

Global Positioning System



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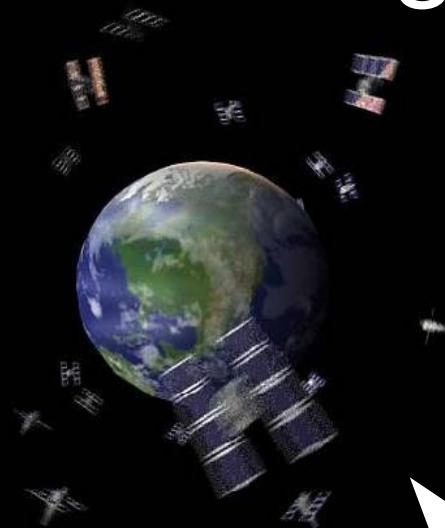
Global Positioning System(s)

- Who / When

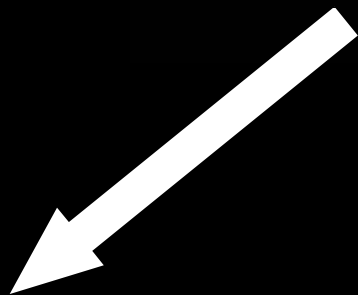
- United States ➡ NAVSTAR GPS 1993
- Russia + India ➡ GLONASS 1993-2009
- European Union+ ➡ Galileo 2011
- China, Japan, India



