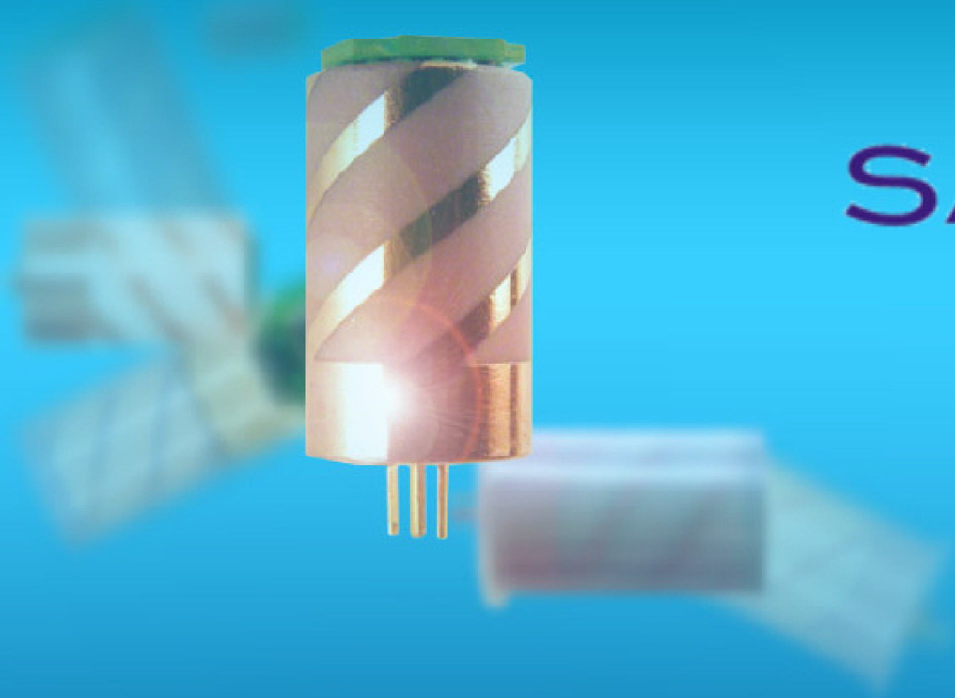


SARANTEL

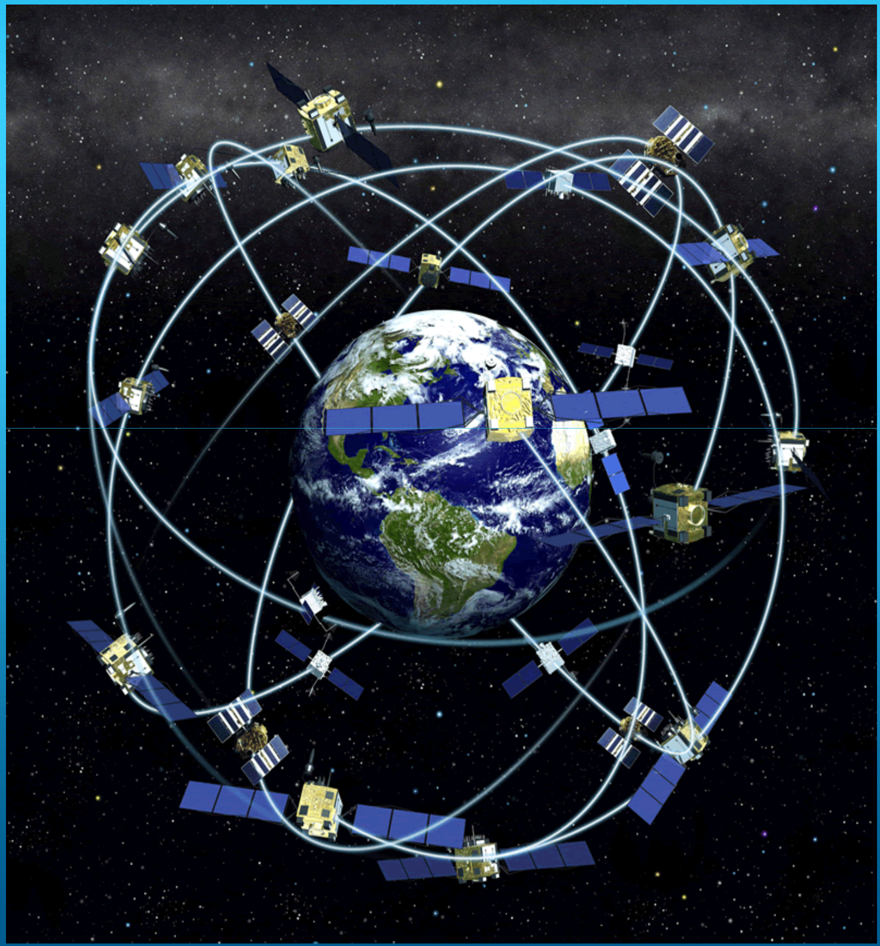
GPS constellation measurements at different points around the World

