Sally K. Ride Papers - KidSat Student Mission Operations Center (SMOC) Teachers Handbook, [with corrections], (folder 2 of 2)

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Here are chapters 6 and 9.

By now you should have received chapters 1-4, and 6,9.

You may have noticed that some of these “chapters” are more for teachers than students (they give you background information you’ll need to run things), while others are more for students (or at least contain material that we intend that students learn). Chapter 9 is for teachers, not students.

You may want to look at this chapter soon, because it will give you an idea of how to set up your SMOC, and hopefully answer some of your questions.
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Introduction

In this chapter we will first introduce some general concepts about orbits, then describe the shuttle's orbit and how to use drawings of the shuttle's ground tracks during the KidSat flight. Students at the SMOC's will be using ground track maps before and during the mission to determine what parts of the world the shuttle will pass over during STS-81, and therefore which areas can be photographed.

This is a long chapter. The last part of it is critical to participation in KidSat, so don't get too bogged down in the first half. The first half contains some background on gravity and why an object stays in orbit; this is not essential to KidSat, but it is interesting (to us, anyway). The second half is quite important; your students will have to be able to read and interpret a shuttle ground track (Chapter 7 will describe the tools we will provide to assist them).

Background

The space shuttle stays in orbit around the Earth because of the speed it is given after launch and the Earth's gravity. As the shuttle repeatedly orbits the Earth following the same circular path, the Earth rotates beneath it. The trace the shuttle's orbit makes on the surface of the rotating Earth below is called the shuttle's ground track. Ground track maps are extremely useful since they reveal the locations on the Earth that the shuttle directly flies over during its orbit.

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Page 6.2
What is an Orbit?

An orbit is simply the path an object travels on as it revolves around another body in space.

The shuttle's orbit can be thought of as a fixed racetrack in space that the shuttle follows over and over again.

Examples of Orbits

Solar System

The Earth and all the planets of our Solar System orbit around the Sun. While the Earth orbits the Sun, other objects can be in orbit around it.

Interesting Facts:

1) It takes the Earth 365 days to make one orbit around the Sun.

2) It takes the moon 29 1/2 days to make one orbit around the Earth at a distance of 240,000 miles.

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The Earth

While the Earth is orbiting the Sun, it is also spinning about its own axis, which is an imaginary line through the center of the Earth from the North Pole to the South Pole. It takes the Earth 24 hours to complete one rotation about its axis, which is what we call a day. The side of the Earth facing the Sun receives light and is in day, but the opposite side is dark and is in night. The Earth spins toward the East (counterclockwise) when viewed from above the North Pole.

Important Facts About the Earth:

1) The Earth rotates counterclockwise towards the East around its axis, making one complete revolution in 24 hours.

2) The Earth can be modeled as a sphere with a radius of 4000 miles.

3) The distance around the equator (or circumference of the Earth) is approximately 25,000 miles.

4) Each degree of longitude at the equator corresponds to 69 miles.

5) Since the Earth rotates 360° in 24 hours, its rotation rate is 15° per hour.
What Keeps Bodies in Orbit? Gravity

The most important force that keeps bodies moving around each other is gravity. Objects are held in orbit by the gravitational pull of the body they move around. The Sun's gravity keeps the Earth and all the other planets rotating around it. The Earth's gravity keeps the moon orbiting around it. The Earth's gravity also keeps the space shuttle in orbit around it.

Interesting Facts about Gravity:

1) The strength of the gravitational force depends on two things: the amount of mass in the objects and the distance between them. More massive objects exert a stronger pull of gravity than smaller objects. Objects that are close together have a stronger pull of gravity than objects that are far apart.

2) The Earth's gravity pulls everything on its surface and everything in the space around the Earth towards its center. The farther we go from the Earth's surface, however, the weaker this gravitational pull becomes.

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A Simple Example to Illustrate Why Orbits Exist

Now that you know something about gravity, we will discuss a simple example that illustrates conceptually why orbits exist. Suppose you are standing on top of a tall building and you start throwing baseballs. We all know from experience that when you throw a ball, it follows a curved path until it hits the ground. The harder you throw it, that is, the more velocity you give it in the forward direction, the farther it travels before it hits the ground. The force with which you throw causes the ball to go outward and the force of gravity pulls the ball to the ground. Now back to the tall building on the surface of the Earth. Remember, because the Earth is spherical in shape, the surface curves downward.

Case A: You throw the ball forward and it lands on the Earth some distance away from the building.

Case B: You throw the ball even further. Gravity still causes the ball to curve downward and strike the Earth, but further away from the building than in Case A.

Case C: You throw the ball just fast enough so that gravity causes its path to curve downward at exactly the same rate that the Earth curves downward. The ball keeps falling around the Earth at a constant height without ever hitting the Earth. The ball stays in a circular orbit around the Earth!
Circular Orbits
The shuttle is in a nearly circular orbit around the Earth. To stay in this orbit around the Earth, the shuttle must be given forward speed initially so that it does not fall to the ground from the force of gravity. If there was no gravity, the shuttle's forward speed would cause it to fly off into space. Gravity keeps the shuttle flying around the Earth by constantly pulling it towards the center of the Earth.

Gravity
Forward Motion
of the Shuttle

Free-Fall Motion
If you were in a circular orbit around the Earth, you would feel like you were falling. This condition is called free-fall. The astronauts and everything inside of the shuttle are falling together at the same rate, no matter how big or heavy they are. In free-fall you do not feel the force of gravity even though gravity is present. The shuttle never escapes the Earth's gravity. In fact, gravity is what keeps the shuttle falling around the Earth!

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How to Describe an Orbit

Now that we know that the space shuttle is in a nearly circular orbit around the Earth, we need some ways of describing what the orbit looks like in space. The following parameters will be used to describe the size, orientation, and location of the shuttle's orbit.

Orbital Plane
If you draw a circle on a piece of paper, the circle represents the orbit and the piece of paper is the orbital plane. The orbital plane always passes through the center of the Earth.

Inclination
The orientation of an orbit is described by an angle called the inclination. The inclination gives the tilt of the orbital plane with respect to a plane that contains the Earth's equator. The highest latitude reached by a body in orbit is equal to its inclination. This means that when the body reaches the northernmost point in its orbit, its latitude will equal the inclination of the orbit. Similarly, when it reaches the southernmost point in its orbit, its latitude will equal its inclination in degrees South.

Example:
The inclination of an orbit in the same plane as the Earth's equator is 0°. The inclination of an orbit in a plane containing both the North and South Poles is 90°.

Example:
The inclination of an orbit in the same plane as the Earth's equator is 0°. The inclination of an orbit in a plane containing both the North and South Poles is 90°.

On STS-81, the shuttle will launch into an orbit with an inclination of 51.6°. Therefore, during STS-81, the shuttle will never go further North than 51.6°N or further South than 51.6°S.
Direction of Motion

The space shuttle is launched in the same direction as the Earth rotates, towards the East, and continues to orbit in a counterclockwise direction around the Earth.

Ascending and Descending Nodes

The ascending node is the point where the orbit crosses the equator going from South to North. In the figure below, the descending node, where the shuttle crosses the equator from North to South, is on the opposite side of the Earth from the ascending node. The ascending and descending nodes can be projected onto the surface of the Earth and given in terms of longitude. As you will see in the following section on ground tracks, the longitude of the ascending and descending nodes provide much information about the shuttle's orbit.

Example:

The shuttle’s orbit crosses the equator going from South to North over the Congo in Africa. The longitude of the ascending node is 15°E.

The shuttle’s orbit crosses the equator going from North to South over the middle of the Pacific Ocean. The longitude of the descending node is 135°W.

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Altitude

The size of the orbit is described by the height of the shuttle above the surface of the Earth, or its altitude.

Orbital Period

The orbital period is the time it takes to make one complete trip around the orbital path. An orbit's altitude and period are related; the higher the altitude, the longer the period.

Example:

<table>
<thead>
<tr>
<th>altitude</th>
<th>period</th>
</tr>
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<tr>
<td>shuttle</td>
<td>200 miles</td>
</tr>
<tr>
<td>commun</td>
<td>24,000 miles</td>
</tr>
<tr>
<td>moon</td>
<td>240,000 miles</td>
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</table>
The Shuttle's Orbit

During STS-81, the space shuttle will rendezvous and dock with Mir, the Russian space station. The orbit designers for STS-81 have to design the shuttle's orbit so that it intercepts Mir on the third or fourth day of flight. The shuttle and Mir stay joined together, orbiting the Earth for four to five days. The shuttle then undocks from Mir and remains in orbit for two to three days before landing.

Important Fact about Mir's Orbit:

The Mir space station is in a circular orbit around the Earth at an altitude of 250 miles and inclination of 51.6°.

Shuttle's Orbit Before Docking

The shuttle is launched into a 51.6 degree inclination orbit to match Mir's. The shuttle is accelerated to about 17,500 miles per hour into a circular orbit around the Earth. The shuttle is put into an orbit with an altitude of 200 miles, lower than Mir's. To maintain this orbit, no more propulsion is necessary except for occasional minor adjustments.

Interesting Fact:

The Shuttle is in a low Earth orbit, extremely close to the ground, when you consider that the radius of the Earth is roughly 4000 miles (20 times the shuttle's altitude).

To put low Earth orbits like the shuttle's in perspective: Imagine the Earth is the size of a peach--then a typical shuttle orbit would be just above the fuzz.
Initially, the shuttle's altitude is less than Mir's so that the shuttle actually goes around the Earth faster than Mir. (Remember that the smaller the altitude of a circular orbit, the smaller its orbital period.) When the shuttle has caught up with Mir, engines are fired to raise its altitude to 250 miles to match that of Mir's. The inclination of the orbit does not change, only the altitude.

### Shuttle-Mir Docking

**Shuttle's Orbit**

| altitude: | before docking | 200 miles |
| after docking | 250 miles |
| inclination: | 51.6 degrees |
| period: | 90 miles |
| speed: | 17,500 miles/hour (5 miles/second) |

**Mir's Orbit**

| altitude: | before docking | 200 miles |
| after docking | 250 miles |
| inclination: | 51.6 degrees |
| period: | 90 minutes |
| speed: | 17,500 miles/hour (5 miles/second) |

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Sally K. Ride Papers - KidSat Student Mission Operations Center (SMOC)  
Teachers Handbook, [with corrections], (folder 2 of 2)  
Transcribed and Reviewed by Digital Volunteers  
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As the shuttle circles the earth in a low Earth orbit, it spends roughly half its orbit above the daylight portion of the Earth (the sunlit hemisphere) and the other half above the night portion of the Earth (the dark hemisphere). During each 90 minute orbit, the shuttle experiences about 45 minutes of daylight and 45 minutes of night.
Ground Tracks

We now know something about what the shuttle's orbit looks like in space. However, what we really want to know is the location of the shuttle with respect to the surface of the Earth. The shuttle's ground track is the path on the surface of the Earth that lies directly below its orbit. A ground track map shows the locations on the surface of the Earth that the shuttle flies over as it travels repeatedly around its orbital path. Utilizing the shuttle's ground track maps is essential for targeting and image selection in KidSat.

All ground track drawings use the latitude-longitude coordinate system. Any point along the ground track is then described by two values: the latitude, which measures how far North or South a point lies from the equator, and the longitude, which measures how far East or West a point lies from the Prime Meridian.

Ground Tracks for a Non-Rotating Earth

The first step in understanding what ground tracks look like is visualizing the ground track the shuttle would have if it were orbiting around a non-rotating Earth. The figure below on the left shows the trace of points on the surface of a non-rotating Earth directly under a circular orbit with an inclination of approximately 50 degrees. On a globe, the ground track looks like an inclined circular path, called a great circle, whose plane slices through the center of the Earth.

Ground Track on a Globe

Ground Track on a Flat Map
What does the inclined circular ground track look like on a flat map projection of the Earth? The easiest way to see this is to think of a flat map as a globe printed on the label of a soda can. When the label is peeled off the can, the ground track for the inclined circular orbit turns an “S” shaped curved on a flat map of the Earth, as shown by the figure on the bottom right of the previous page. If you put the label back around the soda can, the “S” sure turns back into an inclined circular path that extends all the way around the globe. Notice that the “S” shaped ground track extends as far North as it does South. The maximum Northern and Southern latitudes on the ground tracks must equal the inclination of the orbit!

