

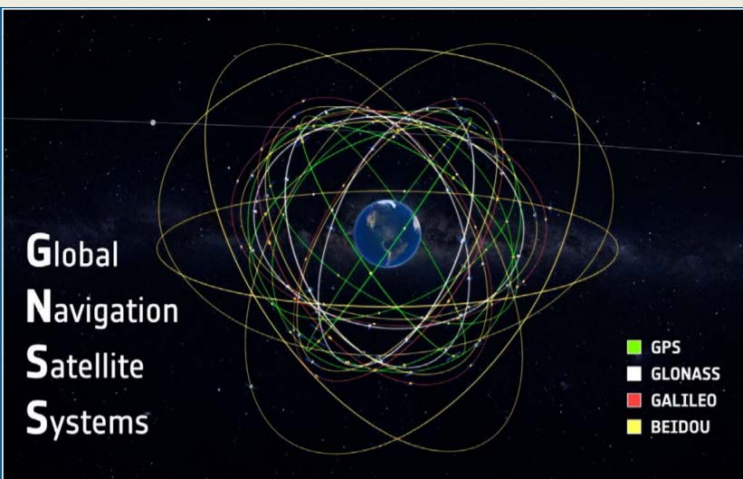
# GLOBALNI NAVIGACIJSKI SATELITSKI SUSTAVI

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Geografski odsjek



Predmet: Kartografija I



# Global Navigation Satellite Systems (GNSS)

## Globalni navigacijski satelitski sustavi

- **GPS**

### Global Positioning System

20 180 km

5 m

– Vojno-civilni

Operabilan globalno

- **GLONASS**

19 130 km

2.8–7.38 m

– Vojno-civilni

Operabilan globalno



GPS CONSTELLATION STATUS, 16.11.20

Total satellites in constellation	31 SC
Operational	30 SC
In commissioning phase	-
In maintenance	1 SC
In decommissioning phase	-

GLONASS CONSTELLATION STATUS, 16.11.2020

Total satellites in constellation	28 SC
Operational	24 SC
In commissioning phase	-
In maintenance	1 SC
Under check by the Satellite Prime Contractor	-
Spares	1 SC
In flight tests phase	2 SC

# Global Navigation Satellite Systems (GNSS)

## Globalni navigacijski satelitski sustavi

- **BeiDou/Compass**

10 m

10 cm (posebno)

– Vojno-komercijalni

– 31. srpnja 2020. potpuno operabilan

### BEIDOU CONSTELLATION STATUS 16.11.20

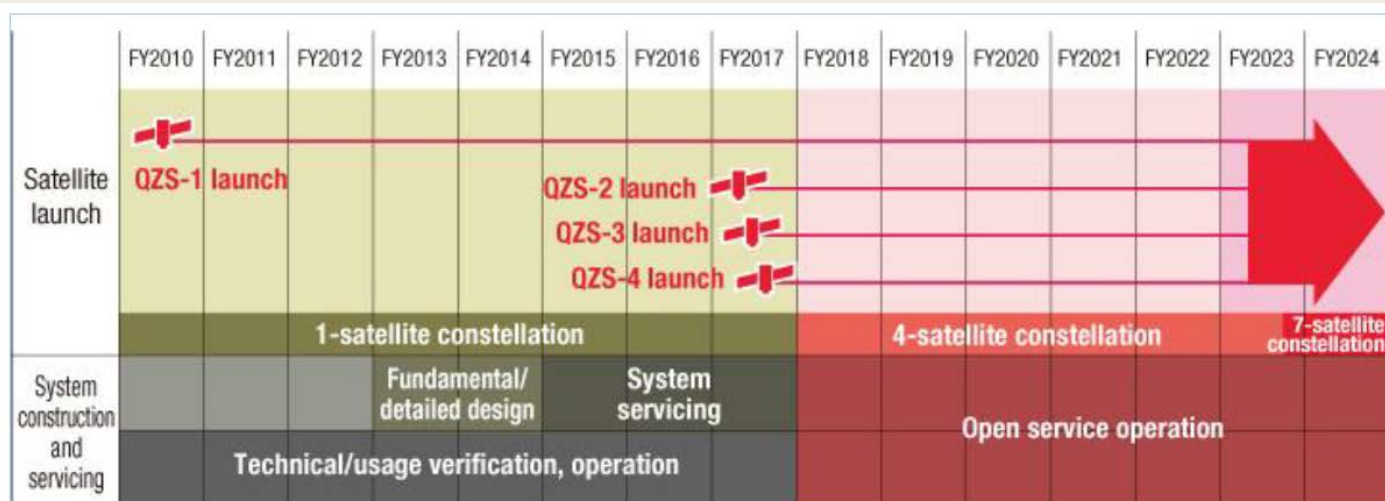
Total satellites in constellation	49
SV is included in operational orbital constellation	44
SV is not included in operational orbital constellation	5



# Global Navigation Satellite Systems (GNSS)

## Globalni navigacijski satelitski sustavi

- Regionalni razmještaj
  - **QZSS** (Quasi-Zenith Satellite System), Japan, 4 satelita (27. 09. 2020.)

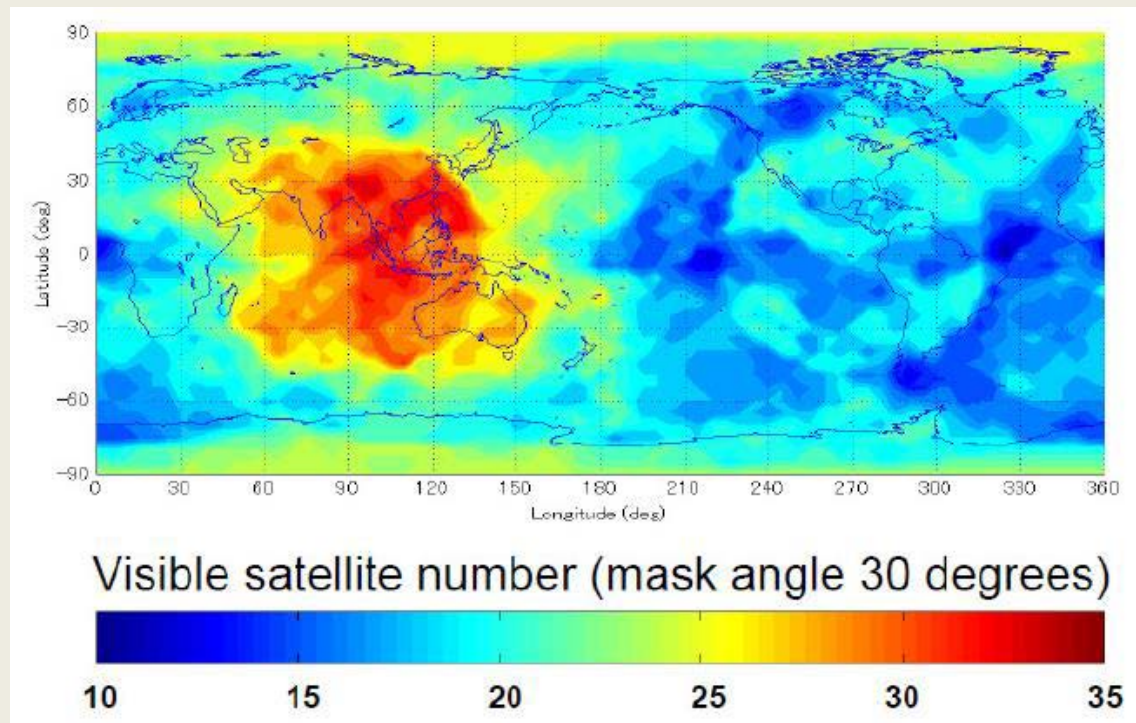


- **NAVIC** (Indian Regional Navigation Satellite System), Indija
  - **NAV**igation **IN**dian **C**onstellation; nāvik 'mornar' ili 'navigator' na Sanskrtu, Hindi.
  - 8 satelita, 2020. civilna uporaba



# Više GNSS signala – u korist korisnika

GPS+GLONASS+Galileo+COMPASS+IRNSS+QZSS



- J, II Azija, Australija s oceanijom – maksimalni broj satelita



# Global Navigation Satellite Systems (GNSS)

## Globalni navigacijski satelitski sustavi

- **Galileo (trenutno 18 satelita u funkciji - FOC)**
  - 23 222 km, 1m, 1 cm (posebno)
  - EU, civilni sustav, u punoj funkciji 2020.??
  - 3 orbitalne ravnine (8 satelita – inklinacija u odnosu na ekvator 56 stupnjeva)
  - Trenutno - 22 satelita (listopad 2018.) 4 – In Orbit Validation (IOV), 18 – Full Operatinal Capability (FOC)



**Total satellites:** 30

**Satellites in orbit:** 18 operational, 2 testing only, 2 unavailable, 2 retired, and 4 commissioning (10/2018)

**Status:** Operational

**Cost:** €10bn

**Operator(s):** GSA, ESA

**Coverage:** Global

**Orbital height:** 23,222 km (14,429 mi)



# Galileo

## Galileo is implemented in a step-wise approach

### By 2020 Galileo will be:

- ★ fully deployed and recognised
- ★ adopted by the widest user communities
- ★ a civilian infrastructure delivering robust positioning and timing services with high degree of performances

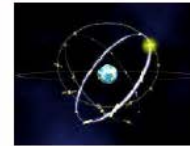
Galileo System Testbed v1  
Validation of critical algorithms  
**2003**



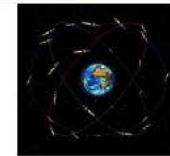
GIOVE A/B  
2 test satellites  
**2005/2008**



In-Orbit Validation  
4 operational satellites and ground segment  
**2013**



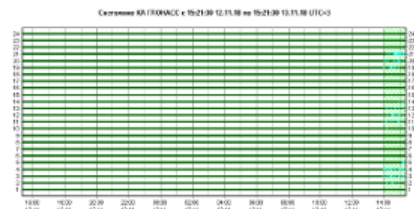
Initial Services Provision  
Initial services for OS, SAR, PRS,  
and demonstrator for CS  
**2016**



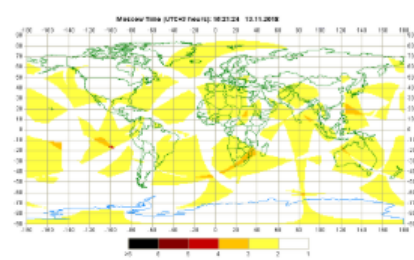
Full Operational Capability  
Full services, 30 satellites  
**2020**



**SC OPERABILITY**



**INSTANT AVAILABILITY**



**EVALUATION OF GNSS CHARACTERISTICS**



**GLONASS NEWS**

06.11.2018 According to GLONASS System Control Centre stopped all works with SC Glonass-M #734 (orbital slot № 5). The SC was removed from GLONASS constellation

21.09.2018 According to GLONASS System Control Centre, maintenance with SC Glonass-M #754 (orbital slot 18) successfully completed at 09:49(MT) 21.09.18, the SC is used for the intended purpose

19.09.2018 According to GLONASS System Control Centre, the SC Glonass-M #754 (orbital slot 18) set unusable from 08:28 (MT) 19.0918, planned commissioning 00:00 (MT) 21.09.18

**SC GLONASS CURRENT POSITION, 15:21 (UTC+3) 13.11.2018**

- orbital plane #1
- orbital plane #2
- orbital plane #3



**GLONASS CONSTELLATION STATUS, 13.11.2018**

Total satellites in constellation	26 SC
Operational	24 SC
In commissioning phase	1 SC
In maintenance	-
Under check by the Satellite Prime Contractor	-
Spares	-
In flight tests phase	1 SC

**OFFICIAL INFORMATION OF THE GLONASS SCC**

[PRECISE EPHEMERIS GLONASS AND GPS](#)