www.sarantel.com

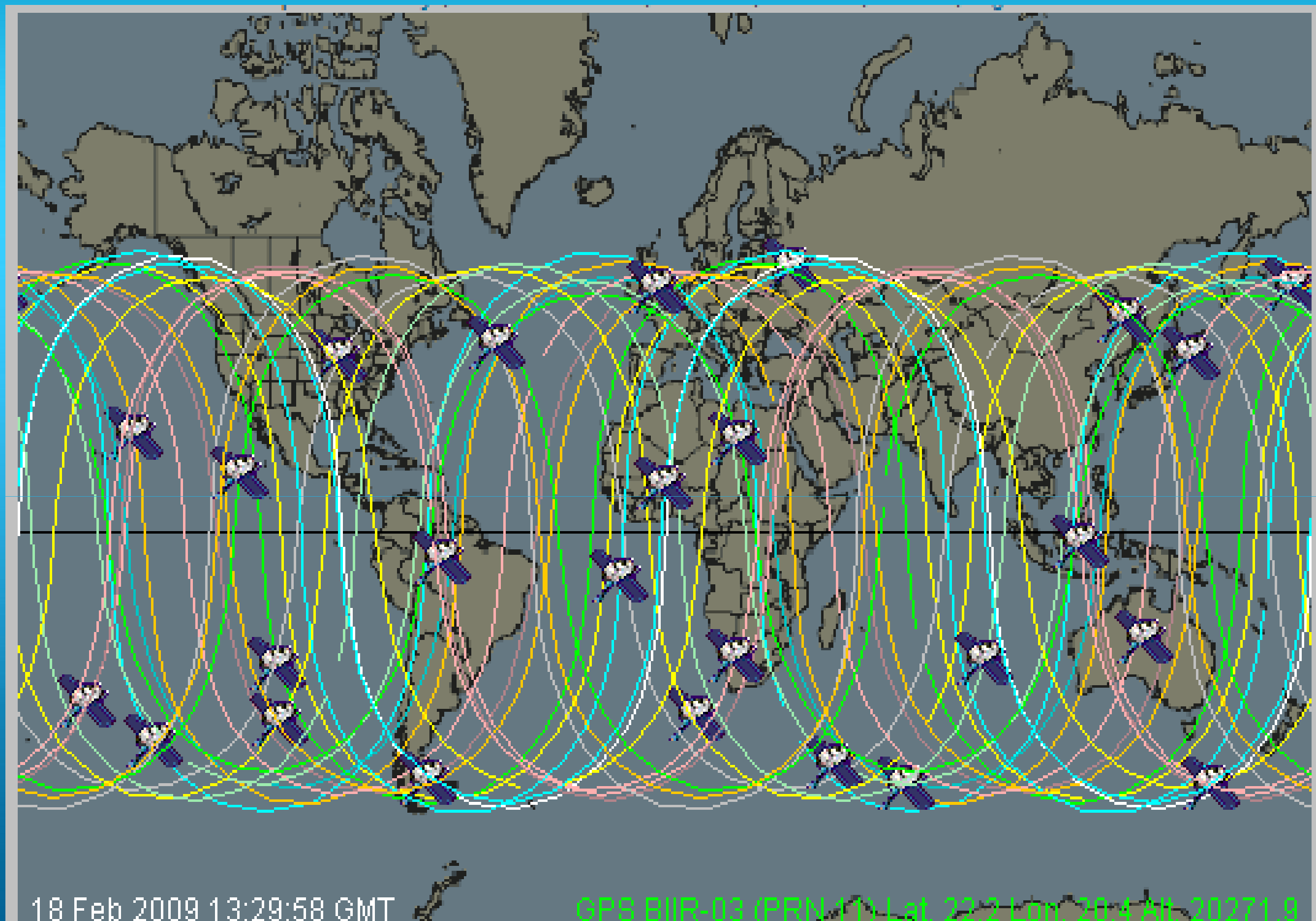
GPS satellite orbits

There are currently 31 operational satellites in the NAVSTAR constellation. These satellites are arranged in 6 orbital planes, which are inclined to the Earth's equator at 55 degrees, and a height of 20,200 km. Within these orbital planes, the satellites make an orbit approximately every 12 hours.

The following slides show the pattern that the satellite orbits makes over the Earth as it spins.

