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University of South Bohemia in České Budějovice

Geographic Information Systems 1
Lecture 11:
Modern Technologies as data source for GIS

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April 20201

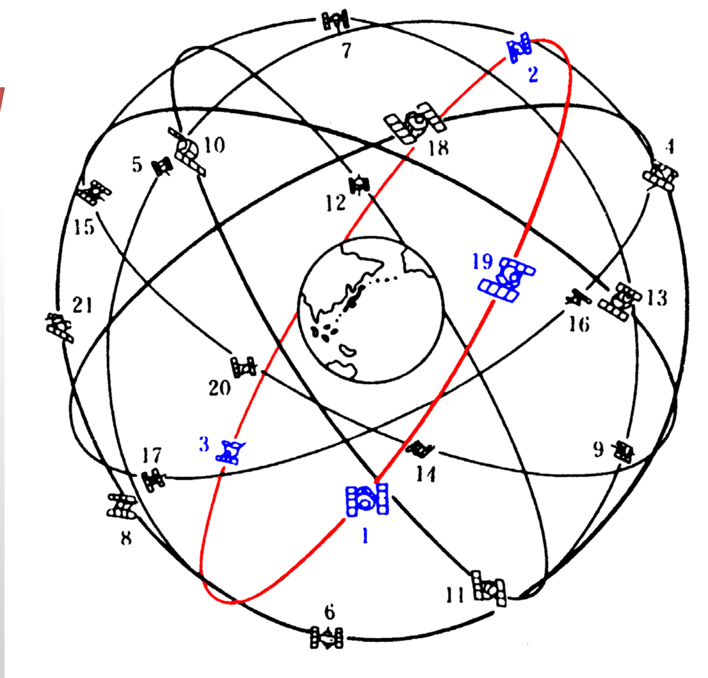
Basic Tools

- Measurement
  - **GPS** – ***(Global Positioning System)***
    – A device for measuring geographic coordinates at any location on the earth.

- Documentation and Analysis
  - **GIS** – ***(Geographic Information System)***
    – A database for maintaining and analyzing spatial features and the relationships between features as they are defined through geographic coordinates or measurements.

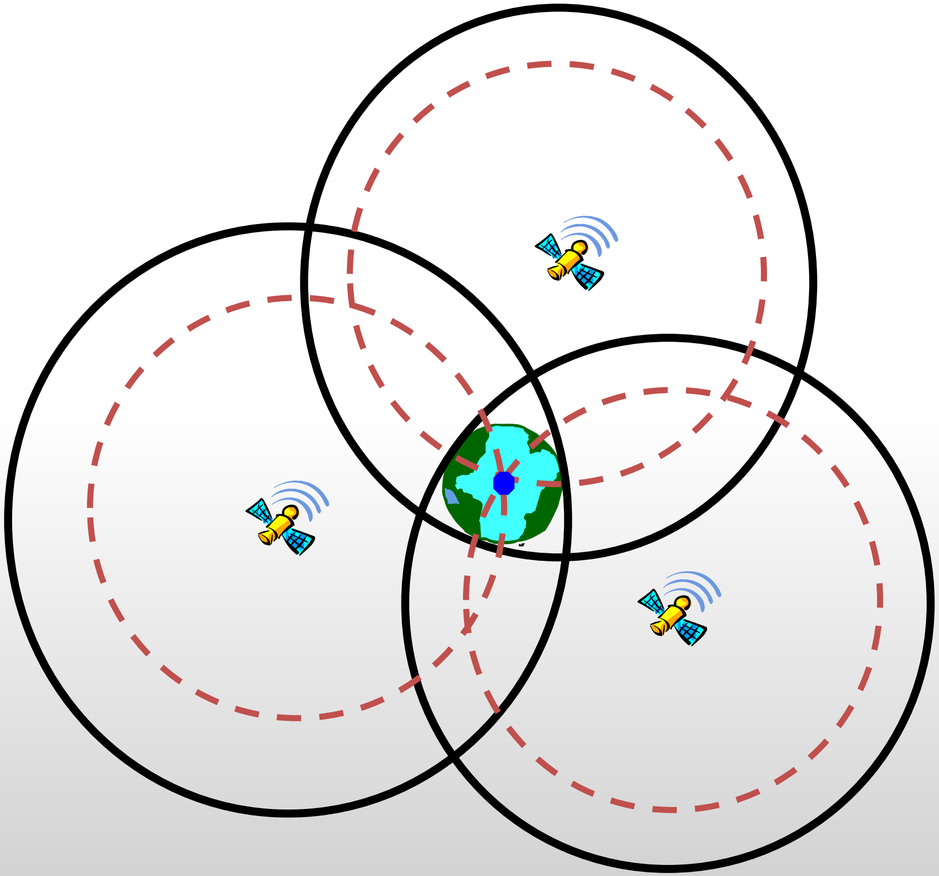
Global Positioning System (GPS)

- A constellation of 24 man-made "stars" (satellites) composed of very accurate atomic clocks put into an approximately 12 hour orbit at an altitude of 20,000km *(meaning that at least 6 satellites should be "viewable" at any time.)*



- The system is maintained by the US Department of Defense giving users access to "quality" measurements anywhere on (or near) the surface of the earth at any time of the day or night.

How does GPS work?



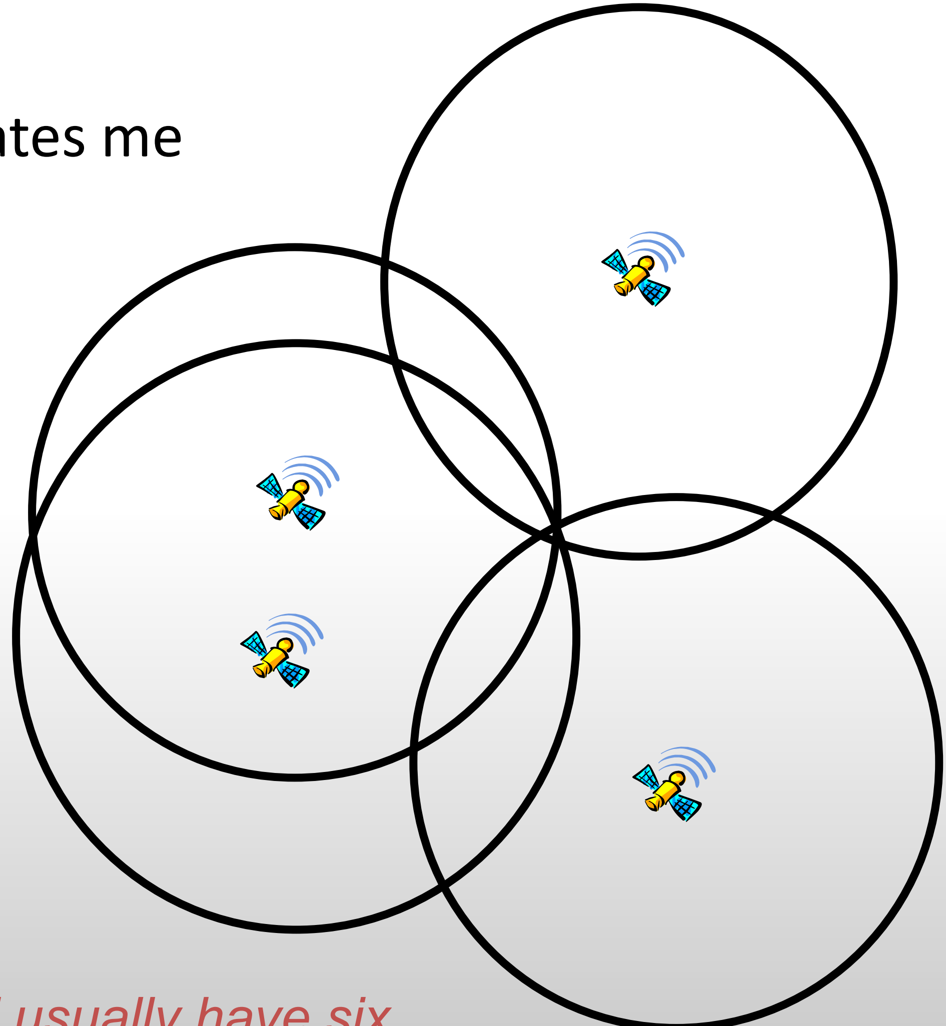
- Satellites are at known points orbiting the earth
- Their range is defined by the difference in time between sending and receiving a signal
- Using resection trigonometry, the location of the receiver clock can be calculated
- Most error in the range intersection is due to error in the receiver clock

Trigonometry

- Quick Trigonometry review –
  - One radius measurement locates me to any point along a circle

