

**The French Institute of Science
and Technology for Transport,
Development and Networks**

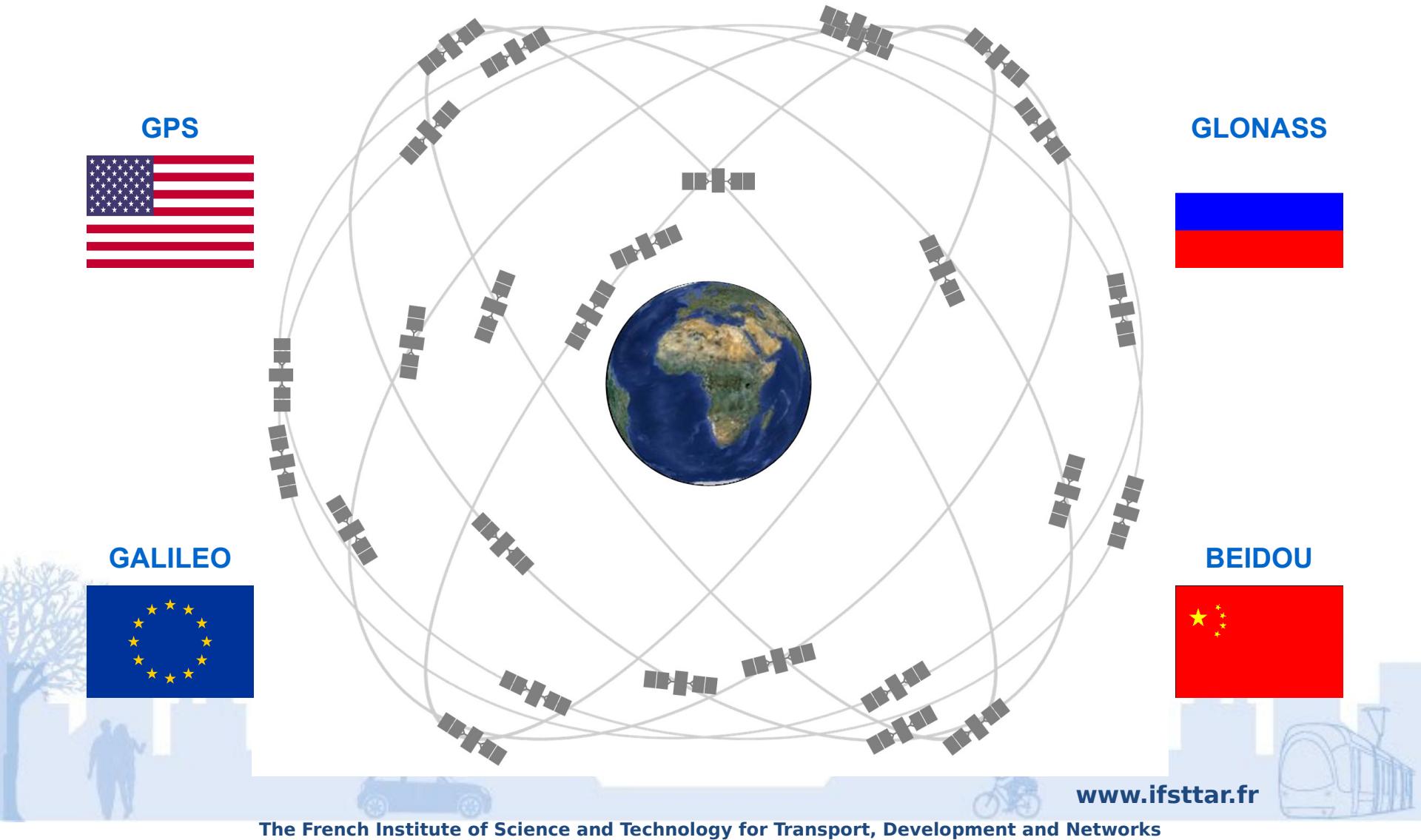
Using GNSS Raw Measurements on Android Devices



