STK Demo for Spacecraft Design Class

**Downloading and Installing STK and Educational License**

STK can be downloaded from <http://www.agi.com/products/stk/stk-10/>

You will need to make an STK account in order to do this. Click the Download STK button and follow the instructions to install STK with a free license. To download the full student license, go to <https://www.agi.com/resources/educational-alliance-program/>. Click the “Get EDU Licenses” link under “Existing Partners” and enter the UF school code after logging in (47648). This will send the license to your professor who can then forward it to you.

**Creating a New Scenario**

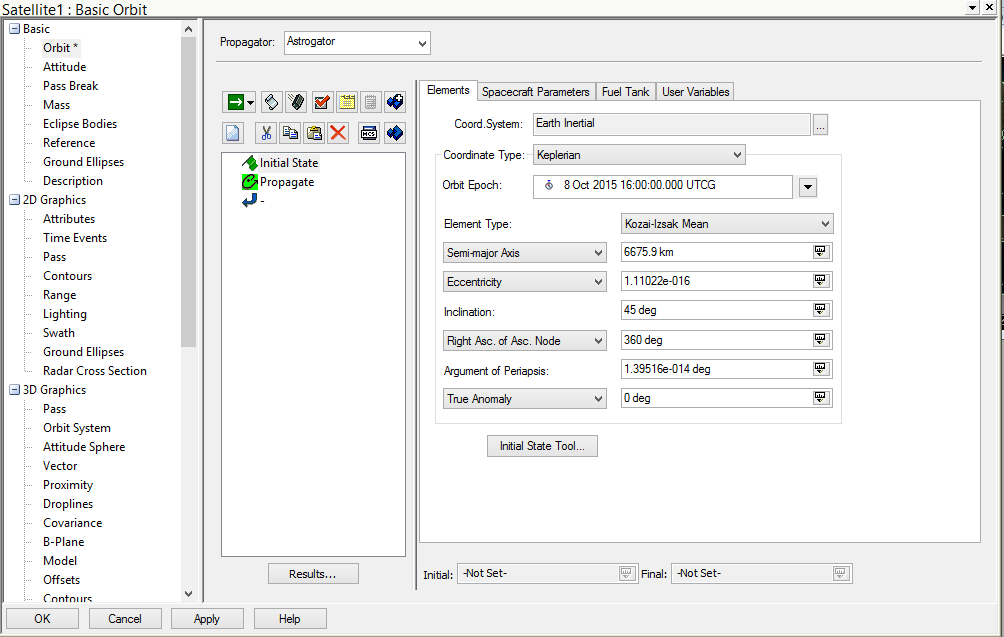
Launch STK and click the “Create a Scenario” button. Name the scenario “STK\_Demo” and set the start date to 10/8/2015 and end date to 10/9/2015.

**Defining Satellites (orbit propagators)**

A window to Insert STK Object should appear when you create the scenario. This menu can also be assessed by clicking Insert -> New from the toolbar. Select the satellite object, click the define properties option, and press insert. The satellite configuration page will appear. Select the orbit tab under “Basic”. You can choose a desired orbit propagator and define your satellite or satellites here. Select “Astrogator” from the Propagator drop down menu in the orbit window.

**Using the Astrogator**

Select the initial state phase in the Astrogator window. Select the Keplarian Coordinate Type and the Kozai-Izsak Mean orbital elements. Keep the default values of the orbital elements, but change eccentricity to zero and inclination to 45 degrees.



Now click on the propagate tab and select “Earth HPOP” as the propagator and set the trip time to 1 day. This propagator is the most advanced and takes into account aero drag, solar pressure, thrid body gravity, and the non-uniformity in Earth’s gravitational field. Specific spacecraft parameters such as mass, drag coefficient, and area can be set in the spacecraft parameters and fuel tank tabs and will affect spacecraft trajectory if using HPOP. To modify the propagator, click the Utility tab from the tool and the select “Component Browser”. Select the “Propagators” Folder. Select “Earth HPOP Default” and click “Duplicate”. Double click your new copy that should have a green arrow next to it. You will now see a window displaying propagator parameters. If you did not want to include lunar gravity in the simulation, you could select the “Moon” parameter and press the red X to delete it. To add parameters to the simulation (such as relativity correction), select the new button and choose the parameter you wish to add. This method allows you to configure any kind of propagator you like, and your new propagator will show up in the propagator selection window within the astrogator. Once you have configured your simulation, click the green “Run Entire Sequence” arrow to run the simulation.

