African School on Space Science

Constellation Details

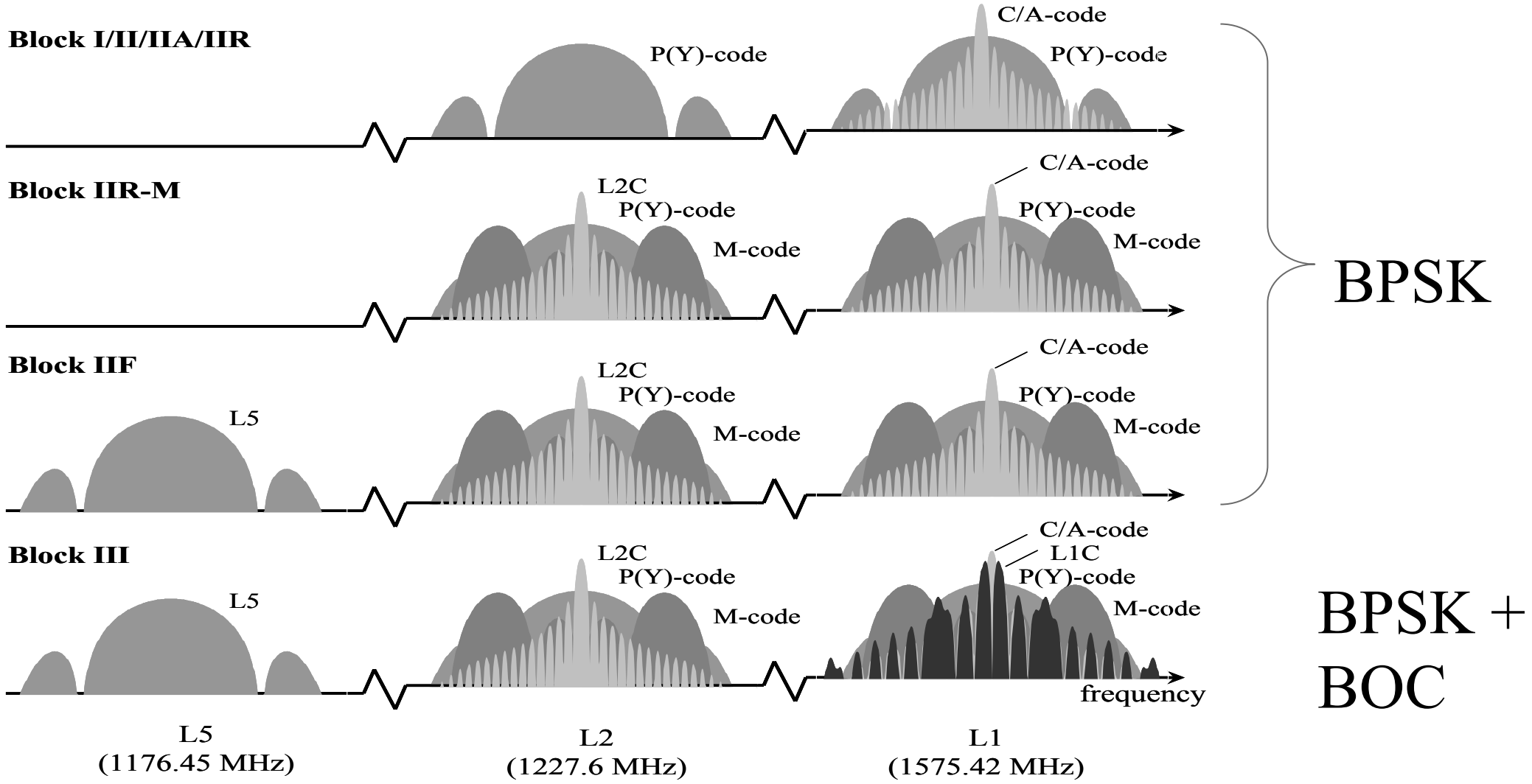
Reference:

Chapter 10 of: "*A-GPS; Assisted GPS, GNSS & SBAS",* van Diggelen.

Outline for this section (now till lunch)

- Signals & spectra for different constellations
- Orbits
- Mini-lab

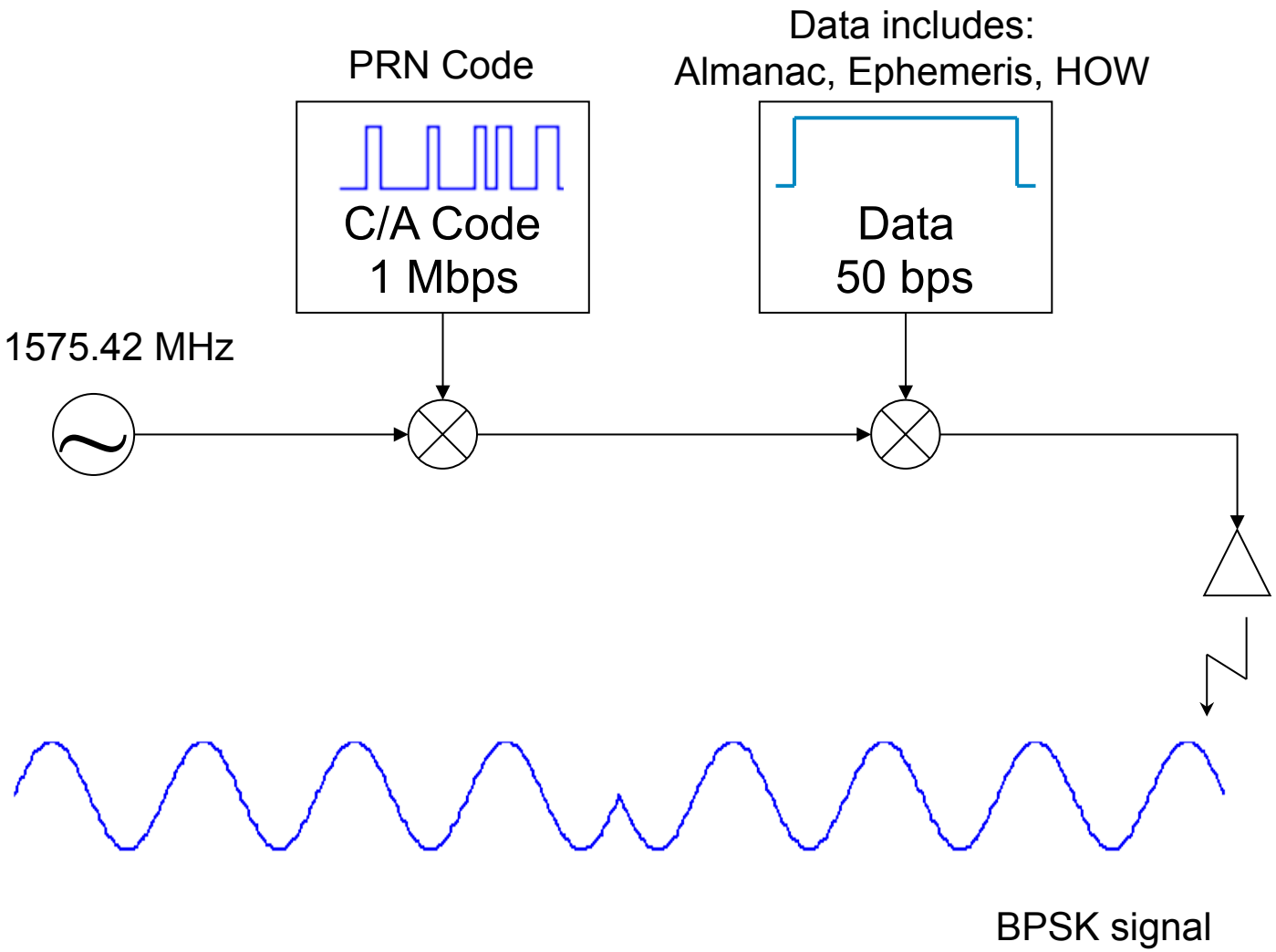
GPS Spectra (from Hegarty & Chatre)



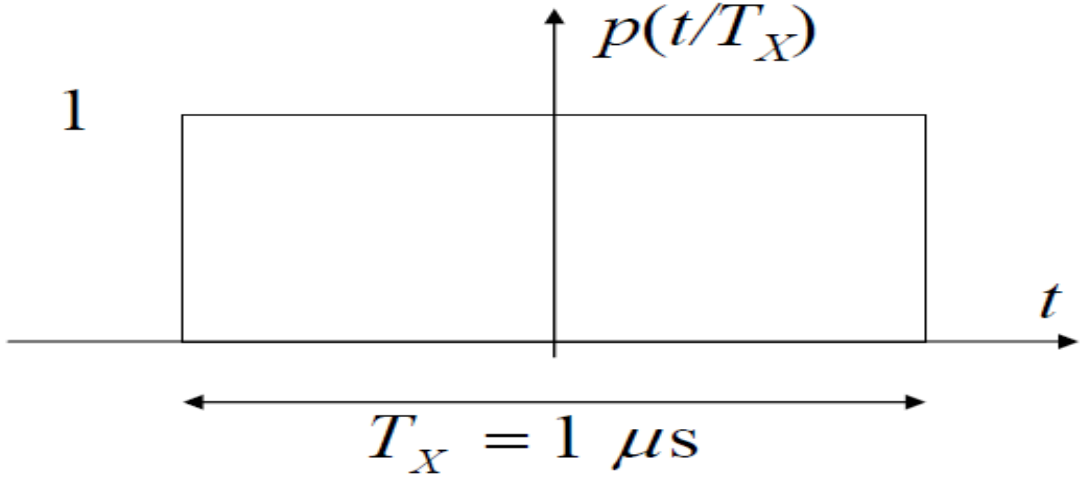
Review of frequency spectra

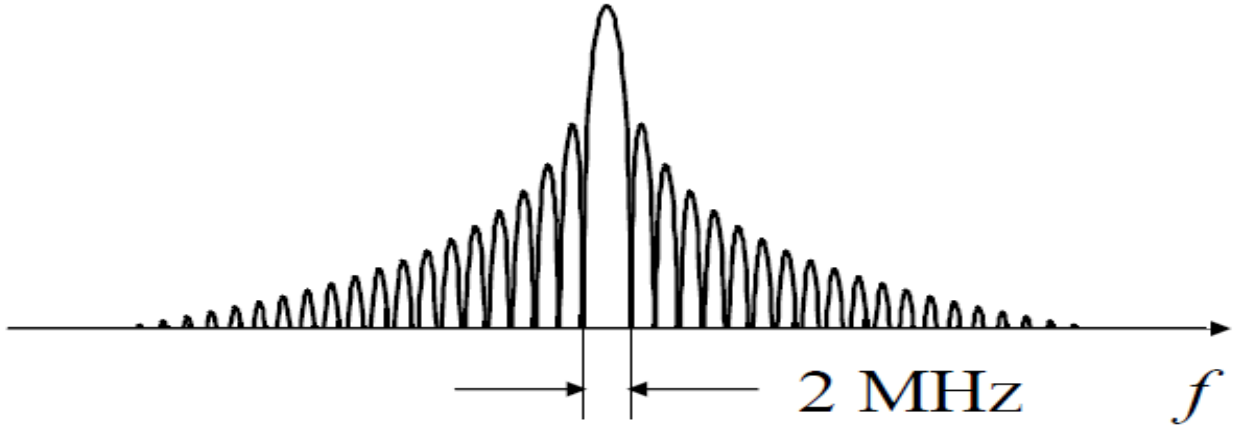
1. Every periodic signal can be represented as a sum of sinusoids (Fourier series)
2. Amplitude spectrum shows us the magnitude of the components of a Fourier series