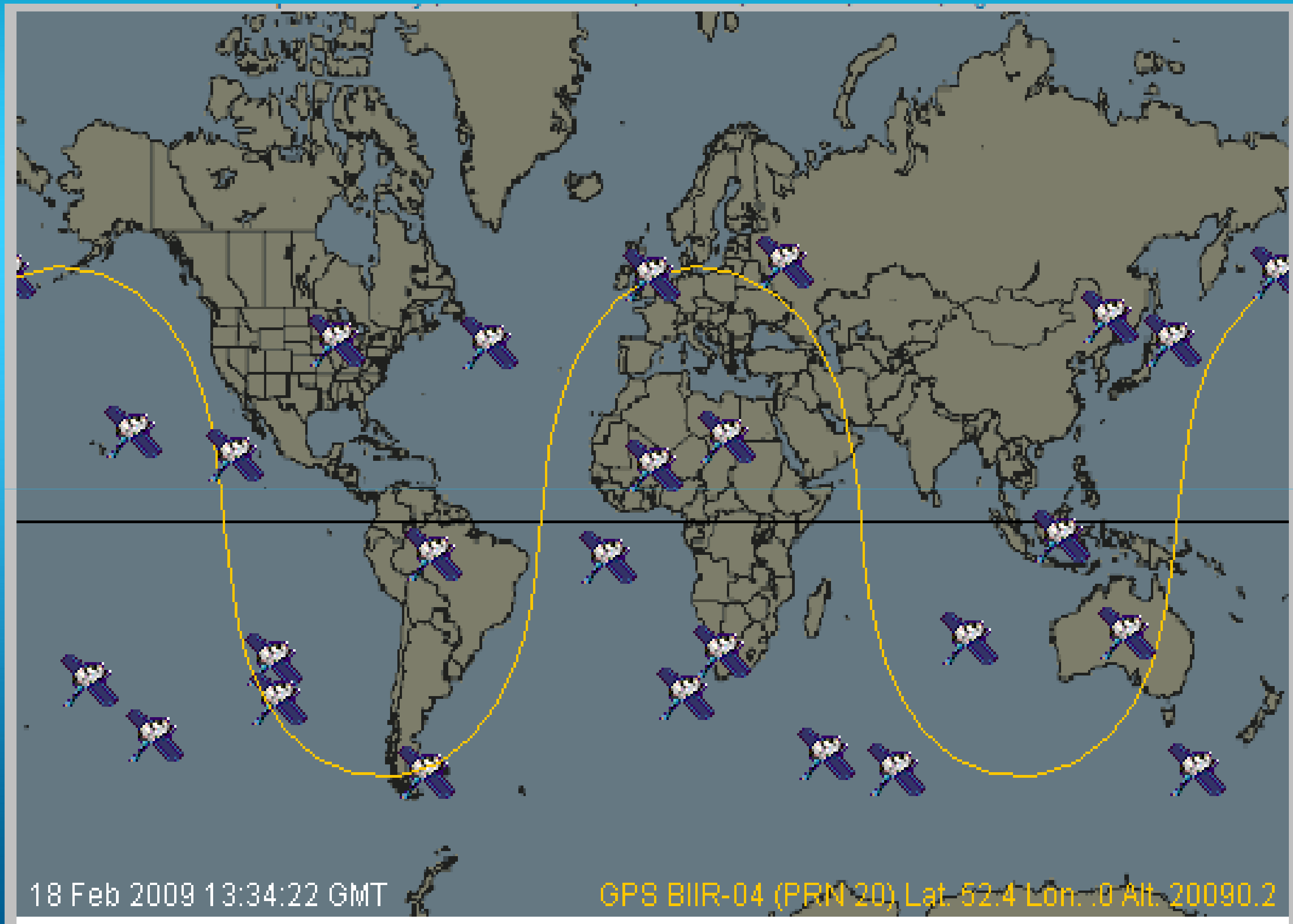


Satellite ground trace – all satellites



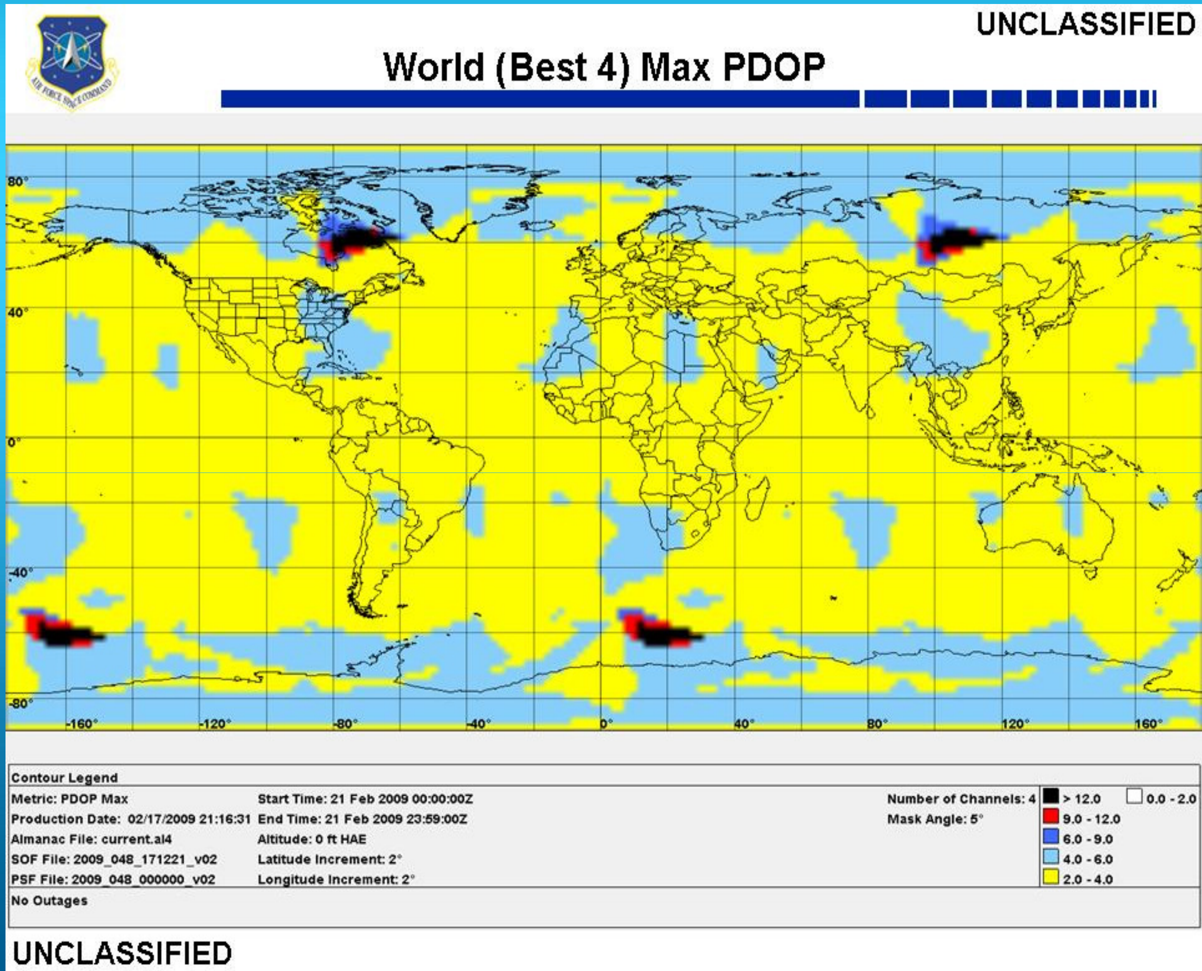
Generated using NASA satellite tracking website
http://science.nasa.gov/realtime/jtrack/Spacecraft.html

Satellite ground trace – PRN 20



Generated using NASA satellite tracking website
http://science.nasa.gov/realtime/jtrack/Spacecraft.html

Data from US Navigation Centre for expected PDOP



http://www.navcen.uscg.gov/gps/pdop.htm

Satellite Constellation Summary

- PDOP (Percent Dilution of Position) is a measure of the geometrical strength of the GPS satellite configuration. The amount of error in your position. PDOP less than 4 gives the best accuracy (under 1 meter). Between 4 and 8 gives acceptable accuracy. Greater than 8 gives poor accuracy.

