Remote Sensing

Using Informed Design and Aerial Photography to Create a Scale Map

NYSCATE

FIELD TEST VERSION

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NYSCATE modules and ancillary materials such as the NYSCATE Pedagogical Framework may be downloaded from http://www.nyscate.net or www.hofstra.edu/nyscate

NYSCATE MODULE GUIDE
Remote Sensing

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NYSCATE MODULE GUIDE
Remote Sensing

I. INTRODUCTION AND OVERVIEW

ABSTRACT

This module is one of 13 NYSCATE modules that feature the integration of mathematics, science, and technology (MST) through an emphasis on design. It introduces the concepts that are central to maps and map making. It does this by challenging students to use basic remote sensing technology. Specifically, they use tethered balloons (or a kite) to take a set of aerial photographs and design an accurate scale map of the area around their school.

The module emphasizes traditional Earth science topics such as maps, map making, topography, and land features. In addition, the more modern topic of remote sensing technology is introduced.

In this module, the teacher:

- provides an engaging Design Challenge;
- fosters cooperative learning as students work in design teams;
- facilitates student acquisition of skills and knowledge in maps and map making, and in the science and mathematics principles related to this content;
- prompts scientific inquiry and mathematical analysis;
- guides students as they identify and explore factors relevant to design performance;
- provides opportunities for improving communication skills through the use of the Design Journal or Design Folio; Design Report; and group presentation of student work; and
- works with groups as they cooperatively compose, construct, test, improve, and present their design solutions.

Rather than proceed by trial and error alone, students are expected to make design decisions based on mathematical and scientific principles that they consciously apply. The module features mathematical, scientific, and technological Knowledge and Skill Builder (KSB) activities that groups complete in order to be informed as they design, construct, and test.

GRADE LEVEL

This module is appropriate for students in high schools and community colleges, grades 9–14.

TIME ALLOCATION IN 45-MINUTE PERIODS

It should take about 21 periods to complete all of the actions recommended in the basic module. However, the number of periods can be reduced by eliminating Knowledge and Skill Builders (KSBs) labeled “optional,” or it can be increased by assigning suggested applications of the student products as found on page 25.

EXISTING COURSES ENHANCED BY THE MODULE

This module has been designed to facilitate student learning in high school Earth science or environmental science courses. Since this is a module that emphasizes the design process, it may also be adapted to fit into high school or community college technology education courses.

SOURCES

Calhoun, J. S., Kite Aerial Photography, http://education.ssc.nasa.gov/crsp-wdet/education/kap.htm, 2000.

H. Beeland, D. Brown, A. Bullwinkel, T. Miskelly, J. S. Calhoun, Remote Sensing Tutorial, http://education.ssc.nasa.gov/crsp-wdet/education/rstutorial.htm, 2000.

EarthKAM Project, http://www.earthkam.ucsd.edu

M. Kerr, National Air and Space Museum, Smithsonian Institution, Cosmic Voyage, http://www.nasm.edu

II. DESIGN CHALLENGE OVERVIEW

SETTING THE CONTEXT FOR STUDENTS

The Design Challenge requires students to make a composite aerial photograph of their school property from separate photographs that they take from a helium-filled balloon. (See "Other Resources" in Section VII, Additional Support for Teachers, p. 27, for information on using kites as an alternative to balloons.)

The challenge is broken into three parts:

1) developing a strategy for taking the separate photos,
2) constructing the composite photograph, and
3) developing an overlay map to place on the composite photo.

The full challenge should be completed in about 21 days, but your students may not need to complete some optional KSBs and that can shorten this time considerably.

Specific ways to reduce the time include:

- focusing student effort solely on the challenge and the Knowledge and Skill Builders (KSBs) that are essential for completing the challenge;
- omitting design and preparation of the overlay map;
- omitting identification of GPS coordinates;
- omitting the additional application activities presented after the challenge in the timeline; and
- omitting the student presentations or using a less time-consuming poster session to display student work.

In the presentation below, you may choose to drop items labeled "Optional."

Note: Much of the information in this section is also provided to students later (see Introductory Packet, p. 34).

Introduction

The planning board of your local government is interested in mapping your community in order to plan for the future. Your school administration has been asked to provide an up-to-date aerial photograph and overlay map of the property on which the school is located and the area immediately surrounding it. Your class has been assigned the project of providing the aerial photograph and developing a labeled transparent overlay map to help interpret the photograph.

Design challenge

You will design a composite aerial photograph and transparent overlay map of your school property and its immediate surroundings. This Design Challenge has three parts:

- Working as a class and using the balloon and camera system provided, you will design a class strategy for taking several photos that together show the entire area of the school property and its immediate surroundings.
- Working in an assigned group, you will use copies of these photos to design a single composite photograph of the property.
- (Optional) Working in your group, you will design a map that can be superimposed on the composite photograph to identify major features of the photo such as buildings, athletic fields, parking lots, and adjoining streets.

Specifications

1) The photo and transparent overlay map of your school property and surrounding area must show a rectangular region at least 200 meters long on one side. The photo and map must have a scale indicating the relationship between the distances in meters on the ground and the corresponding distances on the photo and map.
2) The photo and map must show a level of detail much greater than the 30-meter pixel resolution offered by satellite photos. One must at least be able to distinguish objects the size of a car from other objects.
3) (Optional) The map overlay that you produce must show the GPS coordinates of the photo so that the photographed area's precise location on the globe is known. The coordinates should also permit accurate identification of that area on other local maps.
4) The composite photo and map must be easily transported, stored, and used. They must be in a form that permits their viewing by groups of people; two large posters, overhead transparencies, and computer projections (PowerPoint) are examples of acceptable formats.

Constraints

The composite photo (mosaic) must be developed from separate aerial photographs taken by each of the working groups in your class. These photographs are to be taken using the balloon lift system described in KSB T3: Construction of Aerial Camera Support.

III. GOALS AND LEARNING OUTCOMES

The outcomes promoted by the *Remote Sensing* module are listed below; the order in which they appear is based on the order of the NYS learning standards. (The MST learning standards most closely addressed by each outcome are indicated in parentheses.)

In the *Remote Sensing* module, students learn to apply the process of informed design. In order to do so, they acquire the following MST standards-based knowledge and skills:

- how to carry on informed design **(NYS MST Learning Standard 1)**;
- how to use trigonometry to take indirect measurements **(NYS MST Learning Standard 3)**;
- how to apply proportions to scale drawings, computer-assisted-design blueprints, and direct variation in order to compute indirect measurements **(NYS MST Learning Standard 3)**;
- how to understand error in measurement and its consequences on subsequent calculations **(NYS MST Learning Standard 3)**; and
- how to use geometric relationships in relevant measurement problems involving geometric concepts **(NYS MST Learning Standard 3).**

In this module the teacher:

- prompts acquisition of mathematical analysis, scientific inquiry, and informed design processes **(NYS MST Standard 1)**;
- fosters cooperative learning as students work in design teams **(NYS MST Standards 1 & 2)**;
- provides opportunities for improving communication skills through the use of the Design Journal or Design Folio; Design Report; and group presentation **(NYS MST Standard 2)**;
- introduces students to the design process through an engaging Design Challenge **(NYS MST Standard 1)**;
- involves individuals and groups as they compose, construct, test, improve, and present their design solutions **(NYS MST Standard 1)**; and
- prompts students to realize what they already know about remote sensing and mapping, and about design **(NYS MST Standards 3–5)**; guides students as they identify and investigate factors relevant to design performance **(NYS MST Standards 3–5)**; and facilitates acquisition of mathematical, scientific, and technological principles related to remote sensing and mapping **(NYS MST Standards 3–5).**

In the Additional Support for Teachers section, pages 27–33, there is a subsection devoted to related learning standards, including standards other than the MST learning standards for New York State.

IV. TIMELINE CHART

Suggested order for completion of KSBs by students:

1. Complete Introductory Packet (p. 34).
2. Students complete KSBs T1 (p. 37), T2 (p. 40), M1 (p. 41), M2 (p. 45), T3 (p. 47), and M3 (p. 50).
3. The remaining KSBs [M4 (p. 51), S1 (p. 52), S2 (p. 53), and T4 (p. 54)] are optional and may be completed in any order, or groups may do different ones and then share the information with classmates.

PERIOD	FOCUS MODEL COMPONENT (For Teacher)	INFORMED DESIGN LOOP COMPONENT (For Student)	ACTIVITY
1–2	Focus Discussion on Problem Context	Clarify Design Specifications and Constraints	Discuss remote sensing and Landsat images. Present and discuss the Design Challenge, Student Handout #1.
2–3	Organize for Informed Design		Discuss informed design. Complete KSB T1: The Informed Design Cycle. Specify folio or journal requirements. Describe and clarify student presentation and report requirements, and discuss grading. Form design teams.
3–4	Coordinate Student Progress	Research and Investigation	Explore remote sensing on the Web by completing KSB T2: Remote Sensing Web Search. Investigate the apparent size of objects and viewing distance by completing KSB M1: Power Viewers. Develop the pixel concept by completing KSB M2: Get the Picture.

5–7	Coordinate Student Progress	Research and Investigation	Construct the camera carrier vessel and balloon system by completing KSB T3*:* Construction of Aerial Camera Support. Decide on balloon height by completing KSB M3*:* The Camera Distance and Field of View. (Optional) Study global positioning by completing KSB T4: GPS Explorations.
8–10	Coordinate Student Progress	Generate Alternative Designs Choose and Justify Optimal Design	Develop a strategy for picture taking and test it (Design Challenge, Part I). Select, test, and defend choice of preferred alternative.
11	Coordinate Student Progress	Construct a Working Model	Have the class take the pictures according to the agreed-upon strategy.
12–15	Coordinate Student Progress	Generate Alternative Designs Choose and Justify Optimal Design Construct a Working Model	The class proposes method for making the composite photo (Design Challenge, Part II). Select and defend choice of preferred alternative. Student groups each make a composite photo.
16	Coordinate Student Progress	Generate Alternative Designs Choose and Justify Optimal Design Construct a Working Model	Student groups develop and propose a plan for making the overlay map of the composite photo (Design Challenge, Part III). Select and defend choice of preferred alternative. Students carry out the plan for making an overlay map.
17–20	Unite the Class in Thinking about What Has Been Accomplished	Test and Evaluate the Design Solution(s)	Students study the Design Report guidelines and complete their folio or journal entries. They

			prepare their final Design Reports. Students study the presentation guidelines and prepare presentations. They present their work publicly.
21	Sum Up Progress on Learning Goals		Use appropriate rubrics to evaluate student work. Assign grades. Provide feedback to students.
22 optional			Consider which, if any, of the additional application activities you will have students do.