Also notice that if the Earth did not rotate, the ground track would span 360° of longitude (from 180°W to 180°E) along the Earth’s surface and would always stay the same since the shuttle would pass over the same locations on the Earth, orbit after orbit (A shuttle launched from Cape Canaveral would pass back over Cape Canaveral once every orbit. As you will see in the next section, this does not happen because the Earth does indeed rotate beneath the shuttle).

The direction of the shuttle’s motion along its orbit determines the direction of motion along the ground track. Since the shuttle orbits the Earth in a counterclockwise-direction, its path moves from left (West) to right (East) along the ground track (Note direction of arrow along the ground track).

The location of the shuttle’s ground track on a map of the Earth is given by the longitude of the ascending and descending nodes. In this non-rotating Earth example, the ascending node (South to North equatorial crossing) occurs at the left edge of the map, the descending node (North to South equatorial crossing) in the middle, and another ascending node (of the next orbit) at the far right edge of the map. Notice that the two ascending nodes on the ground track mark the same location in the orbit. One convenient way to mark the beginning and end of an orbit on a ground track drawing is from ascending node to ascending node. In this example, for a non-rotating Earth, this orbit begins and ends over the same location on the Earth’s surface because the left and right edges of the map mark the same longitude. This will not be true when we add in the effects of the Earth’s rotation in the following section.
Important Facts About Ground Tracks:

1) The ground track extends as far North as it does South and the maximum latitude reached always equals the inclination of the orbit.

2) Since the shuttle orbits towards the East, its ground track moves across the map from left (West) to right (East).

Ground Tracks for a Rotating Earth

The shuttle continues to circle the Earth, returning to the same point in space after each orbit. If the Earth did not rotate, then it would also return to the same spot over the Earth after each complete orbit. However, the Earth rotates counterclockwise beneath the shuttle! We mentioned earlier that the Earth rotates at a fixed rate of 15° per hour (360° in 24 hours). So, as the shuttle makes one complete circle around the Earth in 1 1/2 hours (90 minutes), the Earth rotates 22.5° (15°/hour times 1 1/2 hours)! The figure below illustrates this concept. The shuttle begins an orbit directly over location A on the Earth (picture on the left). After 90 minutes, the shuttle completes one orbit and returns to the same point in space from where it started (picture on right). However, since the Earth rotates counterclockwise (towards the East) beneath the shuttle, after one orbit the shuttle is directly over point B at a location 22.5° to the West of point A.

Shuttle starts directly over point A on the Earth.

One complete orbit later, the shuttle has returned to its original point in space. But because of the Earth’s rotation, it is now over point B, 22.5° to the West of point A.

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How does this Rotation Affect the Ground Track Drawing for Successive Orbits?

The Earth's rotation to the East causes the ground tracks to shift to the West after each successive orbit. The easiest way to measure the shift in the ground track is to measure how much the ascending and descending nodes move to the West. After one 90 minute orbit, the nodes shift 22.5° to the West. This means that because of the Earth's rotation, the shuttle only covers 337.5° (360°-22.5°=337.5°) of longitude along the Earth's equator during each 90 minute orbit.

Eventually after several more orbits, a criss-cross pattern forms on the ground track map. Because of the Earth's rotation, a shuttle in a low earth orbit actually sees different parts of the world in every orbit. At the equator 1 degree corresponds to 69 miles so that for each orbit, the ground track shifts about 1500 miles along the equator.

Ground Tracks for STS-81

The figure below shows the shuttle's predicted ground tracks for two orbits during STS-81. The solid line represents orbit 1 and the long dashed line represents orbit 2. Orbit 1 begins at its ascending node, -145° (145° West). Orbit 2 begins at the next ascending node (marked ascending node #2 in the figure), -167.5° (167.5° West). The descending node in orbit 2 moves 22.5° to the West of the descending node of orbit 1.
Day/Night on the Ground Tracks

The shuttle spends roughly half of its orbit over the night side of the Earth and the other half over the sunlit side. This means that during its 90 minute orbit, 45 minutes of the ground track are in day and 45 minutes are in night. The figure below shows a ground track for one orbit during STS-81. The dotted line of the ground track indicated that the shuttle is in daylight and the solid line signifies that that portion of the orbit is in night. KidSat images are taken of locations on Earth which are in daylight. In this example, images can be taken from 130° West (-130°) to 30° East (+30°) in longitude along the ground track.

Important Facts About STS-81 Ground Tracks:
1) The direction of the shuttle's ground track is from West to East.
2) The ground track does not go above 51.6° North or below 51.6° South.
3) The ground track ascending and descending nodes shift 22.5° to the West for each successive orbit.
4) Approximately one-half of the ground track is in daylight for each orbit.

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References

Books:
To Rise From Earth
by Wayne Lee

Understanding Space: An Introduction to Astronautics
by Jerry Jon Sellers

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Activity 6.1

Earth Model
Overview
Students will build a model of the Earth showing the relationship between the equator and the orbit of the shuttle. Before the students begin this activity, you might want to make one Earth model for demonstration purposes.

Time
1-2 class periods

Materials
Basketball (1 per group)
Scissors
Florist Wire
Tape
4 large dot stickers (2 different colors)
2 different colors of construction paper with dimensions of at least 14 in x 14 in
1 classroom globe
Student Worksheet 6.1

Getting Ready
Prepare a classroom earth model and use it to demonstrate this activity. Assign students in groups of three to four.

Procedure
1. Lead the classroom in a discussion of orbital planes. (Important points: the orbital plane passes through the center of the Earth at an inclination of 51.6°. This plane does not change during the flight.)
2. Use the classroom earth model to demonstrate what the students will be doing.
3. In small groups, students will create their own earth model using Student Worksheet 6.1.

Discussion
The equatorial plane is the plane which passes through the Equator, cutting the Earth into two hemispheres. The orbital plane contains the shuttle’s orbit; the shuttle never leaves this plane.
The inclination of the orbit is the angle that the orbital plane makes with the equatorial plane. For Mir docking flights, this angle is 51.6°.
The nodes of an orbit are defined as the intersection of the orbital plane and the equatorial plane. The descending node is the node that occurs as the shuttle passes from the Northern hemisphere to the Southern hemisphere, and the ascending node is the node that occurs as the shuttle passes from the Southern hemisphere to the Northern hemisphere. (Remember in describing the shuttle’s path, that the shuttle travels toward the East around the Earth.)
Student Worksheet 6.1
Earth Model

In this activity, you will make a model of the Earth (the basketball) which shows the equatorial plane and the shuttle's orbital plane.

Procedure

1. Place one dot sticker on the top of the basketball to represent the North Pole.
2. Place a second sticker (of the same color) directly opposite the first sticker (on the bottom of the ball) to represent the South Pole.
3. Find the "equator" on the basketball which separates the Northern and Southern Hemispheres. Wrap a piece of wire around the equator of the ball.
4. Cut the piece of wire. (It should just fit around the ball.)
5. Measure with a ruler the length of the wire to find the distance around the ball.

Question:
What is the circumference of the basketball? __________ in

Making the Equatorial Plane

6. Manipulate the piece of wire to form a circle.
7. Trace the circle in the middle of one of your pieces of paper and cut out the circle. You should now have a piece of paper with a circular hole in the middle.
8. Place the paper around the "equator" of the basketball.

This is your equatorial plane!

Making the Orbital Plane

9. To make the orbital plane, repeat steps six and seven using the second piece of paper, of a different color. Remember: the orbital plane will be at an angle to the equator, but it still has the same circumference. (Why? Because the orbital plane always passes through the Earth's center.)
10. Draw an orbit on the orbital plane.

This is your orbital plane!

11. Take the same wire and cut it in half so that there are now two pieces of wire of equal length.
12. Wrap the wire half-way around the equator, and mark the beginning and the end of the wire on the ball with the other pair of stickers. (These round stickers will represent the ascending and descending nodes.)
13. Lay the orbital plane on the table. Wrap one of the pieces of wire half-way around the inside of the cut-out circle. Mark the paper at the two ends of the wire.

14. Line a ruler up with a two marks that you just made, and draw a line to the edge of the same paper on each side.

15. Cut the orbital plane in half along this line, and set the two halves aside.

16. Take the equatorial plane, place it around the equator and secure it with tape.

17. Put the orbital plane (now in two halves) at an angle to the equatorial plane. (This will take two hands.) The angle between the two planes is the angle of inclination. (The angle should be about 50°.)

18. Tape the orbital plane to the equatorial plane and to the ball so that the orbits are face up. Remember: The orbital plane is a continuous plane.

Compare your model with the classroom model.
Activity 6.2
Flat Map Orbit Projection

Overview
Imagine the Earth is shaped like a soda can. Students will draw an orbital ground track on a map which has been wrapped around a soda can, and then unwrap the map to see what the ground track looks like on a flat map. A trace of the shuttle’s orbit on the soda can looks like a circle slicing through the center of the can. When you flatten out the can, the orbit track looks like an S-curve.

Time
1 class period

Materials
Soda Can (one for each pair of students)
Tape
Rubber band
Scissors
Orbit Map 6.2 (one per student)
Student Worksheet 6.2

Getting Ready
Have your Earth model from Activity 6.1 available.
Assign the students to work in pairs or small groups.

Procedure
1. Remind the students about the shuttle’s orbit from the Earth Model Activity (Activity 6.1) and that the orbital plane is inclined 51.6° relative to the Equator.
2. Have the students cut out the world map along the borders and tape it around the soda can (so that the top of the can represents the North Pole).
3. Have the students place a rubber band (representing the orbit) around the can, as directed.
4. The students will trace along the rubber band, then unwrap the map.
5. Have students complete the exercises on Student Worksheet 6.2.

Discussion
The shuttle’s orbit is a near-circle around the Earth. On STS-81 (and in this activity), the inclination of the orbit is 51.6°. When the circular orbit is shown on a flat map, it looks like the ground tracks illustrated in Chapter 6. The shuttle travels toward the East (from left to right on a flat map); the ground track crosses the Equator twice (at the nodes), and goes between latitudes 51.6° N and 51.6° S.

Helpful Hints, Variations, and Extensions
Have one student hold a wire, representing the orbit, around the can, while the other student rotates the earth counterclockwise, if viewed from the top. What happens to the ground track?
Student Worksheet 6.2
You will create an orbit groundtrack on a flat map using a side can to represent the Earth.

Procedure
1. Cut out the map (Orbit Map #6.2) provided with the activity.
2. Wrap the map around the soda can and secure it with tape.
3. Place a rubber band around the equator.
4. Use small pieces of tape to secure the rubber band to the map at points A and C marked on the map.
5. Stretch the sides of the rubber band between A and C up to point B on one side, and down to point D on the other. (Hint: If you stretch the rubber band slightly higher than point B and slightly lower than point D and allow it to slowly 'unstretch' back to points B and D before taping, your ground tracks will be more accurate.)
6. Secure the rubberband to points B and D with tape.
7. Take the tape from points A and C off of the can so that the rubber band will lay smoothly around the can.
8. Use the rubberband as a guide to trace the ground track on the map with a felt-tip pen.
9. Carefully remove the rubber band.
10. Untape the map, and take it off of the soda can. Lay it out flat to see the groundtrack that you've drawn.

[Image]

map
equator
rubber band

Exercises
1. Mark (with arrows) on your map the direction that the shuttle moves.
2. Label the ascending node. What is the longitude of the ascending node? _________
3. Mark the descending node. What is the longitude of the descending node? _________
4. What is the farthest North latitude? _________ Mark that point.
5. What is the farthest South latitude? _________ Mark that point.
6. What continents does this particular orbit cross?

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Activity 6.3

Orbit Activity

Objective:
In this activity, the students will become familiar with ground tracks, the spacing between orbits, and the speed with which the shuttle crosses the ground. They will answer questions associated with four (consecutive) orbits across the United States (orbits that the shuttle followed on STS-76), and get a feeling for how much of the country they can photograph (not a lot!), and how quickly the shuttle crosses the country.

Time
1 class period

Materials
Student Worksheet 6.3
Map 6.3
Atlas (optional)

Getting Ready
Assign the students to work individually, or in small groups

Procedure
1. Lead a discussion of orbits, particularly noting that because the Earth rotates, the ground track of one orbit is west of the orbit that preceded it.

2. Have the students answer questions on Student Worksheet 6.3, using Map 6.3.

Discussion:
It takes the space shuttle about 90 minutes to orbit once around the Earth. If the Earth did not rotate, the shuttle's orbit would take it over the same part of the Earth over and over and over. Because the Earth rotates underneath the shuttle, the shuttle goes over a different part of the Earth on each orbit.