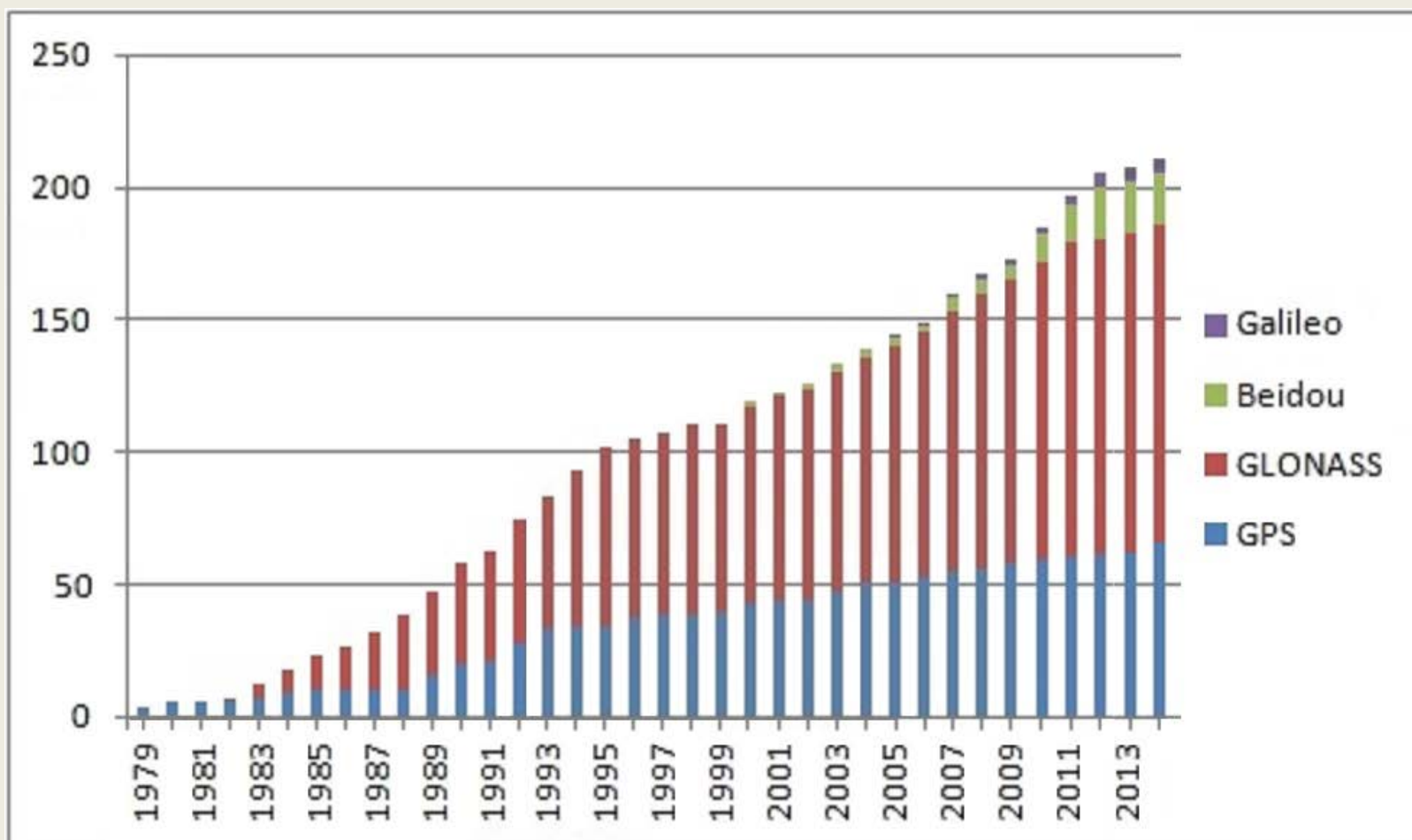
[GLONASS AND GPS ALMANACS](#)

[GLONASS AND GPS BULLETINS](#)

[GNSS USER INFORMATION CENTERS](#)



# Broj lansiranih GNSS satelita 1978. – 2014.



# PDOP (Position Dilution Of Precision)

PDOP is the combination of both the Horizontal and Vertical components of position error caused by satellite geometry.

## PDOP Values

2-4 = Excellent

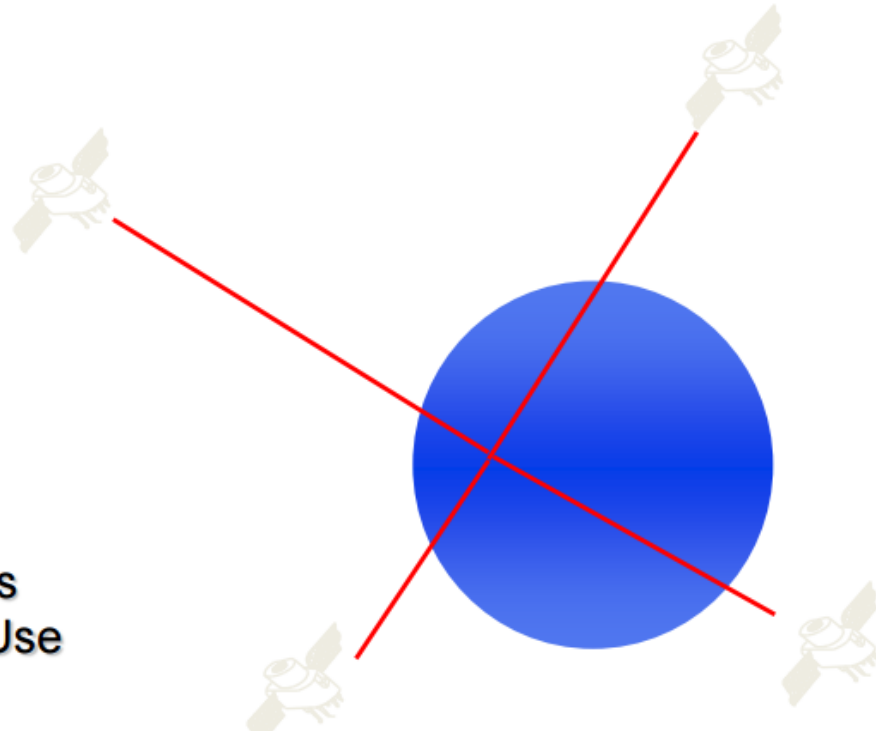
4-6 = Good

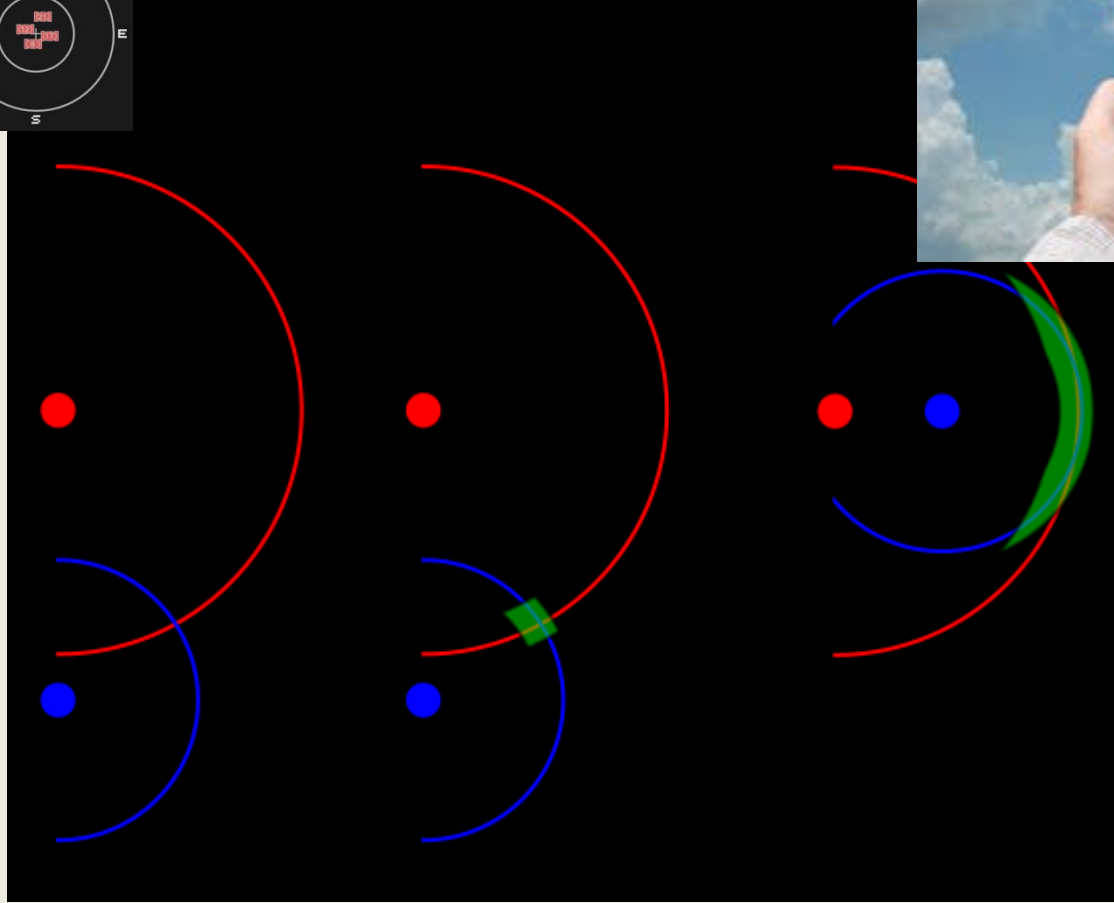
6-8 = Fair

8-10 = Poor

10-12 = Marginal

above 12 PDOP is  
too High Do Not Use



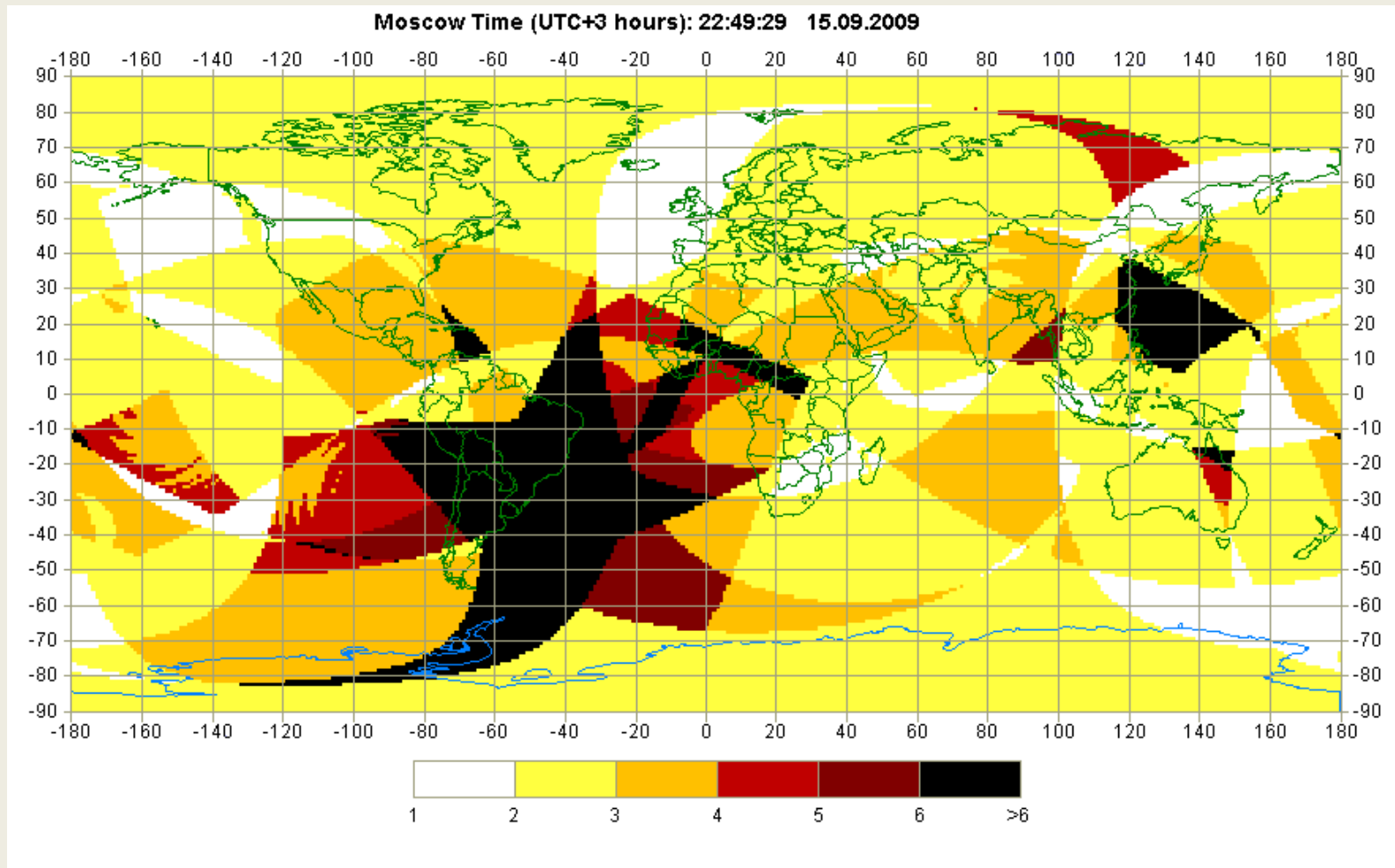


# Pogreške

- Pogreška sata na satelitima (vrlo mala)
- Pogreška sata u GPS prijamniku (4 satelita)
- Pogreška satelitskih orbita
- Efekt ionosfere (ako se ne uzme u obzir – pogreške veće od 10 m) – dvije frekvencije
- Utjecaj troposfere (vodena para)
- Višestruka putanja
- Selektivna dostupnost
- Diferencijalni mod – dva uređaja na bližoj udaljenosti, za jedan znamo točnu lokaciju