V. MATERIALS AND RESOURCES

MATERIALS AND SAFETY CONSIDERATIONS
Provide each student team with the materials needed to complete the challenge, including:

cameras (disposable)
kites or balloons (see Additional Support for Teachers, Other Resources)
lift platform (See KSB T3: Construction of Aerial Camera Support, in the Student Handout section) and assembly guidance, if not preassembled
A variety of linear and angular measuring devices such as:
metersticks
metal tape measures
trundle wheel measures
protractors

After photographs have been taken, students may need access to:
photo-developing services or equipment
photocopying machine
overhead projector
transparencies
computer with inkjet or laser printer
photo-editing and presentation software (e.g., PowerPoint)

They should also have available a variety of standard art materials and tools such as:
poster paper
tracing paper
glue
tape
scissors
box-cutting knives
straightedges

(**Note:** The Introductory Packet provides the following information to students about materials: *You may use only materials and tools provided by your teacher, or materials and tools provided by your group and preapproved by your teacher.*)

Additional materials will be necessary to complete the Knowledge and Skill Builders (KSBs) that help prepare students for the Design Challenge. These materials are listed in the student handouts that accompany the individual KSBs.

SAFETY CONSIDERATIONS

If you plan to take the aerial photographs from tethered balloon supports rather than the alternative kite support, the following considerations are

pertinent: Care should be exercised in identifying and explaining the potential dangers that exist if these balloons come into contact with overhead utility wires or cables. Consideration should also be given to restrictions that might be imposed by nearby airports or regulating authorities on the permissible altitude of these remote sensing balloons. Launch might require FAA acknowledgment or approval if it occurs in an altitude over 300’ or within three miles of an airport, or when visibility is less than five miles, or cloud ceiling is less than 500’. Contact your local Federal Aviation Administration office for further guidance regarding the launch of tethered or moored balloons, before beginning this activity.

RESOURCES

Access to WWW

VI. PROCEDURAL SUGGESTIONS

PEDAGOGICAL FRAMEWORK REFERENCE

A separate document, the NYSCATE *Pedagogical Framework,* provides an in-depth understanding of the NYSCATE challenge statements, the FOCUS on Informed Design pedagogical model for teachers, student Knowledge and Skill Builders (KSBs), the informed design loop for students, and more.

SUGGESTIONS

Here suggested strategies are presented within the context of the NYSCATE FOCUS on Informed Design, a pedagogical model for teachers. The FOCUS components are: **Focus** discussion on the problem context, **Organize** for informed design, **Coordinate** student progress, **Unite** the class in thinking about what has been accomplished, and **Sum up** progress on the learning goals (see NYSCATE *Pedagogical Framework,* pp. 7–9, for more on this model).

Periods 1–2: ***Focusing discussion on the problem context***

The problem. Provide copies of the topographic map along with a Landsat image of the area in which your school is located for each group of three to four students. In their Design Journal or Design Folio, have them note the differences (e.g., no elevations given on image, image shows vegetation and covers more area) and the similarities (e.g., general landscape features, roads, buildings, and bird's-eye view).

Also have the students describe possible uses that a satellite image would provide for studying the planet (weather forecasting, forest management, etc.).

Have them locate the school on both the map and the image. Instruct them to measure the area of the school grounds or the building. Expect them to have difficulty in doing this due to the scale. This problem should lead you and the group into a discussion of *spatial resolution*, the size of the smallest object that can be observed in an image.

Pass out the Introductory Packet from this module guide. Explain that the challenge is for the class to make a map that shows more detail than the topographic map but has a higher resolution than the satellite image.

INTRODUCTORY PACKET

Overview of the Module and Design Challenge

HERE'S WHAT YOU WILL DO

In the NYSCATE module ***Remote Sensing***, you will typically work in a group to:

- Discuss the Design Challenge so that everyone in the class and in your working group understands what the task requires.
- Explore the issues involved in producing a composite photograph and overlay map of your school property for someone else to use. Include why the information must be clear and understandable, and why it should stand on its own.
- Share with each other what you believe are the priorities and special features that the photograph and map must have.
- Design a strategy for taking photographs including the techniques, tools, and materials you will use to produce the composite photograph and map.
- Take the photographs using a balloon and camera system, in keeping with the strategy decided on by the class.
- Gather ideas in your group and then, in a class discussion, decide on a method for producing the composite photograph and map.
- Design a composite photograph and overlay map, and assemble the products into a package for others to use.
- Present your products to the class and review the products of others.
- Note the decisions and design processes that you used in completing the challenge, including what Knowledge and Skill Builders (KSBs) were used by the group, and the teacher, to produce your composite

Discuss the student requirements (see Introductory Packet) after determining whether you will expect the students to use the Design Journal or Design Folio. These documents are provided in the NYSCATE *Pedagogical Framework* along with guidelines for the Design Report and group presentation.

The challenge. Redirect students to the Introductory Packet (p. 34). As you go through the packet's contents together, present the challenge in a manner that will motivate them. Discuss briefly the Here's What You Will Do, Problem Context, and Materials Needed sections.

Periods 2–3: ***Organizing for informed design***

Informed design. (See the NYSCATE *Pedagogical Framework*, pp. 7–9, for a more detailed discussion on focusing students on the process of informed design.) Elicit from students what they know about good design and who engages in design. Ask for examples of good design and poor design.

Tell the class that completing a series of KSBs will help prepare them for addressing the Design Challenge they face. Then introduce the first KSB and provide time to read it.

The information in KSB T1: The Informed Design Cycle should be referred to often as groups work on the Design Challenge. The informed design loop can be particularly useful to the students as they chart their progress using a Design Journal or Design Folio. Like professional engineers, they will find themselves using the loop in an iterative way rather than in a linear way.

Discuss the informed design cycle and stress that although design is normally informed by the designer's

KSB T1: The Informed Design Cycle

A method is shown (see informed design loop below) to achieve informed technological design. The cycle includes several phases. In this model, the phases together are referred to as the design cycle. The model involves repeatable phases that engage you in the design process.

You are to work in a manner similar to that of adult professionals who do engineering design for a living. Engineers and other designers rarely follow these phases in order. Instead, they move back and forth from one phase to another as needed. You also are not expected to go through the phases in the same order each time you design something. Additionally, some decisions are made without complete knowledge and as a result phases must be revisited later on. The designer arrives at solutions, monitoring performance against desired results and making changes as needed. Usually, following design criteria leads to trade-offs taking place. Seldom is true perfection obtained.

Further information on the phases of the informed design cycle follows:

- *Clarify design specifications and constraints.* Describe the problem clearly and fully, noting constraints and specifications. Constraints are limits imposed upon the solution. Specifications are the performance requirements the solution must meet.
- *Research and investigate the problem*. Search for and discuss solutions that presently exist to solve this or similar problems. Identify problems, issues, and questions that relate to addressing this Design Challenge.
- *Generate alternative designs*. Don't stop when you have one solution that might work. Continue by approaching the challenge in new ways. Describe the alternative solutions you develop.
- *Choose and justify optimal design.* Defend your selection of an alternative solution. Why is it the optimal choice? Use engineering, mathematical, and

current knowledge, completion typically requires access to new knowledge. Discuss the need to research what solutions exist to solve this Design Challenge, and how reaching an optimal design solution requires meeting specifications, working within constraints, and making trade-offs.

Tell the class that completing a series of KSBs will help them feel comfortable addressing the Design Challenge.

Student requirements. Discuss the student requirements (Introductory Packet, p. 34) after determining whether the students will use the Design Journal or the Design Folio. (Descriptions of these documents are provided in the NYSCATE *Pedagogical Framework* [pp. 15–16], along with guidelines for the Design Report and the group presentation [pp. 26–28].) Help students see that either of these devices allows them to document progress as they complete literature searches, factor investigations, and Knowledge and Skill Builders (KSBs).

Describe the requirement that each student submit a Design Report and each group make a class presentation at the conclusion of the module. Explain that the report and the presentation will be based on information recorded in the Design Journal or Design Folio. Alert students that the presentations should be multimedia and should detail their design process and results. Help them see that such a presentation summarizes work completed in researching, collecting, and analyzing data; developing models; improving designs; and making refinements. Describe multiple forms of media (e.g., presentation software, color overheads, videos, computer animation) that they might use to enhance their presentations. Assure them that when classmates ask probing questions and challenge group findings at the end of presentations, they are mirroring proceedings that are common at science conferences.

Assigning groups. Talk with some of the students ahead of time to see how experienced they are at working in cooperative groups. Assign students to small working groups (typically three to five students per group) to work on the challenge (see “Forming and Facilitating Design Teams” in the *Pedagogical Framework*, pp. 11–14). Monitor group participation and look for group dynamics problems throughout the module.

Exploring Remote Sensing

Periods 3–4: ***Coordinating student progress***

Students explore the problem.

Through laboratory and library research, and through KSBs, students develop a knowledge and skill base for working on the Design Challenge. The students are likely to flounder unless they obtain background information on remote sensing and its history.

Using the World Wide Web, students should complete KSB T2: Remote Sensing Web Search. This activity will take them on a scavenger hunt on the Web.

Answer Key for Remote Sensing Web Search

2. Teledet SRL.
3. NASDA
4. EOS: Global observation of Earth using polar orbiting and low-inclination satellites
5. Senior Project Scientist, Dr. Michael King, works with EOS personnel at NASA to make sure that scientific and related programmatic requirements were properly implemented.
6. Jeff Allen and Ronald Birk
7. GIS and other related fields
8. Training and development for professionals in GIS and RS
9. Other RS lists and resources
10. Department of Geography at Central Michigan University
11. Online database for jobs in RS/GIS, geoscientists, oceanographers, etc.
12. Definition of RS: "Science of acquiring information about the Earth's surface without actually being in contact with it. This is done by sensing and recording reflected or emitted energy, and processing, analyzing and applying that information."
13. Seven elements of RS: Energy Source; Radiation and the Atmosphere; Interaction with the Target; Recording of Energy by the Sensor; Transmission; Reception and Processing; Interpretation and Analysis; Application

KSB T2: Remote Sensing Web Search

To complete this activity, you will need a computer having access to the World Wide Web and this sheet.

