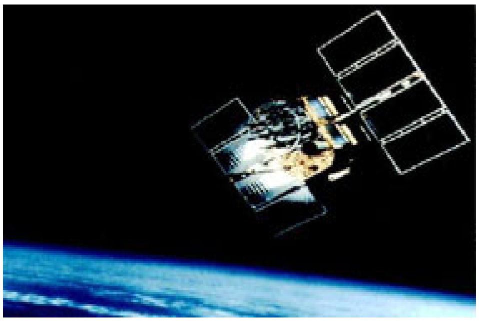
Global Positioning System

This learning unit is planned to be inserted in a module of Topography for the V class of a *Istituto Tecnico Industriale* or a *Istituto Tecnico per Geometri.*



Final version

Clil project.

A brief introduction.

I have decided to plan a learning unit about the Global Positioning System for many reasons. Firstly, it represents today's most advanced positioning technology. Secondly, it's an excellent tool that has limitless applications in many disciplines such as topography, earth science and geography. Moreover, students can connect the knowledge acquired during these lessons to their everyday life. For example, they will have the opportunity to understand that they can use the GPS to plan the route of their travels using special systems such as the TomTom GO. This GPS system displays the current position of a car in a map, represented in a '3 D' navigation view, from the driver's perspective.
The learning unit is inserted in a module of topography for the V class of a *Istituto Tecnico Industriale* or a *Istituto Tecnico per Geometri* and it has to be developed by the teacher of English and the teacher of Topography.
Before giving a detailed description of the various parts of the learning unit I will explain in which part of the curriculum it is usually inserted and I will create a time table for the whole project.
I will develop the second lesson of the learning unit in detail.

Learning unit.

A brief introduction.

GPS is an excellent tool applicable to many disciplines, including mathematics, geography, earth science, environmental studies, and more. It gives the user locational information received from satellites that are orbiting the earth.
This learning unit focus on the GPS and its features in a very simple language. Students will be introduced to the fundamentals of GPS and then taken outside to gain hands on experience using a GPS unit.
The hardest thing to master when someone has to use a GPS is the handbook. The technical jargon may be readily understood by the experts but it is baffling to those who use the system for the first time. Since students have to understand how the system works and how to use it practically, this learning unit is structured to give them the basic knowledge that allows them to answer to simple answers such as:

What is GPS?
How does GPS work?
How do I switch the set on?
Is it working?
Where am I?

Place within the curriculum:

In Italy the learning unit about the Global Positioning System is usually inserted in the following module :

Modulo: **RILIEVO TOPOGRAFICO**	
Unità didattica 1	Strumenti e misure angolari.
Unità didattica 2	Misura delle distanze.
Unità didattica 3	Misura dei dislivelli.
Unità didattica 4	Rilievo topografico.
Unità didattica 5	Il Sistema di Posizionamento Globale.

The learning unit about the Global Positioning System is usually developed in the following way:

Unità didattica: **IL SISTEMA DI POSIZIONAMENTO GLOBALE**	
Lezione 1	Premessa.
	I satelliti Navstar.
Lezione 2	La superficie di riferimento del GPS.
	Il posizionamento GPS mediante misure di Pseudo-Range.
Lezione 3	Il posizionamento GPS mediante misure di fase.
	Precisione del posizionamento GPS.
Lezione 4	Modalità di rilievo GPS.
	Ricevitori GPS per la topografia.

Clil Project.
Learning unit structure.

Topic	Global Positioning System.
Target group	Students of secondary education. (V class of a *Istituto Tecnico Industriale* or a *Istituto Tecnico per Geometri*).
Language level	A2+ (European Framework of Reference for Languages).
Time needed	5 hours.
Place	Classroom, lab, school ground.
Prerequisites	Science and Topography: • Students know the basic principles of Radio Waves Propagation. • Students are able to read and analyse simple topographical maps. Language: • Verbs: regular and irregular forms. • Passive constructions. • Tenses: Present simple, Present continuous, Past simple.

