International Committee on Global Navigation Satellite Systems

GNSS, How it Works and Applications

Historic Navigation

- Reference points in the sky used for navigation
  - The Sun
  - The Pole Star / North Star
  - Southern Cross

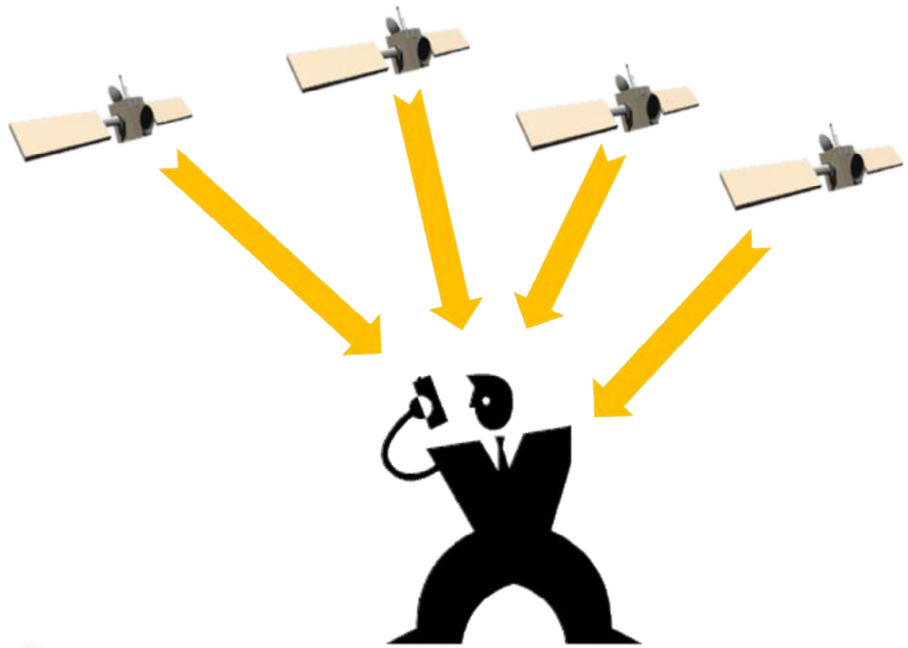
- Gives Direction, but not position

- Add a sextant to give latitude

- And a clock to give longitude

GNSS Principles

- GNSS satellites in the sky are the new reference points
- If my GNSS receiver "sees" 4 or more satellites, it can compute my position
  - "see" means track and process navigation signals



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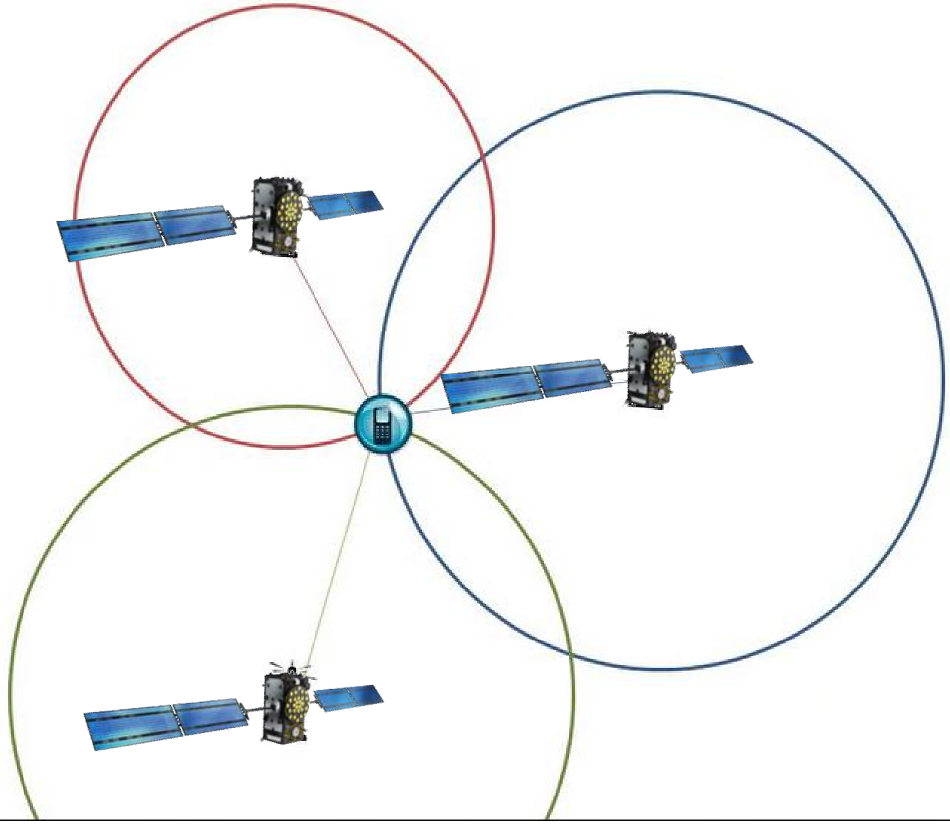
Satellites as Accurate Reference Points