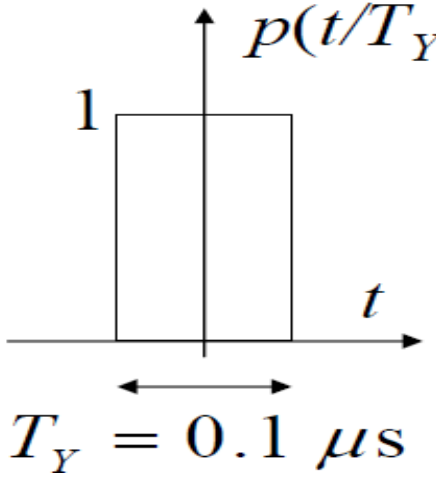
GPS (Civilian) Signal at the Satellite

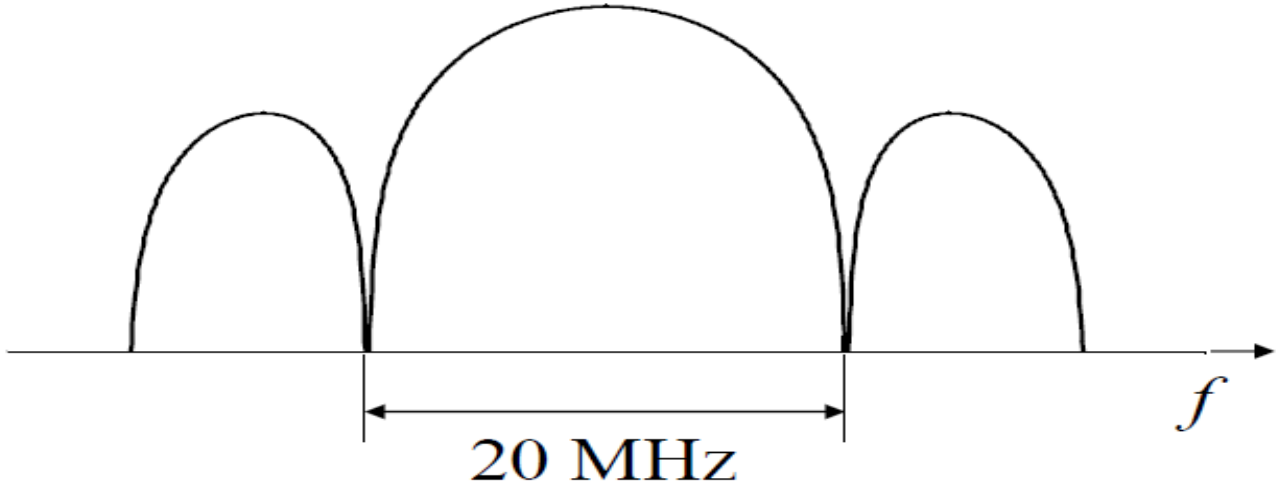


Pulses, and their amplitude spectrums

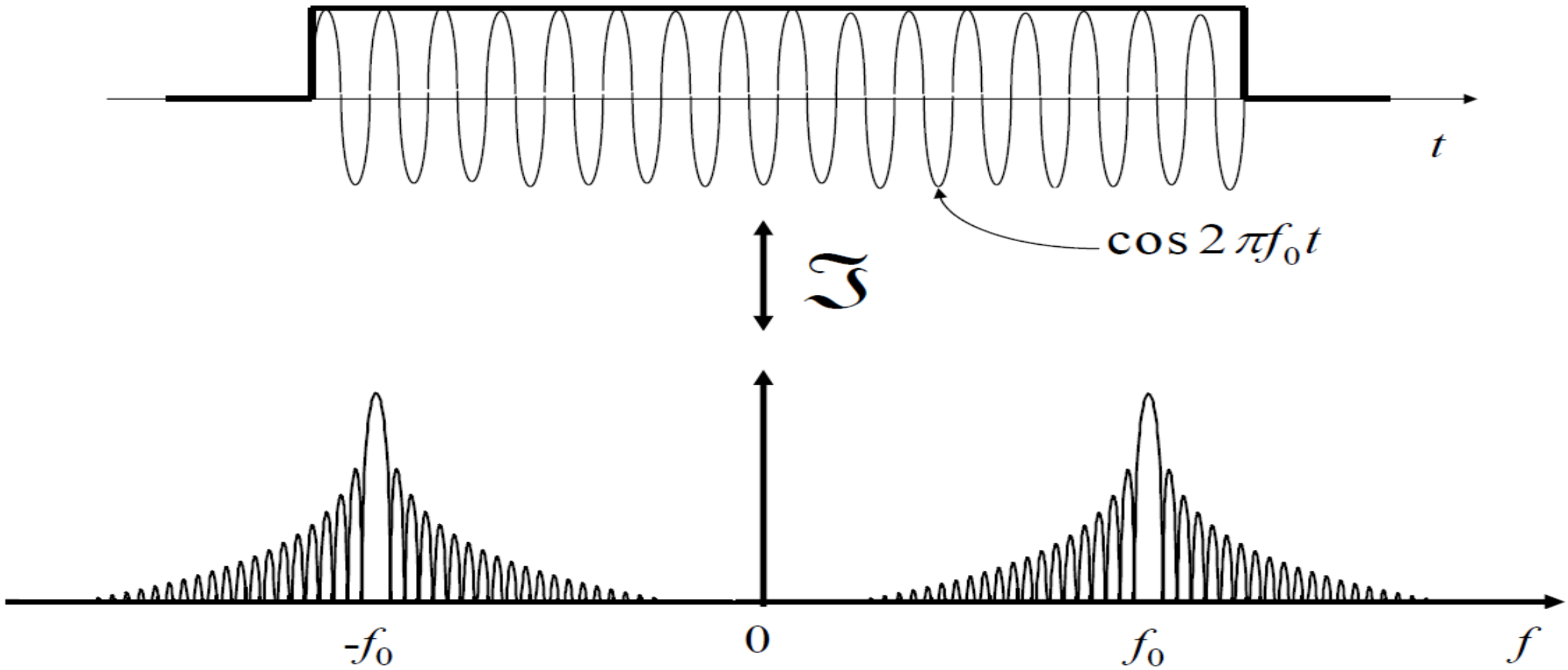




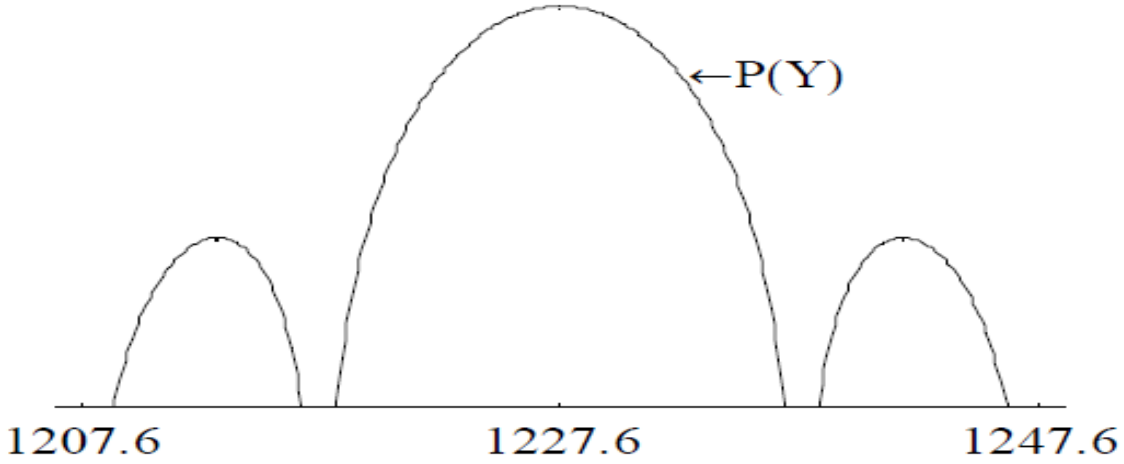


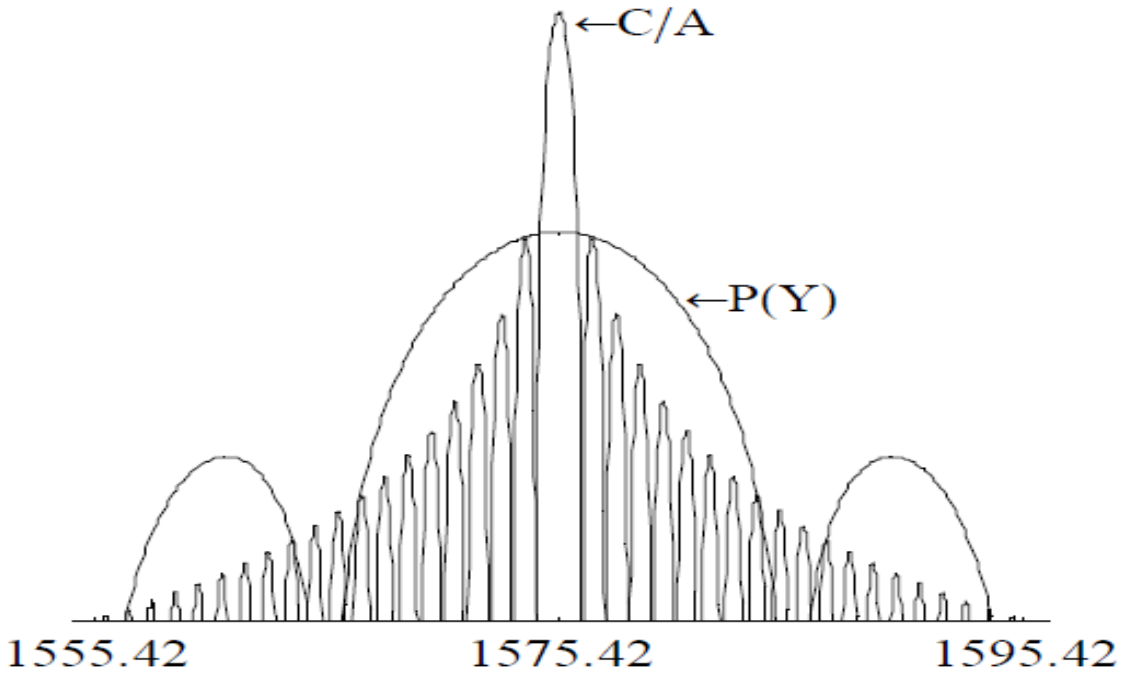


Modulation by carrier wave = shift in frequency spectrum

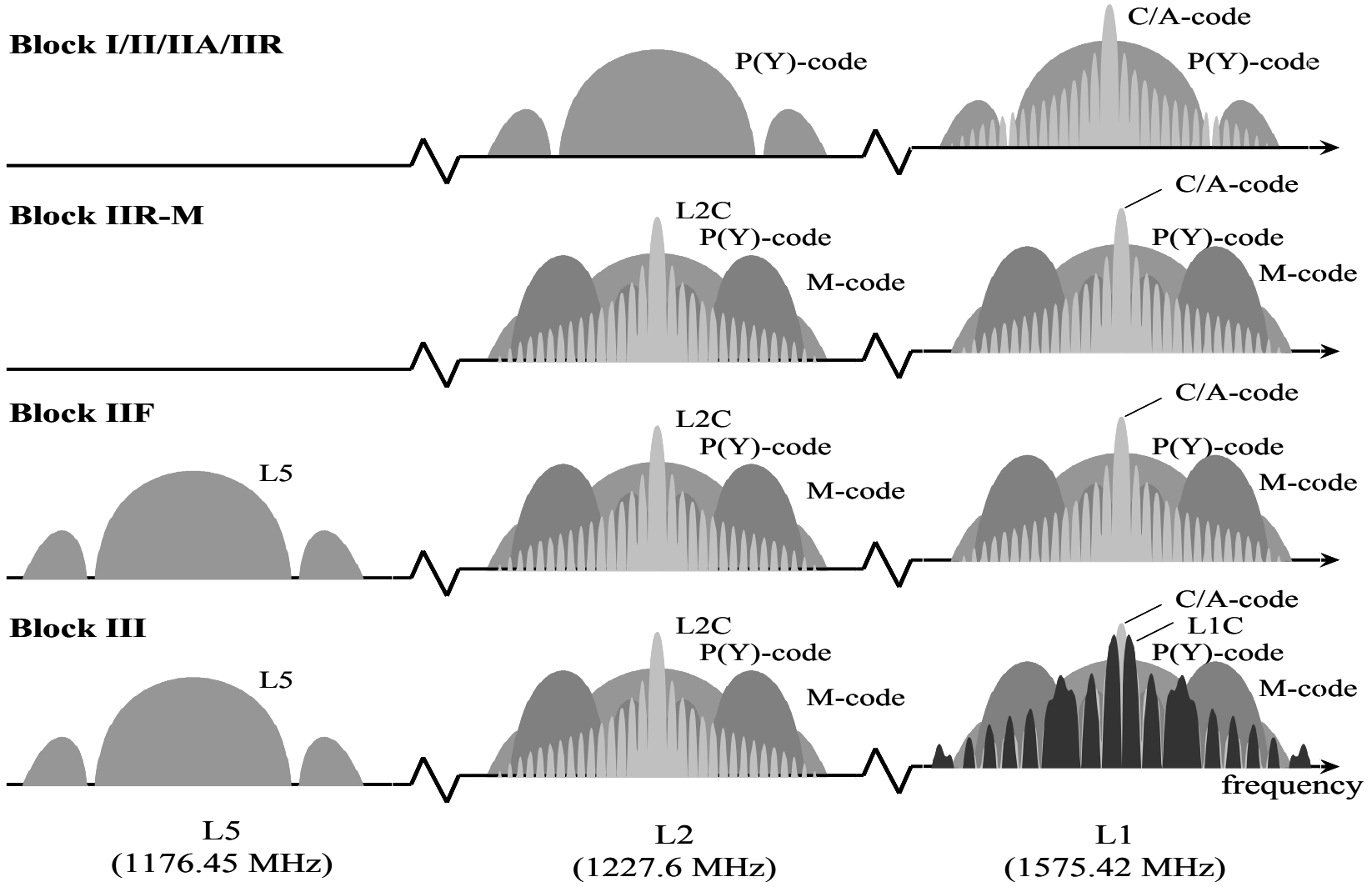


Amplitude spectrum of GPS Signals: with f_{L2} = 1227.60 and f_{L1} = 1575.42 MHz

