Global Navigation Satellite Systems

A very short introduction to Global Navigation Satellite Systems (GNSS)

Global Navigation Satellite Systems

A global navigation satellite system consists of:

SPACE A constellation of typically 24 satellites moving around the Earth twice a day in three distinct orbits that are inclined to each other, and at approximately 20,000km above the Earth's surface (medium Earth orbit or MEO - the space segment),

GROUND A number of monitoring stations on the ground that listen to the satellite broadcasts and assess their quality,

USER The receivers on the ground - in your phone or your car - that can pick up the satellite signals and decode them to give you a position.

GROUND A couple of control stations on the ground that can make adjustments to satellite orbits and configurations,
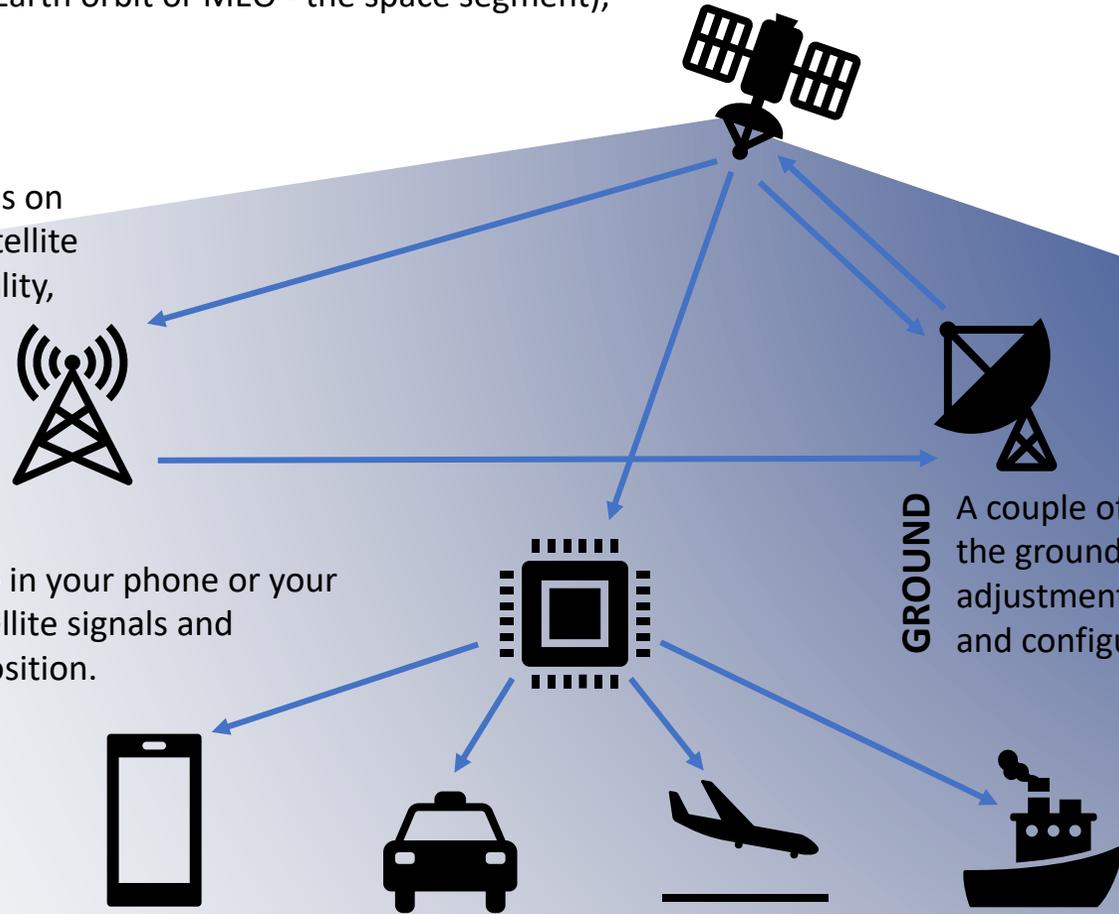
GNSS Components

SPACE

A Russian GLONASS GNSS satellite

The Galileo GNSS satellite constellation

GROUND

An Australian GNSS monitoring station

A GPS Control Station

USER

A GNSS car navigation system

A GNSS enabled drone autopilot

Position: determining a position on Earth using GNSS radio signals

Position and time messages sent from the satellites are received by the Observer at different times.

