Global Positioning Systems (GPS) Friend or Foe?

By the end of this assignment you should be able to answer the following questions;

- What is GPS?
- How does GPS work?
- What is GPS used for?
- What are some of the advantages of GPS?
- What are some of the disadvantages of GPS?

The knowledge gained in this assignment should enable you to draw your own conclusions regarding the critical question, "GPS & Satellite Technology ... Friend or Foe?"

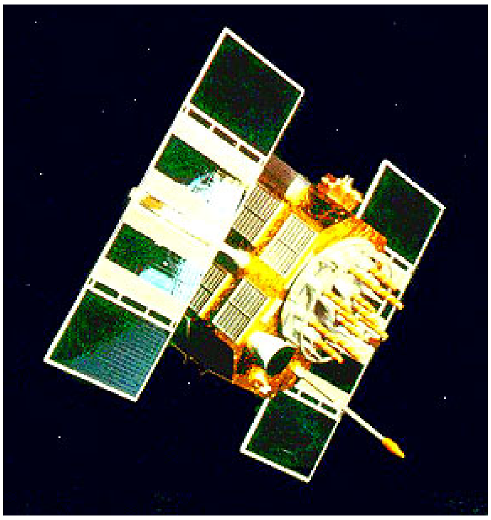
You will cover the following learning outcomes in this assignment.

- **LO1.4** Communicating and presenting information and scientific arguments
- **LO2.2** Indicating and explaining relationships
- **LO2.3** Applying scientific knowledge
- **LO3.1** Evaluating knowledge claims and science's inability to stand in isolation from other fields
- **LO3.2** Evaluating the impact of science on human development
- **LO3.3** Evaluating science's impact on the environment and sustainable development

Satellites around the Earth

The careful study of the motions of natural satellites, like the Moon, has enabled scientists to build artificial satellites and send them into space. Most artificial satellites are orbiting the Earth. A few satellites have been launched to explore other planets of our Solar System. An example of one such satellite is Viking, which explored Mars.

Photo courtesy NASA
NAVSTAR GPS



Launch of a satellite from Kennedy Space Centre by the North American Space Agency (**NASA**).

Powerful rockets are used to send artificial satellites into space. If the launching speed of the rocket is too low the satellite will fall back onto Earth because the gravitational attraction exerted by the Earth on the satellite would be too high for the satellite to overcome. The same happens to a rock thrown by a person from the Earth's surface, if falls back onto the Earth. On the other hand, if the launching speed is too high, the satellite will not be confined by the Earth's gravity and it will escape to outer space. You can imagine that placing a satellite in a particular orbit requires some accurate calculations and careful work.

Artificial satellites serve multiple purposes nowadays. Some examples of varied use of satellites are:

- Telecommunications
- Weather forecasting
- Military applications
- Scientific research
- Geophysics

The orbits of some satellites are synchronized with the rotation of the Earth. If their speed matches exactly the speed of rotation of the Earth, they look as if they are stationary on the sky and they are therefore called geostationary satellites. If the relative speeds are not the same, the satellites look to us like the Moon, rising and setting, sometimes even several times a day.

The Global Positioning System

The Global Positioning System (GPS) is a constellation of about **24 artificial satellites**. The GPS satellites are uniformly distributed in a total of six orbits such that there are four satellites per orbit. This number of satellites and spatial distribution of orbits insures that at least eight satellites can be simultaneously seen at any time from almost anywhere on Earth.

