Introduction to GPS

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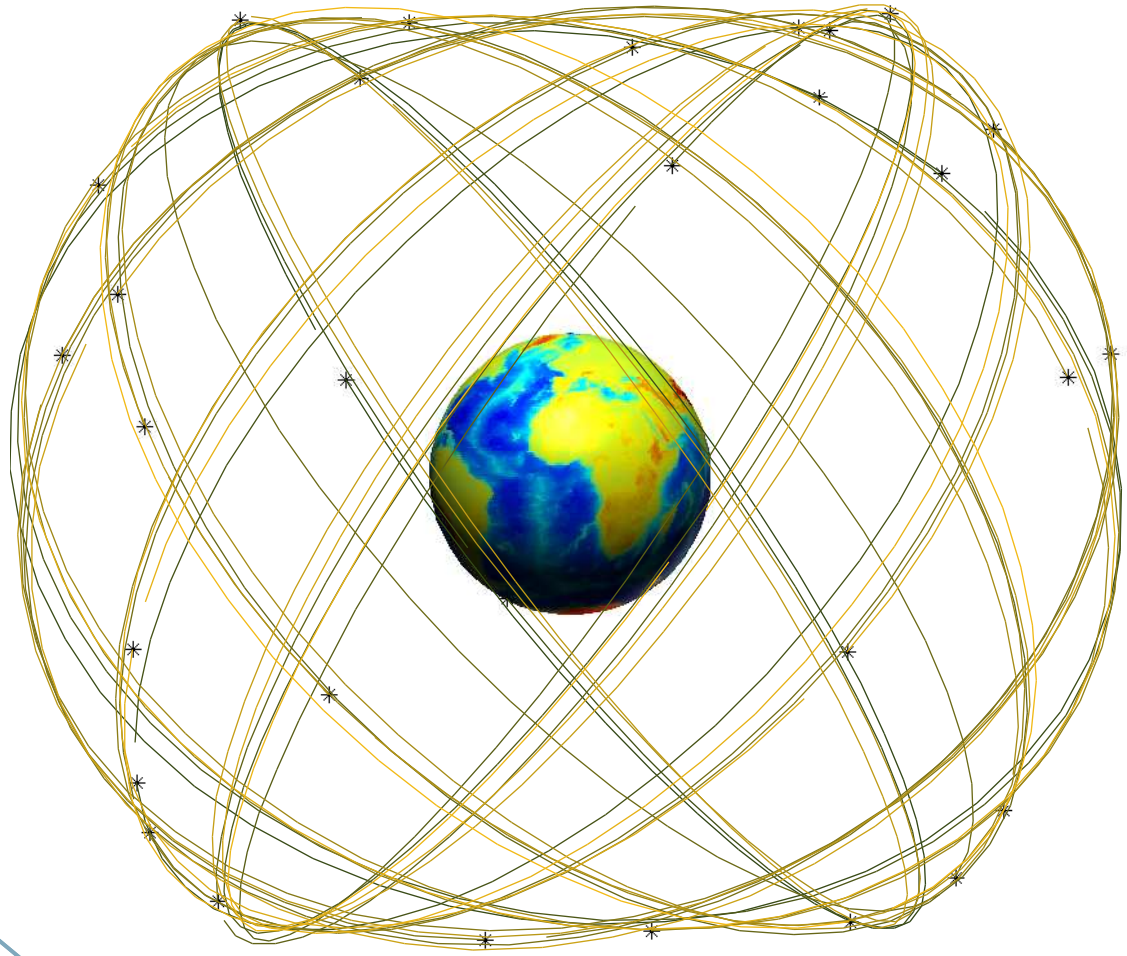