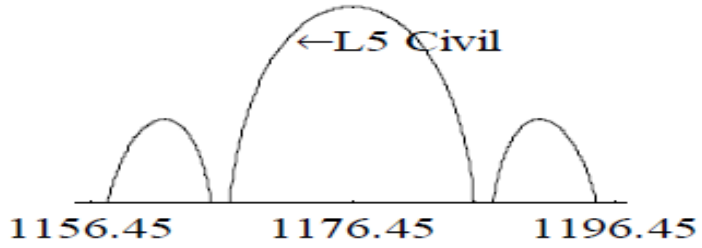


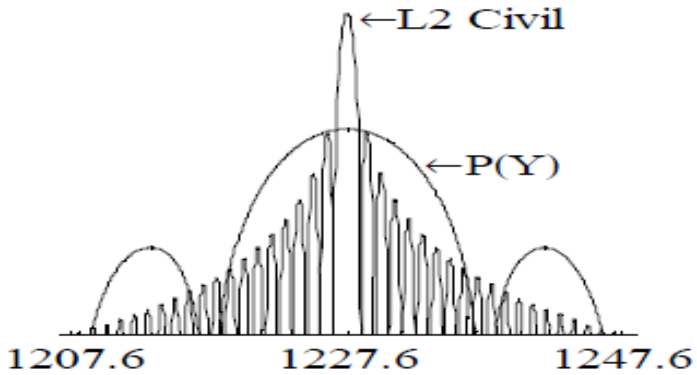


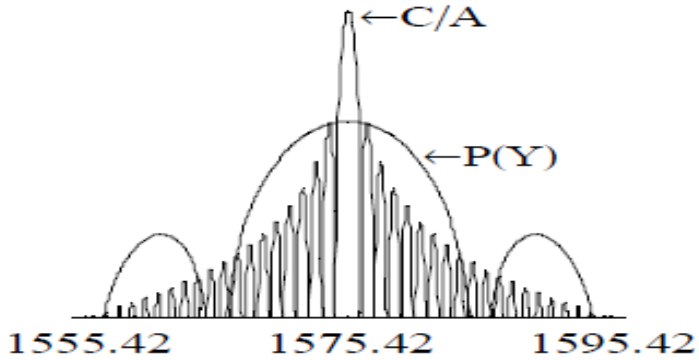
GPS Spectra (from Hegarty & Chatre)



Summary of New GPS Signals







L5 Civil:
- coded access
- longer codes
- faster codes (RFI)
- data-free component
- 4 times more power
- ARNS
- enables assured iono

L2 Civil
- coded access
- longer codes
- data-free component
- not ARNS
- enables iono

L1 C/A:
- legacy users
- coded access
- short codes
- no data-free component
- ARNS

ARNS = Aeronautical Radionavigation Service

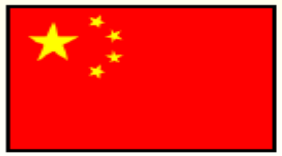
Current & Future GNSS

Global


GPS


GLONASS


Galileo


COMPASS

Regional


QZSS


IRNSS

Augmentation


WAAS


EGNOS


MSAS

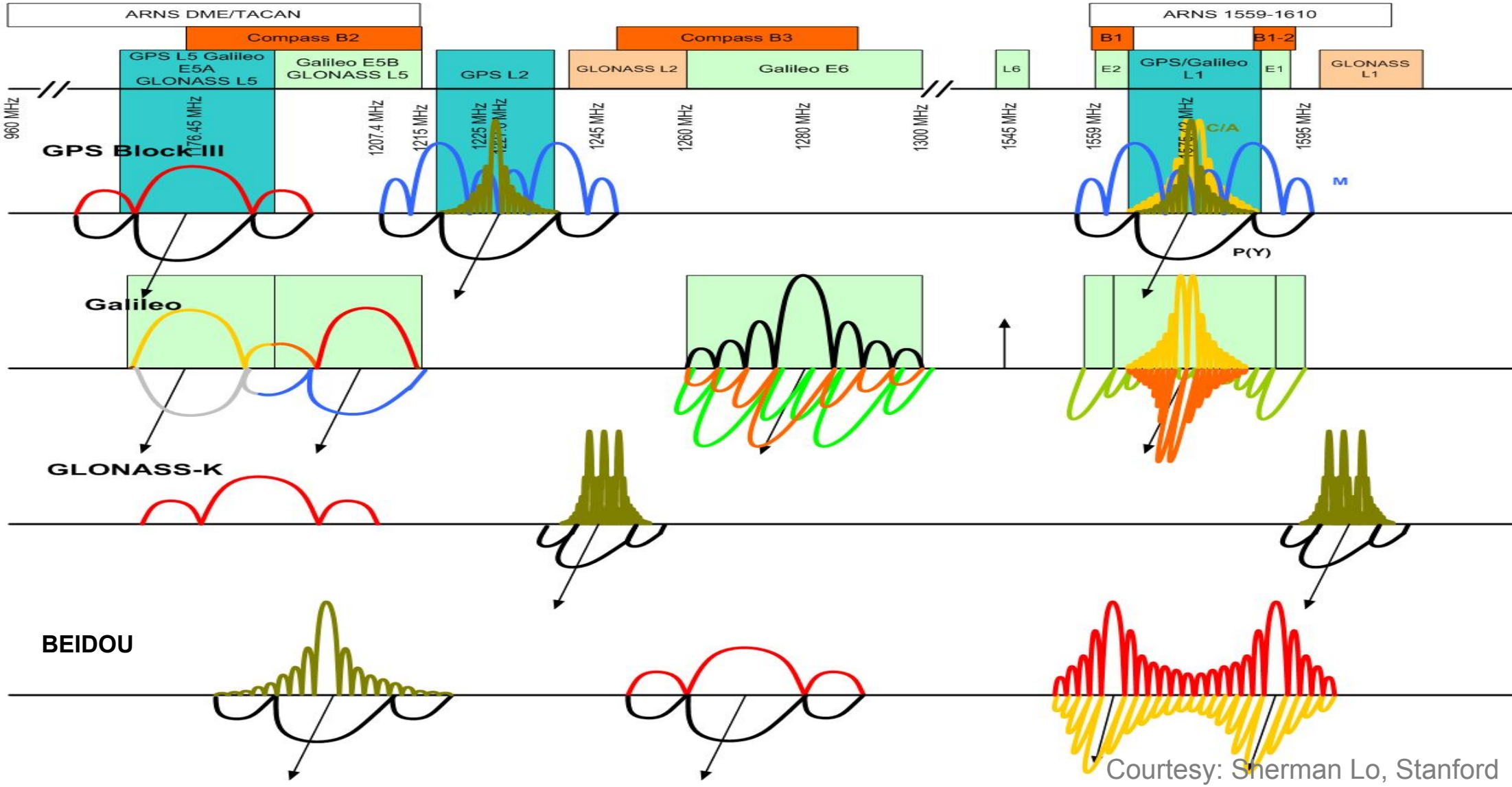

NIGCOMSAT-1


GAGAN

From: Gunter Hein

GNSS Spectrum

Most current codes: BPSK, future: BOC



Courtesy: Sherman Lo, Stanford

Note: In L1 we have different frequencies, but on different satellites
L1 and L5 are the likely two frequencies to be supported in future consumer products

GNSS ZOO (27 JUNE 2014)



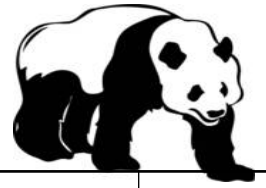


Signal Components	GPS	GLONASS	SBAS	BeiDou	Galileo Pilot	Galileo Data
Carrier	1575.42	1602	1575.42	1561.098	1575.42	
C/A code length	1023	511	1023	2046	4096	4096
period	1ms	1ms	1ms	1ms	4ms	4ms
chip length (approx m)	300m	600m	300m	150m	300m	300m
2nd code length		2		20	25	
period		20ms		20ms	100ms	
chip length (ms)		10ms		1ms	4ms	
Data bit rate	20ms	20ms	2ms	20ms 2ms GEO		4ms

Notes: different frequencies for GLONASS and BeiDou
Higher data rates for SBAS and BeiDou GEOs

GNSS ZOO, NAV DATA



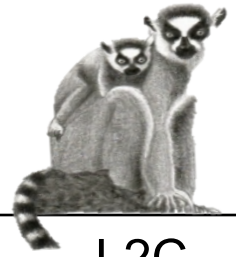

Data Components	GPS	GLONASS	SBAS	Beidou	BeiDou	Galileo
				MEO,GSO	GEO	
Minor Time Component (sec)	604800	86400	3	604800	604800	604800
Major Time Component	Week	N4/Nt*	N/A	Week	Week	Week
Major Time Rollover (years)	19.7	128	N/A	157.5	157.5	78.8
Subframe Period (sec)	6	2	1	6	0.6	6
Frame Period (sec)	30	30	1	30	3	30
Super Frame Period (min)	12.5	2.5	~10	12	6	12
Ephemeris period (sec)	30	30	120	30	30	30
Time given for other GNSS	None	GPS	None	GPS,GLO,GAL	GPS,GLO,GAL	GPS,GLO
Ionospheric Model Period	12.5 min	None	None	30 sec	30 sec	30 sec
Ionospheric Grid Period	None	None	10 min	None	6 min	None
UTC Data Period	12.5 min	2.5 min	10 min	30 sec	30 sec	30 sec

* N4 # 4 year periods, Nt = day in period

Note: Iono grid transmitted by SBAS and BeiDou GEOs

GPS L_i SECTION OF THE ZOO

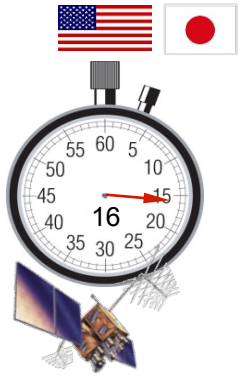


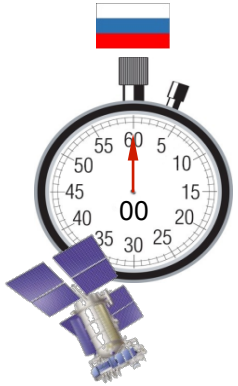


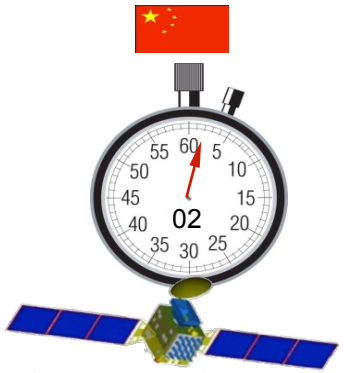

	L1 C/A	L1C		L2C		L5	
		$L1C_P$	$L1C_D$	L2 CM	L2 CL	I	Q
Carrier (MHz)	1575.42	1575.42		1227.60		1176.45	
PRN Code length	1023	10230	10230	10230	767250	10230	10230
period	1 ms	10 ms	10 ms	20 ms	1500 ms	1 ms	1 ms
chip length (approx m)	300 m	300 m	300 m	600 m	600 m	30 m	30 m
First sats:	Block I	GPS III		Block IIR(M)		Block IIF	
# available (Jul 2014)	30	0		13		6	