- Two radius measurements narrows my position to only two points
- A third radius will narrow the position to only one value

- If the timing offset is consistent, a fourth radius measurement will compensate the errors



And remember, we should usually have six satellites available (in perfect conditions)

Accuracy

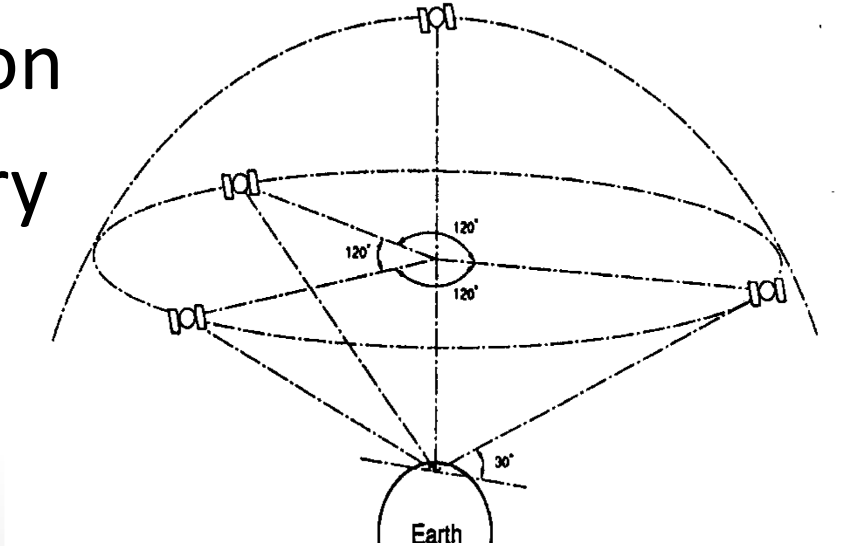
- Basic Accuracy (Post May 1,2000)
  - Uncorrected 10-30 meters (30-100’)
- WAAS (Wide Area Augmentation System)
  - Realtime correction 0.5 –10 meters (2 – 30 ft)
  - Terrestrial based low cost, limited range, terrain obstructions
  - Satellite based has wide coverage but also high cost
- DGPS (Differential GPS)
  - Post Processing (<0.01m) 0.1 ft

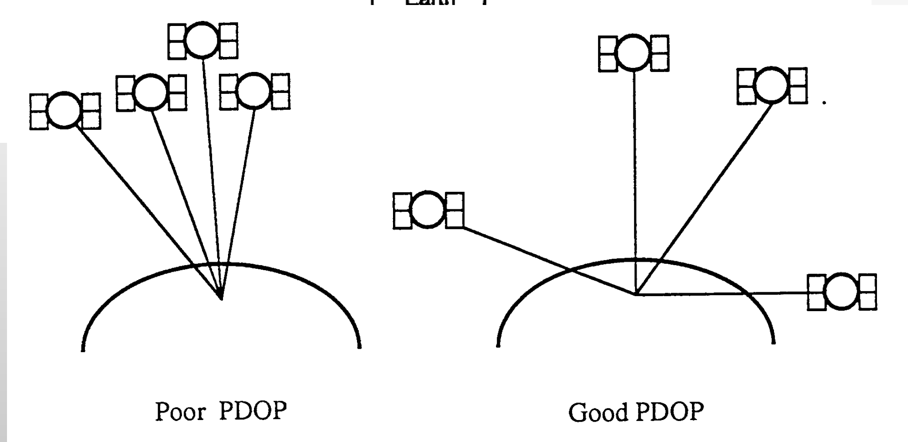
Error Sources		
Per Satellite :	Std GPS	DGPS
Satellite Clocks	1.5	0
Orbit Errors	2.5	0
Ionosphere 5.0	.4	
Troposhpere	.5	.2
Receiver Noise	.3	.3
Multipath	.6	.6
SA	30	0
Typical Position Accuracies		
Horizontal 50	1.3	
Vertical	78	2.0
3-D	93	2.8

Source : Trimble

Measures of Precision

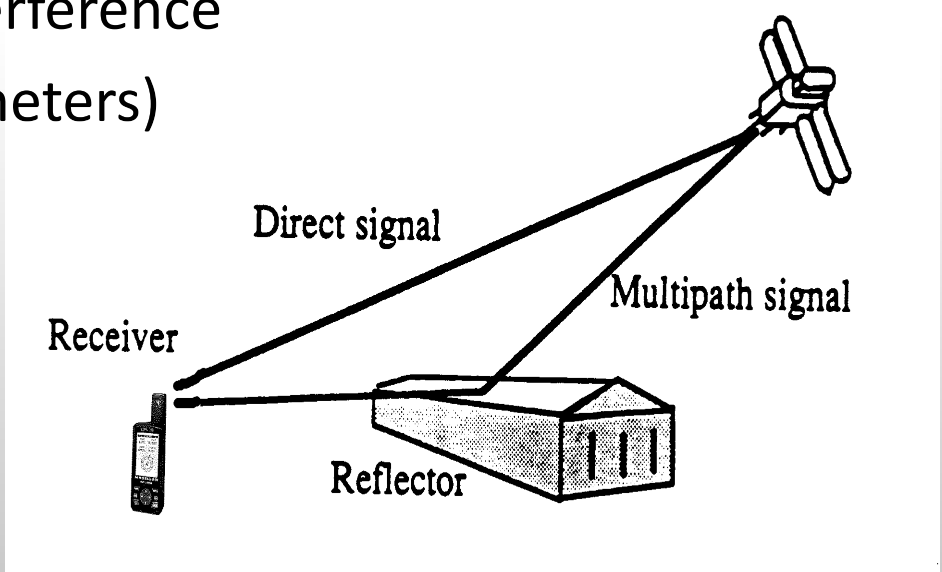
- The symmetry of the satellites will control the level of precision
- These symmetry factors are known as
  - GDOP
  - PDOP
  - VDOP





Reliability

- Many factors can contribute to decrease reliability
  - Receiver quality
  - Proximity to buildings or other obstructions (cliffs, etc.), tree canopy
  - Multipathing
  - Mircowave or other radio interference
  - Blunders (wrong setup parameters)
  - Weight of receiver unit
  - Power source



Transportability

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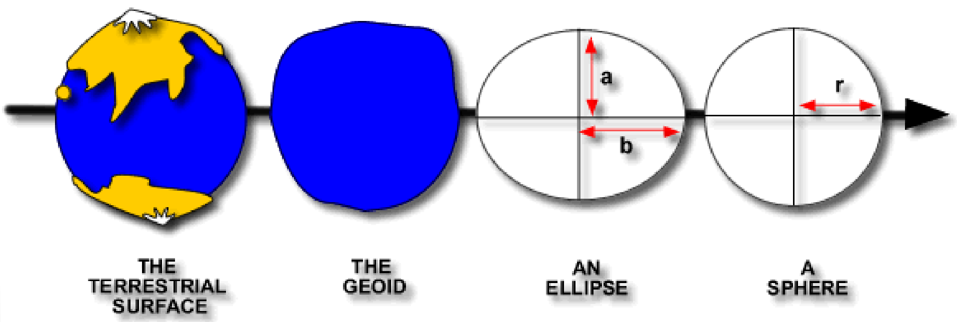
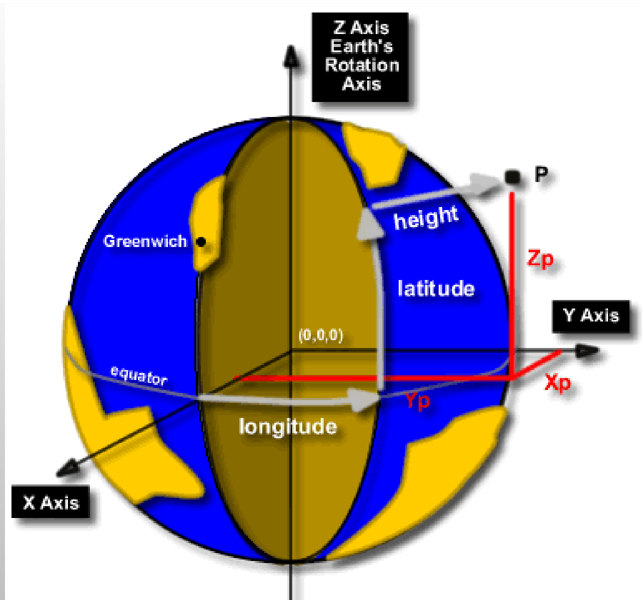
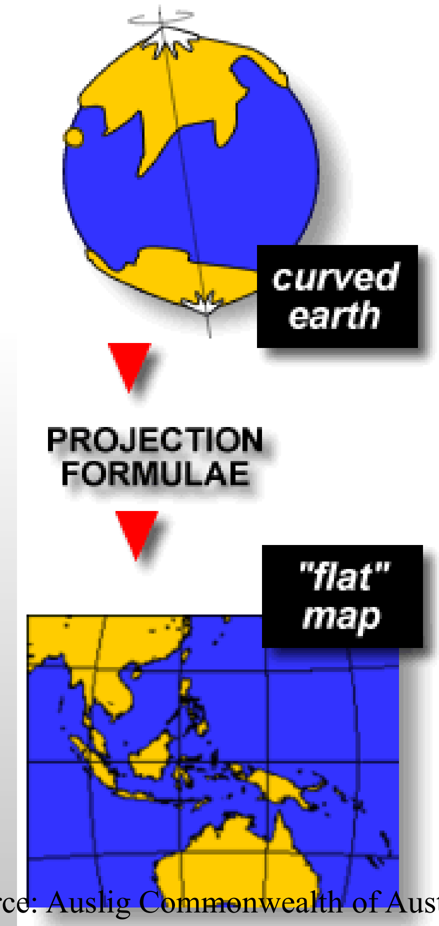
- Projections and datums are important when converting unprojected coordinates to a map