- The data from the US Navigation Centre shows that except for a few patches the PDOP is very good between latitudes of +60° and -60°. This covers all of North America, South America, Africa, Asia, Australia and most of Europe.

- The places where the PDOP drops is the extreme North of Europe and Northern Russia and Antarctica.

- The further North or South you go on the Earth (greater than a latitide of 60 °) then there is a reduction in the Elevation that Satellites travel which is impacting the PDOP.

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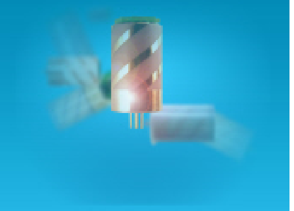


SARANTEL DATA

NMEA data collected and analysed from different points around the World

NMEA data logs – GSV data (satellites in view)

Data log locations

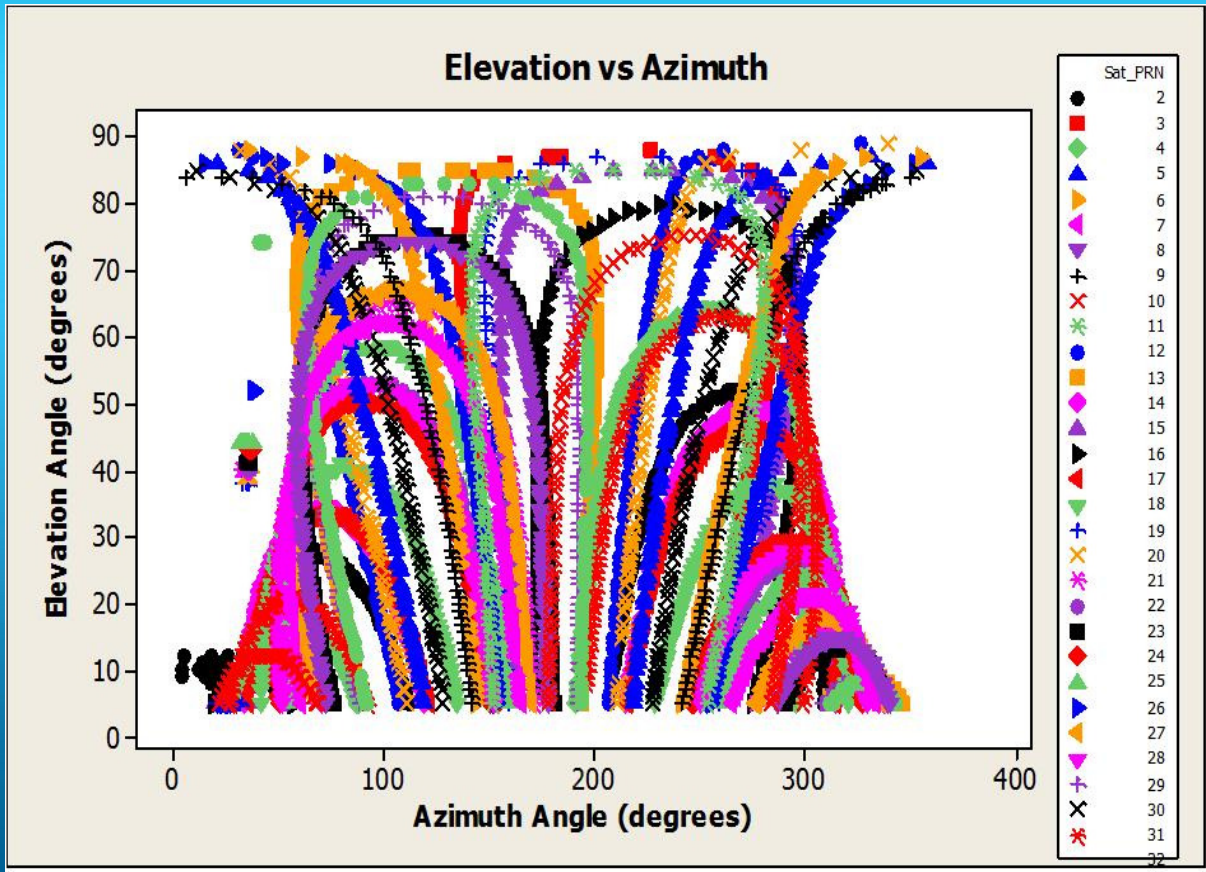
Location	Latitude	Longitude
Portsmouth, UK	50.8	-1.1
Los Angeles, USA	34.1	-118.3
Johannesburg, SA	-25.9	25.2
Singapore	1.3	103.8
Taipei, TW	25.0	121.6

UK data - 24 hour static data log

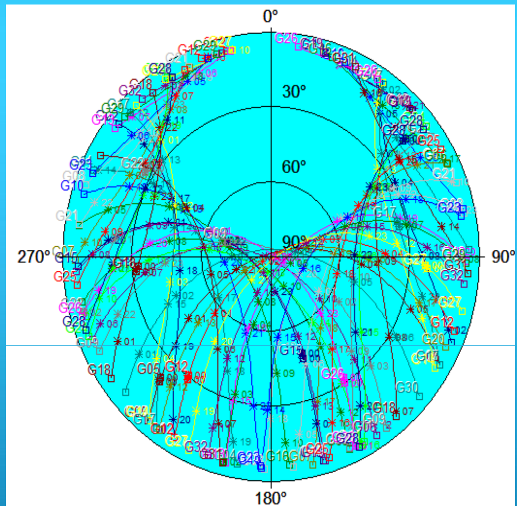
The data adjacent shows that only a few satellite trajectories bring the elevation angle of a satellite above 50°- 60° with only a few satellites travelling above 75°. The most likely place in the sky that a satellite will be is in the region of 10° - 50°.