Students should learn that the shuttle does not go over every part of the world (there is a lot of ground between the orbit tracks, and the KidSat camera can only take a picture of the ground that lays on its orbit track).
Orbit Map 6.2

[Image]
Activity 6.3

Orbit Activity

Objective:
In this activity, the students will become familiar with ground tracks, the spacing between orbits, and the speed with which the shuttle crosses the ground. They will answer questions associated with four (consecutive) orbits followed on STS-76, and get a feeling for how much of the country they can photograph (not a lot!), and how quickly the shuttle crosses the country.

Time
1 class period

Materials
Student Worksheet 6.3
Map 6.3
Atlas (optional)

Getting Ready
Assign the students to work individually, or in small groups.

Procedure
1. Lead a discussion of orbits, particularly noting that because the Earth, the ground track of one orbit is west of the orbit that preceded it.
2. Have the students answer questions on Student Worksheet 6.3, using Map 6.3.

Discussion:
It takes the space shuttle about 90 minutes to orbit once around the Earth. If the Earth did not rotate, the shuttle’s orbit would take it over the same part of the Earth over and over and over. Because the Earth rotates underneath the shuttle, the shuttle goes over a different part of the Earth on each orbit. Students should learn that the shuttle does not go over every part of the world (there is a lot of ground between the orbit tracks, and the KidSat camera can only take a picture of the ground that lays on its orbit track).
Student Worksheet 6.3

The map that goes with this activity (Map 6.3) shows four consecutive space shuttle orbits. (These are orbits that the space shuttle followed on a previous flight, not orbits that it will follow on STS-81).

1. Put an arrow on each orbit to show what direction the shuttle was traveling.

2. The orbit on the far right of the map (the furthest east) was the 11th orbit of this particular shuttle flight (the 11th time the shuttle circled the earth.) Label it Orbit #11.

3. Now label the other orbits by their orbit number.

Answer the following questions by referring to Map 6.3.

Questions:

1. The shuttle passed over Cuba in orbit 11. One orbit later, orbit 12, the shuttle passed over Texas. How many minutes elapsed between when the shuttle passed over Cuba and when it passed over Texas?

2. Do any of the orbits cross the West Coast? If so, which one(s)?

3. Do any of the orbits cross the East Coast? If so, which one(s)?

4. Can you photograph both coasts on any one of these orbits, 11-14?

5. Is there an orbit that crosses your state? If so, which one?

6. Which states does orbit 14 cross?

7. a) About how long does it take the shuttle to cross the US on orbit 12? (Hint: Count the tick marks; remember 1 tick mark equals 1 minute)

   b) Using your answer from part (a) above, determine how many miles the shuttle travelled across the US in orbit 12. (Remember, the shuttle travels at 5 miles/second.)

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Answers to Worksheet 6.3

1. The shuttle passed over Cuba in orbit 11. One orbit later, orbit 12, the shuttle passed over Texas. How many minutes elapsed between when the shuttle passed over Cuba and when it passed over Texas? 90 minutes.

   Explanation: Each shuttle orbit around the world is approximately 90 minutes.

2. Do any of the orbits cross the West Coast? yes
   If so, which one(s)? 13 and 14

3. Do any of the orbits cross the East Coast? no
   If so, which one?

4. Can you photograph both coasts on any one of these orbits, 11-14? no
   Explanation: None of the orbits, 11-14, cross both coasts.

5. Is there an orbit that crosses your state? If so, which one? Orbit 13 crosses over the state of California.


7. a) About how long does it take the shuttle to cross the U.S. on orbit 12? (Hint: Count the tick marks; remember 1 tick mark equals 1 minute.) 7 minutes

   b) Using your answer from (a) above, determine how many miles the shuttle travelled across the U.S. in orbit 12. (Remember, the shuttle travels at 5 miles/second.)

   7 minutes x 60 seconds/minute x 5 miles/second=2100 miles

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CHAPTER 7
How to Select Targets

Objective: To learn how to select areas on Earth that the KidSat camera can photograph.
<table>
<thead>
<tr>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>[2 columns]</td>
</tr>
<tr>
<td>--- Page Number</td>
</tr>
<tr>
<td>Introduction</td>
</tr>
<tr>
<td>What's Involved in Targeting?</td>
</tr>
<tr>
<td>Tools for Targeting</td>
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<td>How to Use the Slider Map</td>
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<td>Code Words: why do we have them; how do you use them?</td>
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<td>Activities</td>
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<tr>
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<td>Using the Web Pages</td>
</tr>
<tr>
<td>[The Target Selection Process]</td>
</tr>
</tbody>
</table>
[Image]

Introduction

In this chapter, students will begin to draw together information from previous chapters, learn how to select sites on the Earth to photograph, and how to specify the information required to take a picture of these sites. The sites, called targets, must lie on the shuttle groundtrack, in the daylight part of an orbit, and within the footprint of the camera. This chapter addresses the mechanics of selecting a target; it does not discuss the different types of targets (e.g., deserts, rainforests, cities) that are available. Before the students being to select targets for the actual mission, they should discuss what types of targets they are interest in photographing.

Note: the Slinder Map referred to in this chapter will be provided by KidSat. We will also provide a separate "manual" on the SMOC web pages. The section on code words is intended for a teacher’s use; the code words themselves will be provided later.

Background

On STS-81, the space shuttle will be in orbit that will take it between latitudes 51.6 degrees N and 51.6 degrees S. That doesn’t mean that the camera can photograph any spot on Earth between those latitudes. Because the camera footprint is only about 100 miles across, only a small area on either side of the shuttle’s ground track can be photographed. In chapter 6, we saw that the ground tracks of successive orbits are widely spaced (about 1500 miles apart at the equator). If the shuttle stayed in orbit long enough, eventually the ground tracks would cover most of the world between the furthest north and south latitudes. But since the shuttle only stays in orbit for a week or two, only a relatively small fraction of the Earth between 51.6 degrees North and South can be photographed during any one shuttle flight.

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What's Involved in Targeting?

What is a target?

A target is a location on the Earth that you have decided to photograph. That location must fall within the footprint of the KidSat camera; that is, it must lie along the shuttle ground track during one of the orbits that the KidSat camera is mounted. The sketch below show a possible target in Australia. The sit lies near a shuttle orbit, and within the footprint of the camera (indicated by rectangle).

[[image]]

Why do you need to know a select target?

You will be selecting a set of targets for each KidSat orbit. You first need to know part of the world the shuttle passes over on the orbit. Then you need to know what part of the orbit is in daylight. With that information, you can pick some tentative targets. After you pick a tentative target, you can then, using the SMOC web pages, determine very precisely whether the camera footprint, you can use the SMOC web pages to determine the exact MET that the shuttle will pass over your target.

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Tools for Targeting

The primary tools for targeting are the Slider Map and the SMOC Map web page. The Slider Map provides a good first look at the ground track of the orbit of your choice. It is excellent for selecting tentative targets; however, it is not accurate enough to determine the exact latitude and longitude of your targets, and cannot tell you the exact MET at which the space shuttle will pass over the target. Once you have a tentative target selected, you will probably want to examine that part of the world in more detail, using an atlas or other reference book; then you will use the SMOC Map web page to find the precise latitude and longitude of your target, and to calculate the MET of the photo.

Slider Map

What is the Slider Map, and why do you need it? The Slider Map is a large world map, and a sheet of plastic with an orbit ground track printed on it. You can slide the plastic overlay to any position on the map; if you know the descending node of the shuttle orbit, you can position the overlay so that its descending node is at that longitude. The overlay then shows the ground track of that particular orbit. You can use the slider map to find the ground track of any orbit on STS-81.

Example

The descending node of orbit 15 on STS-76 was 100° E. To show the ground track of orbit 15, you would position the overlay so that the descending node on the printed orbit was at longitude 100° E at the equator.

The KidSat camera will only be able to photograph parts of the Earth along the ground track in daylight. The Slider Map allows you to see, at a glance, what you can take pictures of on a particular orbit.

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SMOC Web Pages

For targeting, you will be using one particular web page, the Map page, which connects you to a sophisticated program that calculates and displays the space shuttle orbits. This program uses very precise information from NASA to calculate shuttle orbits and the corresponding ground tracks. You can:
• view orbits
• see what part of the orbit is in daylight
• zoom in to view a particular part of orbit.

Using this web page, you can find out what latitudes and longitudes the shuttle goes over; you can also type in a lat/lon you've selected (based on the slider map and the atlas), and find out:
• how many miles the target is off the precise ground track
• whether the target will fall within the footprint of the camera
• at what MET (to the second) the shuttle will pass closest to the target

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How to Use the Slider Map

The slider map consists of a world map and a clear plastic overlay with an orbit ground track printed on it. The map and the overlay will be provided by KidSat. You will use the slider map to find the shuttle’s path over the ground.

To Use the Slider Map:

1. Lay the World Map out on a flat surface, and secure it with tape at the corners.

2. Align the overlay on the map so that the center dashed lined coincides with the equator on the World Map.

3. Slide the overlay to set the descending node at the longitude corresponding to the longitude of the descending node of the orbit you are interested in (during the mission, you will find a list of STS-81 Kidsat orbits, with the longitudes of their descending nodes, on the SMOC Status web page).

After you have set the descending node at the proper longitude, check that the center dashed line is still aligned with the equator on the World Map.

4. Tape the slider map in this position. The orbital track now displays the ground track on the World Map.

Note: If the descending node occurs at longitudes located toward the edge of the map, much of the orbital path may be off the edge of the map; you can solve this problem by repositioning the slider (and noting that longitude 90°E is shown at both the far left and far right on the map)

1. With a waterbased ink marker, mark on the slider map where the orbit intersects 90°E longitude.

2. Slide the overlay to the left or right until the marked point coincides with the other 90°E longitude line.

Once the slider map is taped in place on the world map, it shows you what part of the world the shuttle will pass over on the orbit you have chosen.
How to Use the SMOC Web Pages

There are three SMOC web pages that you will use before and during a mission to select and submit a photo. They are the Mission Status Page, the Orbit Map Page, and the Photo Entry Page. This section describes how to get to these pages, the purpose of each and how to enter and retrieve information.

Entering the SMOC web pages

The SMOC displays can be accessed from the KidSat Mission Operations home page or by typing in the following address:

http://www.kidsat.ucsd.edu/kidsat/smoc

You will then see the Security Page (below). In order to make sure that only KidSat schools access these web pages, a login name and password are required to enter. Your school has been assigned a login name and password. Enter the login, enter the password, then click on "Enter Kidsat Mission Control".
If your login and password are correct, you will enter the Mission Planning Home Page. The page contains icons which lead to different web pages that aid in mission planning and selecting images. These icons will appear on the left hand side of each web page. If you click on an icon, you go to that page. To select targets, you will use the status, map, and photo entry pages.
Mission Status

If you click on the status icon, you will go to the Mission Status page. This page is not interactive; it is the page we use to transmit information to you that you will need for targeting. It contains the most up-to-date calculation of the longitudes of descending nodes for coming orbits; it also gives you the information on day/night on each orbit.

This page contains information about the shuttle itself; and other information relevant to Kidsat (including your photo submission deadlines).

This page shows 4 separate windows, each displaying different information:

Orbits and Nodes: For each orbit, this window displays the ascending and descending nodes. It also shows the longitude where day starts, and the longitude where night starts.

Upcoming Deadlines: This window displays the MET by which you must have submitted all your photo selections for a particular orbit.

Problems/Updates: This window will display any problems that have come up during the mission, as well as any new information that may affect Kidsat or your photo selections.

Environmental Highlights: This window will give information about environmental activities that might be interesting to take a picture of.

For target selection, the most important information on this page is the longitude of the descending node.
If you click on the map icon, the orbit map will appear. This page allows you to get information about your target in two different ways. You may either select your photo by zooming in on a particular orbit and getting the lat/lon... (the most effective way), or you may input a lat/lon directly to find out whether the shuttle goes over it. This is the page you use to perform the precise calculation of target lat/lon and MET. It accesses a sophisticated program running at UCSD, and returns results to you.