The messages are complex in nature and transmitted on several frequencies including the three L bands: L1 (1575.42 Mhz), L2 (1227.60 MHz) and L5 (1176.45 MHz).
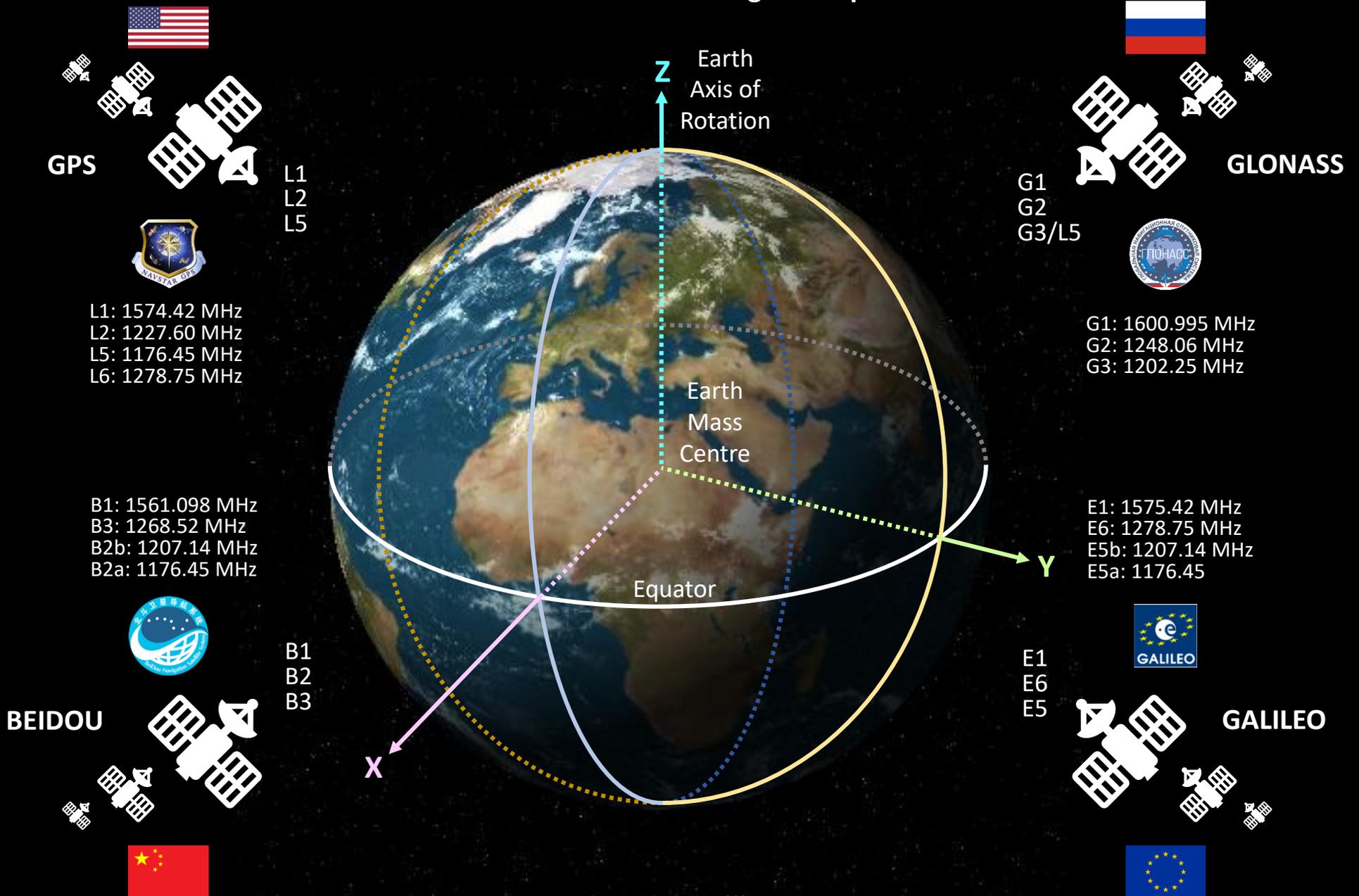
Sat01 $[\Omega,i,\omega,v]_1$ [Time T]