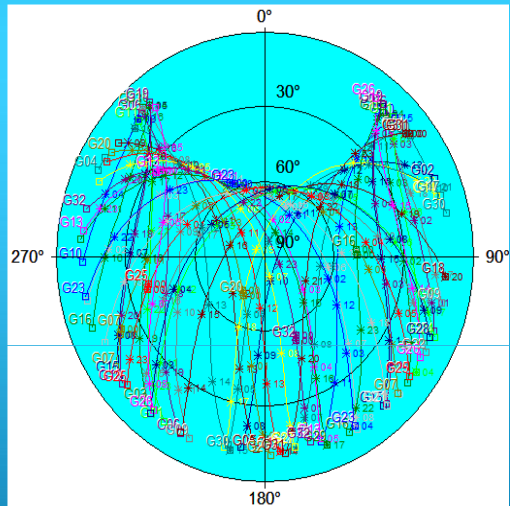
The data also shows an area in the sky you will never see a satellite; centred around an elevation angle of 50° in a Northerly direction (azimuth angle of 0°).

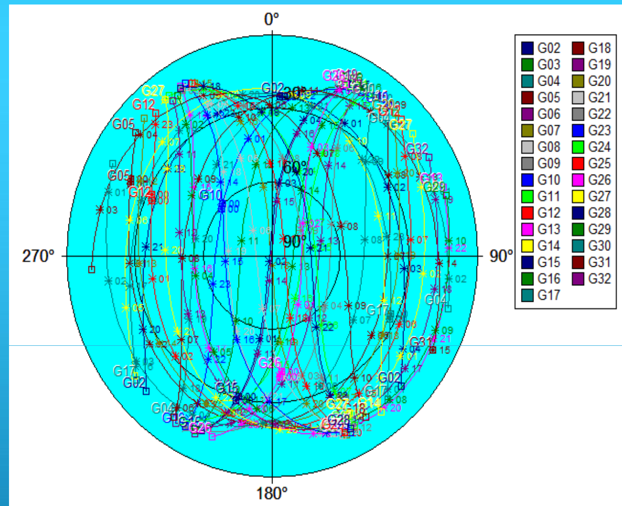
This area with no satellites becomes smaller the closer the observer gets to the equator as shown in the next slide.



