Submarine Force Museum Lesson Plan

Developed by 2015 Submarine Force Library and Museum STEM –H Teacher Fellow
Robert Mayne, Math Teacher, Chariho Regional High School, Wood River Jct., RI

Lesson Name: Global Positioning System-Engineering   Number of minutes in the Lesson: 90/135

Intended Audience: Grades 7-8 Math, High School Geometry, High School Engineering/Tech Education.

Content Standards:

CCSS.MATH.CONTENT.7.G.A.2
Draw (freehand, with ruler and protractor, and with technology) geometric shapes with given conditions. Focus on constructing triangles from three measures of angles or sides, noticing when the conditions determine a unique triangle, more than one triangle, or no triangle.
CCSS.MATH.CONTENT.7.G.A.3
Describe the two-dimensional figures that result from slicing three-dimensional figures, as in plane sections of right rectangular prisms and right rectangular pyramids.
CCSS.MATH.CONTENT.HSG.CO.A.1
Know precise definitions of angle, circle, perpendicular line, parallel line, and line segment, based on the undefined notions of point, line, distance along a line, and distance around a circular arc.
CCSS.MATH.CONTENT.HSG.GPE.A.1
Derive the equation of a circle of given center and radius using the Pythagorean Theorem; complete the square to find the center and radius of a circle given by an equation.
CCSS.MATH.CONTENT.HSG.GMD.B.4
Identify the shapes of two-dimensional cross-sections of three-dimensional objects, and identify three-dimensional objects generated by rotations of two-dimensional objects.
CCSS.MATH.CONTENT.HSG.MG.A.1
Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).
CCSS.MATH.CONTENT.HSG.MG.A.3
Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).

CCSS.MATH.PRACTICE.MP2 Reason abstractly and quantitatively.
CCSS.MATH.PRACTICE.MP3 Construct viable arguments and critique the reasoning of others.
CCSS.MATH.PRACTICE.MP4 Model with mathematics.
CCSS.MATH.PRACTICE.MP5 Use appropriate tools strategically.

ISTE Student Standards 1.c. Use models and simulations to explore complex systems and issues.
ISTE Student Standards 3.a. Plan strategies to guide inquiry.
ISTE Student Standards 3.b. Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media.
ISTE Student Standards 3.c. Evaluate and select information sources and digital tools based on the appropriateness to specific tasks.
ISTE Student Standards 4.c. Use multiple processes and diverse perspectives to explore alternative solutions.

CSS.ELA-Literacy.RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
CCSS.ELA-LITERACY.WHST.11-12.1. Write arguments focused on *discipline-specific content*.
CCSS.ELA-LITERACY.WHST.11-12.2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.
CCSS.ELA-LITERACY.WHST.11-12.7
Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Pre-Visit Materials/Activities: Educators should present the lesson PowerPoint called Evolution of GPS during the Cold War. It is contained as a handout at the end of this lesson plan on pages 6-13, and can be obtained in PowerPoint form from the Submarine Force Museum Education Specialist, in Groton CT.

Set up Before the Lesson Begins: None

Content Objective(s):
Geometry: Students will be able to explain how Global Positioning Systems function and relate the mathematics of GPS to current learning in geometry and/or middle school mathematics.
Engineering: Students will be able to explain how Global Positioning Systems function, relate previously learned mathematical concepts to the mathematics of GPS and the impact of GPS on society, culture, politics, environment, military, and the economy.

Language Objective(s): Distinguish between receptive skills (**listening and reading**) and productive skills (**speaking and writing**). Please **include how you would use them all where appropriate**: Listening, reading, speaking and writing.

Differentiation: Think about: Educators will make individual decisions based on the overall knowledge of their students.

Students with special needs How will you differentiate this lesson for special education students?

Gifted students-

Regular education students: Think about how you would differentiate the lesson for all students on all levels:

High-
Middle-
Low-

Sheltered Instruction Observation Protocol (SIOP) Strategies for ELL and regular Ed Students:
Identify the S.I.O.P features that support English Learners and all learners including thorough and accurate explanations on how they will assist English Learners. Identify Sheltered Instruction strategies throughout the lesson.

- Preparation
- Building Background
- Comprehensible Input
- Strategies
- Interaction
- Practice/Application
- Lesson Delivery
- Review/Assessment

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Initiation: Briefly describe how you will initiate the lesson. (Set expectations for learning; articulate to learners what they will be doing and learning in this lesson, how they will demonstrate learning, and why this is important)

Lesson Development: **(Add a Time for Each Segment of the Lesson)**

Performance Tasks: Describe in outline how you will develop the lesson and what learning activities students will be engaged in order to gain the key knowledge and skills identified in the student learning objective(s).

