Exploring Maps — Exploration

Where do we go from here?

The changes in map data collection and display that have occurred in the 20th century are comparable to the change from pedestrian to astronaut. Information that used to be collected little by little from ground observations, can now be collected instantly by satellites hurtling through space, and recorded data can be flashed back to Earth at the speed of light. Remote sensing devices collect data from parts of the ***electromagnetic spectrum*** outside the narrow band of visible light. Gathering gravity, magnetic, and other data takes us beyond the electromagnetic spectrum, beyond our five senses into new territories, all of which can be mapped.

Fundamental to ***remote sensing*** is the practice of photogrammetry (measuring from photographs). Photogrammetry is built on developments in many fields of science and technology. Leonardo da Vinci (1452-1519), was perhaps the first to write about the theories of ***optics***. Italian and German painters and scientists explored the laws of perspective in the early 1500's; these were enlarged upon in a 1759 treatise by Henry Lambert, a French mathematician, who established the geometric foundation of photogrammetry. ***Stereoscopes*** that allowed two photographs to be viewed simultaneously to create a three-dimensional view were first demonstrated in 1851, creating a source of amusement and education. When photography went airborne, first from balloons and later from airplanes, stereoscopic cameras were used to make topographic maps.

Developments in remote sensing are founded on centuries of scientific work. In 1514, Nicholas Copernicus, a Polish priest, suggested (anonymously at first) that the Sun was the center of the solar system, an act of heresy at the time, although it explained the observed motions of the planets. Galileo Galilei's 1609 telescope demonstrated the importance of lenses for magnification. In 1687, Isaac Newton's *Principia Mathematica* was published, establishing the basic laws of motion and gravitation; Newton—and simultaneously Gottfried Wilhelm von Leibnitz, in Germany—developed the calculus, which helped explain the mathematical principles behind elliptical orbits.

Engineering and computational advancements during the industrial revolution and the spread of computers have taken mappers from ships to spaceships. Developments in aeronautics and rocketry in the early 1900's, and in lasers, computers, and satellites in recent decades, have given cartographers powerful new tools. The 1936 Oswald Dome ***mosaic*** of aerial photographs and the 1937 topographic quadrangle of the same area were part of a test of the use of stereoscopic aerial photographs in topographic mapping. Such photogrammetric methods were incorporated into routine topographic map production in the United States before World War II.

Since the late 1960's, map information has been collected, stored, and used in digital form. Satellites carrying remote sensing devices collect long strings of numeric data and transmit the data to receivers on Earth. The data are then reconstructed into digital ***images*** that look like photographs.

Cartographers now can gather spatial data and make maps faster than ever before —within hours—and the accuracy of these maps is excellent. Moreover, ***digital mapping*** enables mapmakers to experiment with a map's basic characteristics (for example, scale or projection), to combine and manipulate map data, to transmit entire maps electronically, and to produce unique maps on demand.

Geographic information systems (GIS) are computer systems that store, manipulate, and display geographic information in ***layers***, sets of data that can be combined with other layers or manipulated and analyzed individually. Results can be seen instantly on a computer screen, in some cases replacing the need for paper maps, freeing the cartographer to experiment with changes in the base map or in the spatial data. In addition to the information content, the map scale, symbols (points, areas, and line styles), colors, type, and overall layout can be changed quickly, greatly speeding the process of mapping.

For all the benefits this technology offers, however, there is greater danger of cartographic abuse now that powerful mapping tools are in inexperienced hands. Different kinds of data are not always collected at the same scales; data analysis is only as objective as the analyst; display techniques control the information emphasized on a map. Now, more than ever before, some maps may mislead.

Positional accuracy of information is being further refined by the Global Positioning System (GPS), the basis of which is a set of satellites that orbit about 12,000 miles above the Earth. Portable GPS receivers on Earth receive the signals from GPS satellites above the horizon and calculate absolute position to accuracies far better than those on existing maps of most of the globe. The process is basic triangulation, but the new tools provide much greater precision.