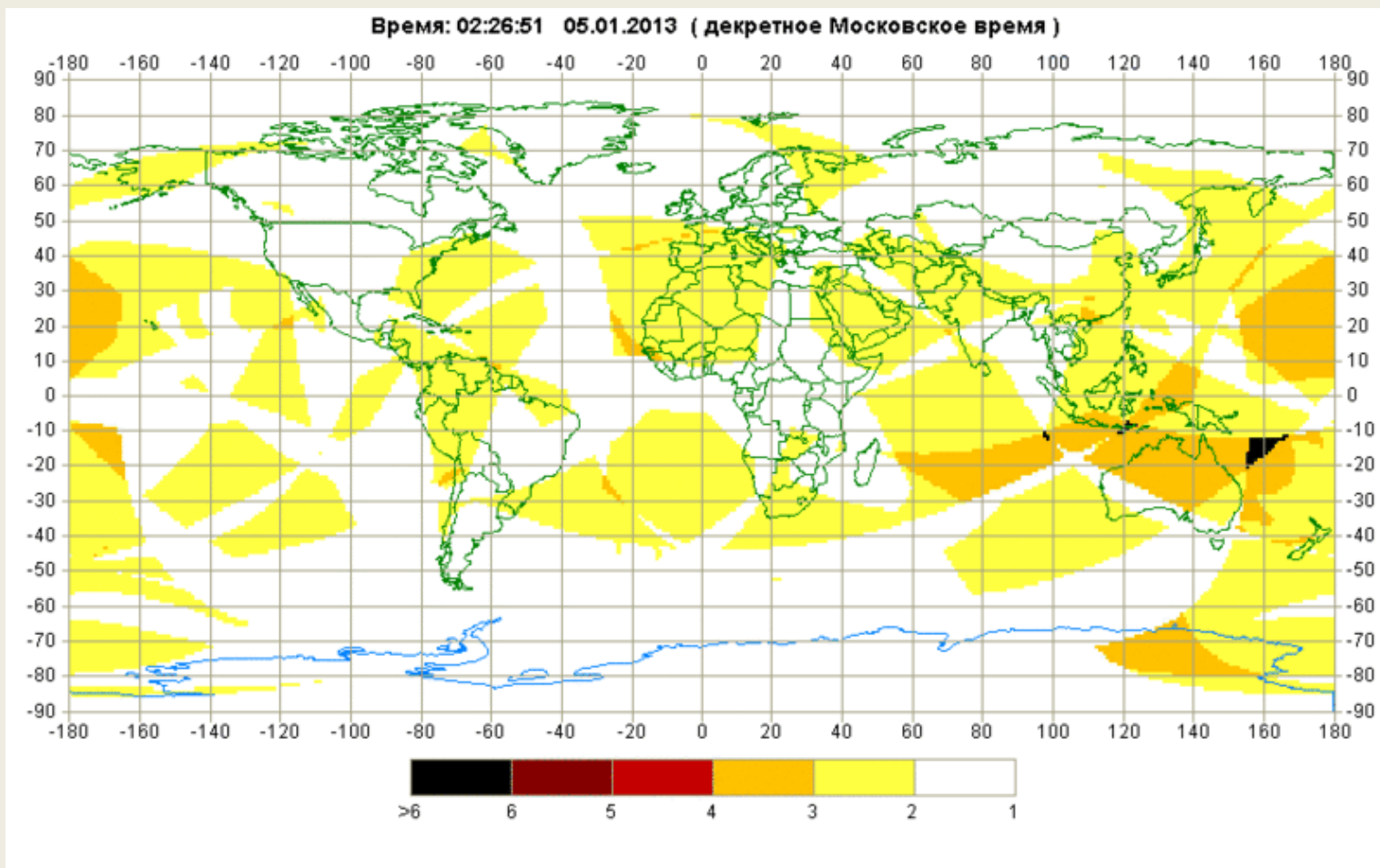


# 2009.

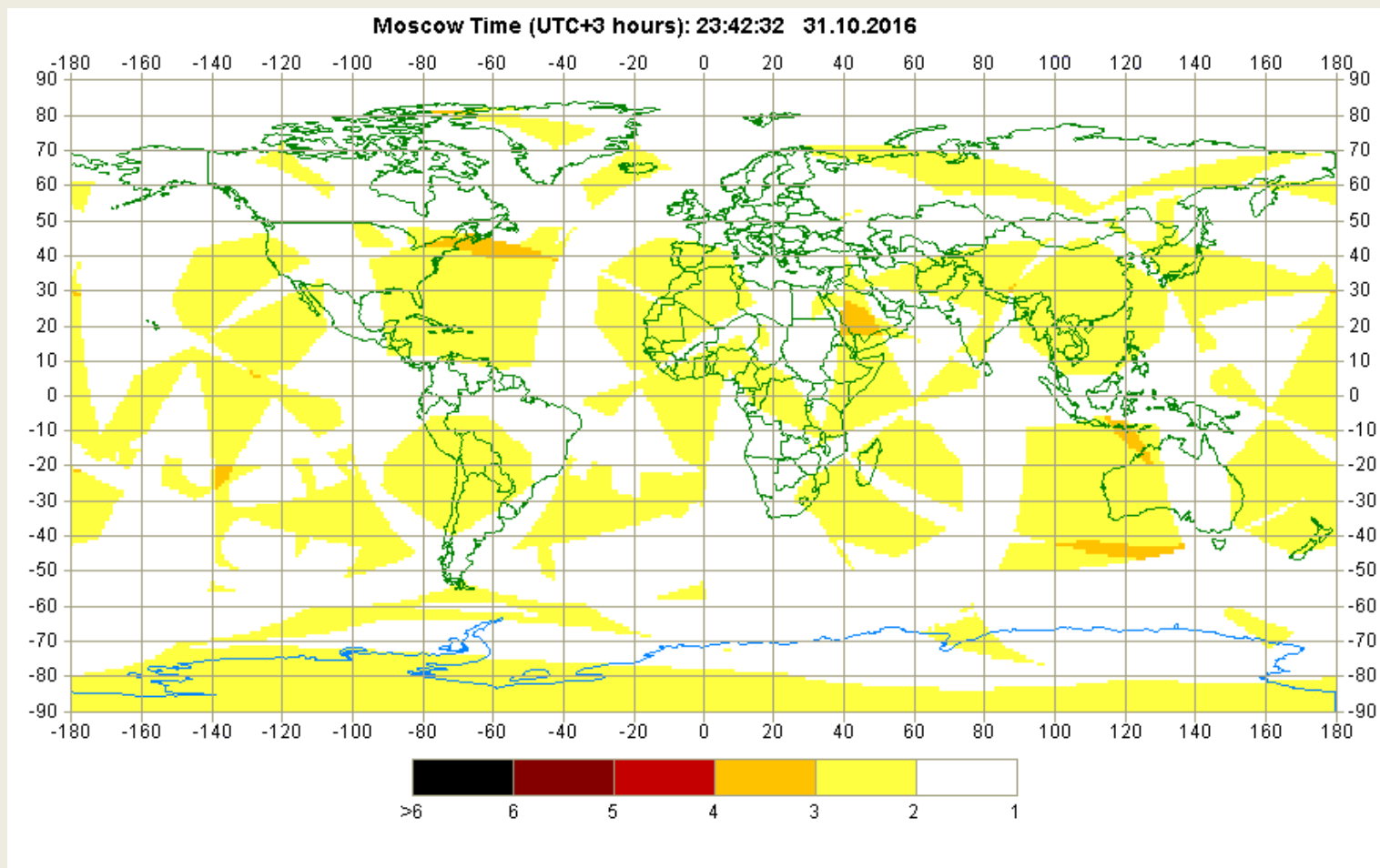




# 2013.



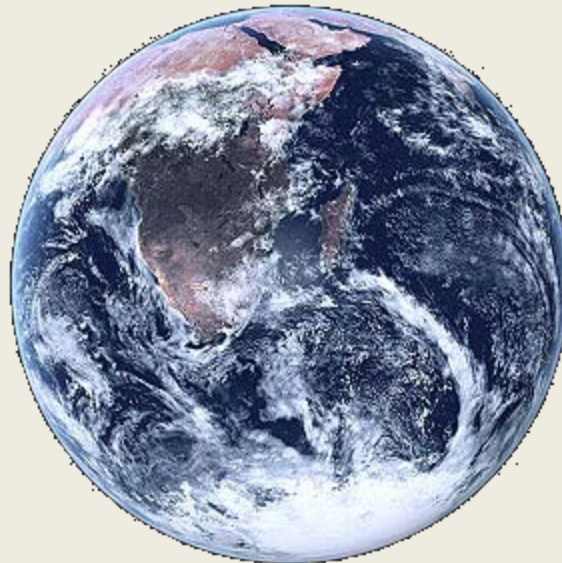
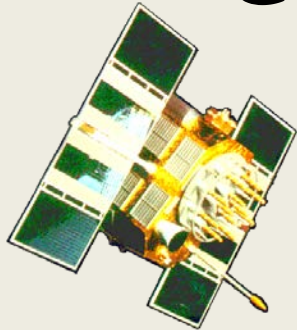
# Trenutne vrijednosti faktora pozicijske geometrije (PDOP – Position Dillution Of Precision) (kut $\geq 5^\circ$ )



# GPS

**Global Positioning System**

**Globalni pozicijski sustav**



# GPS - osnove

- Što je GPS?
- Kako funkcionira?



