# CIVIL AIR PATROL

## INTRO TO SPACE

### STK LESSON PLAN FIVE:

### *EXERCISE ALPHA*

## Part II – STK Scenario

You are a member of the Sydney Australia environmental team. Presently, you and your team are collecting vital information on the South American environmental conditions impacting Australia. The results of your team's efforts will have global impact. The United Nations will use your findings as a foundation for future global environmental treaties.

The GEO satellite constellation that you use to gain information on the environment has been moved to support your county's vital interests. Consequently, you need another satellite to collect the remaining information for your study and to conclude your findings. After you evaluate your team's financial situation, you find that the limited amount of remaining funds restricts your team's options to launching a satellite into a non-GEO orbit. As the environmentalist expert, the team has designated you as team lead. You are responsible for determining the type of satellite needed to meet your requirements and how to conduct operations for launch through mission data collection.

A complete solution will require you to answer the following questions.

1. What type of orbit is needed to have near continuous coverage of South America? (Remember GEO satellites are not an option for this problem.)
2. Define the orbit in terms of the six classical elements.
3. Which booster type will best suit your needs? Assume your satellite weights 2500 pounds.
4. Describe the space system elements required for continuous connectivity between the satellite and the Australia ground facility. Compute the access times between the satellite and the ground facility.

**Good luck mission planner!**

The success of the future UN environmental treaty resides in your hands.

After you have solved the problem, turn the page for a proposed solution, and see how it compares to yours!

**A Solution**

A recommended solution is provided. Due to the open ended nature of the question, other solutions may be valid. How does your solution compare to the recommended solution? To view the recommended solution load **scenario\lesson5\studentprblm** and complete the following steps. The steps are sequenced to provide you a rationale for each question asked above.

**What type of orbit of orbit is needed to have near continuous coverage of South America?**

1. Select the earth map view, expand the screen, and select **START**.
2. Observe a few passes and select **PAUSE.**
    - The map illustrates why a **HEO** satellite is best suited to have near continuous coverage of South America. Observe how long the coverage duration is over South America. In the problem, it stated that originally a GEO satellite was used to collect the information, implying continuous coverage. Although the problem never stated how much time over South America was required, it could be implied that you would want to have as much coverage as possible because of the original coverage. A HEO orbit provides long dwell times over a specific area.

**Define the orbit in terms of the six classical elements**.

1. HEO orbit parameters are defined as follows:

a. **semi-major axis**: 26553.3 km

- A HEO is a non-proportional orbit. The semi-major axis is one-half the distance between apogee and perigee. A 500 km perigee and a 42606 km apogee was selected as input values to determine the semi-major axis.

b. **Eccentricity**: .54.

- By the nature of the HEO orbit characteristics, it is a highly eccentric orbit. Any value between 0.5 and 1 is recommended.

c. **Inclination**: 50. degrees

- The inclination describes the tilt of the orbit away from the equator. The inclination determines the north and south latitude boundaries. A 50 degree inclination was selected because of South America's latitude.

d. **Argument of Perigee**: 90 degrees

- This value determines the location of perigee in the orbit. At perigee, the satellite will travel its fastest. Consequently, you do not want the perigee over South America.

e. **RAAN**: 37.5 degrees.

- The RAAN determines the satellite's orientation in the orbit. Since there is only one orbital plane, almost any value would work.

f. **True anomaly**: 0.0 degrees.

- Since there is only one satellite in the plane, any value would work.

**Which booster type is best suited to lift the satellite to orbit?**

1. A Delta booster is designed to carry this payload weight to a HEO orbit. As an aside, a Hohmann transfer is needed to get the satellite from an initial 28 degree inclined, circular orbit to an inclined 50 degree HEO.

**Describe the space system elements needed to perform operations.**

2. The space system elements needed include an Australian Ground facility (ground segment), a HEO Environmental Satellite, and two relay satellites (space segment). The data transmitted between the ground facility and the satellites represent the data link segment.

3. Although the HEO satellite provides visibility into South America, it does not have constant access to the Australian ground facility. Consequently, the two relay satellites (TDRS east and TDRS west) are employed to provide continuous connectivity to the ground station. Observe their placement.