Mapping technologies are being used in many new applications. Biological researchers are exploring the molecular structure of DNA ("mapping the genome"), geophysicists are mapping the structure of the Earth's core, and oceanographers are mapping the ocean floor. Computer games have various imaginary "lands" or levels where rules, hazards, and rewards change. Computerization now challenges reality with "virtual reality," artificial environments that simulate special situations, which may be useful in training and entertainment.

Mapping techniques are being used also in the realm of ideas. For example, relationships between ideas can be shown using what are called ***concept maps***. Starting from a general or "central" idea, related ideas can be connected, building a web around the main concept. This is not a map by any traditional definition, but the tools and techniques of cartography are employed to produce it, and in some ways it resembles a map. Indeed, our traditional definition of a map is strained when we consider songs of aboriginal storytellers as maps. This reinforces our recognition that maps are many things to many people, and mapping transcends cultures and the ages.

USGS
science for a changing world

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Activity 1: Mapping the Third Dimension

Make a stereoscope. Great advances in mapping in the 20th century were based on the three-dimensional image visible in the stereoscope. In this activity, students work in pairs to construct a simple stereoscope. A pair of stereo photographs is included to use to view a three-dimensional image.

Time:

One 50-minute period for step 1.

30 minutes for remainder of the activity.

Materials for each pair of students:

- One cardboard box (an empty copier box works nicely)
- Knife for cutting the box
- Two locker mirrors (durable, light weight, about 4 by 5 inches)
- Ruler
- Transparent Tape
- Overlapping (stereo) aerial photos (enclosed)

Procedures:

1. Make the stereoscope as follows.

a. Remove the top of the box, leaving the box at least six inches deep.

b. Cut the box in half along the longer dimension (see illustration A) and set one half aside.

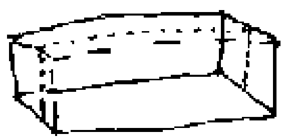


Illustration A

c. Place the half of the box (let's call this the "frame") in front of you so that you are looking into it. Along the back and front edges of the bottom panel, measure half the distance between the left (L) and right (R) end panels. Mark these points C1 and C2 and connect them with a line (see illustration B.) Measure the height of the back panel of the frame (H). Set the frame aside temporarily.

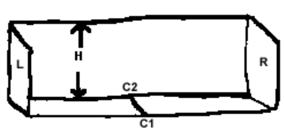
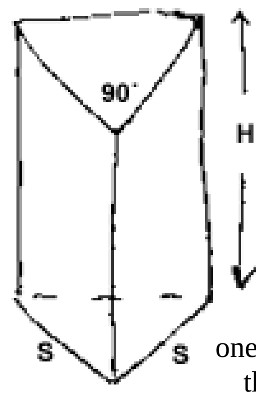


Illustration B

d. Using another piece of the original box, cut a prism-shaped piece that has a 90-degree angle (see illustration C). The two sides (S) of the prism that meet at the 90-degree angle must be the same size, one inch wider than the locker mirrors. The long dimension of the prism need not be longer than the value H.



S=S$4"=w of locker mirror
Illustration C

e. Attach the prism to the frame (see illustration D). Orient the prism so that the edge with the 90-degree angle is on the center line (C1-C2) and is pointed at the open side of the frame. The sides of the prism should be against the back panel of the frame, and the distance (D) between the sides of the prism and the end panels should be equal.

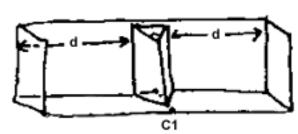


Illustration D

f. Tape the mirrors to the prism, resting them on the bottom panel of the frame, as shown in illustration E.

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Mirrors should meet at the 90-degree angle. This

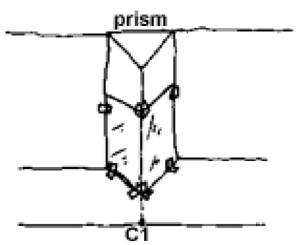

Illustration E

completes the stereoscope.