# Što je GPS?

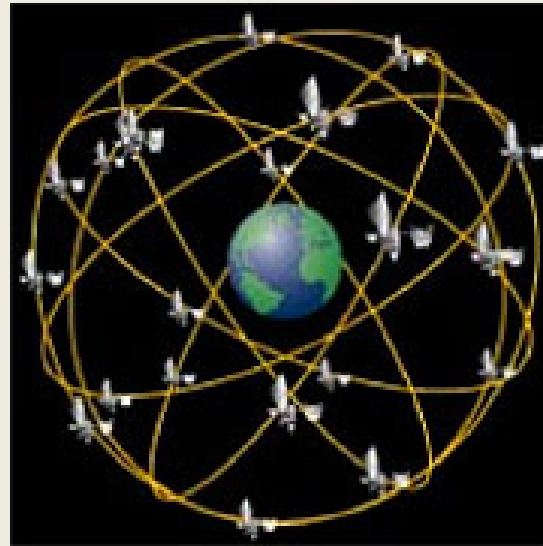
- **NAVSTAR GPS (NAVigation Satellite Timing And Ranging system)**
- 24 satelita u orbiti oko Zemlje (Danas – 28 aktivnih satelita – 4 rezervna aktivna satelita)
- Pozicioniranje, navigacija i vrijeme
- Radi neprekidno 24 h/dnevno, u svim vremenskim uvjetima
- Može se primijeniti svugdje gdje je potrebna informacija o lokaciji
- GPS signal putuje do Zemlje – 0,067 sekundi
- Signali male snage (20 do 50 W)





# Segmenti GPS-a

*Svemirski*



*Korisnički*



*Kontrolni*



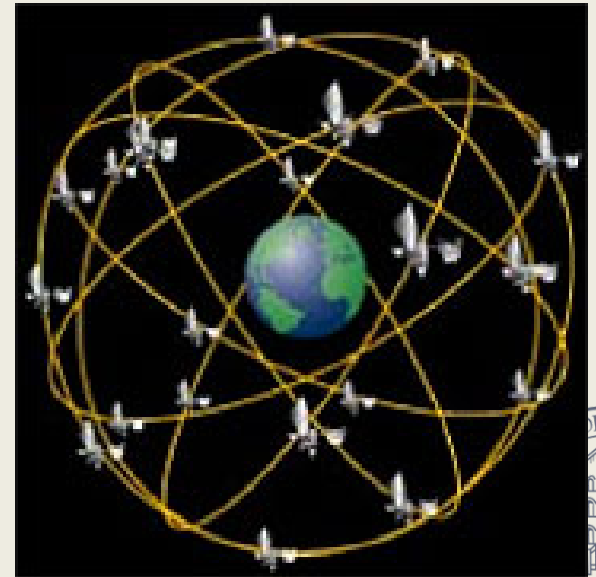
# Svemirski segment: GPS Sateliti

- Napajanje
  - Solarna energija
  - Nicad baterije
- Vrijeme
  - 4 atomska sata



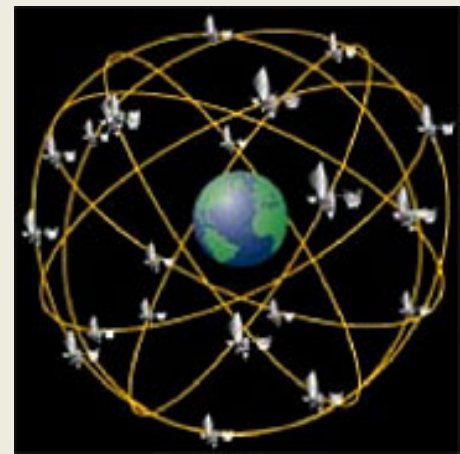
# Sateliti

- 24 satelita u 6 orbitalnih ravnina s inklinacijom u odnosu na ekvator od  $55^\circ$  (4 satelita u svakoj ravnini).
- Sateliti kruže na visini oko 20,200 km. Satelit obiđe Zemlju u 12 sati.



# Sateliti

- Puna konstelacija satelita omogućava globalnu prekrivenost s 4 do 8 satelita, koji se mogu simultano opažati pri elevaciji iznad horizonta većoj od  $15^\circ$
- Ukoliko se elevacijska maska reducira na  $10^\circ$  ili čak  $5^\circ$  moguće je povremeno opažati i do 10 odnosno 12 satelita.

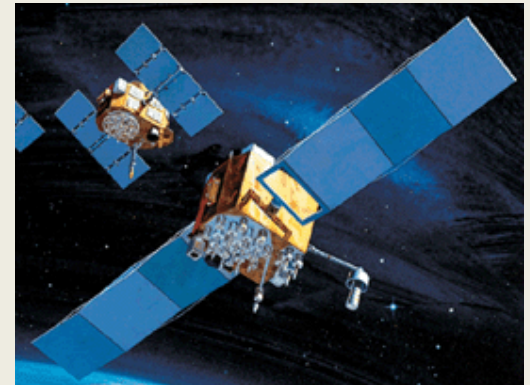


# Satelitski signali

- GPS sateliti emitiraju poruke putem radio signala na dvije frekvencije
  - L1: 1575.42 Mhz (C/A i P/Y kod)
  - L2: 1227.60 Mhz (P/Y kod)
- Na noseće valove modulirani su različiti kodovi, tzv. PRN kodovi (C/A, P) sa svrhom mjerenja udaljenosti iz mjerenja vremena puta signala
- Dvije razine usluge
  - Standard Positioning Service (SPS)
  - Precise Positioning Service (PPS)

C/A – Coarse/Acquisition code (grubo stjecanje) SPS

P/Y – Precision code (Precizni kod) PPS
- Selective availability (selektivna dostupnost – do 1. lipnja 2000.)





# Satelitski signali

- Satelitski signali zahtijevaju direktnu vezu s GPS prijemnicima
- Signali ne mogu prodirati kroz vodu, tlo, zidove ili druge prepreke



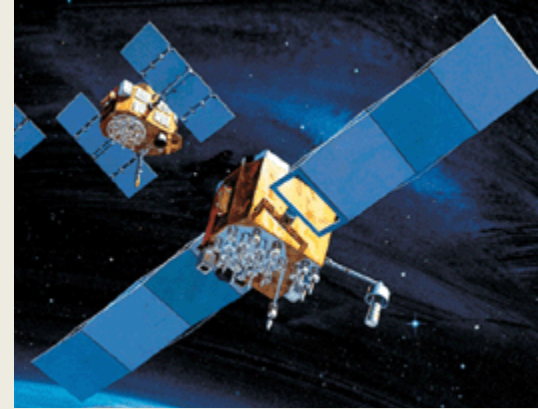
# Kontrolni segment: kontrolne stanice – glavna u Colorado Springsu



# → GALILEO GROUND SEGMENT OVERVIEW



# Korisnički segment



WWW.WALTON.COM





From April 2018

Galileo compatibility required in every new car/van model sold in Europe

1

#### Emergency Call

A 112 emergency call (eCall) is made automatically by the car as soon as on-board sensors (e.g. the airbag sensors) register a serious accident. By pushing a dedicated button in the car, any car occupant can also make an eCall manually.

2

#### Positioning

Via satellite positioning and mobile telephony caller location, the accurate position of the accident scene is fixed and then transmitted by the eCall to the nearest emergency call centre. More information is given in the eCall, e.g. the direction of travel and the vehicle type.

3

#### Emergency call centre (PSAP)

The eCall's urgency is recognized, the accident's location can be seen on a screen. A trained operator tries to talk with the vehicle's occupants to get more information. If there is no reaction, emergency services are sent off without delay.

4

#### Quicker help

Thanks to the automatic notification of the crash site, the emergency services (e.g. ambulance, fire fighters, police) arrive much quicker there. Time saved translates into lives saved.

Today

13 Millions of light vehicles sold every year in EU

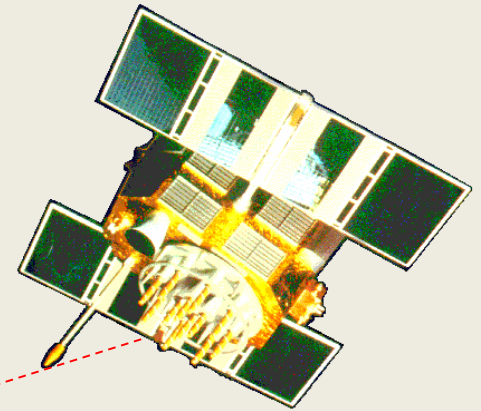
United Nations Economic Commission for Europe (UNECE) working in a eCall harmonised regulation

Decision in 2017



# Kako radi GPS?

## Izračunava poziciju



- GPS prijemnik izračunava svoju poziciju mjereći udaljenost do satelita
- Kako?
- Signal sa satelita sadrži podatke o orbiti i vremenu
- GPS prijemnik na temelju vremena putovanja signala izračunava udaljenost GPS prijemnik-satelit

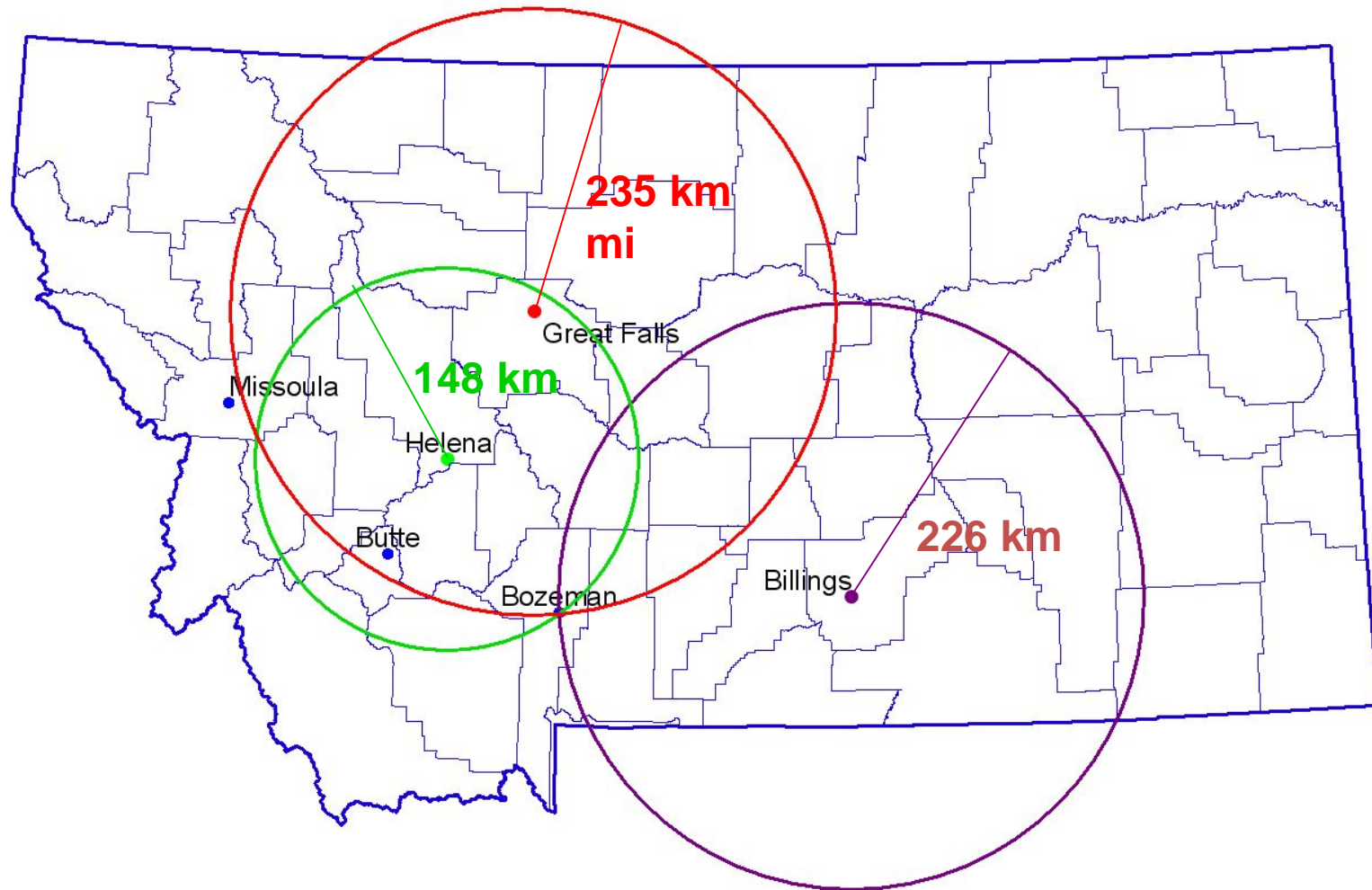
# Izračunavanje udaljenosti do satelita

- 1. Mjerenje vremena koje je potrebno da signal prijeđe put od satelita do prijemnika
- 2. Brzina svjetlosti (300 000 km/h) x vrijeme putovanja = udaljenost
- Potrebno je izmjeriti udaljenost do 4 satelita kako bi se dobila 3-D pozicija (geog. širina, dužina i visina)



