SYSTEMA V4

Migration manual

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1 Introduction

This document is a support for all Systema users that wish to migrate from:

- 4.8.3 Version to the 4.9.0.
- 4.9.0 Version to the 4.9.1
- 4.9.1 Version to the 4.9.2
- 4.9.2 Version to the 4.9.3
- 4.9.3 Version to the 4.9.4

This document does not intend to present the numerous new features proposed by the new releases of Systema. If you wish to learn more about that, please refer to the Systema release notes (in ${SYSTEMA_HOME}/doc).

2 Systema 4.8.3 to 4.9.0

2.1 Trajectory

2.1.1 Physical models

Systema 4.9.0 embeds Orekit library 10.1.

This library relies on some external data for physical models. Typical data are the Earth Orientation Parameters and the leap seconds history, both being provided by the IERS or the planetary ephemerides provided by JPL or IMCCE.

Default configuration of Orekit in Systema uses JPL DE 430 ephemerides from 1550 to 2650, IERS Earth orientation parameters from 1973 (both IAU-1980 and IAU-2000), UTC-TAI history from 1972, Marshall Solar Activity Futur Estimation from 1999, the Eigen 06S gravity field and the FES 2004 ocean tides model.

2.1.2 Frames

The default Earth inertial reference frame is Veis1950. This frame is similar to the Gamma50 frame definition used by Systema prior to 4.9.0.

The Systema J2000 frame is an acronym of the EME2000 reference frame.

2.1.3 Propagation

Systema propagation model is a custom propagator based on the Orekit Keplerian analytic propagator. To be retro-compatible with Systema 4.8.3, the custom model in Systema 4.9.0 considers the J2 potential zonal coefficient

2.1.4 Time scale management

The time scale reference used by Orekit in Systema is Universal Time Coordinate.

UTC is mainly related to TAI, but some step adjustments are introduced from time to time to keep take into account Earth rotation irregularities and to prevent the *legal* time from drifting with respect to day and night. These adjustments require introduction of leap seconds, which means some days are not 86400 seconds long (see https://en.wikipedia.org/wiki/Leap_second).

The impact is negligible for trajectories propagation.

2.1.5 Eclipses detection

Eclipses detection (entering and leaving penumbra and umbra) is done by Orekit. The detection considers the flattening of the occulting bodies.

Because of this, with the use of ephemerides files, and with the integration of the leap seconds from the time scale management, eclipses event dates and durations can be slightly different from Systema 4.8.3.

Depending of the parameters of the trajectories used, the range of differences is of the order of a hundred milliseconds to a few seconds (± 15sec) for duration of eclipses.

2.1.6 Earth and Mars position

The position of Earth and Mars are now precisely computed thanks to the ephemeris files by Orekit. Consequently, the celestial bodies Earth_2020, Earth_2030 , Earth_2040 and Mars_2030 provided in Systema 4.8.3 have been removed from Systema 4.9.0.

To ensure backward compatibility, trajectory files containing reference to Earth_2020, Earth_2030 , Earth_2040 or Mars_2030 are automatically replaced by Earth or Mars in Systema 4.9.0.

2.1.7 Jovian and Martian moons

The satellite positions are calculated using mean orbitals parameters. This is approximation of the general shape and orientation of the planetary satellite's orbit. An accurate ephemerides need to be used for precise celestial body orbitals parameters. Mean orbits parameters provided here come from the Planetary Satellite Mean Orbital Parameters (https://ssd.jpl.nasa.gov/?sat_elem).

To ensure retro-compatibility with Systema 4.8.3, the means parameters has been taken at 04/01/2031 for Callisto, 10/01/2030 for Europa, 12/10/2032 for Ganymede and 07/01/2024 for Phobos.

2.1.8 Planet velocity display

The velocity of a planet can be displayed in a trajectory or mission 3D view thanks to a textual information. Since Systema 4.9.0, the vector is computed in the Sun inertial frame whereas it was computed in the ecliptic plane before.

