LESSON PLAN

Understanding Remote Sensing

1. GENERAL

This class will provide the Mission Team with a basic understanding of RemoteSensing. This includes information on different types of imagery, the electromagnetic spectrum, and examples of imagery. This class is presented to expand the terrestrial and space knowledge of all Galaxy Explorers in order to enhance their competence and confidence of all aspects of space.

2. LEARNING OBJECTIVES

SUBJECT AREA: Understanding Remote Sensing

TASK: The Mission Team must be able to understand essential ideas about remote sensed imagery.

CONDITIONS. Given classroom instruction that includes a lesson plan and power point slides, an overhead projector, and activity handouts.

STANDARD. Must demonstrate a basic understanding of remote sensing.
Must demonstrate a basic understanding of different types of imagery.
Must perform all lesson activities.

3. PRESENTATION GUIDE

a. Introduction (3 minutes) (***Show slide #1***)

Good morning/afternoon, I am (Your Name) and I will be your instructor for Understanding Remote Sensing. Over the next 90 minutes you will learn some basics about remote sensing to include what it is, the different methods, the portion of the electromagnetic spectrum we will discuss, and imagery derived from remote sensing.

b. MAIN LECTURE

1) Lecture/Discussion (25 minutes):

Let's start off with a brief definition of what remote sensing is for this class. (***Show slide #2***) It is the gathering of information about the earth from a distance**.** Can anyone give me an example of a remote sensor**?** ***(Wait for some input then show slide #3)***. Believe it or not, people are remote sensors. People use their eyes, which is a sensor, to take in information around them. The brain is the data storage device that helps compute the image your eyes take in. There are also other ways to gather remotely sensed information. (***Show slide #4***) One of the strangest ways was using pigeons in the late 1800s, strapped with automatic cameras, to take pictures.

There are two types of remote sensing. (***Show slide #5***) Passive, which includes panchromatic, multispectral and hyperspectral imaging, and Active which includes RADAR imaging. This slide helps to demonstrate the difference between the two. (***Show slide #6***) Passive sensors collect reflected or emitted energy from objects. Active sensors emit directed energy at an object, and then measures the return from the object. Here is an example of what each sensor type can contribute (***Show slide #7***) The aerial photo from a passive sensor shows a built up area in the green circle. It is easier to see than in the RADAR image. But in the RADAR image you see something has been done in the red circle, where you cannot really see anything in the red circle of the photo. Each one contributes it it's own way.

Now that we have an understanding of the types of sensors, let's look at the primary methods of remote sensing (***Show slide #8***). There are two primary methods aerial and space-based satellite. Aerial platforms like manned aircraft or unmanned aircraft has the option of taking photos or digital images. Satellites on the other hand take digital images. This allows them to send the images in real time over communication links and not delayed by physically dropping film canisters to earth. Additionally, you can see that both platforms can carry sensors that provide different kinds of images. For this class, we will concentrate on remote sensing from space. Here is a commercial United States remote sensing satellite from Digital Globe (***Show slide #9***).

Since we are concentrating on space, lets look at the advantages and disadvantages of imaging from space. Let's take a look at the advantages first ***(Show slide #10).*** Probably the most important advantage from space is that you have worldwide access. You can image over any country without asking their permission. You can image from an angle or straight down, which increases your chance of being able to image what you want. Imaging from space also allows you a larger field of view or bigger area coverage than an aircraft. There are some disadvantages ***(Show slide #11)***. It is not as flexible as an aircraft, because it is in a specific orbit, which dictates how often it will visit a specific location on the globe. It is not always as responsive as an aircraft, again because it is constrained in a particular orbit. Once you launch the satellite, that is the sensor you are stuck with. An aircraft allows you the opportunity to change out sensors. Electro-optical satellites cannot see through clouds, which limits their ability to see things on the ground. An aircraft may be able to get under the clouds.

We just covered what remote sensing is, the types of remote sensing, and methods of remote sensing. Now let's take a look at a product of remote sensing; an image. Can anyone give me a definition of an image? (Pause) ***(Show slide #12)*** The key to our definition is the word mirror. ***(Show slide #13)*** Here are definitions of the imagery we will be discussing. Earlier we discussed passive and active types of sensing. Photographic and EO imagery is the result of passive sensing, and RADAR imagery is the result of active sensing. For now, let's take a further look at EO imagery. You can see there are four sub categories under EO imagery. Panchromatic is what we see as black and white images. Spectral imagery is what we see as color images. Let's take a look at the EO differences ***(Show slide #14).*** Here is a graphic representation. You can see the difference in sensitivity between panchromatic and spectral resolutions over a portion of the electromagnetic spectrum. This increases the fidelity of your information. For our discussions ***(Show slide #15)***, we will be looking primarily at remote sensed imagery in the visible and IR portions of the electromagnetic spectrum, but I want to briefly mention radio detection and ranging or better known as RADAR remote sensed imagery ***(Show slide #16)***. As we mentioned earlier, it is an active sensor that has a day/night, all weather capability. This gives it an advantage over electro-optical sensing. RADAR uses a transmitter operating in either the radio or microwave frequencies to emit electromagnetic radiation to the earth's surface and uses an antenna on the sensor to receive the reflected signal.

