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Global Navigation Satellite System (GNSS)

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Different Positioning Systems

Why GNSS in transport?

Global availability 24/7

Signals are available free of charge

Receivers are getting smaller and cheaper

Great potential when combined with other data

Global	Regional	local
GPS	WAAS	DGPS
GLONASS	EGNOS	APOS
Galileo	MSAS/QZSS	TEPOS
COMPASS	Beidou	

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Global Positioning System (GPS)

History of GPS

1957 1. Satellite (Sputnik)

1958 Start of NNSS-TRANSIT (Navy Nav. Sat. System)

1964 Start of project Timation (GPS)

1967 1. Satellit in orbit (NAVSTAR7/GPS)

1973 Positioning possible

1997 System fully operational

Planning the Creation of the Global Positioning System
Engineers discussing the Global Positioning System.

Operators

DoDefence

DoTransportation

DoCommerce

DoState

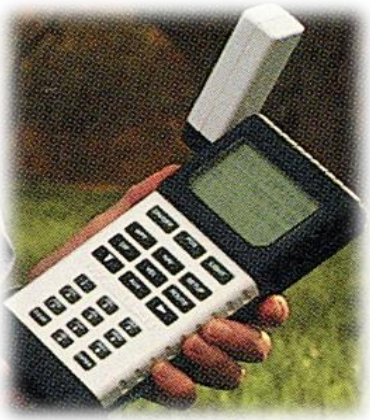
DoInterior

DoJustice

DoAgriculture

Joint Chief of Staff

NASA



1st commercial GPS receiver

Goals

Navigation service for US troops.

Real-time 3D positioning unaffected by radio interference.

Operational at all time and weather between reasonable degrees of latitude.

Today: 95% civilian users.

The successful operation of a satellite navigation system requires around-the-clock monitoring of the satellites' health and the periodic replacement of older satellites.

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Global Positioning System (GPS)

System Parameters

- ❑ 24 satellites
- ❑ 6 orbits with 4 satellites each, inclination 55°
- ❑ Orbit height ~ 20.000 km, time of circulation ~ 12h
- ❑ Life expectancy of satellites 10 years
- ❑ (current average 12 years, maximum 15 years)
- ❑ Limiting factor: Clock (Passive Hydrogen Maser + Rubidium Clock, 2 each, 1 each necessary)
- ❑ Satellite mass 2.03t, power supply min. 1.14kW
- ❑ Solar generators with 13.4m2

GPS Constellation
GPS satellites are positioned in precise, circular orbits 18,000 kilometers (11,000 miles) above the Earth. They orbit once every 12 hours.

Problems

- ❖ Bad signal-to-noise ratio, improvement by stronger signals not possible (GPS secondary user of frequencies)
- ❖ Shadowing effects by trees, buildings an mountains
- ❖ Sole means of navigation in land traffic problematic
- ❖ Update rates of 1 to 50Hz possible – not enough for highly dynamic movements with fast rotation

Layout Decisions

User only receiving, not sending.

Position determined in receiver (satellites not involved).

System still operational when ground control stations destroyed (atomic war).

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Globalnoya Navigatsionnaya Sputnikovaya Sistema(GLONASS)

A space-based satellite navigation system operated by the Russian Aerospace Defense Forces. It provides an alternative to Global Positioning System (GPS) and is the second alternative navigational system in operation with global coverage and of comparable precision.

A Russian military rugged, combined GLONASS/GPS receiver

Yo-mobil was planned to be equipped with GLONASS/GPS navigation device

History of GLONASS

Development parallel to GPS

1960's: CIKADA-system (Doppler navigation like TRANSIT)

1970's: Start of GLONASS

12.10.1982: First satellite in orbit

18.01.1996: System operative

Designed during the cold war

Operational after the cold war!