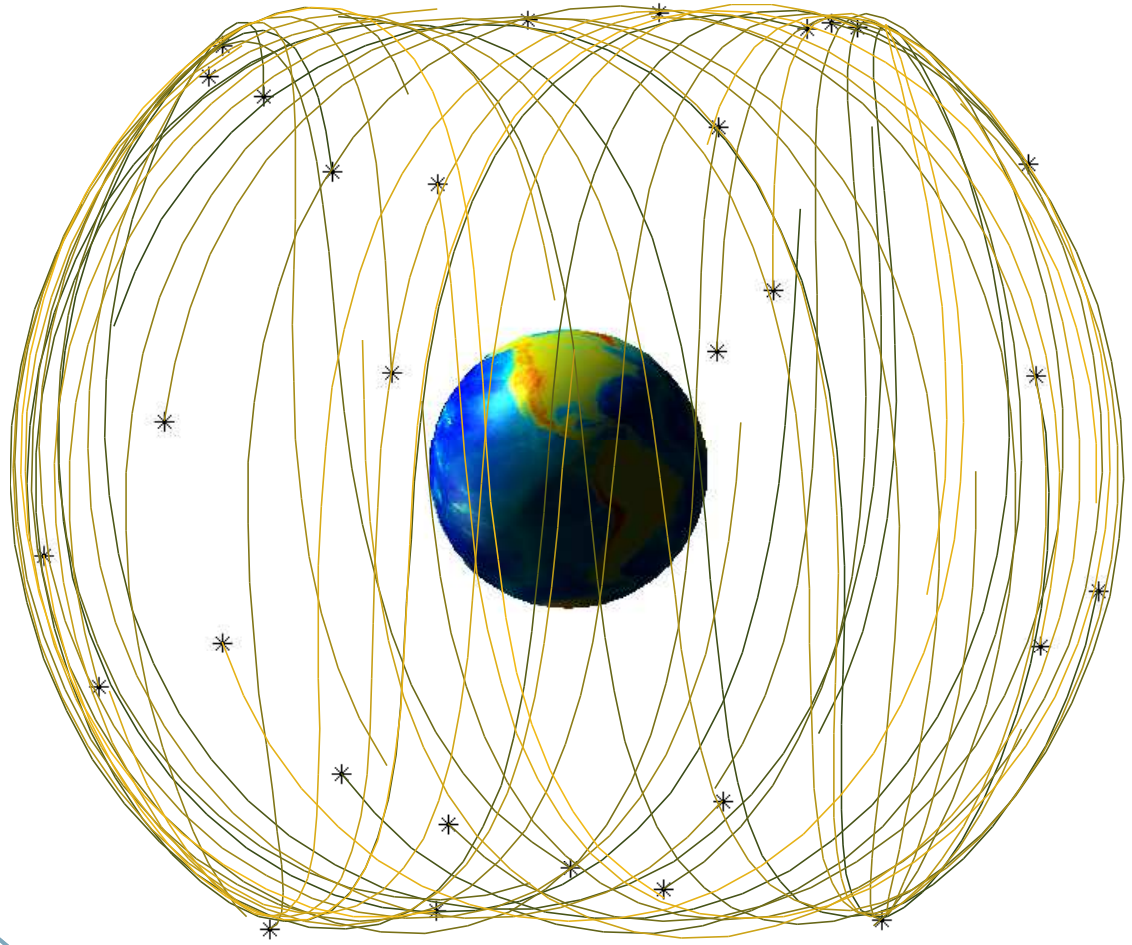
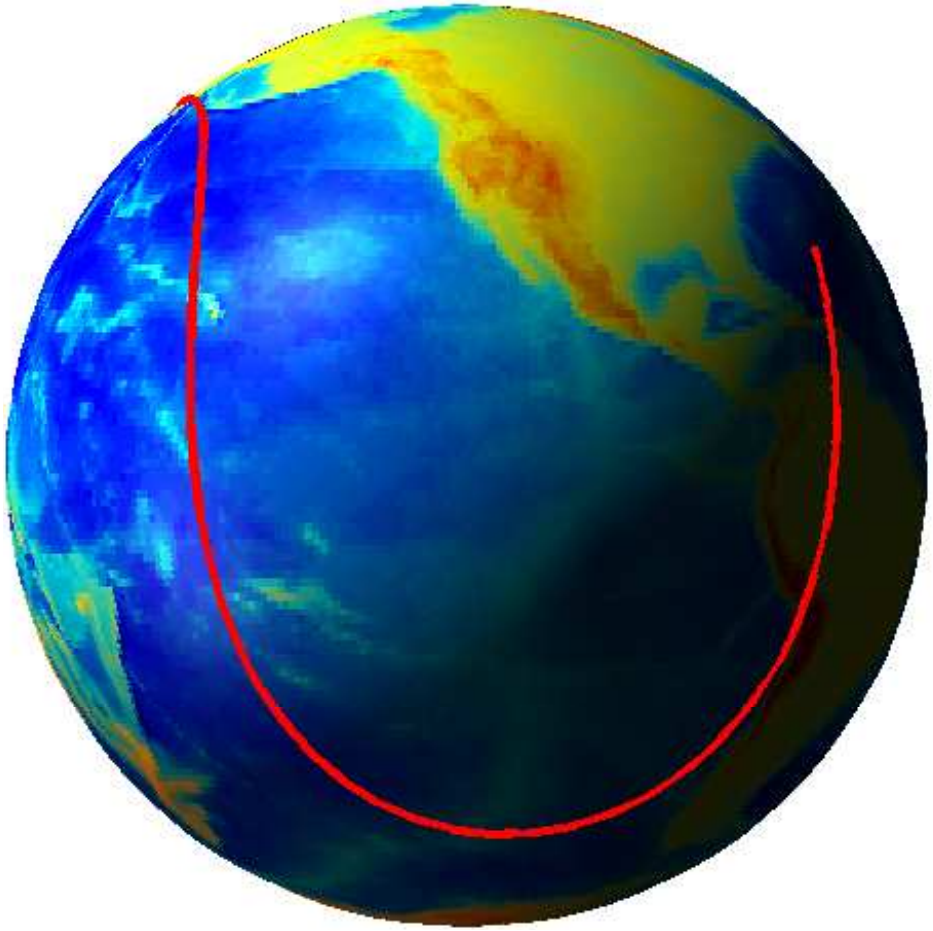
Satelliet orbits as depicted in an inertial frame