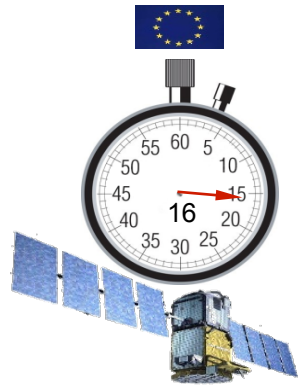
Notes: L1 and L5, likely dual frequency for future consumer receivers

Dealing with time differences

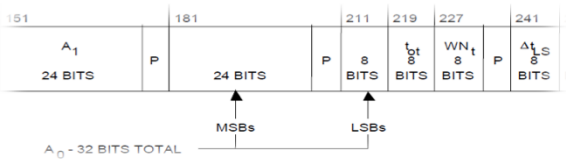




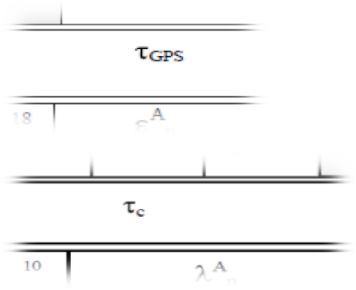




extracts from ICDs

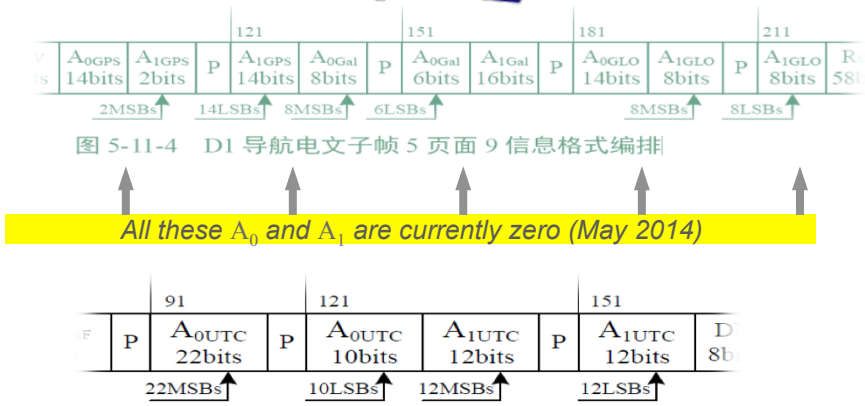


$\Delta t_{GPS-UTC}$



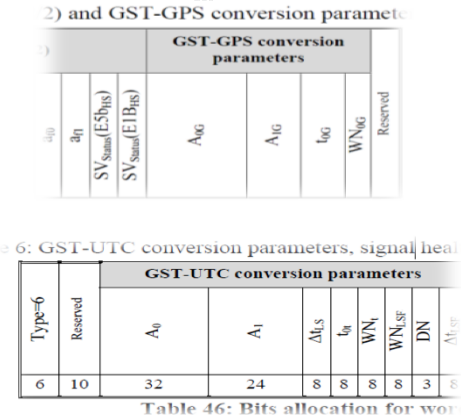
$\Delta t_{GLO-GPS}$

$\Delta t_{GLO-UTC}$



$\Delta t_{BDS-GPS}$, $\Delta t_{BDS-GAL}$, $\Delta t_{BDS-GLO}$

$\Delta t_{BDS-UTC}$



$\Delta t_{GAL-GPS}$

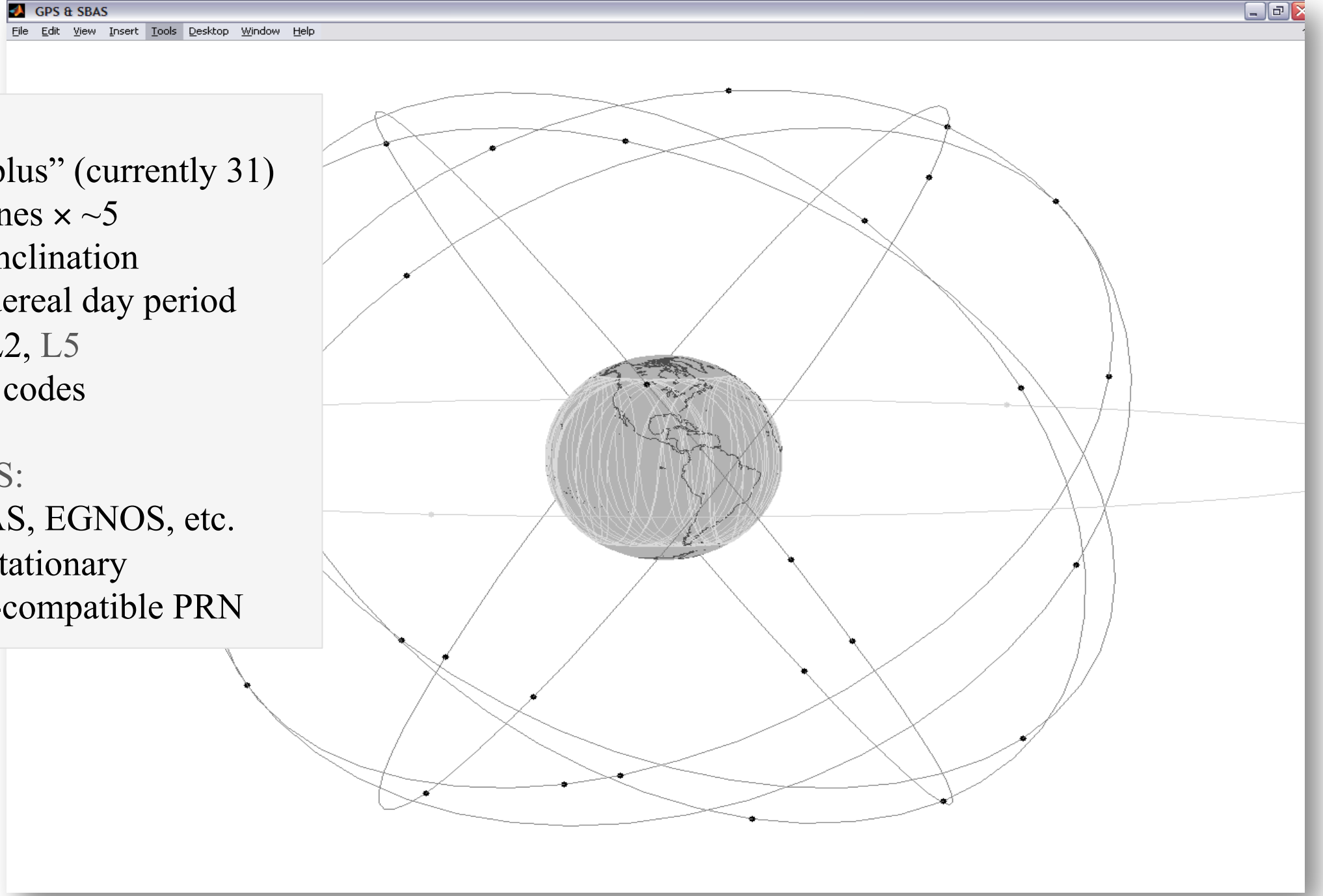
$\Delta t_{GAL-UTC}$

Outline for this section (now till lunch)

- Signals & spectra for different constellations
- Orbits
- Mini-lab

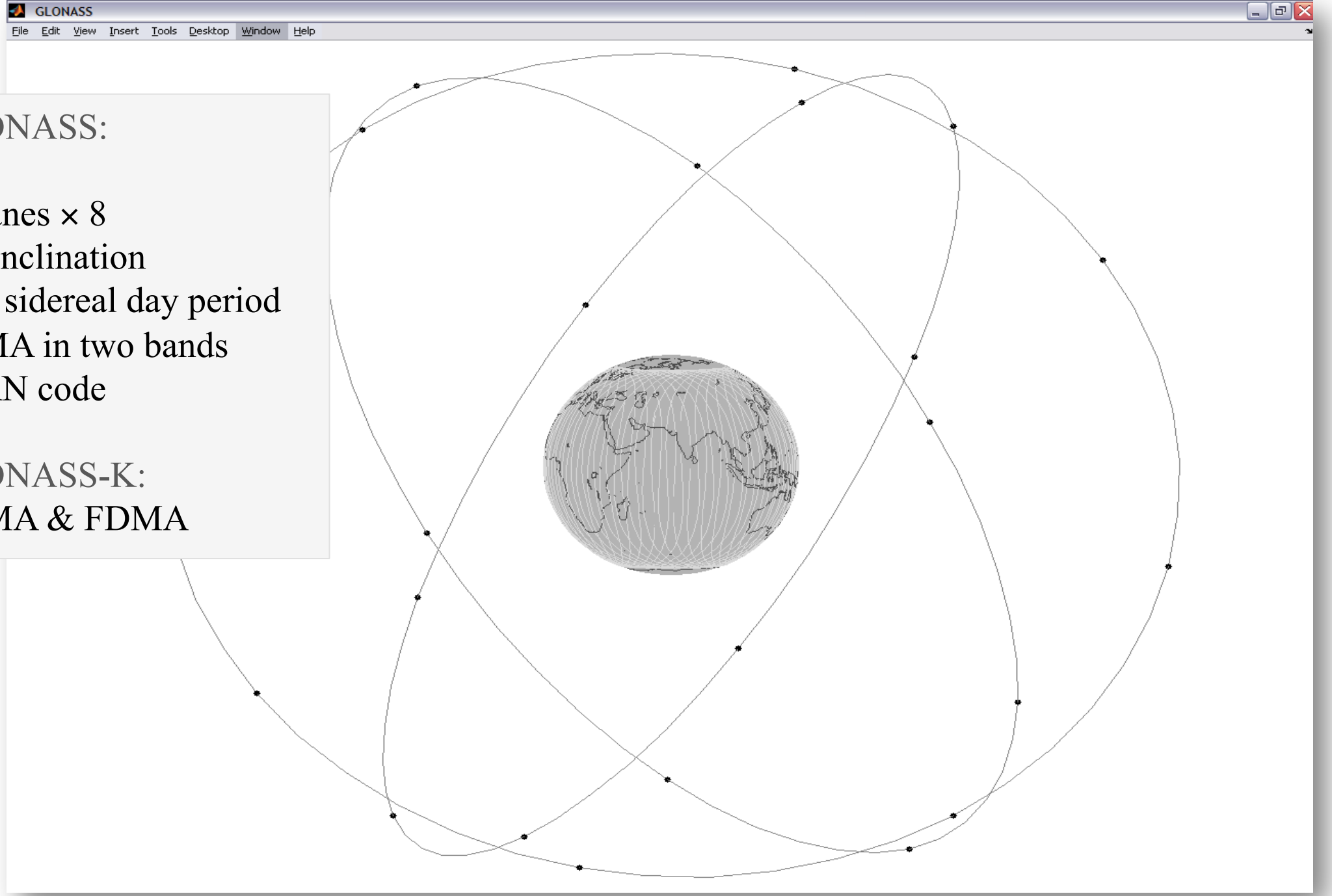
GPS:
"24-plus" (currently 31)
6 planes × ~5
55° inclination
½ sidereal day period
L1, L2, L5
PRN codes