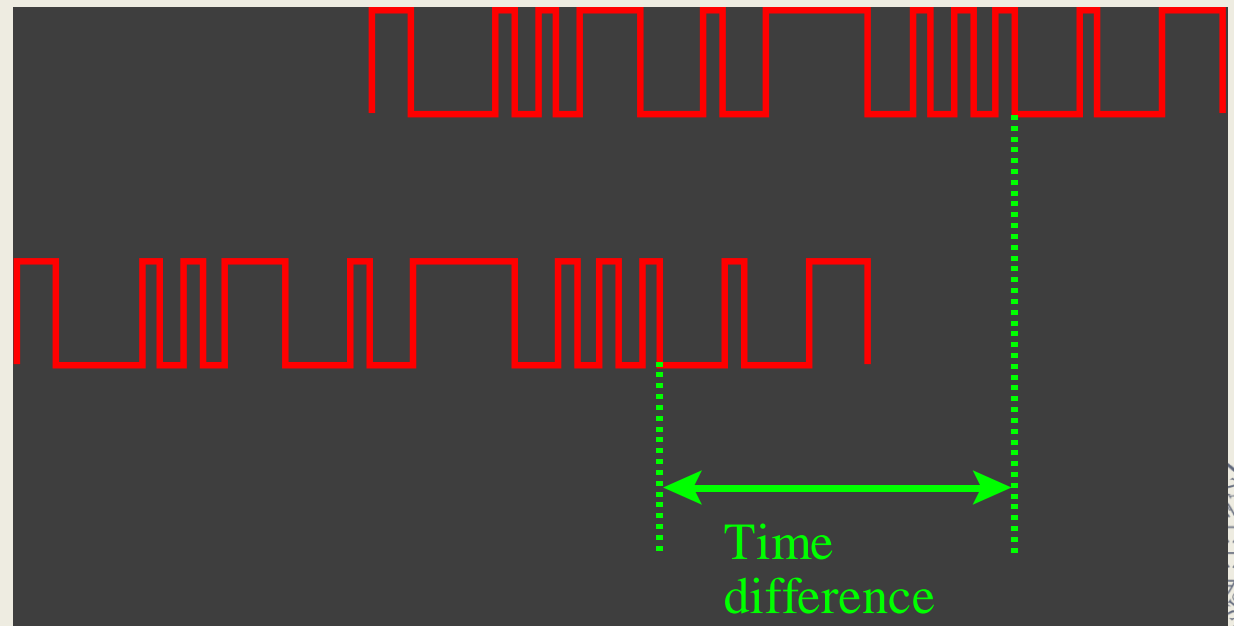


# Izračunavanje 3 udaljenosti

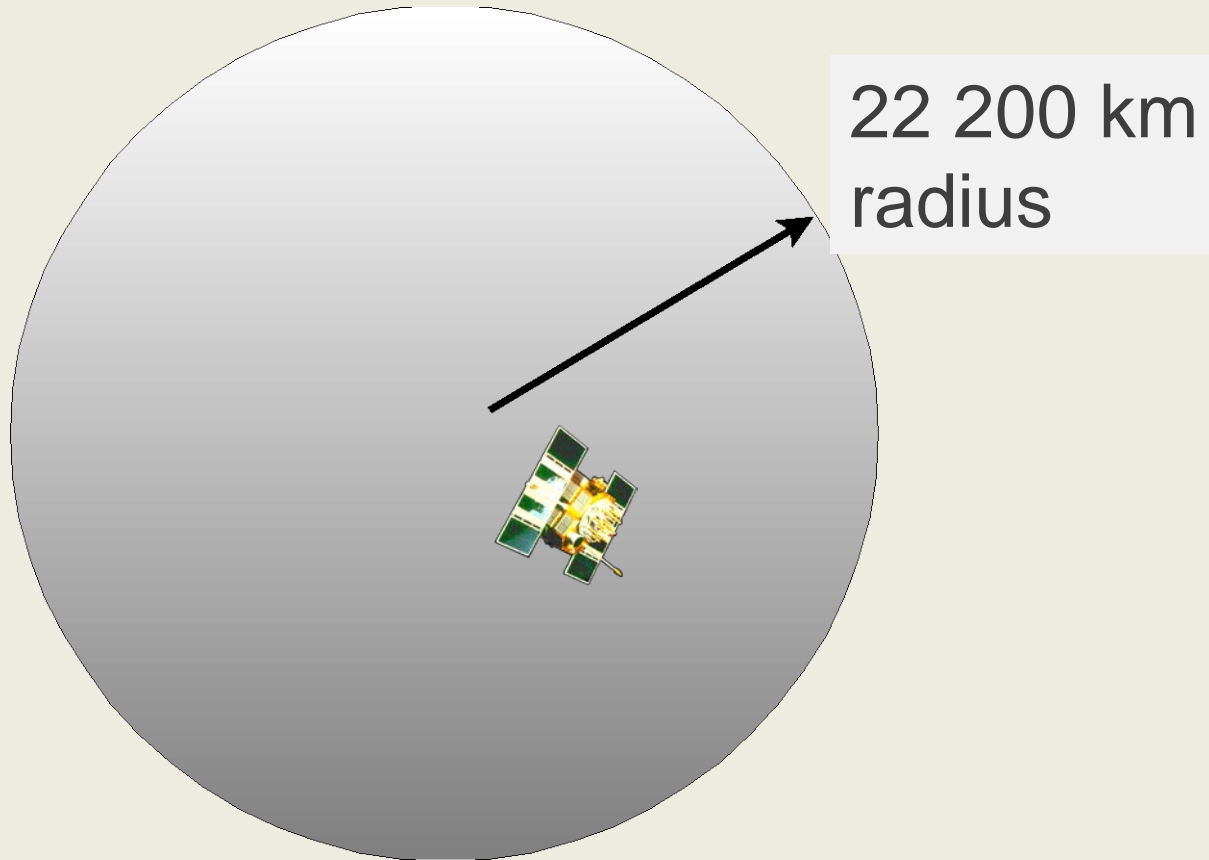


# Mjerenje vremena putovanja satelitskih signala

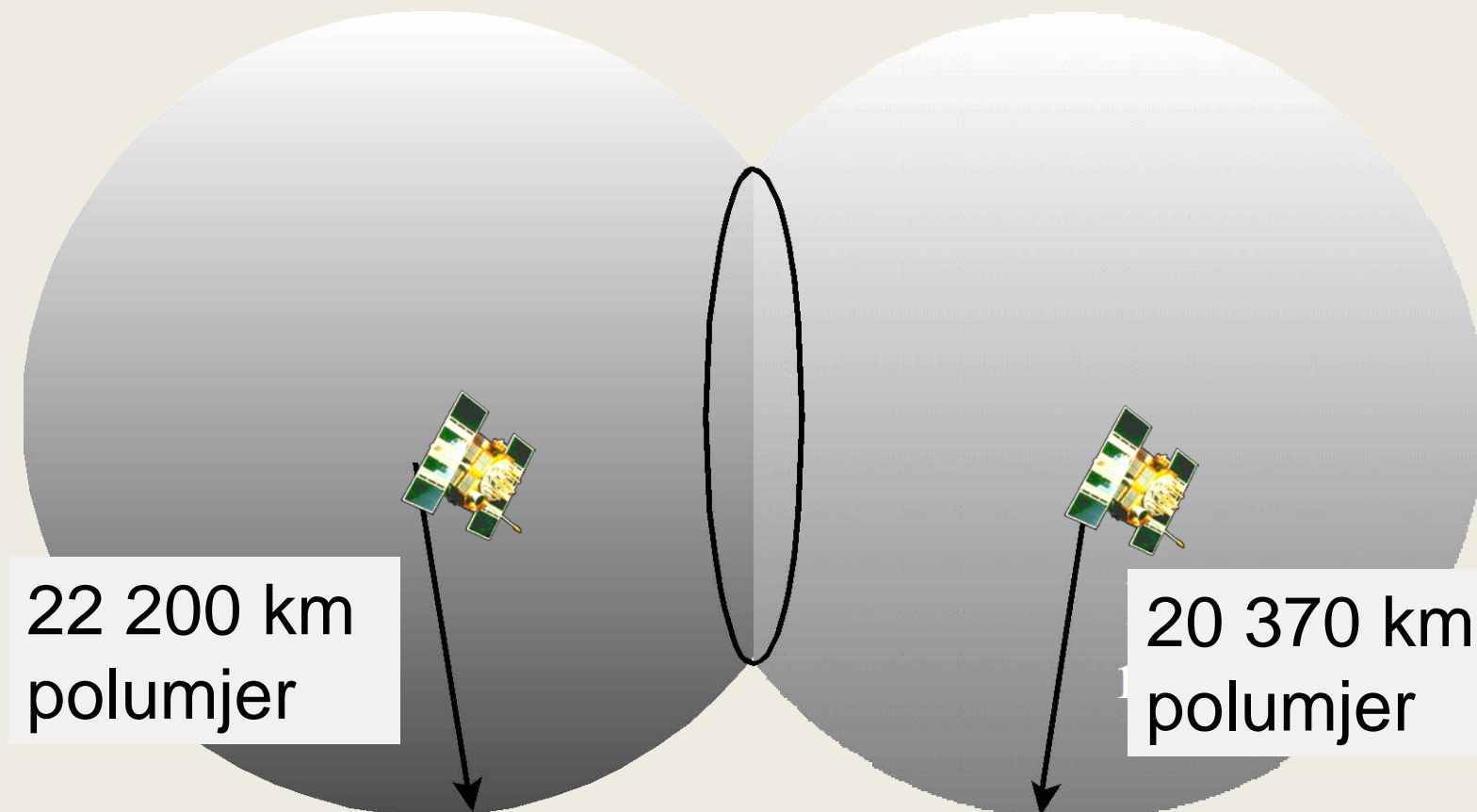
- *Zna li se točno vrijeme kada je signal napustio satelit?*
- *Sinkronizirani kodovi*



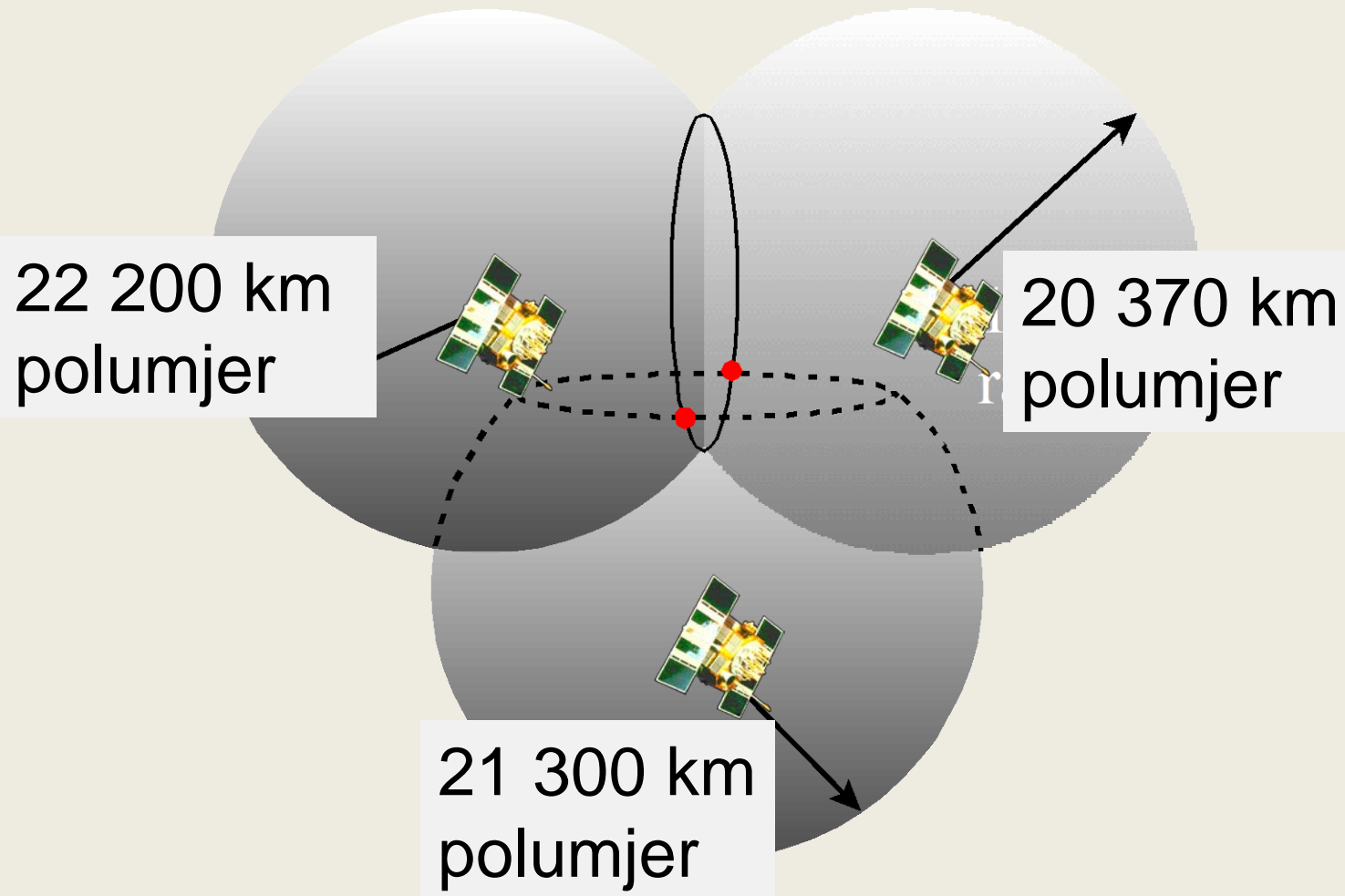
Jedna udaljenost – naš položaj može biti  
bilo gdje na površini sfere  
 $r = 22\,200\text{ km}$