The STK targeter can be used to calculate the control parameters needed to make the spacecraft perform as desired. We will use it to calculate the thrusts requried to do a Hohmann transfer from a 300 km to a 700 km orbit. Add another propagate segment after the first one. Set the stopping condition to periapsis (use the “New Stopping Condition” button). Add a targeting sequence after this. Set the “Action” option to “Run active profiles.” Inside the targeting sequence, add a maneuver and another propagate segment. Set the maneuver to .2 km/s change in velocity along the velocity vector (initial guess). Click the picture of the target next to the delta V amount and a check should appear over the target. Set the propagate segment to terminate at apoapsis. Click the results button when the propagate segment is highlighted, double click the Keplarian elements folder and double click the radius at apoapsis field. Click the target sequence and press the properties button. Check the impulsive maneuver as the only control parameter and the radius of apoapsis as the equality constraint. Set the desired radius of apoapsis to 7178 km and press OK. Add a second targeting sequence with a maneuver and propagate segment. Also set the action to “run active profiles.” Set the maneuver to .2 km/s, select the target button, and set the propagate segment to propagate for 50,000 seconds. Click the results button for this propagate segment and double click mean eccentricity in the “Mean Elems” folder. In the targeter properties, Select the maneuver as the control parameter and mean eccentricity as the equality constraint. Set the desired mean eccentricity to zero and the eccentricity error tolerance to .001. Press the green arrow to run the entire mission control sequence. The targeter should automatically calculate the parameters needed to perform the maneuver.

**STK Attitude**

STK has the ability to simulate the satellite with a specified attitude. Right click the satellite and select the property tab if it is not already open. Select “Attitude” under “Basic”. Select “Sun alignment with nadir constraint” and click “Apply”. Go to the orbit tab and re-run the Astrogator sequence. To view the satellite attitude behavior, go to the 3D satellite view window, click the view from button (picture of an eye), and select “Satellite1”. Press the play button to run the animation and you should see the satellite changing orientation to track the sun.

**Viewing Simulation Results**

To view simulation results in a graphical or numerical format, click the analysis tab and select the report and graph manager. For satellite 1, click the “Classical Orbital Elements” option with a picture of a graph next to it and press the “generate” button. Here you can see the classical orbital elements graphed over time. You can view numerical values by generating the Classical Orbital Elements report instead of graph. To create custom graphs, click the “create new graph style” button at the top right of the analysis window. In the graph options, select Kozai\_Izsak Mean -> ICRF -> Mean Semi-major Axis (double click). Click “Apply” and “OK.” If you generate this graph for satellite1, you will now see a plot of mean semi-major axis vs. time.

**Ground Stations and STK Access**

To insert a ground station, click the insert tab and press “New.” Select “Facility” from the window that pops up, select “Define Properties” and press “Insert.” Enter the latitude and longitude of the University of Florida (29.6483°, -82.3494°) and press “OK.” Rename your facility “UF.” Select Analysis -> Access. Make sure “Satellite1” is selected in the “Access for” field and “UF” is selected in the window below. Press the “Access” button in the reports sub-window on the right side of the screen, and a report will be displayed showing the times the satellite will be within the line of sight of the ground station. The AER button in the reports sub-window can be pressed for a more detailed access report. If you have additional constraints, such as an elevation angle below which you cannot communicate with the ground station, you can set this constraint by right clicking the “UF” facility, selecting “properties”, and selecting “Basic” in the constraints menu. Here you can set your azimuth, elevation, and range constraints, and these constraints will be reflected next time you compute access to the satellite from UF.

**STK Solar Power Generation**

STK can be used to calculate the amount of solar power a satellite will generate for a given attitude and solar panel configuration. This can be done by right clicking on Satellite1 in the component browser and selecting “Solar Panel” under the “Satellite” sub-menu. Select the simulation start and end time for the power generation calculation and press the “Compute” button. A window will open up showing the satellite relative to the sun vector. You can run the simulation to watch the satellite move. You can then press the “Generate” button to view either a graph or a report of the power generated based on the panel configuration. Custom satellite models can be created and a power analysis can be done using these models. To change the satellite model, navigate to the Satellite1 properties menu and click “Model” under the “3D Graphics” submenu. A .dae file containing a custom or built in satellite model can be entered into the “Model File” field.

**Demonstration of Mars Mission**

An example of a full Mars mission using STK Astrogator will be shown in class.

**Additional Resources**

“STK Help” Can be selected from the “Help” menu for additional information. Numerous tutorials and demos exist in the “Get Started” folder of help module. Completing the Astrogator tutorials is recommended to gain familiarity with this module. Unlike most other software, you will probably have better luck using the built in help than looking for stuff on Google. AGI also has basic and advanced certification programs for STK. Information about these programs can be found at <https://www.agi.com/training/certification/>. Both levels of certification should be free for students.