	• Modals: Can, will. • First Conditional. Spoken interaction: • Students can communicate in simple and routine tasks requiring a simple and direct exchange of information. • Students are able to take turns in a discussion.
Vocabulary	General Basic vocabulary.
Learning objectives	• Students are expected to know the basic principles of the Global Positioning System, understanding that its applications are almost limitless. • Students are expected to understand mapping coordinate system of latitude and longitude. • Students are expected to be able to organize a very simple topographical survey by using the Global Positioning System. • Student are expected to write a report based on observations.
Material	Pictures, written texts, web pages, a GPS unit instruction manual.
Aids	Computers, video beamer, a GPS unit.
Methodology	Solving Problems.
Expected outcome	At the end of the module students are expected to determine the location of the school ground.

Clil project.

Time table.

First lesson (1 hour)	Second lesson (1 hour)	Third lesson (1 hour)	Fourth lesson (2 hours)
Lesson to be done in co-presence.	Lesson to be done by the teacher of English.	Lesson to be done by the teacher of topography.	Lesson to be done in co-presence.
Content: - What is GPS? - GPS. A new era.	Content: - How GPS works in five easy steps.	Content: - The applications for GPS. - How you can use GPS.	Content: - Practical activity.

Contents:

FIRST LESSON

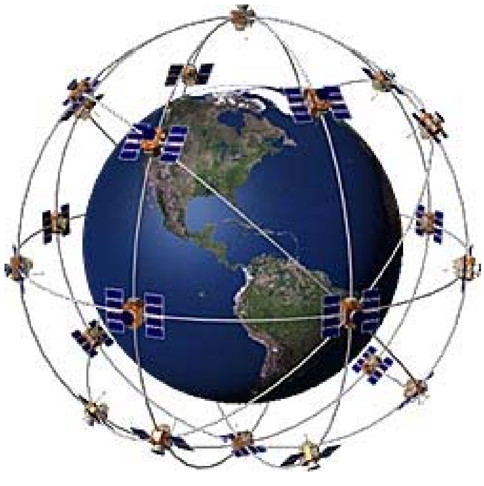
Lesson to be done in co-presence.

1. What is GPS?
   A solution to an age of problems.

Probably right from the time man got up on his hind legs and started to wander around the earth he's looking for some simple way to figure out where he was and where he was going.
It's such a basic problem you'd think we'd have come up with something that really works. But right up until today every system has had problems.
Early travellers probably just marked their trails with piles of stones. But that only works right around your own camp. And what happens when snow falls or when rain washes out the markers?
When man started to explore the oceans, the problem got even worse because there was no place to pile up the stones. And no landmarks to refer to. The only thing you could count on were stars. Unfortunately, the stars are so far away they look pretty much the same no matter where you are. So the only way to use them is to make very careful measurements. And of course these measurements can only be made at night, and only on clear nights.
Even with the best instruments, celestial navigation can only tell you approximately where you are, give or take maybe a mile. And sometimes that isn't good enough, especially when you are trying to find a harbour at night.
Modern man with all his electronic gadgetry has tried a few tricky new systems, but even they have their problems. If you're a sailor you've probably heard of LORAN or DECCA. They are a radio based system that's pretty good for coastal waters where there are LORAN or DECCA chains. But they don't cover much of the rest of the earth and their accuracy varies depending on electrical interference and geographic variations. Another system that uses satellite like GPS is called the Transit System or "Sat-Nav". Unfortunately, the satellites it uses are in very low orbit and there aren't very many of them, so you don't get a fix very often. And since the system is based on low frequency Doppler measurements, even small movements at the receiving end can cause significant errors in position.

2. GPS. A new era.
   A global system everyone can use.

Finally someone got fed up and said. "That's it! We've got to have a system that works." That someone was the U.S. Department of Defence. They really need to know where things are and they've got the kind of money it takes to do the system right.
So they came up with something called the Global Positioning System or GPS. It's based on a constellation of 24 satellites orbiting the earth at a very high altitude. In a way you can think of them as "made-men stars" to replace the stars that we have traditionally used to understand which is our position on the earth.



The satellites are high enough that they can avoid the problems encountered by land based systems and they use technology accurate enough to really give pinpoint positions anywhere in the world, 24 hours a day.
The most exciting feature of the GPS is its potential. It really allows every square meter of the earth surface to have a unique address and its applications are almost limitless.