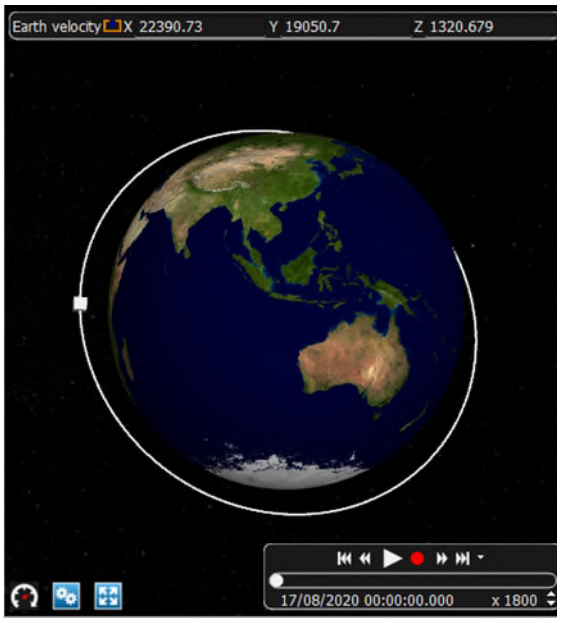


Figure 1 - Systema-4.9.0 - Earth velocity 17/08/2020 00:00:00.000

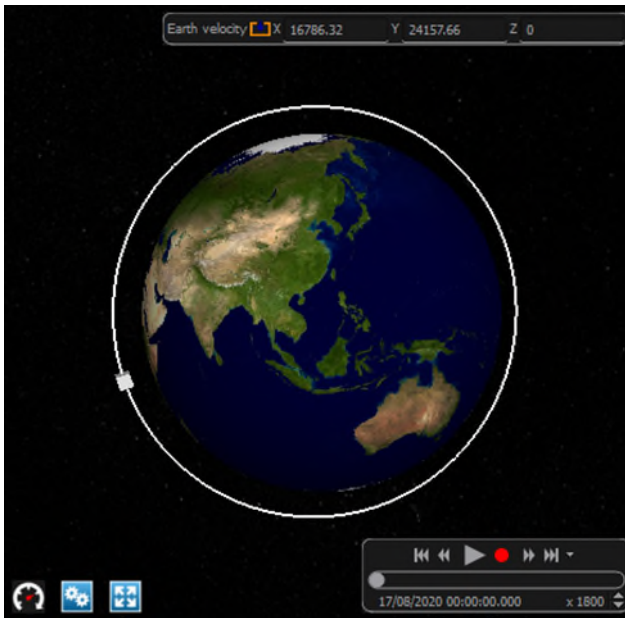


Figure 2 - Systema-4.8.3 - Earth velocity 17/08/2020 00:00:00.000

Please note that the norm of both vectors is similar.

2.2 Miscellaneous

2.2.1 Settings/Profile mechanism

Profiles are stored as .ini files in the directory where persistent application data can be stored. For instance:

- $HOME/.local/share/data/Airbus Defence And Space/Systema/profiles on Linux
- %HOMEDIR%\AppData\Local\Airbus Defence and Space\Systema\profiles on Windows

To use profiles available in SYSTEMA_INSTALL_DIR/data/profiles or provided by other poeple, please use the “Import” function available in “Manage profiles” dialog.