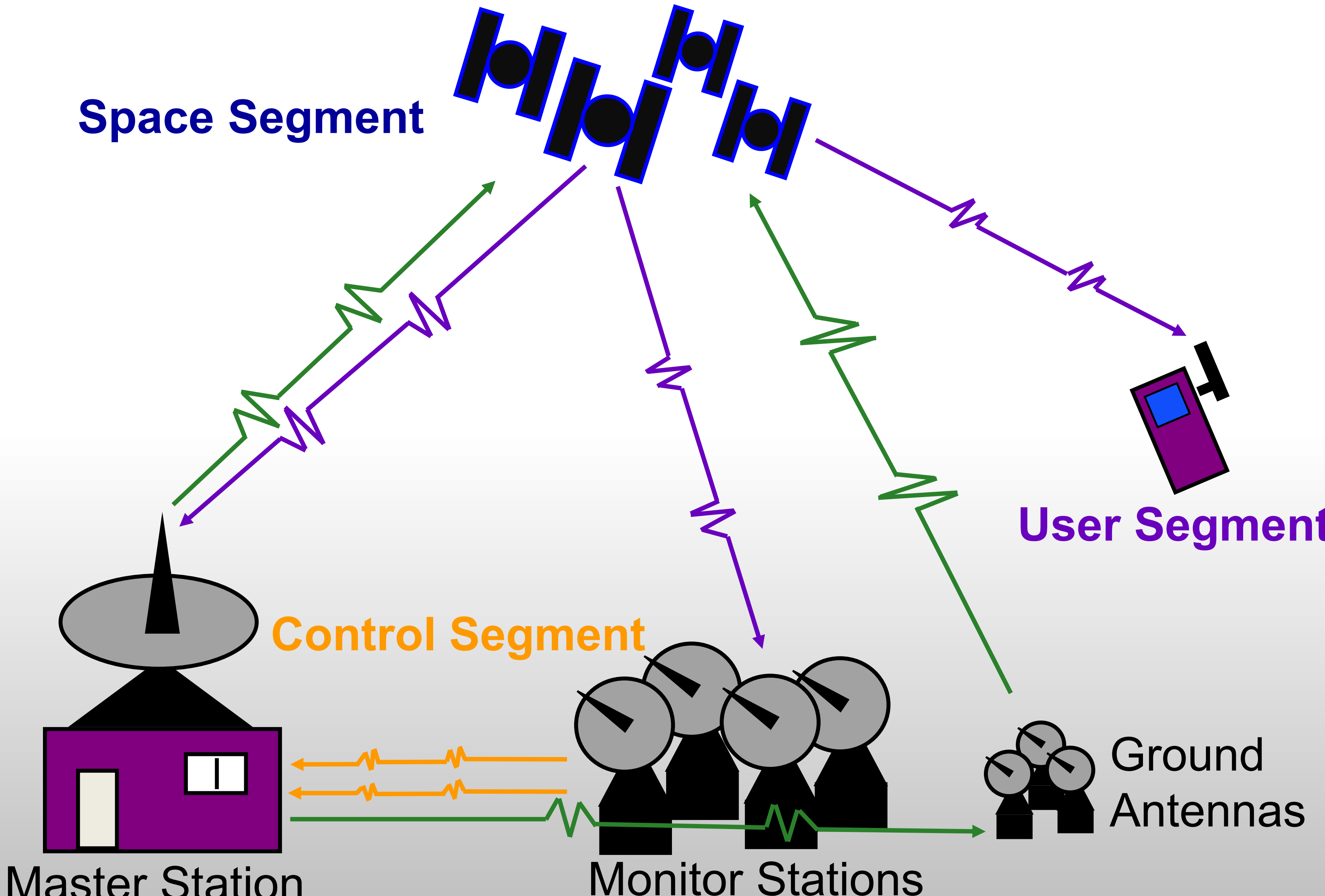




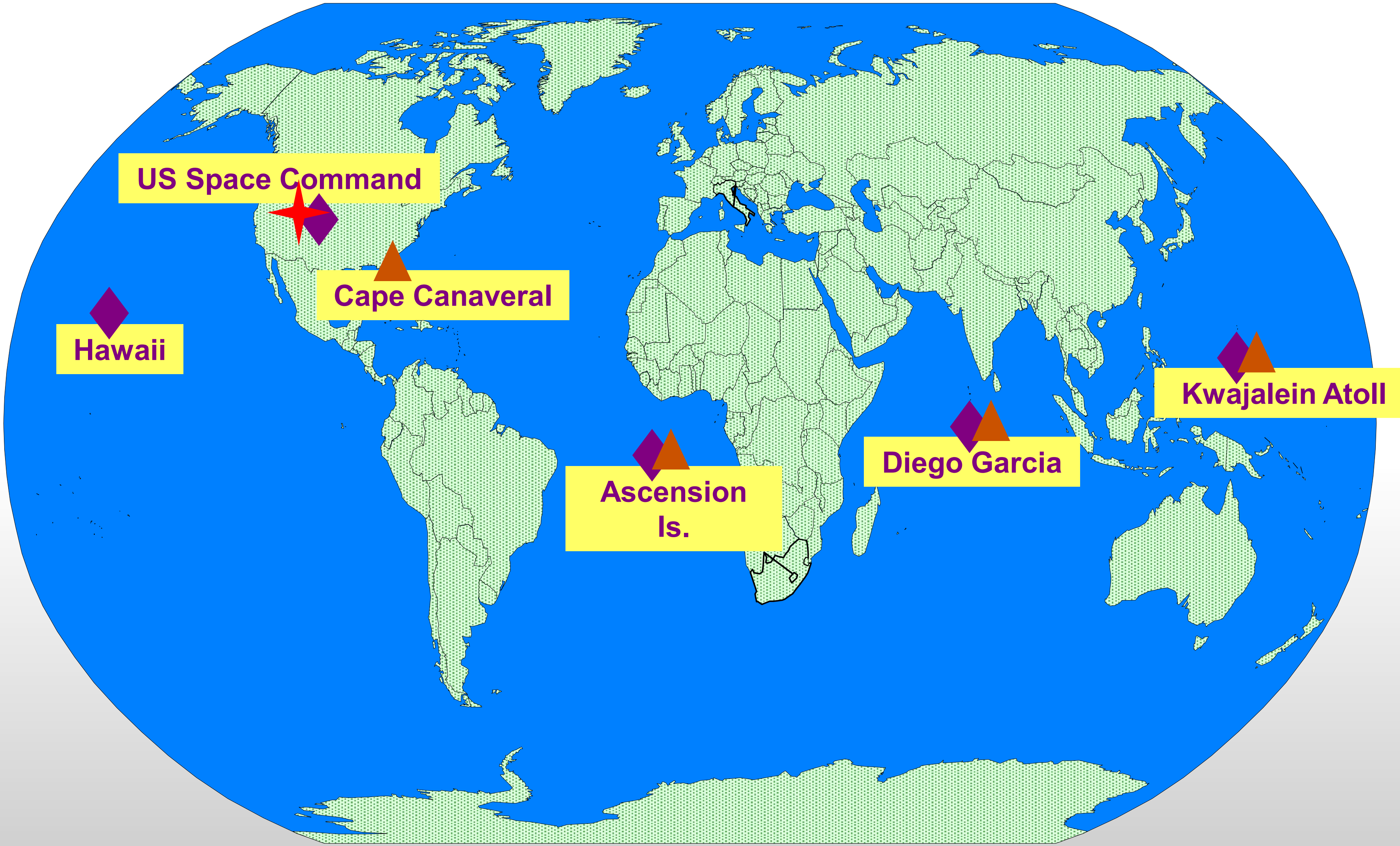


Source: Auslig Commonwealth of Australia

Three Segments of the GPS



Control Segment



Master Control Station   Monitor Station   Ground Antenna

User Segment

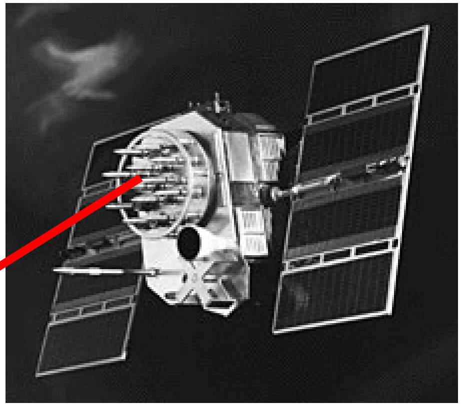
- Military.
- Search and rescue.
- Disaster relief.
- Surveying.
- Marine, aeronautical and terrestrial navigation.
- Remote controlled vehicle and robot guidance.
- Satellite positioning and tracking.
- Shipping.
- Geographic Information Systems (GIS).
- Recreation.