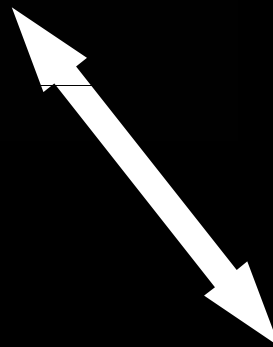
Global Positioning System



The Birds



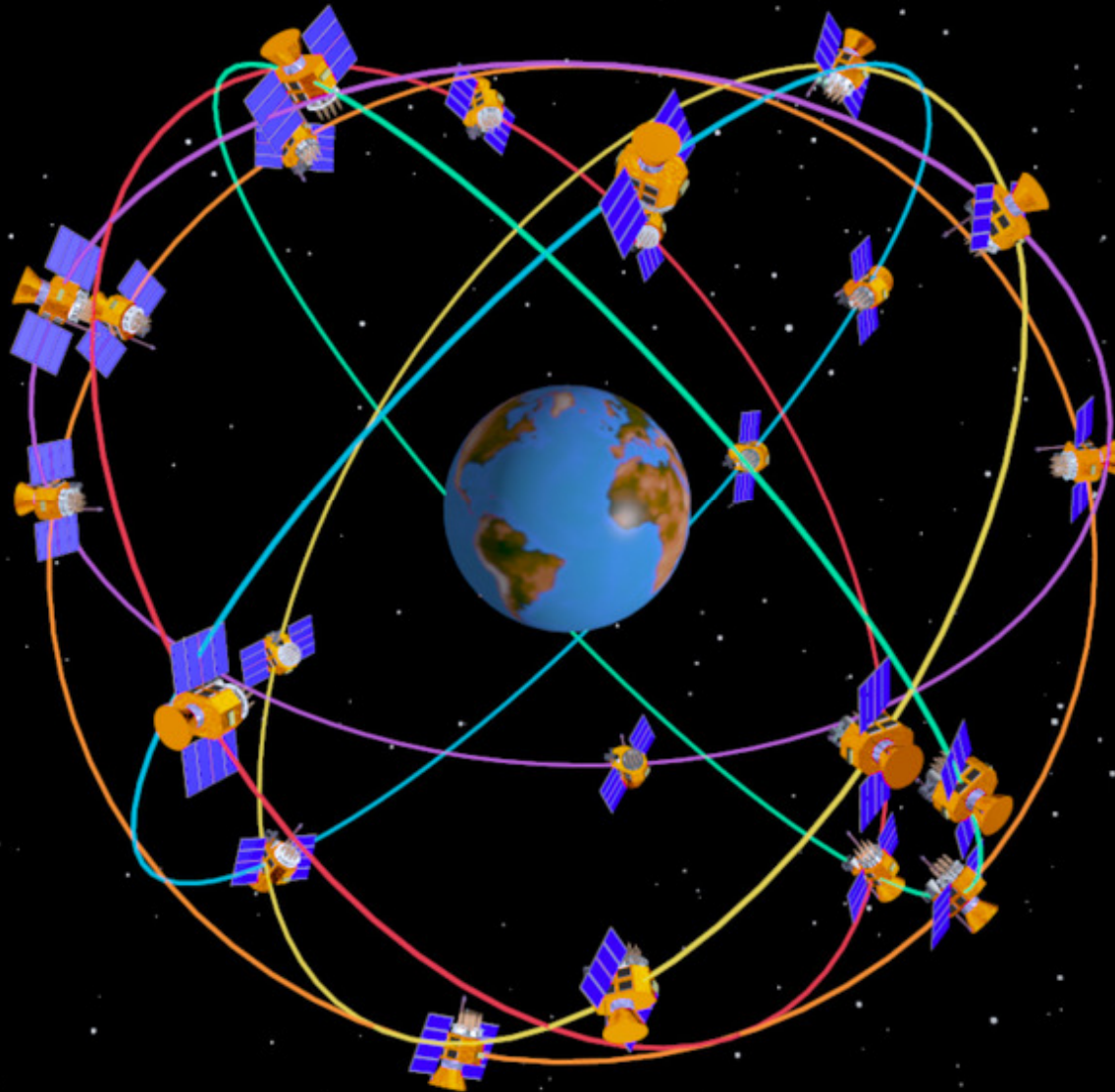
The Users



System Control

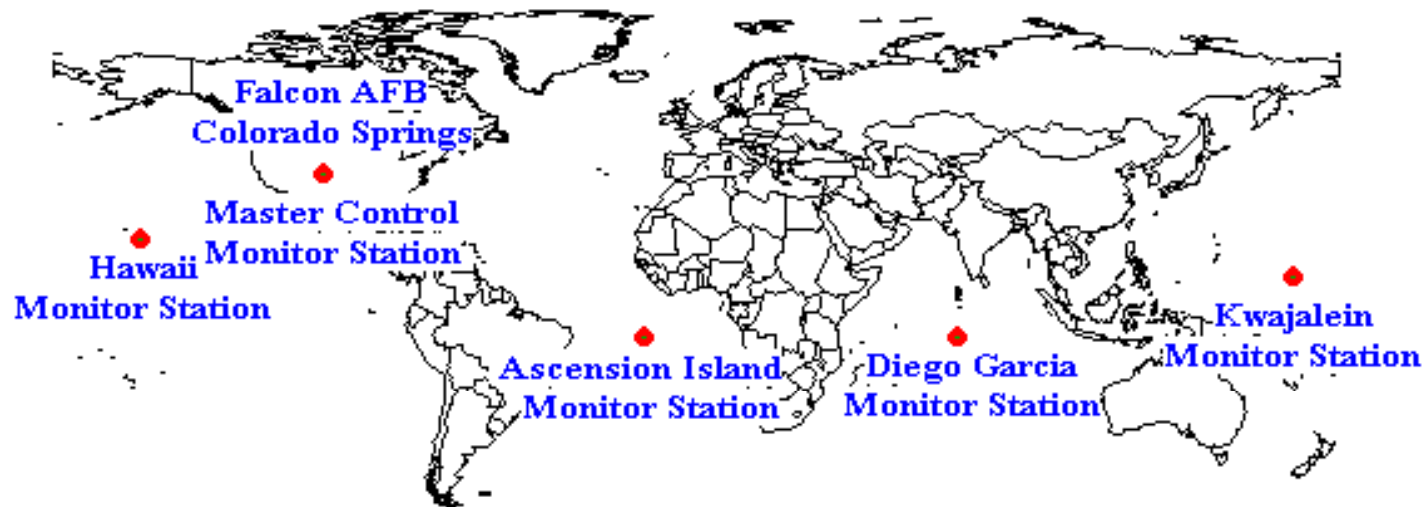


The Birds

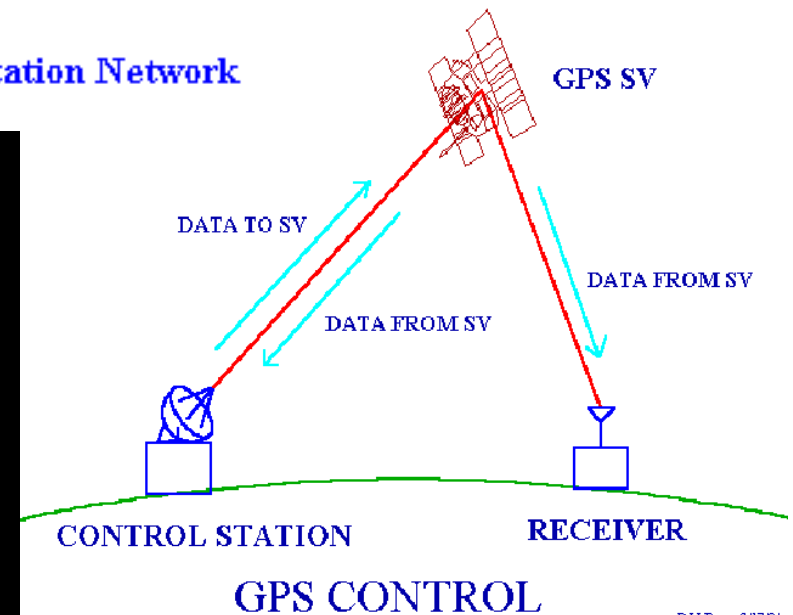


Control

Peter H. Dana 5/27/95



Global Positioning System (GPS) Master Control and Monitor Station Network



GPS – How it works (perfect world)

All satellites have clocks set to exactly the same time.

All satellites know their exact position in space from data sent to them from the systems controllers.

Each satellite transmits its position and a time signal.

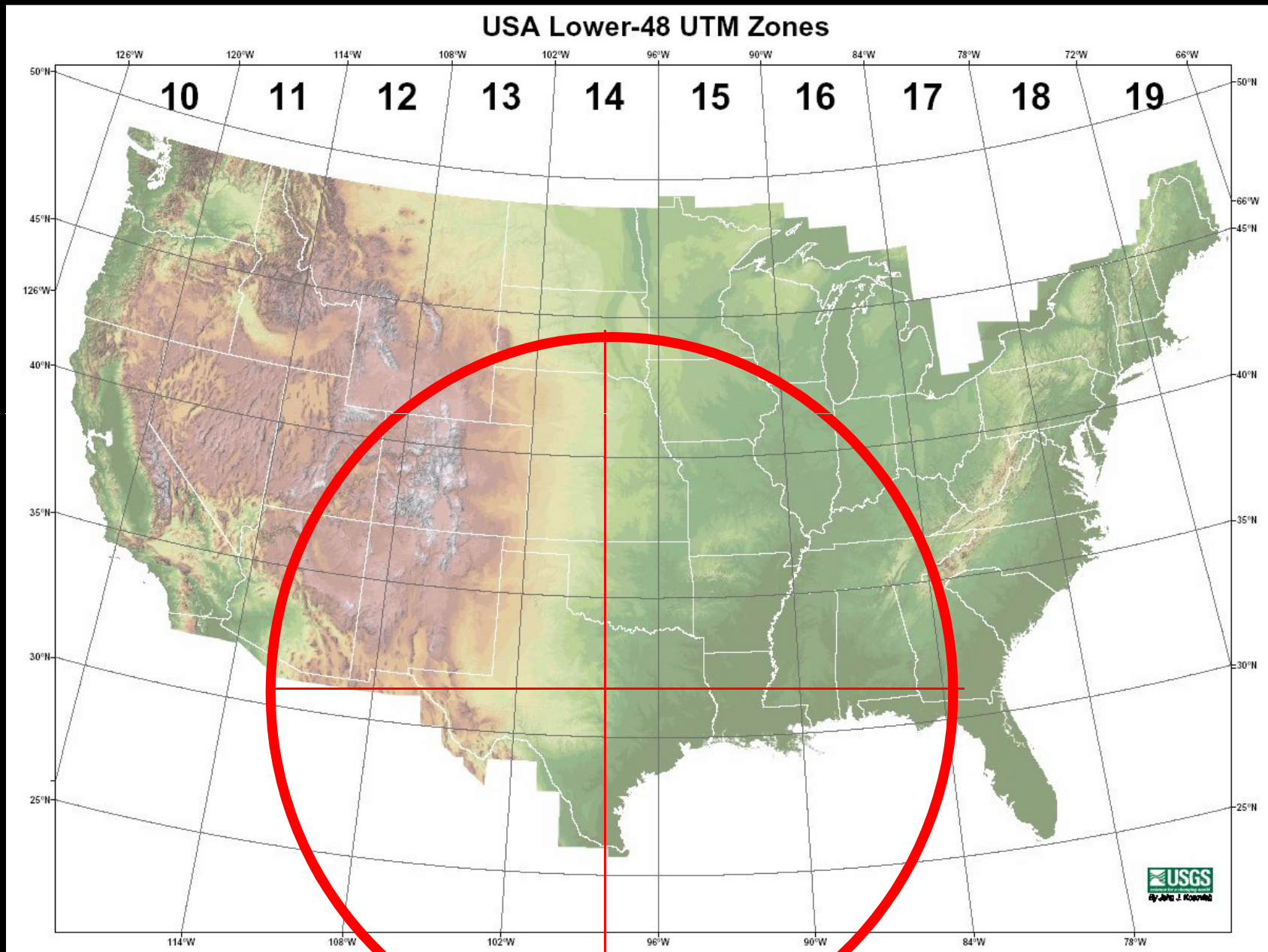
The signals travel to the receiver delayed only by distance traveled.

The receiver calculates the distance to each satellite and trilaterates its own position.