SBAS:
WAAS, EGNOS, etc.
Geostationary
GPS-compatible PRN



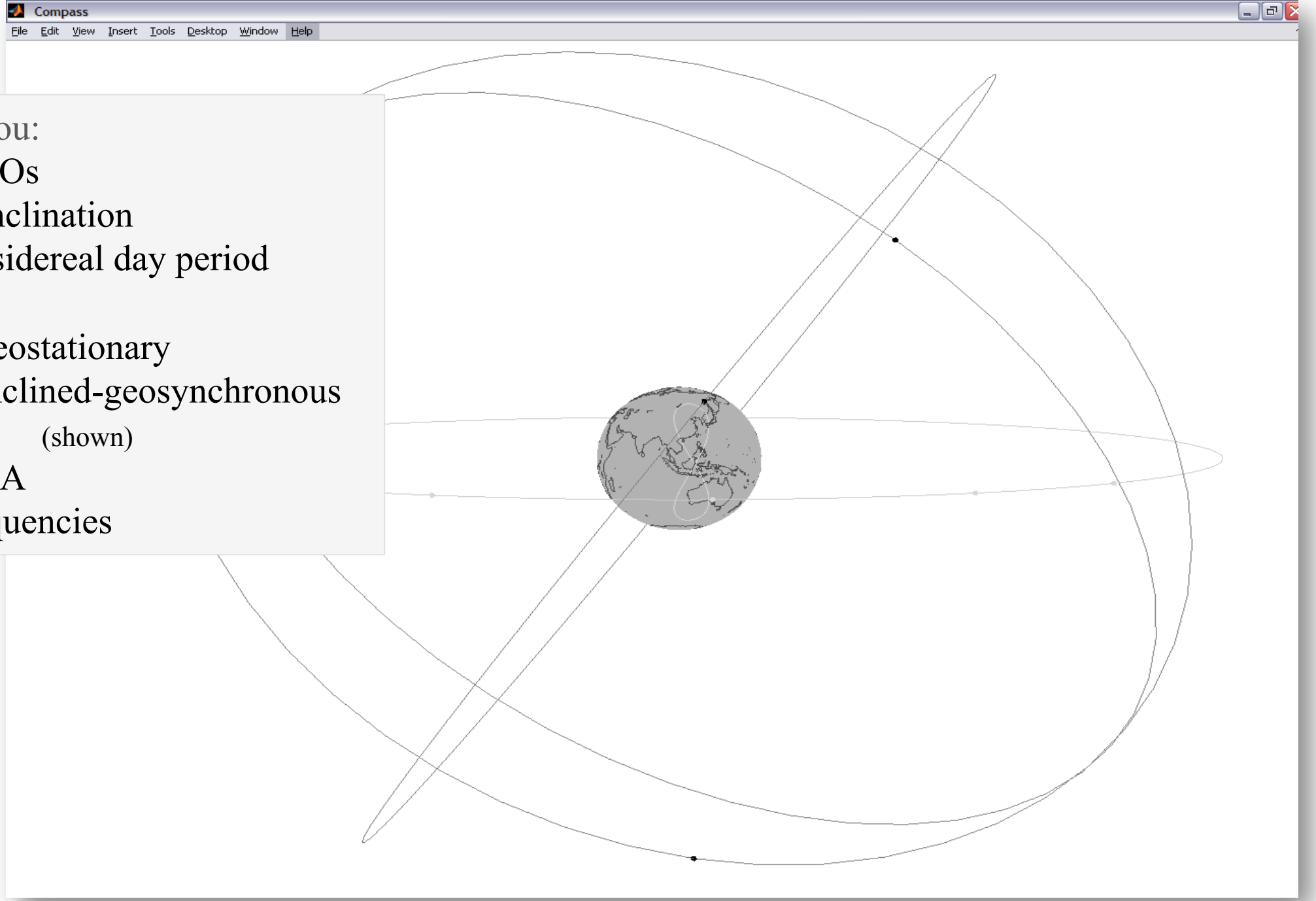
GLONASS:
24
3 planes × 8
66° inclination
8/17 sidereal day period
FDMA in two bands
1 PRN code

GLONASS-K:
CDMA & FDMA

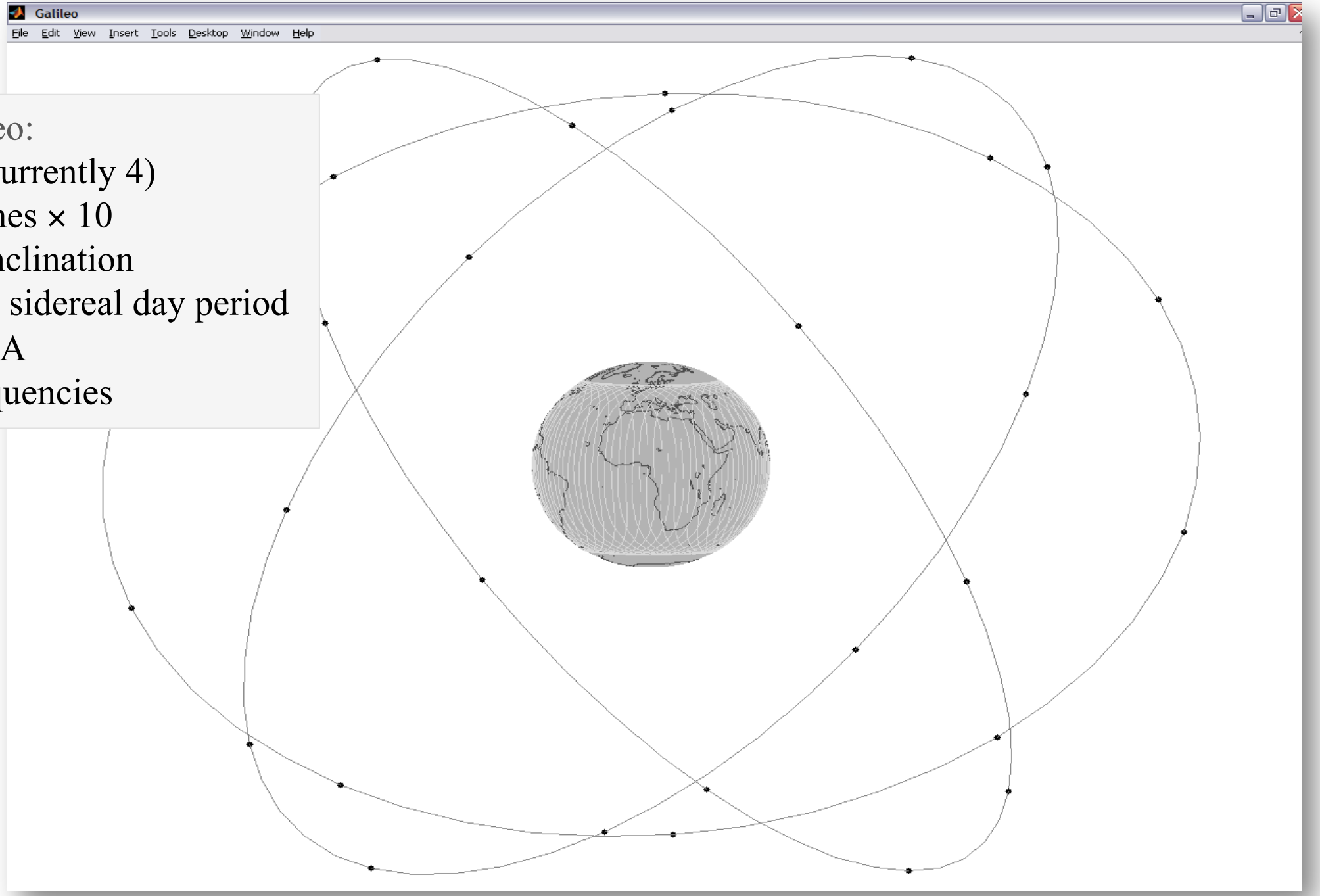


BeiDou:
4 MEOs
55° inclination
7/16 sidereal day period

+ 5 geostationary
+ 5 inclined-geosynchronous
(shown)
CDMA
3 frequencies

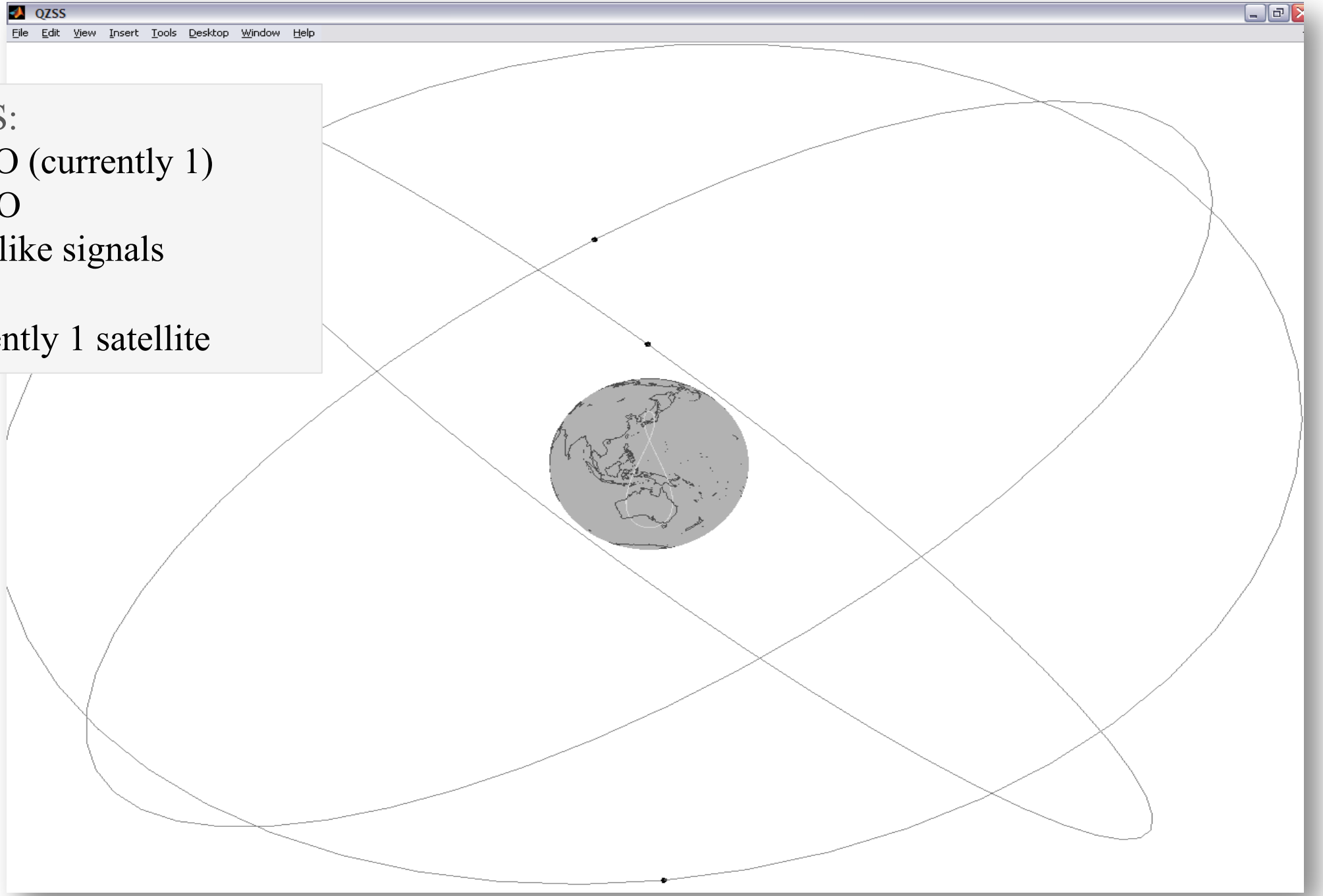


Galileo:
30 (currently 4)
3 planes × 10
56° inclination
10/17 sidereal day period
CDMA
3 frequencies