Four Primary Functions of GPS

- Position and coordinates.
- The distance and direction between any two waypoints, or a position and a waypoint.
- Travel progress reports.
- Accurate time measurement.

Position is Based on Time

Radio waves travel at the speed of light. If GPS signal leaves satellite at time "T"…



T

T + 3

…and is picked up by the receiver at time "T + 3."

Then distance between satellite and receiver = "3 times the speed of light"

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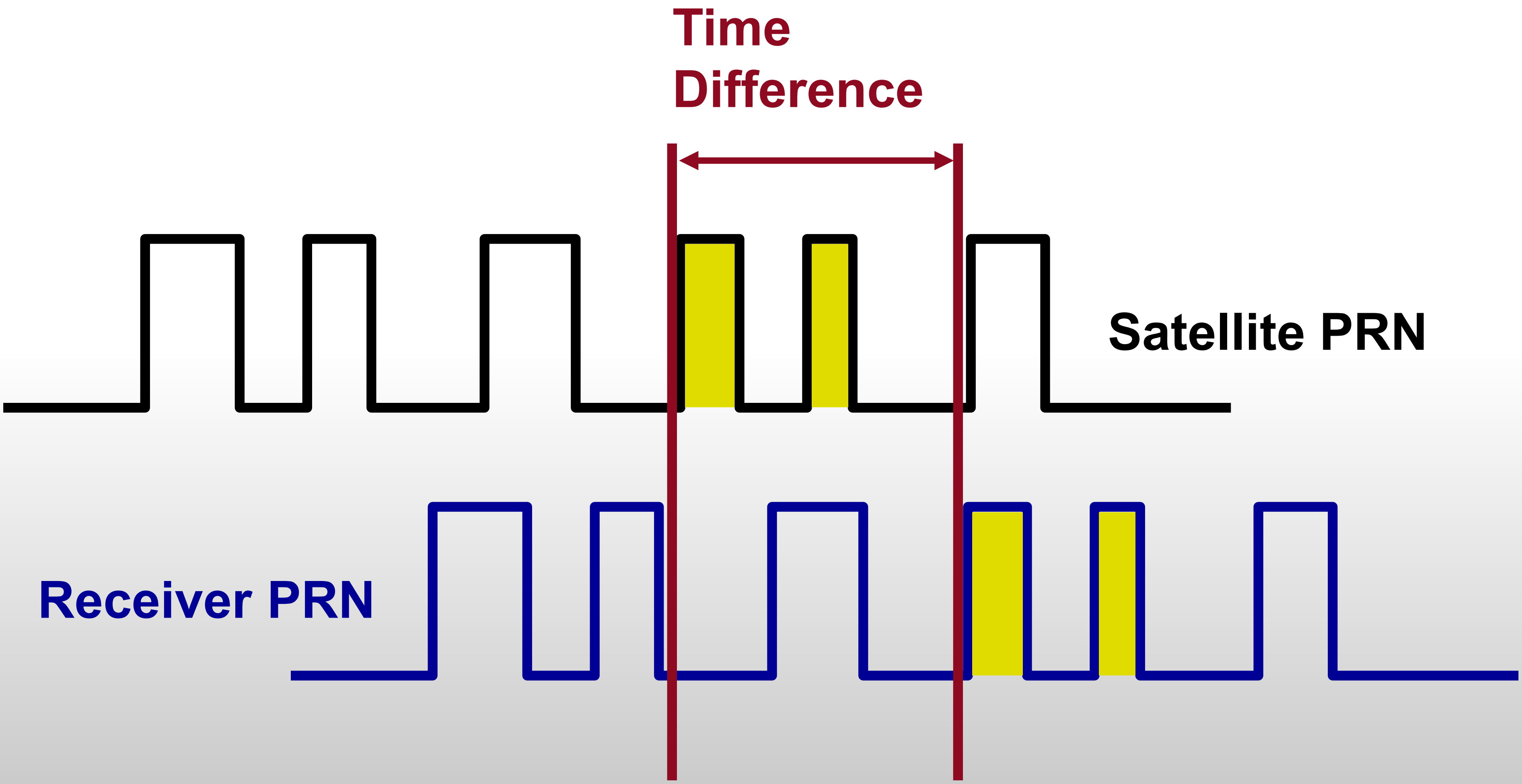
Pseudo Random Noise Code



What Time is it Anyway?

Universal Coordinated Time

Greenwich Mean Time | **GPS Time - 13*** | **Zulu Time**

Local Time: AM and PM (adjusted for local time zone)

↕

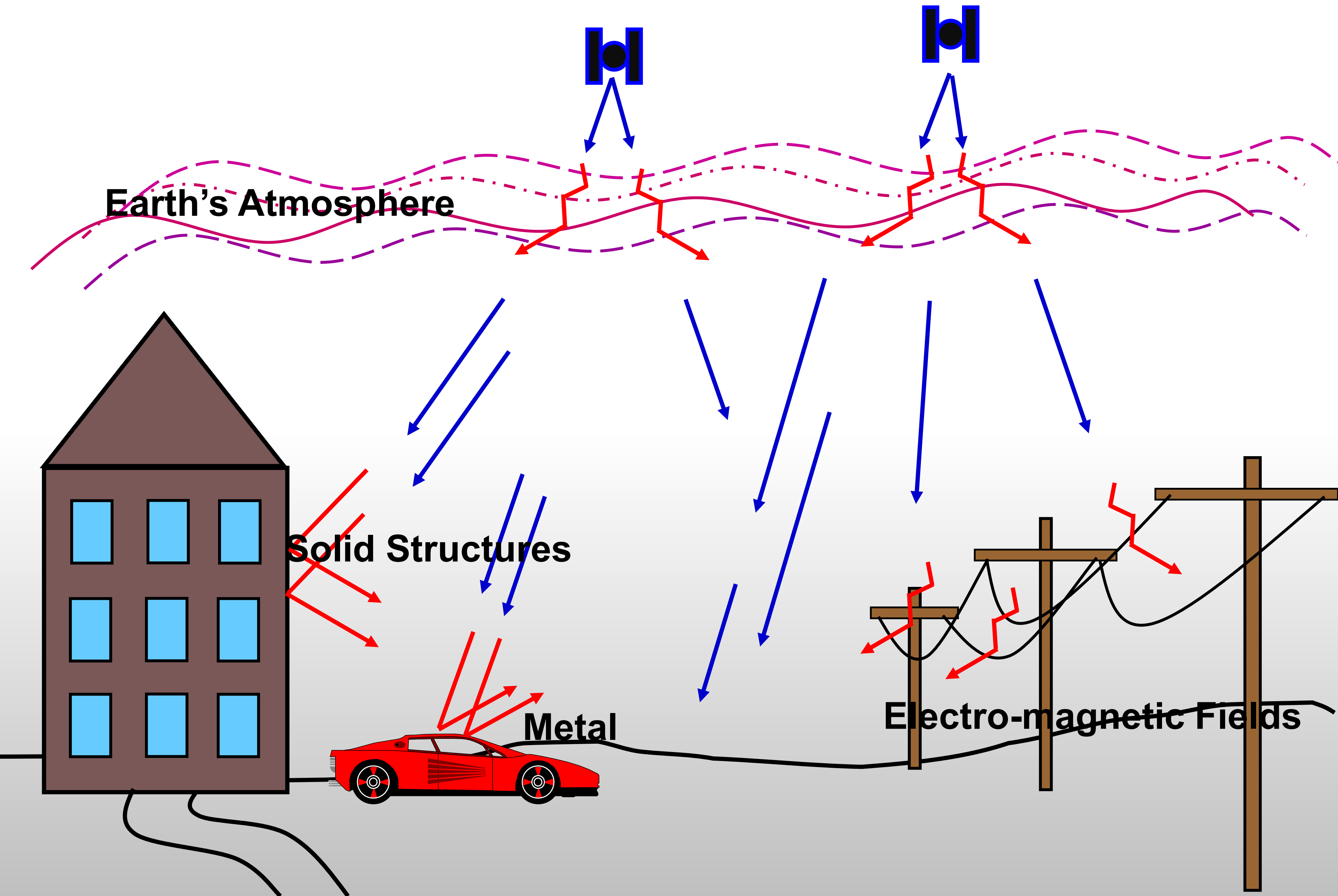
Military Time
(local time on a 24 hour clock)

