Where are you

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English texts of the exhibition
Where are you?

How many times a day do we hear or say the words “Where are you?” during telephone conversations. Now that we have GPS we can answer easily but what did people do before? This exhibition delves into the long adventure that lies behind our modern ability to figure out where we are.

In order to find a position on the globe, we need reference points. These may be the stars, the magnetic north, a church’s bell tower or perhaps a mountain summit. To transfer these to a map, we need topographic instruments: a telescope, graphometer, theodolite or compass, dividers ....

A circuit designed to introduce visitors to orienteering with or without a compass has been set out in the Perle du Lac park as part of the exhibition. Participants will come across amazing trees, surprising statues and some science.

The sense of direction amongst animals

Many animals migrate, sometimes over thousands of kilometres, in search of food, to avoid predators or to reproduce.

They use various methods to orient themselves. Memory, for example, is used by some ant species who have a highly developed capacity to count their steps and memorise changes in direction on the basis of the polarisation of the light of the sun in the atmosphere. Vision helps some animals to memorise reference points. The orientation and intensity of the earth’s magnetic field guides homing pigeons whose nasal nerve fibres contain magnetite. Other birds use ocular photoreceptors called cryptochromes, which sense magnetic fields. Finally, marine birds use their sense of smell to orient themselves in a featureless environment.

With any doubt, fish are the world’s most assiduous migrants. The European eel is a good example. It spends most of its life in continental waters (rivers, lakes and streams). Once it has reached maturity, however, it undertakes a 7000km migration in order to reproduce in the Sargasso Sea (Caribbean). It takes a few months for the hatchlings to be carried back by the Gulf Stream to the coasts of Europe and North Africa. Now transformed into eels, they leave the brackish coastal waters and swim up the rivers at night.
GPS and company

Fifty years ago it was a real technological challenge to fix one’s position on the earth instantly. Now, thanks to GPS, all users of smartphones, tablets and portable computers can know where they are in real time to an accuracy of one metre. This method of satellite geolocation will be further strengthened in the near future with the introduction of European (Galileo), Russian and Chinese services not to mention the Japanese and Indian systems under development.

GPS is used in navigation, mapping, traffic management, guidance systems, tracking ocean pirates, monitoring the logistics of shipping and lorries and for studies of migratory animals. The current and future applications of satellite positioning systems are extremely enticing. In all the excitement, however, we should remember that the receptors in our telephones can also eavesdrop and transmit information about our private lives.

The first geolocations by satellite

The ARGOS system, brought into service in 1978, was one of the first location systems to use a satellite. The satellites pick up signals from terrestrial platforms emitting radio signals with an accuracy of 150m. The system is used, for example, by racing yachts and fishing boats, and for following animals on migration.

Each platform periodically emits its specific signal (around 401.650 MHz). The signal is captured by a network of 5 orbiting satellites which transmit messages in their turn to three main earth receiving stations. The data is then sent to users (rescue teams, biologists, meteorologists, etc.).

Unlike GPS, the siting of Argos’ platforms is not based on triangulation, but on the Doppler effect, that is, the change in wave frequency emitted as the transmitter moves away or approaches the receiver.

Argos is now particularly specialised in environmental studies, the management of natural resources and the protection of human lives.

The Cospas-Sarsat global emergency and rescue beacons localisation system, which has been used on ships and planes and by individuals since 1984, works in a similar way to Argos.

ARYA /DVA: Locating avalanche victims

In 1986, radiolocation led to a new application which is very useful to on-and off-piste skiers: avalanche transceivers. This electronic device can be both emitter and receiver. It emits a specific radio signal which can be quickly localised by a similar model in receiving mode. The wavelength of the radio signal is 457 kHz, a low frequency which can penetrate the snow layers and a human body without being too distorted. Its range though is limited to about 80 metres.

AIS

All commercial vessels are now equipped with an Automatic Identification System (AIS). This enables automatic exchange of messages through VHF (high frequency) radio signals which allow ships and maritime services to permanently monitor the identity, route and position of a freighter located in the navigation zone.

