AAE 532: Orbit Mechanics

Getting Started with GMAT R2020a

Word to the wise: this documentation is NOT intended to be in any way all encompassing. This is a brief introduction to learning to use GMAT and its capabilities. Be aware that, though GMAT is very user friendly, it is not user simple. To take full advantage of GMAT for this course, and in future courses, you are encouraged to work with GMAT on your own.

Download GMAT

The General Mission Analysis Tool (GMAT) is an open-source tool for space mission design and navigation. GMAT is developed by a team of NASA, private industry, and public and private contributors. GMAT is employed in support of a number of NASA missions.

The GMAT development team has recently released GMAT version R2018a. Because you can download it to your personal laptops, we will use GMAT this semester. It is also available on the machine in the AAE computer lab.

To access and download GMAT, go to the following site:

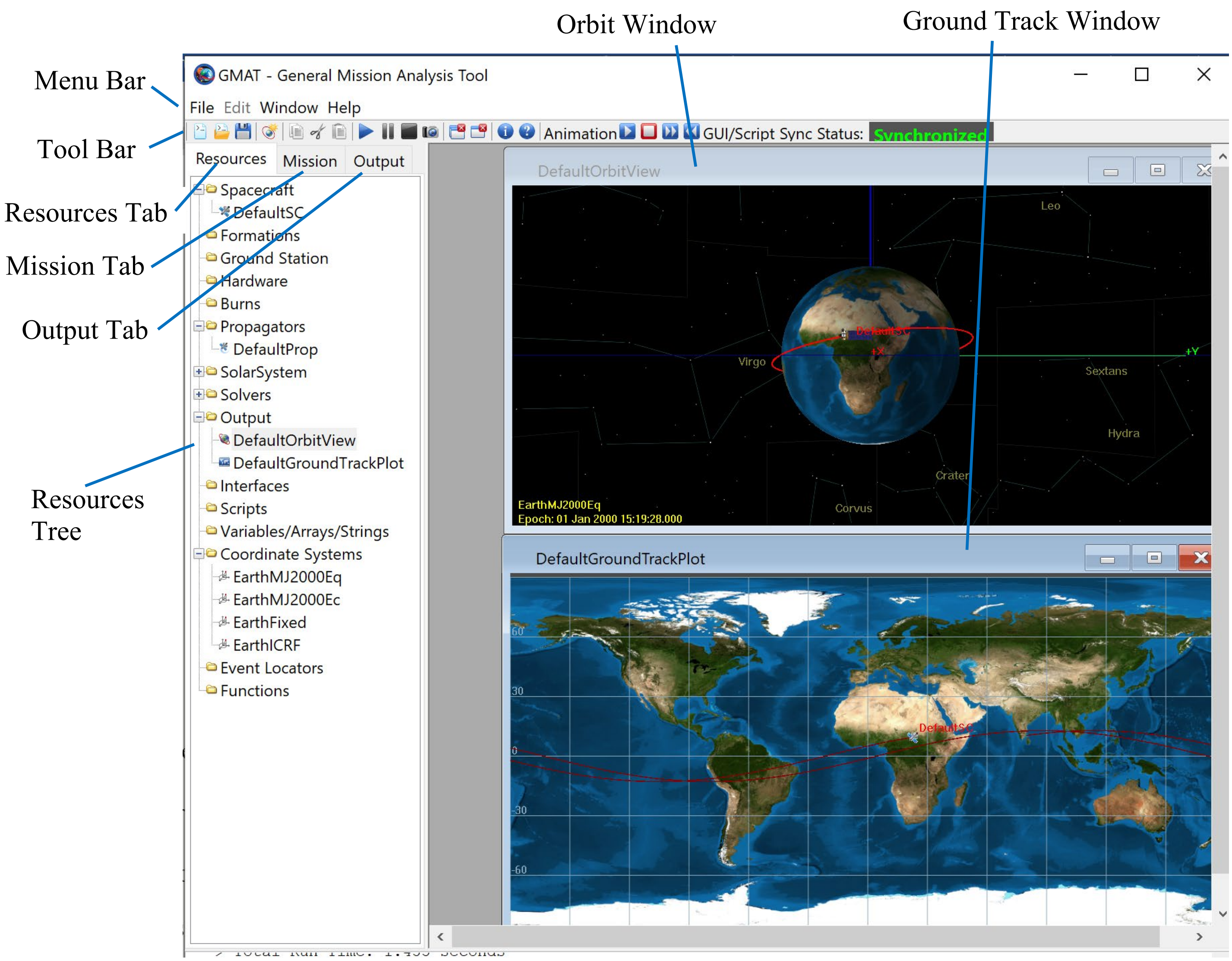
https://sourceforge.net/projects/gmat/

It is easy to run GMAT. This tutorial is intended to aid students in leveraging the capabilities for the concepts that are investigated in this class. A number of additional tutorials will be made available as we move through AAE 532.

Getting Started

From the Start Menu, choose Programs; GMATR2020a
You may see more than one version if you have used GMAT before.
You want GMAT R2020a.

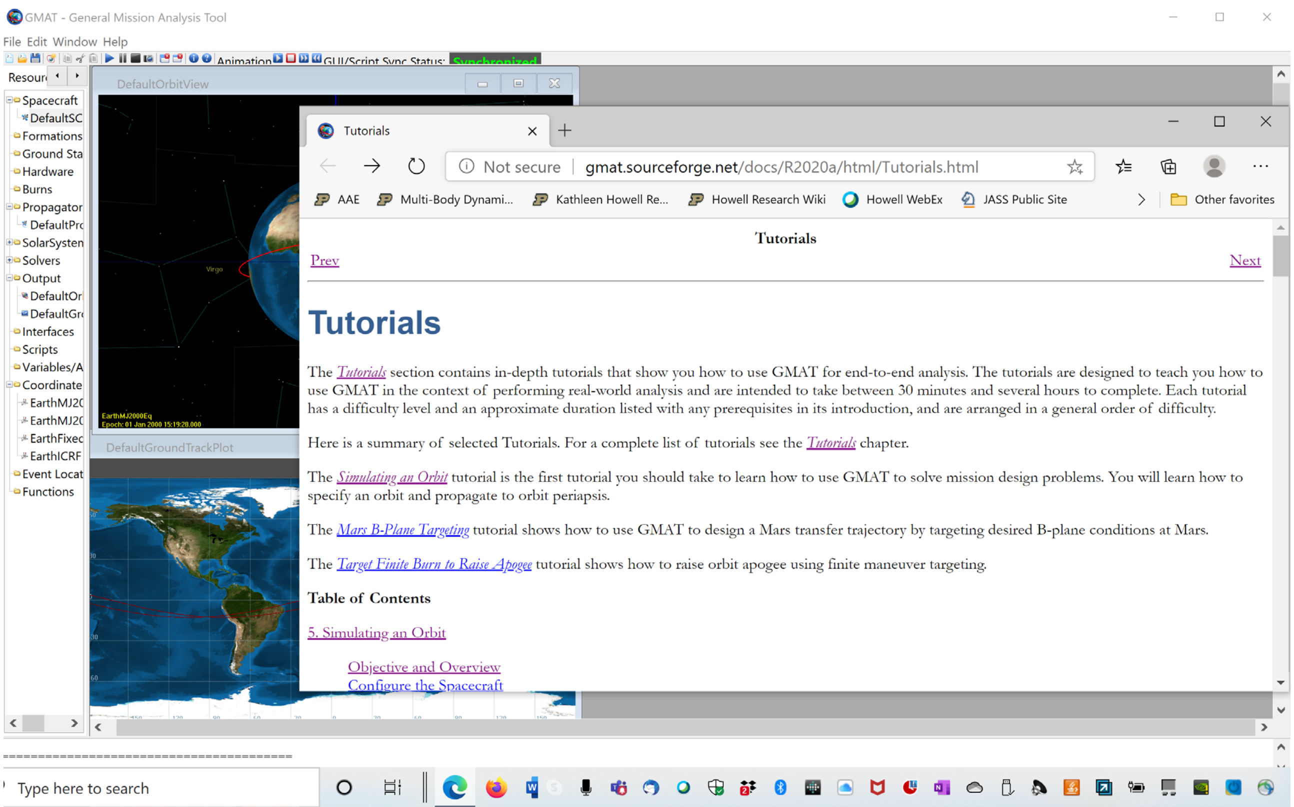
Next, you may get a message about where to store GMAT. The location you identify will allow you to choose where to store your GMAT files by default. Make a new directory (\GMAT 2020 for instance) in your roger folder or on your laptop.