Sky View of GPS Satellite Trajectories





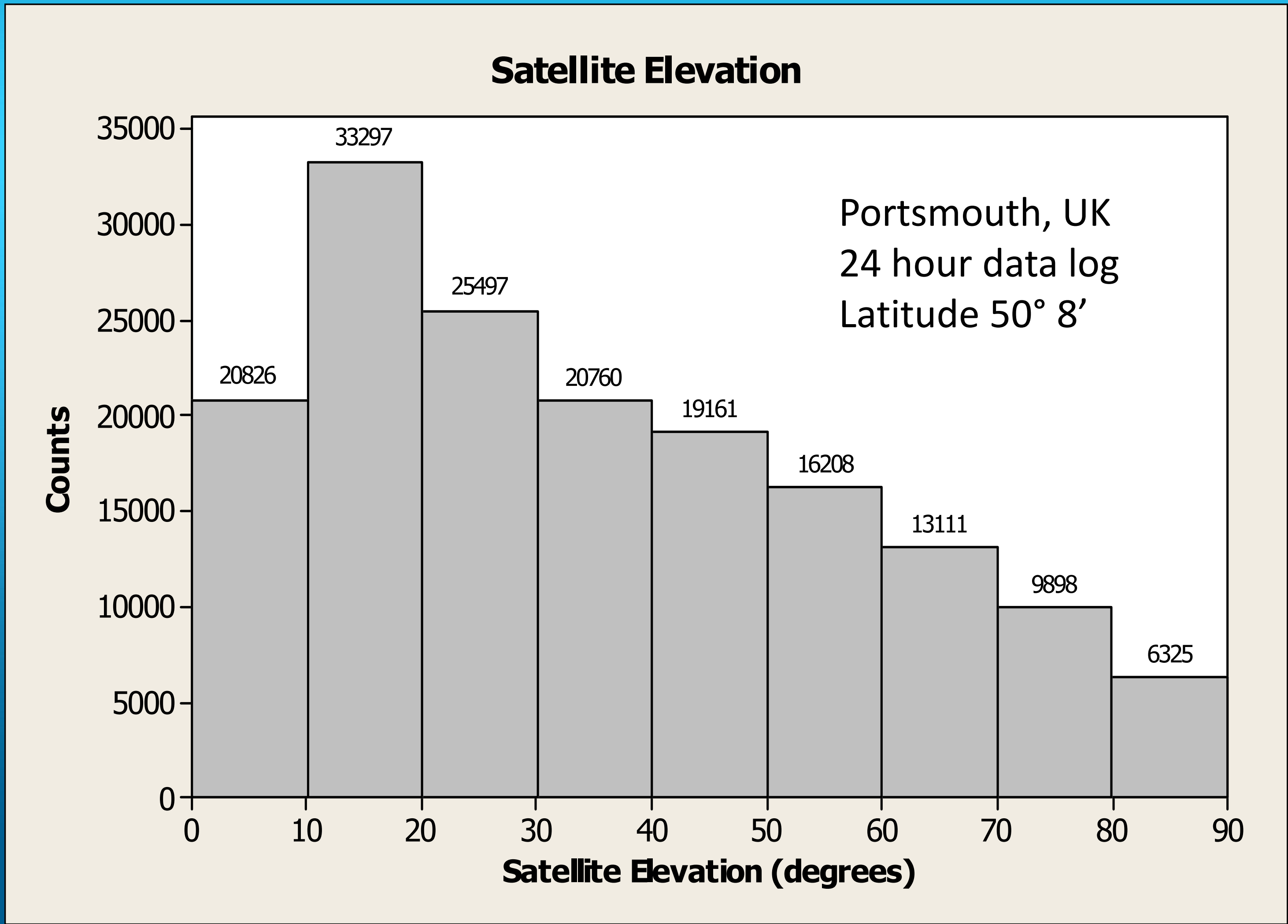


Sarantel HQ
Wellingborough, UK
Latitude 52° 18’

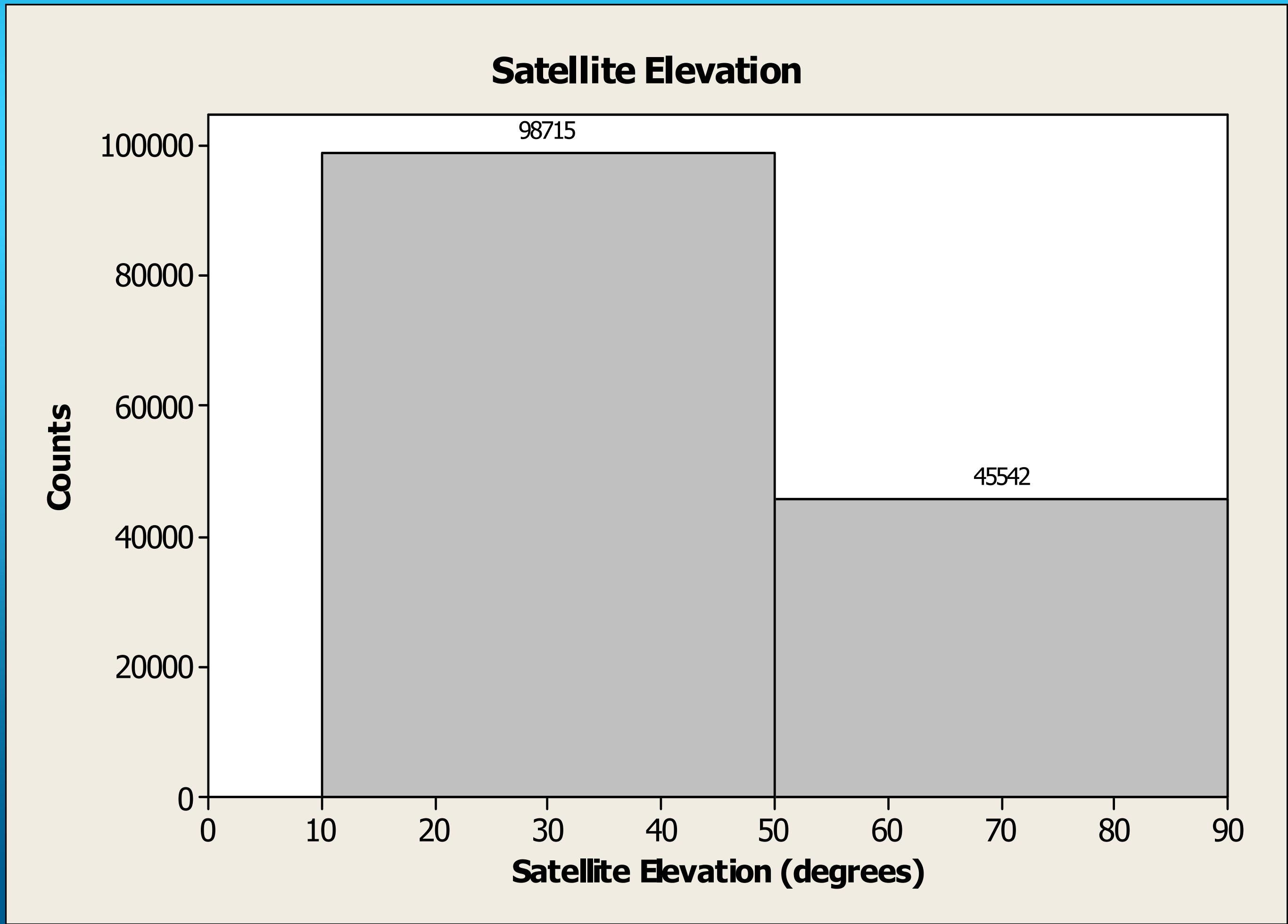
Los Angeles, CA
USA
Latitude 34° 3’

Singapore
Asia
Latitude 1° 22’

Probability Distribution of Elevation Angle – 10° bins



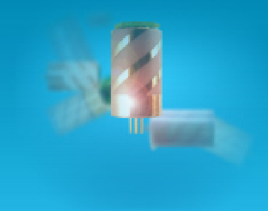
10°– 50° and 50°– 90° Elevation Angle bins