Zooming in and getting target information:

To use this page, you must first select the orbits you want to consider by clicking on one of the following:

- 13-17
- 18-25
- 110
- 110-118
- 118-126
- 126-134
- 134-139

These are the Kidsat orbits: those during which the camera will be able to take pictures. (These were the Kidsat orbits for STS-76, and may change between now and STS-81). In the page on the right, orbits 13-17 have been selected.

If you click on the zoom in 2X button, you will be in the zoom mode. Then clicking at any point on the map (as many times as needed) will zoom in centered around that point. You may zoom out again by clicking on the zoom out 2X bar underneath the orbital map.

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If you click on the Select Lat/Lon button, you will be in the lat/lon mode. Then by clicking at any point on the map, the latitude, longitude, MET, and distance off track will appear as shown below.

Selected Point: Lat: 20°04'36" N
Long: 24°55'23" W
Closest Orbiter Pass: 1
Lat: 19°55'16" N
19.254444 N
Long: 24°37'49" W
24.630278 W
MET: 01/03:23:47
Distance Off Track: 23.48 miles
Descending Node: 7.46 W(orbit20)

In this example, the point clicked on was at latitude 20° 04' 38" N, longitude 24° 55' 23" W, and it was 23.48 miles off the groundtrack at MET 01/03:23:47.
Entering the lat/lon:
If you know the latitude and longitude of a possible target, you may enter this information underneath "Input Latitude & Longitude" and press the Determine Photo Opportunities. This will tell you the closest orbit to your target, distance off track (how far away from the orbit the target is), and the MET of the target.

In this example, a latitude of 12°21'40" N, and longitude of 89°30'00" W were entered. The software found that the shuttle goes within 43.4 miles of that point at MET 01/13:09:15.

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If you click on the photo entry icon, you will go to the Photo Entry Form. This is the actual form that you will fill out to send to UCSD. When you enter this page, it looks like this:

You must enter one of the special code words given to your school; if the code word is valid, the complete photo entry form will appear.
Code Word: Enter the code word first and press return. You can then fill in the following information.

Priority: The priority associated with your code word will appear.

School: Enter your school name.

Photograph Title: Enter the title you have chosen for the photograph.

Latitude/Longitude: Enter the latitude and longitude of your photo.

Radius (with units): Enter the approximate size of the target area.

Orbit Number: Enter the orbit number.

Mission Time Elapsed: Enter the mission time elapsed (MET) for the photo.

Reason and Description: Enter your reason/description for selecting this photo.

Once all of these are filled in, you may click on the send button. Once the submission has been made, a confirmation page will appear (currently under construction).
The following is an example of what your completed photo selection submissions should look like:

[[image: Screenshot of Photo Selection webpage]]

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Code Words: what they are, and why we need them

Once your students have selected and confirmed a target, they will use the Photo Entry web page to send the information associated with that target to the KidSat Mission Control Gateway. When they call up that web page, the first thing they must do is enter a code word. Your SMOC will be assigned a list of 50 code words a few months before the shuttle flight. Once a legal code word is entered, the rest of the Photo Entry form appears on the screen, and your students can enter the information associated with the target.

Your code word list. When you receive your list of 50 code words, each will have a record number and a priority which will be associated with it.

Example:

<table>
<thead>
<tr>
<th>priority</th>
<th>record</th>
<th>code word</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2015</td>
<td>foggy08</td>
</tr>
<tr>
<td>1</td>
<td>2016</td>
<td>shell12</td>
</tr>
<tr>
<td>3</td>
<td>2024</td>
<td>check21</td>
</tr>
<tr>
<td>4</td>
<td>2030</td>
<td>where07</td>
</tr>
</tbody>
</table>

In this example, the code word foggy08 carries priority 1 (the highest) and is record number 2015. There is a record number with each code word. There are five code words for each priority level (Five of your code words will carry priority 1, five priority 2, etc., down to five with priority 10). More on record numbers and priorities later.

Why Code words? You will assign a code word to each photo you select. Code words serve three basic purposes:

Security. Requiring a code word with each photo selection ensures that only KidSat schools can submit photo requests.

Photo prioritization. There are now 15 schools involved in KidSat; we will probably not be able to accommodate all requests, so we ask that you prioritize your photos (with “priority 1” the most important). The way that you communicate your priority to us is through your choice of code word.
Fairness. This method maximizes the possibility that all the SMOCs will get their most important pictures taken, and that no SMOC can flood the system with requests and dominate the camera. Each SMOC has 5 priority 1 photos, 5 priority 2 photos, etc.

How the process should work. When your students have selected a target, confirmed its lat/lon, and determined the MET associated with it, they are ready to submit the request. Before the photo is submitted, the students must assign it priority (priority 1, 2, ..., 10). Once a priority is assigned they should go to the list of your code words and select one which carries that priority. Assign that code word to the target. The students can then use this code word to "unlock" the Photo Entry form and enter the information on that target.

When the request is submitted, all the information your students enter (including the code word) is sent to a database at UCSD. The database knows what record number and priority is associated with each code word.

Why the record number? (Because we learned the hard way during the first KidSat flight!). The record number gives us a way of letting you know the status of your photo request without referring to it by your secret code word. Your students can check the Photo List web page, and see the status of this photo. We don’t want to refer to the photo by code word, because that would reveal your code words to anyone with access to that page... and, as you’ll see below, if others knew your code word, they could go in and alter your photo request.

Modifying a photo request. Suppose your students submit a photo request, then realize that they have typed in the wrong MET; or you’ve been told that the shuttle orbit has changed slightly, and when your students re-check the target, they find that the shuttle still passes over it, but at a slightly different MET. You will want to change the MET that you submitted with that target. You can alter a request by calling up the Submit Request page, and entering the code word associated with that target. The data will re-appear, and can then be edited and re-submitted.

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Changing a target. It could easily happen that after you have submitted a request, new data on the shuttle's orbit will reveal that the shuttle ground track no longer goes over your precise target (it may go over a nearby one; it may not). In this case, you will want to change your target entirely. Once you have selected a new target, go to the Photo Entry page and either (1) create a new code word (then enter the appropriate information), or (2) enter the code word corresponding to a target which is no longer good, and replace the old information with information on the new target, then re-submit.

Re-using a code word. A single code word can't be used to take two pictures. However, if you have submitted a photo using a code word and that photo is no longer one you want to take (for whatever reason), you can re-use the code word.

You will undoubtedly re-use your code words. About 6 weeks before the flight, we will have you plan a complete set of photos. This provides critical practice (for you and for us) and it also gives KidSat a set of METs to load in the camera before launch. You will use your code words to submit your selections. However, the chances are very good that the orbit that the shuttle will actually go into after launch will be somewhat different than the one predicted before the flight. This means that the shuttle will likely not go over the precise targets you chose and submitted before the launch.

Helpful Hint: Keep a running list of used and unused code words, and code words you now consider available for re-use. Note that a "used" code word can revert to a code word available for re-use.

Note: The status of a submitted photograph tells you whether you can/should alter the data associated with a photograph, or re-use the code word. This status is available on the Photo List web page, which will be described elsewhere.

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Keeping Records (a sample)

You will need to devise a method of keeping track of the photos you have requested. We recommend that you keep a master record in your classroom that includes the following information:

- **Title**: a short title describing the target (e.g. San Diego; Mt. St. Helens; Australia; etc.)
- **Lat/Lon**: the latitude and longitude of the target.
- **MET**: the mission elapsed time of the photo (found using the Map web pages)
- **Priority**: the priority that you assign to the photo (1 has the highest priority; 10 the lowest)
- **Code word**: the code word that you have assigned to that target. The code word should carry the priority assigned.
- **Record number**: the record number that goes with the code word. You will use the number to follow the status of your photo after you have submitted it.
- **Status**: students will use this column to keep track of the status of their photo request. The current status is found on the Photo List page.

Sample table

<table>
<thead>
<tr>
<th>Title</th>
<th>lat</th>
<th>lon</th>
<th>MET</th>
<th>priority</th>
<th>code word</th>
<th>record #</th>
<th>status</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>29.2</td>
<td>119.2</td>
<td>07/16:15:01</td>
<td>1</td>
<td>shore17</td>
<td>31</td>
<td>2</td>
</tr>
<tr>
<td>Jebel Toubkal, Morocco</td>
<td>30.83</td>
<td>7.96</td>
<td>07/00:51:02</td>
<td>2</td>
<td>plate34</td>
<td>121</td>
<td>3</td>
</tr>
<tr>
<td>French Coastline</td>
<td>48.97</td>
<td>0.86</td>
<td>06/21:37:13</td>
<td>5</td>
<td>toner51</td>
<td>176</td>
<td>2</td>
</tr>
</tbody>
</table>

You may want to add other information to your own table to enable you to keep track of your photo selection and the status of your requests.

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Using the Slider Map

Overview
In this activity, students will become familiar with the use of the slider map and how to view the ground track of a particular orbit.

Time
1 class period

Materials
Slider map (one world map (22"x42") and one plastic orbit overlay)
Waterbased ink marker (any color but black)
Masking tape
2-4 plastic runners (optional)
Student Worksheet 7.1 and 7.2
Computer with access to the SMOC web pages

Getting Ready
Tape the world map to a table and place the plastic orbit overlay nearby. Students should work in groups of 4 or 5 with one slider map per group. Explain to the students how to use the slider map.

Procedure
1. Lay the world map out on a flat surface, and secure it with tape at the corners.
2. Align the plastic orbit overlay on the map so the dotted line is aligned with the equator on the world map.
3. Slide the overlay to set the descending node at the longitude corresponding to the longitude of the descending node of the orbit you are interested in.
4. Make sure the dotted line is still aligned with the equator of the world map and then secure the plastic orbit overlay to the map.

Note: For more help refer to "How to Use the Slider Map" (page 7.6).

Discussion
Have the students discover possible targets for mission planning. For example, famous cities, interesting landmarks, particular land features, places associated with current events or various geological occurrences.

Note: There are two worksheets for this activity- one that just uses the slider map and one that has the students use both the slider map and the SMOC Status web page. Although these worksheets look similar, they are not identical!

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Student Worksheet 7.1
Using the Student Map

This slider map is used to display the shuttle's ground track for a given orbit.

If you know the longitude of the descending node for a particular orbit, you can see the locations on the world map the shuttle will fly directly over during that orbit.

Procedure:
1. Line up the equator of the plastic orbit overlay with the equator of the world map.

2. You will need to slide the overlay so the descending node of the ground track (longitude of where the ground track crosses the equator from North to South) matches the descending node of the orbit you are interested in (see figure on next page).

3. For example, suppose the descending node for orbit 115 is 76.61ºW.

4. Line up the descending node for orbit 115 (line up the descending node of the ground track as close to 76.61ºW as you can).

Note: Check to make sure the descending node on the overlay is placed at the correct longitude, and that the dotted line lies on the equator. Now that the slider map is aligned properly, use the plastic runners (or another method) to secure the overlay.

The slider map can now be used to determine where the shuttle will pass during this orbit.
Use the slider map to answer the following questions:

1. Does the shuttle pass over Paraguay during orbit 115?  
   If not, is there a possibility it could during another orbit? Why or why not? ________

2. Does the shuttle pass over Mexico during orbit 115?  
   If not, is there a possibility it could during another orbit? Why or why not? ________

3. Does the shuttle pass over Anchorage, Alaska during orbit 115?  
   If not, is there a possibility it could during another orbit? Why or why not? ________

4. The shuttle passes over Costa Rica and Paraguay. Which place does it pass over first? ________
Answers to Worksheet 7.1

1. Does the shuttle pass over Paraguay? Yes
   If not, is there a possibility it could during another orbit? Why or why not?

2. Does the shuttle pass over Mexico? No
   If not, is there a possibility it could during another orbit? Why or why not? Yes. The shuttle could pass over Mexico on another orbit, because Mexico is between 51.6° S and 51.6° N latitude.

3. Does the shuttle pass over Anchorage, Alaska? No
   If not, is there a possibility it could during another orbit? Why or why not? No. The shuttle does not fly above 51.6° N and Anchorage, Alaska is further north than 51.6°N.

4. The shuttle passes over Costa Rica and Paraguay. Which place does it pass over first? Costa Rica, because the shuttle flies from West to East and Paraguay is East of Costa Rica.

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Student Worksheet 7.2

Using the Slider Map and the SMOC Web Pages

The slider map is used to display the shuttle’s ground track for a given orbit.

If you know the longitude of the descending node for a particular orbit, you can see the locations on the world map the shuttle will fly directly over during that orbit.

