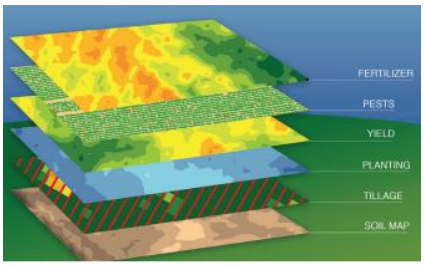
B1.4 GIS and GPS – overview of available equipment

What are GIS's? GIS, or "*Geographic information systems*", are computer-based tools used to store, visualise, analyse, and interpret *geographic data*. Geographic data (also called spatial, or geospatial data) identifies the *geographic location* of features. These data include anything that can be associated with a location on the globe, anything that can be mapped. For example, roads, country boundaries, and fields are types of spatial data.

A GIS system uses computers and software to gather, manage and analyse data based on geography, and visualises the data on a map. GIS *mapping software* uses *spatial data* to create maps and 3D models out of layers of visual information, revealing patterns and relationships in the GIS data. Industries and agencies use GIS to better communicate and solve problems associated with geographic locations and properties of objects.



Example data layers (top) stored and accessible within a typical online farm management system "sa.catapult.org.uk"

How does GIS work?

GIS systems generally consist of the following elements:

- Maps that contain geographic data layers.
- Data, spreadsheets, and imagery that ties data to a particular location.
- Spatial analysis helps to decision-maker to provide insights, gives users more confidence when predicting situations.
- Mobile apps allow GIS data to be used anywhere, at any time.

Generally, perform tasks in three steps:

- Visualisation of data: geographic data is displayed in GIS software.
- Combination of data: layers of data are put to the form of maps.
- Querying: queries are answered for values in layered data.

Sources of Geographic Information Systems:

- Natural Earth Data – GIS data in the public domains.
- Esri Open Data – offers nearly 70,000 open data sets from 4,000 organisations.
- USGS Earth Explorer – Remote sensing data and access to one of the largest databases of satellite and aerial imagery.
- OpenStreetMap (OSM).
- Socioeconomic Data and Applications Centre (SEDAC): provides global socioeconomic data from 15-different themes including: agriculture, climate, conservation, governance, hazards, health, infrastructure, land use, marine and coastal, population, poverty, remote sensing, sustainability, urban and water.

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- Copernicus Open Access Hub[1] or from the EUMETSAT Copernicus Online Data Access point depending on the type of data.
- United Nations Environmental Data Explorer's online database.
- NASA's Earth Observations (NEO) Global satellite imagery accessible in JPEG, PNG, Google Earth and GeoTIFF formats.

The data delivered by the Sentinel satellites can be downloaded either from the ESA Copernicus Open Access Hub or from the EUMETSAT Copernicus Online Data Access point depending on the type of data.

What is a GPS?

Global Positioning System is a satellite-based *navigation system* that consists of a set of operational *satellites*. GPS works in any weather conditions, anywhere in the world, 24 hours a day, with no subscription fees or setup charges.

Today, two satellite systems are functioning: the *American GPS* and the *European Galileo*. The official "United States Department of Defence" (USDOD) name for GPS is *NAVSTAR*. Both satellite systems consist of 24 operational satellites (each with several backup satellites).

How do satellites work?

Satellites circle the Earth twice per day in a precise orbit. Each satellite transmits a unique signal and orbital parameters that allow GPS devices to decode and compute the precise location of the satellite. GPS receivers use this information to calculate an object's exact location and once the position has been determined, the GPS unit gives other information about the object.

How accurate is a GPS?

Today's GPS receivers are extremely accurate: *Garmin* GPS receivers are typically accurate to within 10 metres, Galileo based receivers are a bit accurate. Accuracy is even better on the water because there are no obstructions to interfere with the signal.

Other GPS systems

There are other systems similar to GPS in the world, which are all classified as *global navigation satellite systems* (GNSS). Most Garmin receivers track GPS, GLONASS and Galileo, and some regional variations even track BeiDou and QZSS.

[1] Copernicus Open Access Hub: The data and information delivered by the Copernicus Service are made available to users through the services websites. In most cases, data and information can be browsed/discovered without prior registration but registration is required for downloading. Considered as public goods, the Earth observation data delivered by the Sentinel satellites and the data and information delivered by the 6 Copernicus services are available to users on a free, full, and open basis.

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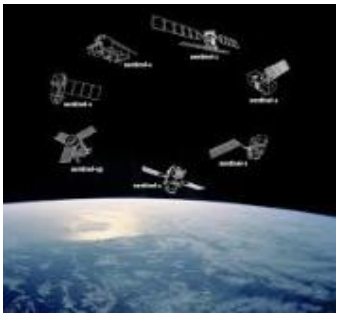
These are sometimes referred to as *multi constellation receivers* since they track and utilise multiple satellite constellations. Within newer Garmin products you could be tracking nearly 20-or 30-satellites.

Some interesting facts about the satellites

Satellite systems are orbiting the Earth about 35.500 km above sea level. They are constantly moving, making two complete orbits in less than 24 hours.