Now you are ready to start learning General Mission Analysis Tool (GMAT).
Return to the start menu and start GMAT R2020a again.

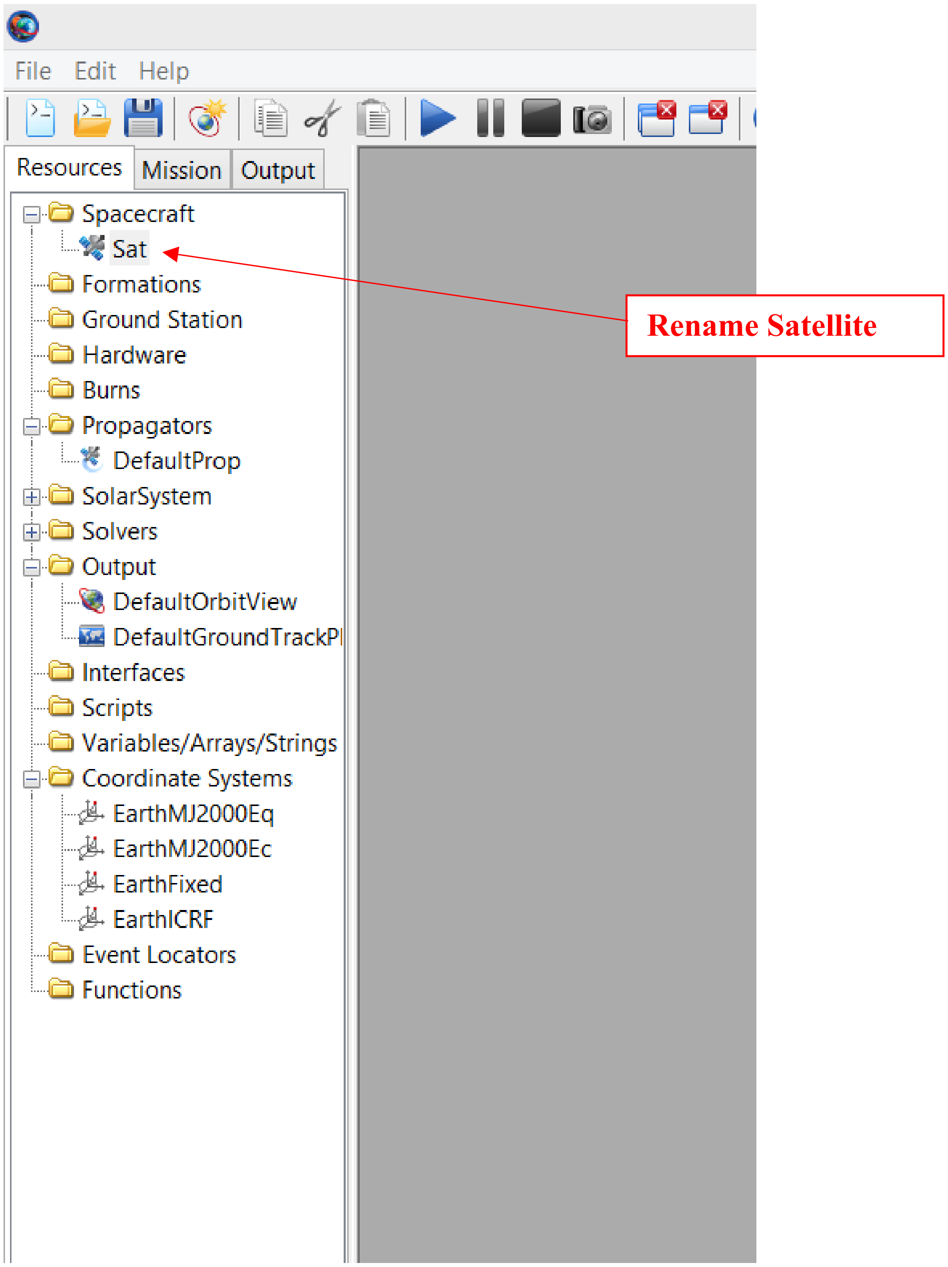
As a first step, use some tutorials to learn GMAT. Check the top bar and seek the help icon. Click ‘Step by Step Text Tutorials’ or view the ‘Video Tutorials’. There is also a YouTube video that is a nice introduction for this latest version → https://www.youtube.com/watch?v=jvF7rSYQ8WI

Experiment with the software. There are also some sample scripts to test.