# Druga udaljenost – smješta našu lokaciju na presjecište dvaju sfera - kružnicu



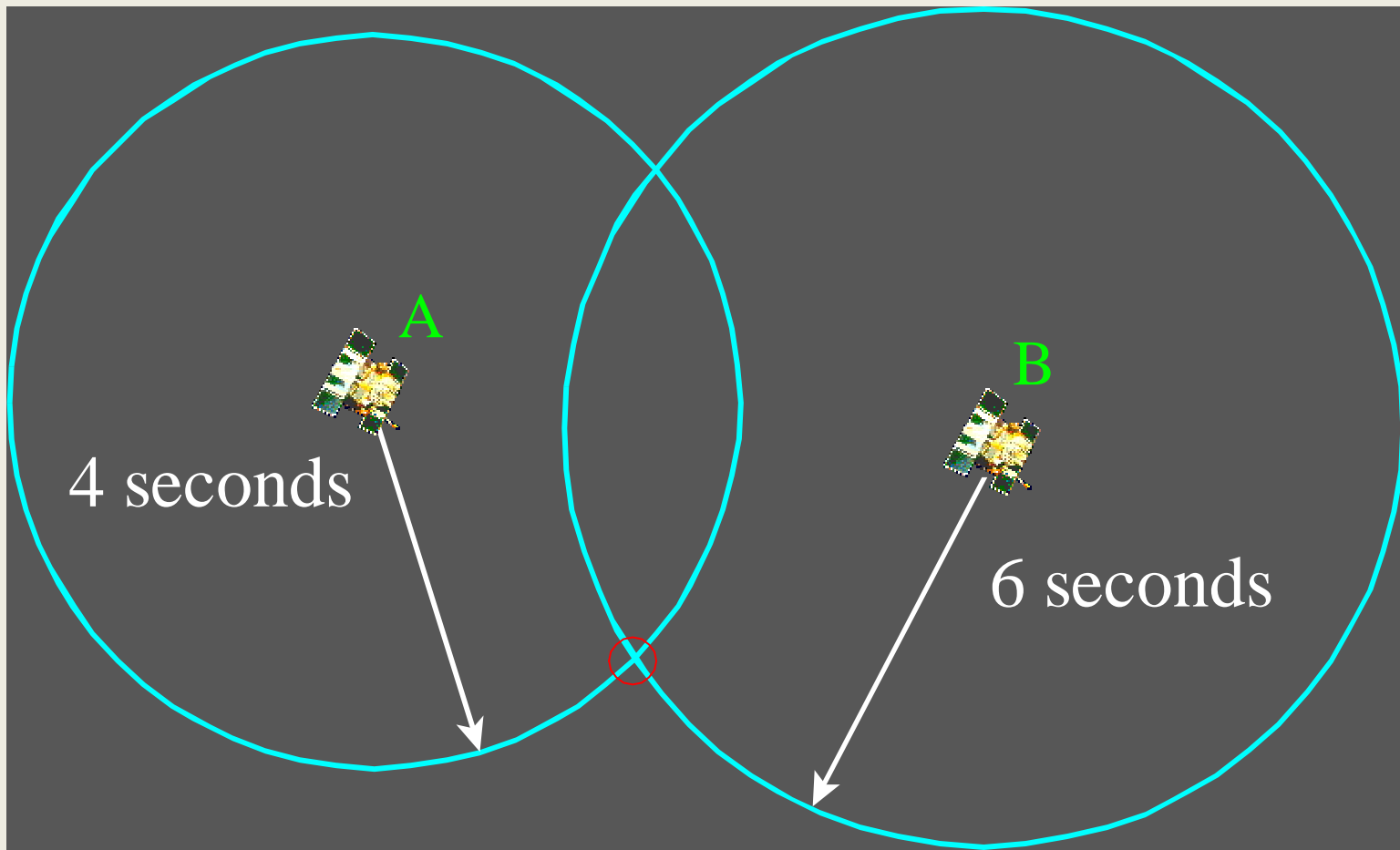
# Treća udaljenost – naš položaj sužava na dvije točke



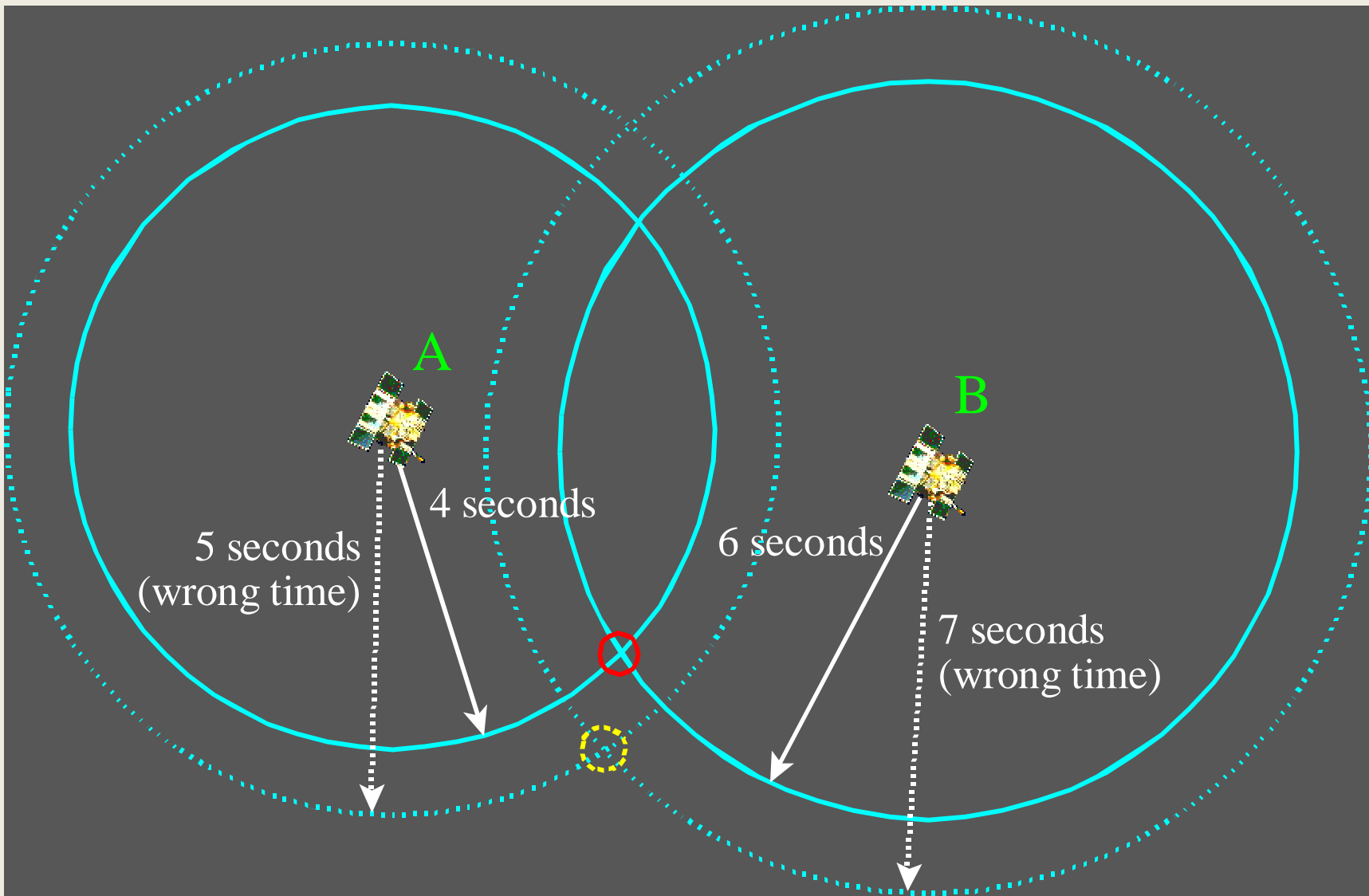
# Korekcija vremena

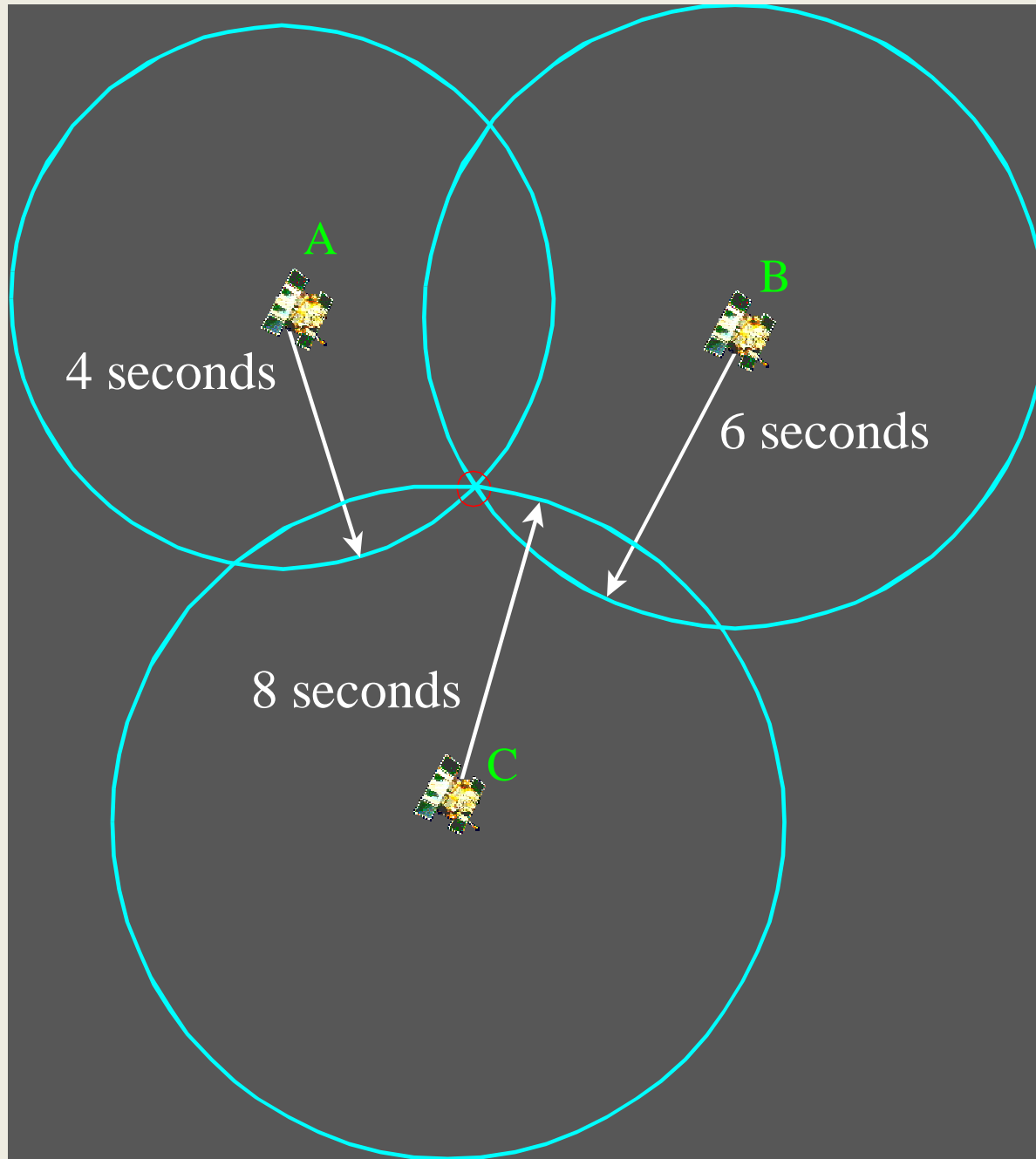
- Signali s tri satelita – omogućuju određivanje našeg položaja
- Četvrto mjerenje je potrebno zbog korekcije (razlika između satelitskih satova i sata u GPS prijamniku)
  - Sateliti – vrlo točni atomski satovi
  - GPS prijamnici – kvarcni satovi