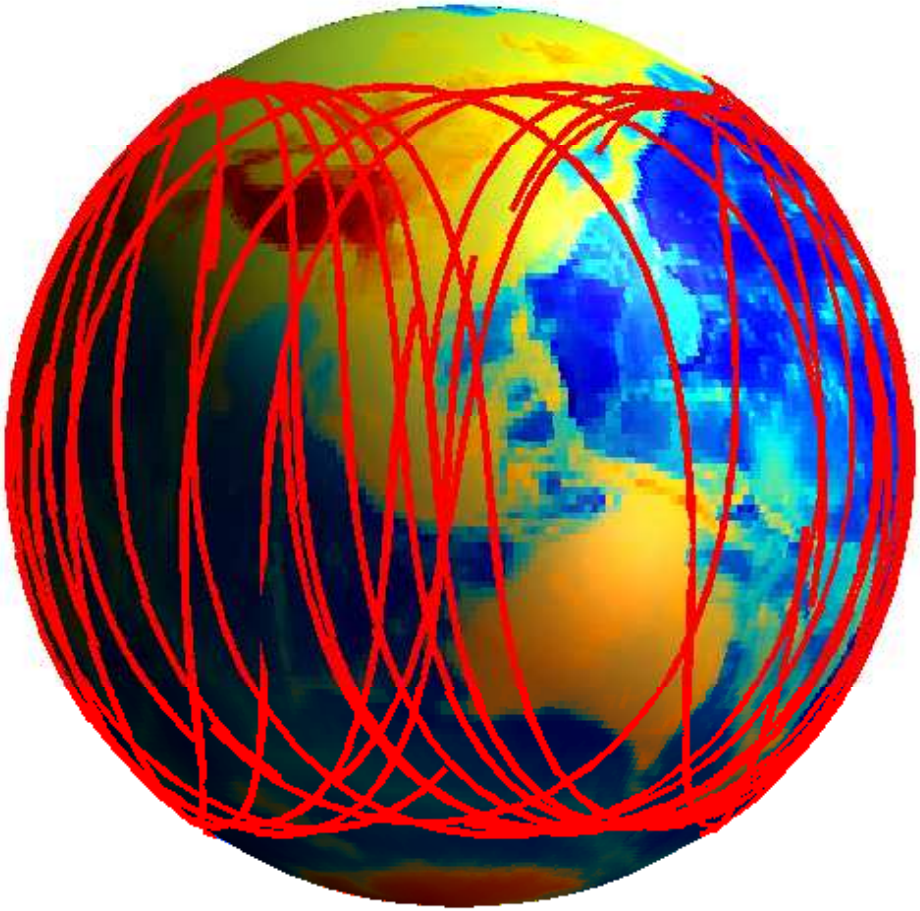
Satellite orbits as depicted in an ECEF frame