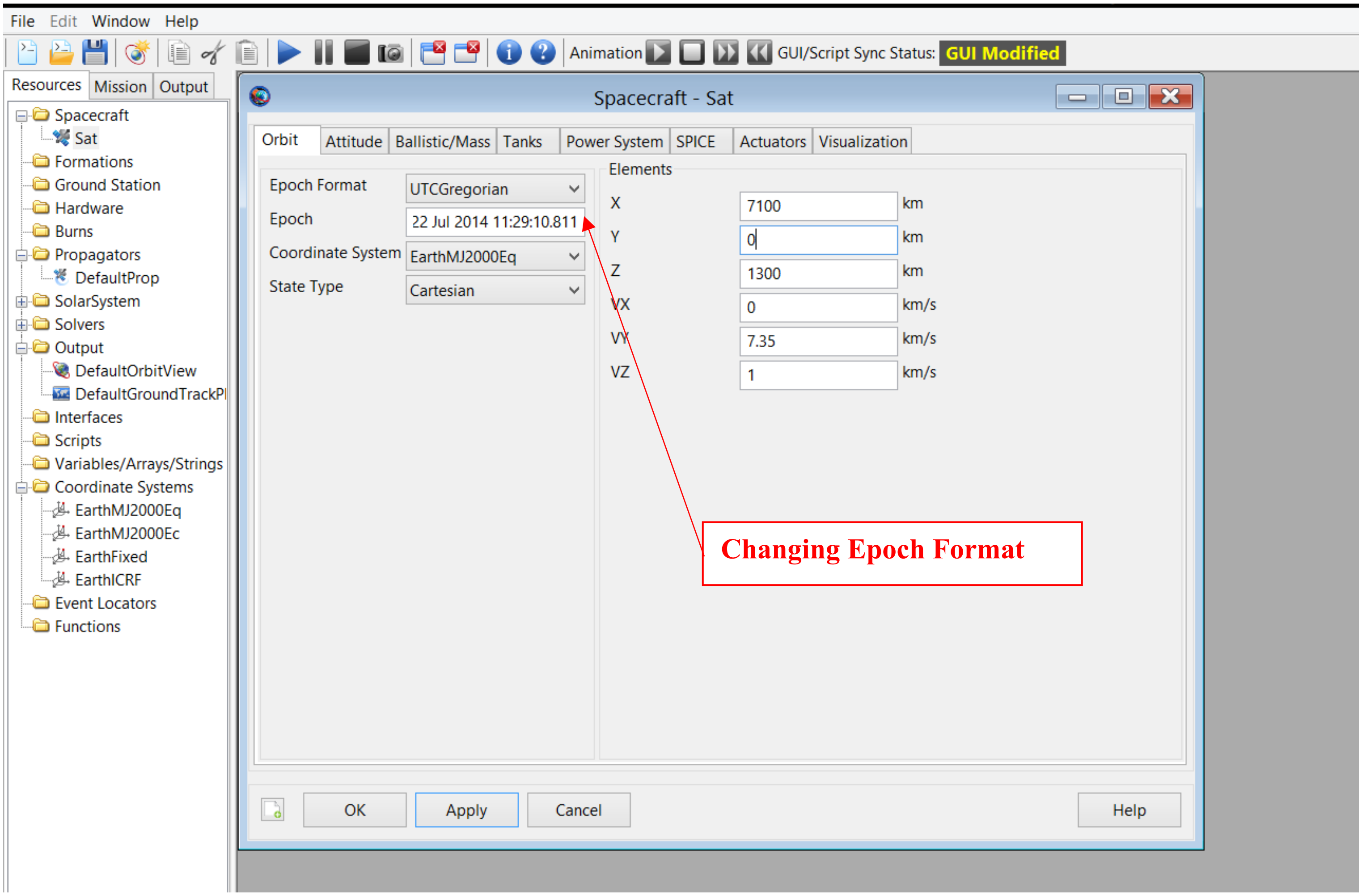


In this class tutorial, we will propagate a spacecraft to periapsis. Follow the steps outlined below. The main objectives will be to establish an initial spacecraft state and epoch, configure a propagator, and propagate the orbital motion to periapsis (the closest approach to Earth).

I. Setting Up Spacecraft



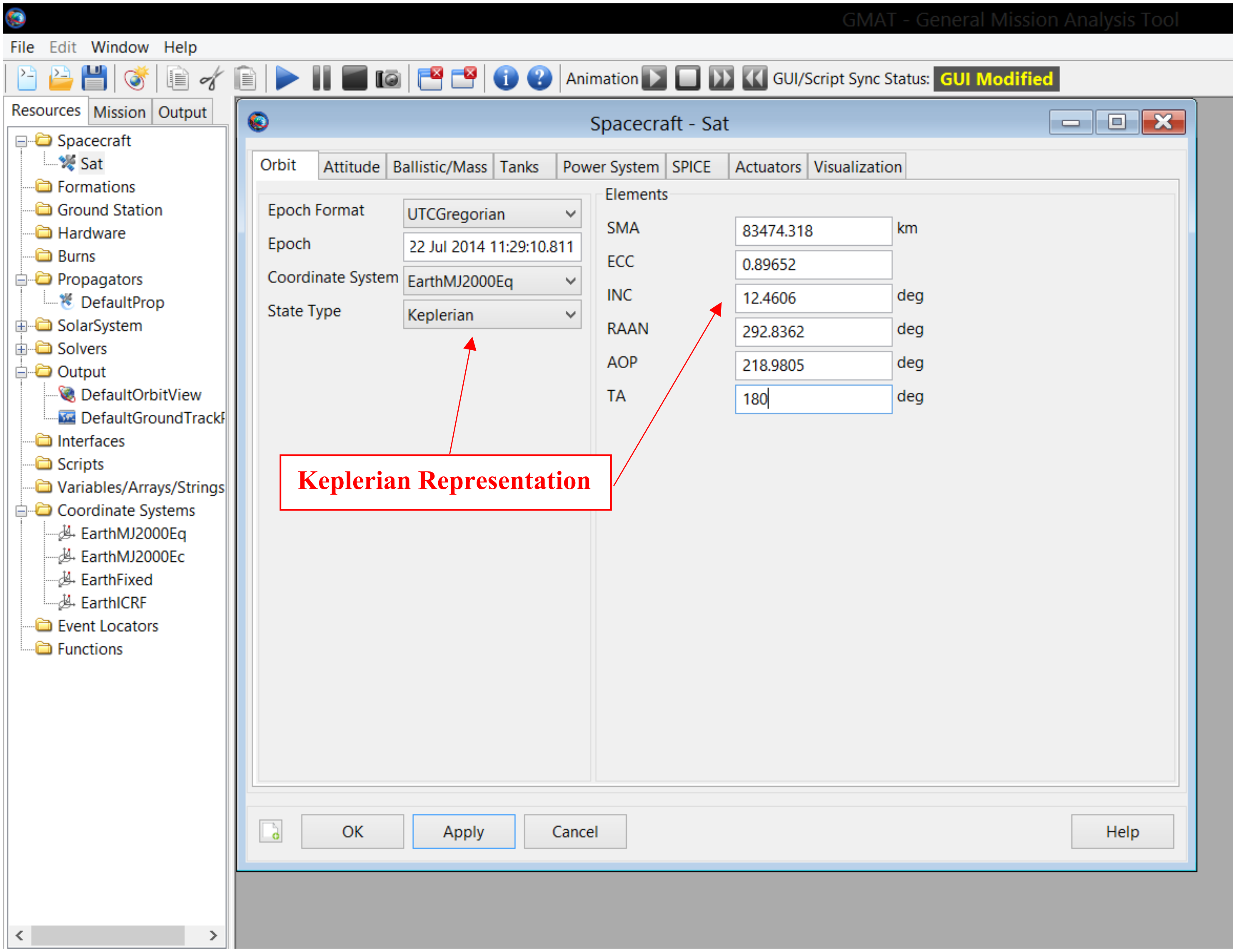
In this part of the resource tree, you will be able to assign name(s) to one or more spacecraft in the simulation by a right click on the spacecraft. To add a spacecraft, simply click on the Spacecraft folder and select 'Add Spacecraft'.



Double-click on 'Sat' and you will see a window pop-up specifying parameters pertaining to that particular spacecraft.

1. In this window, you may change details pertaining to the spacecraft's orbit, epoch, attitude, etc. For now, as an example, under the 'Orbit' tab, change the epoch format to 'UTC Gregorian' and input the date '22 Jul 2014 11:29:10.811'.