Name ______________________ Period ______

Remote Sensing Web Search

Your starting point for this activity is www.vtt.fi/aut/rs/virtual/.

1. Welcome to the WWW Virtual Library: Remote Sensing. This page will be the home page for this activity. Answer the following questions on the basis of the information found at this website.
2. What South American organization provides remote sensing for agricultural and forestry applications? ______________________
3. What is the acronym for the National Space Development Agency of Japan? __________
4. EOS is part of NASA's Earth Science Enterprise. What is the purpose of EOS?
   ____
5. Who is the Senior Project Specialist for EOS and what is that person's responsibility?
   ____

Go back to the home page to answer the following questions:

6. Locate the journal *Earth Observation* and click on "August 2000." Who wrote the article "Flood Mapping Specifications"?
   ____

Go back to the home page.

7. What is the heading for finding information on GIS?
   ____
8. What does PRONET provide?
   ____

Go back to the home page.

9. You want to find more resources on remote sensing. Where would you go? ______________________________________
10. Where could you take a Digital Remote Sensing course online?
    ____
11. What is Earthworks?
    ____
12. Go to "Fundamentals of Remote Sensing Tutorial." What is the definition of *remote sensing*?
    ____
13. On the basis of this tutorial, what are the seven elements that comprise the remote sensing process? List them below.

Introduce KSB M1: Power Viewers. This activity shows the relationship between the apparent size of an object and the distance from the viewer; powers of 10 are used to indicate this relationship.

In preparation for Power Viewers:

Make the Power Viewers. Copy the student worksheet onto transparencies. Each transparency will have three grids and can be used to make three Power Viewers. Cut out the grids, leaving a border around each one. Make frames from poster board.

Copy the student worksheets. Copy two for each student. One will be used for prediction and one for observation.

Set up the viewing area. Find a location with an unobstructed view at least 100 m long. (This will probably be outside.) Ideally, the area will be wide enough for half the students to line up facing the other half of the students. If not, students can take turns making their observations. Mark a starting line. Measure and mark 3 lines: 1 m from the starting line, 10 m from the starting line, and 100 m from the starting line. Locate landmarks that are approximately 1,000 m from the starting line to be referenced later during the discussion.

Then **introduce the activity.** Hold up a Power Viewer and explain to the students that they will use the viewer to observe another student from three different distances: 1 m, 10 m, and 100 m.

Make predictions. Give the students one worksheet each and have them circle "prediction" at the top of the page. Have them draw a stick figure or outline showing how tall they think a student will appear when observed through the grid from each of the three distances: 1 m, 10 m, and 100 m.

Get ready for observations. Give each pair of students a viewer and a clipboard.

Give each student a second worksheet along with instructions to circle "observation" at the top. Emphasize the importance of keeping the viewer the same distance from the eyes for each observation. Remind students to draw what they see through the grid.

Make observations. Have the students move to the viewing area, with half of the students standing at the starting line facing the 1 m line. Instruct the other half of the students to stand at the 1 m line facing the starting line.

KSB M1: Power Viewers

Permission to adapt the following materials has been granted by The National Air and Space Museum, Smithsonian Institution.

You are to investigate the relationship between the apparent size of an object and the distance from which that object is viewed.

How does the apparent size of an object change as we move away from it? In this KSB you predict how tall a fellow student will appear when viewed through a transparent grid at three different distances: 1 m, 10 m, and 100 m. You make observations at each of these distances using the transparent grid. Then you compare predictions to each other's observations and discuss how changing distances affects the apparent size of an object.

Materials

For each student team:
- Power Viewer
- Clipboard or a heavy piece of cardboard with a clip

For the Power Viewers:
- One transparency sheet for every three Power Viewers
- Poster board or file folders (12 cm x 14 cm for each frame)
- Utility knife or scissors to cut frames
- Cellophane tape

For each student:
- Two copies of the "Power Viewers" student worksheet

A student uses the Power Viewer

During the activity, **monitor** student observations and encourage them to keep the Power Viewer the same distance from their eyes and to draw what they actually see through the grid. Have partners stand next to each other on the same line, so they can share a clipboard and viewer. Have students draw an outline or stick figure showing the apparent height of the student standing opposite them 1 m away. When everyone has finished, have the students standing at the 1 m line move to the 10 m line, and again, have all students record their observations. Repeat for 100 m.
Compare the predictions and observations. Have the students compare their predictions to their observations.

An acceptable student response for #2 in the Develop Your Understanding section of KSB M1 would be "As you move farther from an object, the object appears to get smaller. When you move 10 times farther away, the object appears to be about 1/10th its previous size."

Next, have the students complete KSB M2: Get the Picture. In this KSB, students reproduce an unseen picture by coloring in grids while their partner reads the coordinates. This task will introduce them to the pixel concept. Post completed pictures in the room.

As **preparation** for KSB M2: Get the Picture:

Make the folders. Copy the "Pixel Grid" onto transparencies. Copy the sample picture onto regular paper. Place one transparent Pixel Grid and one sample picture into each folder. Label the folder "transmitter." These folders can be reused for other classes.

Copy the Pixel Grid. Make paper copies of the Pixel Grid for the receivers. The paper grids cannot be reused, so copy one for each pair of students in each class.

Make a transparency. Copy the "Effects of Changing Pixel Size" on a transparency or chart paper for class discussion.

KSB M2: Get the Picture

Permission to adapt the following materials has been granted by The National Air and Space Museum, Smithsonian Institution.

In this KSB, you simulate how instruments aboard spacecraft collect and transmit digital images to Earth-based computers. Have you ever wondered how technicians get signals from spacecraft? You will learn how instruments on spacecraft measure the amount of light (electromagnetic radiation) reflected or emitted by objects in space and how this information is transmitted to Earth.

Working in pairs, one of you places a transparent grid over a picture to simulate pixels (picture elements). A gray scale is used to assign a brightness value to each pixel and coordinates to indicate location. You will then transmit the data to another student who represents an Earth-based computer that converts the data to an image.

Materials

For each pair of students:

- Transparent Pixel Grid
- Paper Pixel Grid
- Sample picture
- Folder to conceal sample picture
- Pencil for shading

For the class:

- Transparency: "Effects of Changing Pixel Size"

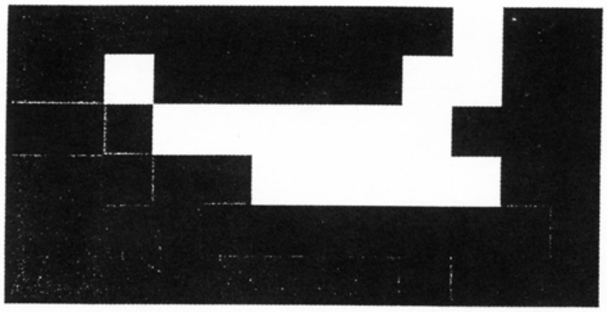
Develop your understanding

1. Describe what a pixel is.
2. Describe a place(s) where you have seen or heard about pixels.
3. We saw how smaller pixels improved the images. What else could be done to improve the images?

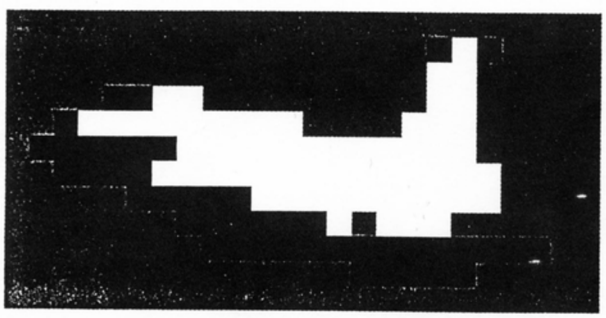
OUTER SPACE

Effects of Changing Pixel Size

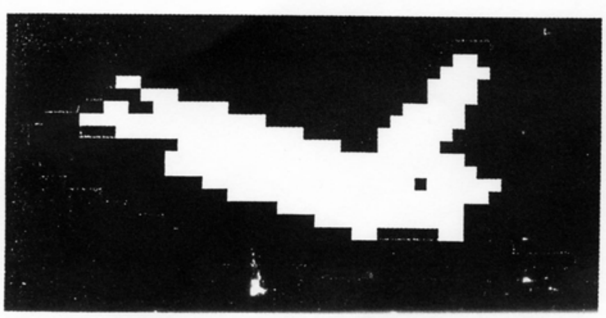
Student Overhead

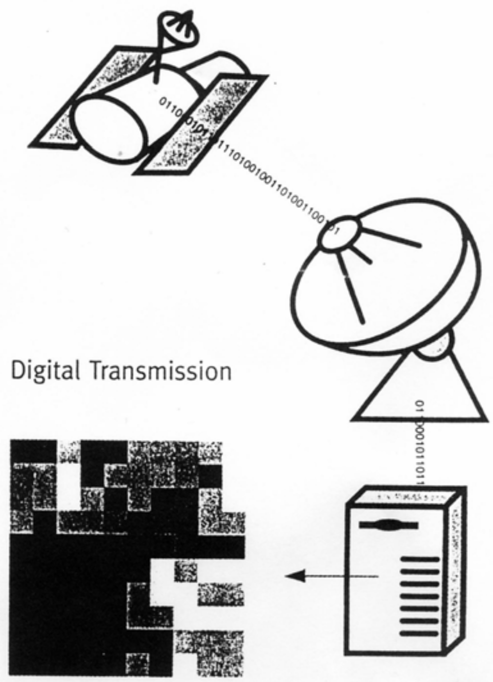


12 x 6 grid



24 x 12 grid





Digital Transmission

Then **introduce this KSB.** Ask students to explain how they think technicians get images from spacecraft that do not return to Earth. Let students know that they will simulate how instruments aboard spacecraft collect and transmit images to Earth.