The incredible accuracy of the GPS can be boosted used a technique called “differential GPS”. The secret of this system is based on the idea that if we put a GPS receiver on the ground in a known location, we can use it to figure out exactly our position.

Main points of the first lesson:

- Navigation has traditionally been an esoteric science.
- GPS was developed by the U.S. Department of Defence as a worldwide navigation and positioning resource for both military and civilian use.
- GPS uses satellites and computers to compute positions anywhere on earth.
- Differential GPS.

SECOND LESSON

Lesson to be done by the teacher of English.

Lesson structure:

Topic	How GPS works. In five easy steps.
Time needed	1 hour.
Place	Lab.
Prerequisites	Knowledge connected to the first lesson: • GPS was developed by the U.S. Department of Defence as a worldwide navigation and positioning resource for both military and civilian use. • GPS uses satellites and computers to compute positions anywhere on earth. Science and Topography: • Students know the basic principles of Radio Waves Propagation. • Students are able to read and analyse simple topographical maps. Language: • Verbs: regular and irregular forms. • Passive constructions. • Tenses: Present simple, Present continuous, Past simple. • Modals: Can, will. • First Conditional. Spoken interaction: • Students can communicate in simple and routine tasks requiring a simple and direct exchange of information. • Students are able to take turns in a discussion.
Objectives	Students are expected to know the basic principles of the Global Positioning System, understanding that its applications are almost limitless.

Vocabulary	General Basic vocabulary.
Material	Power Point Presentation.
Aids	Computers, video beamer.

Content:

How GPS works.
In five easy steps.

The basic principles behind GPS are really quite simple, even though the system itself employs some of the most “high-tech” equipment ever developed. To understand it, let’s break the system into five conceptual pieces and take those pieces one step at a time. We’ll start with the big ideas, and ignore details. Then later, we’ll fill in all the fine points.

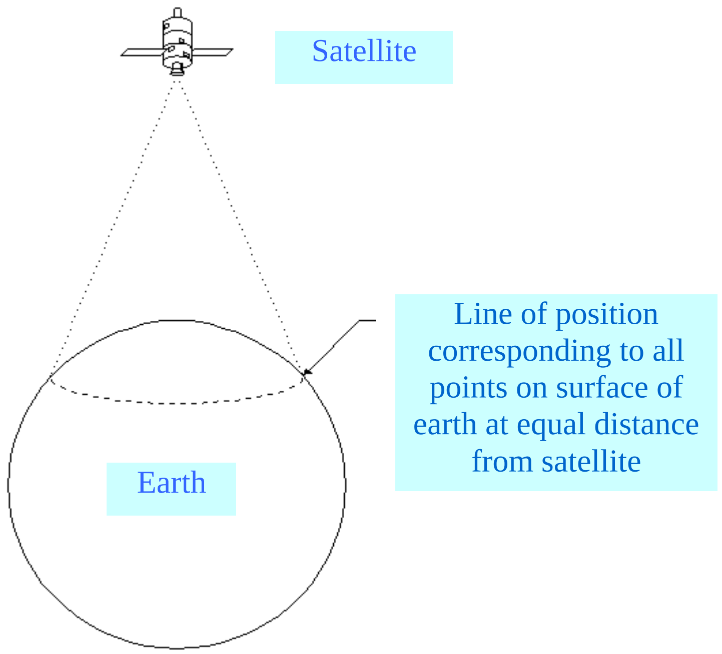
How to start the lesson…

Begin the GPS discussion with a base of familiar objects and concepts.
Ask students, “ If I am 3 metres from the far wall in the classroom, where am I?”.
The answer is anywhere on a straight line that is 3 metres from the wall.
Next ask students, “ If I am 3 metres from this wall and 5 metres from this wall, where am I?”.
The answer is a single point, at the intersection of the 2 lines.
Next, “If I am 3 metres from [Carlo] and I am floating in space?”.
The answer is a sphere with a radius of 3 metres centred on [Carlo].
If students understand THAT, then it’s not a big leap to the following:

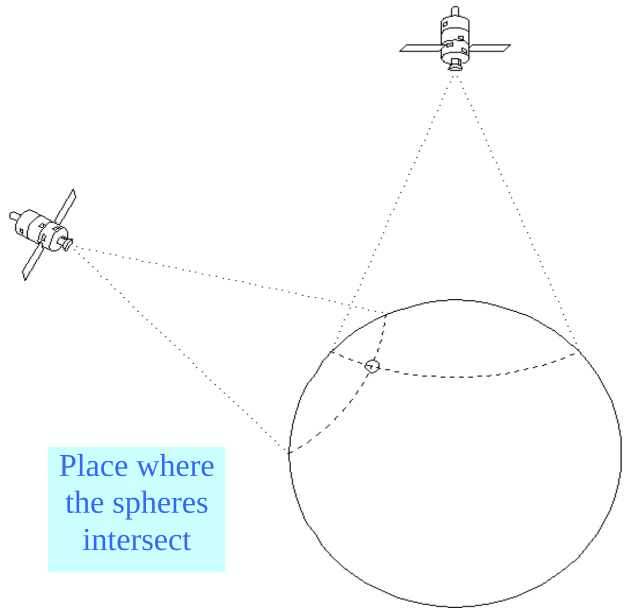
We can determine that we are
11,000 miles from GPS satellite A,
12,000 miles from GPS satellite B, and so on.
The intersection of all those spheres is our current location.

Step 1.
The basic idea: satellite ranging.

GPS is based on satellite ranging. That means that we figure our position on earth by measuring our distance from a group of satellites in space. The satellite act as a precise reference points for us.
The basic concept behind GPS is simple: Let’s say that we’re lost and we’re trying to locate ourselves. If we know that we are a certain distance from satellite A, say 11,000 miles, that really narrows down where in the whole universe we can be. It tells us we must be somewhere on an imaginary sphere that is centred on the satellite and that has a radius of 11,000 miles.



Now if at the same time we also know that we're 12,000 miles from another satellite, satellite B, we have more information about our position. The only place where we can be 11,000 miles from satellite A and 12,000 miles from satellite B is on the circle where the two spheres intersect.



Then if we make a measurement from a third satellite we can really pinpoint ourselves. If we know that at the same time we are 13,000 miles from satellite C, there are only two points in space where we can be, where the three spheres intersect.
How do we decide which one of those two points is our true position? We can do another measurement from another satellite or we can make an assumption. Usually, one of the two points is a ridiculous answer.

Step 2.
Measuring your distance from a satellite.

Since GPS is based on knowing your distance to satellites in space, we need a method for figuring out how far we are from those satellites.
Surprisingly, the basic idea behind measuring a distance to a satellite is just the equation:

Speed of light x time = distance

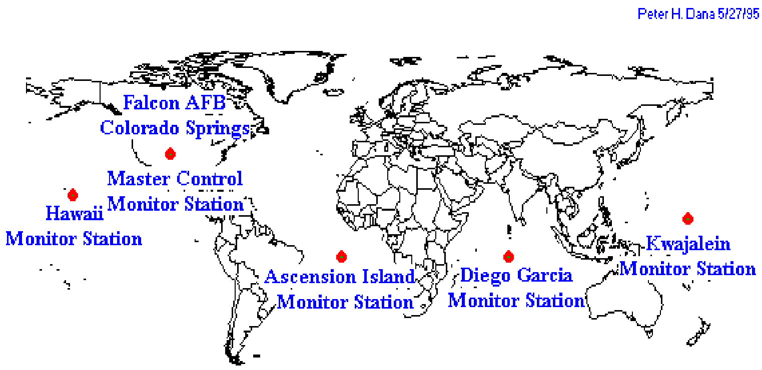
The GPS system works by timing how long it takes radio signal to reach us from a satellite and then calculating the distance from that time.
Radio waves travel at speed of light: 186,000 miles per second. So, if we can figure out exactly when the GPS satellite started sending its radio message and when we received it, we'll know how long it took to reach us. We just multiply that time in seconds by 186,000 miles per second and that's our range to the satellite.

Step 3.
Getting perfect timing.

How do we know both our receiver and satellite are really generating their codes at exactly the same time? This problem is easy to explain: the satellites have atomic clocks on board. They are unbelievably precise and unbelievably expensive. They cost one hundred dollars apiece and each satellite has four, just to be sure one is always working.
Atomic clocks don't run on atomic energy. They get the name because they use the oscillation of a particular atom. This is the most stable and accurate time reference man has ever developed.