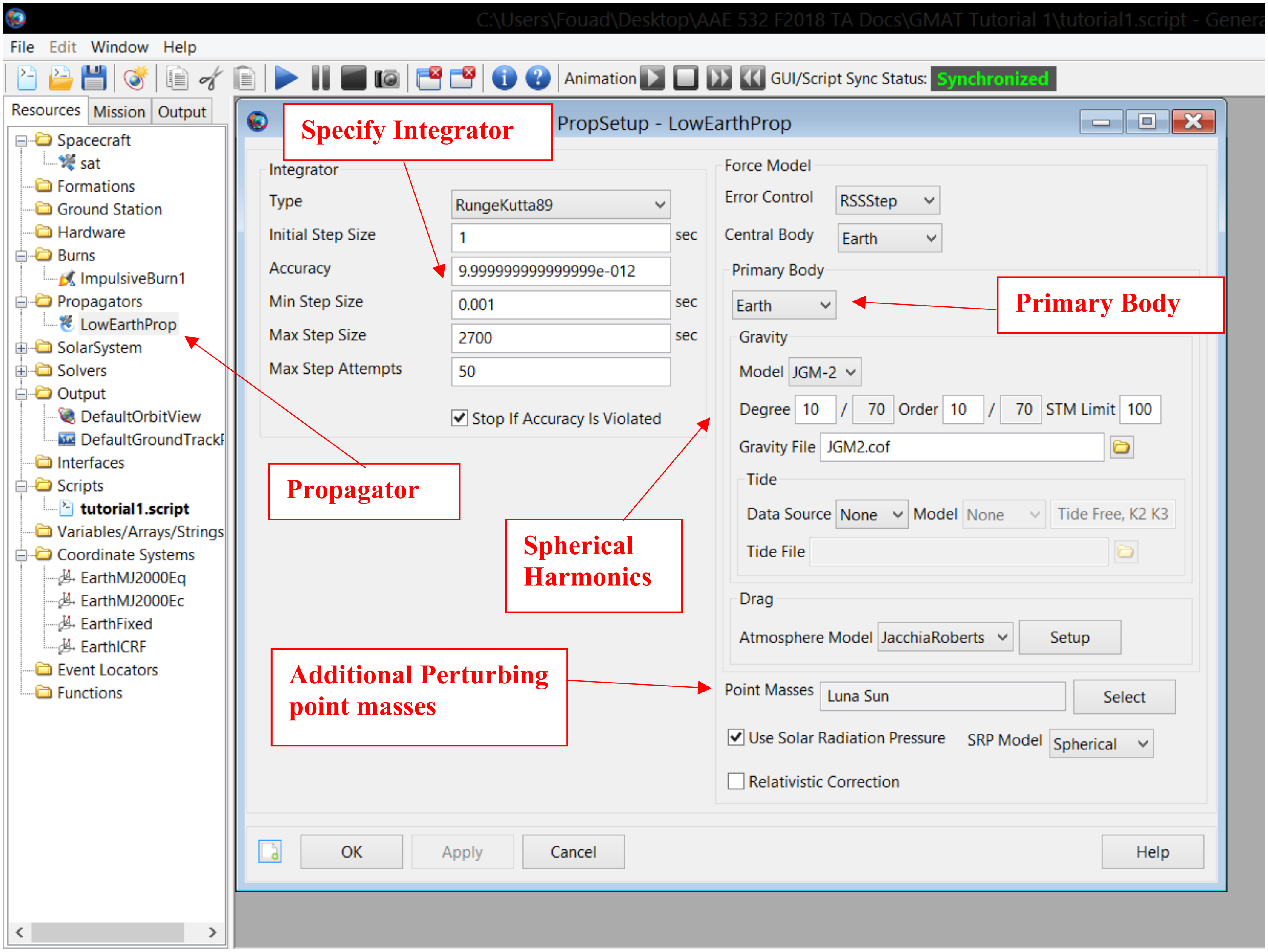
Select 'OK' to save changes.



In the same 'Orbit' tab, select the state type to be 'Keplerian' and fill the values on the right side as specified in the image above.

1. If you are given an orbital state in terms of position and velocity, you may also input those values with the Cartesian state type. You will need to be cautious regarding which frame you employ to specify initial conditions of the spacecraft. Click OK to save the changes.

II. Configure the Propagator



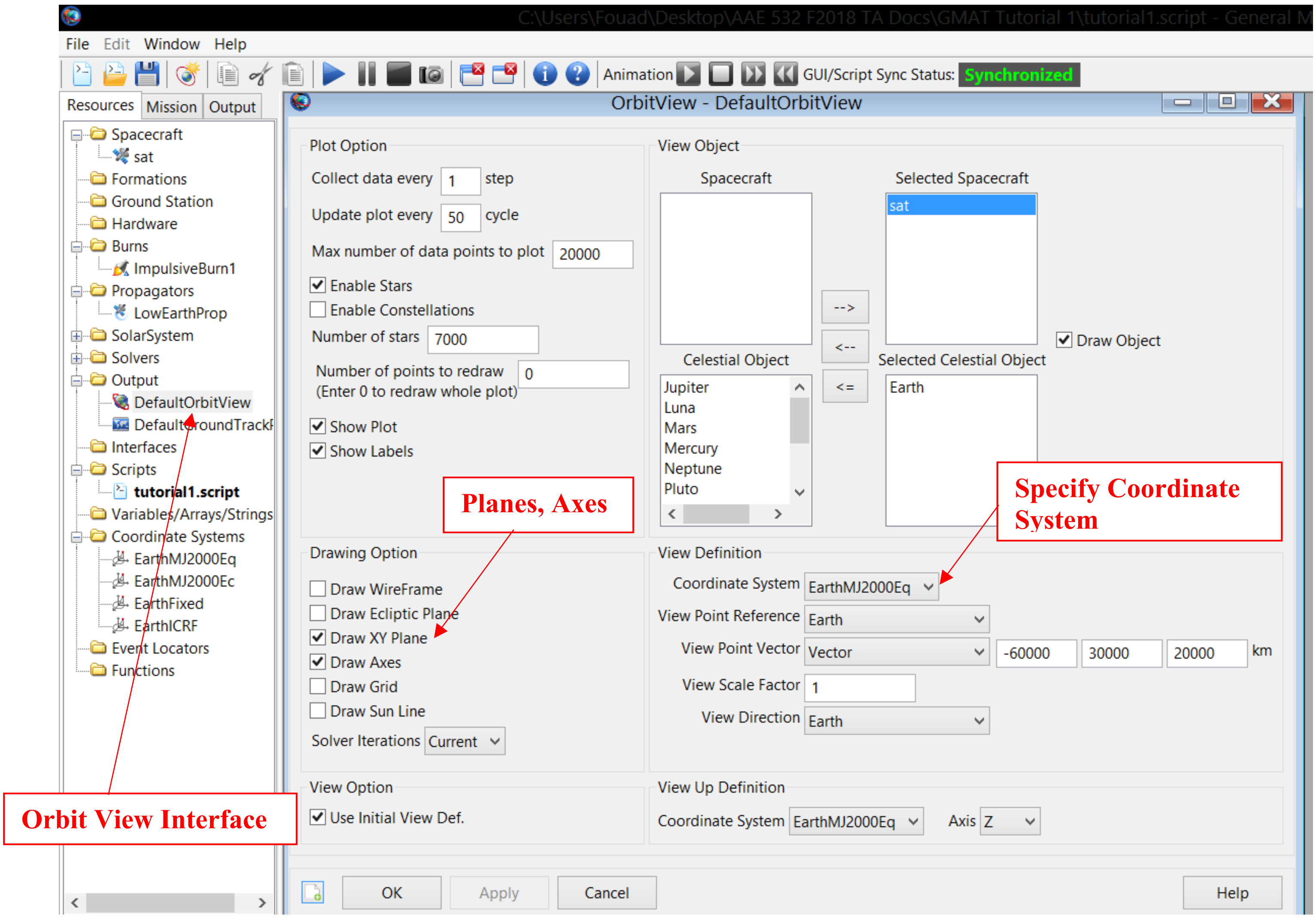
First, change the name of the propagator in the Resource Tree from ‘DefaultProp’ to ‘LowEarthProp’. Double-click in the propagator and a window will appear. In this window, you can specify parameters pertaining to the numerical integration and gravity models.

1. Specify Integrators: Comprised of different types of integrators for the numerical integration of the orbital state. Each integrator can be used for different purposes, for now specify the ‘RungeKutta8(9)’ with the parameters specified above.
2. Primary Body: Specifies the primary gravitational body in the system. For now, specify the primary body as ‘Earth’.
3. Spherical Harmonics: Specifies the gravity terms pertaining to the oblateness effect of the Earth. Usually, most of the orbits in this class will be point mass based

(Model: None), however you may specify additional gravitational terms for different mission scenarios.