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- They travel at speeds of roughly 11,000 kilometres per hour.
- The first GPS satellite was launched in 1978 in the USA.
- A full constellation of 24 satellites was achieved in 1994.
- The European Galileo programme began in 2003.
- The services of the Galileo system were fully operational in 2020.
- Galileo is compatible with the United States' GPS, Russia's GLONASS, and the Chinese BeiDou system.
- The Galileo system was developed by the EU, but in cooperation with China, Switzerland, Norway, Morocco, Ukraine and Israel.
- The cost of Galileo has been estimated to have reached 10 billion euros.
- The European Centre of Galileo is located in Prague, The Czech Republic.
- A GPS satellite weighs approximately 900 kg.
- GPS satellites are powered by solar energy, but they have backup batteries on board in case of a solar eclipse.
- Transmitter power is only 50 watts or less.

The use of satellites in agriculture

Copernicus is the European Union's Earth Observation Programme which is coordinated and managed for the European Commission by the European Union *Agency for the Space Programme* in partnership with the *European Space Agency* (ESA) and the EU Member States.

ESA developed new systems of satellites *Sentinels* specifically assigned for the needs of the Copernicus programme.

Each Sentinel mission is based on a constellation of satellites which enable multi-spectral imaging of land, ocean, and atmospheric monitoring.

- Sentinel-1 (2016) for land and ocean services.
- Sentinel-2 (2015) is assigned for land monitoring: imagery of vegetation, soil and water cover, inland waterways and coastal areas.
- Sentinel-3, 4, 5 and 6 are systems which are searching for data on the environment and climate, and on a multitude of trace gases and aerosols which affect air quality and climate.

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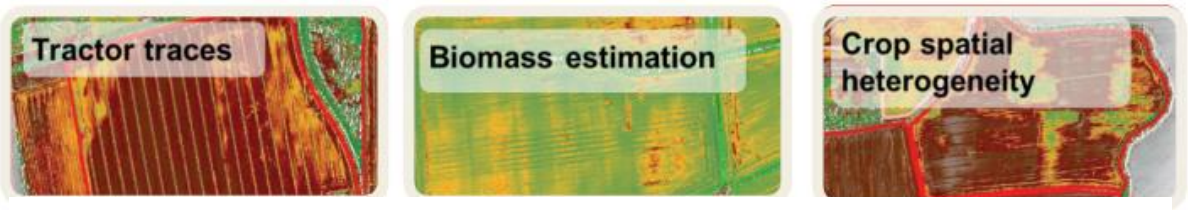
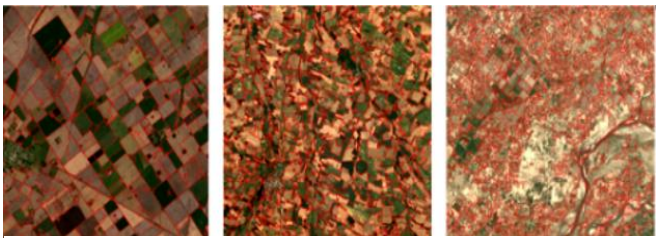
The European Commission "*fund Copernicus*", through specialised bodies, provides the technical implementation; ESA (European Space Agency), EUMETSAT (European Organisation for the Exploitation of Meteorological Satellites), EEA (European environment Agency), ECMWF (European Centre for Medium-Range Weather Forecasts).

Diverse areas of farming operation – such as farm planning, field mapping, soil sampling, tractor guidance, crop scouting, variable rate applications, and yield mapping – are made possible through GPS-based applications.



Spectral images taken by Sentinel 2. A sample of the three layers obtained by processing the spectrum.



Detailed spectral images of fields from which the quality of vegetation, dry areas, etc. can be determined. "sa.catapult.org.uk"

GPS applications can even allow farmers to work during unpleasant weather conditions such as rain, dust, fog and darkness where visibility of the field is minimal. Data collected on location information mapping field boundaries, road locations, irrigation systems, and problem areas in crops (such as weeds or disease), can be combined with GPS data and used for navigating specific locations, building histories of processes, collecting histories of soil samples, and monitoring crop conditions.

Summary

Geographic information systems are computer-based tools used to store, visualise, analyse, and interpret geographic data. Geographic data identifies the geographic location of features. These data include anything that can be associated with a location on the globe, anything that can be mapped. A GIS system uses computers and software to gather, manage and analyse data based on geography, and visualises the data on a map. GIS mapping software uses spatial data to create maps and 3D models out of layers of visual information, revealing patterns and relationships in the GIS data.

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Links to relevant topics

Satellites for agriculture, AHDB, comms@ahdb.org.uk, website: sa.catapult.org.uk

https://simple.wikipedia.org/wiki/Global_Positioning_System

https://www.geotab.com/blog/what-is-gps/

https://en.wikipedia.org/wiki/Geographic_information_system

Key words

geographic information systems
geographic data
geographic location
mapping software
spatial data
Global Positioning System
navigation system
satellites
American GPS
European Galileo
NAVSTAR
Garmin
global navigation satellite systems
multi constellation receivers
Copernicus
European Space Agency
Sentinels

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