INTRODUCTION (2 min)

CIVIL AIR PATROL
INTRO TO SPACE
STK LESSON PLAN TWO:
TYPES OF ORBITS

PP Slide 1

ATTENTION:

Now that you should have a good handle of orbital mechanic, we are going to look at some types of orbits to further your understanding of operating in space.

MOTIVATION:

It is vitally important to know the different types of orbits in order understand how orbits are most effectively used

OVERVIEW:

1. Describe the types of satellites and their mission.
2. Describe why satellites are placed into certain orbits.
3. Input a given orbit into STK and evaluate the orbit type and how it contributes to a mission.

TRANSITION: Let’s now look at the orbits of satellites.

BODY (1 hour)

PRESENTATION.	
A. **PART I – OVERVIEW** 1) Now that we have discussed orbital mechanics, and learned how satellites fly, we will now discuss the background on why and how we use satellites daily. In particular, the lesson will describe why we use satellites; what type of information satellites provide; and illustrate how the type of orbit aids the satellite's mission.	**PP SLIDE 2**
a) Satellites today serve as a link to global information by providing a way to collect and move data from one part of the globe to another. Data can take the form of phone conversations, television broadcasts, worldwide Internet connections, or weather information. Satellites affect your life daily. For example, you may have used satellite information to figure out whether or not to bring an umbrella to work or to school this morning, if you based your decision on a weather forecast you saw on television.	**PP SLIDE 3**
b) Today most weather forecasters use satellite data to predict the weather. Satellites also provide other types of data to help make daily life easier or more fun. In the near future, many new cars will be equipped with location finders. These finders will use satellite data to tell you precisely where you are at all times. This information will help travelers navigate through unfamiliar neighborhoods, or travel across country with relative ease. Satellites are also used to broadcast television signals around the globe. If you happened to watch a concert broadcast live from London last night, satellite technology was used to transmit the show to you. All of these examples illustrate how satellite technology enhances our lives and provides people with a better understanding of what is happening around the world	**PP SLIDE 4**
2) Why Use Satellites? a) A great advantage satellites have over any other data transfer technology system is their "big picture" view of the world. This view is a function of a satellite's altitude above the earth's surface. Altitude, in this context, is defined as the satellite's distance above the earth measured either in feet, kilometers, or nautical miles. The higher the satellite, the more earth area it can see. The expanse of earth the satellite can view at one time is commonly referred to as the satellite's field of view (FOV). The following everyday examples illustrate the altitude and the field of view concepts.	**PP SLIDE 5**

1) Some people attended a football game and decided to stand at the sideline to be close to the action on the field. They soon discovered that the players and coaches moving around the sideline blocked their view and limited their visibility of the playing field. Instead of staying on the sideline, they decided to move up to row 5 in the bleachers. When they took their seats and looked around, they found their visibility of the playing field increased immediately. They decided they wanted to see even more of the playing field, so they moved up the bleachers to row 20. From this position, they could see more of the field than they could when they were sitting in row 5, and a lot more than they could see when they were standing at the sideline. Their increased "altitude" in the bleachers expanded their visibility and gave them a "big picture" view of the playing field. Now apply the same principle to a satellite. The higher a satellite's altitude, the more earth area it can view.	
2) The size of a satellite's field of view is also related to altitude. The greater a satellite's distance away from the surface of the earth, the greater its field of view. Satellites in orbits closer to the earth have smaller fields of view than satellites at higher altitudes. You can observe the relationship between distance and field of view by shining a flashlight on a wall. If you are close to the wall, the flashlight's field of view, or the size of the area on the wall the flashlight illuminates, is relatively small. As you back away from the wall, you'll notice that the area of the wall illuminated by the flashlight increases. Because of this relationship, if you want to illuminate only a small area of the wall with your flashlight, you have to stand close to the wall. If you want to illuminate a larger area of the wall, you must increase your distance from the wall. Similarly, if you require a satellite to have a very large field of view, you have to position it at a greater distance from the earth than you would if you need a satellite with a very small field of view.	
3) Although altitude provides satellites with a "big picture" view of the world, altitude also creates a problem. As a satellite's distance away from earth increases, its ability to observe small objects decreases. Let us use the football analogy once again to illustrate our point. When standing on the field sidelines, the players appeared large in size. As you moved further up the bleachers, the players began to appear smaller. If you sat at the very top row in the bleachers you might even be inclined to use binoculars because the players were too difficult to see. Similarly, as satellites increase in altitude, objects in view appear smaller.	