4. Additional Point Masses: You may also add additional point mass gravity models in your propagator to incorporate gravity effects from the Sun, Moon, Jupiter, etc.

III. Configure Orbit View

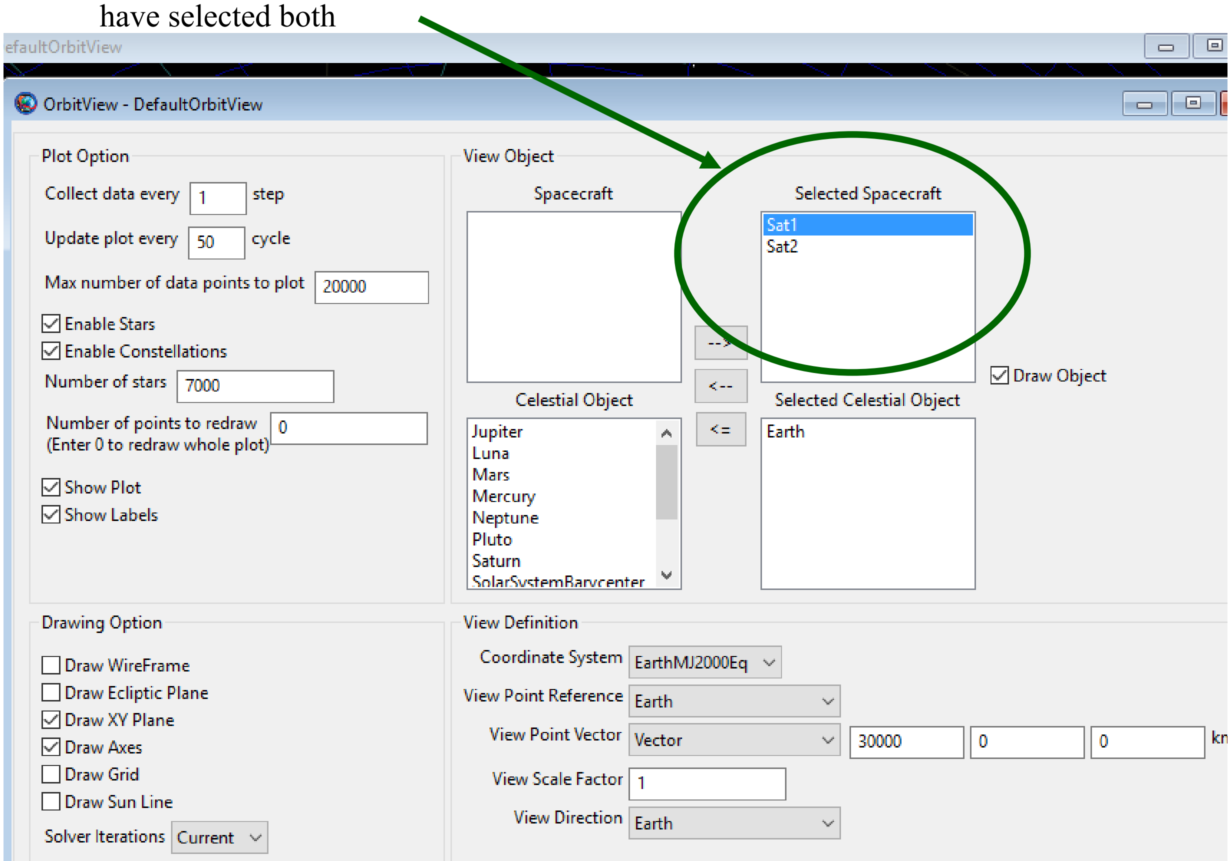


In the resource tree, double-click 'DefaultOrbitView'. A window will appear.

1. In this window, you may modify parameters pertaining to the 3D view of the orbit. You may select to view planes, grids, or the axes of your selected coordinate system.

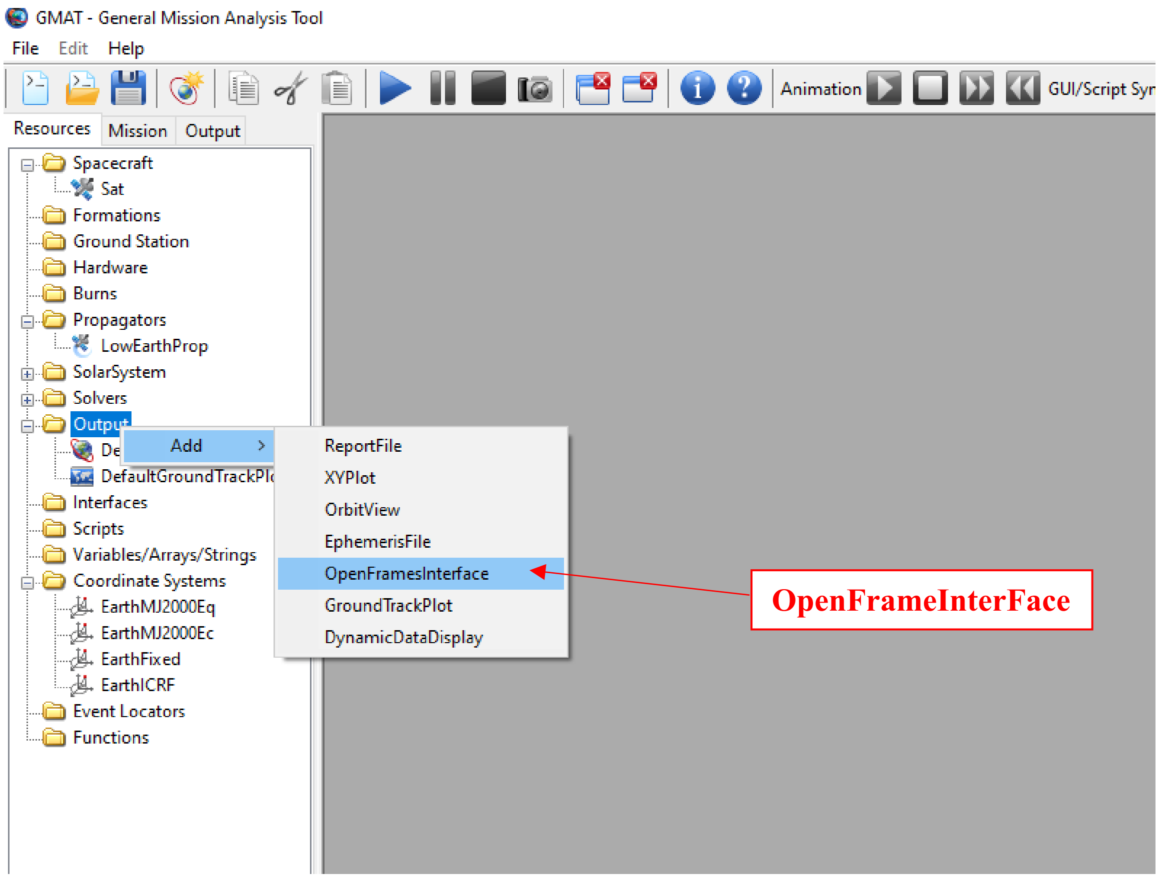
2. You can also specify viewing definitions and coordinate frames. For now, we will select the Inertial Earth MJ2000Eq Frame with a view point vector as shown above. Select OK to save changes.