Sub-satellite points for a single PRN in 12 hours



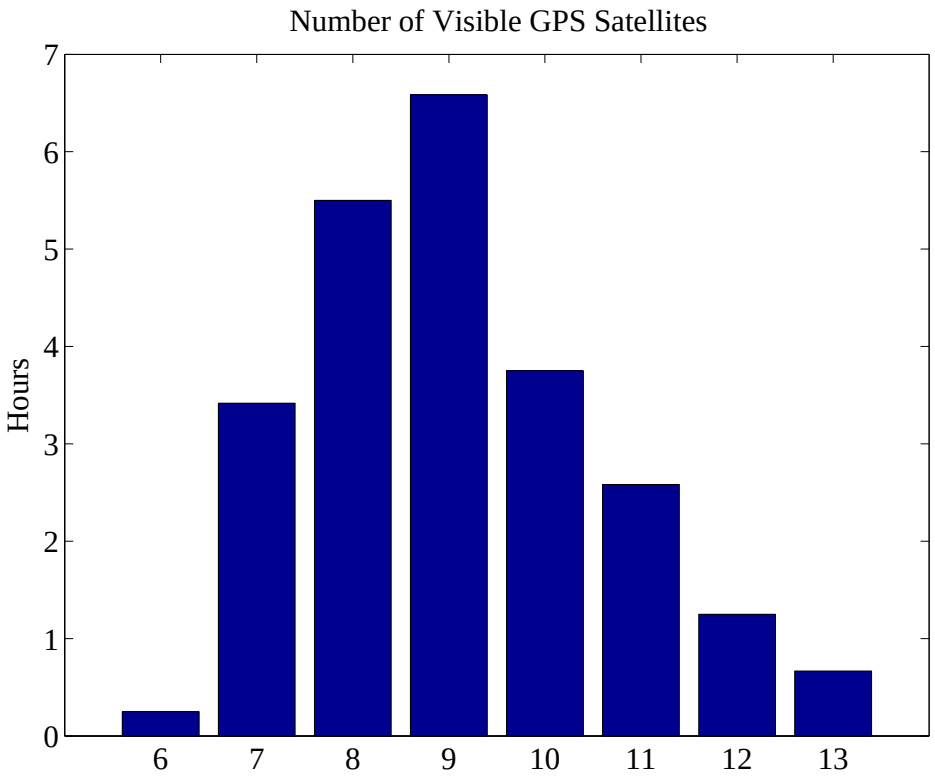
Sub-satellite points for 31 PRNs in 24 hours



Properties of the GPS orbits

- Orbital period is 11 hours 58 minutes
  - two revolutions in one siderial day
  - for a fixed location on the Earth, the GPS satellite passes over every day 4 minutes earlier
- The same satellite is visible over a large area
  - some 6–13 satellites visible simultaneously
  - a satellite passage takes up till 7 hours

Visibility of GPS Satellites



The figure shows the number of visible satellites at the position $\phi = 57°$, $\lambda = 10°$ for cutoff angle 10°.