Sat02 $[\Omega,i,\omega,v]_2$ [Time T]

Sat03 $[\Omega,i,\omega,v]_3$ [Time T]

Sat04 $[\Omega,i,\omega,v]_4$ [Time T]

Observer [Time T]

Sat01 Δt
Sat02 Δt
Sat03 Δt
Sat04 Δt

Sat04

Sat01

Observer

Sat03

Sat02
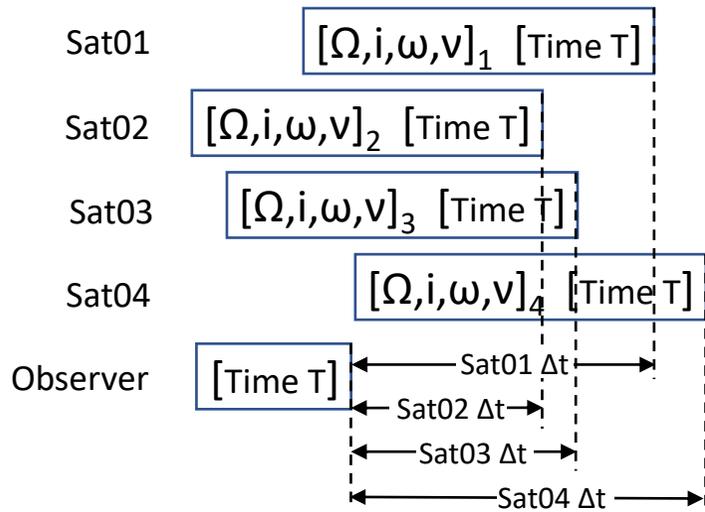
Messages sent at the same time by the satellites are received at different times by the Observer because the signals have