Explain the simulation. Instruments aboard spacecraft divide an image into tiny squares called pixels (picture elements). Each pixel is assigned a number that represents the brightness of that square. In this simulation the squares on the grid represent pixels. Show the Pixel Grid to the students and explain that the student transmitter will place the transparent grid on the sample picture. (Do not show the sample picture provided below.)

Student Worksheet

Pixel Grid

OUTER SPACE

Name ______________________________

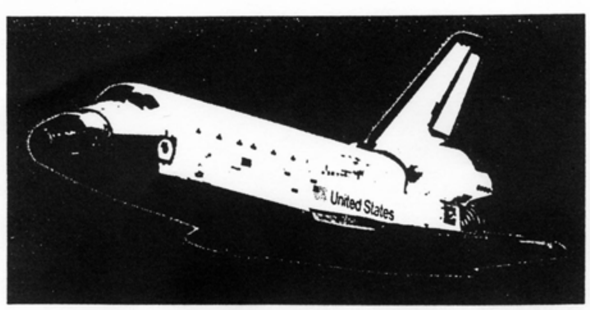
Pixel Grid

	A	B	C	D	E	F	G	H	I	J	K	L
1												
2												
3												
4												
5												
6												

0 1 2

Gray Scale

Sample Picture



The transmitter states the location (e.g., A 1) and assigns a brightness value from the gray scale (black is 0, gray is 1, and white is 2). Each pixel can have only one value, so if a square covers light and dark areas, the transmitter estimates total brightness and assigns one number from the gray scale. The receiver shades the square on the paper grid according to the gray at the bottom. The transmitter begins in the upper-left-hand corner (A1) and reads from left to right for each row.

Complete the simulation. Assign students to work in teams of two. One student will be the transmitter; the other student will be the receiver. Give a folder with the sample picture and transparent grid to each transmitter with directions not to show the sample picture to the receiving partner. Give a paper grid to each receiver. If you have an odd number of students, one transmitter can work with more than one receiver. Have students complete the transmission simulation.

Close the activity. Have students compare the sample picture to the image transmitted. Ask the students what could be done to improve the quality of the image. Show the transparency "Effects of Changing Pixel Size." Ask students what would happen if the squares kept getting smaller.

Teachers who have students who are studying Earth science or who wish to become familiar with the use of remote sensing in science should assign the optional activities for KSB S1: Weather, and KSB S2: Cataclysmic Events. Both of these KSBs engage the students in the study of satellite photographs. These relatively brief experiences may help the students to appreciate how surprisingly useful the products of satellite remote sensing can be in addressing scientific questions.

Part I of the Design Challenge: Balloon Aerial Photography

Periods 5–7: ***Coordinating student progress***

Students develop and refine the photographing strategy (3 periods).

This segment of the module, especially the precutting of the camera carrier vessel, might be completed with the assistance of the technology education teacher(s). The students should be documenting the activities in their journal or folio in keeping with the teacher's instructions. Prior to addressing Part I of the challenge (developing a picture-taking strategy), the following KSBs must be completed and the results documented in the folio or journal.

> **KSB M3: The Camera Distance and Field of View**
> Design and carry out an investigation to answer the following question: For your camera, how does the width of view captured by the camera change as the distance to the camera changes?
> Materials: A camera with film, metersticks, graph paper, access to film developing
> **Develop your understanding**
> 1. On the basis of the results of your investigation, calculate what the width of view would be for your camera if a picture were taken at 100, 200, and 300 meters.
>
> 2. Determine how many pictures will have to be taken to cover the school property at these altitudes (100, 200, and 300 meters). Be sure to have the photos overlap sufficiently. You will probably not be able to control very well the exact location at which the picture is

- In KSB M3: The Camera Distance and Field of View, students design and carry out a small research investigation to understand how distance from a camera affects the size of area captured on film. They then calculate width of field for pictures taken at various distances, and determine how many pictures will have to be taken to capture the whole school property on film at various distances.
- If students are not familiar with map scales, completing the optional KSB M4: Conversions may help them to understand the mathematical relationship between map and ground distances expressed by the map scale.
- In KSB T3: Construction of Aerial Camera Support, students assemble the launch system. The plans and list of needed materials for the system are included in the KSB. Technology education teachers using this module might very well choose to make

> **KSB T3: Construction of Aerial Camera Support**
> **Aerial Camera Material List (for one camera)**
> 8 - round screw eye hooks ½" long (package)
> 5 - machine screws 8/32" x 1½" long (package)
> 1 - package 8/32" machine screws
> 1 - package 8/32" flat washers
> 1 - package rubber bands
> 1 - package jumbo paper clips
> 1 - package 2" finishing nails
> 1 - package lightweight wire picture cord
> 1 - roll 30 – 50lb test braided Dacron fishing line
> 4 - small fishing line snap swivels (package)
> 1 - ½" x ½" x 24" balsawood or light wood stock
> 2 - 1½" x ½" x ¼" balsawood or light wood stock
> 8 - ¾" x 1/8" square balsawood or light wood stock
> 2 - 3" x 2" x ¼" balsawood or light wood stock
> 1 - egg timer (with swivel handle)
> 1 - disposable camera
> 1 - 8' weather balloon
> 1 - 4' x 8' x ½" sheet of dense foam insulation
> 1 - cylinder helium
>
> Assorted tools: X-acto knife, drill bits and drill, hot glue and hot glue gun, hacksaw, and other items as specified by your teacher.

design of the launch system their focus.
- In KSB T4: GPS Explorations, students learn how to determine the GPS of individual locations for reference. This activity is optional as students can complete the challenge without use of GPS techniques.

Periods 8–10: ***Coordinating student progress***

Students develop a picture-taking strategy (1 period). After completing whichever of the above KSBs are assigned, have the class turn to Part I of the challenge, the picture-taking strategy. Facilitate a class discussion in which the class considers several questions: How many pictures will be taken? Where? By whom? Will each group take pictures from all locations? Will the class work together to take the pictures at each location? When will the pictures be taken?

Students test the strategy (1 period). Using the strategy, students should take trial pictures at all locations to verify proper coverage. In a class discussion that takes place after the film is developed, students should make adjustments needed for spacing or height to complete the Design Challenge. If your school has a photography club, members may be interested in processing the film.

Period 11: ***Coordinating student progress***

Students take their photographs. The students will launch their own balloon and camera devices and obtain pictures based on the results of the trial. Help only when necessary to ensure that the class is reasonably successful. The success of the map-building challenge is dependent on having a set of usable, overlapping photographs that cover the school property.

Part II of the Design Challenge: Designing the Composite Photograph and Overlay Map

Periods 12–15: ***Coordinating student progress***

After the film has been developed, the individual groups should get together to assemble the final product, a composite aerial photograph of the designated property. To help everyone become involved, make sufficient copies of the photos so that each group has a complete set with which to work. Copies can be made photographically, or by using a good copy machine, or by scanning them into a computer's photo-editing program and printing copies on a printer.

There are many ways to form the mosaic. The class should discuss various alternatives and decide on a single method that all groups will carry out. Facilitate this discussion but do not preempt students' inventiveness. If you feel they are moving toward an impractical method, ask them how they plan to overcome the potential difficulties you see. Keep in mind that this Design Challenge is intended for students to address.

Some design and display strategies that students might come up with include:

If the scales of individual photographs match reasonably well, students might align photos physically, cutting and pasting them together to form a composite.

If scales do not align well, they might use a copy machine first to alter magnification and bring the scales into alignment.

Original photos might be scanned into a computer's photo-editing program, such as Adobe's PhotoDelux or PhotoShop, which permits resizing and the making of photo composites.

Students might choose to print a computer-generated composite on standard-size paper and then use a copy machine to copy it to an overhead transparency for group display.

A cut-and-pasted composite might be photographed and enlarged as a transparent positive for overhead display, or it might be scanned into a computer and printed as mentioned above.

Part III of the Design Challenge: Students Develop the Overlay Map of the School Property

(Optional) Period 16: ***Coordinating student progress***

Continuing to work in their design teams, students should develop the overlay map as specified in the challenge.

Periods 17-20: ***Unite the class in thinking about what has been accomplished.***

Students record information and develop reports. Continue to work as a facilitator as design teams record their progress and results. Monitor progress as students structure and write the Design Reports that are to be submitted by each individual student. The Design Report should include a discussion of possible redesigns with justifications for the redesign decisions. Provide students with the Design Report guidelines from the NYSCATE *Pedagogical Framework*, pp. 26–27.

Students present the completed work to the class. The work that students complete in groups should be presented to the whole class to enhance learning and help groups reach closure. Encourage them to do quality work, sharpen their communication skills, and improve their skills in reviewing the work of others. The composite photograph and map, and the description of the methods used to develop them, should be presented by each group to the class in an appropriate public format (e.g., a poster session or formal live presentation).

If many of the techniques used were decided upon in class discussions and therefore do not vary much, a session in which each group displays its work as one or more posters might be more appropriate. This method also consumes less class time. The poster session could include the work of one or more classes. Each team member could take a turn staying with the group's display to answer questions while the remaining group members browse and review the displays of other groups. To stay focused while browsing, reviewers might complete feedback or rating forms to be given to presenters afterward.

If it is decided that each group will give a presentation to the whole class, discuss with the class what is considered proper and expected deportment during the presentations. Address the need to use the most appropriate media to help the audience understand the group's work. Review and distribute the presentation guidelines from the NYSCATE *Pedagogical Framework.* During the groups' presentations to the class, encourage students (through example) to ask appropriate questions and provide constructive feedback.