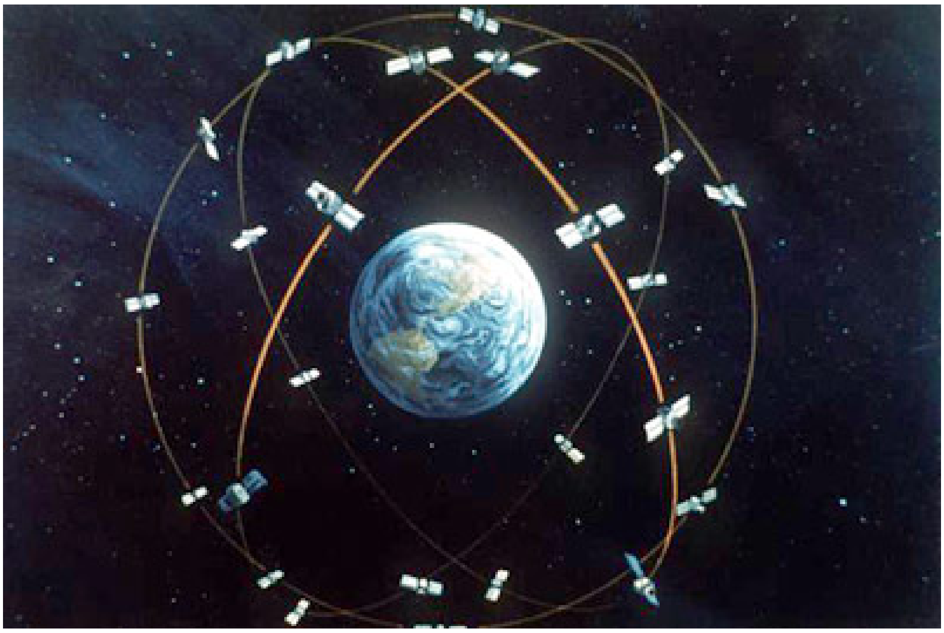


Photo courtesy U.S. Department of Defense
Artist's concept of the GPS satellite constellation

The solar-powered GPS satellites circle the Earth at an altitude of about 20 000 km and complete two full orbits every day. The GPS satellites are not in a geostationary orbit, but rise and set two times per day. Each satellite broadcasts **radio waves** towards Earth that contain information regarding its position and time. We can receive this information by using special receivers, called GPS receivers, which can detect and decode this information. By combining signals transmitted by several satellites and received simultaneously, a GPS receiver can calculate its position on the Earth with an accuracy of a few millimetres to 10m. A good reason for using radio waves for communication is that they are not affected much by weather conditions. One can send and receive them on a perfectly clear day or in the middle of a snow storm, during the day or at night.

Complete Worksheet1: Introduction to Satellites & GPS

Positioning with GPS

When people talk about "a GPS," they usually mean a **GPS receiver**. The usual method is to refer to a position on the Earth by its latitude and longitude. Therefore, most GPS receivers will display their current latitude and longitude.

Photo courtesy Garmin
Garmin GPS 72 handheld

Consider this example of how the GPS receiver is able to determine your position;
If you know you are 20km from satellite A in the sky, you could be anywhere on the surface of a huge, imaginary sphere with a 20km radius. If you also know you are 30km from satellite B, you can overlap the first sphere with another, larger sphere. The spheres intersect in a perfect circle. If you know the distance to a third satellite, you get a third sphere, which intersects with this circle at two points. The Earth itself can act as a fourth sphere -- only one of the two possible points will actually be on the surface of the planet, so you can eliminate the one in space. Receivers generally look to four or more satellites, however, to improve accuracy and provide precise altitude information.

In order to make this simple calculation, then, the GPS receiver has to know two things:

- The location of at least three satellites above you
- The distance between you and each of those satellites

When you measure the distance to four located satellites, you can draw four spheres that all intersect at one point.

http://electronics.howstuffworks.com/gps3.htm (Good animated video clip)

"Seeing" Satellites

We talk about the "visibility" of a satellite, or when we can "see" a satellite. By this terminology, we do not mean that we can, with the unaided eye, see the satellite (although it is sometimes possible to do so, especially when the Sun glints off it). We use the term "visibility" and "seeing" to mean "to have an unobstructed view of." Since the GPS satellites orbit the Earth in a non-geostationary orbit, they will rise and set. After they have set, for example, they are below the horizon and therefore "not visible." We cannot "see" satellites below the horizon. After they rise, satellites are above the horizon and thus potentially "visible." Sometimes, even after satellites rise, their view is obstructed. Sometimes a building or tree will get in the way. That is usually not a good situation.

Complete Worksheet 2: Seeing Satellites & Satellite Visibility

Bibliography for these introductory notes
http://electronics.howstuffworks.com/gps1.htm
http://t4.jordan.k12.ut.us/teacher_resources/Science/gps.html

Google Maps and Satellites (something for you to try for yourself)
Type in a street address in the Google Maps search box; once the address is located, choose "satellite" to get a view of the address from space. You can also pan around and see other features in the area. You can even create a URL to link directly to the satellite location.