A ship equipped with AIS automatically transmits the following information: the name of the vessel, its size, cargo, the type of activity (in port, underway using motor, fishing, etc.), its route, speed and estimated position according to GPS, its destination and estimated arrival time at the port of destination.
GPS

In 1995 GPS (Global Positioning System) was the first system of geolocation by satellite to become operational. Developed by the Americans during the Cold War it was originally a military invention but it has since revolutionised civilian life too. Its applications are numerous and varied: maritime navigation, localisation of trucks, hiking, etc. The 24 original satellites orbit at an altitude of 20,200km around the earth; others have been added since. The way in which GPS functions is very similar to the triangulation method used by surveyors and cartographers. The main difference is that the apex of the triangles are not marked by church belltowers or mountains but, by satellites whose position on their orbits is known exactly.

Galileo

Galileo is Europe’s satellite navigation system.

A joint initiative of the European Commission and ESA, Galileo will provide a highly accurate global positioning and time stamping service at any point on Earth through a variety of services to be available in 2020.

The full system will consist of thirty satellites, 24 active + 6 spare, circling Earth at an altitude of 23,000 km, and a worldwide network of ground stations.

Galileo is a civilian system, with increased accuracy and reliability. Under civilian control, Galileo is Europe’s equivalent to the US GPS, Russian Glonass and Chinese COMPASS, ensuring Europe’s independency in this field of space applications.

Terrestrial reference points

As humans do not have an innate sense of orientation, we have had to rely on stable natural features in order to orient ourselves and find our way over the earth. We have thus observed the direction of sunrise and sunset, the presence or absence of certain stars in the sky and the height of the Polar star around which the sky seems to turn and which indicates the north.

After it was proved that the earth is round, the geographers of Antiquity developed systems of geographical reference points which we still use to position ourselves on the globe: latitude and longitude. Before the advent of GPS, these two coordinates could only be calculated through astronomy or by triangulation.

Terrestrial globe

Each point on earth can be localised by using a system of geographical coordinates known as longitude and latitude.
**Latitude**

Stretching from 0 to 90° latitude is the angle between the Equator – the reference plane – and a point on the globe to the north or to the south of the Equator. If we join all the points on earth lying on the same latitude, we obtain a circle, named a parallel, which is indeed parallel to the Equator.

**Longitude**

This is the angular distance between a point on the earth’s surface and a reference meridian on the same latitude. The meridian is an imaginary vertical circle linking the two Poles. The reference meridian runs through Greenwich. Longitude is measured between 0 and 180° to the east or to the west of the Greenwich meridian.

Geographical north corresponds to the orientation of the earth’s axis.

**Time zones**

The world is divided into zones which share the same time. In general, time zones respect the geographical frontiers of countries. They follow Coordinated Universal Time (UTC) measured with reference to the meridian at Greenwich near London. The difference with the Greenwich meridian is usually a certain number of, usually full, hours but occasionally a half or quarter hour. At the opposite side of the earth from Greenwich, zigzagging between inhabited locations in the Pacific, we find the line where the date changes. Travellers crossing the line in a westerly direction must add one day, while those going east lose one day.

**The North Star/Polaris**

The latitude of a point in the northern hemisphere is found by measuring the height of the North Star in the sky. This star is part of the Ursa Minor [Little Dipper] constellation and is close to the celestial pole. It is therefore a good indicator of the geographic north. The North Star is aligned with the earth’s axis of rotation. At night, all the stars seem to turn around the North Star which appears to be fixed in place. It is not visible from the southern hemisphere.

**Magnetic north**

Because the earth’s magnetic field changes constantly, the direction of magnetic north on the earth’s surface changes too. At Geneva, it currently only deviates by 1°33’ towards the east. At Anchorage in Alaska, however, the deviation is much more marked where it is nearly 17° east, or at Sapporo in Japan where it has moved westwards to 9°28’.

Magnetic declination also varies with time. While the geographical north could reasonably be confused with the magnetic north in Geneva these days, the difference between the two was nearly 20° two hundred years ago!