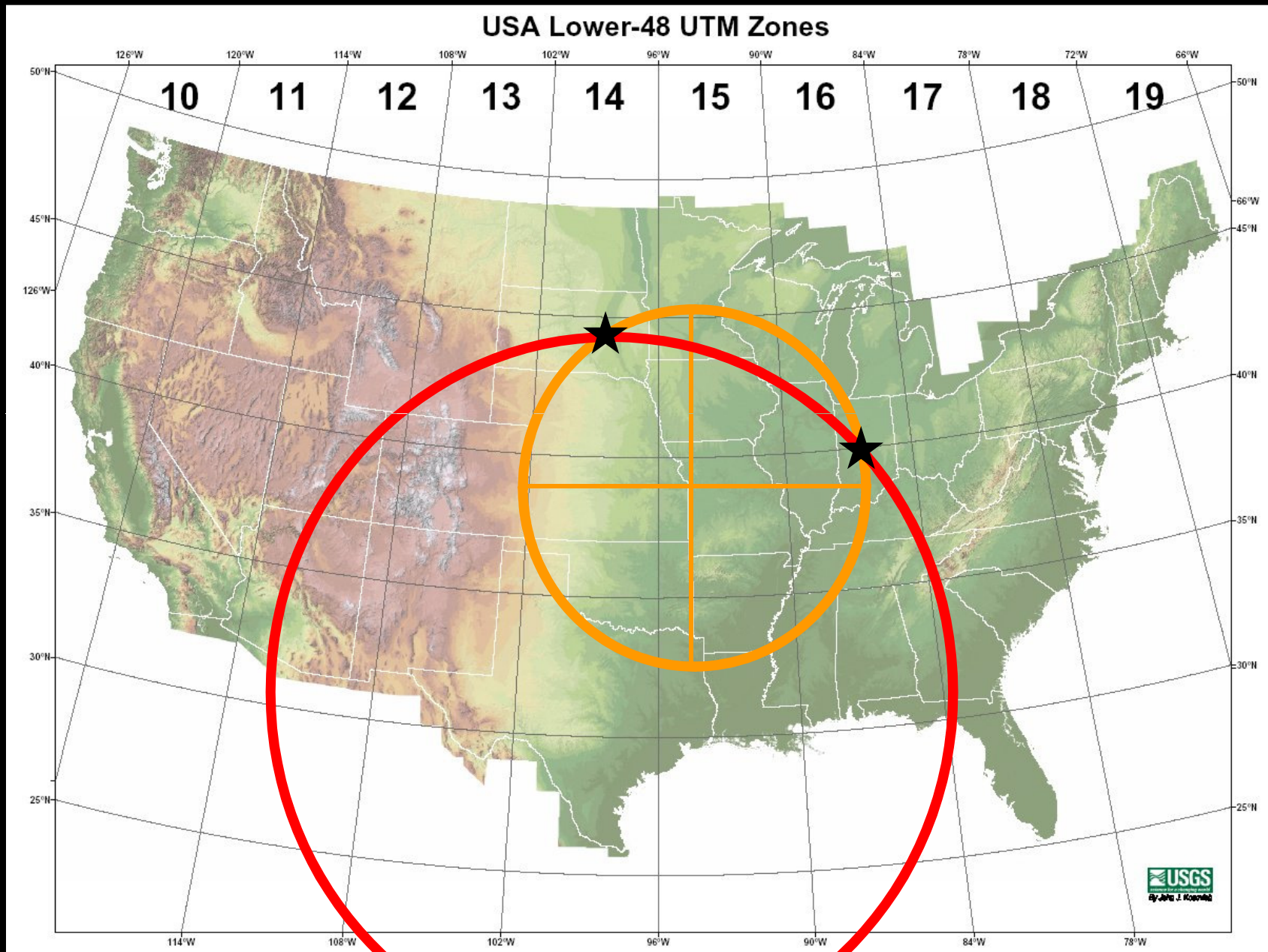
GPS – How it works (details)

- 31 satellites currently active (9/2007)
- Orbit 11,000 miles above Earth
- 6 visible sats from any point on Earth
- 5 monitoring stations synchronize the atomic clocks on board each satellite
- distance from a satellite to a receiver in miles = $(186,000 \text{ mi/sec}) \times (\text{signal travel time in seconds})$