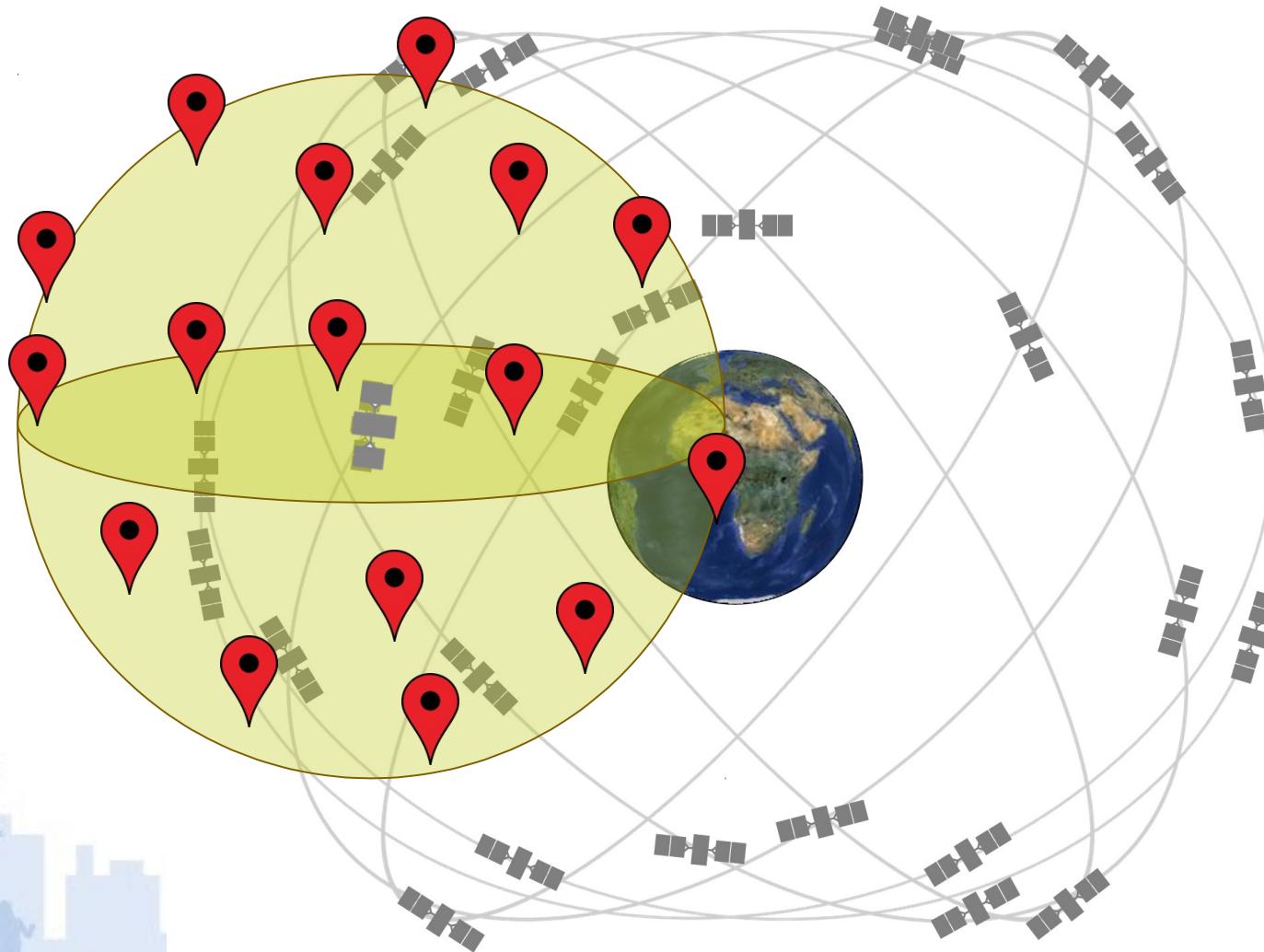
José Gilberto Reséndiz Fonseca

GNSS

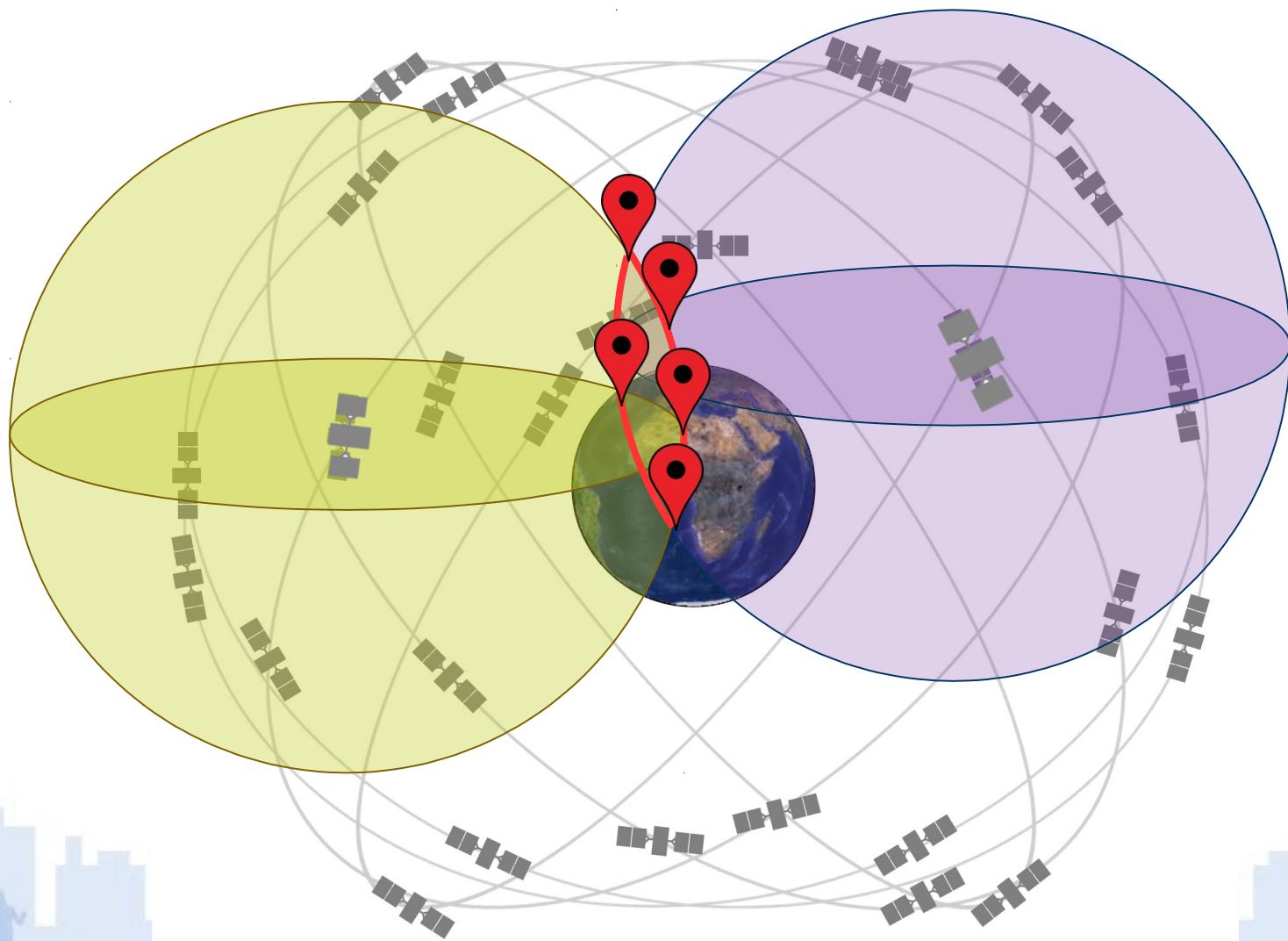
(Global Navigation Satellite System)