Additional Application Activities (Optional)

Make use of the student composite photos:

- Use the photograph to have students prepare maps of the school grounds and surrounding areas, and then have them compare their maps with those from other sources.
- Use the maps and photograph to stimulate proposals for improving the school and its surrounding environment. Students might propose sidewalks; bike paths; a skateboard park; athletic field changes; outdoor tennis, volleyball, or basketball courts; a winter skating or sledding area; improved lighting; an outdoor theater; improved parking; a sound barrier; better traffic control; nature trails; a nature preserve; or a botanical garden.
- Use the completed photograph for teacher-directed scenarios in which students assist the local planning board in the location of parks, malls, recreation areas, or apartment housing. Individual groups would have a copy of the photograph and make recommendations to the planning board on the basis of environmental impacts, zoning laws, etc.
- Use the photo for the study of local watersheds, mining activities, forestry management, natural disaster planning, etc.
- Have students compare the uses they have made or could make of their composite photos with the uses being made of satellite photos by continuing the study of remote sensing of Earth. Why are the uses different? Sources students could consult include:
    - The Smithsonian's "Reflections on Earth – Exploring Planet Earth from Space" activities can be found at www.nasm.edu/ceps/reflect/.
    - The World Wide Web Virtual Library has numerous links to remote sensing sites (www.vtt.fi/aut/rs/virtual/).
    - NASA's Spacelink Series (spacelink.nasa.gov).
    - The GLOBE program (www.globe.gov) has Multispec activities along with a Landsat images quiz.
    - The American Geophysical Union has a journal for teachers and

students entitled *Earth in Space.* The journal reports scientific studies that involve remote sensing.

VII. ADDITIONAL SUPPORT FOR TEACHERS

OVERVIEW OF MODULE CONTENT

A brief description of some of the important concepts featured in this module follows:

Remote sensing is the observation of Earth from a distance, typically through the use of aircraft or satellite systems. Sensors are fixed to these platforms and are able to capture detailed images of Earth. Sensors using the spectral bands in the visible, near infrared, shortwave infrared, and thermal infrared regions of the electromagnetic spectrum are commonly used for satellite remote sensing. For example, the health of an agricultural field can be determined by observing vegetation in the infrared wavelength. Information on soil condition, plant stress, fertility, moisture content, and other parameters can be obtained from appropriate analyses.

Images captured by sensors are transmitted digitally or returned physically to ground controllers. Analysts interpret the captured images and use the information to map land, detect pollution, determine crop yields, understand climatic changes, and address many other issues.

Additional information on the use of remote sensing in Earth science is available at http://www.earth.nasa.gov.

Spectral measurements are taken with satellite sensors consisting of thousands of small detectors that measure the electromagnetic radiation being reflected off Earth's surface. The information obtained by the sensors is converted into digital information and returned to Earth, where computers process the data into an image.

Sensors can be designed to measure reflected energy in the visible, near infrared, shortwave infrared, thermal infrared, and microwave portions of the electromagnetic spectrum. Sensors measuring reflected energy are passive sensors. Active sensor systems such as radar transmit energy to Earth and measure the returned signal.

Image analysis is typically carried out using computers and specialized software. Software designed for this purpose enables the user to view, enhance, and analyze satellite images as well as superimpose other geographical features onto the image. The software can be used to measure distances, accurately mark the position of objects, combine separate images into a continuous mosaic, and even develop a 3-D view of the image.

Mosaics are formed by combining several overlapping images. This is typically done with computer imaging software.

Image types are defined by the sensor system used to capture information. Panchromatic images are obtained from sensors measuring energy reflectance in one portion or band of the electromagnetic spectrum. These become black-and-white images. Multispectral images are obtained from sensors measuring energy reflectance in many bands of the spectrum. Color images are created from this information. Hyperspectral images will be created from sensor systems that measure hundreds of energy levels. Such systems are in development.

Spatial resolution refers to the size of the smallest object that can be observed in an image. As resolution becomes higher, more detail is shown. For example, a 10-meter resolution image can distinguish more objects than a 30-meter resolution image. Generally speaking, a higher resolution image will cost more and require greater digital storage capacity than a lower resolution image.

Global positioning system (GPS) is a satellite-based navigation and positioning system developed by the United States Department of Defense. The system consists of 24 satellites orbiting Earth in precise paths and transmitting radio signals that can be received and interpreted by GPS receivers. The GPS receiver is able to display the user's elevation and location by latitude and longitude. A recent change in the GPS system is the deactivation of GPS selective availability (SA). This change immediately improved basic GPS positioning to an accuracy better than 20 meters.

BUILDING KNOWLEDGE AND SKILL

The challenge your students face involves designing a picture-taking strategy that uses a remote sensing technique, designing a composite map, and designing a map overlay. Many will want to proceed by trial and error alone. To prevent this, you must convince them that they need to find out what they now know as a group and what they will need to know about remote sensing and the process of design in order to complete the challenges in an informed way. The Knowledge and Skill Builders (KSBs) are meant to help students become informed in both of these areas. Refer to the NYSCATE *Pedagogical Framework* for additional information on the informed design process (pp. 10–11).

In KSB M1: Power Viewers, students begin their observations at a distance of 1 meter and move ten times farther away for each subsequent observation.

In KSB M2: Get the Picture, should you need to review coordinate systems with your students, elicit from them how to name a location using a letter and number.

A digital image is composed of pixels (picture elements) that are arranged in rows and columns. Each pixel is assigned a numerical value that represents its relative brightness in the image: the larger the number, the brighter the pixel.

Spacecraft use charge-coupled devices (CCDs) to collect images. A CCD is a computer-run system that measures the amount of light falling on an area. The surface of a CCD is a grid with light-sensitive squares called pixels. The light that falls on each pixel is converted to an electric signal, which is given a numerical value representing the brightness of the light. The Hubble Space Telescope uses four CCDs. Each CCD has a grid consisting of 640,000 pixels for a total of 2,360,000. In the simulation used, the grid has only 72 pixels. The Hubble uses a gray scale that ranges from 0 (black) to 255 (white) for a total of 256 shades. To simplify the simulation, the pixels have only three possible values (0, 1, and 2).

Digital images can be transmitted by radio waves. The numerical values from digital images are converted to a data stream of binary numbers. These are transmitted, via radio signals, to a satellite and then relayed to Earth. Computers on Earth convert this data stream back to the original numbers, which can then be processed into images or spectra.

(Adapted from Space-Based Astronomy: A Teacher's Guide with Activities, NASA.
August 1994)

OTHER RESOURCES

The Kite Alternative to Balloons for Aerial Photography. If using helium-filled balloons is not practical for your situation because of cost or lack of availability, a reasonable alternative is to use kite aerial photography (KAP). To research this possibility, use an Internet search engine such as Google (www.google.com) and type in "kite aerial photography." A number of sites providing information on KAP, kites, and camera box design are listed there.

LEARNING STANDARDS THAT RELATE TO *REMOTE SENSING*

Remote Sensing places major emphasis on the following learning standards:

Learning Standards for Mathematics, Science, and Technology (The University of the State of New York, The State Education Department)

Standard #1 – Analysis, Inquiry, and Design: Mathematical Analysis (MA) - Key Idea #3; Scientific Inquiry (SI) - Key Idea #3; and Engineering Design (ED) - Key Idea #1:

Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.

MA-3. Critical thinking skills are used in the solution of mathematical problems.
SI-3. The observations made while testing proposed explanations, when analyzed using conventional and invented methods, provide new insights into phenomena.
ED-1. Engineering design is an iterative process (involving modeling and optimization), which is used to develop technological solutions to problems within given constraints.

Standard #2 – Information Systems: Key Idea #1:

Students will access, generate, process, and transfer information, using appropriate technologies.

1. Information technology is used to retrieve, process, and communicate information and as a tool to enhance learning.

Standard #3 – Mathematics: Key Idea #5:

Students will understand mathematics and be confident by communicating, reasoning, and applying mathematics in real-world settings, and solving problems through integrated study of number systems, geometry, algebra, data analysis, probability, and trigonometry.

5. Students use measurement in both metric and English measure to provide a major link between the abstractions of mathematics and the real world in order to describe and compare objects and data.

Standard #4 – Science - Physical Setting (PS): Key Idea #1:

Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

PS-1. The Earth and celestial phenomena can be described by principles of relative motion and perspective.

Standard #5 – Technology: Key Ideas #1 & 2:

Students will apply technological knowledge and skills to design, construct, use, and evaluate products and systems to satisfy human and environmental needs.

1. Engineering design is an iterative process involving modeling and optimization used to develop technological solutions to problems within given constraints.
2. Technological tools, materials, and other resources should be selected on the basis of safety, cost, availability, appropriateness, and environmental impact; technological processes change energy, information, and material resources into more useful forms.

Standard #6 – Interconnectedness: Key Ideas #2, 3, 5, & 6:

Students will understand the relationships and common themes that connect mathematics, science, and technology and apply the themes to these and other areas of learning.

2. Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design.
3. The grouping of magnitudes of size, time, frequency, and pressures or other units of measurement into a series of relative order provides a useful way to deal with the immense range and the changes in scale that affect the behavior and

design of systems.
5. Identifying patterns of change is necessary for making predictions about future behavior and conditions.
6. In order to arrive at the best solution that meets criteria within constraints, it is often necessary to make trade-offs.

Standard #7 – Interdisciplinary Problem Solving: Key Ideas #1 & 2:

Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions.

1. The knowledge and skills of MST are used together to make informed decisions and solve problems, especially those relating to issues of science/technology/society, consumer decision making, design, and inquiry into phenomena.
2. Solving interdisciplinary problems involves a variety of skills and strategies, including effective work habits; gathering and processing information; generating and analyzing ideas; making connections among MST themes and presenting results.

Learning Standards for Career Development and Occupational Studies (The University of the State of New York, The State Education Department)

Standard 2 – Integrated Learning
Integrated learning encourages students to use essential academic concepts, facts, and procedures in applications related to life skills and the world of work. This approach allows students to see the usefulness of the concepts they are being asked to learn and to understand their potential application in the world of work.

- Demonstrate the integration and application of academic and occupational skills in their school learning, work, and personal lives.
- Use academic knowledge and skills in an occupational context, and demonstrate the application of these skills by using a variety of communication techniques (e.g., sign language, pictures, videos, reports, and technology).
- Research, interpret, analyze, and evaluate information and experiences as related to academic knowledge.

Standard 3A – Universal Foundation Skills
Basic skills include the ability to read, write, listen, and speak as well as perform arithmetical and mathematical functions.

- Use a combination of techniques to read or listen to complex information and analyze what they hear or read.
- Convey information confidently and coherently in written or oral form.
- Analyze and solve mathematical problems requiring use of multiple computational skills.

Thinking skills lead to problem solving, experimenting, and focused observation and allow the application of knowledge to new and unfamiliar situations.

- Demonstrate the ability to organize and process information and apply skills in new ways.