to travel different distances. These time differences can be used to calculate those distances. With a knowledge of the satellites' positions and their distance from the Observer, the Observer can calculate its position on the Earth's surface.
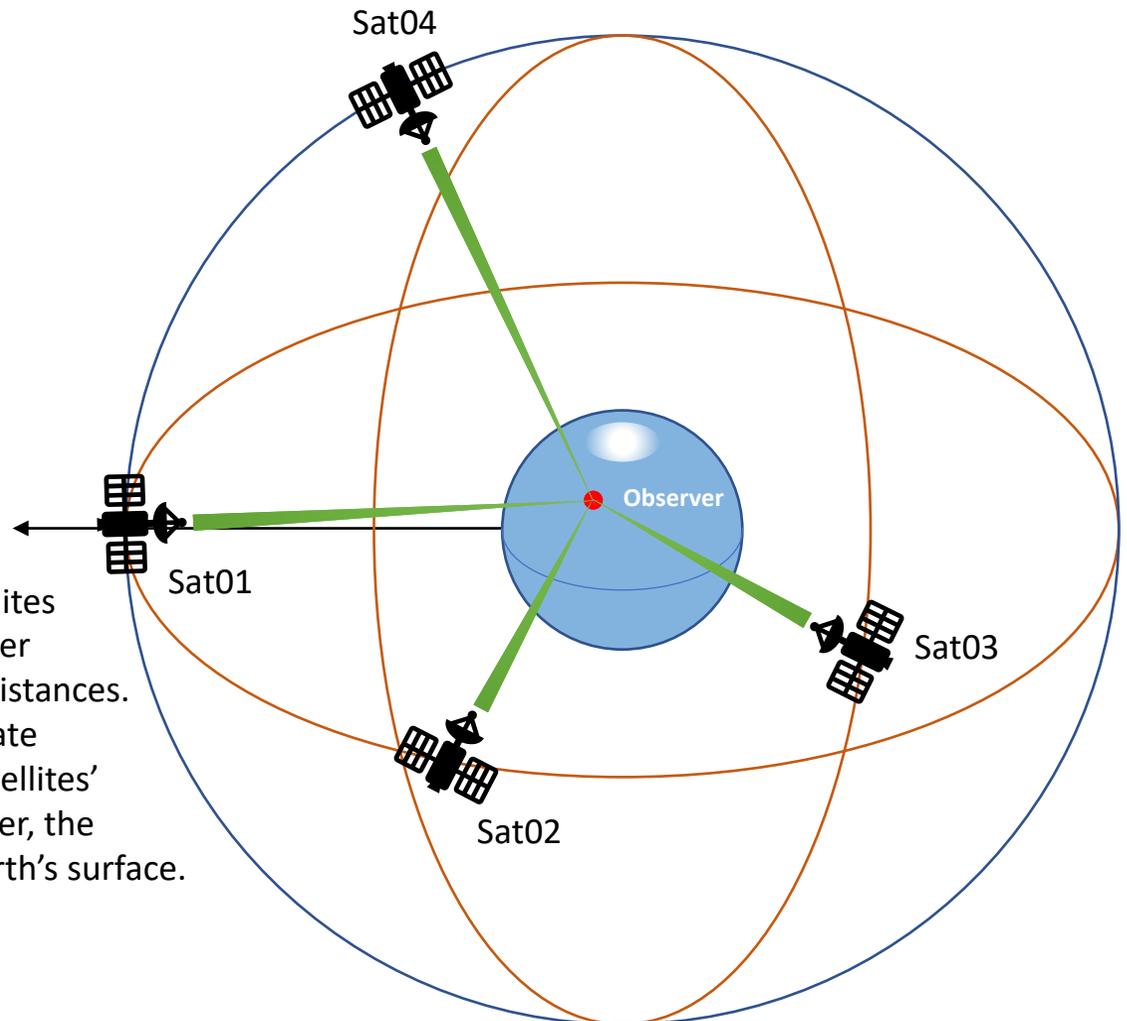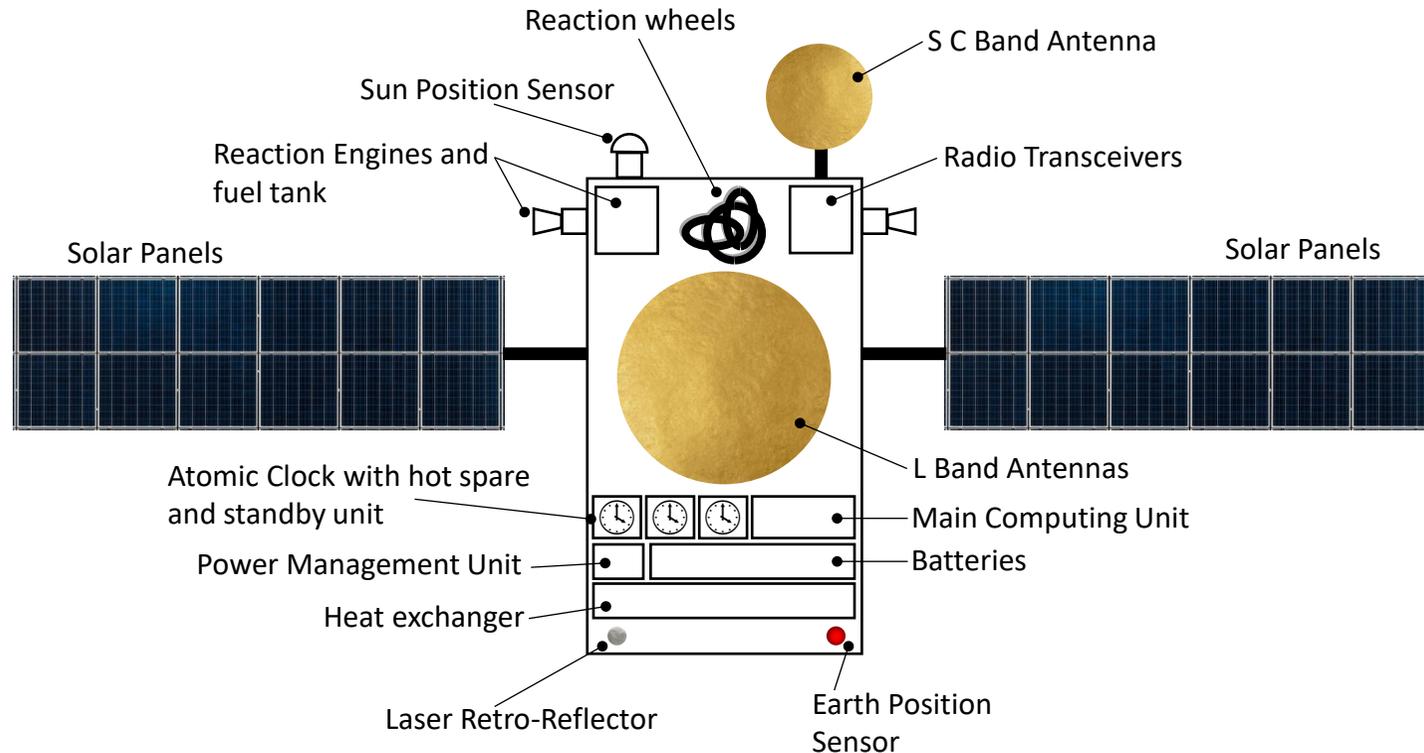
GNSS Constellations – with signal frequencies