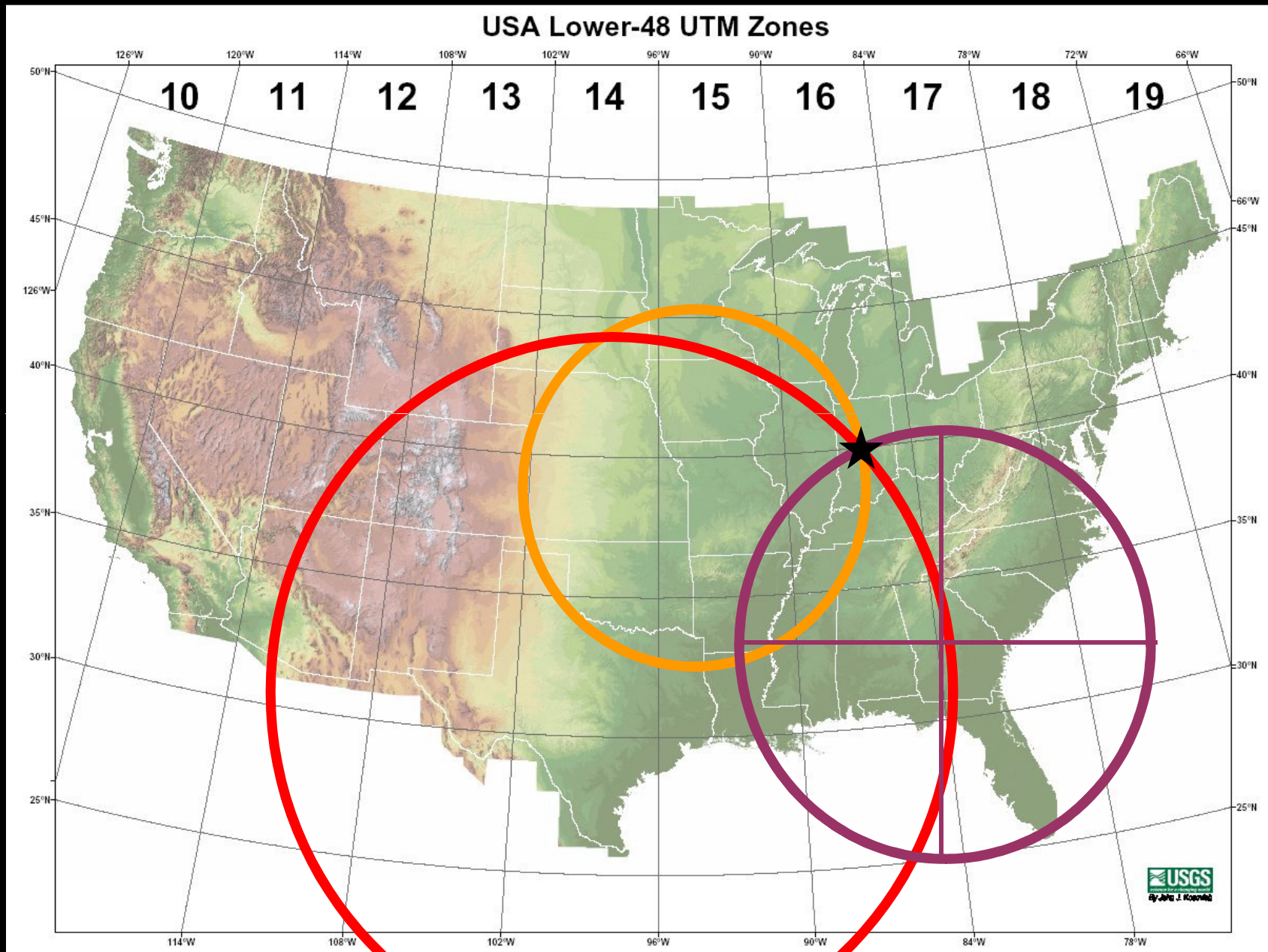
GPS – Triangulation



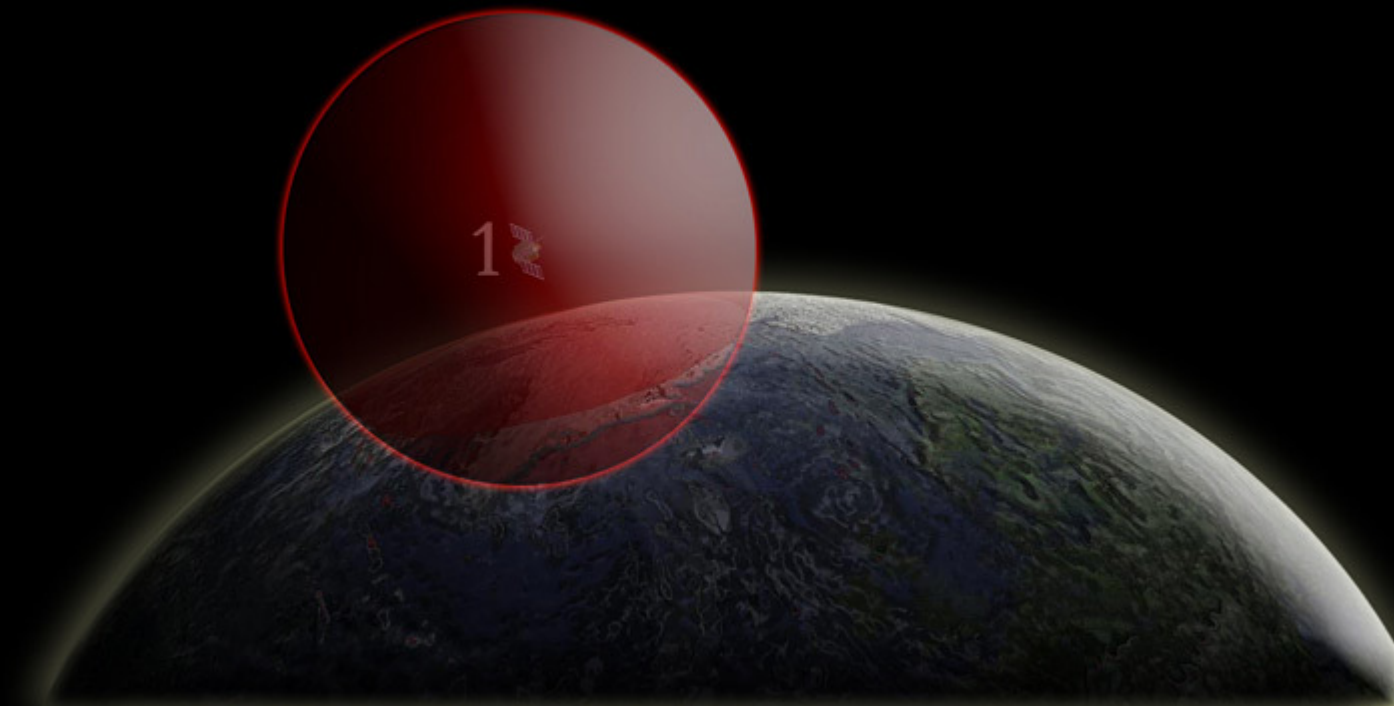
GPS – Triangulation



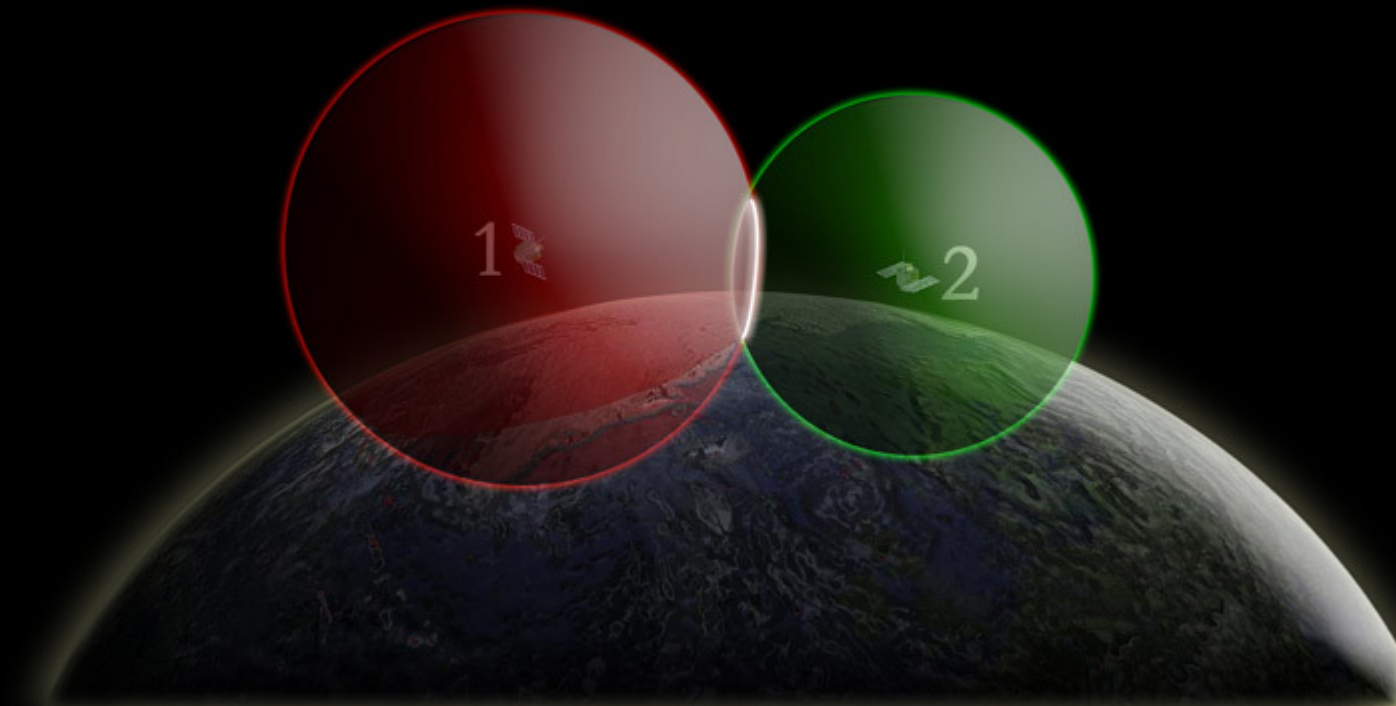
GPS – Triangulation



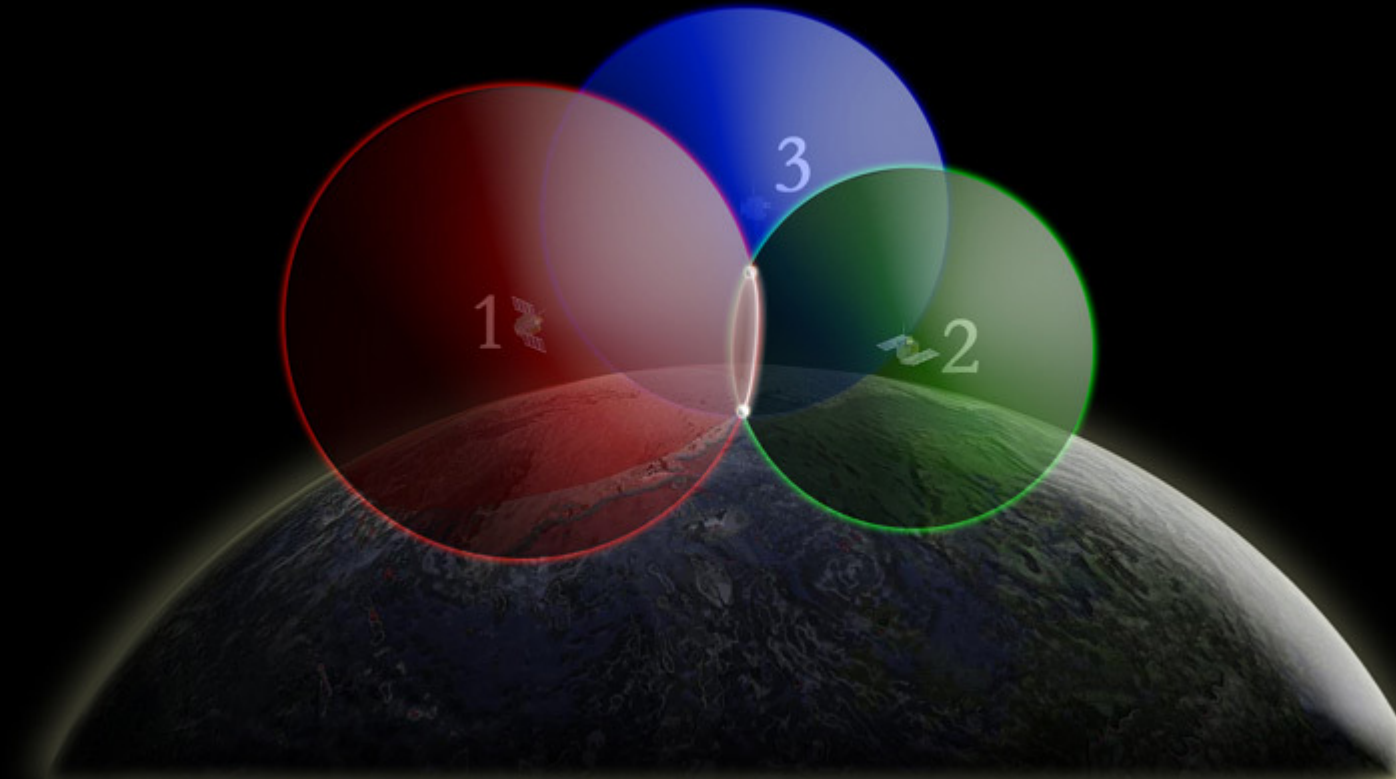
GPS - Triangulation



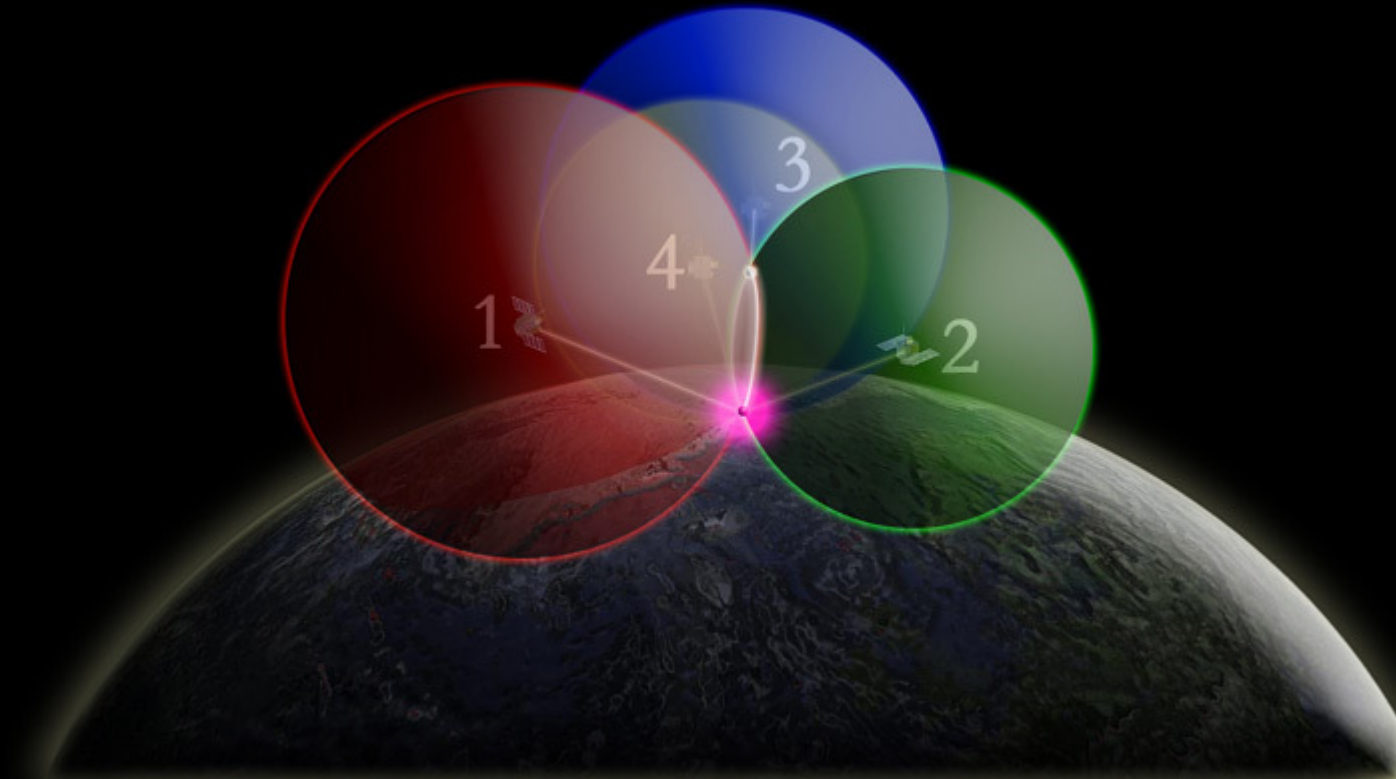
GPS - Triangulation

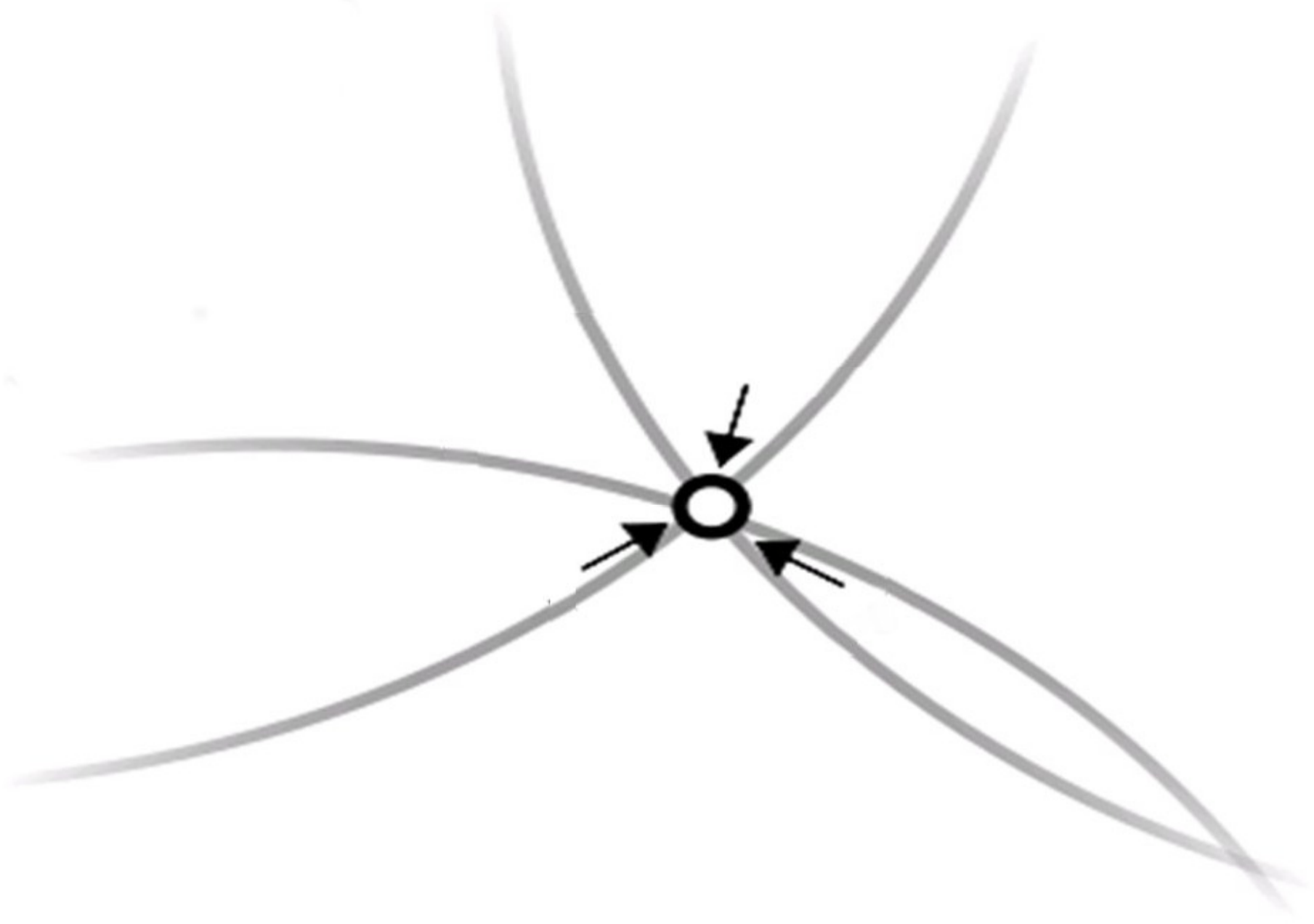


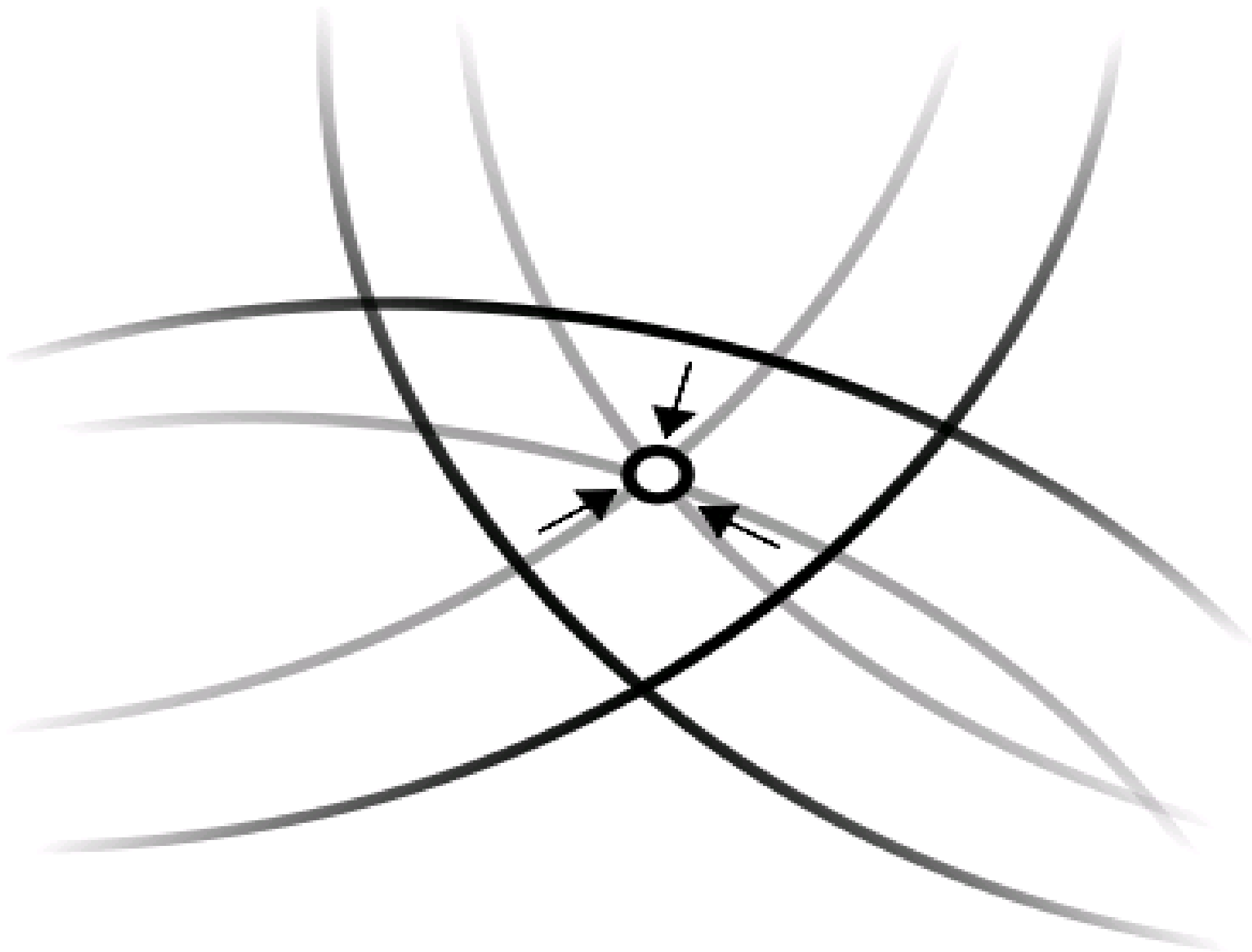
GPS - Triangulation