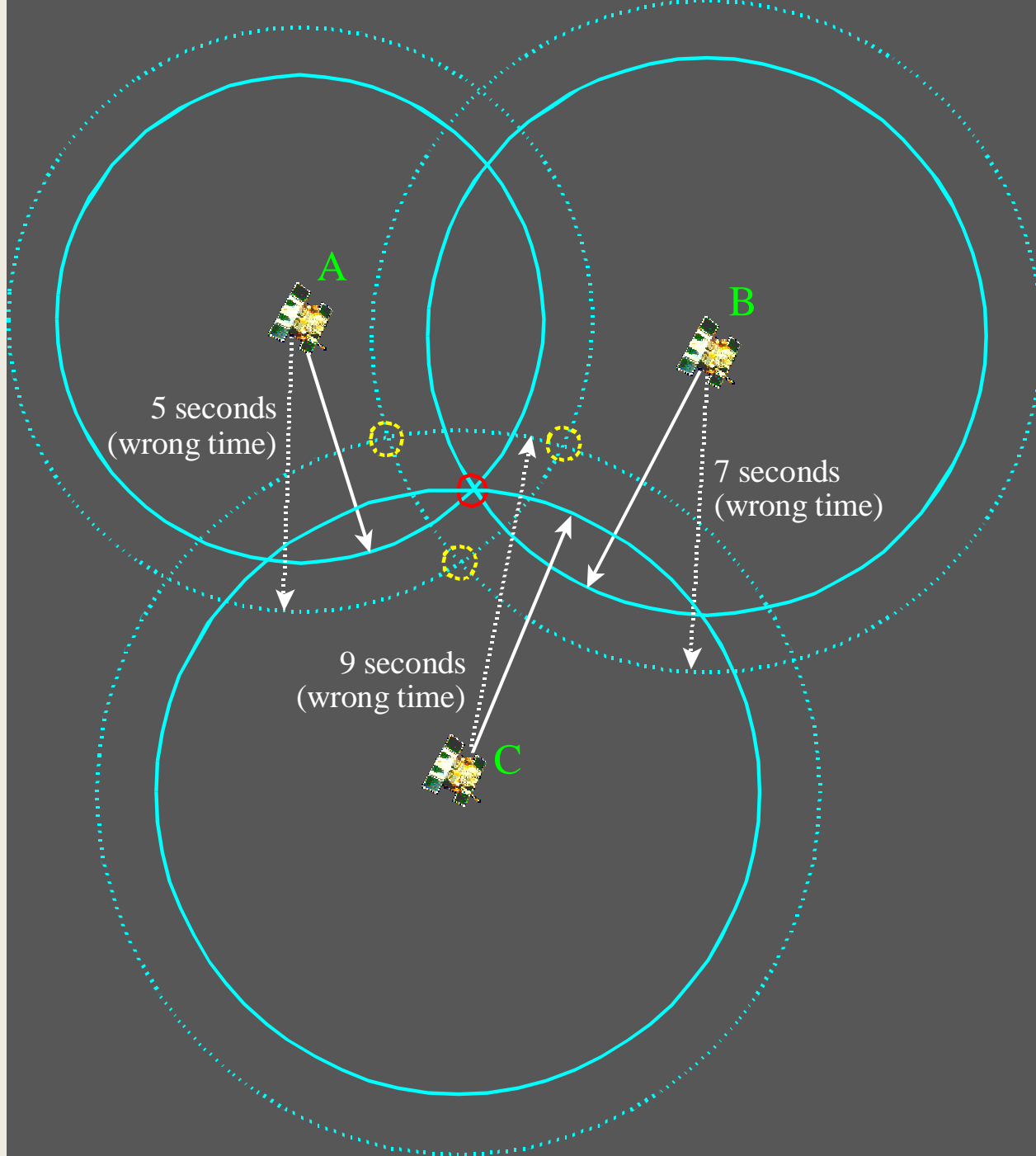












# Što nije u redu na ovoj slici?





# Što nije u redu na ovoj slici?

The GeoExplorer receiver should be held level so it can receive signals from all GPS satellites above

The Omnistar receiver cannot receive differential corrections because it is upside-down