National Standards for Technological Literacy

Standard 2
Students will develop an understanding of the core concepts of technology.

- Z: Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste.
- AA: Requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development.

ASSESSMENT STRATEGIES FOR *REMOTE SENSING*

Assessment of student design work should consider many factors and focus on the design process as well as the finished product (design solution).

Each component of design-related student activity is represented in preliminary rubrics (scoring guides) found in the NYSCATE *Pedagogical Framework* (pp. 30–34). That set of rubrics is generic to all NYSCATE design activities. However, the rubrics can be tailored to a particular assignment and should be discussed with students in advance so that they are aware of the evaluation criteria.

A sample from the set of rubrics is presented here for the design solution:

The Design Solution

A. An accurate sketch of your final design, as built, was drawn.

4. Drawing was on graph paper to scale with all elements included. Isometric view or multiple views (top, side, and front) were shown.
3. Drawing was on graph paper to scale with all elements included. Drawing showed the design in two dimensions (a flat view).
2. Drawing was on graph paper approximately to scale with most elements included.
1. Drawing was not to scale and important elements were missing.

B. Materials and tools were planned and used appropriately in constructing project.

4. Listed materials and tools are present, as well as a description of how they should be used.
3. Prepared complete list of materials required and tools necessary to fabricate with these materials.

2. List of materials was essentially complete; some tools required were not mentioned.
1. Mentioned only a few materials and no tools.

C. The solution worked. It met the design specifications and constraints.

4. The solution solved the problem statement; this was explained in the write-up along with how the specifications and constraints were addressed and/or how the design was modified to assure their being met.
3. The solution solved the problem statement and the constraints and specifications were met.
2. The solution solved the problem but not all constraints and specifications were met in doing so.
1. The solution did not solve the problem; constraints and specifications were not met.

D. The design was creative.

4. The solution was unique; never or seldom has this design been formulated.
3. The solution was functional, but not unique. Similar solutions were common.
2. The solution was similar to others; it may have been a modification or interpretation of someone else's solution.
1. The solution appears to have been copied from someone else's work.

In addition to your assessment of student design process and products, you should assess the quality of students' Design Journals (or Design Folios), Design Reports, and group presentations to the class. You might include multiple choice, short answer, or extended response questions that provide assessment of design understandings, content knowledge, and technical skill.

VIII.STUDENT HANDOUT SECTION begins on the next page

INTRODUCTORY PACKET
Overview of the Module and Design Challenge

HERE'S WHAT YOU WILL DO

In the NYSCATE module ***Remote Sensing***, you will typically work in a group to:

- Discuss the Design Challenge so that everyone in the class and in your working group understands what the task requires.
- Explore the issues involved in producing a composite photograph and overlay map of your school property for someone else to use. Include why the information must be clear and understandable, and why it should stand on its own.
- Share with each other what you believe are the priorities and special features that the photograph and map must have.
- Design a strategy for taking photographs including the techniques, tools, and materials you will use to produce the composite photograph and map.
- Take the photographs using a balloon and camera system, in keeping with the strategy decided on by the class.
- Gather ideas in your group and then, in a class discussion, decide on a method for producing the composite photograph and map.
- Design a composite photograph and overlay map, and assemble the products into a package for others to use.
- Present your products to the class and review the products of others.
- Note the decisions and design processes that you used in completing the challenge, including what Knowledge and Skill Builders (KSBs) were used by the group, and your teacher, to produce your composite photograph and map.

PROBLEM CONTEXT

Introduction

The planning board of your local government is interested in mapping your community in order to plan for the future. Your school administration has been asked to provide an up-to-date aerial photograph and overlay map of the property on which the school is located and the area immediately surrounding it. Your class has been assigned the project of providing the aerial photograph and developing a labeled transparent overlay map to help interpret the photograph.

Design challenge

You will design a composite aerial photograph and transparent overlay map of your school property and its immediate surroundings. This Design Challenge has three parts:

- Working as a class and using the balloon and camera system provided, you will design a class strategy for taking several photos that together show the entire area of the school property and its immediate surroundings.

- Working in a group, you will use copies of these photos to design a single composite photograph of the property.
- (Optional) Working in your group, you will design a map that can be superimposed on the composite photograph to identify major features of the photo such as buildings, athletic fields, parking lots, and adjoining streets.

Specifications

1) The photo and transparent overlay map of your school property and surrounding area must show a rectangular region at least 200 meters on a side. The photo and map must have a scale indicating the relationship between the distances in meters on the ground and the corresponding distances on the photo and map.
2) The photo and map must show a level of detail much greater than the 30-meter pixel resolution offered by satellite photos. One must at least be able to distinguish objects the size of a car from other objects.
3) (Optional) The map overlay that you produce might show the GPS coordinates of the photo so that the photographed area's precise location on the globe is known. The coordinates should also permit accurate identification of that area on other local maps.
4) The composite photo and map must be two separate items that can be easily transported, stored, and used. They should be in a form that permits their viewing by groups of people; two large posters, overhead transparencies, and computer projections (PowerPoint) are examples of acceptable formats.

Constraints

The composite photo (mosaic) must be developed from separate aerial photographs taken by each of the working groups in your class. These photographs are to be taken using the balloon lift system described in KSB T3: Construction of Aerial Camera Support.

MATERIALS

Your teacher or group may provide materials and tools. Your teacher must approve in advance materials and tools provided by your group.

STUDENT REQUIREMENTS

- You will be expected to maintain a Design Journal or Design Folio in which you will gather and record information as you address the Design Challenge for this module. The information will include literature searches, hands-on research, and completion of the Knowledge and Skill Builders (KSBs). Your teacher will review these documents with you and suggest which of the two methods of recording your progress would be most appropriate for this module.
- You are required to complete a final Design Report for this module that summarizes your work and your findings. You will draw upon information from your Design Journal or Design Folio when composing the Design Report.
- Each group must develop a presentation to summarize the work done in researching, collecting and analyzing data, developing ideas, improving the designs, and suggesting further refinements. You are expected to use multiple forms of media (e.g., presentation software, color overheads, video, computer animation) to enhance your presentations. As part of the presentation, your classmates will have an opportunity to ask probing questions and challenge your group's work.
- You will be assessed on the quality of your work on the MST Knowledge and Skill Builders, Design Journal or Design Folio, Design Report, and group presentation.

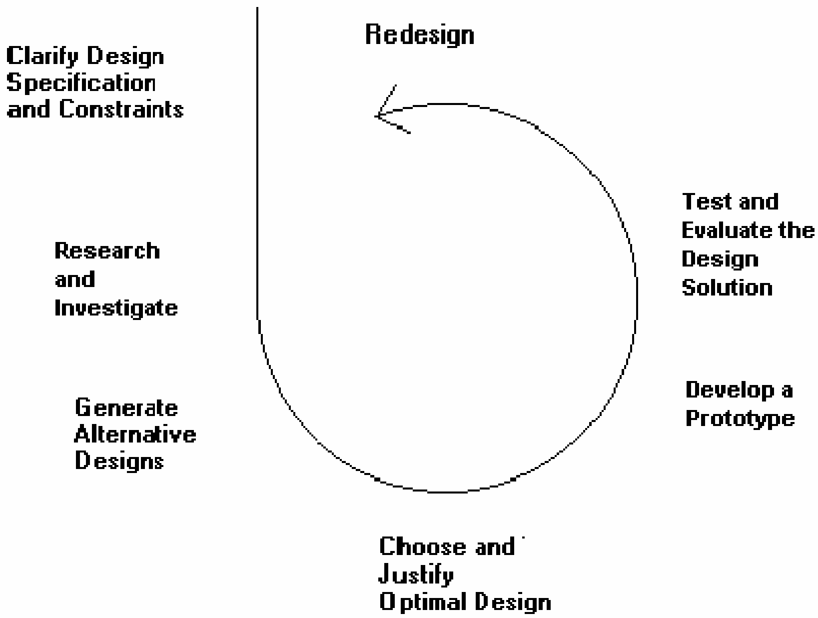
KNOWLEDGE AND SKILL BUILDERS (KSBs)

This listing for these KSBs is by subject. They need not be presented in this order.

- KSB M1: Power Viewers
  Apparent object size and viewing distance
- KSB M2: Get the Picture
  Digital images and pixels
- KSB M3: The Camera Distance and Field of View
- KSB M4: Conversions (Optional)
- KSB S1: Weather (Optional)
- KSB S2: Cataclysmic Events (Optional)
- KSB T1: The Informed Design Cycle
- KSB T2: Remote Sensing Web Search
- KSB T3: Construction of Aerial Camera Support
- KSB T4: GPS Explorations (Optional)

KSB T1: The Informed Design Cycle

A method is shown (see informed design loop below) to achieve informed technological design. The cycle includes several phases. In this model, the phases together are referred to as the design cycle. The model involves repeatable phases that engage you in the design process.



You are to work in a manner similar to that of adult professionals who do engineering design for a living. Engineers and other designers rarely follow these phases in order. Instead, they move back and forth from one phase to another as needed. You also are not expected to go through the phases in the same order each time you design something. Additionally, some decisions are made without complete knowledge and as a result phases must be revisited later on. The designer arrives at solutions, monitoring performance against desired results and making changes as needed. Usually, following design criteria leads to trade-offs taking place. Seldom is true perfection obtained.

Further information on the phases of the informed design cycle follows:

- *Clarify design specifications and constraints.* Describe the problem clearly and fully, noting constraints and specifications. Constraints are limits imposed upon the solution. Specifications are the performance requirements the solution must meet.
- *Research and investigate the problem*. Search for and discuss solutions that presently exist to solve this or similar problems. Identify problems, issues, and

questions that relate to addressing this Design Challenge.

- *Generate alternative designs*. Don't stop when you have one solution that might work. Continue by approaching the challenge in new ways. Describe the alternative solutions you develop.

- *Choose and justify optimal design.* Defend your selection of an alternative solution. Why is it the optimal choice? Use engineering, mathematical, and scientific data, and employ analysis techniques, to justify why the proposed solution is the best one for addressing the design specifications. This chosen alternative will guide your preliminary design.

- *Develop a prototype.* Make a model of the solution. Identify possible modifications that would lead to refinement of the design, and make these modifications.