**The compass**

Invented by the Chinese to indicate the south, their reference direction, compasses were introduced into Europe during the Middle Ages. As they were further developed they became a navigation instrument indispensable to sailors and explorers needing to orient themselves. However, they quickly realised that the north indicated by the compass rarely coincided with the geographic north. This is because magnetic north varies not only from one terrestrial location to another but also over time. Today, the magnetic North Pole is at a distance of about 2000km from the geographic North Pole and it moves by more than 50km a year.
Surveyors and cartographers: from field to map

Orientation is the method by which we locate ourselves, or determine our position, in the field. But it is also the ability to represent that position on a map.

The first demarcation of property boundaries and cultivated land was by Egyptian surveyors who redefined the boundaries of the fields after each Nile flood.

While surveyors measure property boundaries and transfer the information to plans, cartographers show all the physical features too: relief, watercourses, isolated buildings, roads, towns. Surveyors and mapmakers often use the same measuring and surveying instruments in the field.

Surveying instruments

Surveying instruments fall into 5 general categories.

Sighting instruments

These are essentially alidades* or sight rulers with a telescope. Directions observed can be directly drafted onto a map or onto a plan of recorded directions.

Instruments for measuring angles

These occur in a wide range of styles and forms and include trigometers, compasses, graphometers* and the survey wheels which replaced them, as well as theodolites* which are still widely used. These instruments were used during triangulation or for measurement of height.

Levels

The main function of levels* is to measure the horizontality of water or air. They are used to determine the altitude of a range of different points.

Distance counter

In Antiquity the measurement of distance between two terrestrial reference points was sometimes carried out by surveyors who, while they walked, carefully counted their paces. They were later replaced by mechanical step-counters (podometers) and odometers* (wheels). The most common measuring instruments are still the metallic tape and the surveyor’s chain.
Drawing tools
Absolutely vital for mapmaking, these tools are used to draw plans on a map, reproduce distances or angles and to work at different scales, etc. The following list is not exhaustive: protractor, pantograph and dividers, proportional dividers.

Orienting a map
Before finding our position on a map we have to orient it, that is, turn it so that the north of the map is in line with the geographic north. If we don’t have a compass, we can turn the map so that it corresponds to visible natural features such as a lake, a river or a mountain. Although contemporary maps face north, their orientation was east in the past in the direction of the Holy City of Jerusalem, hence the term “orientation”. It was only in the 17th century that they began to point north.

Triangulation
Until the 18th century, surveyors and mapmakers drew their plans and maps using a plane table. This was very simple to use and didn’t require complicated calculations. Using the plane table, directions found with the help of an alidade, a kind of sighting device, could be transcribed immediately onto paper. This method worked well for drawing maps of fortifications, a town or a small territory.
It wasn’t until the second half of the 18th century and the development of reliable optics that accurate maps at the scale of a whole country or continent could be produced. Since then, using the new tools, cartographers have used triangulation.
Triangulation is used in surveys to determine an unknown distance by trigonometry rather than by direct measurement. The distance to be measured is covered by a network of triangles touching each other and the apexes are notable landmarks (clock towers, steeples, summits, etc.). In practice, triangulation is initiated by measuring a reference distance on the ground which becomes the first side of the triangle. Starting from two points, one at each end of the base, the distance to an unknown point (the third apex of the triangle) is calculated by measuring the angle formed between this point and the two reference stations. Mapping is then continued by attaching other triangles to the first ....
**Levelling**

Levelling is used to determine a height or a degree of slope. It is carried out with the help of a level and graduated vertical rods.

**The Orienteering circuit**

As part of the exhibition "Where are you?", the History of Science Museum invites visitors to test their skills in determining their location on a mini-orienteering circuit in the park which surrounds the Museum.

Orienteering originated in Scandinavia in the 19th century. It’s an outdoor sport which usually takes place in a locality unfamiliar to the participants and involves following a pre-determined trail. Several control points are put in place. Participants can only use a map and a compass. Real orienteering courses are run. The winner is the person who reaches all the control posts in the fastest time.

The circuit the Museum is proposing is not timed and a compass is not necessary. The only equipment is a specially designed orienteering map at a scale of 1:2500, much more detailed than a topographical map. You can choose between three different circuits, each of which has a dozen posts to find and where you stamp your control sheet.