**Compute the access times between the satellite and the ground facility**.

4. Access time must be computed each time the scenario is loaded. The following steps describe how to compute the access time for this scenario.

   a. Highlight **HEO_Env_Sat** under EnvProblem.

   b. Select **TOOLS** and then **ACCESS** from the draw down menu. An **ACCESS WINDOW FOR SATELLITE** appears.

   c. Select each associated object individually and then **COMPUTE**. Access computation is complete when an **“*”** is in front of the file.

d. Cancel out and then highlight the **TDRS_East**.

e. Select **TOOLS** and then **ACCESS**.

f. Once again the **ACCESS FOR SATELLITE** window appears. Select **Aus_Ground Facility** and then **COMPUTE**. Repeat for TDRS West.

g. Cancel out and thin highlight the **TDRS_West**.

h. Select **TOOLS** and then **ACCESS**.

i. Select **Aus Ground Facility** and then **COMPUTE** to complete the access computations.

j. Back out and select the **Earth View map**. Select the **RESET.**

- The map will show connectivity of all space system elements. At all times in the orbit, the satellite is connected to the Australian Ground Facility. The static, thin red line connects TDRS East with TDRS West. It is a continuous data link connection. The static, thin blue line connects TDRS West with the ground facility. These two lines represent the relay satellites providing information from the satellite to the ground facility. The magenta lines represent the satellite’s connectivity to the different elements throughout the orbit. Compared to the relay satellite lines, this connectivity is dynamic.

k. Select **START** to observe the relationships.

- During most of the orbit, the HEO satellite has multiple paths to relay information to the ground facility.

**l. At time 12:35** select **PAUSE.**

- Note that the only path to collect satellite information over South America is through TDRS East. Select **START**.

m. View as often as necessary.

**n.** When complete, select the **PAUSE.**

o. Select **X** and **OK**. **Do not save file. This step will take you out of the STK VO software.**

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## INTRO TO SPACE

### STK LESSON PLAN FIVE:

### *EXERCISE BRAVO*

Everyone knows about GPS. But does anyone really know what the constellation looks like?

Do we really know how GPS operates?

How many satellites do you need to get a good ‘fix’?

**In this problem, you are to display the GPS constellation. Then compute access times for your location for different times of day**.

Does coverage change over time? Why??

# <u>Proposed Solution</u>

1. To display the GPS constellation, you must first open STK and create a new scenario.

   Click on **File**, then **New**, and **Scenario.**

2. Name it GPS Constellation.

3. Remember to go to **Properties, Basic**, and enter the appropriate times: today's date for **Start** and **Epoch**, and a date a few days in the future for **Stop**.

4. Go to **Tools**, then **Satellite Database**.
   You must ensure you are using the proper satellite database. Go to the top of the window and click on the square that has the 3 dots in it.

   Then select the database called:

   **stkActiveTLE.sd** and select **Open**.

   This database lists only active satellites. We only want to display the active GPS satellites, not every single GPS satellite there ever was…

5. Next check the '**Common Name**' box. Type a "*" then GPS then another '*', so it looks like this: ***GPS***
   The * acts as a wildcard, so when the database is searched, every active GPS satellite will be displayed.

6. Select **Perform Search.** A new window will appear listing all the active GPS satellites.

7. In that window, highlight the satellite at the top of the list, hold down the shift key, scroll down to the bottom of the list, and highlight the last satellite. This should highlight every satellite listed. Hit OK.

   You have just added all the GPS satellites to your scenario.

8. Go to **Tools**, then **City Database**.
   Check **City Name** and type in your city, Select **Perform Search**. Highlight the city and select **OK**.

   You have just added your City to the scenario.

9. Go to **STK VO**. The GPS constellation is now displayed. Zoom out so you can see the entire constellation. It consists of six orbital planes with 4 satellites in each plane. That's how you get 24 hour coverage!!

10. Go to the **STK window**. Highlight your city. Then select **Tools** then **Access**. In the window, highlight the top GPS satellite, scroll down, hold the shift, highlight the bottom one and select **Compute.**

11. If you really want to, you can compute an Access or AER report. But they will be very long and confusing!

12. Go back to **STK VO**. **Start** the animation. Observe what happens when the GPS satellites come into view of your city. The lines indicate your city can see the indicated satellites.

    How many lines are there at any one time??

    You need at least 3 satellites to be able to triangulate your position using a GPS receiver. But 4 or more is better!

    GPS satellites send out a timing signal. Your receiver takes the signals from the different satellites and computes you location. It's all based on time!!

13. Replay as many times as necessary. Change the time or day of the scenario and observe how the access times change.