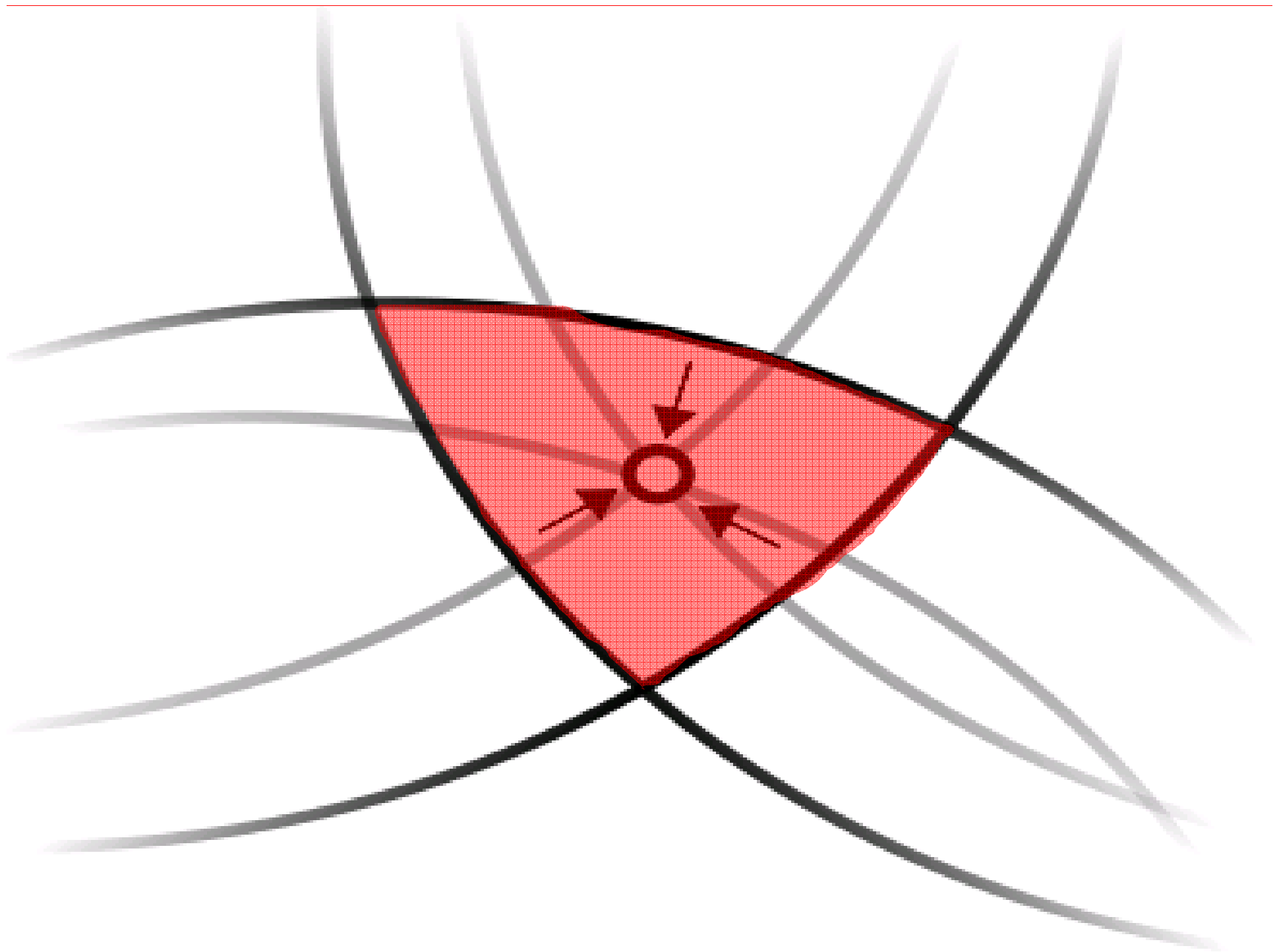


GPS - Triangulation









GPS

- Accuracy – sources of errors
 - Ionospheric effects ± 5 meters
 - Tropospheric effects ± 0.5 meter
 - Ephemeris errors ± 2.5 meters
 - Satellite clock errors ± 2 meters
 - Multipath distortion ± 1 meter
 - Numerical errors ± 1 meter

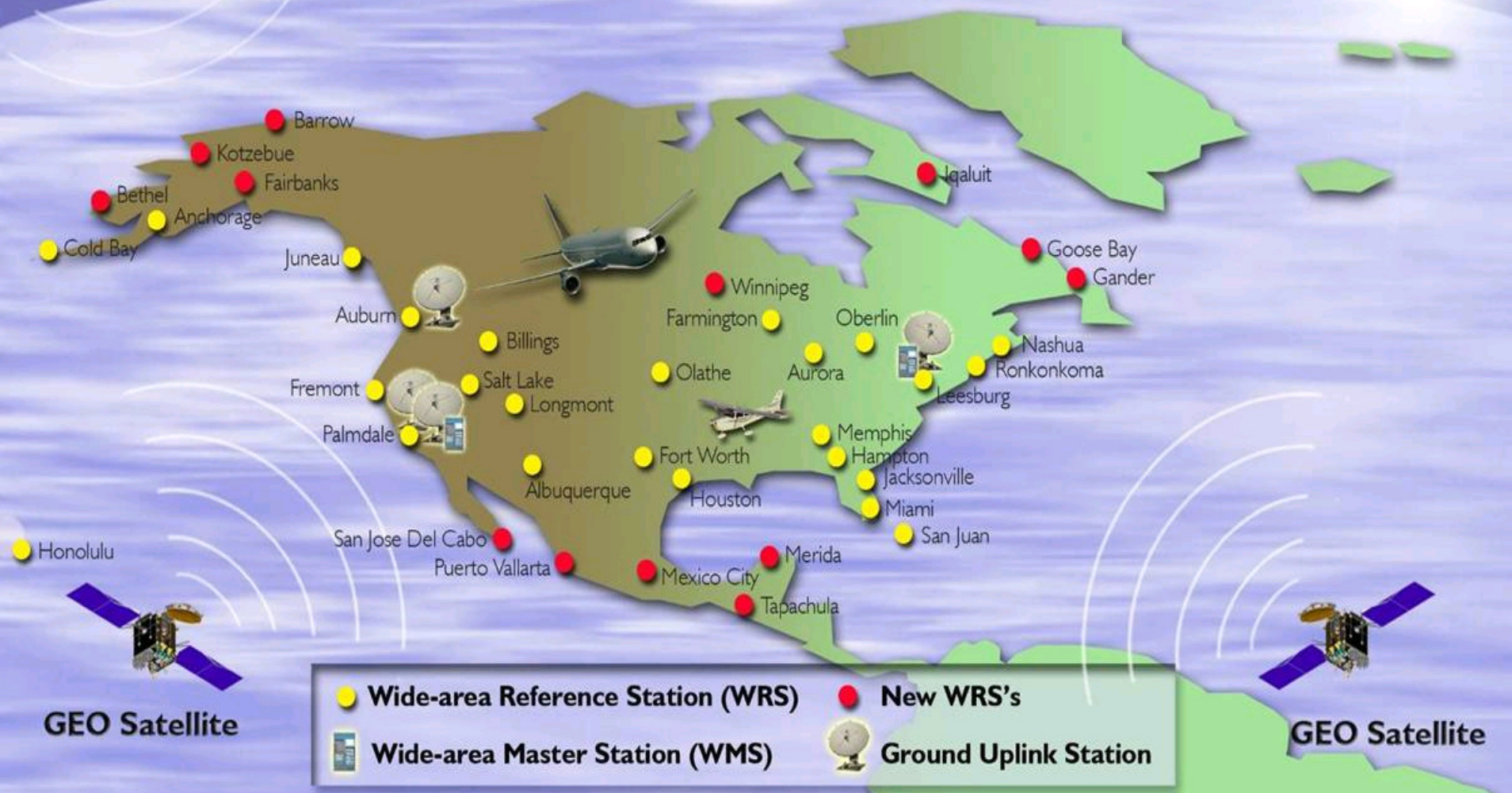
GPS – WAAS

Wide Area Augmentation System To The Rescue!

WAAS

wide area augmentation system

GPS Satellites



WAAS Satellites (7/30/07)

<http://science.nasa.gov/Realtime/jtrack/3d/JTrack3D.html>

WAAS / NMEA #	PRN #	Latitude	Satellite Name
* 35	122	142.0°W	Inmarsat 3 f4
* 47	134	178.0°E	Inmarsat 3 f3
48	135	133.0°W	<u>Galaxy 15</u>
51	138	107.3°W	<u>Anik F1R</u>

<http://earthnow.usgs.gov/>

GPS Accuracy – Getting Better

- 100 meters: Accuracy of the original GPS system under the government-imposed Selective Availability (SA) program.
(turned off 5/1/2000)
- 15 meters: Typical GPS position accuracy without SA.
- < 3 meters: Typical WAAS position accuracy.

Garmin WAAS capable GPS



Foretrex \$120



eTrex Legend \$120



Nuvi 660 \$540

GPS as art

Mowing the Lawn [2006]
7.5 km of GPS tracks
www.gpsdrawing.com





Dog Drawings

This method involves fixing a GPS receiver to energetic dogs and letting them run free in an open space. The less well-behaved the better.