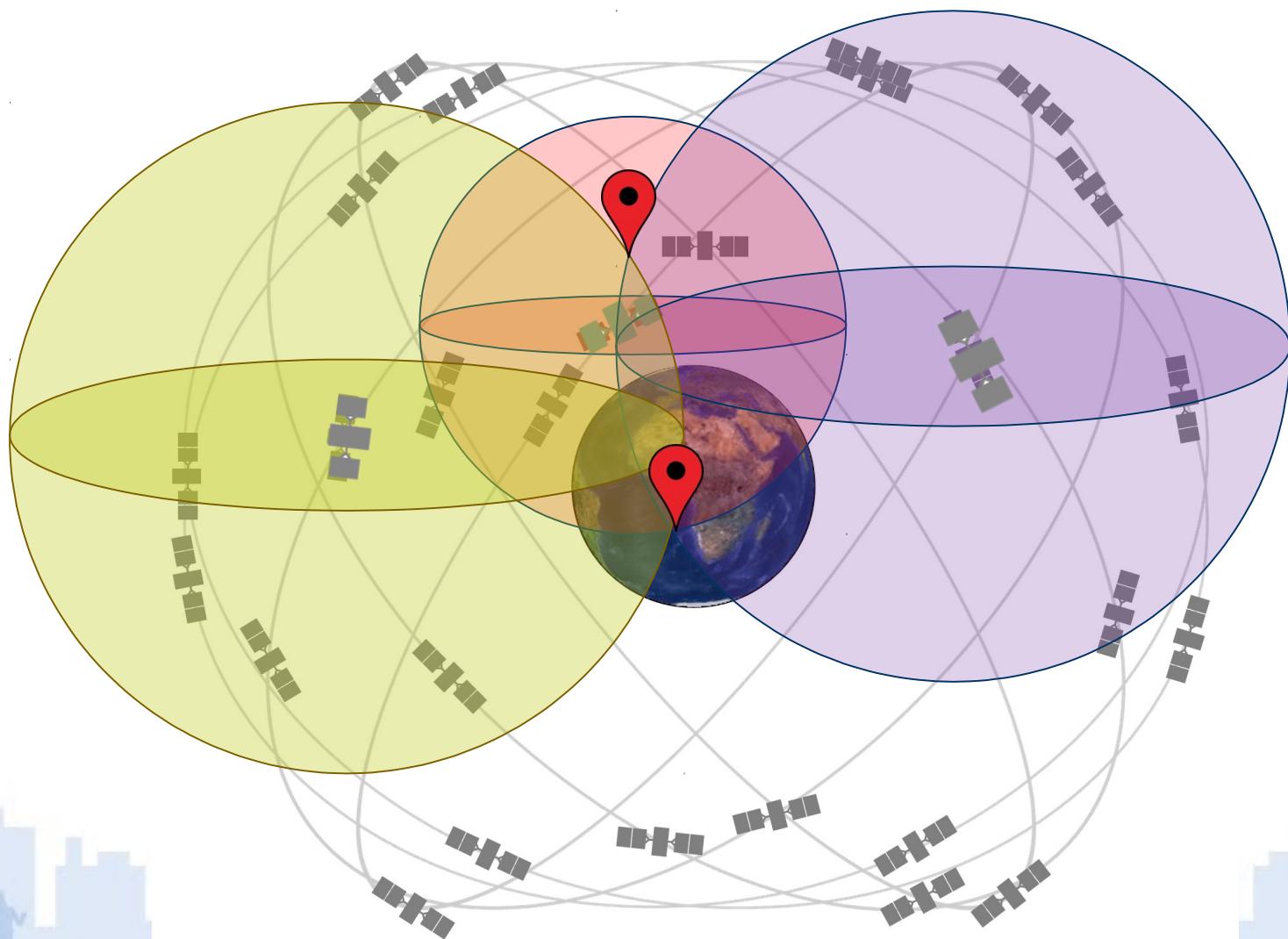
Positioning Principle



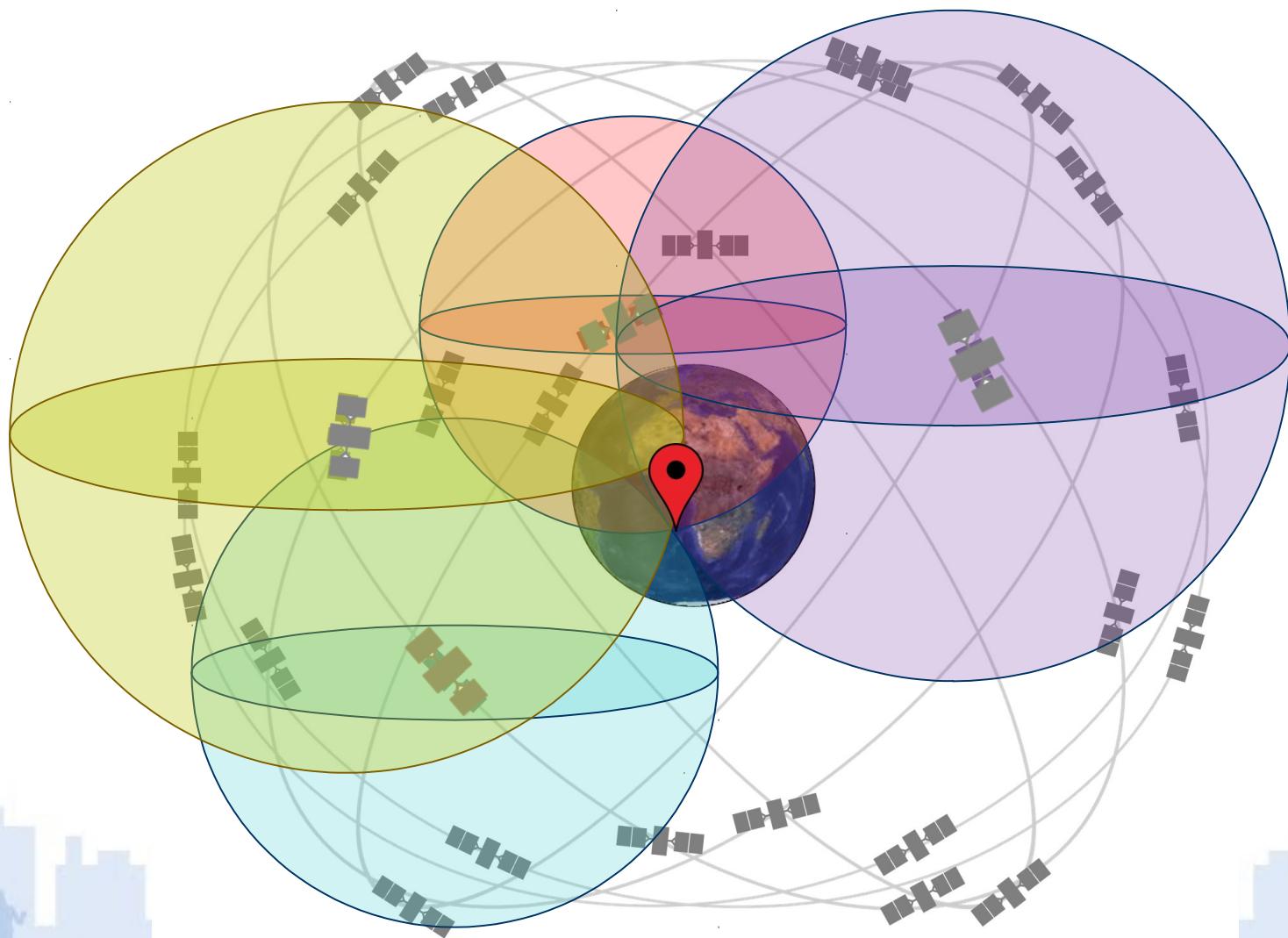
Positioning Principle



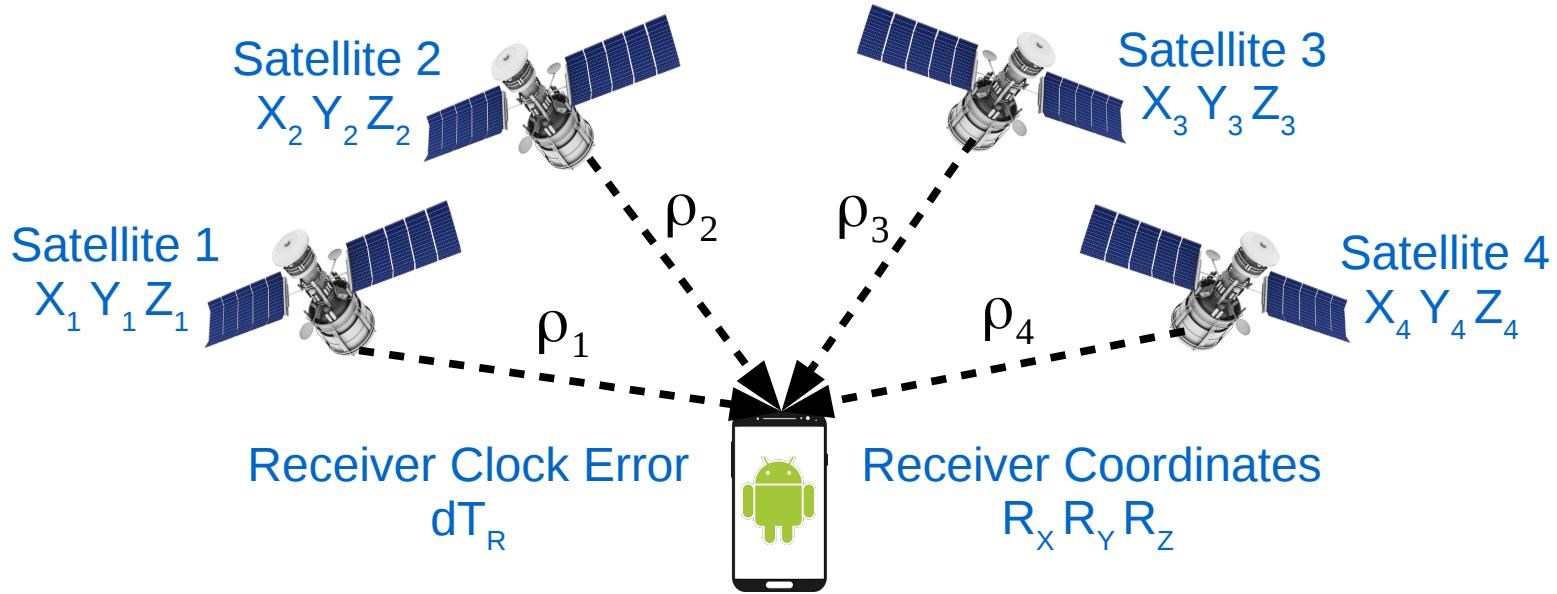
Positioning Principle



Positioning Principle



Navigation Solution



$$\rho_1 = \sqrt{(X_1 - R_x)^2 + (Y_1 - R_y)^2 + (Z_1 - R_z)^2 + c(dT_R)}$$

$$\rho_2 = \sqrt{(X_2 - R_x)^2 + (Y_2 - R_y)^2 + (Z_2 - R_z)^2 + c(dT_R)}$$

