Lesson A8–5

Understanding Global Positioning Systems (GPS)

Unit A. Mechanical Systems and Technology

Problem Area 8. Technology Systems

Lesson 5. Understanding Global Positioning Systems (GPS)

New Mexico Content Standard:

Pathway Strand: Power, Structural and Technical Systems

Standard: XI: Explain geospatial technology to demonstrate its applications.

Benchmark: XI-A: Employ appropriate techniques to demonstrate application of GIS/GPS systems principles.

Performance Standard: 1. Explain the concept and principles. 2. Describe equipment. 3. List techniques used. 4. Explain the application of GIS/GPS systems with map development output.

Student Learning Objectives. Instruction in this lesson should result in students achieving the following objectives:

1. Describe how satellites can be used to determine the position of objects on earth.
2. Describe how GPS satellites are used to navigate variable rate applications of agricultural inputs.
**List of Resources.** The following resources may be useful in teaching this lesson:

**Recommended Resources.** One of the following resources should be selected to accompany the lesson:


**List of Equipment, Tools, Supplies, and Facilities**

- Writing surface
- Overhead projector
- Transparencies from attached masters
- Handheld GPS Receiver

**Terms.** The following terms are presented in this lesson (shown in bold italics):

- Control segment
- Global Positioning System (GPS)
- NAVSTAR
- Parallel swathing
- Space segment
- Triangulation
- User segment
- Variable Rate Application

**Interest Approach.** Use an interest approach that will prepare the students for the lesson. Teachers often develop approaches for their unique class and student situations. A possible approach is included here.

Draw a map of a 40 acre field that needs fertilizer. Show the students that it has been sampled every 4 acres, for a total of 10 smaller sections within the field. For maximum yields in those 10 sections, 5 of them need 175 lbs. of fertilizer/acre, 2 need 275 lbs./acre, 1 needs 135 lbs./acre, another needs 150 lbs./acre, and the final section needs 250 lbs./acre. Ask the students how much fertilizer they would order per acre for the farm. Would they put on 275 lbs./acre so that every acre could reach it’s maximum potential? How could they use GPS technology to be able to apply the correct amounts to each section within the field?
Summary of Content and Teaching Strategies

**Objective 1:** Describe how satellites can be used to determine the position of objects on earth.

**Anticipated Problem:** How can satellites determine the position of objects on Earth?

I. The **Global Positioning System** (GPS) was created by the Department of Defense in the early 80’s, and became fully operational on April 27, 1995. It was originally designed to serve as a world-wide navigational aid for the United States Military. The system can now be used for commercial, industrial, and civilian uses. GPS receivers can determine their position 24 hours a day in all weather conditions. The Global Positioning System is divided into three parts—Space Segment, Control Segment, and the User Segment.

A. The **space segment** consists of 24 **NAVSTAR** (Navigation by Satellite Timing And Ranging) Satellites. Of the 24, there are 21 in use, and the other three serve as functioning spares. The satellites orbit at 10,900 nautical miles above the earth’s surface.

1. Each satellite circles the earth twice per day, once every twelve hours. There are six orbital paths with four satellites in each path. This organization guarantees that there are always at least four satellites available to a GPS receiver. The GPS receivers can only receive information from those satellites that are “above the horizon,” meaning that the receiver must be in the line of sight of the orbiting satellite in the sky.

2. Each satellite is equipped with a radio transmitter and receivers for sending and receiving radio waves. Their signals are similar to those received by a television set, but at a higher frequency. The satellites also contain atomic clocks, which keep time based on natural periodic vibrations within atoms. These precise clocks are what make it possible for GPS to be used for mapping and navigation.

B. The **control segment** is the network of monitoring stations that track and monitor GPS satellites all around the world. The Master Control Station is located at Falcon Air Force Base in Colorado Springs, Colorado. The stations measure radio wave signals that are continuously transmitted by the satellites and relay the information to the stations. The Master Control Monitoring Station uses this information to compute the exact orbits of the satellites and to update their navigation.

C. The **user segment** consists of military and civilians who use GPS receivers for determining the position of a vehicle or location. GPS receivers use **triangulation**, which means taking information from three or more satellites to determine an exact location on the earth. The distance to each satellite can be determined when compared to the other satellites in the group.

A variety of methods can be used to assure student comprehension of this material. Assigned readings in the recommended resources will prove helpful to students in fully understanding the content of the objective. Use TM: A8–5A and TM: A8–5B to illustrate the constellation of GPS satellites in orbit today.
and to show that only satellites in view of the horizon can be used. TM: A8–5C will show how triangulation works to determine an object’s position on earth. Hand-held GPS receivers can be demonstrated to show how they are able to use four or more satellites to determine their position.

**Objective 2:** Describe how GPS satellites are used to navigate variable rate applications of agricultural inputs.

**Anticipated Problem:** How can GPS be used to utilize variable rate technology and to more accurately apply agricultural inputs.