2. Using paper clips, attach the enclosed stereo photographs to the ends of the box, being careful to position them so that the right eye sees the area of overlap in the right mirror and the left eye sees it in the left mirror.

3. Position the stereoscope so that both photographs are illuminated equally.

4. Look straight at the near edge of the mirrors from about a foot away (see illustration F). Tips for seeing the three-dimensional image: As you look for the stereoimage, try closing first one

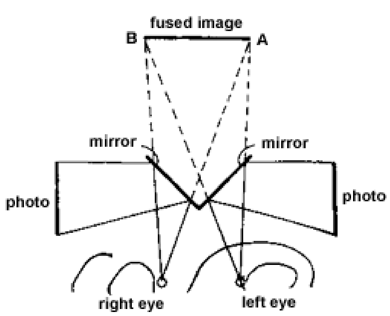

Illustration F

eye and then the other. Choose a distinctive feature and find it on both photographs. As you look, keep one image fixed and move the other image slightly to make the images of a distinctive feature on the two photographs come together. The three-dimensional image of the whole scene may suddenly appear (and perhaps, disappear). Once you see the stereoimage, it is generally easier to see it again.

5. As a class, discuss how your brain constructs a three-dimensional from the two, two-dimensional air photos. Photographs are taken sequentially along a flightline so that adjacent photographs overlap by about 60 percent. The left photo shows the perspective from the left camera station, and the right photo shows the perspective from the right camera station. Thus, your left eye sees the image from a different perspective from the right eye. The brain fuses the two images so that you see the entire area of overlap in three dimensions.

6. In this exercise, the three-dimensional image in your brain exaggerates the vertical relief; the slopes look steeper and buildings look taller on the stereo image than they are. This vertical exaggeration is a function of the geometry of the camera and the altitude of the camera when the photographs were taken. Vertical exaggeration, which can be useful in topographic mapping, can be quantified (or even eliminated) by photogrammetric mapping instruments. Judging by the vertical relief in the stereo image you see, sketch a topographic map of the area of overlap; select a contour interval and make the map at the same size as the stereo image.

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Activity 2: The Landscape of a Novel

As an individual or class exercise, use the geographic information in a book and map the places described. The book can be fiction or non-fiction, but should not be too long or involved. This activity develops the ability to collect data, envision spatial features, and design a map.

Time:

One 50-minute class period (after reading a book).

Materials:

- Notebook (for each student)
- Scrap paper
- A few sheets of blank paper or transparent mylar
- Chalkboard or flip chart

Procedures:

1. On scrap paper, list the kinds of features you will he mapping, such as towns, buildings, houses, rivers, lakes, roads, and airports.
2. On paper or clear plastic, draw maps of each separate layer. Include place names, scale, latitude, and longitude. Combine the layers (redrawing if necessary) to create a generalized view that could be used as a frontispiece for the book.
3. Write a short essay discussing how geography affected the events in the book. Note how the new frontispiece might affect a reader's impression of the book.
4. On a chalkboard map the plots and sub plots of the book using concept mapping (see example in illustration G); start from any central story line (from any point in the book) and try to fill the space available.

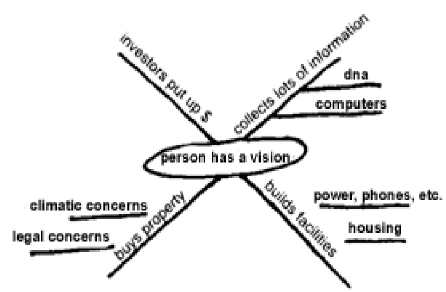

Illustration G

Glossary:

concept map

digital mapping

elecromagnetic spectrum

image

layer

mosaic

optics

perspective

positional accuracy

remote sensing

stereoscope

Additional activities

Visit a local government agency or private mapping organization for a demonstration of its mapping operation. If possible, visit a GIS (geographic information system) facility.