$$\rho_3 = \sqrt{(X_3 - R_x)^2 + (Y_3 - R_y)^2 + (Z_3 - R_z)^2 + c(dT_R)}$$

$$\rho_4 = \sqrt{(X_4 - R_x)^2 + (Y_4 - R_y)^2 + (Z_4 - R_z)^2 + c(dT_R)}$$

Android Studio

- Official Integrated Development Environment (IDE) for Android
- Programming languages:
 - Kotlin
 - Java



GNSS on Android Devices



Android 6.0 Marshmallow

- Straightforward location:
 - PVT (Position, Velocity and Time)

Android 7.0 Nougat

- Raw measurements:
 - Reference Times
 - Pseudorange Generation
 - Navigation Message

- Advantages:

- Own algorithms implementation
- Increase position accuracy
- Position in harsh environments

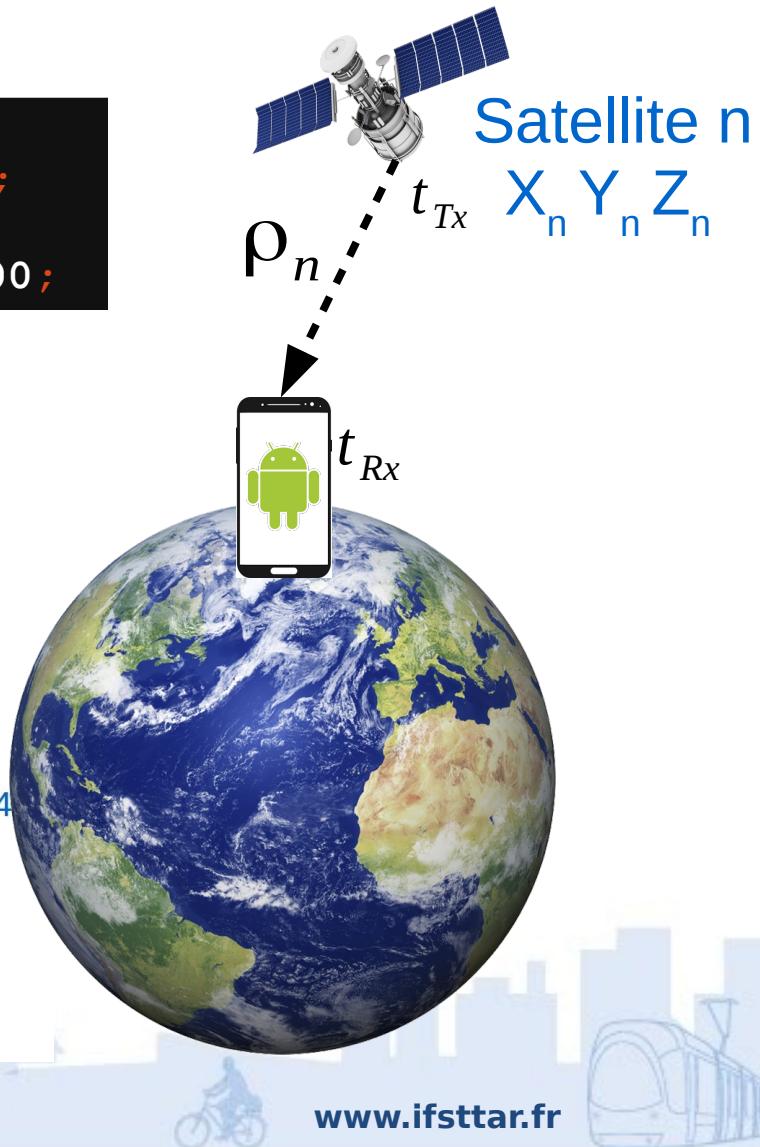
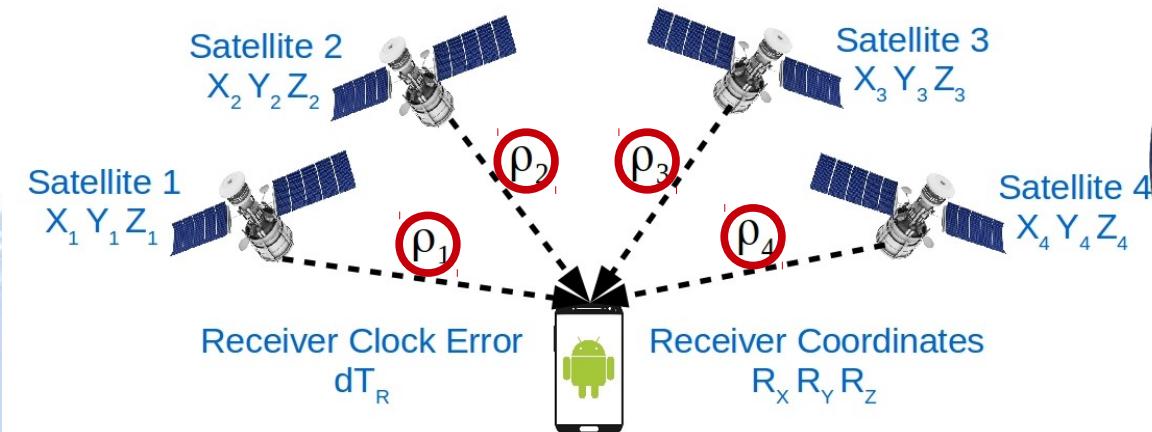