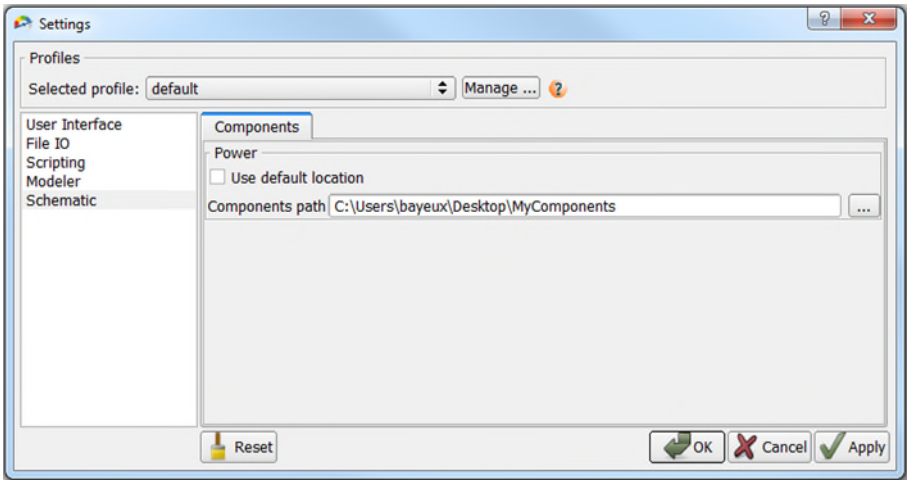
2.3 Power application

2.3.1 Settings and environment variables

It is now possible to load another component library by setting an environment variable:
It is also possible to load another component library by using the File/Settings option of the menu bar:

SYSTEMA_COMPONENTS_PATH = path allows to define the path where the components are stored (this also requires a restart of Systema)

- Click File/Settings in the menu bar
- Click on “Schematic” in the settings list
- Unselect “Use default location”
- Choose your own components path
- Apply



Warning:

- In all cases it is then necessary to restart Systema in order to load the components corresponding to the modified path.

- if the environment variable SYSTEMA_COMPONENTS_PATH is set, the component path specified in the settings is no more taken into account. Please unset the environment variable to use the components path defined in the settings.

2.3.2 Component library

In the previous versions, some basic components were directly included in the Power application and they could be used without any powcmp file. These were the following components:

- Resistance
- Diode
- Switch
- Isource
- PowerLoad
- Heater
- Vdrop
- Vsource
- Capacitance
- Self
- Integrator
- Comparator

Other "external" components (defined by a powcmp file) could be added by the user to enrich the library.

In the 4.9.0 version, all the available components are defined by a powcmp file so that the user can modify it if he wishes. In addition, the library of components directly supplied with the Power application has been extended. Here is the list of the components available in the 4.9.0 version:

Component in 4.9.0	***Equivalent component in previous versions***
Battery	-
Capacitor	Capacitance
Comparator	Comparator
Diode	Diode
Inductor	Self
Integrator	Integrator
Isource	Isource
Linear Regulation	-
MPPT	-
PowerLoad	PowerLoad
Resistance	Resistance
Shunt Regulator	-
Solar Array	-
Switch	Switch
Vdrop	Vdrop
Vsource	Vsource

In v4.9.0, it is still possible to access the basic components of the previous versions by adding the suffix "_Old" when calling the component. For instance, Resistance becomes Resistance_Old and Self becomes Self_Old. This is done only for convenience and validation issues but these components are now deprecated.

Several components have been modified in the 4.9.0 version compared to the previous versions (Name, parameters, default values …). The following table lists all the modifications. The red color indicates that the modifications cause down compatibility problems. Please refer to the next section for more details about down compatibility management.

Component in 4.9.0	*Modifications*
Battery	New component
Capacitor	Name of component, parameter description
Comparator	Default values
Diode	Deletion of a parameter Roff, default values
Inductor	Name of component, parameter name and description, default value
Integrator	parameter description, new parameter "Initial"
Isource	-
Linear Regulation	New component (parameter name different between internal and commercial libraries and new parameter "Delta V")
MPPT	New component (default values different between internal and commercial libraries)
PowerLoad	New parameter "Offset", new option txt input file
Resistance	-
Shunt Regulator	New component (name parameter, default value and parameter description different between internal and commercial libraries)
Solar Array	New component
Switch	parameter name, parameter description
Vdrop	-
Vsource	default value

2.3.3 Down compatibility issues

As some components have been modified, the down compatibility with the schematic file is not guaranteed. The user should rebuild the schematic from zero to be safe, instead of loading schematic from previous versions.

For very specific cases, if the user cannot rebuild the schematic from zero, a set of suitable components can be provided to ensure the down compatibility. Please contact the Systema support team to get these components (engineering.software@airbus.com).