Step 4.
Knowing where a satellite is in space.

How do we know where satellites are in space? First of all, like the moon, which has reliably spun around this old planet for millions of year without any significant charge in period, our GPS satellite are orbiting very predictably. Then, GPS satellites are constantly monitored by the U.S. Department of Defence. They go around the planet once every twelve hours, so they pass over one of the Department of Defence monitoring stations twice a day. This gives the Department of Defence a chance to precisely measure their altitude, position and speed.



Global Positioning System (GPS) Master Control and Monitor Station Network

Step 5.
Ionospheric and atmospheric delay.

As perfect as the system seems to be, there are a couple of sources of error that are very difficult to eliminate. The most significant of these errors arises from the earth's ionosphere which affect the speed of light and so affect the speed of the GPS radio signals. Fortunately, this error can be eliminated with mathematics and geometry.

A description of the GPS Satellites

Name: NAVSTAR.
Manufacturer: Rockwell International.
Altitude: 10,900 nautical miles.
Weight: 1900 Ibs (in orbit).
Size: 17 ft with solar panels extended.
Orbital Period: 12 hours.
Orbiltal Plane: 55° to orbital plane.
Planned lifesplan: 7.5 years.
Constellation: 24 satellites.

Main points of the second lesson:

Step 1.

- Position is calculated from distance measurements to satellites.
- Mathematically we need four measurements to determine exact position.
- Three measurements are enough if we reject ridiculous answers.

Step 2.

- The distance to a satellite is determined by measuring how long radio signal takes to reach us from that satellite.

Step 3.

- Accurate timing is key to measuring distance to satellites.

Step 4.

- To calculate our position we not only need distance, we also need to know where our satellites are in space.
- GPS Satellites are so high up, their orbits are very predictable.
- Minor variations in orbits are measured constantly by the U.S. Department of Defence.

Step 5.

- The earth's ionosphere and atmosphere cause delays in the GPS signal that can translate into error position.
- Some of these errors can be eliminated with mathematics and geometry.

Lesson plan:

TIME	ACTIVITY	MATERIALS	AIMS	PROCEDURE
5 minutes	WARM UP. Class work.	Power Point Presentation. Slide 1	Checking previous knowledge. Introducing the topic of the GPS.	The teacher asks students to look at the slide and to say in turn, but freely, what they know about the GPS.
15 minutes	Development 1. Introduction.	Power Point Presentation. Slides 2, 3 and 4.	Begin the discussion about the GPS with a base of familiar objects and concepts.	The teacher asks students three questions about their position on earth. Students try to answer to these questions.
25 minutes.	Development 2.	Power Point Presentation. Slides 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15.	Explain the GPS system in five easy steps.	The teacher shows the slides and explains how the GPS system works. The teacher asks students questions in order to understand if they find difficulties in his/her explanation.
10 minutes	Development 3.	Power Point Presentation. Slides 16, 17, 18, 19.	Give various examples of topographical maps loaded using a GPS system.	The teacher shows the four slides to give various examples of topographical maps loaded used a GPS system. Students can ask questions if they have difficulties in understanding these maps.

THIRD LESSON

Lesson to be done by the teacher of topography.

Who's using GPS?
…Scientists, sailors, pilots, policemen, topographers and even wildcatters!

GPS is a powerful tool for a wide variety of people and industries because its applications are countless. Aviation, oil and gas exploration, offshore exploration, natural resource management,

transportation and fleet management, public safety and surveying are some of the most important applications for GPS.
Topography is one of the countless applications for GPS. On land the system can be used for rescue services offering topographers the opportunity to determine exact positions.

Units of measurements.

The displayed units of distance and speed can be altered on most sets to suit the local or professional conventions. People flying or boating will need nautical miles and knots. Hill walkers, Antarctic explorers, desert crossers and participants to the Paris-Dakar Rally will need kilometres or statute miles. Luckily any of these three unit scales can be chosen according to your requirements.

How you can use GPS.
Initial programming and simple instructions.

