# ASEN 6008 – Interplanetary Mission Design
# Laboratory 1 – Part 2: Introduction to Astrogator
# Due January 28, 2016

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**Launch of a Geostationary Satellite**

Setup Scenario

- Setup your scenario to cover a 5-day time period, with any epoch you choose.
- Set animation start time to the epoch you chose, and set the time-step to 60 sec.
- Create a new satellite
- Set the satellite's 2D Graphics Pass properties to:
  - Ground Track Lead Type: None
  - Orbit Track Lead Type: All
- Set the satellite's 3D Graphics Pass properties to "Inherit from 2-D graphics."

Setup Map Views

- With the 2-D map active, go to its Properties. Change the 2-D projection to Orthographic with a display height of 100,000 km, viewing from the North Pole. Display coordinate frame: ECI.
- With the 3-D window active, click on the "View From/To" button Set the options to view from the satellite and view to the satellite. This will allow you to rotate around your satellite.

Setup Astrogator MCS for Launch

- Bring up Astrogator Master Control Sequence browser. (Go to the Satellite's properties page and change the propagator to "Astrogator").
- If an Initial State or Propagate segment exists, delete it.
- Insert a Launch segment at the beginning of the sequence
- Make sure the launch epoch matches the scenario epoch
- The following should be the default launch conditions (if not, change them)
  - Latitude: 28.6 deg
  - Longitude: -80.6 deg
  - Altitude: 0.0 km
- Change Burnout to Geodetic. The following should be the default burnout conditions:
  - Time of Flight: 600 seconds
  - Latitude: 25.1 deg
  - Longitude: -51.3 deg
  - Altitude: 300 km
- Click Burnout Velocity and change the Fixed Velocity to 7.29976 km/sec

Propagate Parking Orbit

- Insert a Propagate segment after Launch segment and rename it to "Parking Orbit" by right clicking on the propagate segment and selecting Properties.
- Set the Propagator to Earth Point Mass. Note: There are two Propagators buttons. Keep the upper left Propagator at Astrogator and change the other.
- Stopping Condition: Duration
- Trip: 5 hours
- Click the green run arrow and then OK.

Determine Parking Orbit Orbital Elements

- Go to the Satellite's Properties and under the 3D Graphics Data Display menu, show the Classical Orbit Elements.
- Animate the scenario forward to somewhere slightly more than 600 seconds (i.e. after the end of the launch sequence). You'll notice that the elements change until the launch segment has been completed, after which (surprisingly enough), they stay fairly constant.
- Note the orbit elements: What are the sma, inclination and eccentricity?

a 6675.129418 km

e 0.000122

i 28.019 degrees

Propagate through one entire parking orbit, then to perigee

- Change the duration of the "Parking Orbit" segment to approximately one orbit period. What is the period of this orbit?

  P = 2*pi*sqrt(a^3/mu) = 5427.5 seconds

- Insert another Propagate segment (Copy the "Parking Orbit" and paste) after the "Parking Orbit" segment. Rename to "Propagate to Perigee".
- Insert a stopping condition to stop at perigee. Delete the duration stopping condition.
- Click green run arrow and OK in Astrogator window.
- What is the satellite's velocity in J2000 ECI coordinates (use the Summary button or Data Display with J2000 PositionVelocity)? Is this different than what you would expect, i.e. using analytical equations involving the orbit elements (if so, why)?

|V| 7.728444 km/s

V_peri = sqrt(2*mu/(a*(1-e))-mu/a)

$|V|_{computed}$ 7.728439 km/s

They are basically the same. I used 3.986e5 as my mu, the point mass model is probably a little different.

Inject into Geosynchronous Transfer Orbit

- Insert a Maneuver, and rename it “DV1”. Maneuver Type: Impulsive.
- What do you think is the best Attitude Control Setting (assuming we’re not going to do any plane changes during this burn)?

  Along Velocity Vector

- What is the sma of a geosynchronous orbit ($a_{GEO}$)? What is the sma of the transfer orbit ($a_t$)? To get to geosynchronous, what should the velocity be after the impulsive maneuver ($V_{pt}$)? What should the magnitude of the $\Delta V$ be?

  $a_{GEO}$ 42164 km

  $a_t$ 24419.158 km

  $V_{pt}$ 10.154788 km/s

  $\Delta V_1$ 2.426348 km/s

- Don’t worry about the engine model and do not decrement mass based on fuel usage.

Propagate to the apogee of the Transfer Orbit

- Copy the “Parking Orbit” Propagate segment and paste after “DV1”, rename it to “Transfer Orbit”. Change the color of the segment (right-click on segment, and choose properties).
- Change the stopping condition to Apogee. How long should it take to get from perigee to apogee on the transfer orbit?