During the mission, you will be given the longitude of the descending node of each orbit on the SMOC Status web page. Then you will set up the slider map to display that orbit.

Note: The information on the SMOC Status web page will change before and during the flight.

Procedure:

1. Line up the equator of the plastic orbit overlay with the equator of the world map.

2. Look on the SMOC Status web page under Orbits and Nodes to find the descending node for orbit 19.

Question:

1. What is the descending node for orbit 19?_______

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3. Slide the overlay so the descending node of the ground track (longitude of where the ground track crosses the equator from North to South) matches the descending node for orbit 19 (see figure below).

Note: Check to make sure the descending node on the overlay is placed at the correct longitude, and that the dotted line lies on the equator. Now that the slider map is aligned properly, use the plastic runners (or another method) to secure the overlay.

The slider map can now be used to determine where the shuttle will pass during this orbit.
Use the slider map to answer the following questions:

2. Does the shuttle pass over Algeria during orbit 19? If not, is there a possibility it could during another orbit? Why or why not?

3. Does the shuttle pass over Norway during orbit 19? If not, is there a possibility it could during another orbit? Why or why not?

4. Does the shuttle pass over Brazil during orbit 19? If not, is there a possibility it could during another orbit? Why or why not?

5. The shuttle passes over Newfoundland and Nigeria in orbit 19. Which place does it pass over first?

4. Look on the SMOC Status web page to find the longitude of day and night for orbit 19.

Question:

6. What is the longitude of day for orbit 19?
7. What is the longitude of night for orbit 19?
5. Identify these longitudes on the slider map and mark them with a small x using your water-based pen (or removable stickers).

Note: The area between these two small x's indicates the daylight portion of the ground track. The camera can only take pictures during this time.

Question:

8. Can the camera take a picture of the Congo River during orbit 19? (Is it in daylight?) __________

9. Can the camera take a picture of the Great Salt Lake in Utah during orbit 19? (Is it in daylight?) __________

10. Identify two more locations the camera can take pictures of during this orbit. ______________

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Sally K. Ride Papers - KidSat Student Mission Operations Center (SMOC) Teachers Handbook, [with corrections], (folder 2 of 2) Transcribed and Reviewed by Digital Volunteers Extracted May-08-2020 09:42:03
Answers to Worksheet 7.2

Note: The information on the SMOC Status web page may change!

1. What is the descending node for orbit 19? 14.90° E

2. Does the shuttle pass over Algeria during orbit 19? Yes. If not, is there a possibility it could during another orbit? Why or why not?

3. Does the shuttle pass over Norway during orbit 19? No. If not, is there a possibility it could during another orbit? Why or why not? No. Norway lies north of 58°N and the highest latitude the shuttle flies over is 51.6° N.

4. Does the shuttle pass over Brazil during orbit 19? No. If not, is there a possibility it could during another orbit? Why or why not? Yes, it could because Brazil lies between 51.6° N and 51.6° S.

5. The shuttle passes over Newfoundland and Algeria in orbit 19. Which place does it pass over first? Newfoundland, because the shuttle flies from West to East and Nigeria is East of Newfoundland.

6. What is the longitude of day for orbit 19? 74° W

7. What is the longitude of night for orbit 19? 143° E

8. Can the camera take a picture of the Congo River during this orbit? (Is it in daylight?) Yes, it is under the daylight portion of the groundtrack.

9. Can the camera take a picture of the Great Salt Lake in Utah during this orbit? (Is it in daylight?) No, it is not under the daylight portion of the groundtrack.

10. Identify two more locations the camera can take pictures of during this orbit.

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Activity 7.2
Selecting Targets

Overview
In this activity students will practice choosing targets using the slider map, an atlas, and the SMOC mission planning web pages. They will then practice submitting these selections to the KidSat Mission Control Gateway via the SMOC Photo Entry web page.

Time
1 class period

Materials
Slider map
Computer with access to the SMOC web pages
Student worksheet 7.3
Atlas
Paper
Six practice code words (enclosed)

Getting Ready
Have the slider map out.
Have the computers turned on and connected to the SMOC pages via NetScape. (http://www.kidsat.ucsd.edu/kidsat/smoc)
Assign students to work in groups of 4 or 5.

You may have each group rotate through all the steps below, or you may have the students specialize and have one group use the slider map, pass their results on to a group using the targeting web pages, who pass their results on to the group who will submit the photos.

Discussion
Discuss possible images: Before you begin looking at ground tracks, you will want to have some idea of the types of features you would like to photograph. For example, if you decide you’re interested in rainforests, you should be familiar with the location of rain forests around the world. A particular orbit might not go over the Amazon in Brazil, but it might go over the rainforests of Central Africa. In the past, schools have targeted coastlines, rivers, mountains, deserts, cities, etc.
Step (1). Maps

Lay out the world map and plastic overlay.

You may also want to create a clear plastic overlay that you can tape to the world map, then use waterbased markers to mark the areas of interest. Then when you put the orbit overlay on top of the map (see step 2 below) you can see at a glance whether the ground track passes through those regions. For example, if you want a picture of the Outback you can see if the shuttle will pass over Australia during the orbit you are selecting targets for.

Step (2). Orbit Tracks

Set up the slider map for a particular orbit (see activity 7.1 or page 7.6). Look on the SMOC Status web page to find the longitude of the descending node (indicated below) for each orbit.

Step (3). Identify the Daylight Portion of the Orbit

Next, you need to know what part of the orbit is in daylight. The camera can only take pictures during this time. This information will be available on the SMOC Status web page (indicated above).
Step (4). Pick Target Sites
Search for interesting targets under the daylight portion of the orbit track. The slider map provides only a rough estimate of where the shuttle will be passing over. You will need to cross-reference these targets with a more detailed map or atlas in order to pick more specific targets. For example, the descending node for orbit 18 is 38.19° E. If you line up the ground track for this orbit, it looks like the shuttle may pass over Spain and Madagascar. You will then need to accurately check whether these selections lie within the camera footprint using the SMOC Map web page (see step 6 below).

The SMOC Status web page will also list current weather and geological occurrence information in the Environmental Highlights box. Additional weather and geological occurrence information should be obtained using world wide web weather sites (see page 2.17 of Chapter 2 for more information).

Step (5). Keep a Record of Your Target Selections
You'll need to keep track of your selections, and of important information associated with them as you go through the steps of selecting your targets. Write down the target name, orbit number, the latitude, longitude, MET, reason for selection and priority on your "list of targets." Refer to page 7.33 to see an example of how to keep track of your selections.

Step (6). Confirm Targets
Use the SMOC Map web page to confirm the site is under the orbital track, within the camera footprint, and in daylight (see page 7.10-7.13 on "How to Use the Map Page"). The SMOC Map web page will tell you exactly how many miles off the ground track your selection is.

Step (7). Determine MET of the Photograph
Use the SMOC Map web page to find the MET of the site, and record it on your list of targets (see pages 7.10-7.13 on "How to Use the Map Page"). The SMOC Map web page will give you a precise MET of when the shuttle will pass over your target.
Step (8). Prioritize Your Image Selections
After selecting all your sites for an orbit (repeating all the above steps) prioritize your image selections. Record the priority for each site and write it on your target list.

Step (9). Submitting Your Photo Requests
Once you have selected a priority for your image request, select a codeword that has that priority associated with it. Then go to the SMOC Photo Entry web page to submit your photo request. Enter the codeword and press return. After entering the codeword, fill the following information: school, photo title, latitude, longitude, radius, orbit number, MET, reason and description. When entering your photo requests be sure to enter all of the information in the correct format or your entry will not be accepted. Once you type all of the information, click on the send button. All of the information will then be sent to a database at UCSD. If your entry is accepted a confirmation will appear along with the record number for that photo. You will later use the record number to find out the status of your photo request.

During the flight (or simulations preceding the flight), there will be photo submission deadlines displayed on the SMOC Status web page in the Upcoming Deadlines box. Be sure to pay attention to the deadline of when your photo selections must be submitted to the MCG at UCSD for each orbit. If they are not submitted in time, your photos will not be able to be taken.

Step (10). Checking the Status of Your Photo Requests
Now you can check the SMOC Photo List web page to see the status of your photo requests. You will be able to sort the photos by MET, record number, status, orbit number, school, or title. The Photo List Page will tell you whether your photos have been taken, if they need to be replanned etc.
### Example Target List

<table>
<thead>
<tr>
<th>Title</th>
<th>Orbit #</th>
<th>Lat.</th>
<th>Lon.</th>
<th>MET</th>
<th>Reason for Selection</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Puerto Rico</td>
<td>114</td>
<td>18.87°N</td>
<td>67°W</td>
<td>07/05:32:13</td>
<td>to see if we can see the castle ruins</td>
<td>1</td>
</tr>
<tr>
<td>Amazon River</td>
<td>114</td>
<td>1.5°S</td>
<td>52°W</td>
<td>07/05:38:54</td>
<td>to see the effects of clear cutting around the river</td>
<td>10</td>
</tr>
</tbody>
</table>

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Combining the Image Requests of the Class

Overview
This activity will give students experience combining their image requests with those of their classmates. They will then make the final selections of photo requests, prioritize them and assign a code word to each of them using the six practice code words enclosed. The selections will then be submitted using the SMOC Photo Entry web page.

Time
1 class period

Materials
Student target lists
Butcher Paper to make a class list of photo selections
Markers
Student Worksheet 7.4
Computer with access the SMOC web pages
Six practice code words (enclosed)

Getting Ready
Be sure students have gone through and understand Activities 7.1 and 7.2.
Make five groups of students.
Have the computers turned on and connected to the SMOC pages via Netscape.
(http://www.kidsat.ucsd.edu/kidsat/smoc)

Procedure
1. Using the selections students made for Student Worksheet 7.3, have students combine their image requests with those of the rest of the class by putting their selections and the information they have collected up on a master list.
2. Once all of the requests have been put on the class list, check for any conflicts (i.e. 2 pictures of the same location, too many pictures close together, etc.).
3. Have the class narrow the list down to 6 selections.
4. Prioritize the final list of requests (use priorities 1-6).
5. Assign a code word to each site, based on the priority you assigned it.
6. Write does the record number associated with that codeword.
7. Have each group of students enter one selection from the final list of selections into the SMOC Photo Entry page using the six practice code words.
8. Have each group then look up the status of their photo on the SMOC Photo List page and record its status on the master list.

Note: This activity is an extension of Activity 7.2.

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In order to keep track of your classes image selections, put together a master record (see example on page 7.37). We suggest your master record include the information listed below, but you may want to add other information to help you keep track of your photo requests and their status.

Title: one or two words describing the target (i.e. Nile River, Himalayas etc.)

Latitude and Longitude: the latitude and longitude of the target (found using the SMOC Map web page)

MET: the mission elapsed time of the site (found using the SMOC Map web page)

Priority: the priority you have assigned to the target (1 is the highest and 10 is the lowest)

Code Word: the code word you have assigned to the target (based on the priority you give it)

Record number: the record number that corresponds with the code word you have chosen (you will use this to find the status of the photo after you submit it)

Status: you will find this on the SMOC Photo List web page.

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Note: To help you with this activity, refer to Student Worksheet 7.3.

Procedure:
1. Using the selections you made for Student Worksheet 7.3, combine your image requests with those of the rest of the class by putting your selections and the information you collected on a master list.

As a class:
2. Once all of the requests have been put on the class list, check for any conflicts (i.e. 2 pictures of the same location...).
3. Narrow the list down to 6 selections.
4. Prioritize the final list of requests.
5. Assign a code word to each site, based on the priority you assigned it.
6. Write down the recorded number associated with the code word.
7. Now your group will enter one selection from the final list of selections into the SMOC Photo Entry page using one of the six practice codewords.
8. Look up the status of your photo on the SMOC Photo List page and record its status on the master list.