Complete the two-page "Engineering Assessment" on pages 4 and 5 that follow.

Teaching and Learning Strategy: Strategies that you used during the lesson, including **modeling, guided practice and independent practice** where applicable.

Monitoring and Adjusting: How do you know the students have learned what you taught them and that they have achieved the objective?

Assessment: How will you ask students to demonstrate mastery of the student learning objectives? Attach a copy of any assessment materials you will use, along with assessment criteria.

Closure: Briefly describe how you will close the lesson and help students understand the purpose of the lesson. (Interact with learners to elicit evidence of student understanding of purpose(s) for learning and mastery of objectives)

Post-Visit Materials/Activities: Provide additional materials if they would reinforce a good learning experience after leaving the museum.

Technology: Please explain the technology used: why you will use it, how you will use it and how you will assess the results of using this technology.

Key Vocabulary: Words students need to know in order to reach the objectives.

Extension: What do you have in place in case during the lesson you finish early, run out of time or need to accommodate students who complete the class work before other students, or your technology fails?

Finish Early:
Run out of time:
Technology Fails:

Materials: List the materials you will use in each learning activity.

Resources: Include any resources you may use such as textbooks and any technological resources.

Name Date

Engineering Assessment Global Positioning Systems

Directions: Answer the following questions based on the presentation on Global Positioning Systems.

1. List three industries that benefit from the implementation of GPS and explain how they benefit. *(Example: A taxi driver benefits from GPS. They are able to drive a customer to any location even if they have never personally been there. Customer satisfaction will increase since they are relatively sure they will get to their destination.)*

2. Briefly explain how GPS works. Illustrations may be used to add clarity to your explanation. Be sure to include the terms radius, sphere, circle, and intersection.

3. Identify and explain the social impact of the Global Positioning System (GPS). (Social impact refers to how GPS affects the community.)

4. Identify and explain the cultural impact of GPS. (Cultural impact refers to how the technological advancement affects popular culture such as art, film, games, literature, music, theater, sports or holidays.)

5. Identify and explain the economic impact of GPS. (An economic impact refers to how GPS affects the economy such as general cost, business revenue, business profits, personal wages, and/or jobs.)

6. Identify and explain the political impact of GPS. (Political impact refers to how GPS affects anything political such as political power domestically and internationally, bills and legislation, regulation of industry or constitutional interpretations to name a few.)

7. Identify and explain the environmental impact of GPS. (An environmental impact or environmental consequences, positive or negative, of a plan, policy, program, or project.)

8. Identify and explain the military impact of GPS. (Military impact refers to how GPS influenced military technology, philosophy and design of equipment.)

9. Identify and explain one positive and one negative impact of GPS.

10. If GPS were never created, would it have an impact on your life today? Explain.

11. Identify three types of engineering involved in the creation of GPS. Explain how each would be involved.

12. Explain how math and science are used in the creation and operation of GPS. (There is no need to list the different types of mathematics or sciences. A general explanation of how they are related is sufficient.)
13. Research the answers to the following questions through the web. Be sure to use reliable sources and cross-reference your answers. Create a list of websites used at the end of your answer.

    Possible list of questions:

    a. How are surveyors able to use GPS for such detailed global positions (within centimeters) even though the positions provided with GPS are within 3.5 meters?
    b. What global tragedy brought the airline industry into GPS before the system was ever finished, who authorized the access and how did it change the airline industry?
    c. Is GPS under U.S. military control?
    d. How could atmospheric conditions affect the overall reliability and accuracy of GPS?
    e. What is selective availability with respect to GPS and can it ever be re-implemented?
    f. Is military GPS more accurate than civilian GPS?
    g. Is it illegal to jam GPS? Why or why not?
    h. How vulnerable is GPS to malicious jamming and could a terrorist with a GPS jammer cause airplanes to crash?
    i. How can GPS tell us how many feet above sea level we are? How does it know my speed?
    j. Does the government have the ability to track my every move with GPS?

Global Positioning

The Evolution of GPS during the Cold War

In the beginning...

- The U.S. military started its investigation into the GPS system starting in 1963.
- First satellite launched in 1974.
- From 1978 - 1985 eleven satellites were launched to test the system.
- Government contracts with private companies to make portable GPS receivers in 1985.
- Personal, portable GPS products appear on the market in 2001.