A model of a GLONASS-K satellite displayed at CeBit 2011

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Globalnoya Navigatsionnaya Sputnikovaya Sistema(GLONASS)

GLONASS System Parameters

- 24 satellites in 3 orbits (8 satellites in each orbit)
- 64,8° inclination, repetition of ground trace every 17 orbits (8 days) → better availability in high latitudes than GPS
- Orbit height: 19 100km
- Orbit time: 11h16m
- Average satellite life expectancy 3 years
- Satellite mass 1,48t
- Power supply 1,6kW from 17.5m2 solar panels
- Satellites have reflectors on surface → positioning from the ground with laser possible

Uragan-M
the second generation of GLONASS satellites

Problems of GLONASS

- Life expectancy of satellites (2-3 years compared to 12 years for GPS)
- 24 satellites → 8 new satellites per year, finances not available after the cold war
- GLONASS still not fully operational as a solitary system
- Can be used to improve the results of GPS

Differences to GPS

- ✓ Each GLONASS satellite has its own frequencies for sending
- ✓ Frequency Division Multiple Access instead of Code Division Multiple Access like in GPS
- ✓ Explicitly open for civilian users .Topic of unauthorized use of signals never had a high priority
- ✓ Never artificial deterioration of results like with SA
- ✓ unknown if due to technical reasons or as a political decision
- ✓ 2-frequency receivers for GLONASS are available

NAVSTAR GPS + ГЛОБАЛЬНАЯ НАВИГАЦИОННАЯ СПУТНИКОВАЯ СИСТЕМА GLONASS = YES!

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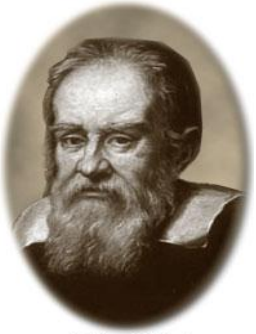
Galileo

Galileo is the global navigation satellite system (GNSS) that is currently being created by the European Union (EU) and the European Space Agency (ESA).It is named after the Italian astronomer Galileo Galilei.

History

- **1999:** Different concepts proposed (from Germany, France, Italy and the United Kingdom) for Galileo, compared and reduced to one
- **17. Jan. 2002** a spokesman for the project stated that, as a result of U.S. pressure and economic difficulties, "Galileo is almost dead.
- EU and ESA agreed in **March 2002** to fund the project, pending a review in **2003**
- Test satellites launched in **2005** (GIOVE-A) and **2008** (GIOVE-B)
- **April 2008:** Galileo Implementation Regulation approved

Signature of the Galileo Ground Mission Segment contract and Galileo Ground Control Segment Contract



Galileo Galilei
(1564-1642)

International Partners

China (since **2003**)

Israel (since **2004**)

Ukraine (since **2005**)

Morocco (since **2005**)

South Korea (since **2006**)

Norway (since **2009**)

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Galileo

System Description

- ❑ 30 satellites
- ❑ orbital altitude: 23,222 km
- ❑ 3 orbits, 56° inclination, ascending nodes separated by 120° longitude (9 operational satellites and one active spare per orbit)
- ❑ satellite lifetime: >12 years
- ❑ satellite mass: 675 kg
- ❑ power of solar arrays: 1,500 W (end of life)

Galileo - Mid term review

- ○ Limiting to 18 satellites would lead to Significantly reduced performance and increased problems in case of satellite loss
- ○ Each year's delay of full operation will decrease the value of the benefits by 10-15 % owing to both the loss of revenue generated and the development of alternative solutions and competing systems.

Galileo launch on a Soyuz rocket, 21 October 2011

Services

- ❖ Galileo satellite-only services
  - – Galileo Open Service (OS)
  - – Safety of Life (SoL) not before 2020 if at all
  - – Commercial service (CS)
  - – Public regulated Service (PRS)
  - – Support to Search and Rescue service (SAR)
- ❖ Galileo locally assisted services
- ❖ EGNOS service
- ❖ Galileo combined service

Next steps

- ➢ Need to launch first services in 2014-15
- ➢ Services will cover Open Service, Search and Rescue and Public Regulated Service but without accuracy and availability at their optimum level
- ➢ The EU budget Galileo and EGNOS was €3.4 billion until 2013.
- ➢ It is estimated that €1.9 billion will be necessary for the 2014–2020 period to complete the Galileo infrastructure.
- ➢ The operational costs of Galileo and EGNOS estimated at € 800 mill/a