GPS

L1
L2
L5

L1: 1574.42 MHz
L2: 1227.60 MHz
L5: 1176.45 MHz
L6: 1278.75 MHz

B1: 1561.098 MHz
B3: 1268.52 MHz
B2b: 1207.14 MHz
B2a: 1176.45 MHz

BEIDOU

B1
B2
B3

GLONASS

G1
G2
G3/L5

G1: 1600.995 MHz
G2: 1248.06 MHz
G3: 1202.25 MHz

E1: 1575.42 MHz
E6: 1278.75 MHz
E5b: 1207.14 MHz
E5a: 1176.45

GALILEO

E1
E6
E5

Z

Earth Axis of Rotation

Earth Mass Centre

Equator

Y

X

Rupert W Brown May 2021

The space segment - satellite

A representation – not an accurate depiction – of a GNSS satellite.

Electrical power is generated by the **Solar Panels**. The **Power Management Unit** controls the distribution of power to onboard systems and the **Batteries**. The **Batteries** ensure that the satellite continues to operate when the solar panels are not in sunlight. The **Sun Position Sensor** identifies the direction of the Sun.

The **Reaction Engines** are used to maintain the satellite's position in orbit as part of a constellation. A satellite typically carries a finite amount of fuel which is depleted over time and restricts the satellite's useful working life. The **Reaction Wheels** use angular momentum to adjust the satellite's orientation.

A **Radio Transceiver** creates the L Band signals – the positioning signals – which are broadcast via the **L Band Antennas**. The fully redundant **Atomic Clocks** provide vital timing data to create the positioning signals. The **Earth Position Sensor** ensures that the positioning signals are pointed at the Earth.

The **Main Computing Unit**, working with the **S and/or C Band Antenna** receives and processes telemetry, tracking and command data to keep the satellite working correctly and in the right place. The **Laser Retro-Reflector** is used by ground based ranging lasers to determine the satellite's position and latitude.

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