Here is the process if the user wants to load a schematic (built in previous versions 4.8.X) in 4.9.0 and run the simulation:

- copy and paste the set of component "components_483_to_490" in the folder of components used for the simulation 4.8.X. If some components already exist, replace them with supplied components.
- Launch Systema-Power 4.9.0
- Use the file/settings option to change the path of the component folder. Choose the folder used for the simulation 4.8.X in which the “components_483_to_490” have been copied.
- Restart Systema-Power 4.9.0 to update the component library
- Load the schematic 4.8.X and run the process normally

3 Systema 4.9.0 to 4.9.1

3.1 Plumflow Interface

An option has been added in Systema 4.9.0 so that Plumflow interface module points either to a default location of the Plumflow V3 installation or to a user defined directory.

The default directory changed and is now SYSTEMA_INSTALLATION_PATH/applications/Plumflow-Interface-SYSTEMA_VERSION.

Plumflow V3 modules are now automatically installed in this folder.

Regarding the license, Plumflow V3 modules no longer need a V3 license file. The relevant tokens for Plumflow V3 modules must be provided in a V4 license file. Plumflow V3 modules require that the license file is located in SYSTEMA_HOME/licenses. If the SYSTEMA_HOME environment variable is not defined, it is automatically set to SYSTEMA_INSTALLATION_PATH by PlumflowInterface. For V3 modules, the length of any file path including the license file must be lesser than 80 characters.

4 Systema 4.9.1 to 4.9.2

4.1 Long term support release

Systema-4.9.2 is the new Long Term Support (LTS) version. Exporting files for the previous LTS version (4.8.3) is provided for any kind of Systema files as follows:

- Model
  - Conversion of radiative enclosures from string to integer. The value may be modified.
  - Grid help item conversion (removal of grid length and number of cells)
  - Suppression of transformations on cutters to avoid issue in Systema-4.8.3

- Meshing
  - Removal of solar lamp specific items for Thermica meshing

- Trajectory
  - Time position velocity arcs with ICRF data are removed. This conversion does not take into account the conversion of the external files (for instance, STK ephemerid file in ICRF ref frame)
  - Time position velocity arcs with Planet inertial data and earth centered are replaced by Gamma50/Veis1950 data
  - Time position velocity arcs with Planet inertial data and non-earth centered are removed

  Note that how trajectories are dynamically computed and the planet ephemerids provided by Orekit till Systema-4.9.0 are now exported.

- Kinematics
  - Kinematics bodies using ICRF axis pointing laws are removed
  - Ecliptic north kinematics laws are replaced by Gamma50 Z pointing laws
  - Kinematics bodies with 2 pointing vectors laws based on at least one ICRF axis are removed
  - Processing
  - Option “Processing Directory” used to build the result directory is replaced by “Default Result Directory”

To export a file into a previous version, please select “Export : SYSTEMA .. file – version 4.8.3 (*.sys…)” in the “Save as” file selection dialog. Moreover, downgrading a file requires also that this operation is also performed for all dependents files.

4.2 Reference frames

The supported reference frames in Systema are clarified to avoid confusion.

In Systema-4.9.2, J2000 and Gamma50/Veis1950 are now always Earth centered. Previously, the center was not clear for celestial bodies different from Earth. Thus, when importing trajectory files

with Time-Position-Velocity arcs from previous versions in Systema 4.9.2, the data format must be checked. There is not automatic modification.

The supported formats in Time-Position-Velocity format are now for cartesian position and velocity:

- “Cartesian position and velocity in Veis1950”: inertial reference frame. Earth centered. In previous version, it was "Cartesian position and velocity in planet inertial reference Gamma50". With the Python API, use “Cartesian G50” for this kind of data.
- "Cartesian position and velocity in planet inertial frame”: inertial reference frame. Orbit reference centered. In previous version, it was "Cartesian position and velocity in planet inertial reference J2000". With the Python API, use “Cartesian Planet Inertial” for this kind of data.
- "Cartesian position and velocity in J2000": inertial and earth centered reference frame. With the Python API, use “Cartesian J2000” for this kind of data.
- "Cartesian position and velocity in ICRF": inertial reference frame, solar system barycenter centered. With the Python API, use “Cartesian ICRF” for this kind of data.