*** GPS Time is currently ahead of UTC by 13 seconds.**

Selective Availability (S/A)

- The Defense Department dithered the satellite time message, reducing position accuracy to some GPS users.
- S/A was designed to prevent America's enemies from using GPS against us and our allies.
- In May 2000 the Pentagon reduced S/A to zero meters error.
- S/A could be reactivated at any time by the Pentagon.

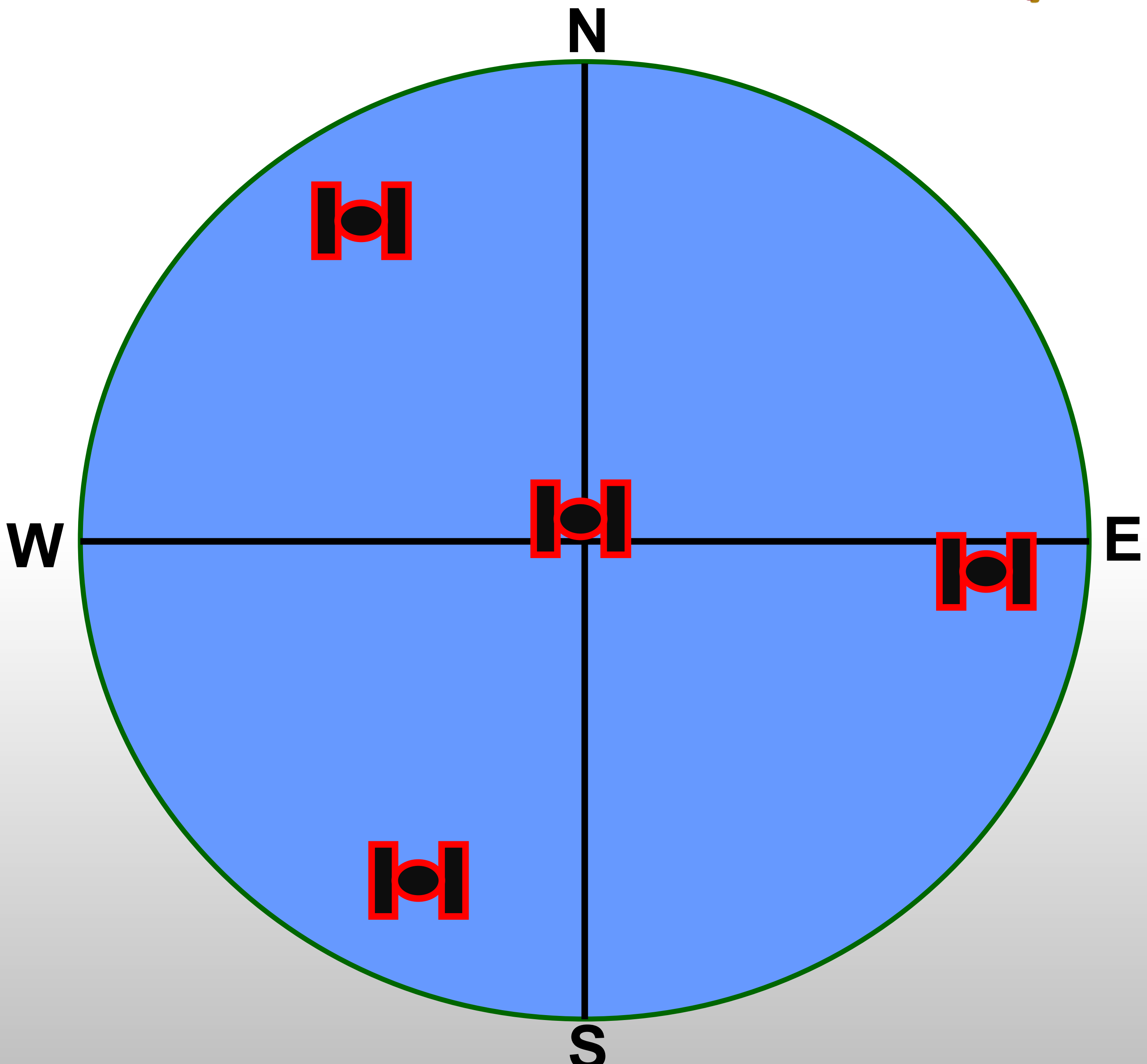
Sources of Signal Interference



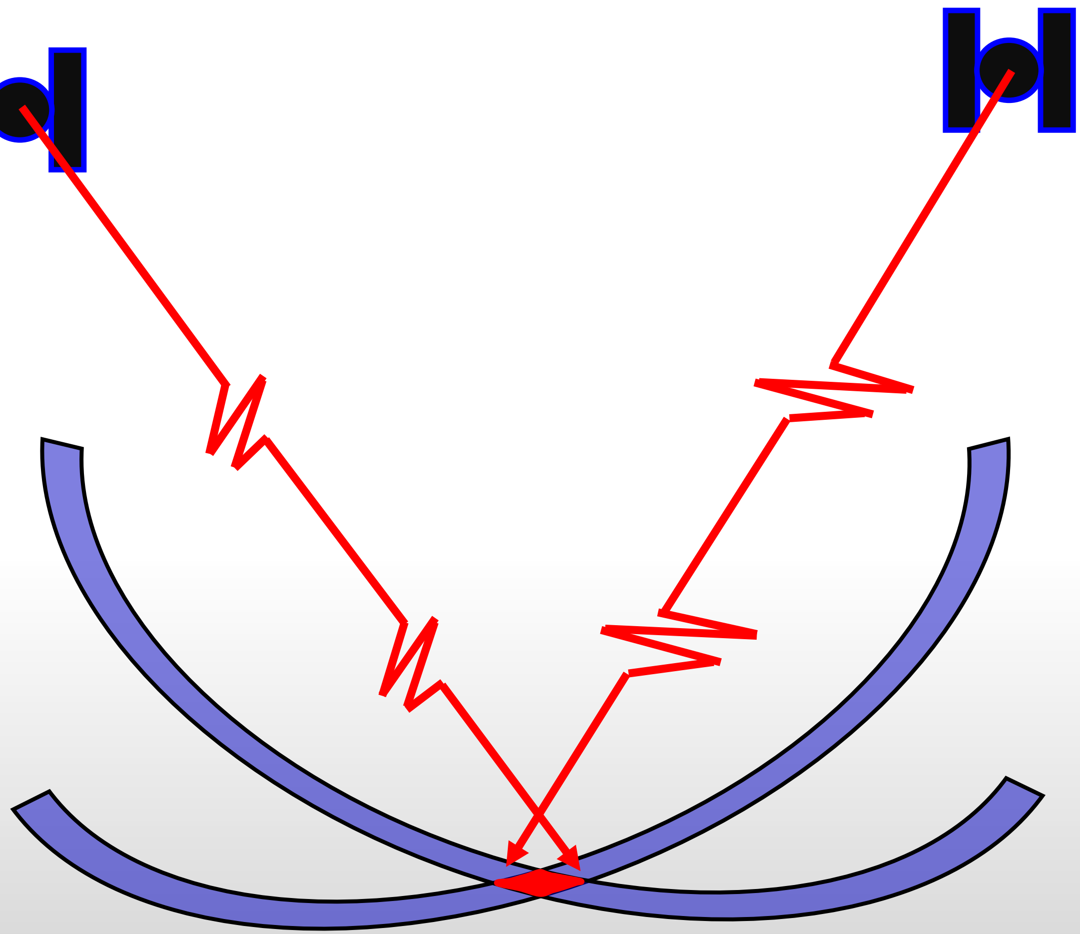
GPS Satellite Geometry

- Satellite geometry can affect the quality of GPS signals and accuracy of receiver trilateration.
- Dilution of Precision (DOP) reflects each satellite's position relative to the other satellites being accessed by a receiver.
- There are five distinct kinds of DOP.
- Position Dilution of Precision (PDOP) is the DOP value used most commonly in GPS to determine the quality of a receiver's position.
- It is usually up to the GPS receiver to pick satellites which provide the best position triangulation.
- More advanced GPS receivers can filter out poor DOP values.