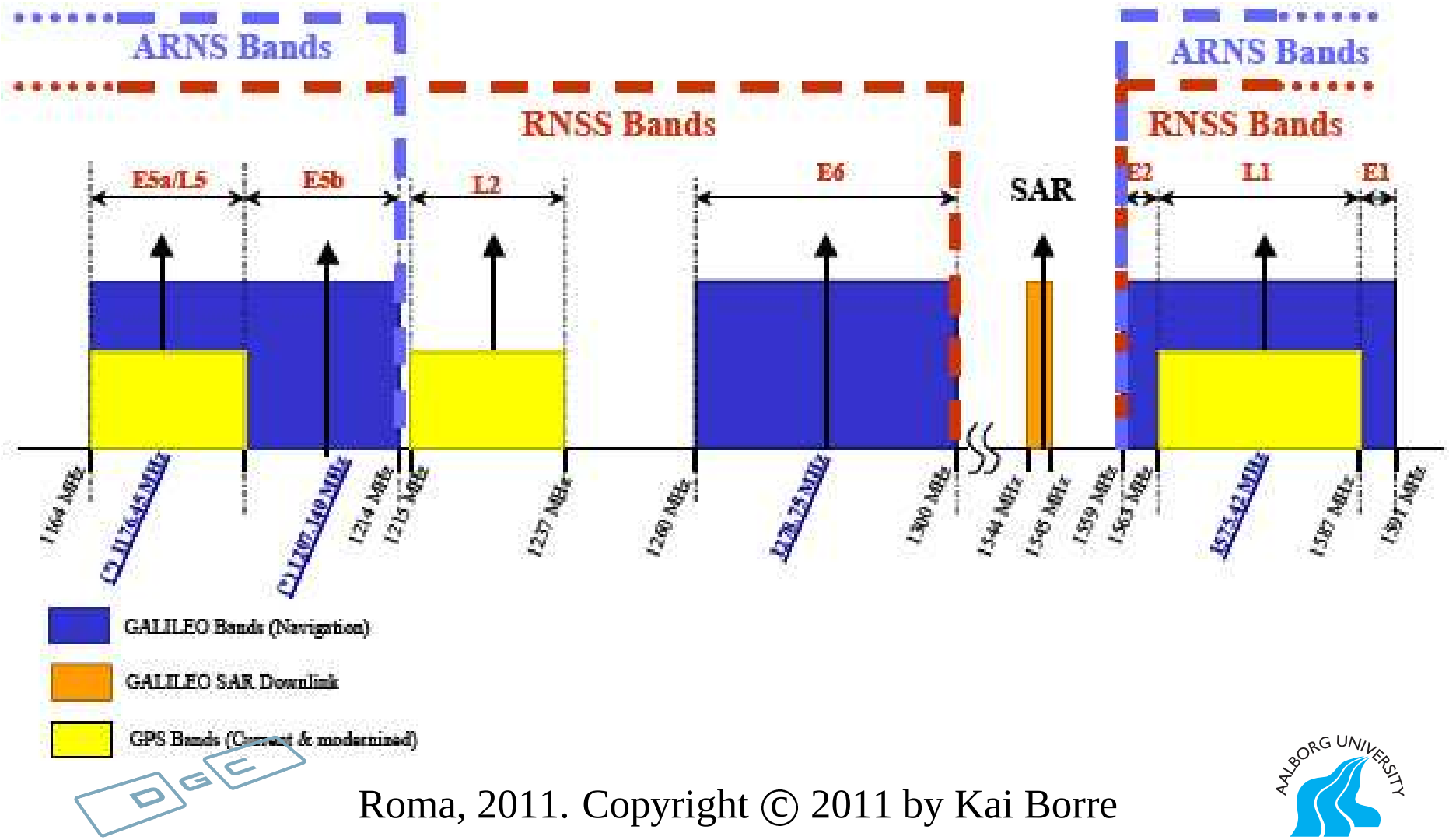
How to Create the Above Plot

After running `easy11` the parameter `visible` is in the workspace. Next, type the following code and the plot is created:

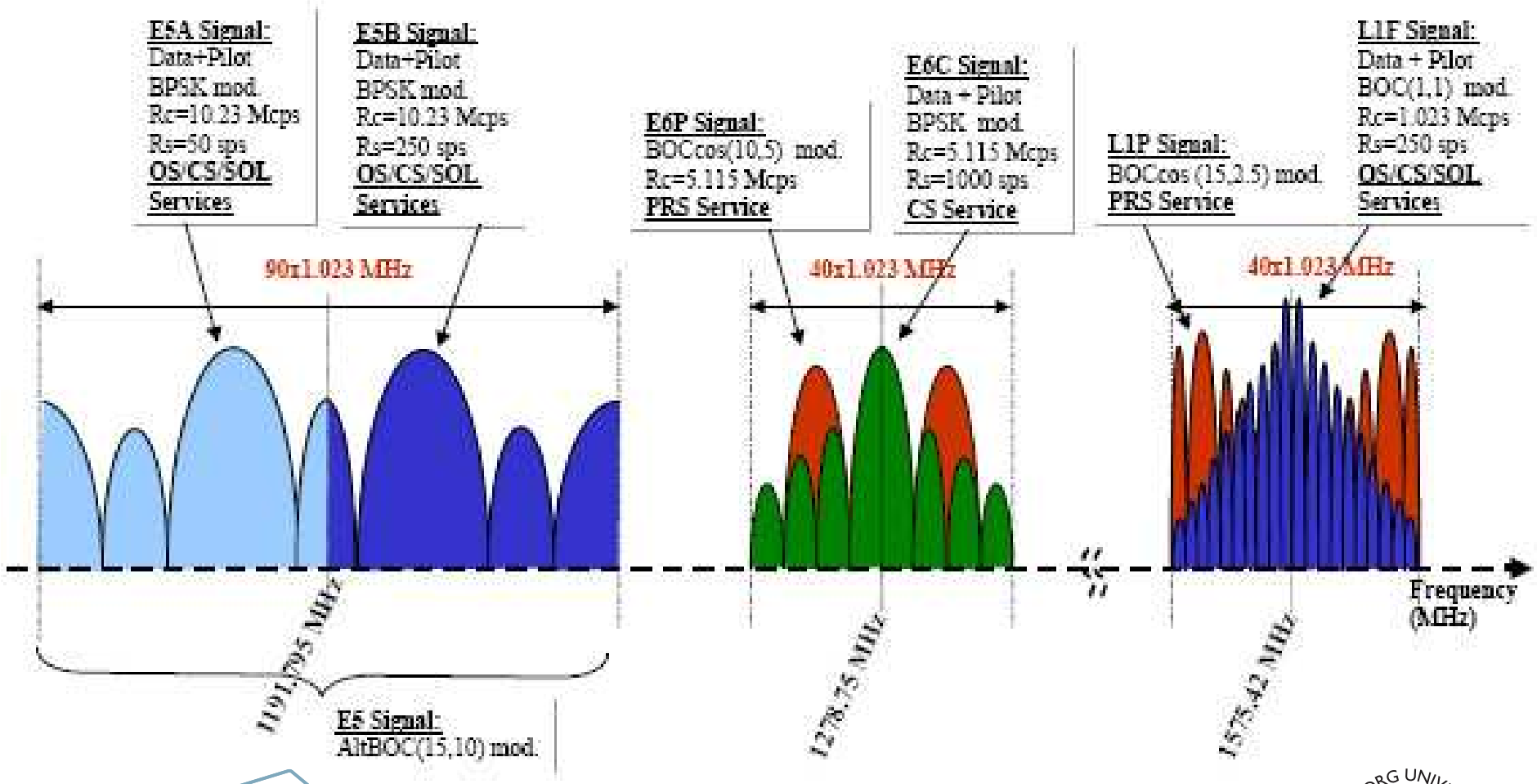
```
figure(4);
set(gca,'Fontsize',16);
an = sum(visible,1);
total = zeros(1,14);
for i = 1:288
    j = an(i);
    total(j) = total(j)+1;
end
bar(6:13,total(6:13)/12); % total is in unit of hour
title('Number of Visible GPS Satellites')
ylabel('Hours')

print -depsc2 easy114
```