- GNSS signals contain information about the satellites' positions
  - very accurate reference points
- Measure the distance from the satellites to the receiver



- Knowing at least three distances from three reference points gives position

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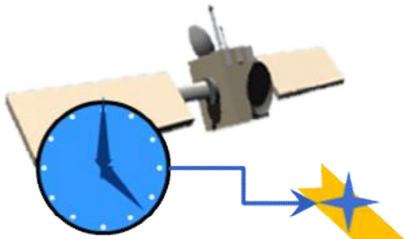
How do you measure distance?



speed = distance / time

⇨ **distance = speed x time**

satellite signals contain 'time stamps'

time = $t_{sent} - t_{received}$

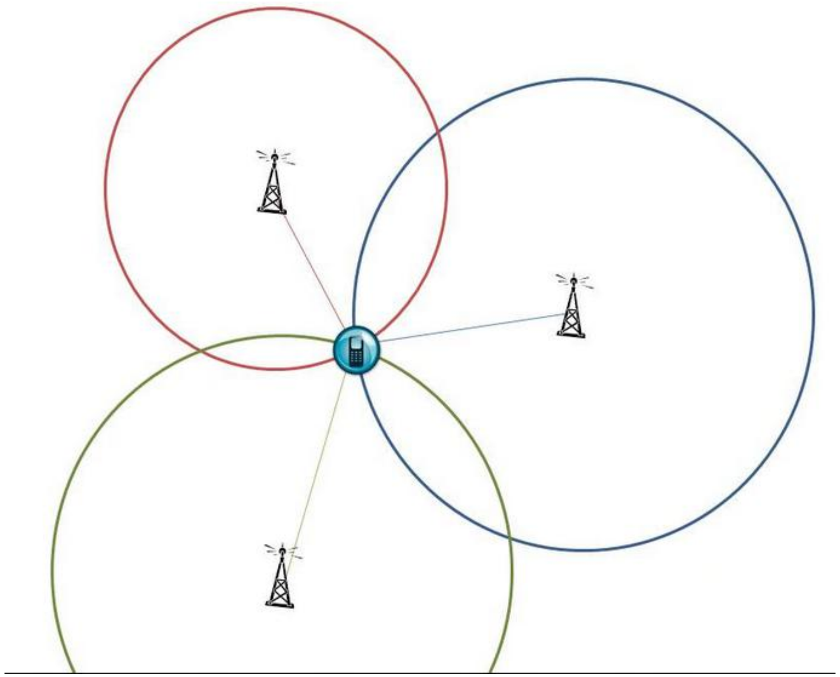
radio waves travel

at light speed **"c"**

– 300,000km in 1 second
– 300km in 1ms (1/1000th)
– 300m in 1μs (1/millionth)
– 300mm in 1ns