- *Test and evaluate the design solution*. Develop a test to assess the performance of the design solution. Test the design solution, collect performance data, and analyze the data to show how well the design satisfies the problem constraints and specifications.

- *Redesign the solution with modifications*. In the redesign phase, critically examine your design and note how other students' designs perform to see where improvements can be made. Identify the variables that affect performance and determine which science concepts underlie these variables. Indicate how you will use science concepts and mathematical modeling to further enhance the performance of your design.

Develop your understanding

1. Review the informed design cycle and explain how you might use the phases to guide efforts for your situation. Identify any procedural changes you would add, delete, or change. Defend your recommendation(s).

2. Review the NYSCATE Design Folio (DF) and determine if you would choose to use it or the Design Journal to help you document your work.

3. Pick one example of a product or system that was poorly designed. Explain possible reasons why the manufacturer might have allowed it to be produced with design flaws. Explain consequences (both positive and negative) that might result from a less-than-optimal design.

4. Provide an example of a product or system that you think could benefit from an improved design.

KSB T2: Remote Sensing Web Search

To complete this activity, you will need a computer having access to the World Wide Web and this sheet.

Name ____________________________ Period ______

Remote Sensing Web Search

Your starting point for this activity is www.vtt.fi/aut/rs/virtual/.

1. Welcome to the WWW Virtual Library: Remote Sensing. This page will be the home page for this activity. Answer the following questions on the basis of the information found at this website.
2. What South American organization provides remote sensing for agricultural and forestry applications? ________________________
3. What is the acronym for the National Space Development Agency of Japan? ___________
4. EOS is part of NASA's Earth Science Enterprise. What is the purpose of EOS? ____
5. Who is the Senior Project Specialist for EOS and what is that person's responsibility? ____

Go back to the home page to answer the following questions:

6. Locate the journal *Earth Observation* and click on "August 2000." Who wrote the article "Flood Mapping Specifications"? ____

Go back to the home page.

7. What is the heading for finding information on GIS? ____________________
8. What does PRONET provide? ____

Go back to the home page.

9. You want to find more resources on remote sensing. Where would you go? ____
10. Where could you take a Digital Remote Sensing course online? ____
11. What is Earthworks? ____
12. Go to "Fundamentals of Remote Sensing Tutorial." What is the definition of *remote sensing*? ____
13. On the basis of this tutorial, what are the seven elements that comprise the remote sensing process? List them below.

KSB M1: Power Viewers

Permission to adapt the following materials has been granted by The National Air and Space Museum, Smithsonian Institution.

You are to investigate the relationship between the apparent size of an object and the distance from which that object is viewed.

How does the apparent size of an object change as we move away from it? In this KSB you predict how tall a fellow student will appear when viewed through a transparent grid at three different distances: 1 m, 10 m, and 100 m. You make observations at each of these distances using the transparent grid. Then you compare predictions to each other's observations and discuss how changing distances affects the apparent size of an object.

Materials

For each student team:
- Power Viewer
- Clipboard or a heavy piece of cardboard with a clip

For the Power Viewers:
- One transparency sheet for every three Power Viewers
- Poster board or file folders (12 cm x 14 cm for each frame)
- Utility knife or scissors to cut frames
- Cellophane tape

For each student:
- Two copies of the "Power Viewers" student worksheet

Student Worksheet

Power Viewers

Name______________________

Grid 1 Distance = 10^0 or 1 meter

Circle One: Prediction or Observation

Directions for Prediction: Draw an outline or stick figure that shows how tall a student would appear if observed through a grid at each of the distances.

Directions for Observation: For each grid on the handout, move to the correct viewing line. Look through the transparent grid at another student and draw what you see. Make sure you draw it in the correct grid for that distance. Remember to hold the Power Viewer the same distance from your eyes for each observation.

Grid 2 Distance = 10^1 or 10 meters

Grid 3 Distance = 10^2 or 100 meters

Develop your understanding

1. If your observation differed from your prediction, describe the difference(s).

2. How does the apparent size of an object change as you move farther away?

3. Each time you made an observation you moved 10 times farther away. If you continued, the next observation would be l,000 m away. If your view was not blocked by anything, do you think you could see the student from this distance? How tall do you think the student would appear to be?

Develop your understanding extension

You might want to extend the lesson by following up on these suggestions:

1. You can develop a data chart or graph comparing distance and apparent height.

2. You can use the Power Viewer to do a perspective drawing.

3. If this KSB has piqued your interest, you might want to investigate related astronomy topics, such as angular size and inverse square law.

KSB M2: Get the Picture

Permission to adapt the following materials has been granted by The National Air and Space Museum, Smithsonian Institution.

In this KSB, you simulate how instruments aboard spacecraft collect and transmit digital images to Earth-based computers. Have you ever wondered how technicians get signals from spacecraft? You will learn how instruments on spacecraft measure the amount of light (electromagnetic radiation) reflected or emitted by objects in space and how this information is transmitted to Earth.

Working in pairs, one of you places a transparent grid over a picture to simulate pixels (picture elements). A gray scale is used to assign a brightness value to each pixel and coordinates to indicate location. You will then transmit the data to another student who represents an Earth-based computer that converts the data to an image.

Materials

For each pair of students:
- Transparent Pixel Grid
- Paper Pixel Grid
- Sample picture
- Folder to conceal sample picture
- Pencil for shading

For the class:
- Transparency: "Effects of Changing Pixel Size"

Develop your understanding

1. Describe what a pixel is.

2. Describe a place(s) where you have seen or heard about pixels.

3. We saw how smaller pixels improved the images. What else could be done to improve the images?

Develop your understanding extension

1. Pixels, which look like tiny squares or dots, can often be seen in photographs. Look for pixels in photographs in magazines or newspapers. Examine them closely using a magnifying glass.

2. This KSB demonstrates how simple black-and-white images can be transmitted. Find out how data for color images are collected.

3. Visible light is only one form of electromagnetic radiation. Astronomers examine radio waves, infrared light, ultraviolet light, x-rays, and gamma rays to learn about the universe. Find out how scientists use these other forms of electromagnetic radiation to study the universe.

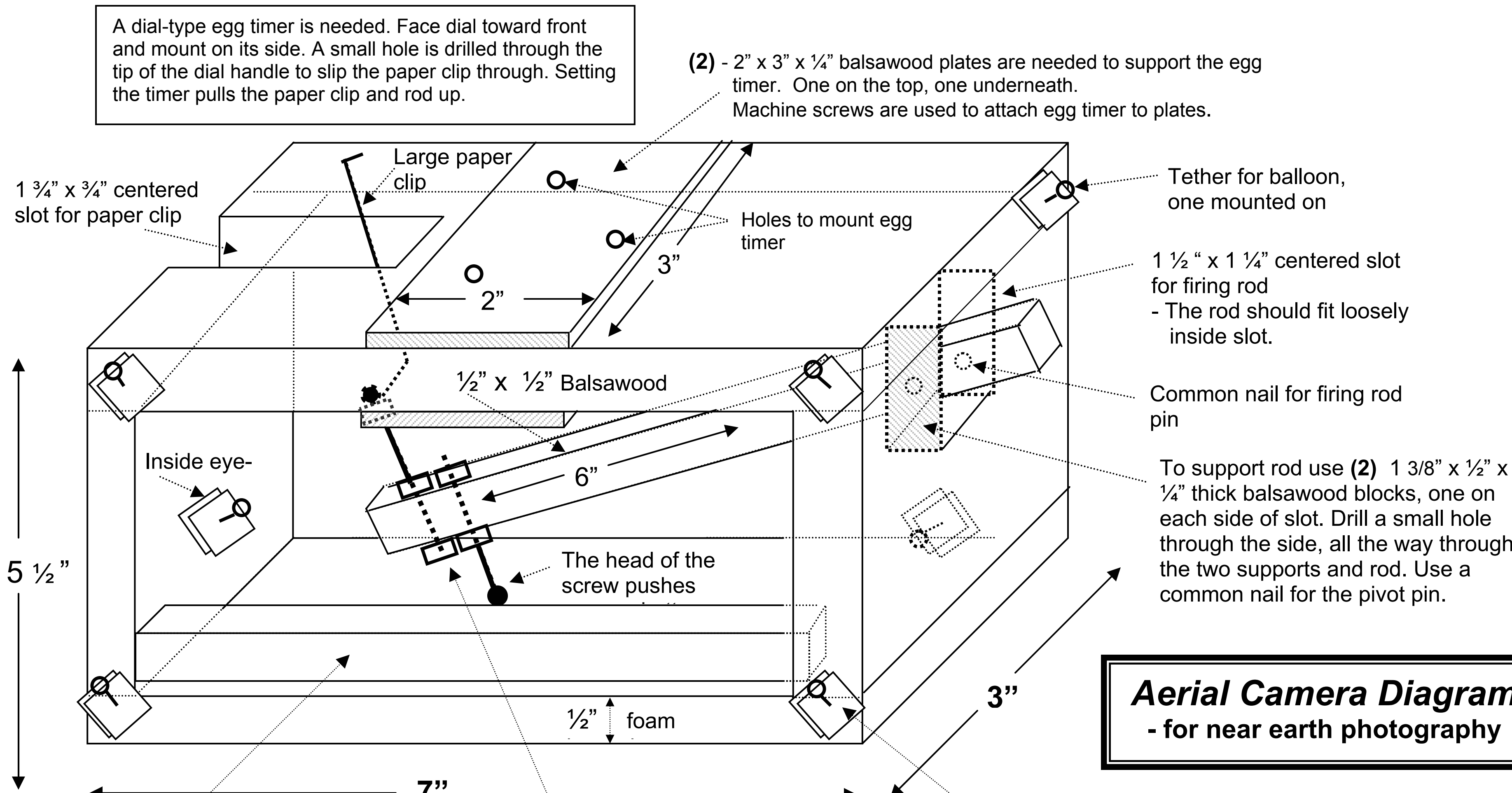
4. The Hubble Space Telescope has several sophisticated instruments for collecting images. Find out more about the instruments present on the Hubble Space Telescope.