3) Types of Orbits	
a) Technically speaking, an orbit is defined as the gravitationally bound path followed by an object around a celestial body. However, the easiest way to describe an orbit is to imagine a satellite moving around the earth in a racetrack pattern, repeatedly. What is really important is how long in time it takes the satellite to go around the earth one time. Time is important because it determines how long a satellite will remain over a given point on the earth. The time it takes a satellite to go around the earth one time is related to its distance from the earth's surface, or its altitude.	**PP SLIDE 6**
b) As you remember from our mechanics lesson, there are four basic types of satellite orbits: low earth orbit (LEO), medium earth orbit (MEO), highly elliptical orbit (HEO), and geostationary earth orbit GEO). Each orbit type has unique characteristics and features.	
1) **LEO.** A low earth orbit (LEO) is characterized by its average 175 NM (~ 324 KM) distance above the earth's surface. In this orbit, it takes a satellite approximately 90 minutes to go around the earth one time. It takes the earth approximately 24 hours (one day) to complete one revolution. Because the earth rotates from east to west the satellite will not be over the same spot on the earth each time it completes its revolution around the earth. In fact, the satellite will cover area further west of you. Eventually, the satellite will be over the horizon. Thus, a person on the ground will not be able to see the satellite until the earth's rotation brings it into view once again.	
a) A low earth orbit has both advantages and disadvantages. First, LEO satellites travel over more of the earth's surface in a given period of time than satellites in other types of orbits. Second, LEO satellites are close to the earth's surface and can view any spot on the earth with more clarity than a satellite in higher orbits. This aspect is especially important if you want to take detailed pictures of the earth. However, the characteristics of a LEO satellite mean the satellite is not always covering the same point on the ground. Thus, one LEO satellite cannot collect continuously over one point on the earth. When a mission requires more coverage over a specific area, multiple LEO satellites are used in the orbit to compensate for visibility gaps. Primarily, LEO orbits are used by earth sensing and some weather satellites.	

2) **MEO.** A medium earth orbit (MEO) is located approximately 10,000 NM (~18,520 KM) above the earth's surface. It takes a MEO satellite 12 hours to orbit the earth. Compared to the earth's rotation, the satellite makes two orbits for every one rotation of the earth. From the ground observer's perspective, a satellite will pass over twice a day in nearly the same spot.	
a) The MEO has several advantages. First, a satellite in a medium earth orbit can see a larger percentage of the earth compared to a satellite in a low earth orbit. Second, the satellite is over a spot on the earth for a longer period of time resulting in longer periods of time to communicate with the satellite. Like the LEO, observers on the ground do not have continuous access to the satellite. More than one satellite is placed in the orbit if the mission requires more continuous coverage.	
3) **HEO.** The highly elliptical orbit (HEO) is characterized by a non-proportional orbit from the center of the earth. One-half of the orbit is at a very great distance away from the center of the earth, approximately 25,000 NM (~ 46,300 KM), and the other half of the orbit is very close to the earth, at approximately 300 NM (~ 556 KM). Based on the laws of physics, the highly elliptical orbit causes a satellite to move very fast when it is at perigee, the point where the satellite is closest to the earth. Conversely, when a satellite reaches apogee, it is at a greater distance away from earth and travels very slowly in its orbit. Like satellites in LEO and MEO, the HEO does not permit continuous access to the observer on the ground. However, HEO satellites cover certain areas on the earth for much longer periods than LEO and MEO satellites. In general, highly elliptical orbits are used for communication satellites that cover extreme northern or southern latitudes.	
4) **GEO.** A satellite in geosynchronous earth orbit (GEO) is located approximately 22,000 NM (~ 40,744 KM) away from the earth's surface. Mathematically translated, a satellite in a GEO has a velocity equivalent to the earth's rotation. Consequently, from the ground observer's perspective, the satellite will always be over the same spot on earth. Additionally, only three satellites are required to cover completely the earth because a single satellite can see approximately one-third of the earth's surface.	