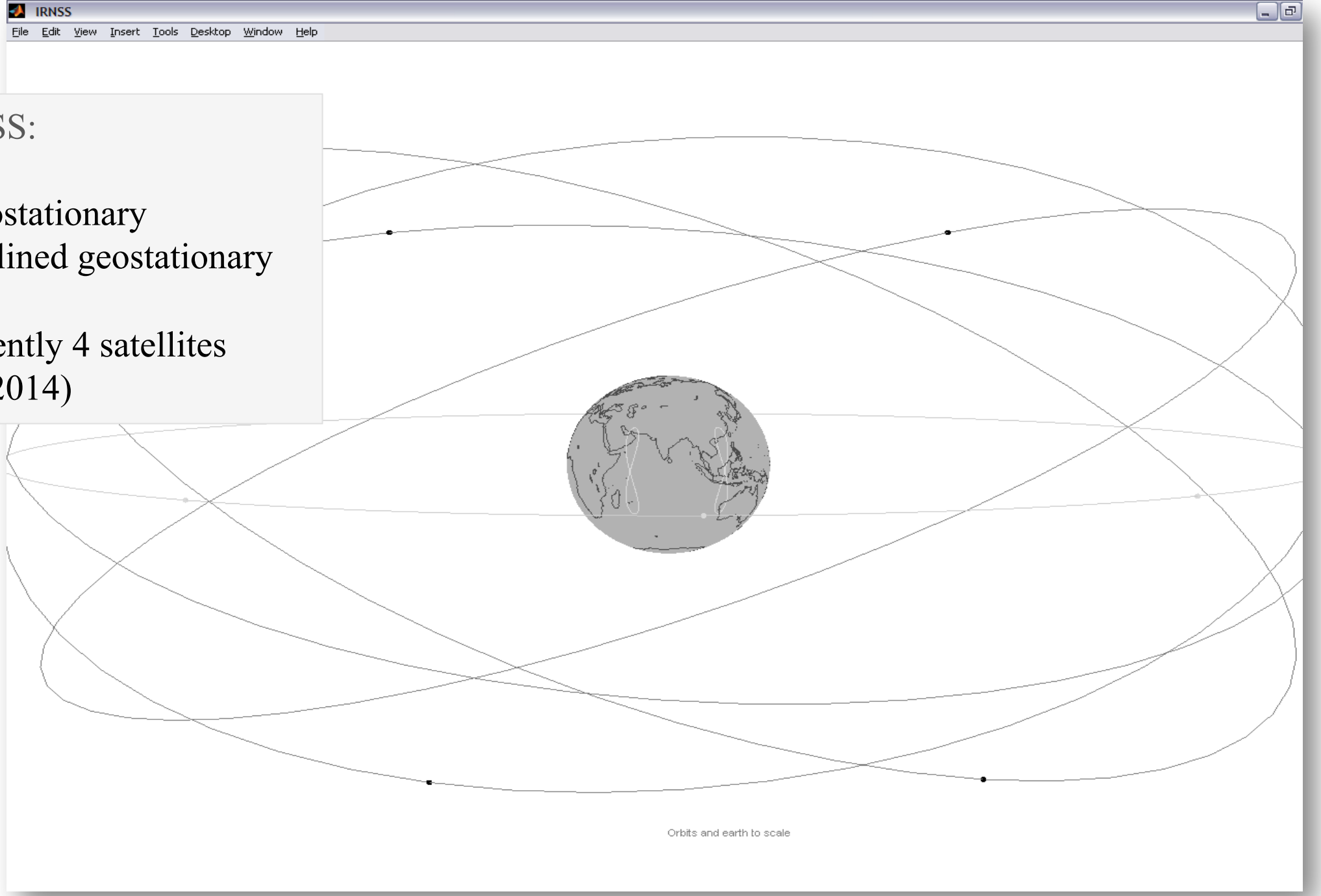
QZSS:
4 GSO (currently 1)
3 GEO
GPS-like signals

Currently 1 satellite

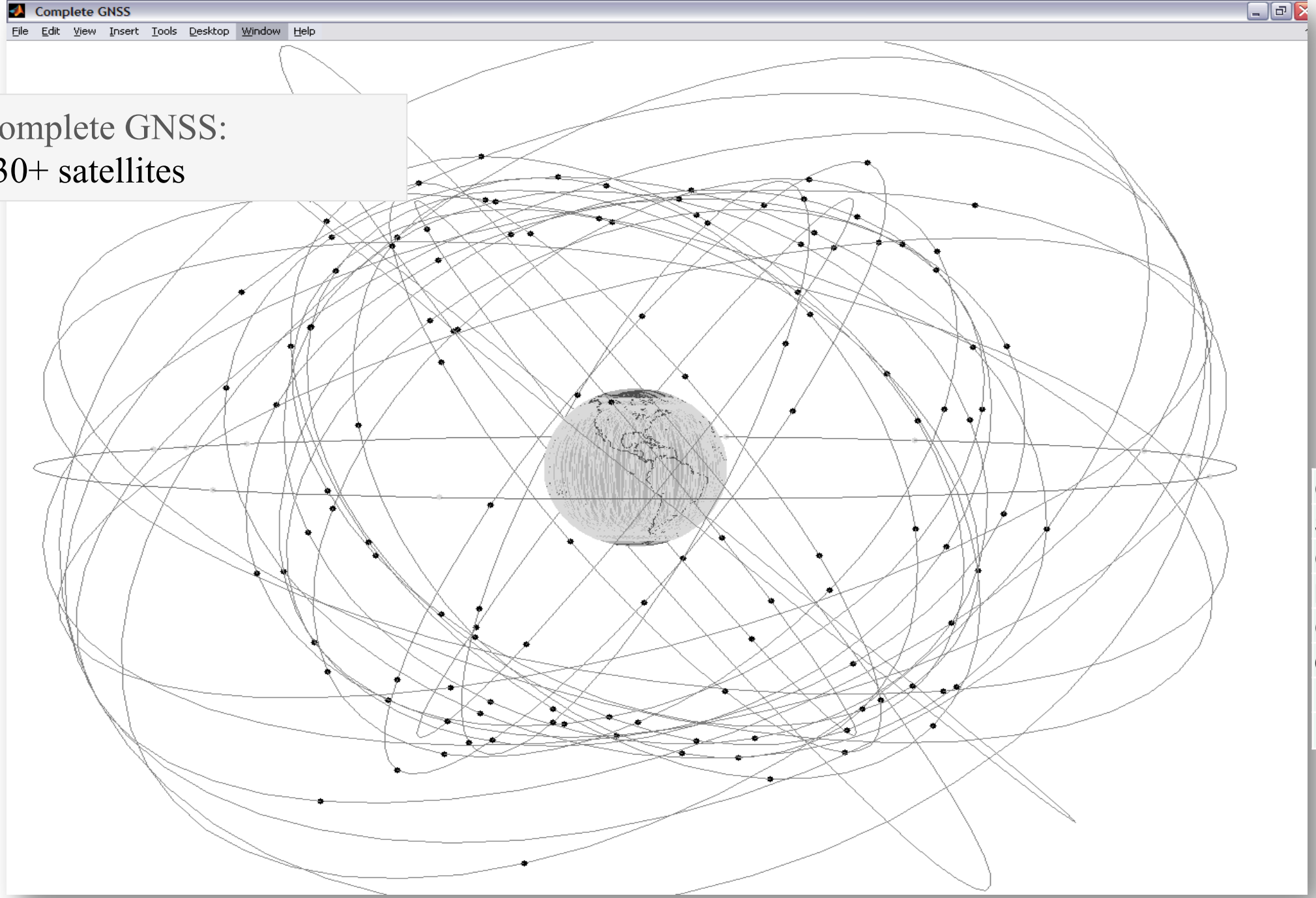


IRNSS:
7
3 geostationary
4 inclined geostationary

Currently 4 satellites
(Jul 2014)



Complete GNSS:
130+ satellites



Future:

GPS	30
SBAS	8
GLO	24
BDS	30
GAL	30
QZS	7
IRS	7
	136

Jul 2014:

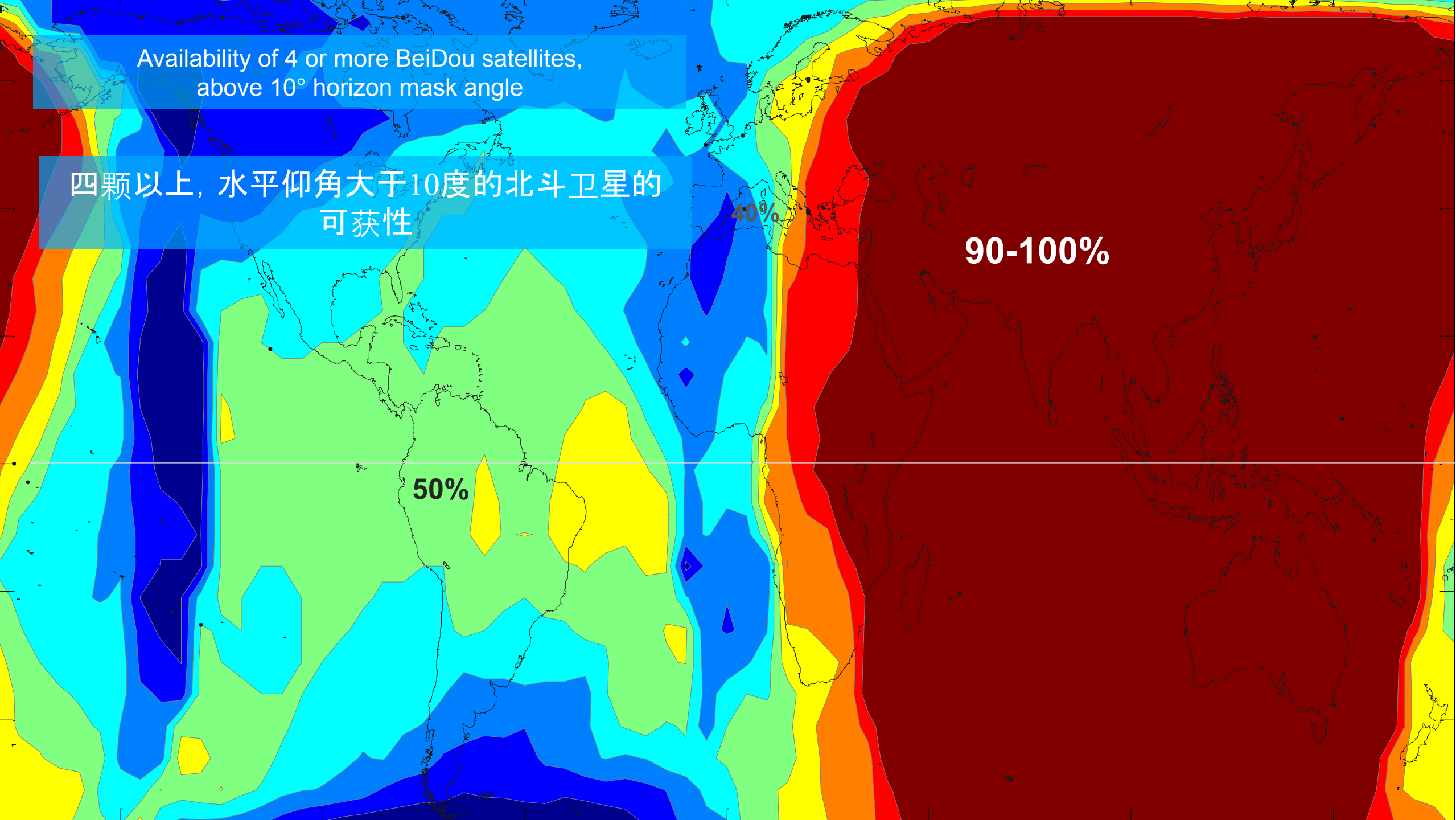
GPS	31
SBAS	7
GLO	24
BDS	14
GAL	4
QZS	1
IRS	7
	88