Summary data

10° - 50° = 68.4%

50° - 90° = 31.6%

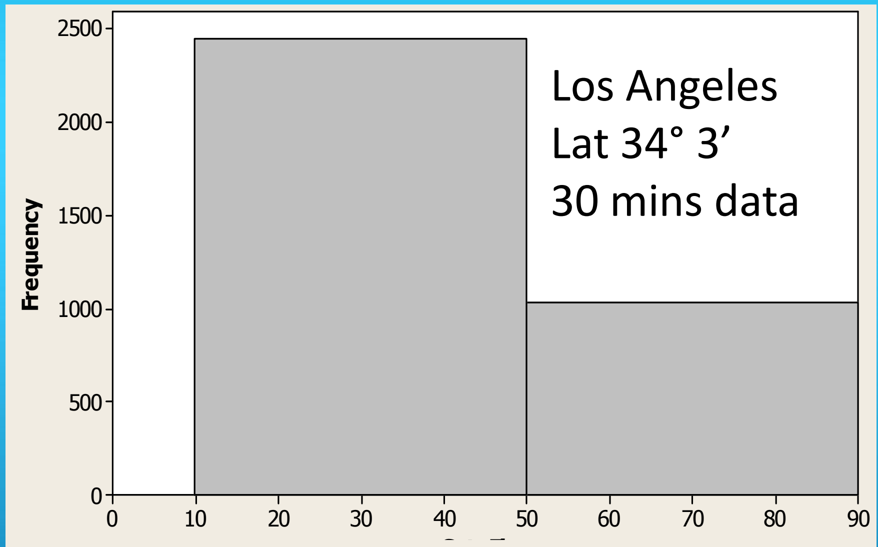


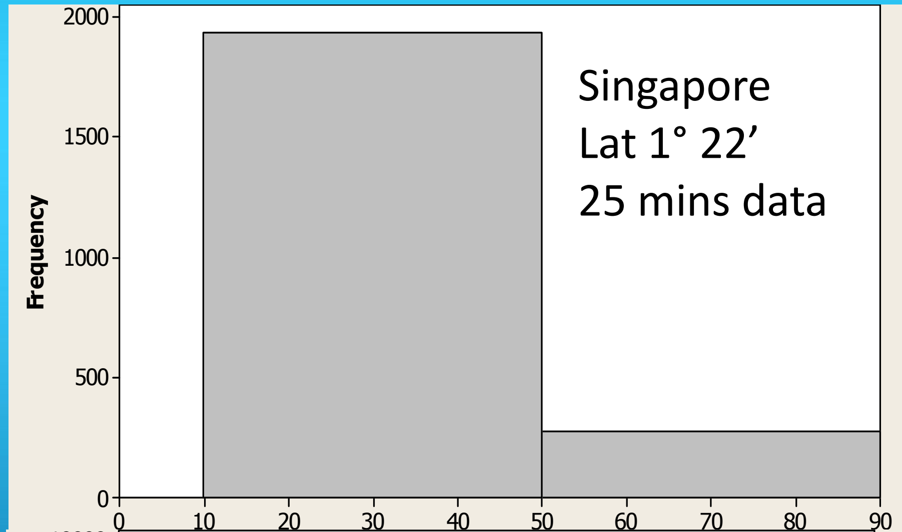
Comments – probability distribution

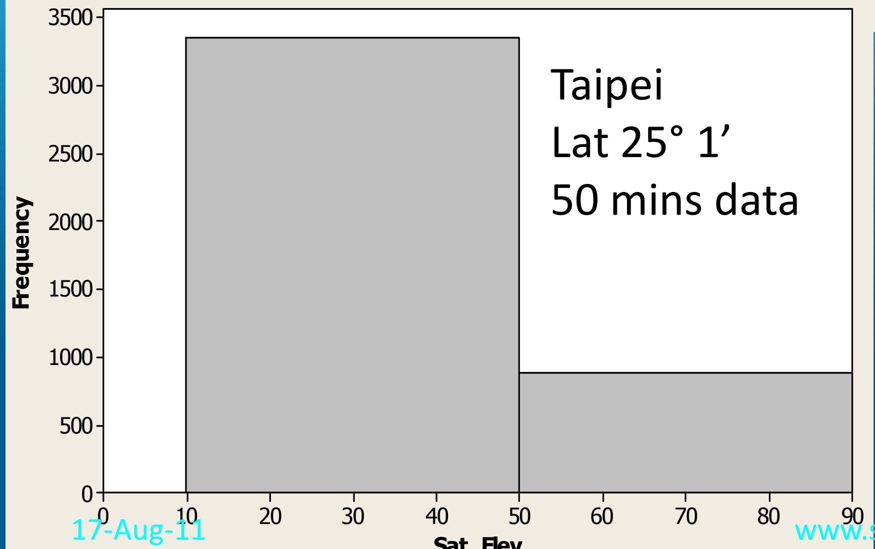
- The 10° bins histogram shows that as the Elevation Angle increases the probability of a satellite being in that area of the sky reduces (90° = directly overhead)
- It is more than twice as likely that you will see a satellite at an elevation angle between 10° and 50° than between 50° and 90°
- From an antenna perspective it is more important that the antenna has good omni-directional gain especially at lower elevations
- More emphasis on the antenna specification should be placed on gain at lower elevations than on the peak Zenith gain of the antenna