Military Need for GPS

A major reason for the development of satellite navigation during the Cold War was to ensure that the U.S. Navy's SSBN's (Submarine Submersible Ballistic Nuclear) could accurately fix their positions and provide targeting information for their missiles.

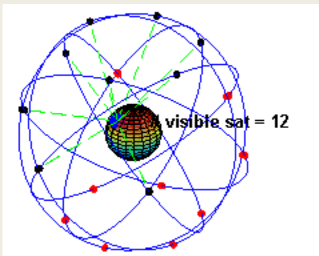
How else could the U.S. military use this system?

Today's GPS

- Maintained and operated by the U.S. Air Force.
- Uses 24 navigational satellites. Extra satellites are in orbit in case of failure of other satellites.
- Use of satellites is free and available to anyone with a capable receiver.

How GPS Works

- The Global Positioning System (GPS) satellites are orbiting on trajectories that ensure four satellites are “visible” anywhere on Earth.



- GPS receivers need a clear view of at least three satellites to fix a position on Earth.
- The receiver locates four or more satellites, computes the distance to each by measuring the time it takes to send and receive a message.
- This process is based on the mathematical principle of triangulation.

Example of Triangulation

You are lost somewhere in New England. You have no phone or any other type of technology. The only information you get are from hearing conversations of people passing by.

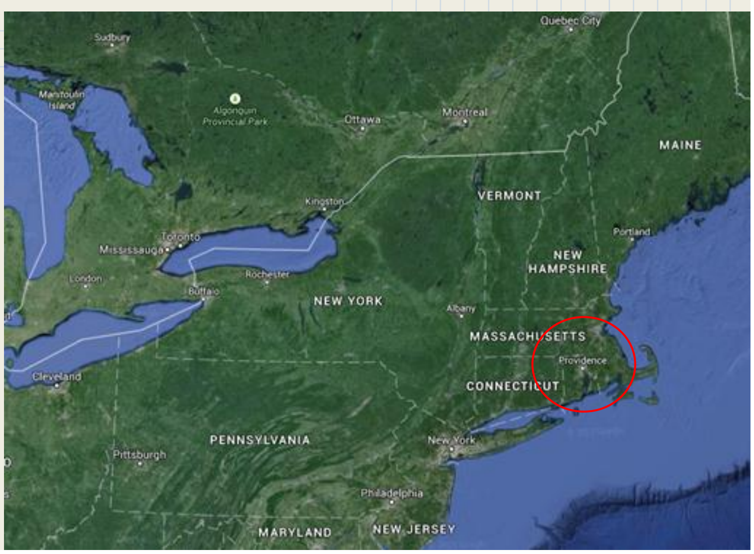
“Did you pack a lunch for the long 55 mile drive from Providence, RI this morning?” jokes a woman passing by with her friend.

“The 150 mile trip from Albany, NY only took us about three hours today,” comments a dad to his daughter.

“I’m Philly born and bred. I love my Flyers and Eagles! We traveled 220 miles to get here.” a little boy tells another kid wearing a New York Giants jersey.

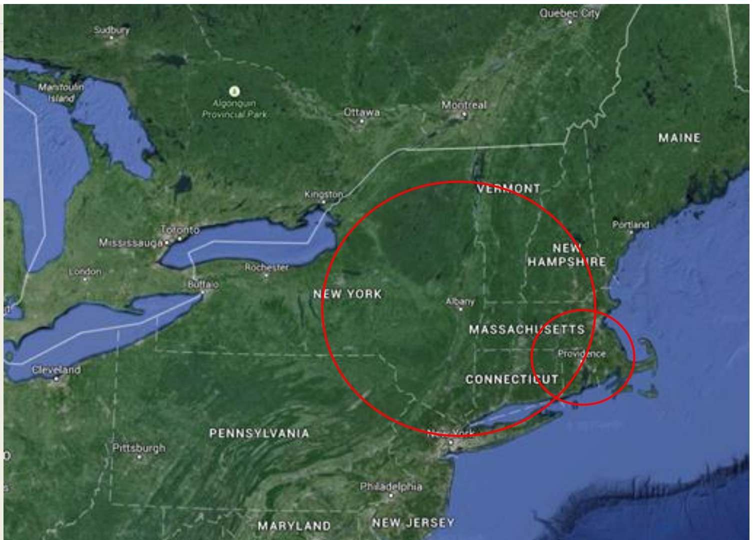
Where am I?

“Did you pack a lunch for the long 55 mile drive from Providence, RI this morning?”