Pseudorange Generation

```
long ttx = getReceivedSvTimeNanos();  
double trx = trxGnss - weekNumberNanos;  
double pseudoRange = (((trx - ttx) /  
    numberNanoSecondsSecond) * c) / 1000;
```

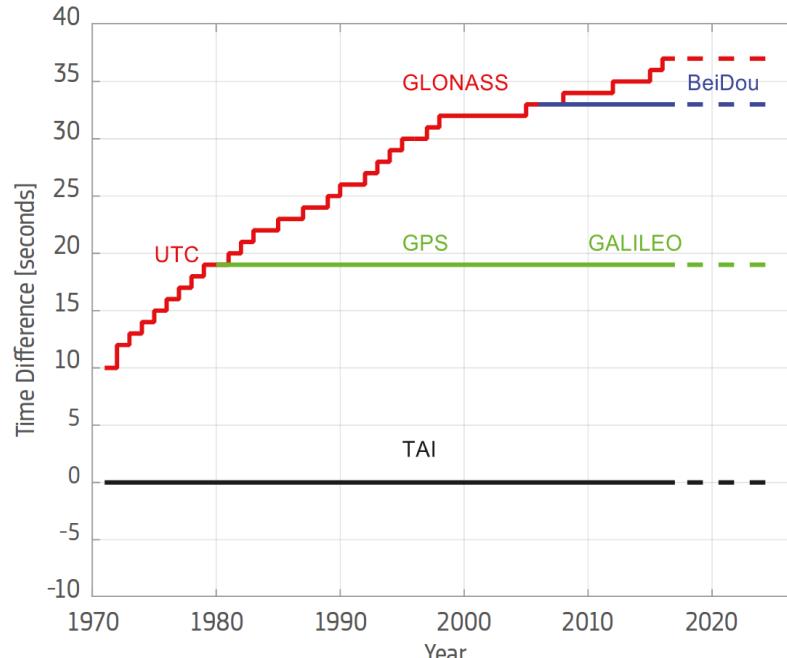
$$\rho_n = (t_{Rx} - t_{Tx}) * c$$

$$\rho_n = \sqrt{(X_n - R_x)^2 + (Y_n - R_y)^2 + (Z_n - R_z)^2} + c(dT_R)$$

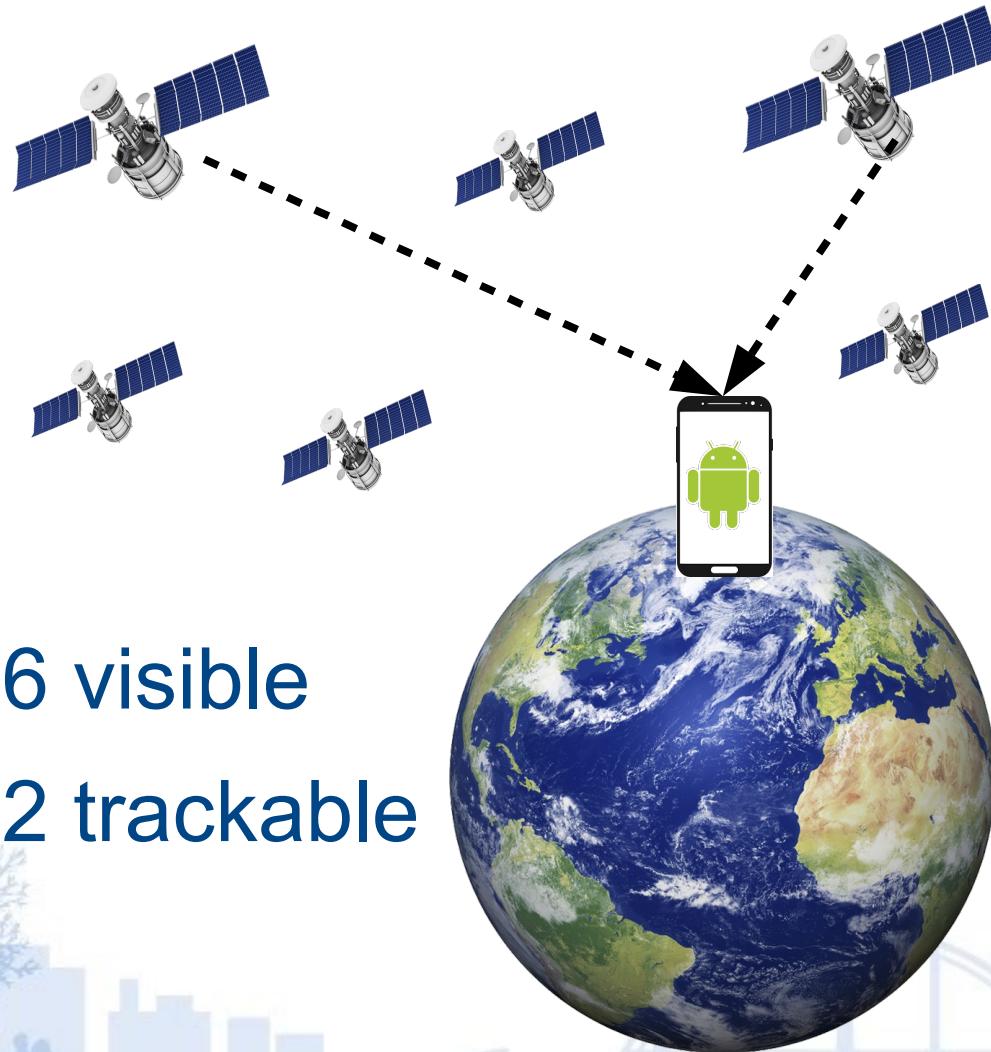


GNSS Reference Times

Systems	Relationship
GPST - TAI	$TAI = GPST + 19$
GST - TAI	$TAI = GST + 19$
GLONASST - TAI	$TAI = GLONASST - 3h + \text{leapsecond}_{\text{UTC-TAI}}$
UTC - TAI	$UTC = TAI - \text{leapsecond}_{\text{UTC-TAI}}$
BDT-TAI	$TAI = BDT + 33s$



Pseudorange Generation