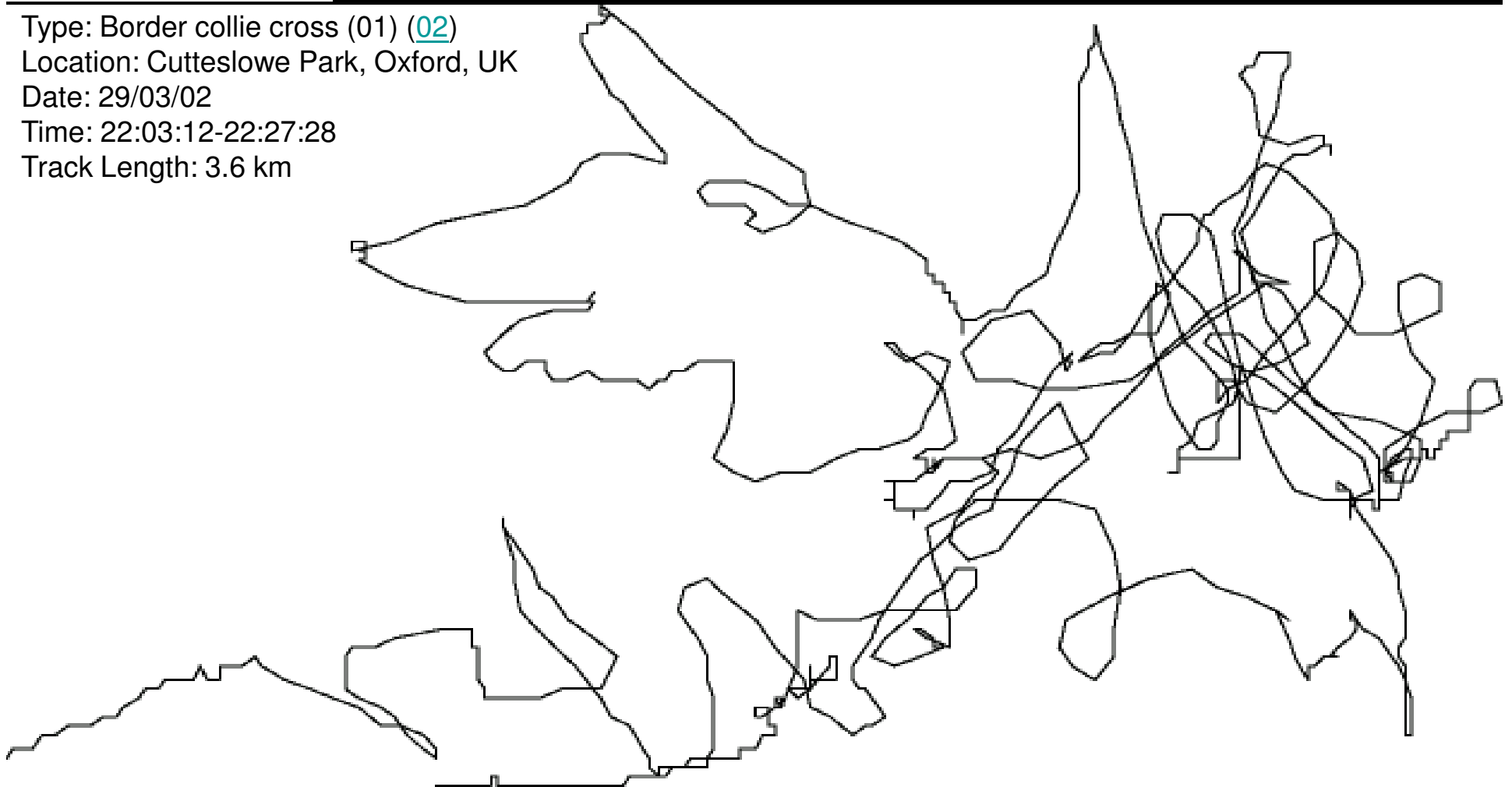
Type: Border collie cross (01) ([02](#))

Location: Cutteslowe Park, Oxford, UK

Date: 29/03/02

Time: 22:03:12-22:27:28

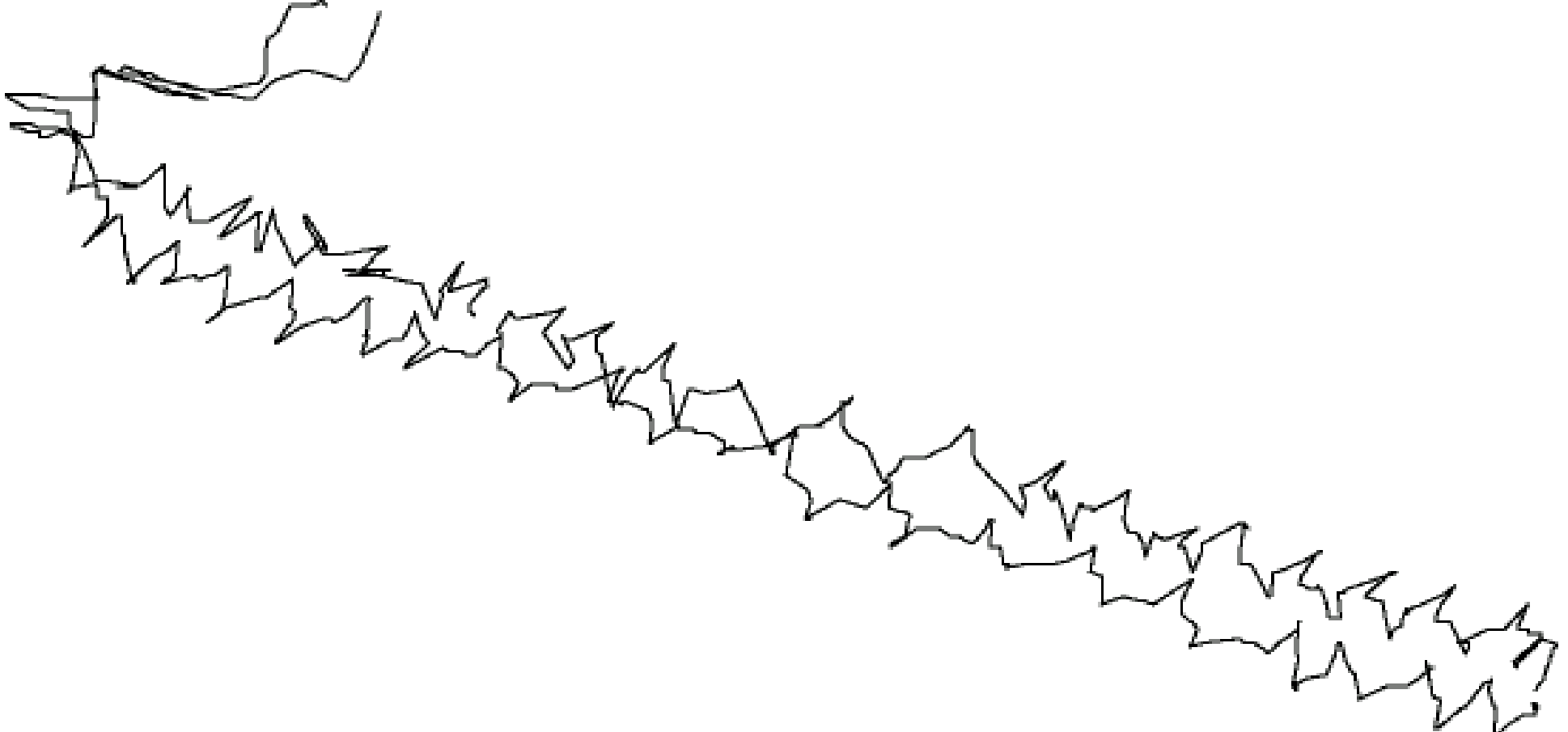
Track Length: 3.6 km



Type: Jack Russell Lakeland Terrier cross
Location: Brighton Beach, East Sussex, UK
Date: 28/02/02
Time: 07:17:08 - 08:20:05
Line Length: 4.89 km
www.gpsdrawing.com



The drawing was made by walking in a straight line along the beach with Louis over-willingly retrieving an object being thrown in alternating directions. The same action was repeated along a parallel path on the way back. The shape is about 850 meters long.



Credits

NASA

Lockheed Martin

United States Air Force

Garmin International

NOAA

www.gpsdrawing.com