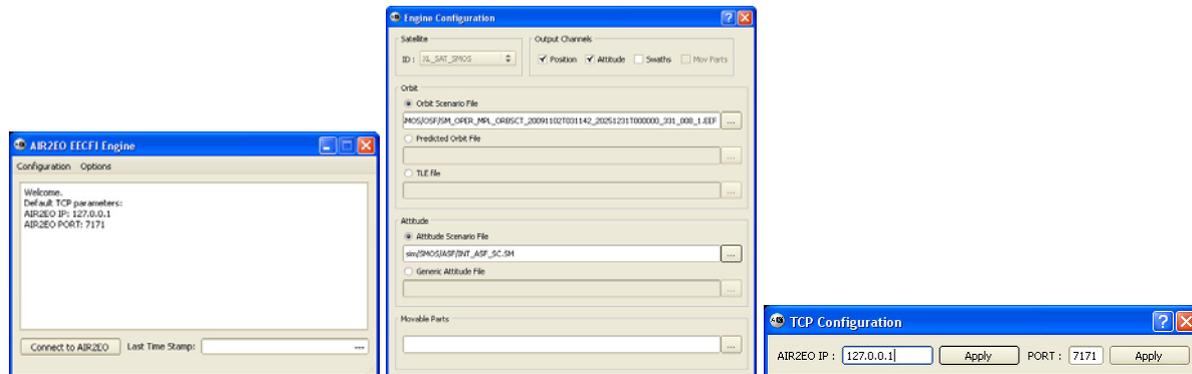
The log file includes:

- simulation time (reference J2000)
- satellite position (long, lat, alt)
- satellite attitude (quaternion).

5.2 Engine Interface

5.2.1 Satellite Engine

The Satellite Engine input data can be set by selecting the menu item Configuration > Show



The <Satellite> <ID> shows the list of satellites defined in the current mission.xml file.
The user selects the satellite to be driven.
The user **must** select an <Orbit> file type:

- Orbit Scenario File* – select an ESA predefined file from the OSF sub directory
- Predefined Orbit File* – select an ESA predefined file from the POF sub directory
- TLE File* – select a-predefined file from the TLE sub directory.

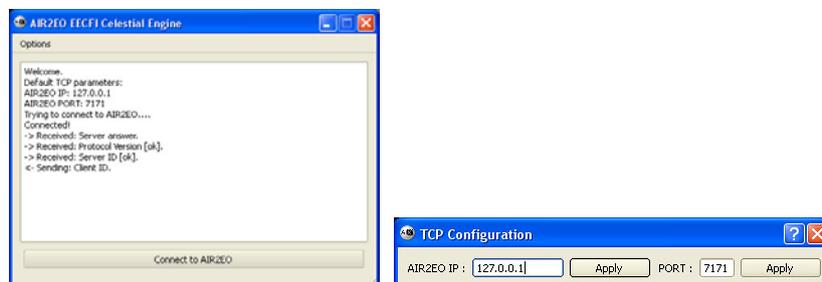
The user can select an <Attitude> file type:

- Attitude Scenario File* – select an ESA predefined file from the ASF sub directory
- Generic Attitude File* – select an ESA predefined file from the ATT sub directory.

The user can select <Movable Parts> file from the ANIM sub directory.

The user can enable / disable the defined output channels (Position, Attitude, Swath and Movable Parts).

5.2.2 Celestial Engine



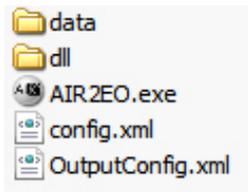
6 - REQUIRED RESOURCES

6 REQUIRED RESOURCES

The AIR²EO application requires a number of configuration and data file to be available. The tables hereunder list the various files and their content for the AIR²EO and the ENGINES.

6.1 AIR²EO Application Data Files

The executable and the configuration files are at the top of the AIR²EO directory.