- 6 visible
- 2 trackable

GNSS App

SEARCH

CONSTELLATION TYPE: 1

ID: 15

DISTANCE: 23081.34002080285 km

Constellation : GPS ID : 15
23081.34002080285km

Constellation : GPS ID : 17 0.0km

Constellation : GPS ID : 20 0.0km

Constellation : GPS ID : 24 0.0km

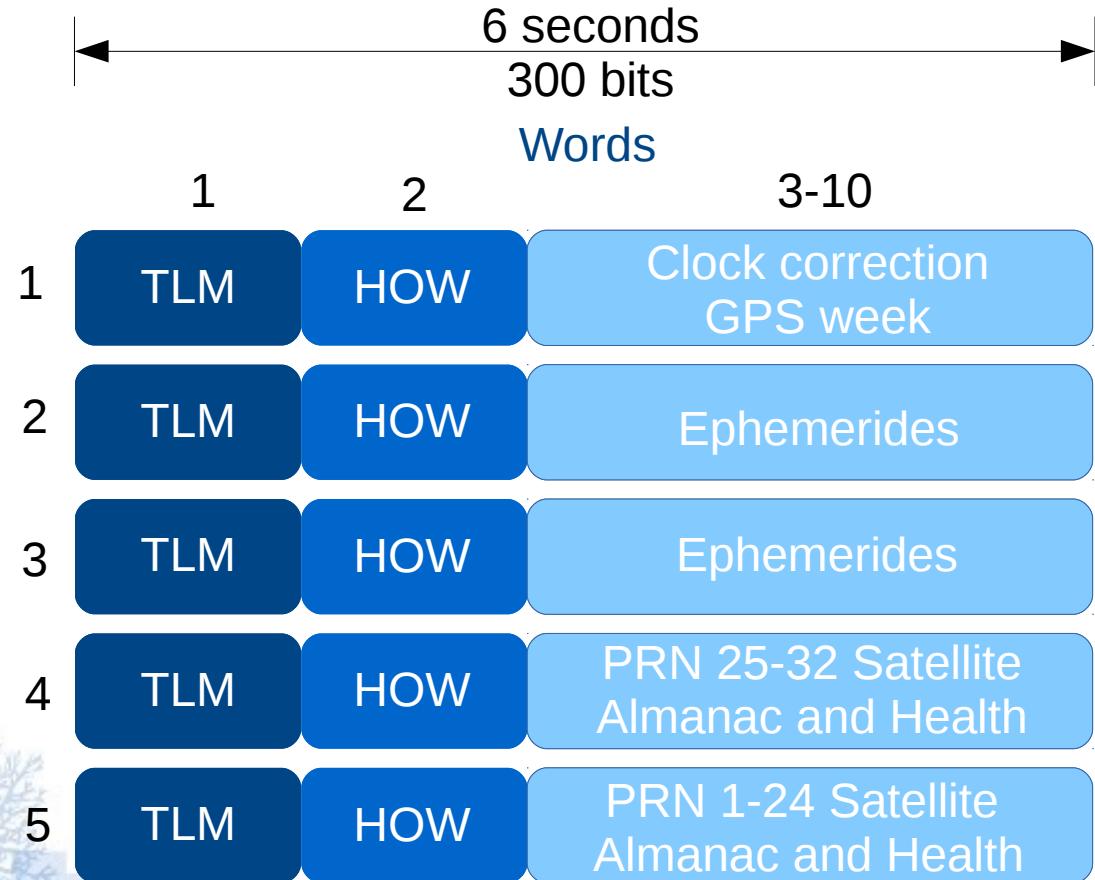
Constellation : GPS ID : 25 0.0km

Constellation : GLONASS ID : 18
22959.64916562887km

< ○ □

Navigation Message

GPS Navigation Message



Satellite n

$X_n Y_n Z_n$



Navigation Message

- Time of week
 - 291852 seconds
 - Wednesday 09:04:12

```
public long getTow() {  
    String tow = words[1].substring(0,17);  
    return Long.parseLong(tow,2)*6;  
}
```