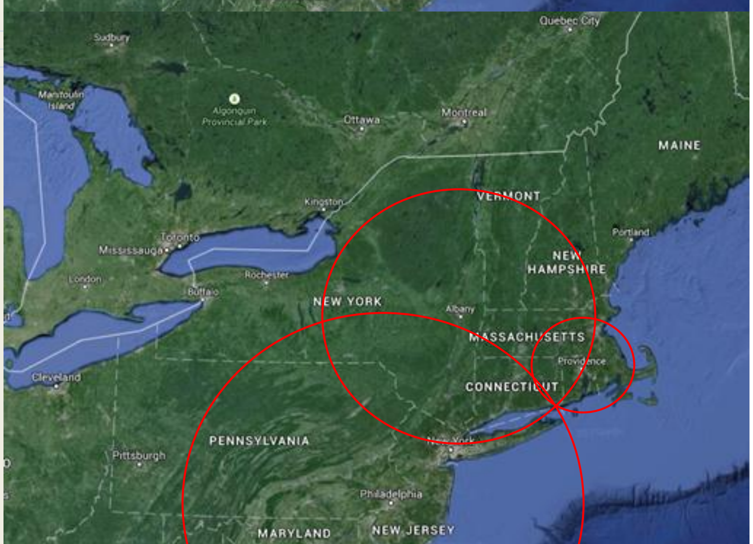
Where am I?

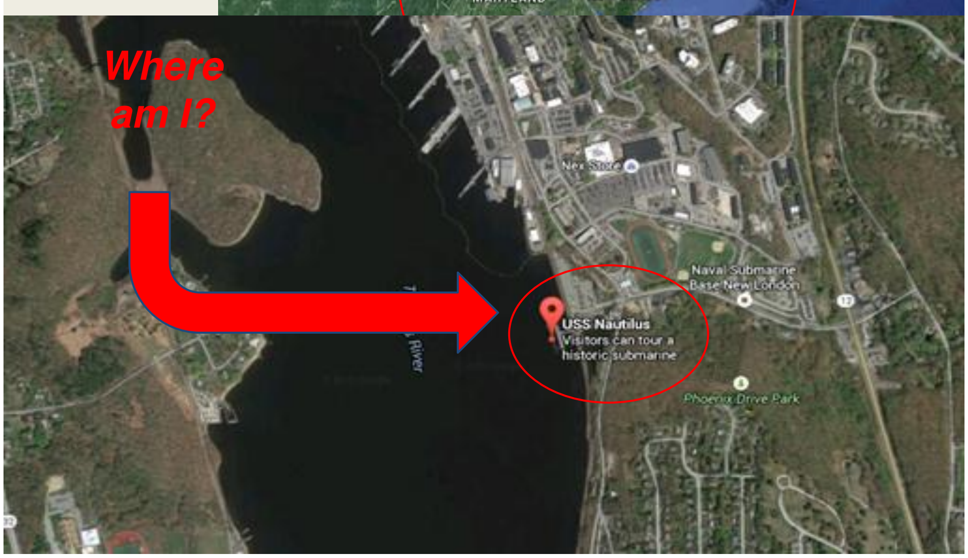
"The 150 mile trip from Albany, NY only took us about three hours today."



Where am I?

"I'm Philly born and bred. I love my Flyers and Eagles! We traveled 220 miles to get here."





“Triangulation” in Space

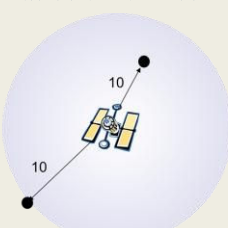
- Triangulation works in space but instead of working with circles now we work with spheres.
- Imagine if we created a dome over Providence, RI that was 55 mile in radius!
- Gives the 55 mile radius three dimensions.

How Receivers Work

- Receivers computer the time it takes a signal to travel from the satellite to the receiver.
- Radio waves travel at the speed of light (186,000 miles/second).
- The receiver converts the time it takes for the signal to travel the distance using simple mathematics.

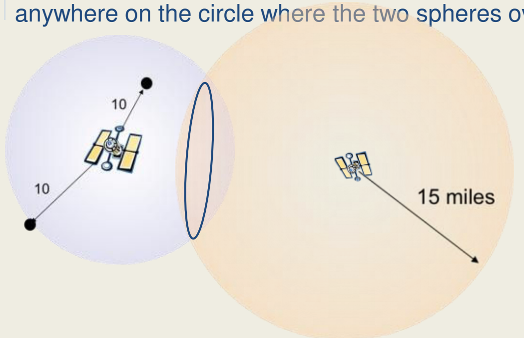
3D Triangulation

If you are 10 miles from a satellite, you can be anywhere on a sphere with a radius of 10 miles.