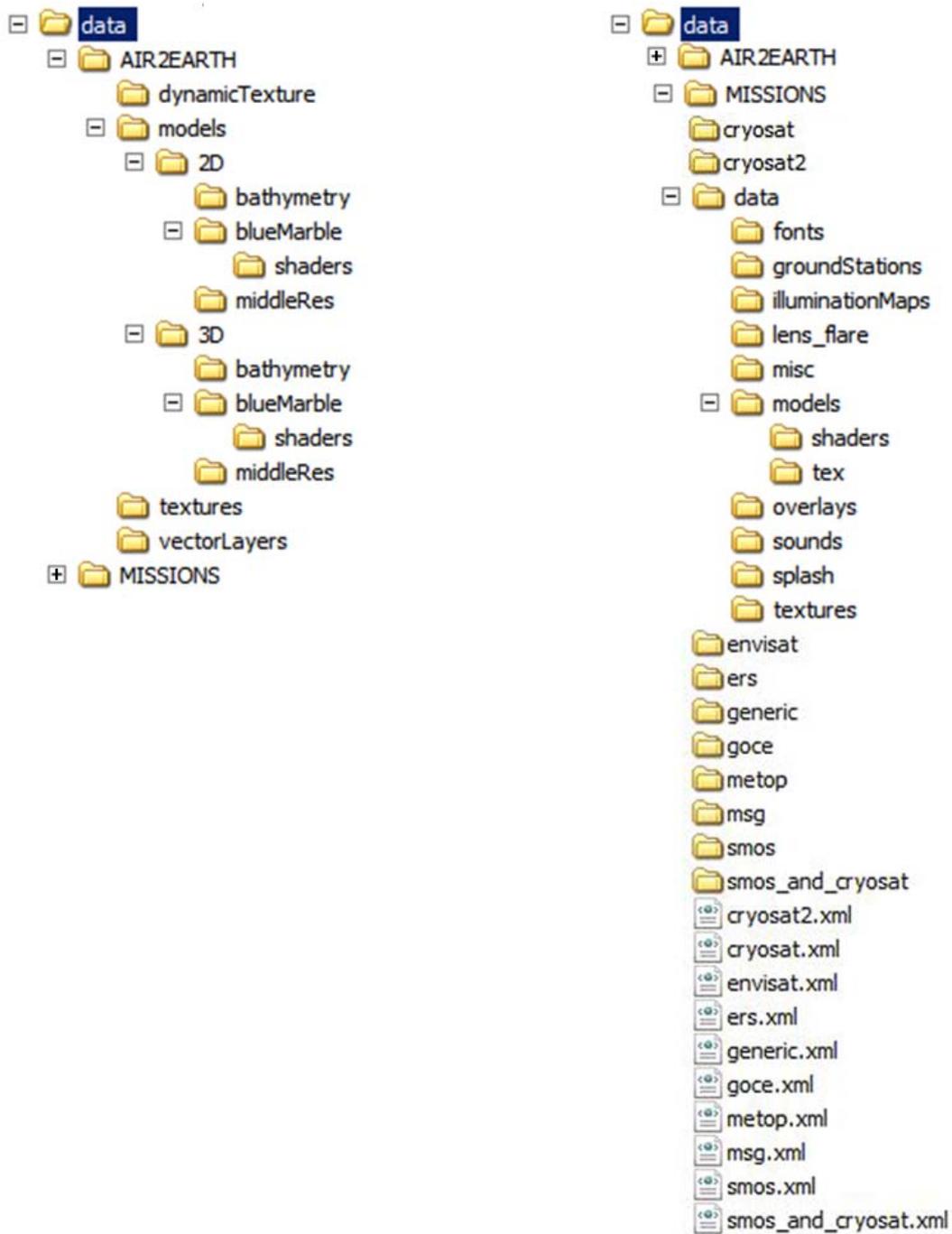


| | |
|--|-----------------------------------|
| | Any user can edit content |
| | Only specialists can edit content |
| | Do not edit content |

| AIR2EO | | |
|------------------|--|--------|
| Directory / File | Description | Access |
| AIR2EO.exe | Executable file. Start AIR ² EO main application | |
| config.xml | Internal paths pointing to Earth models | |
| OutputConfig.xml | Screen Shots and Video presets used by AIR ² EO output pop up menu | |
| dll | Contains all necessary dll files, including OpenSceneGraph libraries and other third party files | |
| data | All data used by AIR ² EO – see detailed description below | |