GNSS ZOO, ORBITS

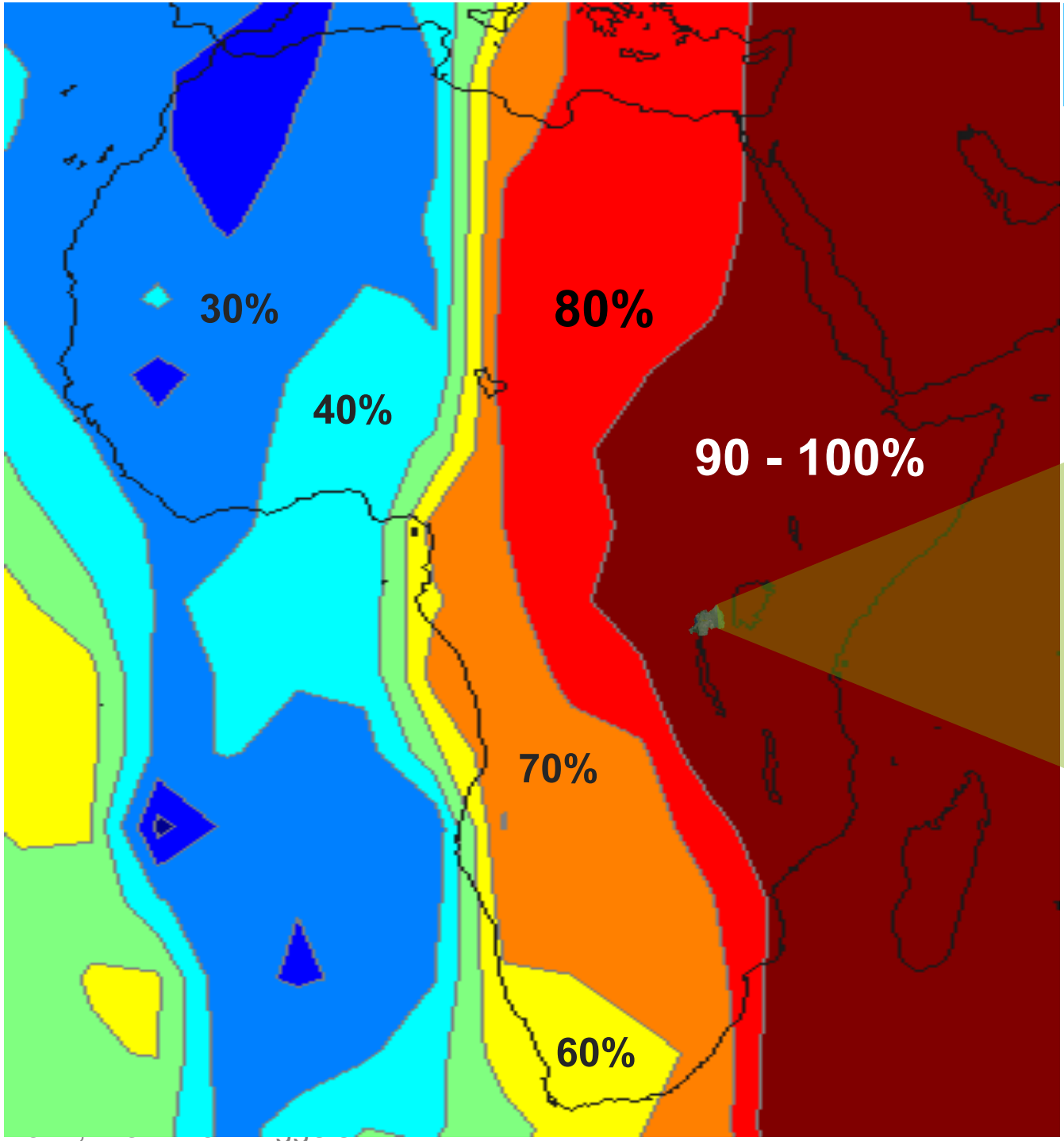




	GPS	GLONASS	SBAS	BeiDou		Galileo
				MEO	GEO, GSO	
Altitude (km)	20,180	19,100	35,786	21,500	35,786	23,223
Orbital period (sidereal days)	½	8/17	1	7/13	1	10/17
Repeat period (sidereal days)	1	8	-	7	-, 1	10
Inclination	55°	66°	0°	55°	0°, 55°	56°


Availability of 4 or more BeiDou satellites,
above 10° horizon mask angle
四颗以上，水平仰角大于10度的北斗卫星的
可获性
40%
90-100%
50%

Availability of 4 or more BeiDou satellites, above 10° horizon mask angle

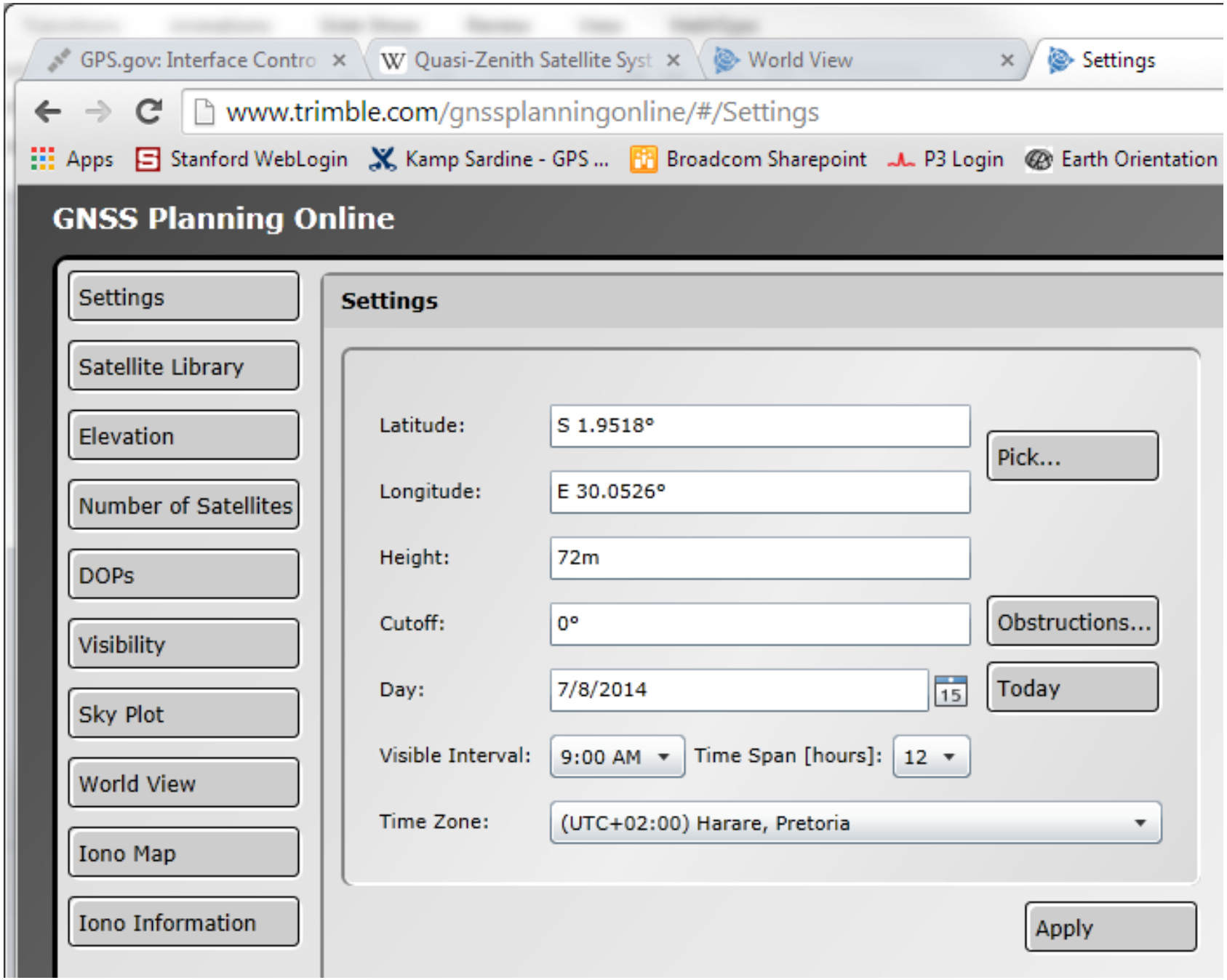


Outline for this section (now till lunch)