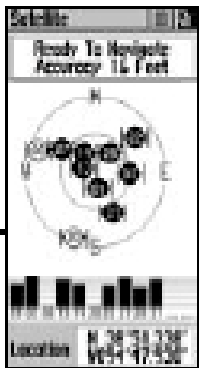


# Ručni GPS uređaj (Garmin)

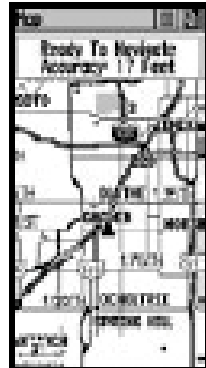
- Model eTrex-Vista



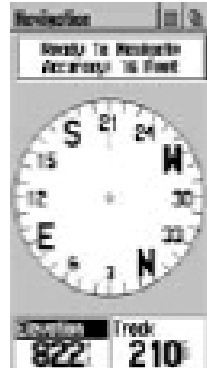
# Osnovni izbornici



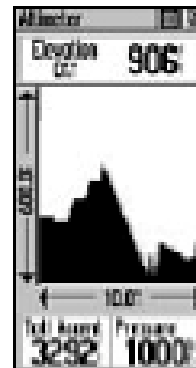
*Satellite Page*



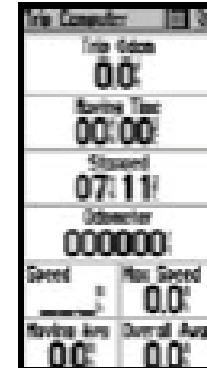
*Map Page*



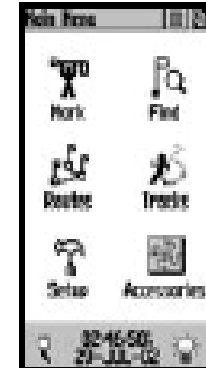
*Navigation Page*



*Altimeter Page*



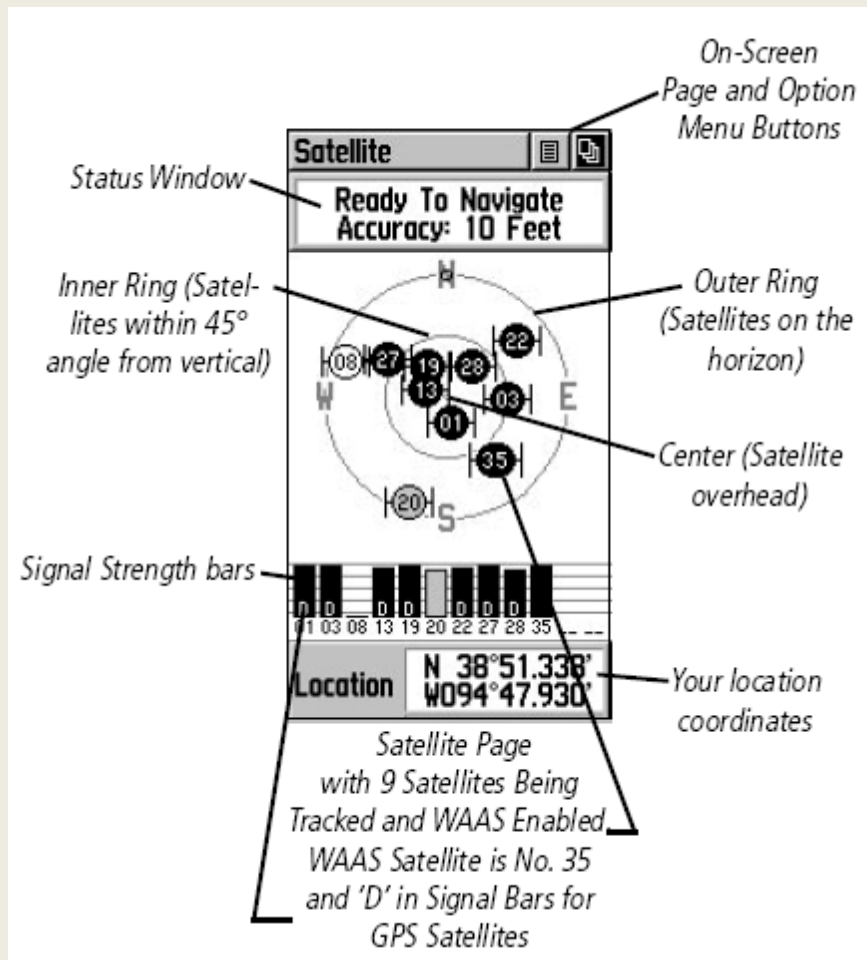
*Trip Computer*



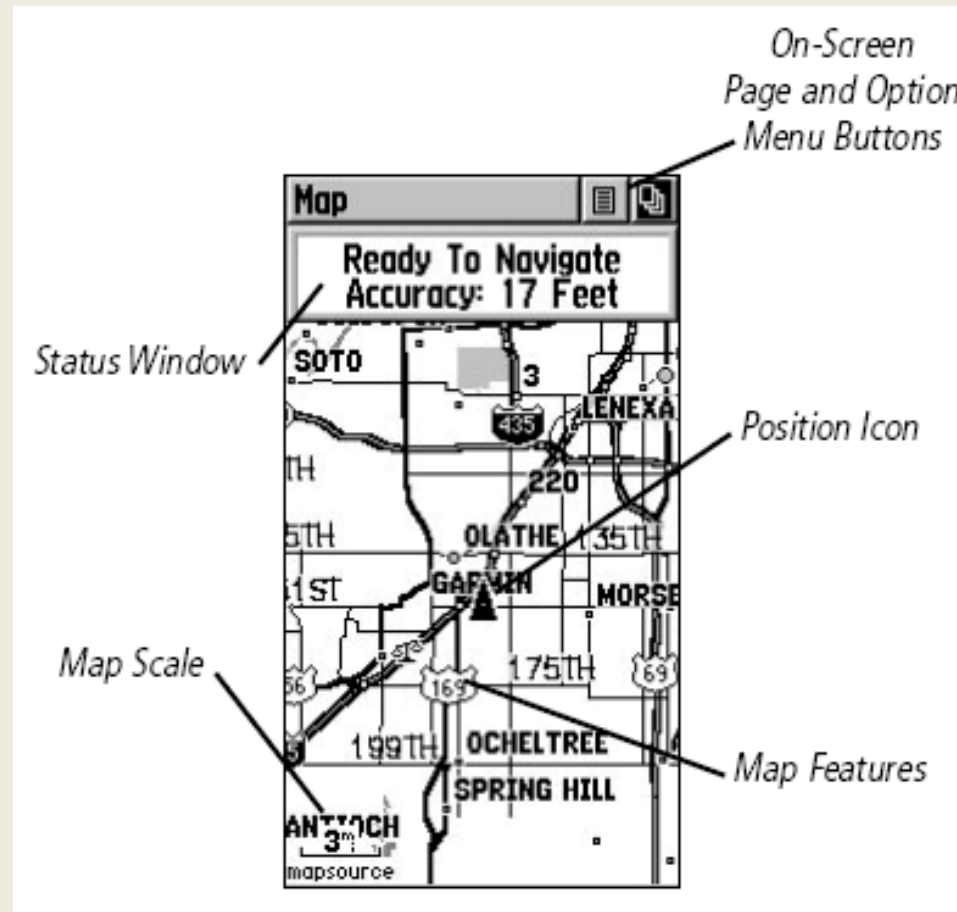
*Main Menu*



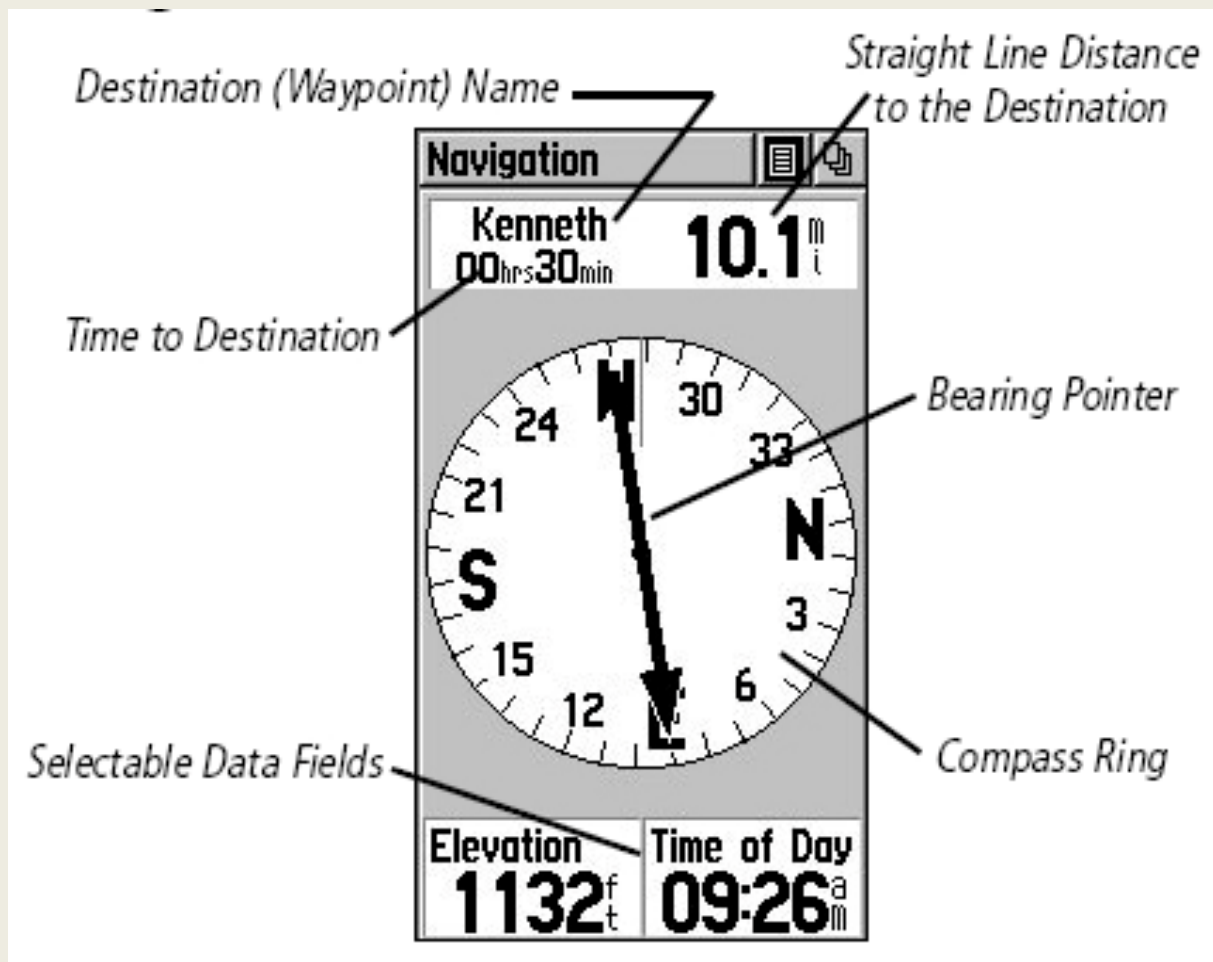
# Izbornik - Sateliti



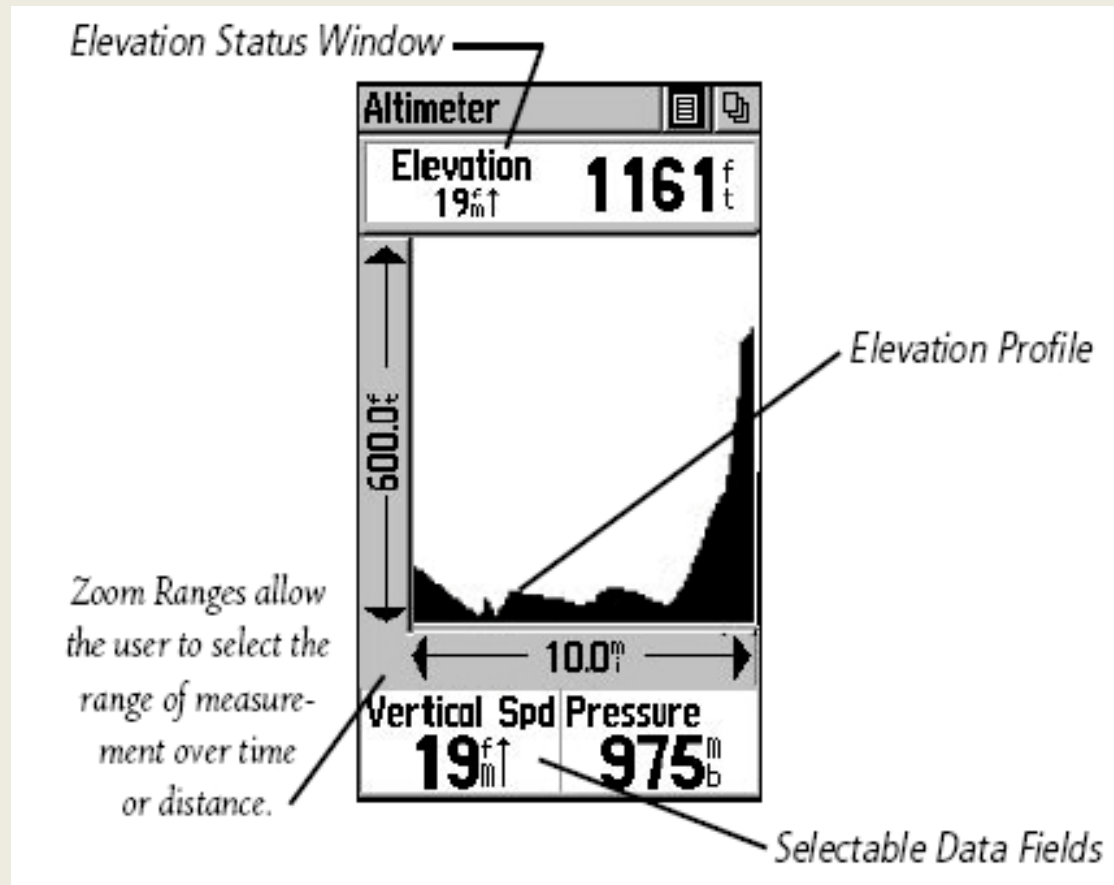
# Izbornik - Karta



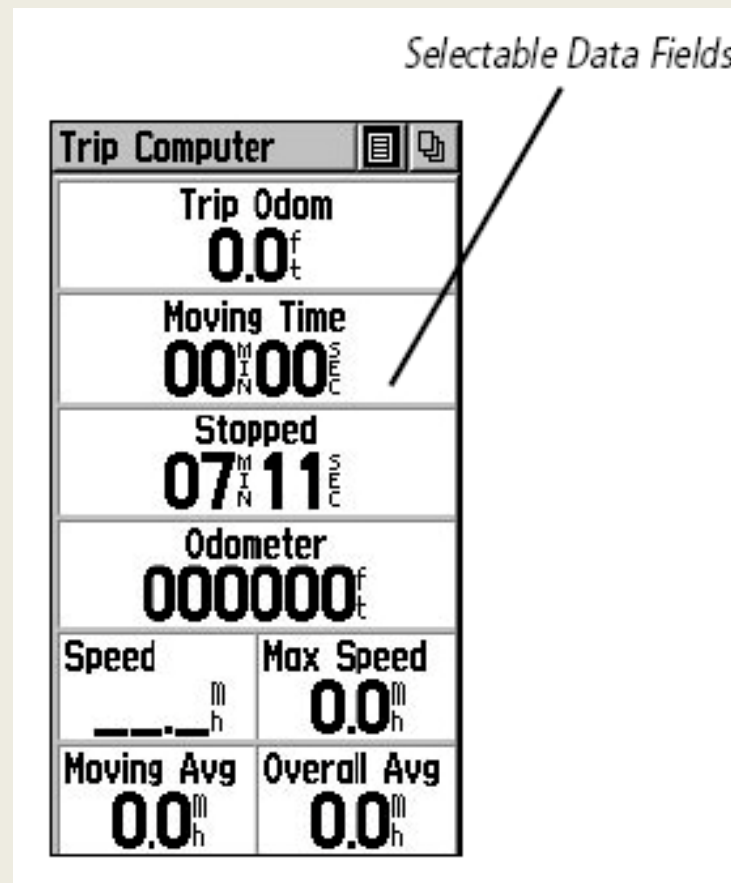
# Izbornik - Kompas



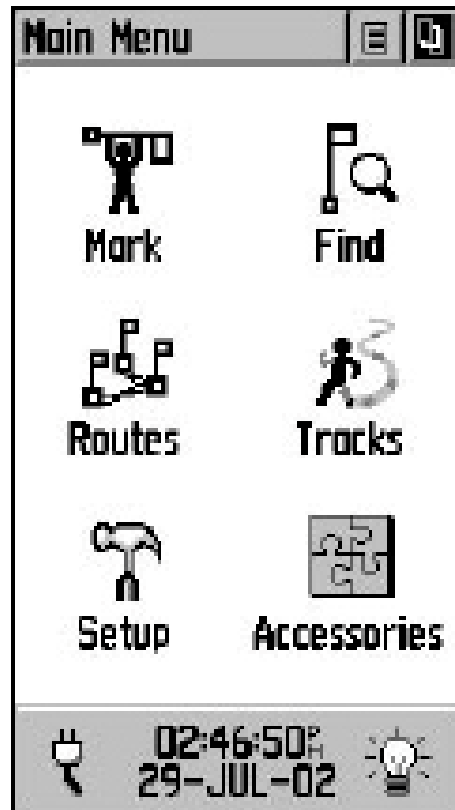
# Izbornik - Altimetar



# Izbornik – putno računalo



# Glavni izbornik



Tablica 1. *Postojeći i planirani satelitski navigacijski sustavi.*

<b>Država</b>	<b>GNSS</b>	<b>RNSS</b>	<b>SBAS</b>
SAD	GPS		WAAS (Wide Area Augmentation System)
Rusija	GLONASS		SDCM (System for Differential Corrections and Monitoring) – u razvoju
Europa	Galileo		EGNOS (European Geostationary Navigation Overlay Service)
Kina	BeiDou		SNAS (Satellite Navigation Augmentation System) – u razvoju
Indija		NavIC	GAGAN (GPS and GEO Augmented Navigation)
Japan		QZSS	MSAS (Multi-functional Satellite Augmentation System)

SBAS-a (Satellite Based Augmentation Systems) (tablica 1). SBAS pruža informacije o točnosti, integritetu i dostupnosti navigacijskih rezultata dobivenih GNSS-om. Međusobna interoperabilnost svih tih sustava omogućit će veću pouzdanost i dostupnost sustava uvođenjem novih poboljšanih signala i servisa namijenjenih ponajprije civilnim korisnicima.