The data directory includes two main sub directories:

- AIR2EARTH which contains all the elements related to the earth display
- MISSIONS which contains all the required elements to simulate and display a specific mission.



| AIR2EARTH | | |
|----------------------|---|--------|
| Directory | Description | Access |
| dynamicTextures | Textures used in Dynamic Texture mode (only last texture is used) | |
| models | Flat and geoid Earth models | |
| models/2D | Flat Earth models | |
| models/2D/bathymetry | Flat Bathymetry Earth model | |
| models/2D/blueMarble | Flat Blue Marble Earth model | |
| models/2D/middleRes | Flat Earth model use in “other texture“ mode | |

| AIR2EARTH | | |
|----------------------|--|---|
| Directory | Description | Access |
| models/3D | Geoid Earth models |  |
| models/3D/bathymetry | Geoid Bathymetry Earth model |  |
| models/3D/blueMarble | Geoid Blue Marble Earth model |  |
| models/3D/middleRes | Geoid Earth model use in "other texture" mode |  |
| textures | Textures usable in playlist and "other texture" mode |  |
| vectorLayers | Vector data visible on Earth (Flat and Geoid) |  |

| MISSIONS | | |
|-----------------------|---|---|
| Directory / File | Description | Access |
| cryosat.xml | Main CRYOSAT xml mission file, calling files in "cryosat" folder |  |
| envisat.xml | Main ENVISAT xml mission file, calling files in "envisat" folder |  |
| ers.xml | Main ERS xml mission file, calling files in "ers" folder |  |
| generic.xml | Main GENERIC xml mission file, calling files in "generic" folder |  |
| goce.xml | Main GOCE xml mission file, calling files in "goce" folder |  |
| metop.xml | Main METOP xml mission file, calling files in "metop" folder |  |
| msg.xml | Main MSG xml mission file, calling files in "msg" folder |  |
| smos.xml | Main SMOS xml mission file, calling files in "smos" folder |  |
| smos_and_cryosat.xml | Another main xml mission file, calling files in "smos_and_cryosat" folder, describing a mission with SMOS and CRYOSAT |  |
| cryosat | Sub xml files, called by the main cryosat.xml mission file |  |
| envisat | Sub xml files, called by the main envisat.xml mission file |  |
| ers | Sub xml files, called by the main ers.xml mission file |  |
| generic | Sub xml files, called by the main generic.xml mission file |  |
| goce | Sub xml files, called by the main goce.xml mission file |  |
| metop | Sub xml files, called by the main metop.xml mission file |  |
| msg | Sub xml files, called by the main msg.xml mission file |  |
| smos | Sub xml files, called by the main smos.xml mission file |  |
| smos_and_cryosat | Sub xml files, called by the main smos_and_cryosat.xml mission file |  |
| data | Global data folder for missions |  |
| data/fonts | Usable fonts for HUDs |  |
| data/groundStations | Ground Stations visibility masks 3D and 2D models |  |
| data/illuminationMaps | Textures used to describe illumination model on celestial billboards |  |
| data/lens_flare | Textures used to draw lens artifacts |  |
| data/misc | Contains Star catalogue and POI catalogue |  |
| data/models | Satellites and movable parts 3D models |  |
| data/overlays | Textures usable as HUDs |  |
| data/sounds | N/A | N/A |

| MISSIONS | | |
|-------------------------|---|---|
| Directory / File | Description | Access |
| data/splash | Per mission Splash Screen |  |
| data/textures | Satellites billboards and celestials textures |  |
| data/splash | Per mission Splash Screen |  |
| data/textures | Satellites billboards and celestials textures |  |

To modify a mission splash screen, the user shall edit the main xml file related to the mission, and change the parameter between `<SplashScreen>` tags. The specified file must be an existing texture file in the data/splash directory.