Before we look at some imagery examples, lets make sure we understand the difference between the colors of light and the primary colors of pigment we are used to with our eyes ***(Show slide #17)***. As you can see, the primary colors of pigment are red, yellow, and blue. The primary colors of light are red, green, and blue. You can also see that when you add all the colors of pigment you get a dark black, but when you combine the primary pigments of light you get white. Here is an example of white light through a prism ***(Show slide #18)***. Here you see the sun's white light coming through water vapor in the earth's atmosphere (which acts like a prism) is broken apart to create this rainbow.

Now lets take a look at some imagery examples. Here is a panchromatic image ***(Show slide #19)***. As we mentioned earlier, this is 1 band that covers the visible spectrum. It is a gray scale image used for higher resolution (closer looks) images. Next we have a multispectral image ***(Show slide #20)***. It provides the enhancement of features through color. It has been used traditionally for broader area coverage than panchromatic imagery. Multispectral data gives you the ability to glean more information from a scene than panchromatic imagery, particularly the discrimination of solid and liquid materials. Here is a multispectral image from the NASA Landsat sensor ***(Show slide #21)***. You can see that the image covers a larger area than the previous panchromatic image, but it does lack the same resolution fidelity (the airfield). Next we have a hyperspectral image ***(Show slide #22)***. Hyperspectral data also enhances features with color, but provides even more information than multispectral. It allows further identification of solids and liquids, as well as the detection and identification of gases. You can see the additional detail hyperspectral provides ***(Show slide #23)***. The image on the left is from the NASA Landsat multispectral sensor and the image on the right is from the NASA Hyperion hyperspectral sensor. The hyperspectral sensor allows you to further identify the forest by particular tree type. You can see the higher fidelity hyperspectral data provides in this histogram ***(Show slide #24)***. The bands are more narrow (5-10 nanometers wide) and reveal more information on a particular material when compared to the large bandwidths of the two multispectral sensors.

At this time were going to do a couple of activities. This first activity concerns the mixing of colors.

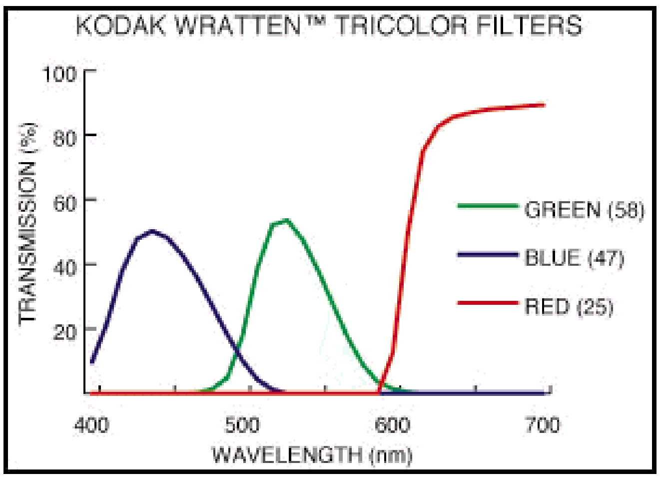
2) ACTIVITY (15 minutes): **Mixing Colors of Light** ***(Show slide #25)***

a) **Directions:** Groups will shine the three flashlights onto a piece of white paper and create as many colors as possible. List the colors in the chart provided. Then, use the numbers in the key to describe how much colored light you use to make each color. The first one is done for you. Discuss results with the teams. **Note:** Encourage the teams be creative and make new colors! Experiment with your flashlights by pulling them back from the paper. Use numbers 1 to 9 to describe the brightness of the colored flashlight, 1 is dim and 9 is very bright. Use 0 if the flashlight is off.

b) **Training aids needed**: Flashlights with blue, green and red lenses. Activity Sheet (slide #25).

3) ACTIVITY (20 minutes): in this second activity, the objective is to show how satellites use monochromatic sensors to collect data on the color of objects on the Earth's surface. [1]

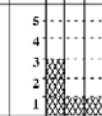
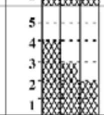
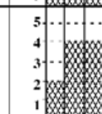
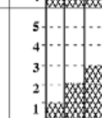
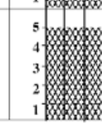
a) **Directions:** Stray Light - It is very important to use good color filters for this exercise. You may have trouble if you do not use gel filters. Ordinary colored cellophanes and plastics may pass other colors. This is called "stray light". For instance, green objects may actually look green when using the blue filter. This means the blue filter is not blocking all of the yellow light. Stray light at other color frequencies allows the students see the actual colors of the objects making the exercise much easier and ruining the desired effect. Good filters will pass only the colors desired while minimizing stray light. Inexpensive professional color filters are available from vendors like Edmund Scientific. This chart illustrates the frequencies of light passed by KODAK gel filters:



Try out your filters ahead of time to make sure they work well with the objects you have chosen. You will find the red filter is most effective at blocking light from other parts of the color spectrum. It is best to start this activity with the red filter first. For the first part of this exercise, it's fun to use large colorful toys that have a certain color associated with them e.g.: a red fire hat, a yellow school bus, green Kermit the frog etc. For the second part, use geometric shapes, boxes or other uncharacterizable objects for the unknowns e.g.: a blue swimsuit, a red ball, a green glove, a yellow box etc. Have fun; bring in some unusually colored objects, like a blue banana, a yellow apple...Any fluorescent colored object will throw the class off. These colors reflect light in quite a different way from 'standard' colors like blue, red or green.

[1] *Two Lessons: Studying Ocean Color from Space*, from a lesson plan developed by Rebecca Farr, Ground Data Systems Manager, NOAA NESDIS, Landsat 7 Mission Management Office, Greenbelt, MD 20771

b) **Results:** Here is an example of some results drawn as histograms:

Object	Val. R G B	Object Name	Actual Color
1.		**Firehat**	**Red**
2.		**School Bus**	**Yellow**
3.		**Kermit the Frog**	**Green**
4.		**Cookie Monster**	**Blue**
5.		**Space Shuttle**	**White**

c) **Additional Teacher Discussion:** Remote Sensing Realities - You will find it practically impossible to find two objects from different sources with exactly the same color. The class will even notice a difference in the histograms of objects that appear to be nearly the same color in white light, illustrating the power of this analytical spectral technique for color recognition. If slight color differences can be seen using this technique with toys and the naked eye, imagine how discerning satellites are!! Satellite digital spectral analysis is sensitive enough to allow analysts to discern the different chemical make-up, and thus origins, of paint on vehicles on the ground miles below. Students may complain about glare on an object, lack of reflectivity from a furry toy, or lack of discernability because the object is too small. These complaints illustrate three important limiting factors in characterizing objects using satellite remote sensing:

- Aspect, or surface area visible
- Surface roughness or reflectivity and
- Sun glint

Because of the small sampling size of this exercise, it will not be totally clear to everyone that a 'red' unknown object can be correctly deduced from the histogram of a known red object. Three important remote sensing ideas can be presented here:

- Data analysis is a subjective process based on data collection, analysis and hypothesis.
- This subjectivity can be lessened by taking more data and applying statistical analysis.
- Ground truth data provide the only key to understanding the rest.

Someone may ask 'Why not just use a color camera rather than a whole collection of sensors sensitive to different bands of color?' The early Landsat satellites did indeed have both a black and white camera and a digital sensor called a Multi-Spectral Scanner (MSS). At that time, the camera was actually more dependable than the electronic sensor. Over the years, researchers and engineers have perfected digital sensors and continue to refine them. Today's Earth satellites use digital sensors almost exclusively.

Digital sensors have two main advantages over film or television cameras:

1. Cameras produce analog images, not digital data. This means you cannot perform mathematical calculations or manipulations on analog images, making it impossible to derive quantities such as chlorophyll concentration from the image, even though cameras can be equipped with color filters to collect data in several color bands.

2. While the resolution of a camera is limited by the chemistry of its film emulsion, the resolution of electronic sensors gets better every year with advances in technology. Someone may ask if three or more discreet spectral sensors can really see everything. The answer is "No, but it's the best we can do for now". The ideal sensor would cover a broad and continuous spectral range. Until recently, this has not been possible because of limitations in sensor and spacecraft technologies. However, new designs for future satellite sensor systems employ this idea. These new satellites are called "hyperspectral" satellites.

It is somewhat likely you will have at least one student in the class who cannot distinguish the difference between red and green. This is a genetic trait known as red-green color blindness, and it occurs in approximately 8/100 of males. His observations will be different from those of the other students. Discuss how they are different. The class should soon realize that he is not perceiving the red and green in the same way

d) **Training aids needed**: Slide projector; Color filters: red, green and blue; Various colored objects (fruit, paper cutouts, color photographs, plastic toys, etc.); and a dark room.

4) This concludes the lesson. Now I would like to ask you a few questions.

a) Who can give me a definition of remote sensing? (If no response, discuss with Mission Team)

b) What are the types of remote sensing? (If no response, discuss with Mission Team).

c) What are the primary methods of remote sensing? (If no response, discuss with Mission Team).

d) Name two advantages and two disadvantages of imaging from space? (If no response, discuss with Mission Team).

e) What are the primary colors of light? (If no response, show slide #16).

c. Conclusion. (2 minutes) **(*Show slide #26*)**

This concludes our lesson. Over the last 90 minutes you have learned some basics about remote sensing to include what it is, the different methods, the electromagnetic spectrum, and viewed some imagery examples. I hope it has provided you a little more insight into remote sensing and what can come from it.