Compute position

distance = speed x time



- **speed** = $3x10^8$ m/s
- **time** = $t_{sent} – t_{received}$

- but, receiver time not accurately known
- so the time stamp from a fourth satellite is measured
- compensates for the missing receiver time

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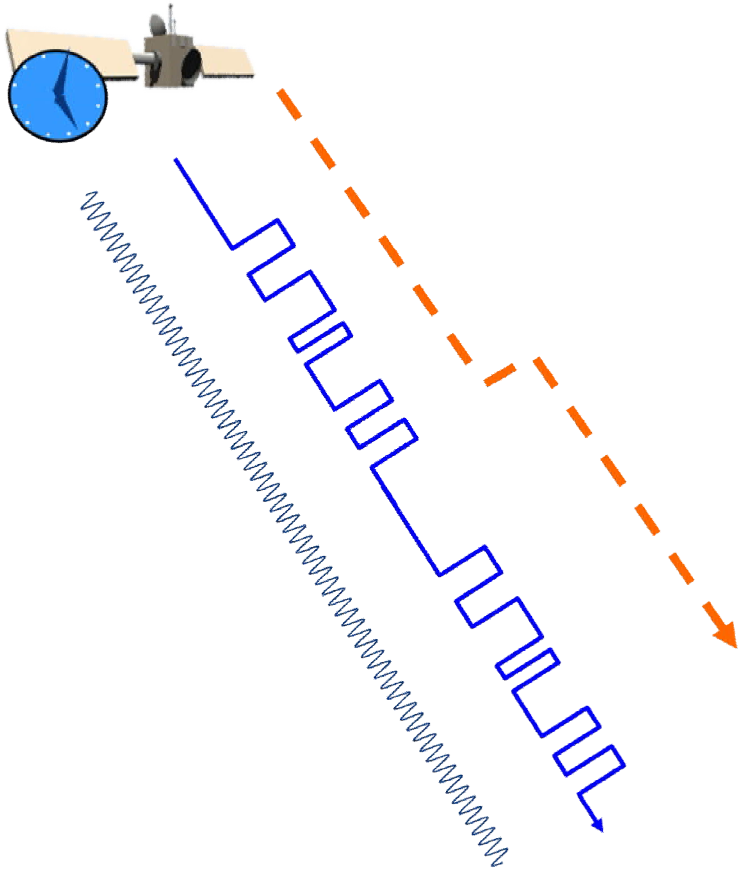
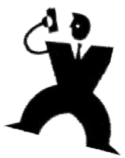
Example GNSS Signal



- radio frequency at "L-band"
  - typically 1575MHz
- at satellite: signal energy spread by a code
- at receiver: spread signal energy is unlocked and refocused
  - "code gain"
- allows simple antennas to receive low power signals



- and to share the frequency with other satellites/systems

Position relative to?

- A position is pointless without having a ground reference
- A world reference is used, eg WGS84
  - World Geodetic System 1984
- Allows position fix to be placed on a World grid
- Maps can be referenced to the same grid
- you can determine where you are on a map

What is GNSS used for?

PNT

- Positioning surveying and mapping
  - location based services
  - air traffic management
  - search and rescue
- Navigation a given. cars, ships, cranes
  - remember GNSS gives position, you still need reliable/up-to-date maps and routing software
- Timing?... most large networks synchronised
  - telecoms
  - electricity distribution
  - banking microseconds matter for transactions!

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What about?

- Monitoring sea/lake/snow levels
  - uses GNSS reflections seen into a fixed receiver
- Atmospheric measurements
  - GNSS signals change as they pass through atmosphere: air quality, gaseous content, etc
- Space weather monitoring
  - measuring changes in the ionosphere
- Soil and vegetation moisture measurements
- Volcanic plume density measurements
  - atmospheric ash uncertainty after eruptions
- Sea surface roughness, wind direction and more
- Earthquake/tsunami monitoring .

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etc, etc