For example, the SMOS mission, included in the setup package, is defined by its main xml file "smos.xml", containing :

```

<Header>
  <Description>Mission SMOS</Description>
  <Author>Silicon Worlds</Author>
  <CreationDate>29/07/2010 10:00:00</CreationDate>
  <LastChangeDate>30/08/2010 17:14:51</LastChangeDate>
  <StartTime>15/05/2010 16:48:00</StartTime>
  <TimeSpeed>1</TimeSpeed>
  <SplashScreen>splash.png</SplashScreen>
</Header>

```

Note that the user can edit manually any parameter of the header.

To modify the POI catalogue, the user can directly edit the data/misc/esa_sites.conf file, or create a new file based on the same model, place the file in data/misc directory, and modify the parameter in planet.xml (sub xml file in related mission directory) between `<Configuration>` tags.

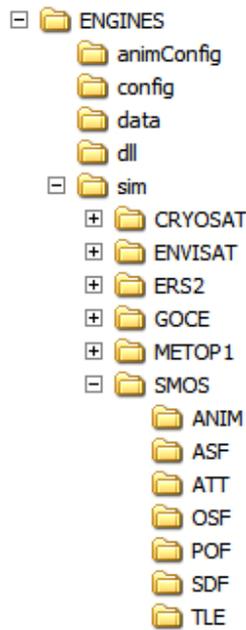
For example, the SMOS mission included in the setup package contains a planet.xml file with:

```

<POI>
  <Configuration>esa_sites.conf</Configuration>
  ...
</POI>

```

6.2 Engines Data Files



6.2.1 Definition

| ENGINES | | |
|---------------------|---|----------|
| Directory / File | Description | Access |
| CelestialEngine.exe | executable file. Launches Engine driving Earth, Moon and Sun | ████████ |
| SatelliteEngine.exe | executable file. Launches a satellite engine | ████████ |
| animConfig | Automatically saved configurations when using camera animation in AIR2EO main application | ████████ |
| config | Configuration files saved by user to define a satellite simulation | ████████ |
| data | Bulletin B Mod file used by EECFI | ████████ |
| dll | All necessary dlls, including EECFI modules | ████████ |
| sim | This Folder contains all EECFI files usable to describe satellites simulation | ████████ |
| sim/SMOS/ANIM | Ascii files defining movable parts states based on time | ████████ |
| sim/SMOS/ASF | Put here EECFI Attitude ScenarioFiles | ████████ |
| sim/SMOS/ATT | Put here EECFI Generic Attitude Files | ████████ |
| sim/SMOS/OSF | Put here EECFI Orbit Scenario Files | ████████ |
| sim/SMOS/POF | Put here EECFI Predicted Orbit Files | ████████ |
| sim/SMOS/SDF | Put here EECFI Swath Definition Files | ████████ |
| sim/SMOS/TLE | Put here ASCII files containing TLE data | ████████ |

6.2.2 Animation file example

The format of the .ani file, an Ascii file defining movable parts based on mission time, is as follows:

| 7 | | | | | | |
|------------|-------------|-------------|-------------|-------------|--------------|---------------|
| Time | THRUSTER_01 | THRUSTER_02 | THRUSTER_03 | THRUSTER_04 | SMOS_SA_LEFT | SMOS_SA_RIGHT |
| 3662.43480 | 1 | 0 | 0 | 0 | 0 | 0 |
| 3662.43484 | 0 | 1 | 0 | 0 | 0 | 0 |
| 3662.43485 | 0 | 0 | 1 | 0 | 0 | 0 |
| 3662.43486 | 0 | 0 | 0 | 1 | 0 | 0 |
| 3662.43487 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3662.43490 | 0 | 0 | 0 | 0 | 1 | 0 |
| 3662.43500 | 0 | 0 | 0 | 0 | 1 | 1 |
| 3662.43510 | 0 | 0 | 0 | 0 | 0 | 1 |
| 3662.43520 | 0 | 0 | 0 | 0 | 0 | 0 |

The first line defines the number of columns in the file.

The time corresponds to the mission time at which the animation of the movable part will be executed.

The identification <name> of the “movable part” shall be identical as the one defined in the dialog box of the GUI.

The trigger of the “movable part” is a Boolean (ex. 0 = off 1 = on for a thruster or 0 = stowed and 1 = deployed for a solar panel).