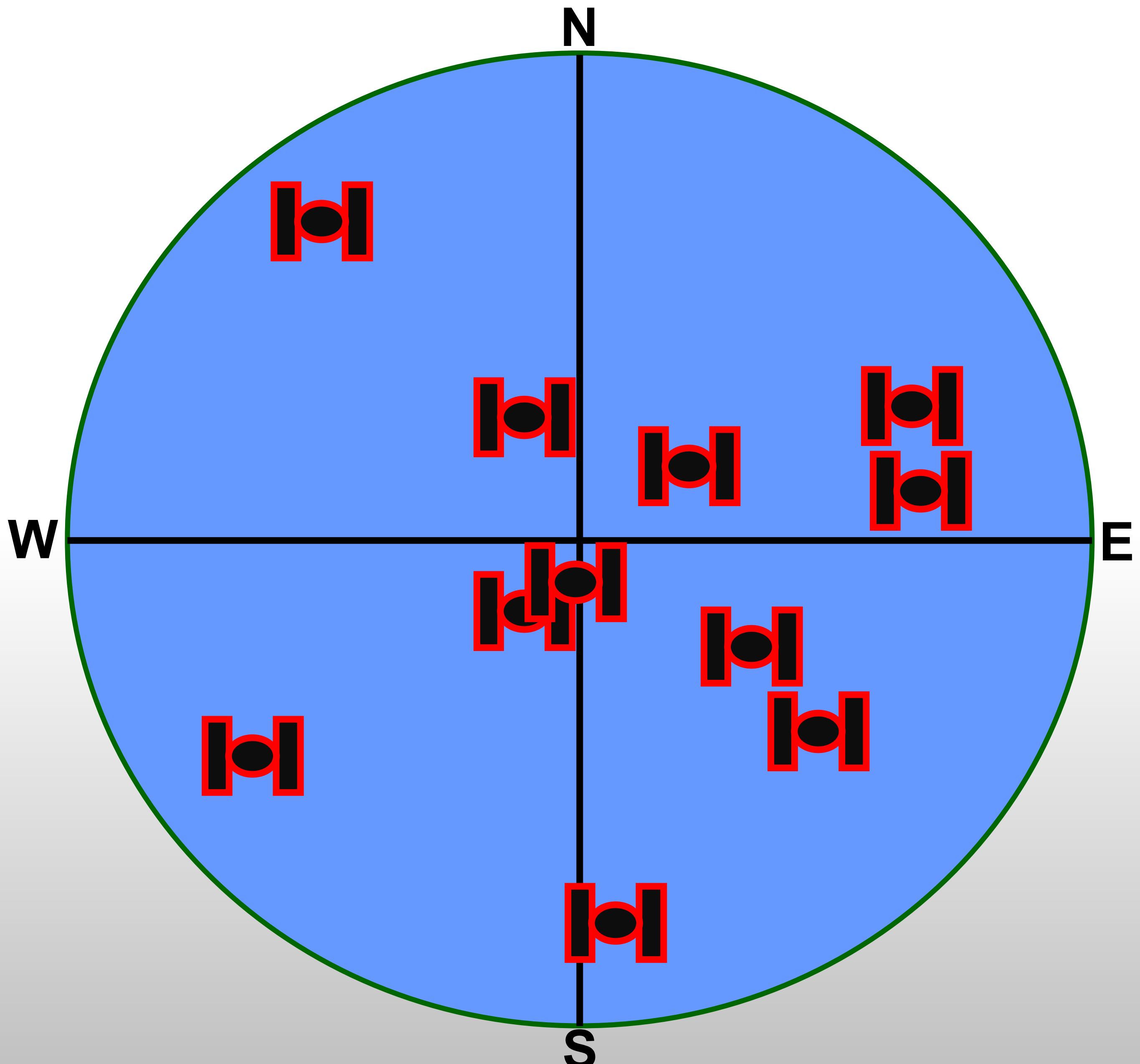
Ideal Satellite Geometry



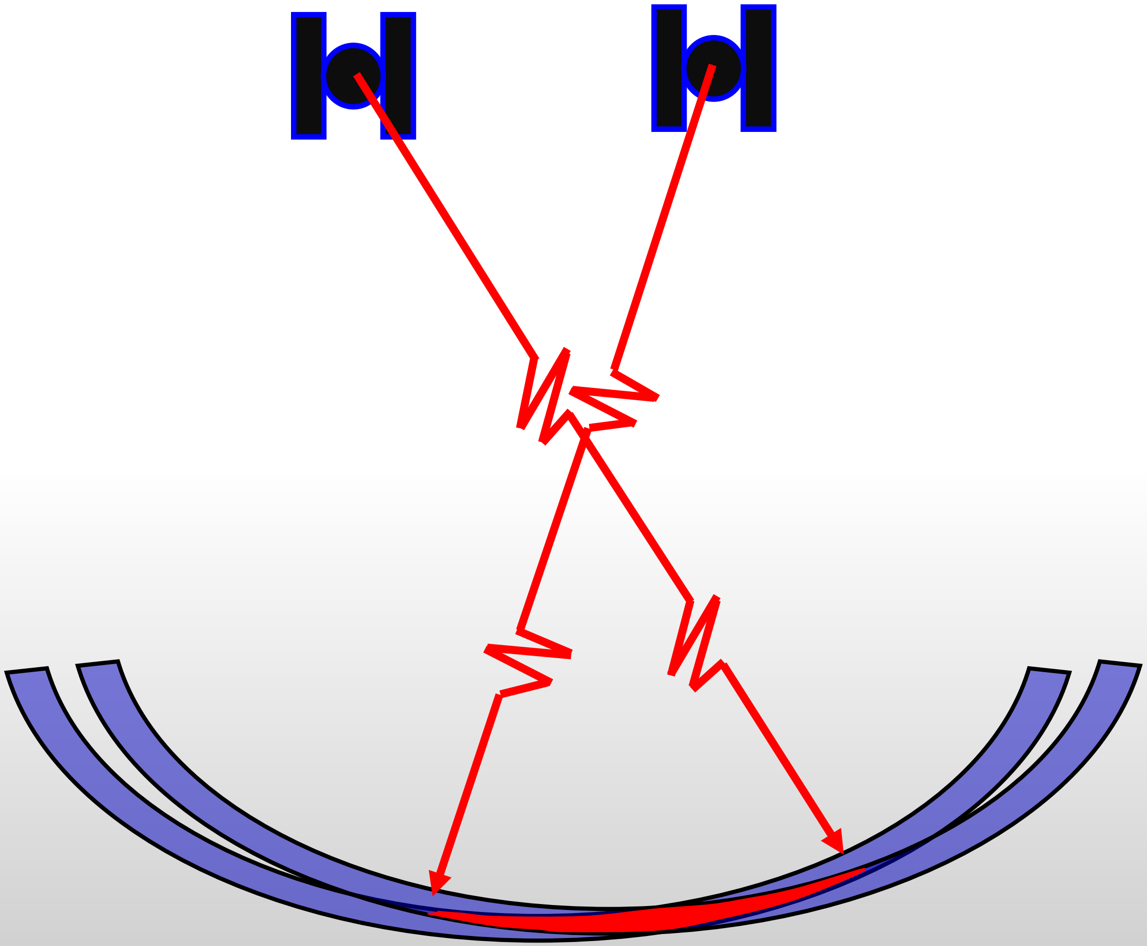
Good Satellite Geometry



Poor Satellite Geometry



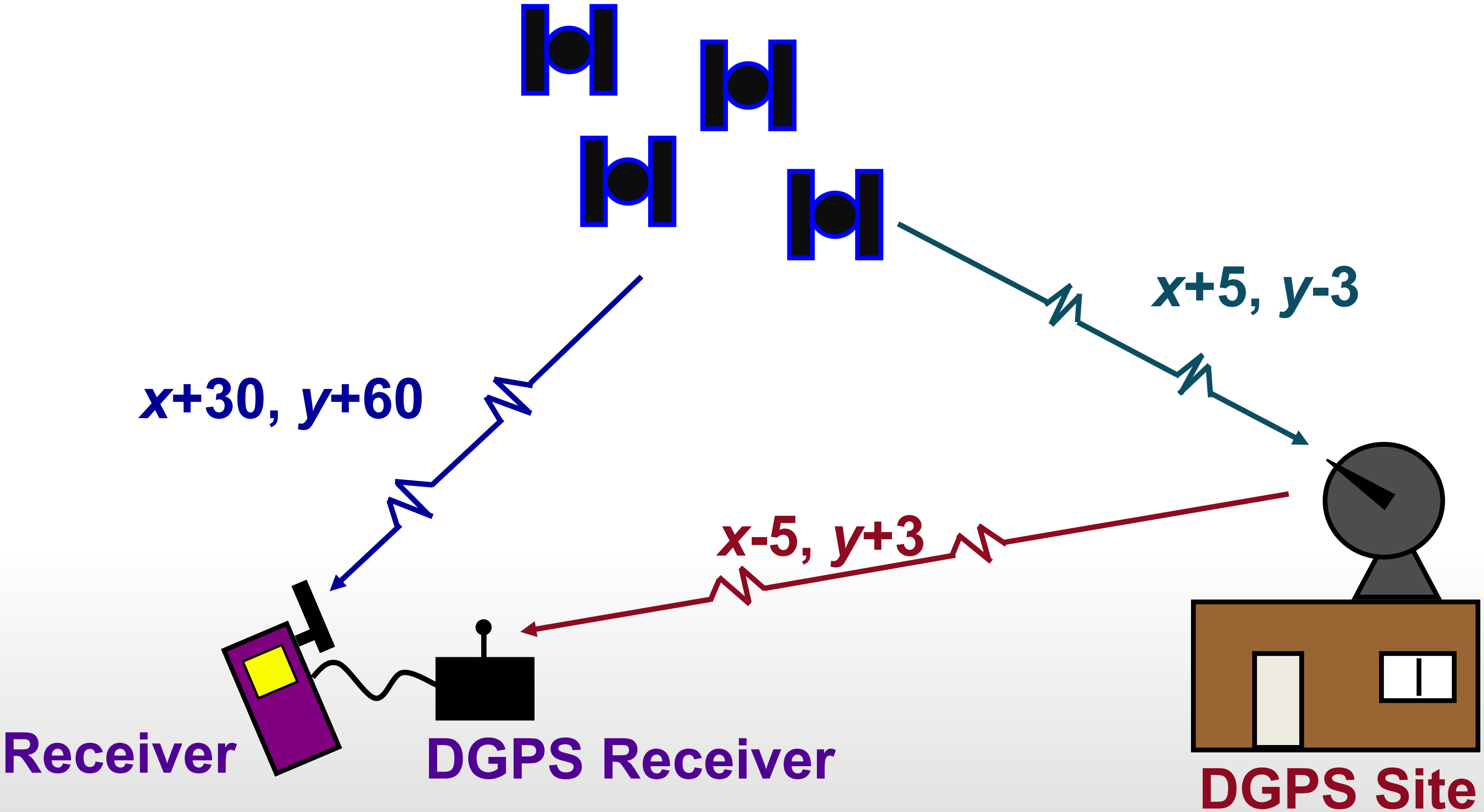