- Week number
 - 978 (mod 1024)
 - 2002 (since Jan 6 1980)

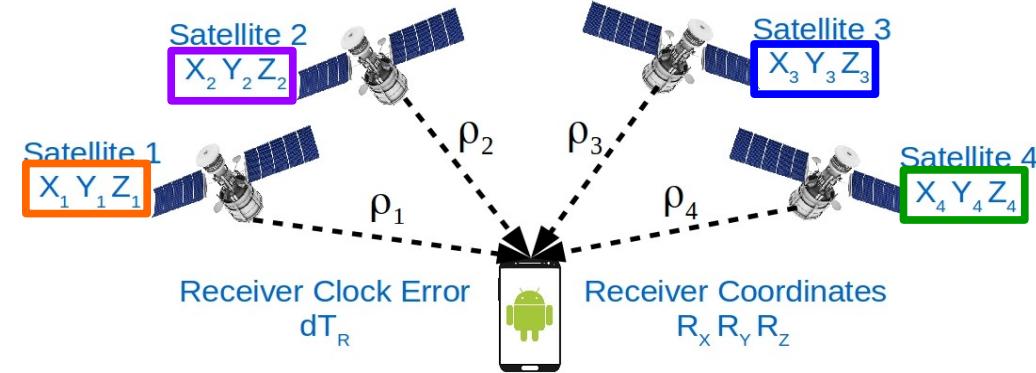
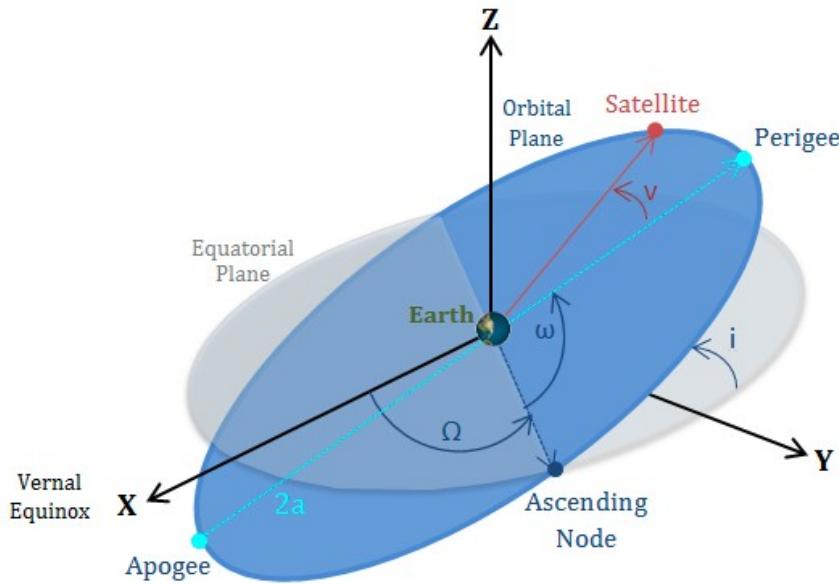
GNSS App

Ephemerides

TOW : 291852 s
WN : 978
Toc : 295200.0
Af2 : 0.0
Af1 : 5.684341886080801E-13
Af0 : 0.0015993150882422924
Crs : 26.9375
DeltaN : 1.6840431271702982E-9
M0 : 0.9371848641894758
Cuc : 1.3615936040878296E-6
E : 0.010263262898661196
Cus : 1.0542571544647217E-5
SquareA : 5153.744915008545
Toe : 295200.0
Aodo : 27900.0
Cic : 1.2200511991977692E-4
Omega0 : 0.21560871042311192
Cis : 1.2189522385597229E-4
I0 : 0.2955072312615812
Crc : 159.84375
Omega : 0.21560871042311192
OmegaDot : 1.9047658952331403E-6
Idot : 6.87805368215777E-11



Keplerian Elements



$$\rho_1 = \sqrt{(X_1 - R_x)^2 + (Y_1 - R_y)^2 + (Z_1 - R_z)^2} + c(dT_R)$$

$$\rho_2 = \sqrt{(X_2 - R_x)^2 + (Y_2 - R_y)^2 + (Z_2 - R_z)^2} + c(dT_R)$$

$$\rho_3 = \sqrt{(X_3 - R_x)^2 + (Y_3 - R_y)^2 + (Z_3 - R_z)^2} + c(dT_R)$$

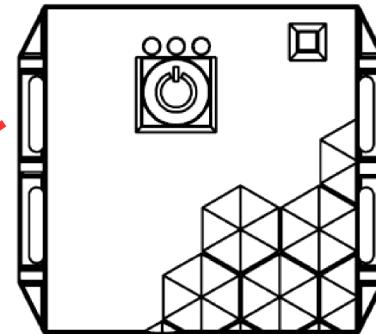
$$\rho_4 = \sqrt{(X_4 - R_x)^2 + (Y_4 - R_y)^2 + (Z_4 - R_z)^2} + c(dT_R)$$

Future test

- Trace comparison between GNSS receiver and Application made



PEdestrian Reference SYstem



www.ifsttar.fr

Thank you for your attention!



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