KSB T3: Construction of Aerial Camera Support

Aerial Camera Material List (for one camera)

8 - round screw eye hooks ½” long (package)
5 - machine screws 8/32” x 1½” long (package)
1 - package 8/32” machine screws
1 - package 8/32” flat washers
1 - package rubber bands
1 - package jumbo paper clips
1 - package 2” finishing nails
1 - package lightweight wire picture cord
1 - roll 30–50lb test braided Dacron fishing line
4 - small fishing line snap swivels (package)
1 - ½” x ½” x 24” balsawood or light wood stock
2 - 1½” x ½” x ¼” balsawood or light wood stock
8 - ¾” x 1/8” square balsawood or light wood stock
2 - 3” x 2” x ¼” balsawood or light wood stock
1 - egg timer (with swivel handle)
1 - disposable camera
1 - 8’ weather balloon
1 - 4’ x 8’ x ½” sheet of dense foam insulation
1 - cylinder helium

Assorted tools: X-acto knife, drill bits and drill, hot glue and hot glue gun, hacksaw, and other items as specified by your teacher.



Aerial Camera Diagram

- for near earth photography

6" long ½" x ½" dense foam insulation. Helps keep camera inside box. One in front of the camera, the other behind it.

(4 – 5) 8/32" x 1 ½' machine screws
- 2 for the camera firing rod
- 2 – 3 for the top plate

8 – ½" squares light wood or ¼" balsawood with eye hooks screwed in each one
2 – Mounted on the inside of the box with a rubber band stretched between them. This helps to keep camera inside.
4 – Tether box to the ground stakes. Use one on each bottom corner. 30 lb. fishing line is used to attach the eye hooks using fishing snap swivels.
2 – Tether balloon to top of box using either 30 lb. fishing line with snap swivels or picture wire cord.
These should be placed in the very top corners.
The weight of the egg timer will offset the balance of the placement, making the box hang level.

a. The entire camera box is made of ½" dense foam insulation. The disposable camera sits inside the box. Two 6" strips of ½" x ½" dense foam insulation; wedge strips inside the box, one in the front, one in the back. The camera is further protected from falling out, by looping a rubber band around the camera secured between the two inside eye hooks.

b. The dense foam insulation for the box and the balsawood are hot glued together. The mounting hooks are also hot glued onto the camera box.

To make c. To make the camera take a picture, two rubber bands are wrapped underneath the camera box & around the firing rod right between the two screws. This keeps the firing rod always in a firing position. When you set the egg timer, it pulls the paper clip and firing rod up. Then when the egg timer times out it pushes the camera button down, taking a near earth remote picture.

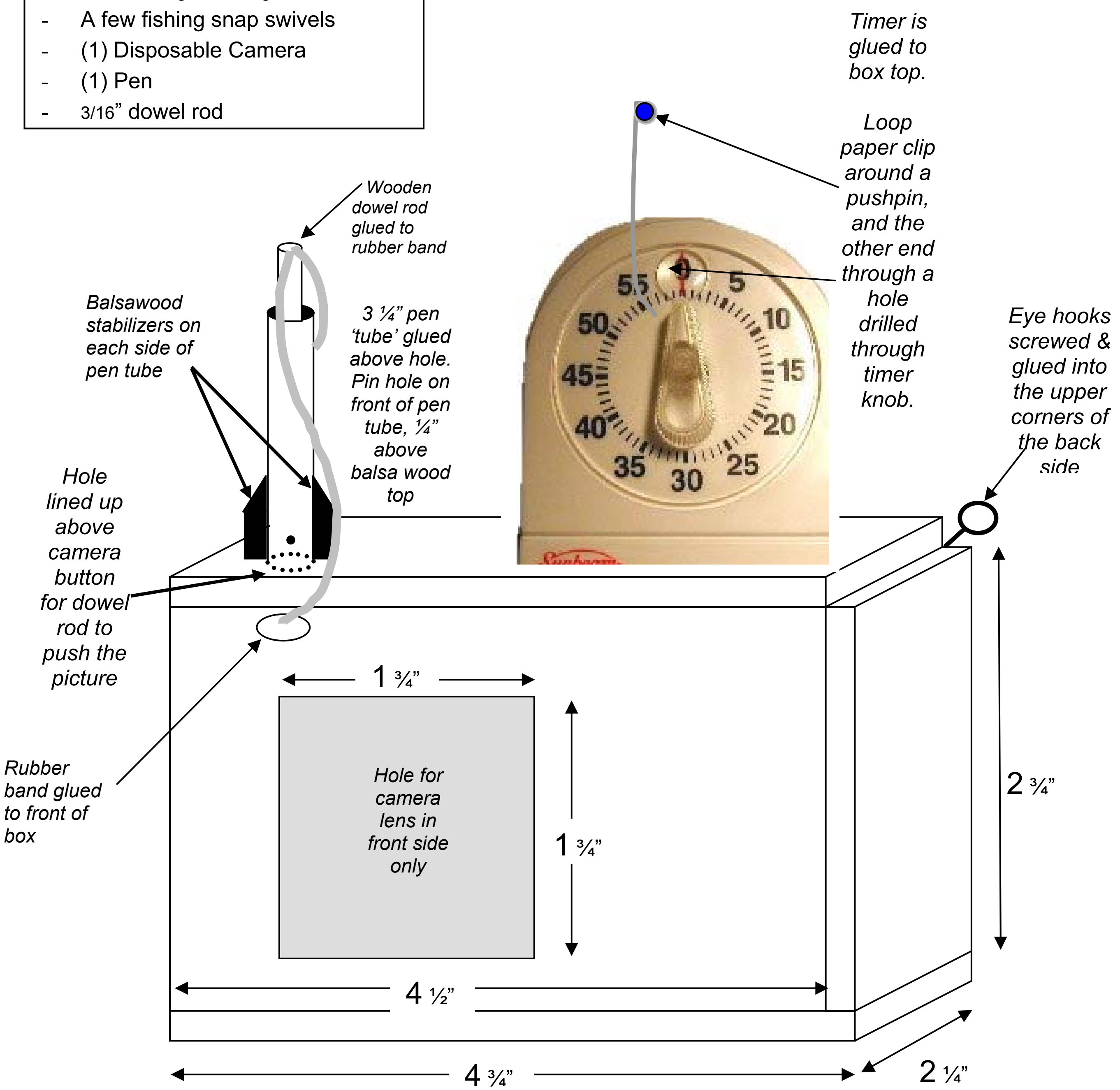
Kite Aerial Photography Alternative; Camera Box and Timer

Materials You Will Need to Take Kite Aerial Photographs

- (1) Sunbeam Kitchen Timer
- (1) Pushpin
- (1) Paper clip
- (2) Eye screws
- Hot Glue Gun or Epoxy
- Rubber bands
- ¼” Balsa Wood (*see plans for size*)
- Kite, String & String Winder
- A few fishing snap swivels
- (1) Disposable Camera
- (1) Pen
- 3/16” dowel rod

Balsawood Box Parts

- (2) 2 ¾” x 4 ½” x ¼” *(front & back)*
- (1) 2 ¼” x 4 ¾” x ¼” *(bottom)*
- (1) 2 ¾” x 2 ¼” x ¼” *(right side)*
- (1) 2 ¼” x 4 ½” x ¼” *(top)*



KSB M3: The Camera Distance and Field of View

Design and carry out an investigation to answer the following question: How does the width of view captured by your camera change as the distance to the camera changes?

Materials: A camera with film, metersticks, graph paper, access to film developing

Develop your understanding

1. On the basis of the results of your investigation, calculate what the width of view would be for your camera if a picture were taken at 100, 200, and 300 meters.

2. Determine how many pictures will have to be taken to cover the school property at these altitudes (100, 200, and 300 meters). Be sure to have the photos overlap sufficiently. You probably will not be able to control very well the exact location at which the picture is taken.

KSB M4: Conversions (Optional)

Using a ruler and the Buenos Aires, Argentina, EarthKAM photograph, determine the scale by dividing the known width of the land the photo covers (80.70 km) by the actual width (in cm) of the photo itself.

Materials
Metric ruler

Develop your understanding

1. Using this scale (km/cm) and a ruler, determine the length of the land and convert to km.

2. How does the calculated length compare to the given length (120.74 km)?

3. Calculate the width of the Rio de la Plata, using the EarthKAM photo and a ruler.

4. Using a map with a given scale of Buenos Aires, determine the width of the Rio de la Plata again.

5. How close are these values?

6. Use the following equation to determine the percent difference (less than 10% difference is very good):

% Difference = (Difference between the two distances)/(Average of the two distances) X 100

KSB S1: Weather (Optional)

Use the website http://www.earthkam.ucsd.edu to study the photos called "Cloud Patterns."

Develop your understanding

1. Postulate a relationship between clouds and water or land, and speculate on possible causes that would help explain the relationship.

2. Using an "If…then…" format, hypothesize the conditions that resulted in the cloud patterns shown.

3. Download live images of clouds from weather sites on the Web, examine them, and comment on them.

KSB S2: Cataclysmic Events (Optional)

Study the EarthKAM photos called “Eruption of Klyuchevskaya Volcano” and “Forest Fires in Sumatra.” Research these events.

Develop your understanding

1. In paragraph form, speculate on the impact of these events on physical and human environments.

KSB T4: GPS Explorations (Optional)

In order to enhance your response to the Design Challenge, you may wish to find your exact location on Earth. One way to accomplish this is through an exploration using a global positioning system (GPS) unit. Information regarding how GPS works can be obtained from various websites or printed materials. A good resource is the GLOBE program's website www.globe.gov. Simply follow the links from the home page to the teacher's guide and click on the GPS "Investigation" found under the chapter's heading.

After your teacher provides information on how and where you will be performing your GPS measurement, download and print the GPS data worksheet found in the GLOBE website (this data sheet is found in the appendix). Your teacher may request that you record measurements for 5 minutes instead of 15. Take the average of the readings and write your results below. Be sure to include them in your folio.

Develop your understanding

Latitude ______________________________

Longitude_____________________________

Compare your readings with those of the rest of your class. About how far apart did you and your classmates have to be to obtain different readings? _______________________________

If you were lost in the woods, describe some ways you might use a GPS unit to find your way out.

You have found an excellent fishing ground located in a large lake. How could you use a GPS unit to locate this spot again?

How effective would a GPS unit be in the following situations? Be sure to explain your answer.

a) nighttime

b) extensive cloud cover

c) dense forest