GPS and Galileo Frequency Bands



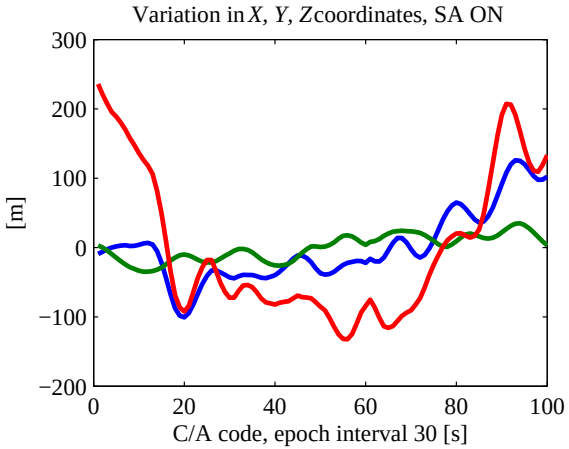
Galileo Signals

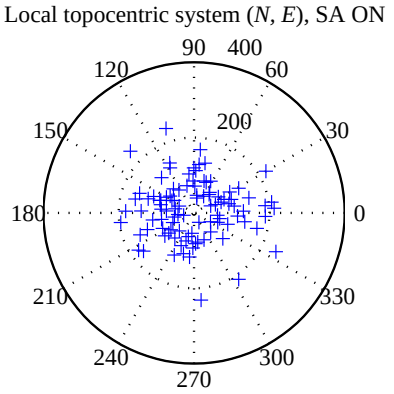


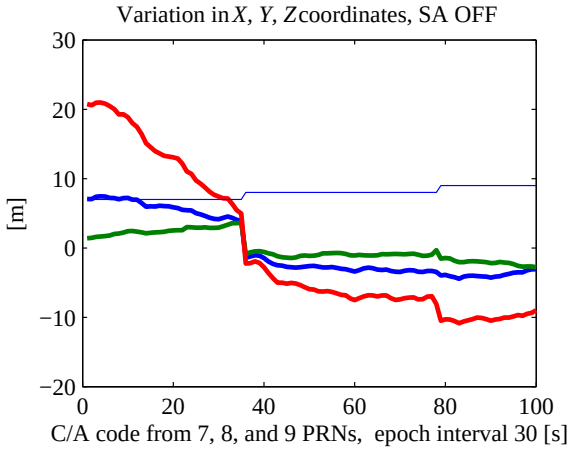
GPS and GLONASS

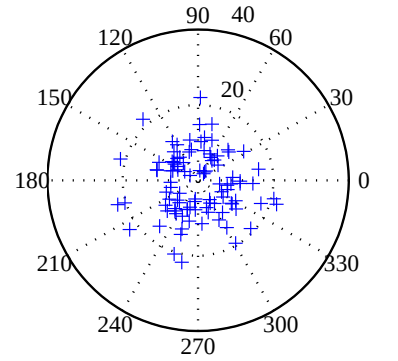
GPS	GLONASS
C/A code L1	C/A code L1
P code L1	P code L1
No C/A code L2	No C/A Code L2
P code L2	P code L2
Code division	Frequency division
SA not active, AS	No SA/AS
6 orbital planes	3 orbital planes
Altitude 20 180 km	Altitude 19 100 km
Period 12 hours	Period 11 hours 15 min.
WGS 84	SGS 85
Almanac every 12.5 min.	Almanac every 2.5 min.