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### Example Master List

<table>
<thead>
<tr>
<th>Title</th>
<th>Orbit #</th>
<th>Lat.</th>
<th>Lon.</th>
<th>MET</th>
<th>Priority</th>
<th>Code Word</th>
<th>Record #</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>112</td>
<td>29.2 N</td>
<td>119.2 E</td>
<td>07/16:15:01</td>
<td>1</td>
<td>shore17</td>
<td>31</td>
<td>2</td>
</tr>
<tr>
<td>Jebel Toubkal, Morocco</td>
<td>112</td>
<td>30.83 N</td>
<td>7.96 W</td>
<td>07/00:51:02</td>
<td>2</td>
<td>plate34</td>
<td>121</td>
<td>3</td>
</tr>
<tr>
<td>French Coastline</td>
<td>111</td>
<td>48.97 N</td>
<td>0.86 E</td>
<td>06/21:37:13</td>
<td>5</td>
<td>toner51</td>
<td>176</td>
<td>2</td>
</tr>
</tbody>
</table>

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CHAPTER 8
Guide to Looking at Images

Objective: To learn how to look at an image.
[[arrow pointing to "an"]]
Change the
Exploring the Images

As seen from space, Earth is a beautiful planet. The pictures that your students will take using the KidSat camera capture that beauty in a direct and personal way. The astronauts themselves find similar awe in looking at and photographing Earth from their orbital vantage point:

"We were astonished to discover that, during a flight, you have to learn anew not only to look, but also to see. At first the finest nuances of color elude you, but gradually your vision sharpens and your color perception becomes richer, and the planet spreads itself before you with all its indescribable beauty"

Vladimir Lyakhov

So, please, before you go any further, stop reading this and take a closer look at the images, either the printed or on-line images that accompany these materials, and find a couple of pictures that speak to your heart with their beauty.

Keep those images in mind as you proceed with the activities and information in this chapter.
Images and Inquiry-based Learning

Images of Earth are especially powerful tools to help your students become familiar with other parts of the world, learn about some of the basic processes of geological change on both local and planetary scales, and recognize the human presence and impact on Earth. Perhaps most importantly, your students can see the drama of the Earth as an integrated system, with the ground, water and atmosphere interacting in very visible and comprehensible ways.

However, for most students, and even for many adults, looking at images requires new skills. The images show unique parts of the world, often from an unfamiliar perspective. Although they have photographic clarity, we are not used to the distance scale or colors of the images.

In this chapter we provide some guidance on how to approach the images — how to find images that are especially interesting, how to get oriented on their scale and location, and how to pursue investigations stimulated by the images.

We emphasize investigations and inquiry-based learning because we have found that students often learn best when they are personally engaged — when they have questions they are pursuing and a genuine interest in the images. Each image has a story to tell (or several interwoven stories), and through the investigations these stories unfold. This focus on investigations also mirrors how scientists typically explore and make use of images in their own research.

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Three Phases of the Investigation

Based on our experiences with scientists and students, we find that there are three general phases of exploring an image. As detailed below, these phases help students:

1) get started wondering about an image
2) get oriented to the features, scale and viewing angle of the image
3) use the images as the focal point for extended investigations.

In the discussion which follows, we interweave a sample investigation into the discussion of the three phases.

As your students pursue their investigations, it will be helpful for them to have a notebook to record their progress. The investigation may end up following a “wandering line of inquiry” as one question leads to another. The notebook will help them keep track of their questions, conjectures and insights in this process.

Provide your students with plastic overlays and fine-line markers. Placing the overlays over the images enables your students to label features in the image, note areas of interest, mark and trace patterns, etc. A magnifying lens can also be very helpful.

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Phase I - Getting Interested

The first step is to spark your students' interests. You need to provide a wide range of images in the classroom environment. For example, pass around all the printed images provided with KidSat. Let students explore KidSat and EarthRISE (http://earthrise.sdsc.edu) images on-line. Check your library for books with a rich assortment of images, and let students peruse them. You can also get posters that show various areas of the Earth as seen from space (an excellent resource is SpaceShots 1-800-272-2779).

Some books with a wealth of images:

The Third Planet by Sally Ride and Tam O'Shaughnessy (ISBN #0-517-59361-0) (middle school level)

Seeing Earth From Space by Patricia Lauber (ISBN #0-531-05902-2) (high school level)

Touching the Earth by Roberta Bondar (ISBN #1-55013-575-9)

Embracing Earth by Payson Stevens and Kevin Kelley (ISBN #0-8118-0135-7)

The Home Planet by Kevin Kelly (ISBN #0-201-15197-9)

Looking at Earth by Priscilla Strain and Frederick Engle (ISBN #1-878685-16-3)

Orbit by Jap Apt, Michael Helfert, Justin Wilkinson (ISBN #0-7922-3714-5)

As your students scan the images, one or more should grab their attention. Perhaps the image has a strong visual appeal, or it may show a region of the world that a student has visited, or it may show an exciting event such as a volcano exploding or have unique patterns that arouse their curiosity. You know from your teaching that students learn best when they are interested in the topic. So too with images: they usually need a hook, a point of interest, to open their minds to an image, and continue through to the next phase.
As an example, let's begin with the picture of the Mississippi River Delta, which many people find to be an especially beautiful and intriguing picture. To the right is a black and white version with labels. Refer to the color version which accompanies this chapter.

Take a few moments yourself to study the color image. Look at the overall shapes, the colors of the water and the land, the motion and fluidity implied by the textures and patterns. What do you think is going on here? What do you recognize? What surprises you? What questions does the image raise for you? What aspects would you like to investigate further?

Some sample intriguing questions:
What are the light brown patterns (A and elsewhere in the image)?
What is the branching pattern (B)?
Why is the city (C) located on the river but away from the coast?
Why does the river have such sharply defined banks (D)?
What caused the islands (E)?
Which way are the ocean currents flowing?

To summarize this phase, the central idea is for your students to select pictures that are especially interesting, and start to think about what it is that caught their attention. They may be able to articulate the "hook" as a specific feature or question, or it may simply be a general feeling that the picture is intriguing.
Phase II - Getting Oriented

In the second phase, your students search for more details on the context and content of the image. Where in the world is this? Which way is north? What is the scale? What are the key physical features shown in the image? What are your initial conjectures as to the “story” of the image? Answers to these questions help you and your students get oriented to the image.

There are two key resources in this phase:

Reference information associated with the image - Each photo has a unique identifier number, which helps you find out where and when the picture was taken, what type of image it is (such as a shuttle photo or Landsat false color). It might also include the scale, which way is North, and the date and time of the picture.

In KidSat and EarthRISE, reference information is available on-line when you access the image. For NASA prints, it usually is on the back of the picture.

Atlas(es) - You will learn a lot by cross-referencing the image with maps and other reference information in atlases. Goode’s World Atlas is common in schools and has very good physical maps and an especially broad-ranging set of thematic maps. The Times Atlas of the World (or other comparable high quality atlas) shows considerably more detail, and can be of real value in direct cross-reference with KidSat and other shuttle images.

It may take a little work to find or figure out this information, but it is an essential part of the process.
Mississippi River Delta as an example (Phase II) (image #STS51C-143-027)

24-27 January 1985  STS51C-143-027
Johnson Space Center, Houston, Texas

STS-51C Earth View (Mississippi River Delta, Louisiana) -- This near-vertical photograph taken in January, 1985, shows the distribution pattern of muddy fresh water from the Mississippi River as it flows into the Gulf of Mexico. New Orleans, with its surrounding urban area, is highly reflective and appears at the top center. Light colored streaks of developed land extend on natural levees along the ancient La Fourche Delta to the west located at the top left of the view. The Chandeleur Islands, to the east of the present Mississippi Delta (center right), are remnants of the older delta lobe.

To further explore the Mississippi River Delta investigation, you and your students now need to do some “getting oriented.” Look on the back of the picture. There is written information about this image, provided by NASA. It tells you that this picture was taken by an astronaut on the space shuttle in January 1985, on flight STS-51C. The image reference # is 51C-143-0027. You can use this number to get more information via NASA's image web site (http://eol.jsc.nasa.gov/sseop.html).

NASA has also provided a descriptive paragraph, which says that the picture "shows the distribution pattern of muddy fresh water from the Mississippi River as it flows into the Gulf of Mexico. New Orleans, with its surrounding urban area, is highly reflective and appears at the top center."

11/05/96    Page 8.8
Time to look at a map. Find an atlas that shows the Mississippi River Delta region, preferably large enough so that you can correlate features between the image and the map. Now do what is sometimes called "this is that." Find New Orleans (C) in the image, and find New Orleans on the map. You're correlating the two: New Orleans in the image ("this") with New Orleans on the map ("that"). Do the same with the unique shape of the delta, finding it in the image and on the map. Now trace the Mississippi River in the image and on the map.
The atlas also lets you put the image in a larger context. A map of North America shows the full path of the Mississippi, as it flows and grows over a thousand miles, from its headwaters in Minnesota, through the heartland of North America, to its end point here in the image.

Now we know what part of the world is shown in this image. We also start seeing hints of answers to some of our questions. The Mississippi River (brown because of all the silt it is carrying) flows through the center of the image, and out into the Gulf of Mexico (which appears dark blue). The wispy patterns in area A result from the muddy river flowing into and then mixing with the waters of the Gulf of Mexico. There is a lot more to this story, but at least we have begun to figure it out.

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The next step is to figure out which way is north. You might begin by holding the picture vertically, with the NASA caption at the top. This is the way that NASA labeled it and provided it to you. If you hold it this way, is north at the top?
Refer back to the map. This way of looking at the image doesn't match the map. It makes it appear that the river is flowing to the right. So, turn the image around until it closely matches the orientation of the map. Here is the way it should be oriented in order for north to be up in the image:

You don't have to look at the image with north up. However, it is important to know which way is north in order to cross-reference with maps which typically follow the "north is up" convention. Remember, as the shuttle orbits the Earth, it does not follow a precise north/south or east/west orientation, and the KidSat or other shuttle pictures have no inherent orientation. If you're using a plastic overlay to label the image, record the north arrow in proper orientation.

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Finally, let's get a sense of the scale. You may be able to guess by looking at the image. How far do you think it is from New Orleans (C) to the end of the delta (A)? Take a guess. This is actually a good exercise for your students. You may find that they have no basis on which to have a sense of the scale. For example, the dendritic patterns in the delta resemble the pattern in a leaf, with the river as the stem. Until your students gain more experience with images, scale may be very confusing for them. So, this is worth a little effort. Ask your students to guess how far it is from New Orleans to the delta. Ask them in miles, kilometers, or a personalized scale such as "how long would it take to travel the distance in a canoe?"

Presumably, the map has a scale, so you can calculate the corresponding distance on the map from New Orleans to the tip of the delta. You'll find that this distance is about 140km (90 miles). Therefore, the distance between points A and C on the image is exactly the same: 140km (90 miles). How long do you think it would take a canoe to travel that distance on the river (actually the river length is a little longer, since the river meanders a bit)?
With a little more calculation, you can figure out that the area covered in the picture is about 150 km x 200 km (90 miles x 135 miles). These calculations can be an excellent math lesson for your students. You can even make a scale bar for the image (you might ask a geography or math teacher to help your students do this). Here is the scale bar that we calculated for this image:

Not all images need a scale bar for your analysis. However, a rough sense of scale in the image is essential. Depending on the nature of the investigation, it may be adequate simply to have a sense of the size of the region shown in the image, in correlation with a globe or map. In fact, it is difficult to make a scale bar for views that show large areas of the Earth or that extend to the horizon, because the scale might differ from one part of the image to another.

To summarize, in this “Getting Oriented” phase, you and your students find out basic information which helps get them oriented to the image, such as:

• location shows in the image
• type of picture
• date
• image reference number
• cross-reference with a map
• the larger context
• central features in the image
• which way is north
• scale and size of area shown in the image
Phase III -- Pursuing the investigation

The third phase is both detailed and open-ended. Based on questions raised about the image, students can examine the image in more detail, comparing the image with other sources of information, search for other images of the same location or similar features, and in general use the image as the central aspects of a student-driven investigation. The key to this phase is making sure that students have real personal interests in the image and that the questions they investigate emerge from this interest. As Bertrand Russell said “Education is not the filling of a bucket, but the lighting of a fire.”

Some insights on this process from scientists who routinely use images in their research:

Look at the big picture and the details - You need to shift your thinking back and forth between the broad context (which extends beyond the image itself) and the little details. For example, in examining an image of a section of a river, you should understand the full flow of the river: where does it originate? what tributaries feed into it? what terrain does it flow through? You also need to look at the details show in the image: does it meander? how steep are the banks? is there evidence of erosion caused by the river? The big picture and small details inform each other.

What are the surprises? - Often the most fruitful lines of investigation derive from mysteries. Why does the river turn here? Why is the city in that particular location? What is causing the smoke? Why are there clouds over the Gulf but not the nearby land? The more students study images, the more observant they will be of anomalies, and the more these anomalies will spark their curiosity.

