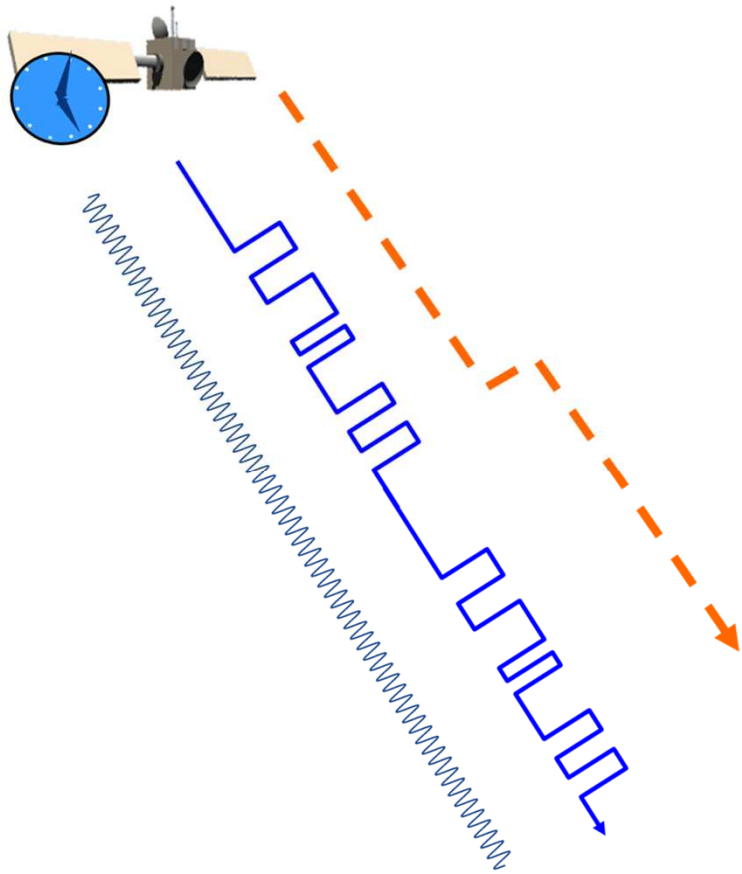




GNSS compared to terrestrial signals (why GNSS is vulnerable)

GNSS signal power



- radio waves disperse energy as they propagate
- satellites are 23,000km away
- signal emitted at about 30W
- signal strength proportional to: $1/distance^2$
- at 23,000 km, GNSS signal reduced by a factor of about 10^{18} !
- Imagine trying to see a lightbulb 23,000km away
signal levels are below the natural background radiation



Terrestrial signal powers

- mobile phone base station
 - typical transmit power, 10-100W
 - signal power reduction depends on range
 - at 10km, signal power reduced by factor of 10^{11}
 - at 1km, reduced by 10^9compared to the GNSS signal (10^{18} reduction) it is over billion times stronger
- mobile phone, typical transmit power, 0.1-1W connected to a cell tower at 1km
 - typical signal reduction 10^9still over a million times stronger than the GNSS signal!



Expected receiver signal power levels

- GNSS receivers expect to receive and can operate at signal levels even below the natural background radiation level, the "noise floor"
- **GNSS receivers** need a minimum power level "**-130dBm**"
 - GNSS receivers designed to work at these low levels
 - provided they are not overloaded by other signals
 - modern GNSS receivers can use even lower levels!
- **Mobile phones** (eg GSM) expect a minimum "**-104dBm**"
 - around a thousand times higher than GNSS



Consequences of the different levels

- The large difference between GNSS and mobile signal levels make GNSS receivers comparatively more susceptible to interference
 - mobile network devices also have the luxury of being able to raise their power levels in steps to cope with obstructions and poor radio environments - GNSS cannot, the low power level is fixed
- If GNSS signals shared frequencies with mobile systems, they would be swamped by interference
- **GNSS reception would not be possible**



How do you avoid interference?

- To avoid such interference, the **Radio Regulations*** separate different types of services (eg terrestrial mobile, satcoms, TV) into different frequency bands
 - eg mobile at 900MHz
 - TV at 600MHz
 - satcoms at 1650MHz
 - GNSS at 1575MHz
- However, when high power services operate in nearby frequencies, interference to GNSS is still possible (covered later)

* the Radio Regulations is treaty text agreed between the 195 member states of the International Telecommunication Union