When using a STK ephemeris file, CoordinateSystem is now taken into account as follow:

- B1950 : Veis1950
- J2000 : EME2000 (so earth centered in Systema). For STK it can be centered on another body defined by CentralBody field. This is ignored
- ICRF : ICRF (so solar systema barycenter centered in Systema). For STK it can be centered on another body defined by CentralBody field. This is ignored
- Other values or no header == Planet inertial (for compatibility purpose)

When using IDM-CIC OEM files, REF_FRAME keyword is taken into account as follow:

- EME2000 : EME2000
- ICRF : ICRF
- Other : Planet Inertial

In the mission log, M50 is replaced by (Planet Inertial). Note that the velocity in J2000 is now earth centered.

4.3 Kinematics

Until Systema-4.9.0, the Z directions of J2000 and Gamma50 were in fact oriented to the normal to the ecliptic plane. Thus, when importing kinematic files defined in the J2000 reference frame for example, the use of the "Orbit planet reference north direction" law was necessary. This confusion has been corrected in Systema-4.9.0 and as a result, it was no longer possible to point the ecliptic to the north.

The Ecliptic north law is now restored in Systema-4.9.2 and so can be used when migrating a kinematics file Systema-4.8.3 to Systema-4.9.2.

5 Systema 4.9.2 to 4.9.3

5.1 True anomaly computation

The accuracy of the true anomaly computation has been increased in Systema-4.9.3.

- The duration of trajectories defined prior to 4.9.3 with end date based on number of revolutions will be different in Systema-4.9.3
- The computation points defined in mission based on true anomaly step will be different in Systema 4.9.3.

Examples of difference between 4.9.2 and 4.9.3

- 4.9.2P1:
  - Sun synchronous
  - Mean solar time : 22:30:00.000
  - altitude : 800
  - Anomaly : 0
  - Reference date : 06/08/2018 00:00:00.000
  - Start date : 06/08/2018 00:00:00.000
  - End date : 1 revolution <-> **06/08/2018 01:40:55.999**

- 4.9.3:
  - Sun synchronous
  - Mean solar time : 22:30:00.000
  - altitude : 800
  - Anomaly : 0
  - Reference date : 06/08/2018 00:00:00.000
  - Start date : 06/08/2018 00:00:00.000
  - End date : 1 revolution <-> **06/08/2018 01:40:52.422**

- 4.9.2P1:
  - Keplerian
  - SMA : 15378.14
  - Excentricity : 0.5
  - Inclination : 99.4789
  - Raan : 0
  - Argument of Periapsis : 0
  - Anomaly : 0
  - Reference date : 09/05/2023 00:00:00.000
  - Start date : 09/05/2023 00:00:00.000
  - End date : 1 revolution <-> **09/05/2023 05:16:21.999**

- 4.9.3:
  - Keplerian
  - SMA : 15378.14
  - Excentricity : 0.5
  - Inclination : 99.4789
  - Raan : 0
  - Argument of Periapsis : 0

- Anomaly : 0
- Reference date : 09/05/2023 00:00:00.000
- Start date : 09/05/2023 00:00:00.000
- End date : 1 revolution <-> **09/05/2023 05:16:18.710**

For mission files, you can easily convert computation points based on the true anomaly to fixed dates one by using a python script provided in Systema 4.9.3. The conversion must be performed with a previous release such as Systema-4.9.2:

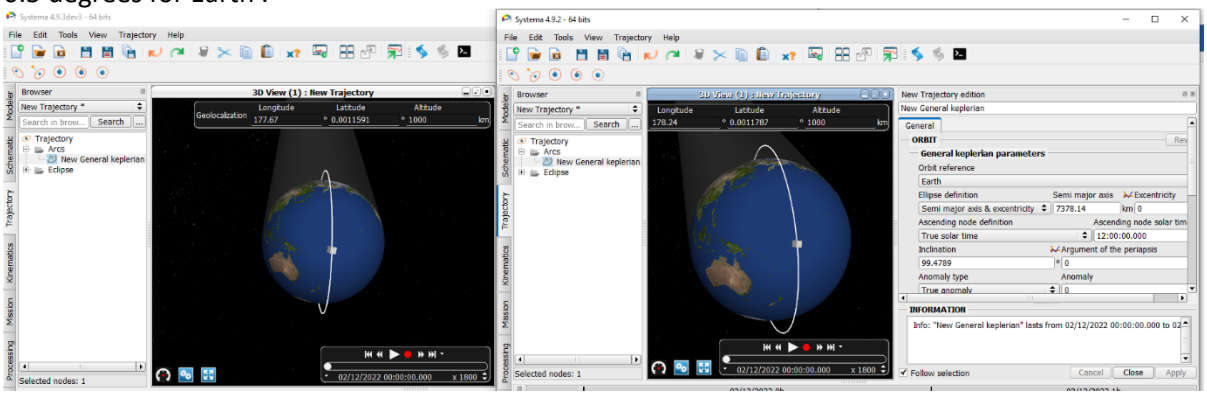
```
def convertMission493(inFile, outFile):
    '''
    convert mission file from version prior to 4.9.3
    As true anomaly computation is more precise in 4.9.3 and mission
computed event are generated each 15deg anomaly,
    the computation points date are not the same.

    Parameters
    ----------
        inFile : mission file to be converted
        outFile : path of the converted mission file
```

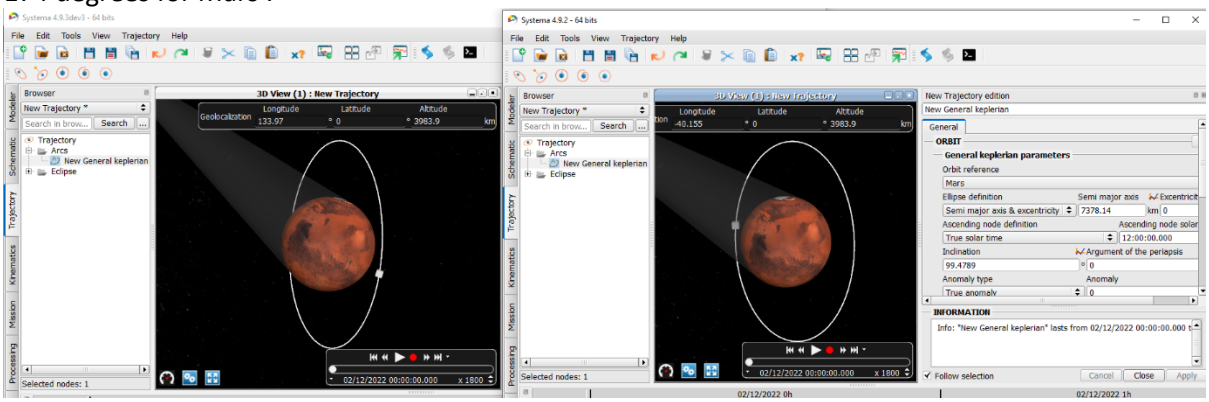
5.2 Conversion true solar time / RAAN

The accuracy of the conversion of right ascension of the ascending node to/from the true solar time is improved in 4.9.3. Thus this conversion will give different results than previous 49 releases. For instance, the delta on right ascension is about:

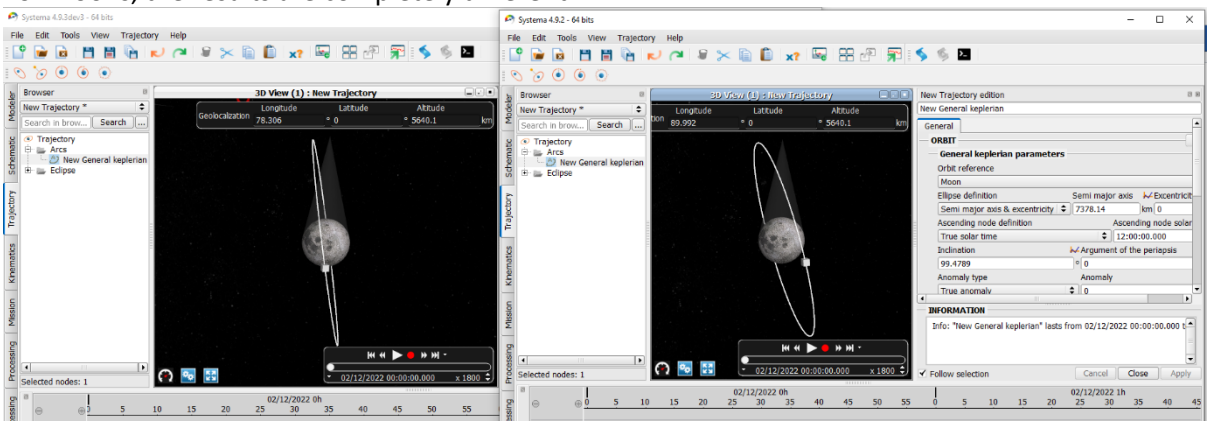
- 0.5 degrees for Earth :