- Signals & spectra for different constellations
- Orbits
- Mini-lab

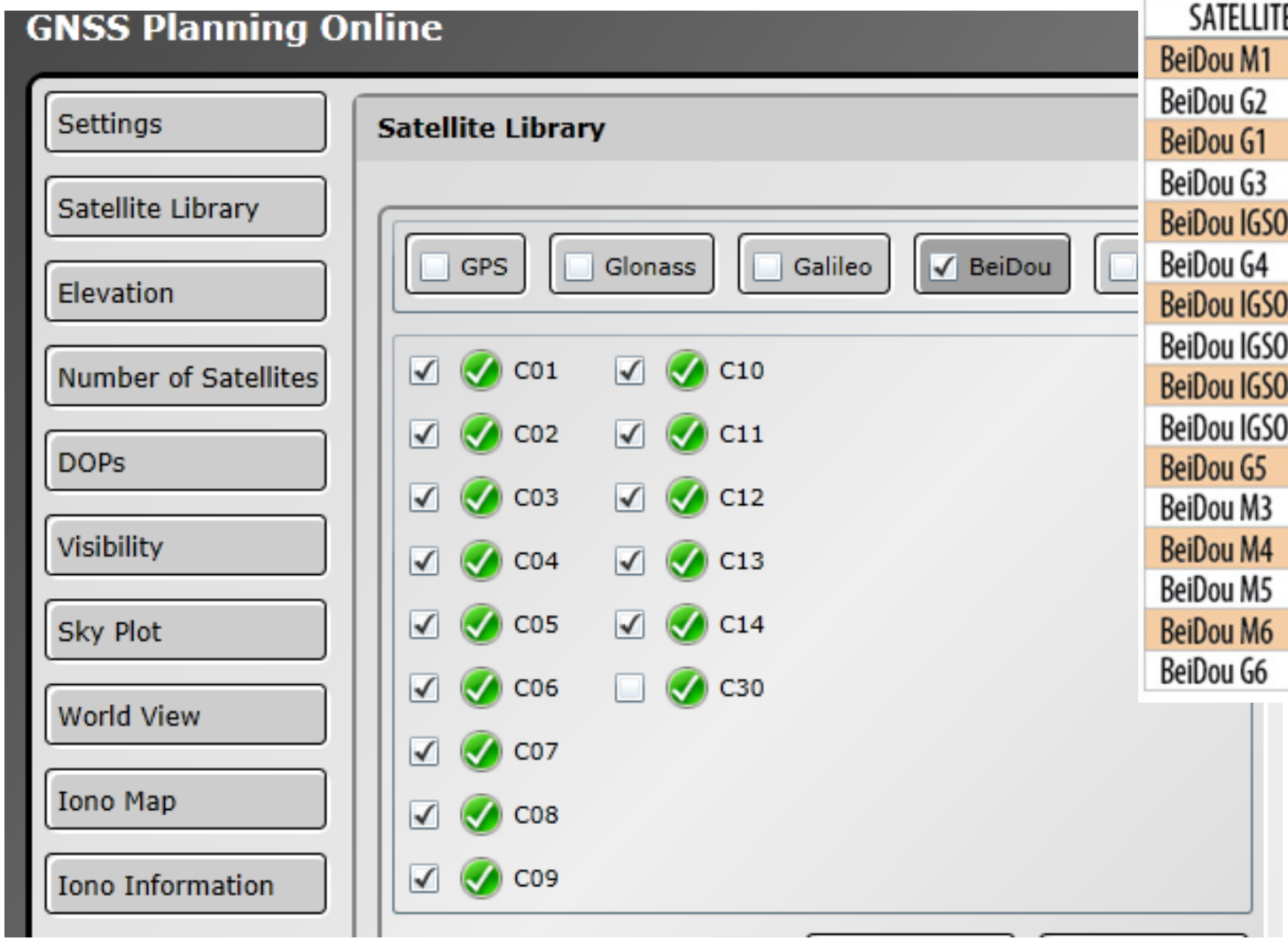
Trimble GNSS Planning online

www.trimble.com/gnssplanningonline



www.trimble.com/gnssplanningonline

gpsworld.com/the-almanac/

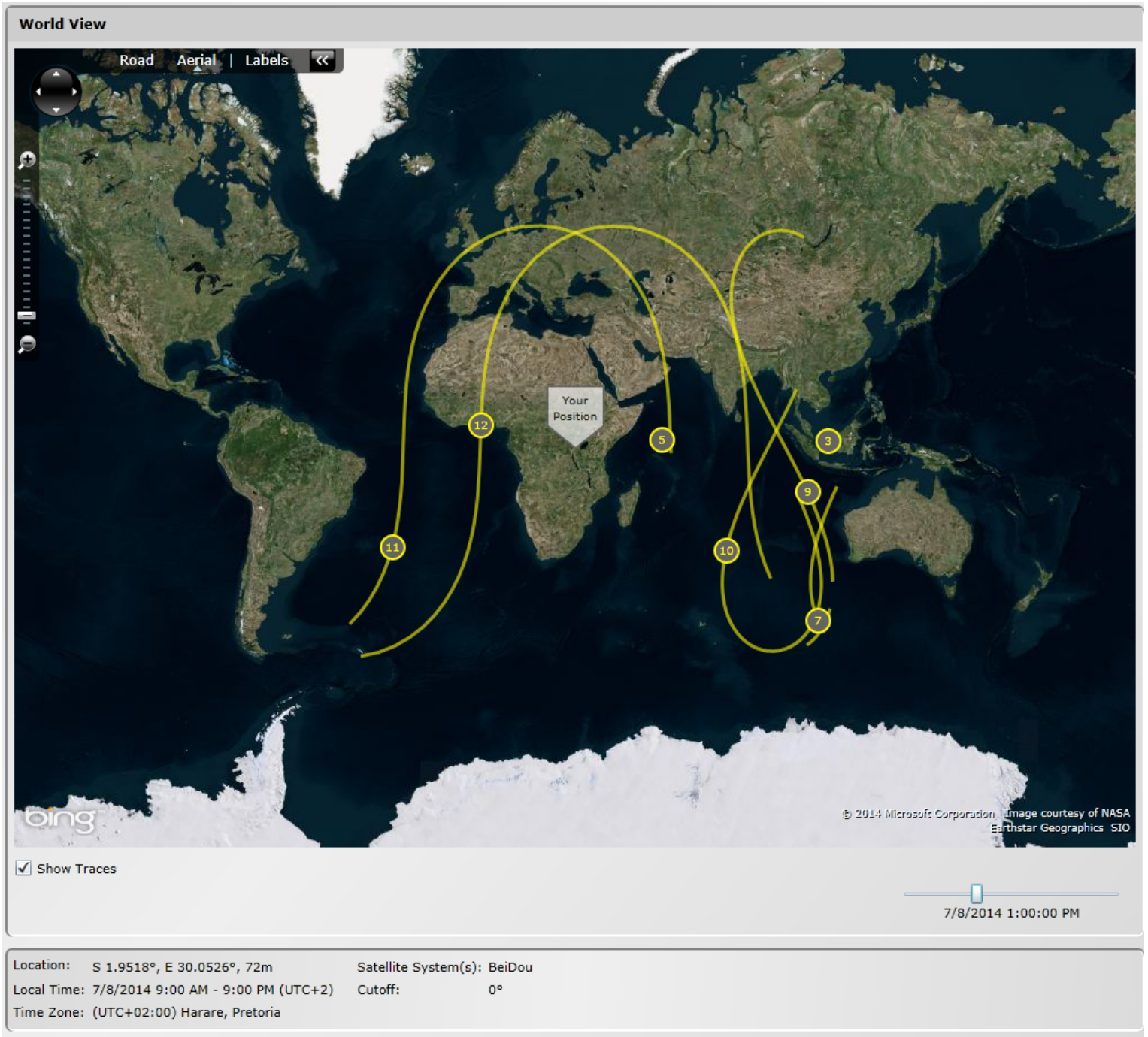


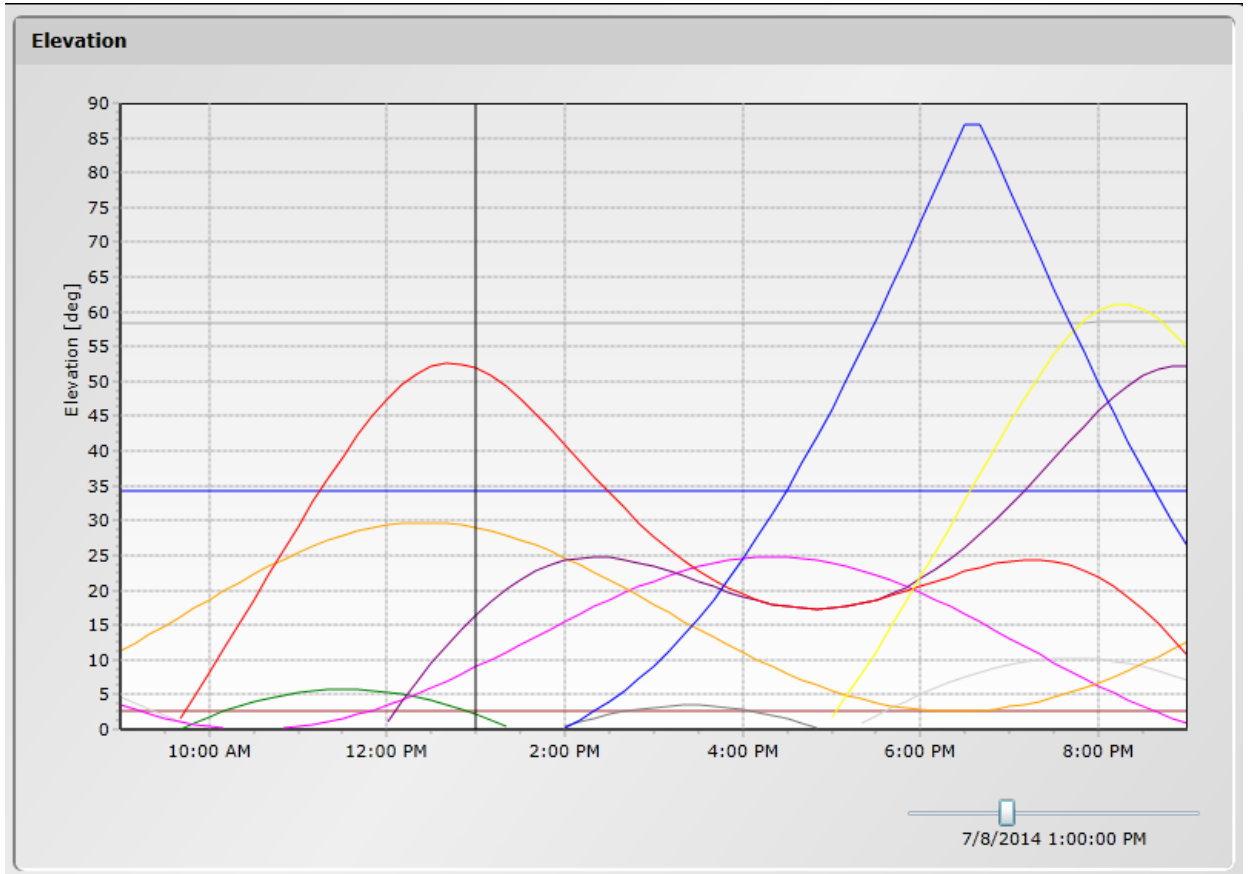
SATELLITE	NORAD ID	PRN	LAUNCHED	ORBIT	NOTES
BeiDou M1	31115	C30	4-13-07	MEO period 12.89 hours	A
BeiDou G2	34779	N/A	4-14-09	GEO drifting	B
BeiDou G1	36287	C01	1-16-10	GEO 140° E	C
BeiDou G3	36590	C03	6-2-10	GEO 110.5° E	D
BeiDou IGSO1	36828	C06	7-31-10	IGSO 118° E, 55.0° incl.	
BeiDou G4	37210	C04	10-31-10	GEO 160.0° E	
BeiDou IGSO2	37256	C07	12-17-10	IGSO 118° E, 55.0° incl.	
BeiDou IGSO3	37384	C08	4-9-11	IGSO 118° E, 55.0° incl.	
BeiDou IGSO4	37763	C09	7-26-11	IGSO 95° E, 55.0° incl.	
BeiDou IGSO5	37948	C10	12-1-11	IGSO 95° E, 55.0° incl.	
BeiDou G5	38091	C05	2-24-12	GEO 58.75° E	
BeiDou M3	38250	C11	4-29-12	MEO period 12.89 hours	
BeiDou M4	38251	C12	4-29-12	MEO period 12.89 hours	
BeiDou M5	38774	C13	9-18-12	MEO period 12.89 hours	
BeiDou M6	38775	C14	9-18-12	MEO period 12.89 hours	
BeiDou G6	38953	C02	10-25-12	GEO 80° E	

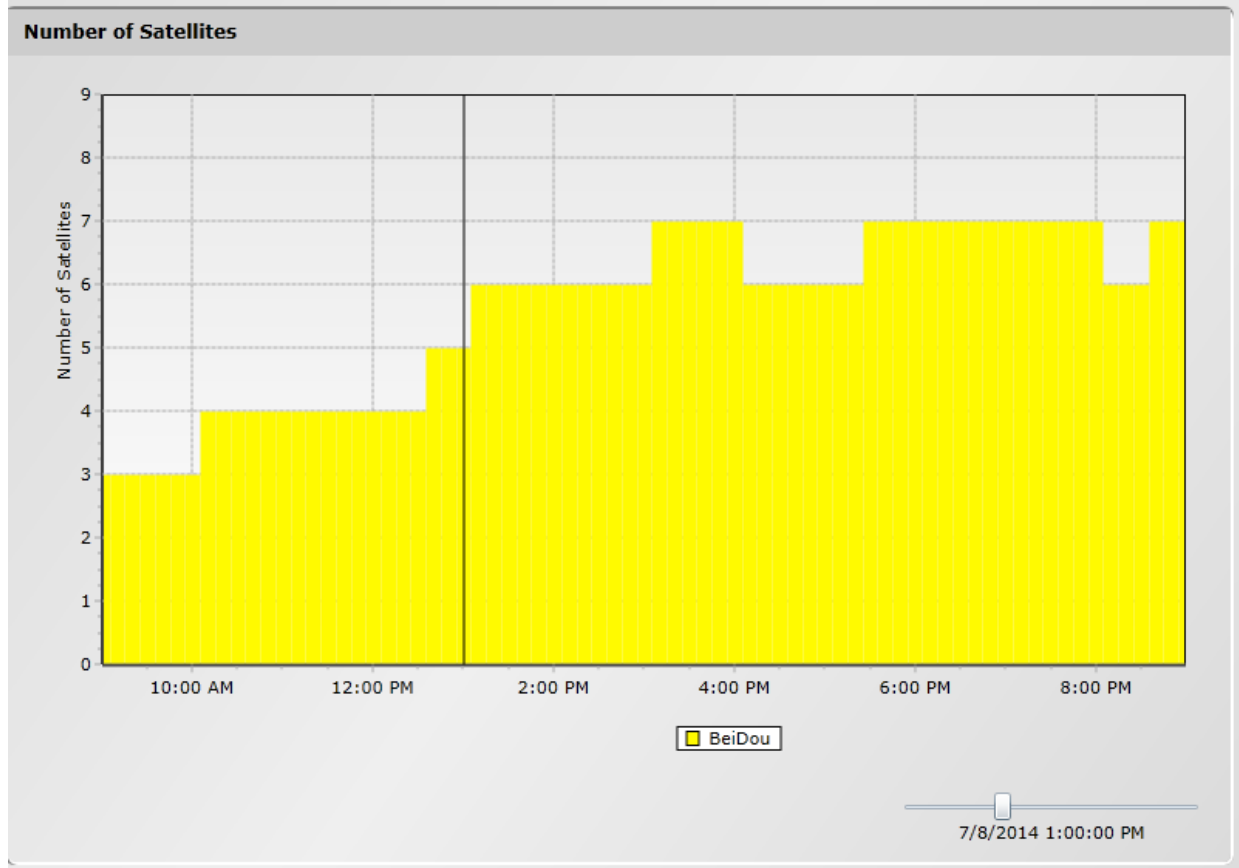
Notes:

A. Inactive.

. . .







MINI-LAB

How many BeiDou satellites can we see from Kigali?