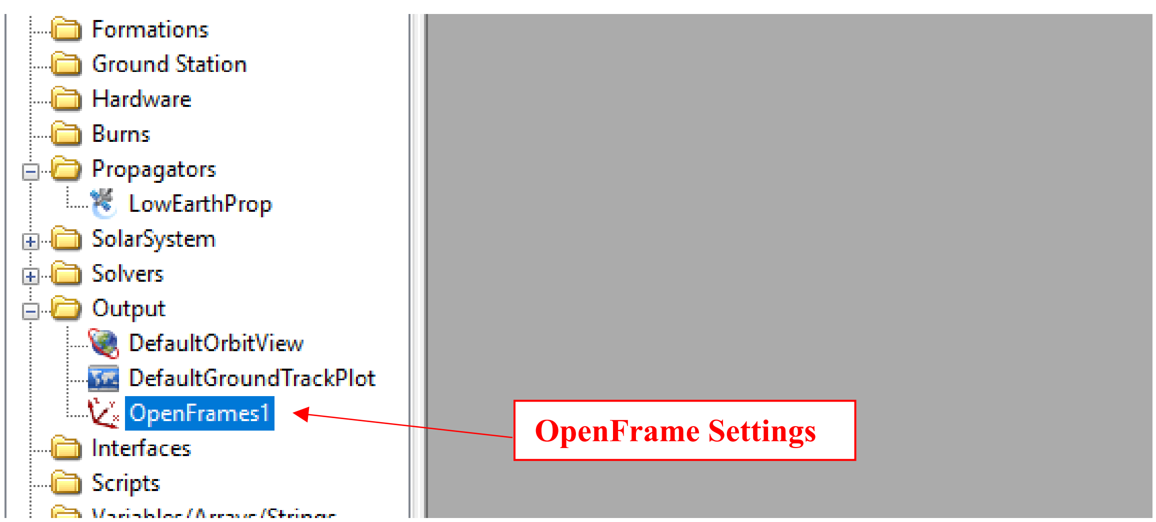
3. If you had defined two spacecraft and choose to propagate both, be sure that you have selected both



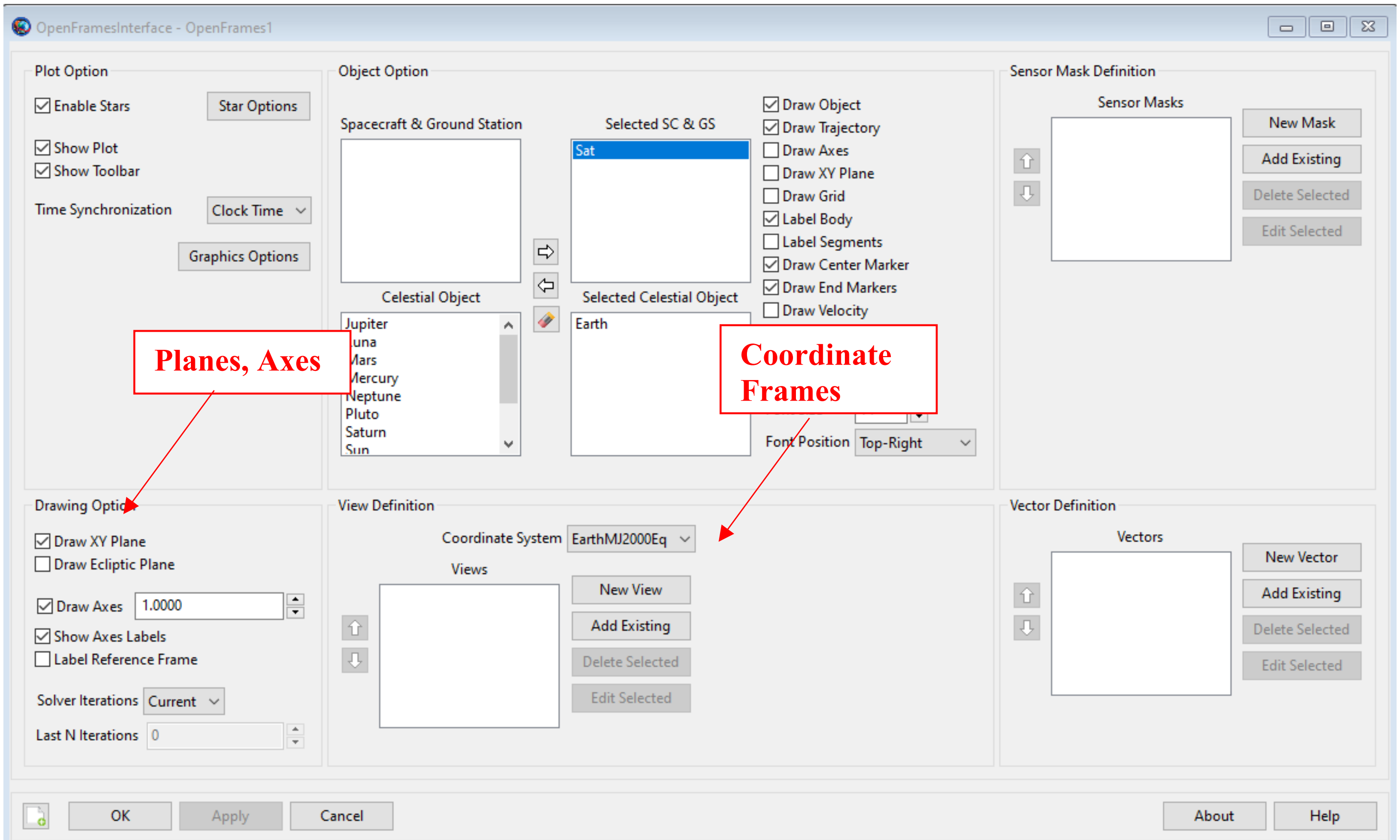
IV. Add OpenFrameInterface

In resource tree, right click on the 'Output' folder. After clicking on 'Add', you will see 'OpenFrameInterface.' By clicking on it, you can create a 'OpenFrames1' button inside the folder. Double-click 'OpenFrame1' and a window will appear.