  18987.9 seconds

- What is the velocity (J2000 ECI) of the satellite at apogee? Does this agree with your calculations?

  $|V|$ 1.607449 km/s

$|V|_{computed}$ 1.607443 km/s, agrees

Inject into Geosynchronous Orbit

- Copy the “DV1” segment and paste after the “Transfer Orbit” segment; rename it to “DV2”.
- What should the Attitude Control Setting be (assuming no plane change)?
  Along Velocity Vector
- What is the magnitude of the V?\ 1.467221 km/s

Propagate and change planes into a Geostationary Orbit

- Copy the “Transfer Orbit” segment and paste after “DV2”, rename to “Geosync Orbit”. Change the color.
- What should the stopping condition be in order to perform a plane change to a geostationary orbit? (there are really several choices)
  Ascending or Descending Node
- Change the stopping condition accordingly, but allow the orbit to first complete one full revolution. You can do this by changing the repeat count to 2 (to the right of the Tolerance field).
- Copy the “DV2” segment and paste after “Geosync Orbit”, rename to “Plane Change”.
- What are the best Attitude Control and Thrust Axes for this maneuver?
  Thrust Vector, VVLH(Earth) as Thrust Axes
- What is the inclination just before and after the maneuver?
  Before: 28.018789 degrees
  After: 0.000055 degrees
- What is the direction and magnitude of the burn? (this is a bit tricky)
  Magnitude: 1.48863 km/s
  Burn vector: -0.360370 in-track, 1.444358 anti-orbit-normal
- Copy the “Geosync Orbit” segment and past after “Plane Change”. Rename it to “Geosta Orbit” and change the color.
- What are the Orbital elements (according to STK) just after the final impulsive maneuver? Over what continent is the satellite positioned?

  a 42163.841 km e 0.0000007

i 0.000055 degrees______ RAAN 310.654 degrees___

Arg. Per. 131.337 degrees__     True Anom 228.663 degrees

Satellite Position Over Africa__________________

Sketch a picture of the 2-D map, as viewed from the North Pole (i.e. lat = 90$^o$, lon = 0$^o$). In your sketch, make the Earth smaller than it really is, in order to be able to see the Parking Orbit. Label the segments of the orbit:

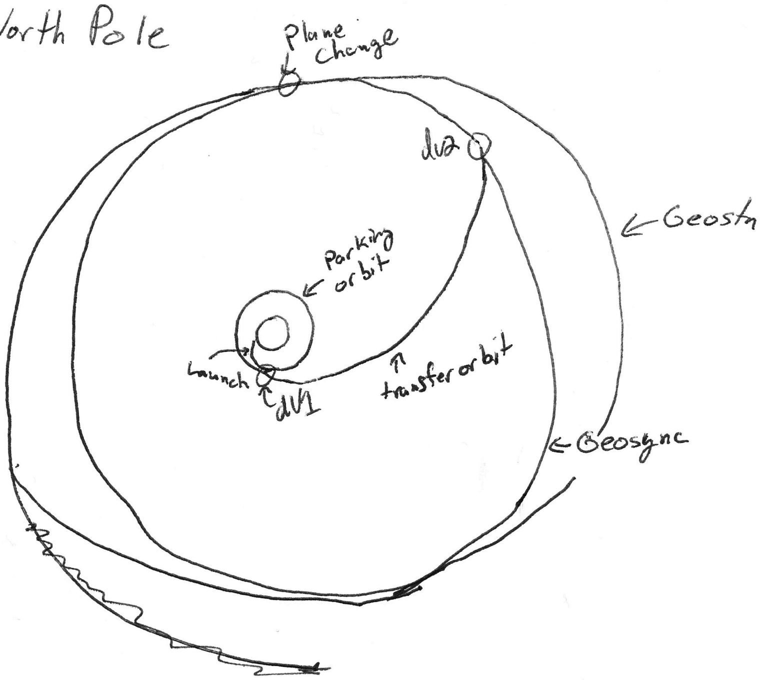
Attached at end.

Change the Projection on the 2-D map in order to view from lat = 0$^o$, lon = 0$^o$. Sketch the 2-D map view.

Attached at end.

Finally, change the projection type on the 2-D map to Equidistant Cylindrical. On the Satellite Graphic Properties page, on the Pass tab, under Ground Track, select Lead Type: One Pass. View the entire sequence. During the Geosynchronous portion, the ground track should be a figure 8, and during the Geostationary portion, it should be stationary.

View from North Pole




Lat = Lon = 0°