When you press ON or PWR button to power up your GPS set the display will indicate the software version.
When your GPS set is fresh out of the box your GPS receiver will need some essential information to help it lock onto the next satellite as it passes overhead. Initially the GPS receiver forms an 'almanac'- a calendar of satellite passes – so it knows which one is coming next and the time of each pass. To help the set to get started you will have to key in the date and the correct time according to the Universal Time Coordinate. Ideally these information should be inserted as accurately as possible, but in practice plus or minus ten minutes is good enough. By the time the set has calculated the coordinates from the first satellite this time will have been corrected by the atomic clocks working in each of the GPS satellites.
The set will also ask you to enter your local time. Another data is the height of the antenna of your GPS set. After these information have been entered your navigator will start to work, finding your position on earth. The position is displayed as a set of latitude and longitude coordinates for plotting on a chart or a map, even if some sets can show position information in a variety of ways. Move outside, if you haven't already done so, so that the GPS hardware can locate your position.
Hold On or the PRW key down for several seconds to switch off. During this period many sets display the message "Turning off OK?" to check that you really intend to switch off.

Main points of the third lesson:

- The countless applications for GPS.
- Handbook.

FOURTH LESSON

Lesson to be done in co-presence.

Practical activity.
Final problem solving.

Since the fundamental job of the GPS is to tell you where you are, students have to use a GPS set in order to understand the topographical and geographical position of the school ground. They have to understand which are the latitude-longitude coordinates for plotting on a chart or map their school. During the practical activity students will follow the instructions of the teacher of topography.

GLOSSARY

Anywhere fix: the ability of a receiver to start position calculations without being given an approximate location and approximate time.

Bandwidth: the range of frequencies in a signal.

Channel: a channel of a GPS receiver consists of the circuitry necessary to receive the signal from a single GPS satellite.

Data message: A message included in the GPS signal with reports the satellite's location, clock corrections and health.

Differential GPS: A high-accurate refinement of the GPS system based on corrections broadcast by special ground stations.

Ionosphere: the band of charged particles 80 to120 miles above the earth's surface.

Orbit: the curved path of an object moving round a planet.

Satellite constellation: the arrangement in space of a set of satellites.

Universal Time Coordinate (UTC): The standard time used by GPS systems (for all practical purposes Greenwich Mean Time, or GMT).

ASSESSMENT

After the practical activity, students have to write a report based on their observations.
They have to record their observations at the location (buildings, flora and fauna).
Students have to use the following worksheet:

The Global Positioning System

My report

Name:
Class:

Date:

Observation date:

Describe the particulars of your project:

What have you observed?

Location of your project:

Where have you made your observations?

Latitude:

Longitude:

Altitude:

General observations at the location:

ASSESSMENT CRITERIA

GRID A

This grid has to be used by the teacher of English.

The student is able to…	**- 1**	**2**	**3**	**4**	**5+**
- use appropriate vocabulary : A: technical words; B: common words used technically.					
- use appropriate structures.					
- give the reader all the information necessary for comprehension.					
- write short, basic descriptions of his/her personal experience.					
- put thoughts in logical order.					
- use simple linkers such as *and*, *but* and *because*.					

GRID B

This grid has to be used by the teacher of Topography.

The student…	**-1**	**2**	**3**	**4**	**5+**
- knows the basic principles of the Global Positioning System.					
- is able to organize a very simple topographical survey by using the Global Positioning System.					
- understands mapping coordinate system of latitude and longitude.					
- is able to use a GPS set in order to understand the topographical and geographical position of the school ground.					
- understands which are the latitude-longitude coordinates for plotting on a chart or map their school.					

GRID C

Teachers self-reflection.

A. What happens during the activities which take place within the learning unit?
B. What does the student feel doing it?
C. Are the students interested in some of the activities of the learning unit? Which ones?
D. Are students able to use cooperation strategies?

GRID D

Student self-evaluation.

		☹ I can't do it .	😐 I can do it well.	☺ I can do it very well.
1.	*I can write a simple report based on my observation.*			
2.	*I know the basic principles of the Global Positioning System.*			
3.	*I can organize a very simple topographical survey by using the Global Positioning System.*			
4.	*I can understand which are the latitude-longitude coordinates of a ground, such as the school ground of my school.*			