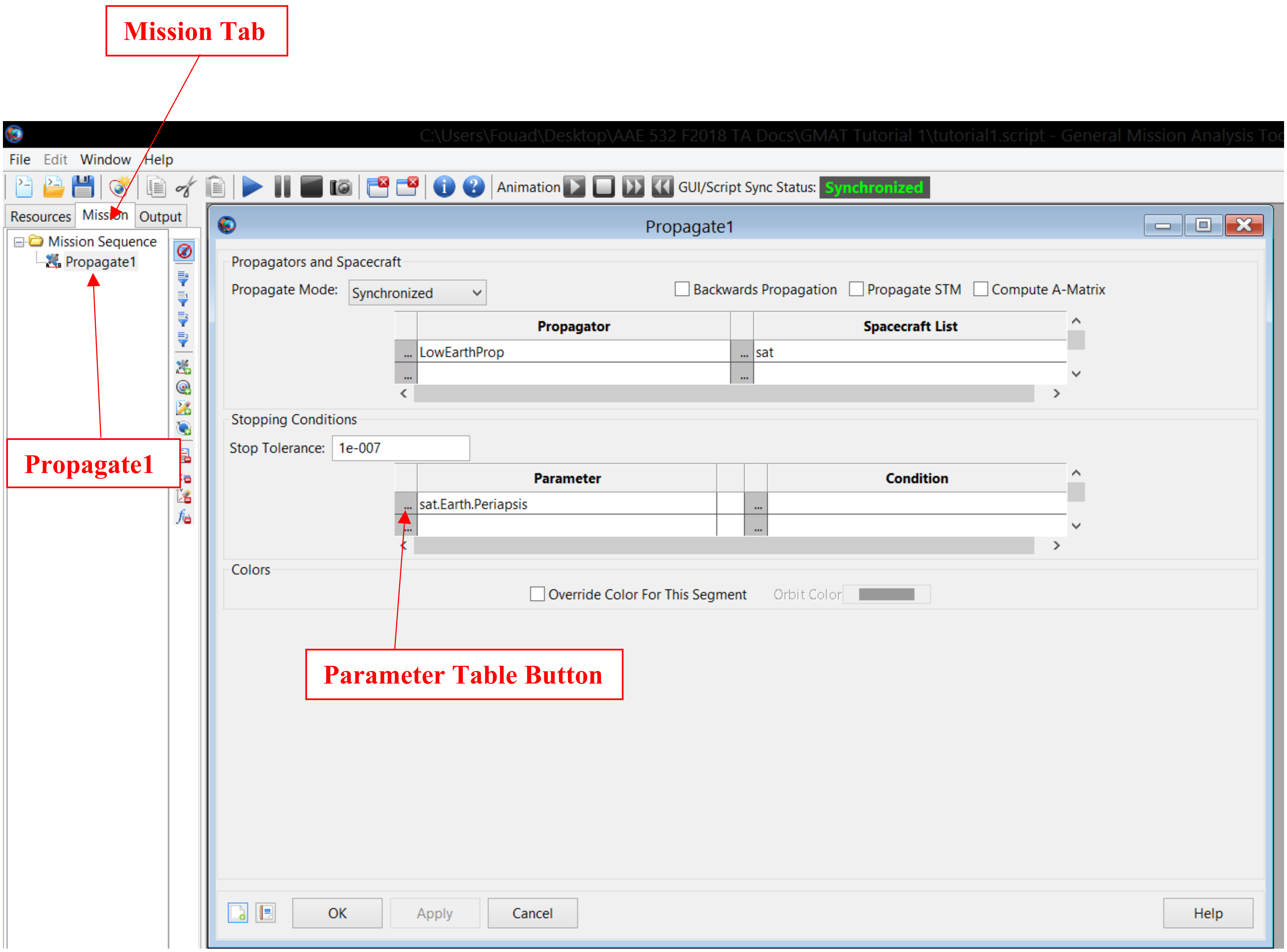


1. You can select to view planes, grids like you did in the previous section. Same for the viewing definitions and the coordinate frames.



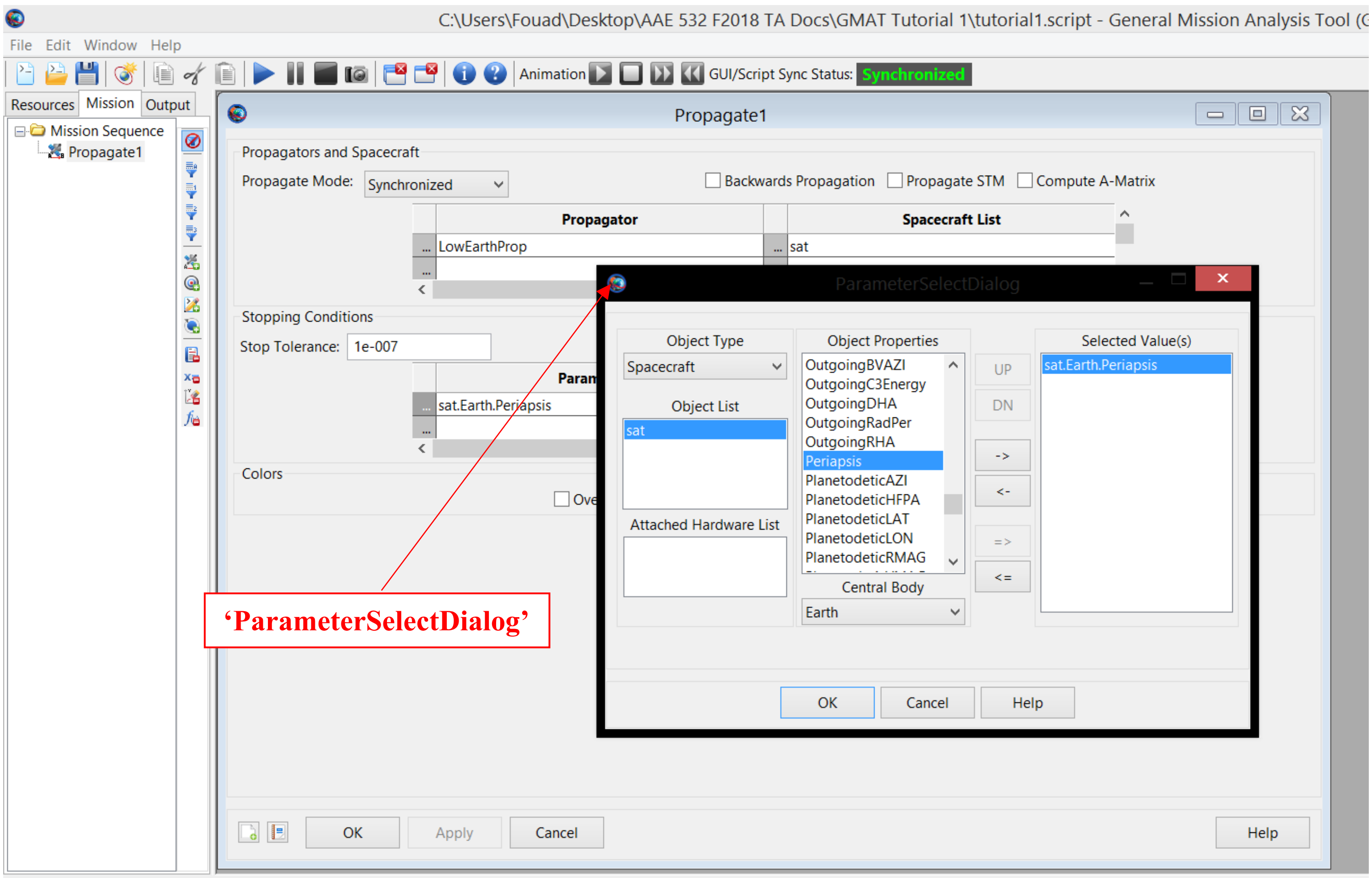
V. Configure Propagate Command

In resource tree, select 'Mission Tab'. Double-click 'Propagate1' and the following window will appear.



You may choose to rename 'Propagate1' with a more useful notation in case there are multiple propagate or maneuver profiles in the mission scenario. Under the space 'Stopping

Conditions', click the (…) button to the left of the parameter table. This will display the 'ParameterSelectDialog' window.