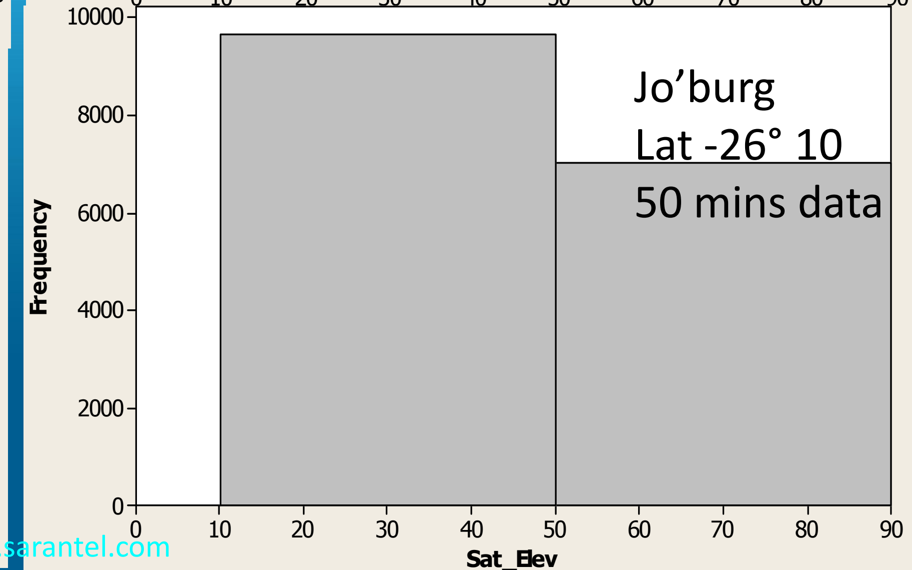
Additional locations – Short data logs

This data has been added for completeness but we would like to regenerate these graphs with longer datalogs







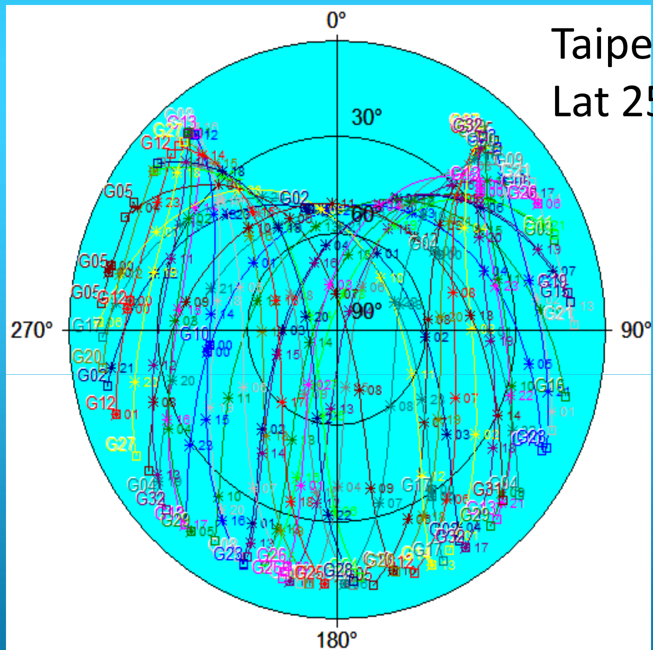


Comments on additional location data

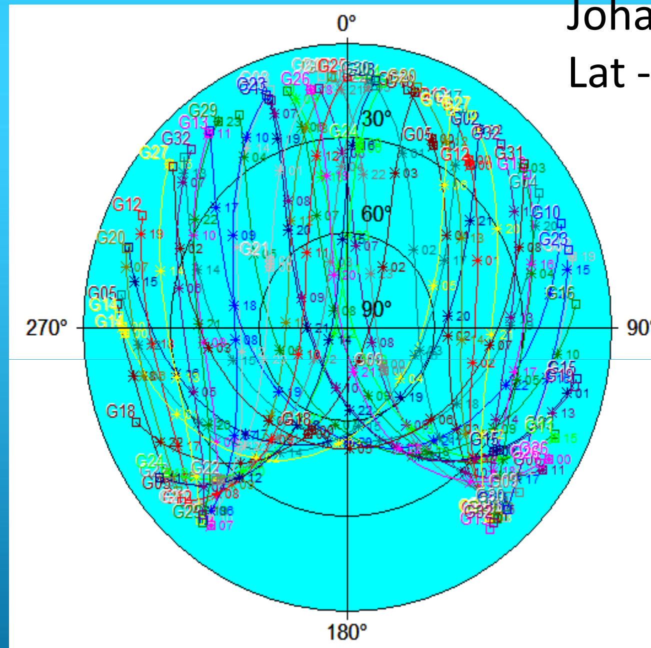
- The trend of the higher probability for seeing more satellites at elevation angles between 10°and 50° is shown at different locations around the world
- In order to gain more confidence in the data longer data logs would need to be taken
- The data for Taipei and Johannesburg should be very similar as they are at similar latitudes, 25°North and 26° South respectively but show a different probability
- The difference in the Taipei and Johannesburg data shows the need for longer data logs

Taipei and Jo'burg Satellite traces

Taipei
Lat 25° 1'

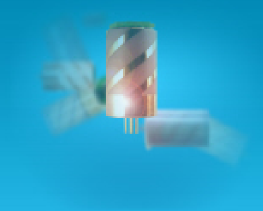


Johannesburg
Lat -26° 10



Even though the area of the sky where satellites can be seen are almost identical, Taipei has a gap to the North and Johannesburg has a gap to the South, the graphs on page 15 show very different results. This difference highlights the need for longer data logs.

Conclusions



- The data shows that at different places around the world satellites can be seen at elevation angles up to 90° (directly overhead)
- There is twice the probability of satellites being at an elevation angle between 10° and 50° than at an elevation angle of between 50° and 90°
- In order to ensure good GPS performance anywhere in the world it is essential to have a GPS antenna with an omni-directional antenna pattern at all elevation angles