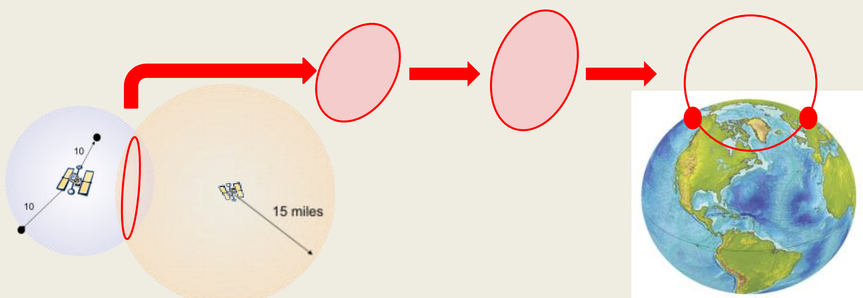
3D Triangulation

If you are 10 miles from one satellite and 15 miles from another, you can be anywhere on the circle where the two spheres overlap.



3D Triangulation

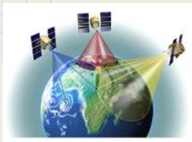
The Earth itself is a sphere. The intersection of the circle and Earth provides two possible locations along an arc on the Earth's surface.

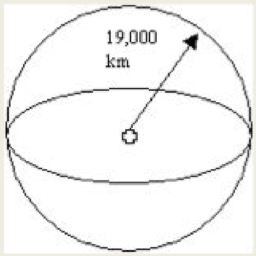


3D Triangulation

A third satellite's signal will form a sphere that intersects with only one of these two points, defining the receiver's correct location.

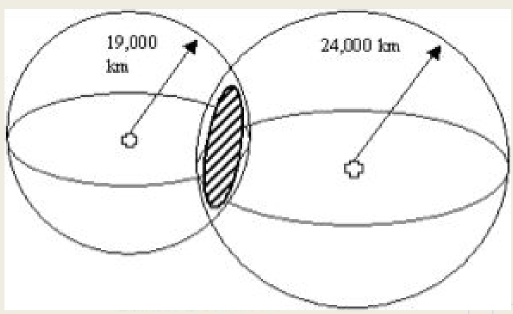
Final Illustrations





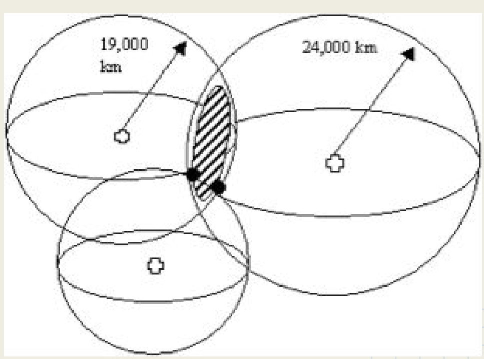
1 Satellite

Final Illustrations



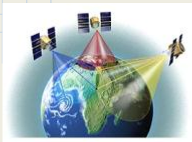
2 Satellites

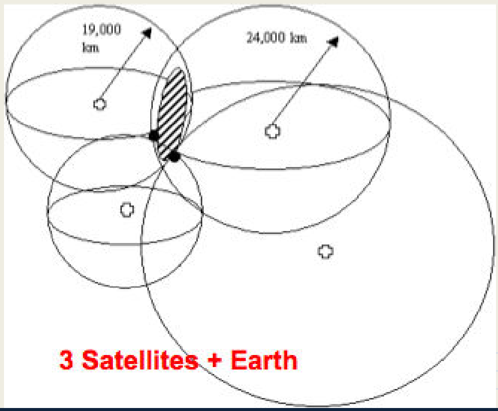
Final Illustrations



2 Satellites + Earth

Final Illustrations





Thought Provoking Questions

Additional topics for research…

- How accurate are GPS receivers?
- Why does the GPS sometimes tell me I am on one road when I am on a road parallel to it?
- If the GPS was developed in part to help SSBN's find accurate position, does that mean the signals travel through water?
- Do atmospheric conditions affect GPS? Rain? Snow? Humidity?
- How can GPS tell us how many feet above sea level we are? How does it know my speed?
- Does the government track my every move with GPS?
- Do the military and civilian receivers provide the same amount of accuracy?
- How do surveyors use GPS for mapping out property?