- 174 degrees for Mars :



- For moons, the results are completely different :



6 Systema 4.9.3 to 4.9.4

6.1 LTS

Systema 4.9.4 is the new LTS version. Any Systema files created with Systema 4.9.4 can exported to previous LTS release (4.9.2, 4.8.3, 4.5.1).

6.2 Red hat 8 support

RedHat 8.10 is now supported.

6.3 Earth inertial frame

The inertial frame used for arcs around the earth is now True equator of Date (instead of Veis1950 before). This inertial frame takes into account precession and nutation effects. This frame enables to increase the accuracy on the definition of the ascending node with a mean solar time. Systema-4.9.4 computations are very closed to the theoretical equation of time:

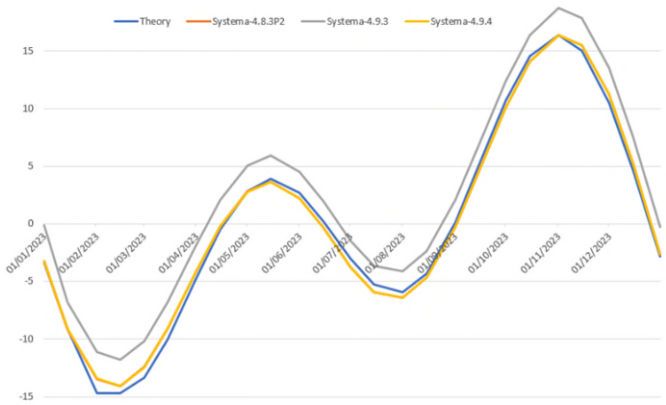


Figure 3 - Equation of time

As Keplerian parameters are defined in a given frame, some slight discrepancies (especially in longitude) may be noticed when loading trajectory files from previous release.

Example:

Arc definition	**Systema 4.9.4**	**Systema 4.9.2P2** **Systema 4.9.3**
Orbit reference = Earth Sma = 7378.14 km Excentricity = 0 RAAN = 0 Inclination = 99.4789° Argument of the periapsis = 0° True anomaly = 0° Reference date = 27298 gamma50 Date = Reference date	Longitude = -5.906° Latitude = 0.00029957° Altitude = 1000 km	Longitude = -4.9489° Latitude = 0.00024645° Altitude = 1000 km

Note: In the graphical user interface, RAAN is labeled as “East longitude in inertial Gamma50 frame”. Gamma50 must be ignored.

To convert trajectory from previous release, you can:

- Export the trajectory from previous release of Systema (File -> Export points) and load this file in a Time-Position-velocity arc with “Cartesian position and velocity in veis1950” data format to avoid any frame dependency
- Use python API to convert Keplerian parameters. This method is only applicable for general keplerian arcs. Example of python code:

```
trajFile = getCurrentTrajectoryFile()
trajFile.convertKeplerianParameters('VEIS1950', 'TOD/2010 simple EOP')
```

Moreover, EOP stands for 'Earth Orientations Parameters'. These data are provided in SYSTEMA_INSTALL\data\OREKIT-DATA\Earth-Orientation-Parameters. They can be updated by downloading the latest version from IERS website :

- IAU 2000 : finals2000A.all (https://datacenter.iers.org/data/9/finals2000A.all)
- IAU 1980 : finals.all (https://datacenter.iers.org/data/7/finals.all)

It is recommended to update these files once a year for accurate transformations between inertial and Earth fixed frames.

Arcs around other celestial bodies are not impacted by this modification.