II. GPS can be used to navigate agricultural equipment and to correctly apply varying rates of inputs to maximize yields.

A. GPS can be used to guide equipment through the field accurately. This process is known as parallel swathing. **Parallel swathing** is simply driving or flying a vehicle in straight, parallel paths without leaving gaps or overlapping between passes. When applying fertilizers or pesticides, a producer does not want to leave gaps or fertilization and pest control would not be complete. Overlaps lead to over-application, which leads to excessive cost, crop damage, or environmental damage. Parallel swathing navigates machinery so that applications can be made with great accuracy. The operator of the equipment simply hits a start key when beginning a field. When they come to the other end of the field, they can hit the stop key, and then the GPS receiver will guide them through the rest of the field based on the first pass.

B. **Variable Rate Application** refers to the use of site-specific data of cropping inputs such as seeds, fertilizer, lime, and pesticides. Other inputs can be achieved using the Global Positioning System. In this process, producers can vary the rates applied to their land based on information that has been collected from that acreage over the past years. These decisions could be based on soil type information, drainage, past yields, soil sample data, or any other information that is a part of the data layers collected on that farm.

C. The data is collected and entered into a computer program that analyzes the information. The producer and their consultant determine what their application rates will be for whatever input they will be applying. In this instance, let’s say fertilizer. The application data is put into the computer in the fertilizer spreader, which controls the output of the spreader at different locations throughout the field.

D. The GPS receiver gives the fertilizer spreader’s computer the information as to where it is within the field, and the computer uses that information to adjust how much is applied at differing locations throughout the field.

E. GPS technology can be used on sprayers, planters, combines, soil sampling equipment, or any implement that can collect data about exact points within a field. This data is stored in a computer, and can then be used to analyze the amount of inputs that will be used in the future.

A variety of teaching strategies can be employed to enhance student learning. Have students read the suggested chapters in the recommended resource texts. Consider a field trip to your local fertilizer and crop
protection retailer. Ask them to talk about GPS and variable rate applications of fertilizers and pesticides. They can show maps that have been generated, and allow students to see the computers within application equipment that receive GPS signals.

**Review/Summary.** Use the student learning objectives to summarize the lesson. Have students explain the content associated with each objective. Student responses can be used to determine which objectives need to be reviewed or taught from a different perspective.

**Application.** Hold a GPS scavenger hunt. The teacher can place certain objects in different locations around the school ground, or around town if the groups can be chaperoned. The teacher can provide a list of coordinates where these objects are hidden. This could be played with two groups, one of which hides items and provides the coordinates for the other team. Then switch roles. The students will see how a GPS can be used for navigation.

**Evaluation.** Evaluation should focus on student achievement of the objectives for the lesson. Various techniques can be used, such as student performance, on the application activity.

**Answers to Sample Test:**

**Part One: Matching**

1 = a, 2 = d, 3 = c, 4 = e, 5 = f, 6 = b

**Part Two: Completion**

1. Variable Rate Application
2. triangulation
3. twice
4. Department of Defense
5. space
6. above the horizon—or in the line of sight

**Part Three: Short Answer**

Triangulation works by comparing the distance an object is from each satellite in view. These distances will intersect in only one location, which is the position of the GPS receiver in question.
Test

Lesson A8–5: Understanding Global Positioning Systems (VRT)

Part One: Matching

Instructions. Match the term with the correct response. Write the letter of the term by the definition.

a. global positioning system  d. 21
b. parallel swathing        e. control segment
c. six                    f. user segment

_____ 1. Receivers can determine their position 24 hours a day in any weather.
_____ 2. Number of Satellites in use for GPS purposes.
_____ 3. Number of orbital paths, each containing 4 satellites.
_____ 4. The network of monitoring stations that track and monitor GPS Satellites.
_____ 5. Civilians or military who utilize GPS for determining their position.
_____ 6. Using GPS satellites to maneuver application equipment in straight parallel lines.

Part Two: Completion

Instructions. Provide the word or words to complete the following statements.

1. _______________ _______________ _______________ refers to applying different rates of inputs at different locations within a field.
2. The use of three or more satellites to determine an objects position is called _______________.
3. Each satellite circles the earth _________ per day.
4. Global Positioning was created by the _______________ __ _______________.
5. The _____________ segment consists of 24 NAVSTAR satellites.
6. GPS receivers can only access satellites that are _______________ __ _______________.

New Mexico Agricultural Mechanics and Technology Lesson Plan Library
Part Three: Short Answer

Instructions. Provide information to answer the following question.

Explain how triangulation in GPS can determine the position of an object.
GPS SATELLITE CONSTELLATION
SATELLITE TRIANGULATION DETERMINES LOCATION

Satellite A

Satellite B

Satellite C