a) GEO satellites have two advantages. First, it is able to see a large percentage of the earth at one time. Additionally, ground observers have continuous access to the satellite and do not have to wait for a specified time to communicate with a GEO satellite, provided the ground observer is located within the area of the earth the satellite is covering. However, satellites in GEO are very far away from the earth's surface and the satellite's ability to distinguish between objects becomes more difficult. Consequently, satellites in GEO usually have powerful onboard sensors to help them see better. GEO satellites are primarily used for communication and weather satellites.	
4) Relating Mission to Orbit Type	**PP SLIDE 7**
a) Satellites are launched into LEO, MEO, HEO, or GEO to optimize satellite performance and their planned missions. The GOES system is a good example to demonstrate the relationship between mission and orbit.	
1) The GOES mission is to provide weather imagery and quantitative sounding data to many weather observers and forecasters. The satellite provides updates every one-half hour. GOES imaging covers the regions of the Central and Eastern Pacific ocean; North, Central and South America; the West and Central Atlantic Ocean; the Pacific ocean including Hawaii, and the Gulf of Alaska.	
2) To cover the vast region identified, only two satellites are required. One satellite is positioned at 75W longitude and the second at 135W longitude. To ensure the mission is met, two GOES satellites are placed in GEO orbit, at approximately 23,200 NM altitude. The end result is these satellites at GEO orbit provide continuous access to the regions specified to accommodate the observation time interval requirements dictated by the mission. However, because GOES is located so far from the earth, the satellites are designed with high-resolution sensors to compensate for their very high orbit altitude above the earth.	
This concludes the lecture portion of the lesson for this chapter. It's now time to use STK again!!	**PP SLIDE 8**

B. PART II - STK SCENARIOS This portion of the lesson plan illustrates the satellite concepts you have learned about so far. To do this, you will run four self-guided scenarios using STK/VO software. Each scenario will help you visualize the characteristics associated with one of the four basic satellite orbits described earlier. The instructions below are a step-by-step guide to help you load, view, and understand the scenarios. **REFER TO CHAPTER TWO, PART II - FOR STK SCENARIOS ONE THRU FOUR AT ATTACHMENT** *Recommend handing out the attachements to the students and let them accomplish the scenarios at their own pace.*	
C. PART III - STUDENT PROBLEM This portion of the lesson plan provides an opportunity for you to apply the concepts you have learned in Part I and Part II by solving a problem.	
Problem	You have been tasked to survey the volcano activity in Kabankalan, Philippines. Your requirement is to take volcanic temperature data readings once every three days. What type of orbit would be best suited for a survey mission? What would be the advantage/disadvantage to your mission by placing the satellite in your proposed orbit?
Proposed Solution **REFER TO CHAPTER TWO, PART III - FOR STK PROPOSE SOLUTION, AT ATTACHMENT**	A remote sensing type satellite in a LEO would be best for meeting the requirements specified in the problem. A LEO satellite, as demonstrated in scenario one, will collect the data on the volcanic activity at a minimum of once every three days. Since the LEO is closer to the surface of the earth, the sensors can collect the data more easily. Thus, the LEO altitude offers an advantage over the other type orbits.

D. PART IV - SUMMARY In this lesson, we have reviewed several concepts. First, satellites provide us varied services on a daily basis. Second, there are four basic orbits, each having unique characteristics. Using different orbits allows us to enhance a satellite's performance by placing it at the perfect altitude to best do its job.	
TRANSITION: Are there any questions?	
BREAK !! You have completed Scenario Two.	