Poor Satellite Geometry



Differential GPS

- Realtime
- Post process

Real Time Differential GPS



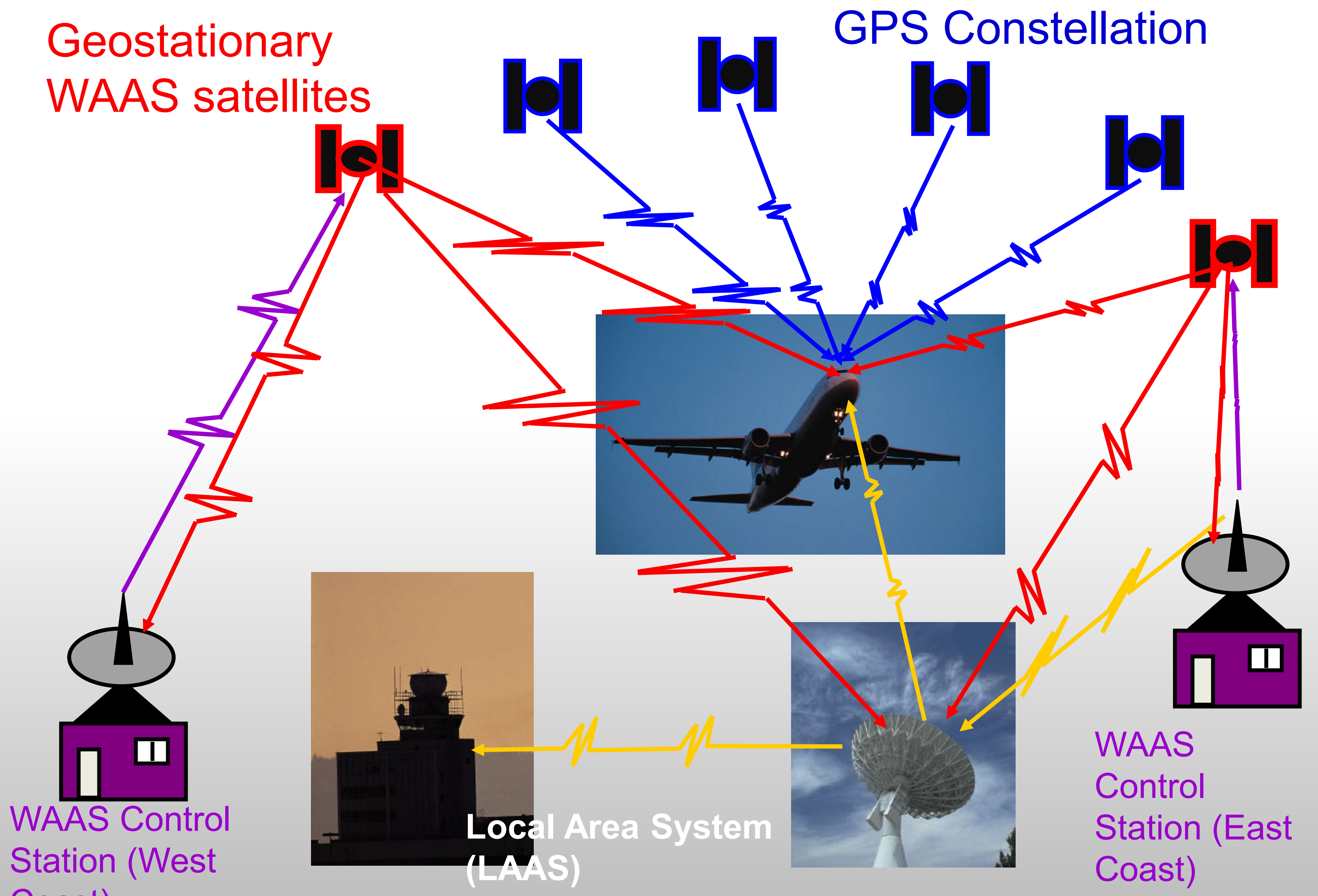
DGPS correction = *x*+(30-5) and *y*+(60+3)