The Effect of Selective Availability









Modernization of GPS

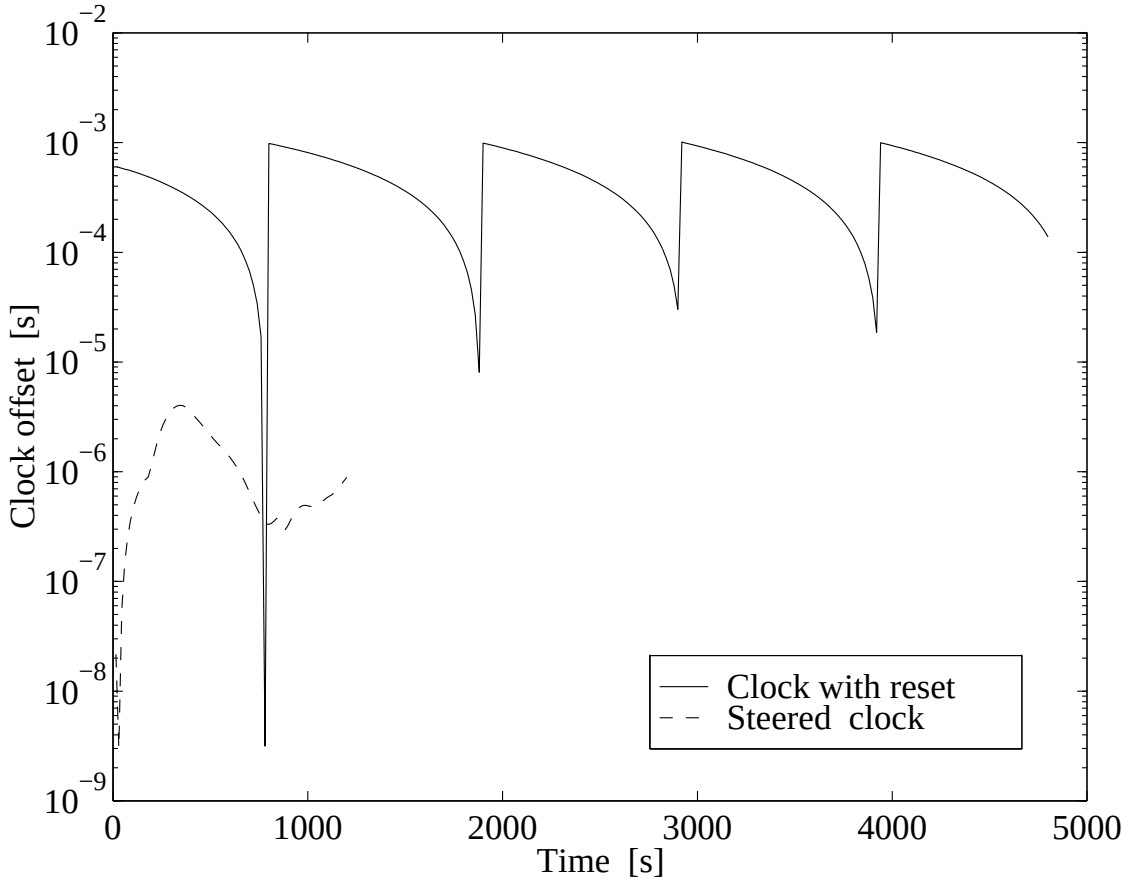
Standard Positioning Service (SPS), σ in meters

Error Source	With SA	Without SA	C/A code on L2 and/or L5	With AII[a]
SA	24.0	0.0	0.0	0.0
Ionosphere	7.0	7.0	0.01	0.01
Troposphere	2.0	0.2	0.2	0.2
Orbit and Clock	2.3	2.3	2.3	1.25
Receiver Noise	0.6	0.6	0.6	0.6
Multipath	1.5	1.5	1.5	1.5
User Equivalent Range Error	25.0	7.5	2.8	2.0
HDOP	1.5	1.5	1.5	1.5
Stand-Alone, Horizontal Acc., 95%	**75.0**	**22.5**	**8.5**	**6.0**
Implementation Date		May 2, 2000	2003–2006	2005–2010

Operational Control Segment improvements from 2000
Source: GPS World, September 2000, pp. 36–44

[a] Accuracy Improvement Initiative

Receiver Clock Offset



The Pseudorange Puzzle

$$\begin{aligned}\text{time at sat.} = {} & \text{Z-count} \times 1.5 \\ & + \text{number of navigation data bits transmitted} \times 20 \times 10^{-3} \\ & + \text{number of C/A-code repeats} \times 10^{-3} \\ & + \text{number of whole C/A-code chips}/(1.023 \times 106) \\ & + \text{fraction of a C/A-code chip}/(1.023 \times 106)\ \text{seconds}\end{aligned}$$