Stay with the image for a while - Scientists often spend an extended period of time examining individual images. The longer they look, the more they see. So encourage your students to stick with their investigation, going deeper and extending it in new directions. This is like the concept of “wait time” when you ask questions in class.

Cross-reference - To investigate an image, your students should cross-reference with other resources. Encourage your students to look at physical and political maps of the same region, compare with thematic maps showing vegetation or population patterns and learn about the human and geologic history of the region. The more your students learn and the richer the variety of resources, the more they will see in the images.
Mississippi River Delta as an example (Phase III) (image #STS51C-143-027)

Now we can extend an inquiry of the Mississippi River Delta further. Let's focus on the question "What happens when a river flows into the ocean?" In fact, that question becomes more and more interesting, the deeper you look into it.

Before we think about the generalized question, let's look at the specific local question: "What happens when the Mississippi River reaches the Gulf of Mexico, as shown in this image taken in January 1985?" First you have to go to the larger context and make sure your students understand some basic information about the Mississippi River. Have them look at a map of the US, and follow the river from the headwaters in Minnesota to the New Orleans delta. Make sure they notice how other rivers feed into it, and how it grows as it moves south.

Now have them look at the the image, and trace the pathway of the river. It bends just south of New Orleans and then continues relatively straight into the delta region. Does it all flow out of one point (such as area A)? Or does it flow out in many places? Have them look more closely at area B, where the river branches, then sub-branches and sub-sub-branches. What is going on here?

Now let's look at the issue of the dirt in the water. Ask your students why they think the river is brown (they probably expect it to be blue). They will probably guess or figure out that the river is brown because of the silt, or dirt, it picks up and carries as it flows. Some dirt settles in along the banks and floor of the river, but much gets carried all the way to the delta. This makes the river into a very powerful force in the erosion and deposition of the Earth's surface. Have your students look at how brown the whole area of the delta is. Do they think dirt is being deposited in the delta? In fact, that's how the delta formed, by the constant deposition of soil from the river.

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Now have them look at area F. Can they see any similarities between area B and F? They should recognize similar branching patterns. How can that be if the river doesn't flow into area F? Ask them to speculate.

Now have them look more closely at the river as it flows from New Orleans to the delta. They may notice that the banks of the river are precisely defined. Look, for example, at area A. It doesn't branch in A as it does in B. It looks human engineered, like a channel created to force the water in a particular direction. The same precise edges can be seen all the way back to New Orleans.

Notice how the city (C) is to the river. If rivers flood, isn't that a dangerous location? Perhaps this whole portion of the Mississippi has been engineered for safety, flood control and management of the deposition. Maybe the river used to flow into area F, but now the river is directed elsewhere through some combination of natural changes in the river's path and human engineering. The description on the back of the image says that the Chandeleur Islands (E) are "remnants of the older delta lobe." What does that mean?

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So let's get an even broader view. Have your students look at a map of Louisiana. It won't take much examination for them to see that the delta is actually much larger than the little tip they have been looking at. It extends up to Baton Rouge, and covers almost the entire southern coast of Louisiana. New Orleans itself is only a small area on the edge of part of the delta. The large size of the full delta shows how much of an impact the deposition from the Mississippi River has been over hundreds, thousands and even millions of years.

We now have a better sense of the answer to the original question: What happens when a river flows into the ocean? Or at least we have a better sense of the answer in the case of the Mississippi River, as of January 1985.
However, this in turn leads to other questions that your students can pursue in their extended investigations:

What happens with other rivers? —— Your students might examine images of the Nile River delta (such as image #STS057-75-053) to compare and contrast with the Mississippi. Your students can search the KidSat and EarthRISE data bases for images of other river deltas. And they can target river deltas around the world for new KidSat images during upcoming missions.

How do deltas relate to human history? —— Why is New Orleans located on the delta? Why was the fertile Nile delta the home of some of the earliest human civilizations.

How has the Mississippi River delta changed over time? —— Current images give hints about the past, but your students may need to refer to geology or other related references to the formation and development of the Mississippi. As they learn more background knowledge, they can interpret more of the hints of the past shown in the image.

Your students may want to extend their investigations with classroom experiments, such as using a stream table to model the flow of water through sand and dirt. Or they might want to study a nearby river, investigating how much soil it is carrying, and whether it is depositing any of it further downstream on banks of the floor of the river.

To summarize, this is an open-ended phase, in which your students pursue multi-faceted investigations. They study the image, find features they recognize, raise questions, try to find answers, pursue alternative resources, annotate the image, and otherwise pursue what is likely to be a “wandering line of inquiry”. Ideally, they share their work with others in visual, written and verbal forms. They develop skills of inquiry and investigation, they learn how to look at images with increasing levels of understanding and sophistication, and they identify new areas of inquiry to extend their work.
Other Images --

A Sampler of Potential Investigations

Here are a few more sample images, with suggestions for possible student investigations. Each image, or group of images, can provide as rich a focal point for investigations as the Mississippi River Delta image.

These images and comments are merely illustrative. The best idea is for your students to explore these and other images, select some that interest them, and then launch into all three phases: "getting interested", "getting oriented" and "pursuing the investigation."

Please refer to the detailed color prints which accompany these materials.

A special thanks to Dr. Cindy Evans of the Johnson Space Center, who selected most of these images and provided essential commentary.

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South Island, New Zealand (image #STS056-101-064)

Background for the teacher: This image shows snow-capped mountains, with rivers that run off into two prominent lakes. It is a good image for exploring the relationship among mountains, snow, rivers, lakes and agriculture. The upper valleys are glacial. There are canals coming off the lakes.

Possible starting points for investigations:

• Find South Island, New Zealand on a map or globe.
• Why are the rivers braided?
• Trace one of the rivers back to the snow fields where it originates. Are there multiple sources of the rivers?
• Why are the tops of the mountains white and the bases brown?
• What is the linear shape coming off the lakes? Why isn’t it curved like the rivers?
• What is the green area on the right side, and why does it have small green and brown rectangular areas?
Florida Image #1 (of 3) (image #S31-151-155)

Background for the teacher: The shuttle’s window frames this image and adds drama to it. It shows all of Florida, in an oblique view looking up towards Georgia and the Carolinas. To the right are the Bahamas. The darker blue areas are deeper areas of the ocean. North of Florida you can see patterns of the rivers.

Possible starting points for investigations:

- Try to understand this oblique perspective, orienting yourself with a map of the Southeast US.
- Identify Florida, the Atlantic Ocean, the Gulf of Mexico and the Bahamas.
- Why is there a contrast between dark and light areas of water?
- Why are there more clouds over the land than over the water?
- Notice how thin the atmosphere is on the horizon? How thin is it?
Florida image #2 (of 3) (image#STS51C-44-026)

Background for the teacher: This image shows more detail of Florida. It is especially vivid because of the clear skies. Many features of Florida can be identified.

Possible starting points for investigations:

• Cross-reference this image with a map of Florida. As with the previous image, the shape appears distorted because of the oblique angle of view.
• Find Lake Okeechobee. How can you recognize a lake from space?
• Find the Everglades. How does this region differ from other parts of Florida?
• Can you see Miami? How can you recognize a city from space?
• Can you see Disney World? (no, too small to see such details)
• Can you see mountains? (no, Florida has no mountains)
• Can you see Cape Canaveral, where the shuttle is launched? (the next image shows a close-up of Cape Canaveral)
• Why are there no clouds over land, but clouds over the ocean?

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Florida image #3 (of 3) (image #STS077-713-010)

Background for the teacher: This image is a close-up of Cape Canaveral. It shows NASA’s facilities for space launches and the area that has built up around it. Several areas are labeled: the two shuttle launch pads, the landing strip, the Vehicle Assembly Building and residential areas. You can trace the roads from the Vehicle Assembly Building, where the shuttle is prepared to the launch pads. Notice the roads and bridges connecting the residential area to the launch area.

Possible starting points for investigations:

• Look closely at the whole image, and at the labeled areas.
• Have you ever seen a shuttle launch? Think about the steps in the process of preparing the shuttle, launching and landing. Trace the steps in the image.
• Why was a coastal site selected for launching space flights?
• Why Florida?
• Why are the residential and commercial areas away from the launch area?
• Can you find the inland waterways?
• What else can you see in this image?

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NOTE: The four images of volcanoes make a nice sequence, each providing different insights on volcanoes. Many other volcano images are available. Volcanoes also are good targets for your students' future KidSat missions.

Background for the teacher: This is Fogo Island, Cape Verde. The image is a good starting point for this series of volcanoes. It shows a single volcano, so strikingly present as an island in the ocean. Don't tell your students that it is a volcano. Let them explore the image and figure it out for themselves.

Possible starting points for investigations:

• Is this island flat or does it have mountains? Draw the island in cross-section.
• What is the darker area in the middle of the island?
• Why do clouds form in a circle around the center of the island?
• How big is this island?

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Volcano Image #2: Java, Indonesia (image #STS046-90-029)

Background for the teacher: Each of the white patches is clouds forming around a volcano. As your students pursue their investigations, they will learn that this line of volcanoes formed as a result of Earth's plate tectonics. Over the course of millions of years, a surface plate has moved over a subsurface hot spot. Periodically the hot spot would erupt through the surface, forming another volcano. Since the plate moves but the hot spot doesn't, the result is a line of volcanoes.

Possible starting points for investigations:

• What are the white patches?
• Why do they form in a line?
• Cross reference with a map to learn about the physical features of Java.
• Why are the volcanoes in a line?

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Volcano Image #3: Kamchatka, Russia (image #STS053-95-008)

Background for the teacher: This image shows a broad expanse of the Kamchatka region, covered with snow. The prevailing features are volcanoes, spread throughout the region.

Possible starting points for investigations:

• What are these shapes?
• How are they similar to the volcanoes in images 1 and 2?
• How are they different?
• Why is this area covered in white?
• Why are the volcanoes spread throughout, rather than in a line like Java?
• Why is one coast irregular and the other more linear?

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Volcano Image 4: Klyuchevskaya volcano (image #STS068-214-045)

Background for the teacher: This dramatic image shows a volcano exploding, throwing large amounts of ash and steam into the atmosphere. This volcano is in Kamchatka, the same region shown in the previous image (this volcano is just outside of the area shown in that image).

Possible starting points for investigations:

• What is happening in the image? What is the billowing brown stuff?
• Which way is the wind blowing?
• How frequently do volcanoes explode in this region?
• How frequently around the world? (hint: try the volcano web site: http://volcano.und.nodak.edu/)
• How much do volcanoes impact on the atmosphere?
CHAPTER 9
How to Set Up Your SMOC

Objective: To learn how to set up and operate your SMOC.
Introduction

Over the next few pages, we show you how to create a KidSat Student Mission Operations Center (SMOC). We assume that you either have the flexibility to rearrange your room in this way, or that you have another room available for your use as a SMOC.

You only need this arrangement during the actual mission (and if possible during the training and simulation sessions). The rest of the time, your classroom can retain its normal order — as long as your students can access (by computer) and study the images taken on your KidSat mission.

The design presented here is an example. It organizes the room into functional areas needed during the mission, ranging from monitoring the status of the shuttle flight, to selecting targets, to analyzing the images as they’re sent down from the shuttle.

We believe that this organization makes sense, but it is just a suggestion to help you get started. The best idea is for you and your students to design your own SMOC. The design presented here will help you understand what types of functions a SMOC needs to support.

No matter what design you use, remember that each KidSat mission is very intense and highly collaborative. During the actual mission, your students need to work closely and communicate well with each other — and the SMOC design needs to support both the individual functions and the collaborations among them.

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An operating SMOC should have:

- at least 3 computers with internet connection
- reference books (atlases, etc.)
- slider maps (KidSat will provide these)
- TV to show NASA TV before and during the mission
  (Optional, but nice to have)
- lots of workspace
- 2 clocks (1 for MET)
- blackboard or large paper for master records and status

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All Those Computers?

Computers and the Internet are central to the SMOC. Your students use computers to:
• monitor the status of the shuttle
• get the exact orbital track
• find out current weather
• confirm and submit photo requests
• view the newly acquired pictures

How many computers you use depends on your resources. In this design, there are six computers, each connected to the Internet. You could survive with three, but your mission operations would become less efficient by having each computer used alternately for different functions.