Invite an optometrist to class to discuss the physics behind the instruments used in a typical vision test.

Select two quotations from the Poster Side 2 that seem especially pertinent to this activity sheet, and write an essay that discusses the ideas of both writers.

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Recommended reading:

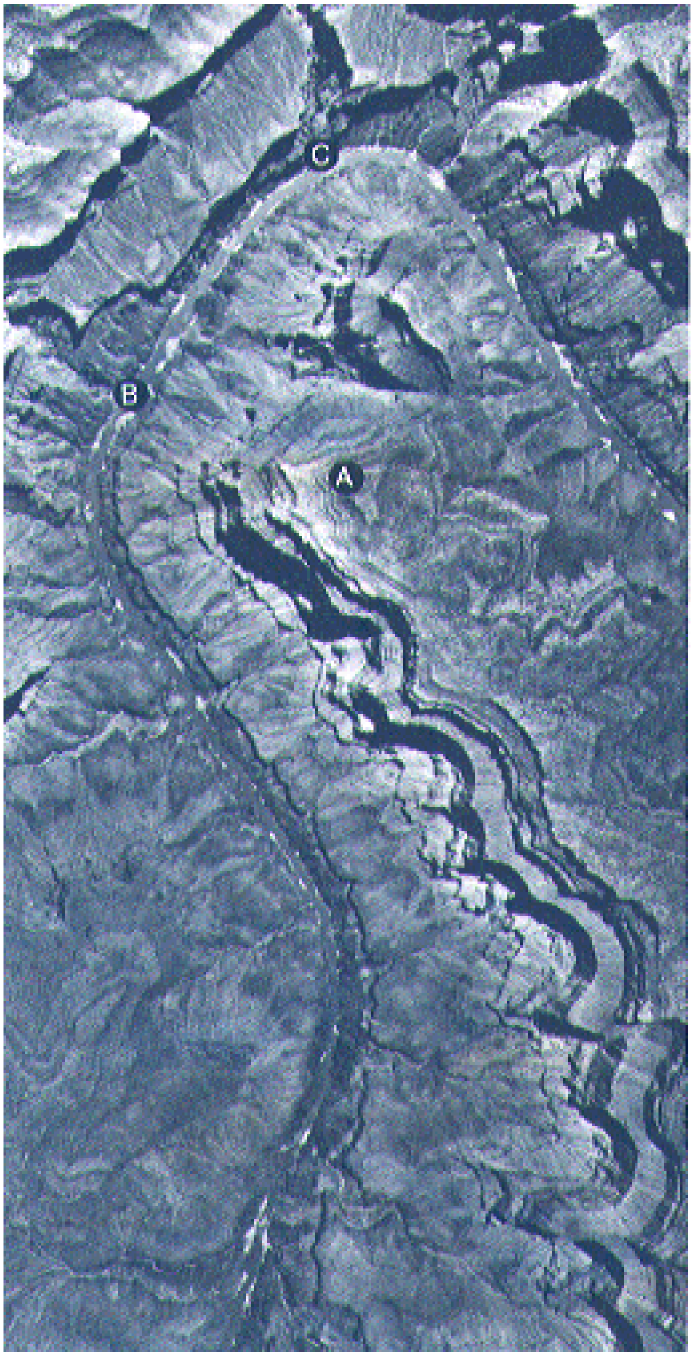
Hall, S.S. *Mapping the Next Millennium—The Discovery of New Geographies*. New York: Random House, 1992.

Strain, Priscilla, and Engle, Frederick. *Looking at Earth*. Atlanta: Turner Publishing, Inc., 1992.

Geographic Information Systems. U.S. Geological Survey poster. 1992.

Planetary Maps. U.S. Geological Survey poster. 1992.

Topographic Mapping. U.S. Geological Survey booklet. 1991.


C
B
A