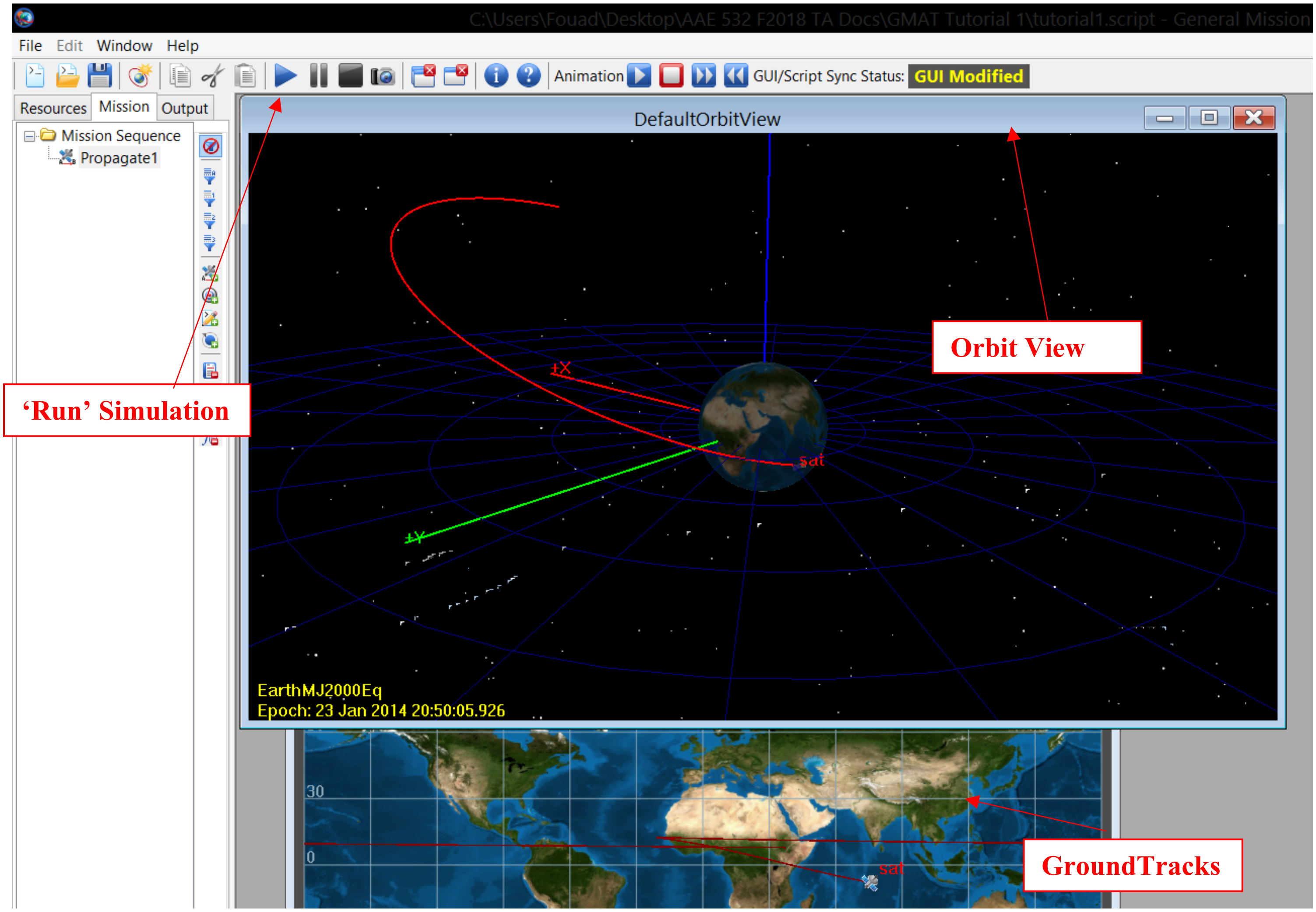
In the 'Object Properties' list box, click (from left to right): 'Sat' – 'Periapsis'.

1. Click the right arrow '->' to move it to the 'Selected Value'. This value notifies GMAT to stop propagation when periapsis (closest approach) is reached.
2. There are also stopping conditions pertaining to time, orientation, energy, etc. and these can be implemented for different mission scenarios.

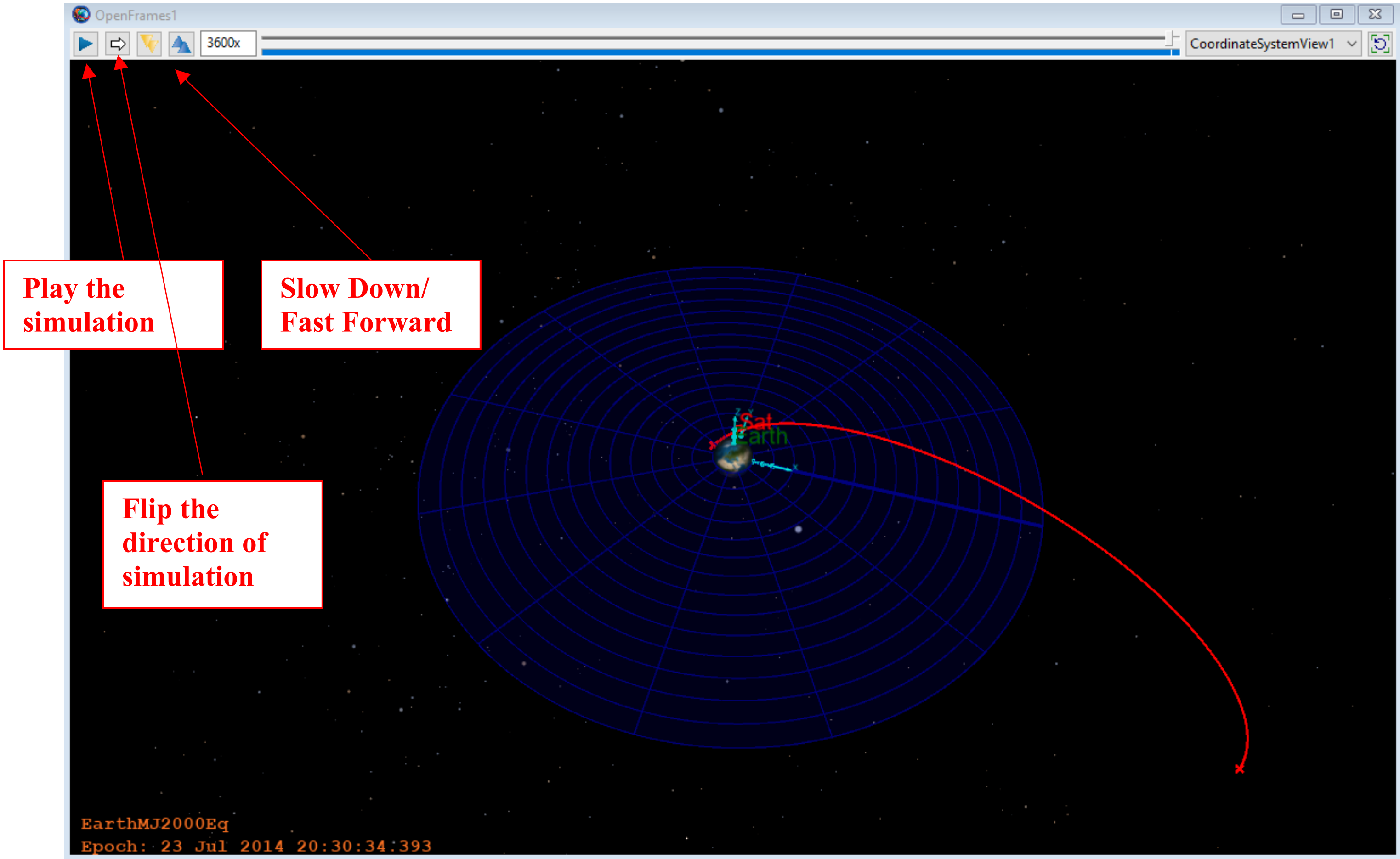
Select OK in the 'Propagate1' box to save changes.

VI. Run and Analyze Results

Save your GMAT file before running the simulation. Press the 'Run' Button to view the Orbit



Finally, the orbit can be simulated with the `OpenFrame1' window.



You can press ‘Play’, ‘Pause’, ‘Fast Forward’, to view the orbit animation in detail. For class assignments, taking screenshots of your orbits will suffice for most orbital figures that are required.