All the computers need to be connected to Internet and the World-Wide Web, in order to communicate and get important information. Therefore, each computer in the SMOC needs a high-speed connection to the Web (at least 14,400 baud). Your connection can be by modem, local area network, or dedicated Internet connection into your classroom. You may need a technical specialist to help you get connected.

Technical specifications (for each of the computers):

Mac or PC, w/color monitor and hard disk (at least 8M RAM)
Internet connection by modem or local network (at least 14,400 baud)
Software: Netscape
Optional: color printer
Go with the Flow

To help you understand the design of the SMOC, let's first walk through the steps of the targeting process (at the end of each step, we've indicated where this take place. These areas are described in the SMOC Layout, later in this chapter).

1. Prior to the mission - your students identify several broad areas of interest, such as the rain forests of South America, Africa and Asia, or coastal transition zones. They also identify a few specific targets, such as the Hawaiian islands, or the coast of Somalia. These pre-selections give guidance for the selection of the actual targets once the precise orbital tracks are confirmed. (Reference Area)

2. Shuttle launch - Your students may want to watch the launch on NASA TV, and feel the excitement of the start of their mission. Based on the actual launch time, they adjust their anticipated KidSat work schedule. (NASA TV area)
3. Monitor the Shuttle-- Students use a computer to access NASA and KidSat's Web pages, to get current data on the location and activities of the shuttle. Your students especially await confirmation that the KidSat camera has been placed in the shuttle window. They also get and post the official data on the position of the upcoming orbital tracks. (KidSat and Shuttle Status Area)

Note: During the flight, the following steps are repeated for each new orbit (every 90 minutes):

4. Position the orbital overlay on the base map-- Based on orbital data from the KidSat Mission Operations web page, your students align a plastic overlay of the orbital track on top of the base map. This is done for the next orbit for which students can select targets. They place the overlay in the same position on two separate maps, each on a different table. (Target Selection Area)

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5. Current Weather-- Students use the Web to access the latest satellite weather maps, showing cloud cover around the world. They give this information to the targeters, who will use it to either avoid cloud covered areas or to identify interesting weather to target. (Reference Area)

6. Preliminary Selection of the Targets — Students select targets along the orbital track. If they're interested in rain forests, for example, they look for where the orbit passes over rain forests. If they're looking for specific cities, they check to see if this orbit passes over any of the desired cities (Targeting Area)
7. Reference Support —— If the students need more information to help with the targeting, they ask for help from the reference specialists. For example, they might find the exact location of a volcano which has just begun to erupt. (Reference Area)

8. Specify Lat/Lon of each target —— Another group of students write the precise latitude and longitude of each target on a "Target request Form" that they will pass on to other students. (Targeting Area)
9. Confirm and Submit Requests —— Students take the "Target Request Form", and use KidSat's web page to confirm that the target was correctly specified, is on the orbital track, within the camera footprint, and is in daylight. If the request form has errors, they give it back to the Targeting group to check and fix it. Otherwise, they get the precise MET, which will tell the KidSat camera exactly when to take the picture. They then assign the target a priority, choose a code word with that priority, and submit the request through the appropriate web page. (Confirm and Submit Request Area)

10. Posting the Request —— Once the request has been submitted, it is hand-written on a bulletin board listing all the requests by orbit #, title, MET, lat/lon, and including code word and record numbers; and the location is marked with a push-pin on a world map. The paper records are filed, with all requests for a given orbit in a single folder. (Confirm and Submit Request Area)
11. Follow the Status of the Photo —— There could still be several reasons that the photo might not be taken. KidSat Mission Operations keeps track of the status (e.g. sent to the shuttle, photo taken, etc.), and posts it on the Photo Status web page. Students follow the status on the web page. If a photo is not taken for some reason, they report that the code word is available for re-use. (Image Status and Analysis Area)

12. View and Study the New Images —— Within hours of submitting your request, the KidSat camera take the picture(s) and they’re downloaded to the KidSat central image database. Then your students can access them by the KidSat Data System web page, view them, and report to the SMOC that the pictures have been received. (Image Status and Analysis Area)

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Welcome Area and SMOC Director

Purpose: Students display information and have handouts for visitors. Also, the student SMOC director has his or her desk here.

KidSat is a high-visibility project, so you are likely to have visitors during the mission. You should have a bulletin board with information about KidSat, the shuttle, your students and the images of Earth. Your students will certainly think of other things to add to the display. You should also have handouts to give to the visitors. It helps to have one or two students responsible for welcoming the visitors and showing them around the room. The welcome Area should be located near the door to the SMOC.

Also, this is a good place to have a desk or table as the home base for the student SMOC director. This student has overall responsibility for the SMOC operations. You probably will want to have a few different directors who can take turns in this position. The Director is a supportive position, with the students in each area having primary responsibility for their own tasks. The Director should observe the entire process to make sure there are no snags, and to resolve any problems that might arise.
Sally K. Ride Papers - KidSat Student Mission Operations Center (SMOC) Teachers Handbook, [with corrections], (folder 2 of 2) Transcribed and Reviewed by Digital Volunteers
Extracted May-08-2020 09:42:03
Purpose: students use an orbital map to select the targets for each orbit.

At the center of the room are two tables, each with a world map as a base, and a clear plastic orbital overlay. The base map is taped to the top of the table. The slider overlay, with the shuttle orbital track precisely marked, is laid on top of the base map. For each orbit, longitude of the descending node is provided (via the "KidSat and Shuttle Status Area") to let students know exactly where to position the orbital track overlay.

The two tables are similar in appearance, but serve two different functions:
Targeting Table - The students at this table select the targets. The targets must be exactly under the orbital track. In general, the students look for three types of targets:
- pre-defined sites: Are any of their pre-defined target sites (such as Hawaii) under the orbital track?
- broad regions: Does the orbital track cross a region of interest (such as the Asian rain forests)?
- targets of opportunity: What else under the track looks interesting?

Lat/Lon Table - The students at this table determine the latitude and longitude of each target. When the students at the targeting table select a target, they go to the lat/lon table and mark its location. Then the students at this second table identify the exact latitude and longitude, and record it on a Target Request Form.

Experience has shown that these two functions (selecting targets and determining the latitude and longitude) are best handled separately. This way the targeters can focus on the targeting, and the lat/lon experts can focus on specifying the location. The two functions can, however, be performed at the same table, with one map.
KidSat provides your school with the base maps and the orbit overlays (the slider map). Each table has the same base map and the same orbital overlay.

However, the target selection process can be improved if you create two additional overlay maps for the Targeting Table:

• Pre-defined largest - an overlay on which your students have marked (with water-based pens) the specific target sites and general regions that they’re especially interested in. This helps them notice when the orbital track passes over the areas of interest.

• Weather maps - an overlay which will change every few hours, on which your students record major weather features (weather maps are views via the Web). They should record broad areas of cloud cover which would obscure potential targets. They should also record the location of weather, such as hurricanes, which would be interesting targets to photograph.
Kid Sat and Shuttle Status Area

Purpose: Students monitor the progress of the shuttle flight and post important information about the orbits and the status of the KidSat camera.

At the center of this area is a computer with two Netscape windows open:

- NASA’s shuttle site -- which provides on-going updates on the shuttle flight, and displays the current location of the shuttle
- KidSat Mission Operations Status page -- which the Gateway uses to send essential status messages to the schools, to update deadlines, and to provide the longitude of the decending [[descending]] nodes to position the orbital overlay map.

On the left side is a KidSat Status bulletin board. In the illustration above, the left side of the board is used to record each orbit’s “descending node” and where day and night begin in the orbit. This information is used to position the orbit overlay. Also, the deadline to submit requests for the next orbit is posted, as well as any other vital information about the KidSat mission.

On the right side is a Shuttle Mission Status bulletin board. This includes information about the overall shuttle mission, such as launch and landing time, upcoming key events and the NASA TV schedule.

This area also has 2 clocks: Local Time and Mission Elapsed Time or MET (time since launch - shuttle operations are scheduled on the basis of MET).

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Purpose: Students monitor the NASA TV channel and videotape images of Earth or other important events.

NASA TV is a 24-hour channel, distributed by satellite. During the shuttle missions, it is used almost exclusively to show the status of the mission, including scenes of astronauts on board the shuttle, mission control center, and live scenes of Earth from the shuttle's video cameras. It also frequently shows the current shuttle location and orbital track.

One student should monitor the NASA TV channel, so that he or she can videotape scenes of the shuttle flying over Earth or other interesting activities. (This might be the same student(s) who are responsible for the KidSat and Shuttle Status Area.) This student also should notify the classmates when there is something important to watch, such as interviews with the astronauts or even a special KidSat announcement.

The TV should be positioned so that you can see it throughout the SMOC, because it is an important element of setting the climate. Your students feel much more connected with NASA and the excitement of a shuttle mission when NASA TV is on in the Background. If your local cable company does not carry NASA TV, check with your local NASA Education representative to find out how to receive it.
Reference Area

Purpose: Students provide important reference information to help with the selection of targets.

This area provides direct support to the targeters. For example, they might want to help in selecting among several potential targets showing rain forests in the Amazon. In this case, the reference specialists would find a more detailed map of the Amazon, and help pinpoint good targets. Also, individual students might have particular areas of expertise, such as rain forests or Islands of the Pacific, and they could be called on for help.

The reference area has three parts:

• computer — connected to the Web to provide live weather data, to keep track of newsworthy events that might be seen from space (such as a volcano) and to support web-based searches of reference information about any of the potential targets.

• library — a set of reference books such as atlases, Earth science textbooks, encyclopedias, books about the space shuttle, or any other related reference. A globe would also be helpful.

• work table — where students can spread out their reference materials during their active use.
Submit Request Area

Purpose: Students confirm that each target was correctly identified, determine the MET, and submit the request.

This is a busy area, and would benefit from 2 computers. The process takes place in four steps:

• confirm the selection — Using the KidSat map webpage, a student checks to be sure that the location (latitude, longitude) specified in the Target Request Form is actually under the orbital track (within the footprint of camera) and in daylight. If not, they give it back to the Lat/Lon Table to be corrected. Otherwise they get from the webpage of the MET (which defines the precise time that the camera will pass over the target), and pass the form along to the next stage.

• assign priority, and select the corresponding code word

• submit the request — Using the KidSat Submit Request webpage, another student enters the full request information, including the code word, target name, lat/lon, and MET.

MET Post the request — Once the request is submitted, it is handwritten onto a bulletin board list, and a push-pin is used to mark a location on a map on the wall of your classroom. Your students also file the Target Request Form into a folder (one folder per orbit).

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Image Analysis Area

Purpose: Students monitor the status of their picture requests, and see the pictures as soon as they're available.

Each request is also reviewed at the KidSat Mission Control Gateway (at UCSD) to check the accuracy of the data, to make sure that there is not an overload of requests for a given orbit, and to make sure that there is enough time between each request for the KidSat camera to get ready for the next picture. If there are any problems, the request is sent back to the SMOC (with a description of the problem). The Image Analysis team monitors the Photo Status web page, and notifies the Targeting Team if a request has been rejected or a photo not taken.

After your students submit all the requests for a given orbit, the KidSat Gateway consolidates the requests from all SMOCs, and sends the list to NASA, which in turn sends it to the shuttle. The KidSat camera then takes the pictures and stores them in a digital file. Then, when the shuttle is on the nightside of the Earth, the images for that orbit are sent to NASA's ground station, and forwarded to the KidSat data system at JPL.

In other words, within hours of submitting the requests for each orbit, the KidSat camera has taken the pictures, and they're available for your students to see them in your classroom, via the KidSat Data System web page.

The Image Analysis team will monitor the availability of the images, and then display (and possibly print) a select few as they arrive. This will be an exciting moment; be sure your class sees the results of their hard work. You may also have a group of students who proceed directly with a more detailed analysis of the images, perhaps in collaboration with the students in the Reference Area.

However, at this point, most of your students will be so busy selecting new targets, that it will be difficult for them to concentrate on seeing the newly acquired images. So, the more intense image analysis will take place in the days, weeks and months after the KidSat mission.

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The mission of the Smithsonian is the increase and diffusion of knowledge - shaping the future by preserving our heritage, discovering new knowledge, and sharing our resources with the world. Founded in 1846, the Smithsonian is the world's largest museum and research complex, consisting of 19 museums and galleries, the National Zoological Park, and nine research facilities. Become an active part of our mission through the Transcription Center. Together, we are discovering secrets hidden deep inside our collections that illuminate our history and our world.

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