True coordinates = *x*+25, *y*+63

True coordinates = *x*+0, *y*+0

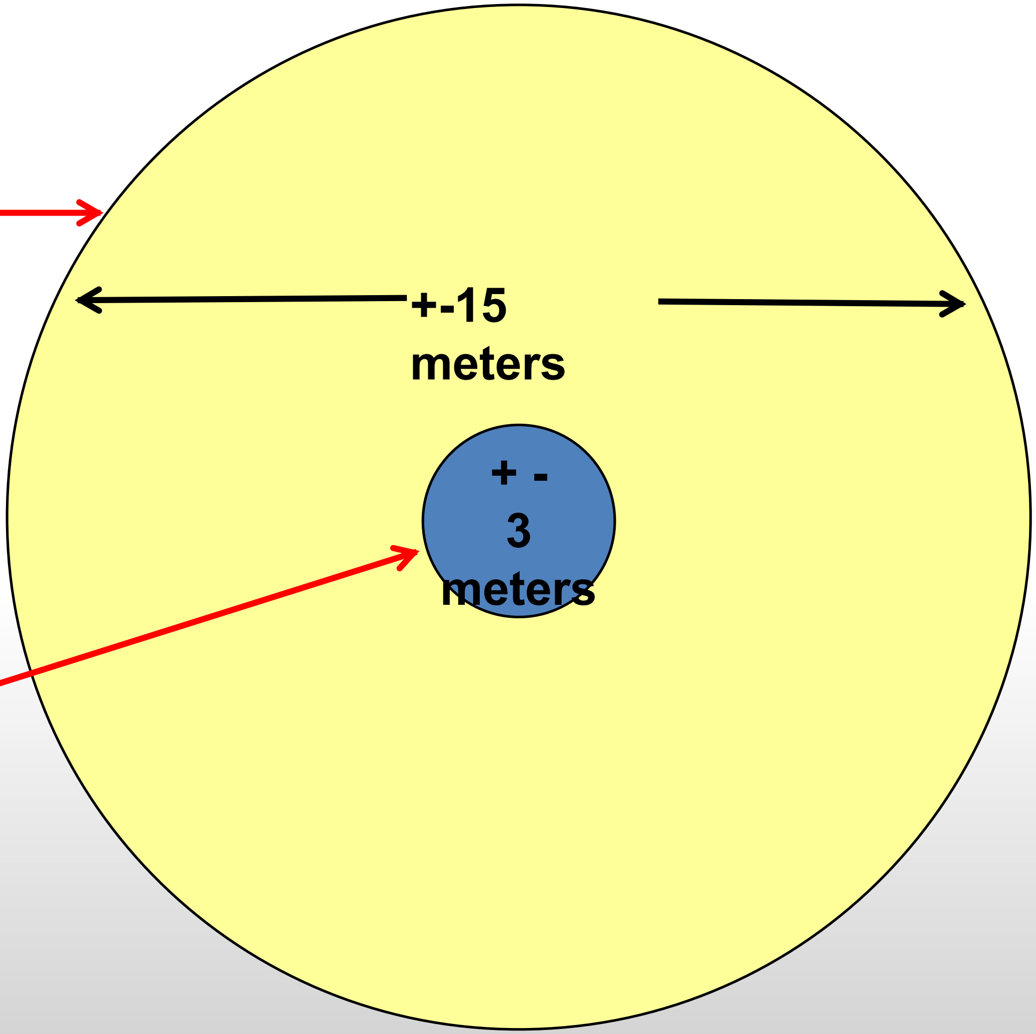
Correction = *x*-5, *y*+3

Wide Area Augmentation System



How good is WAAS?

With Selective Availability set to zero, and under ideal conditions, a GPS receiver without WAAS can achieve fifteen meter accuracy most of the time.*



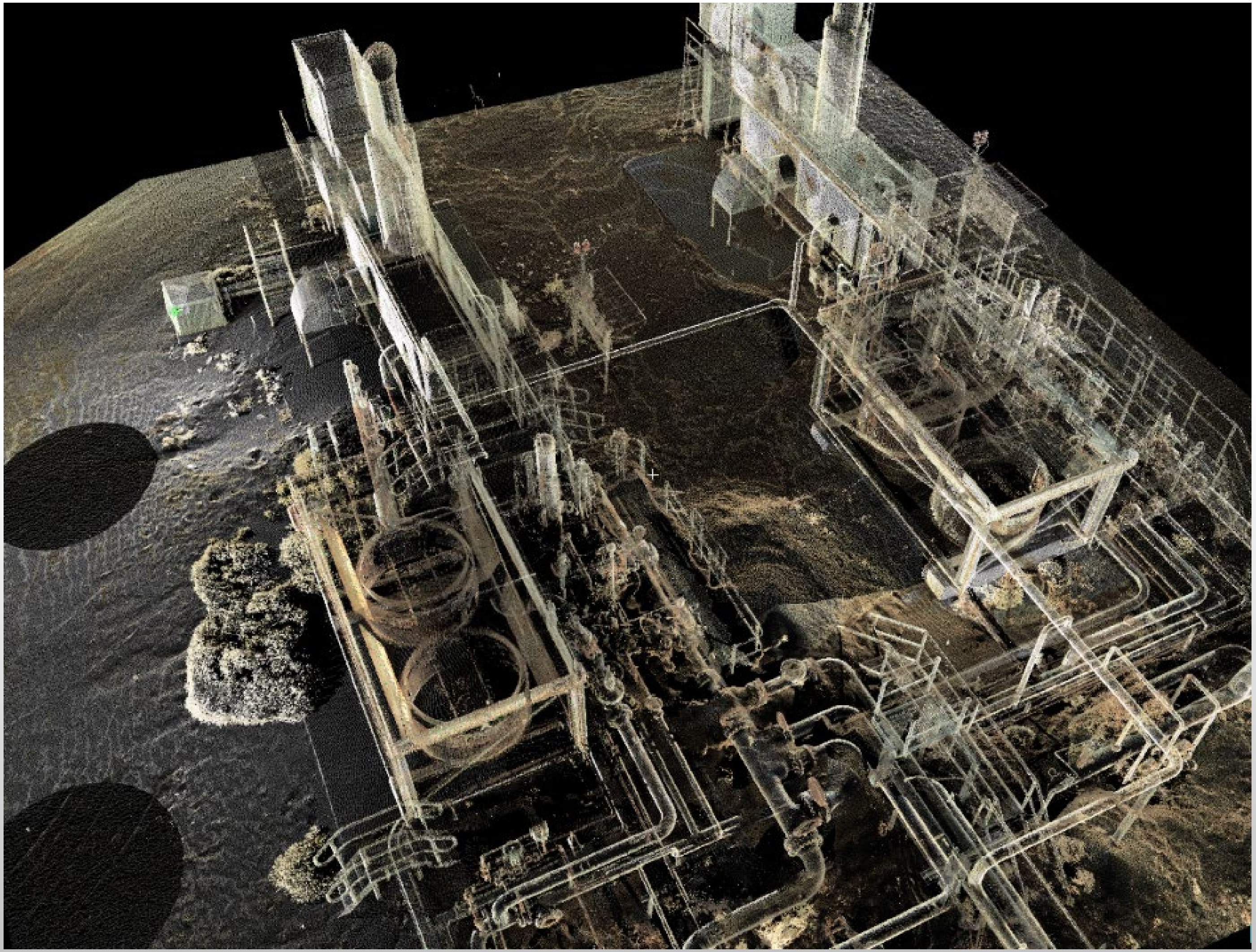
Under ideal conditions a WAAS equipped GPS receiver can achieve three meter accuracy 95% of the time.*

* Precision depends on good satellite geometry, open sky view, and no user induced errors.

Useful Conclusions on GPS

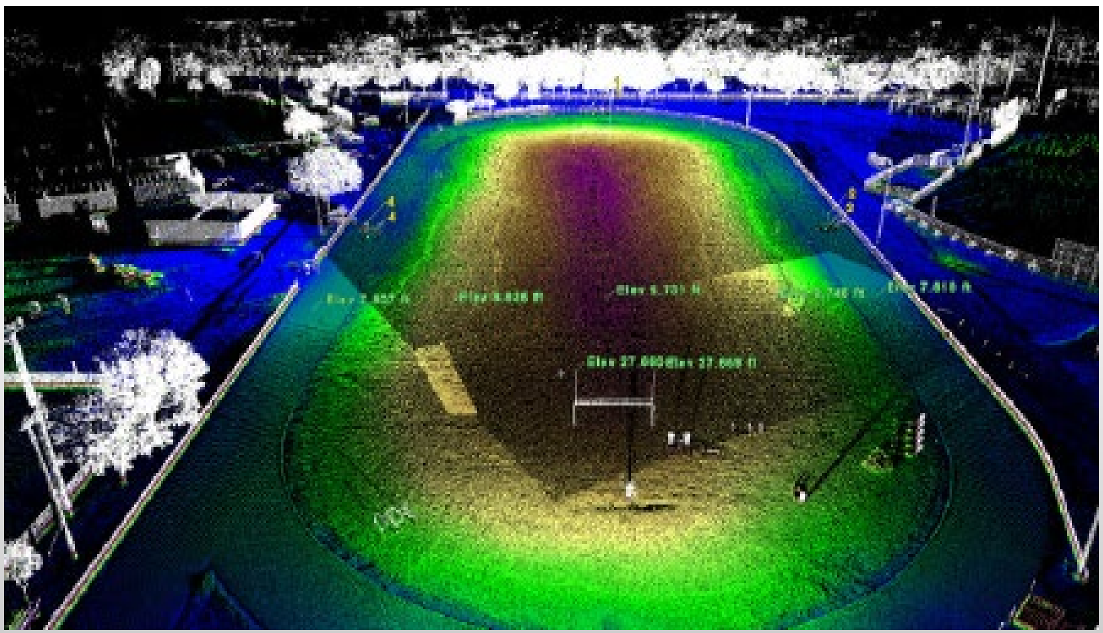
- Buy the best equipment that you can afford that will give you the level of reliable accuracy that you need
- Carefully plan (and execute) data collection trips
  - Watch satellite geometry – PDOP, GDOP
- Be sure to understand
  - Datums and projections of data target
- Be sure to check
  - Cables, batteries, setup options
- Be sure to avoid sources of interference
  - Microwaves, buildings, cliffs, trees, etc.

Laser scanning



Introduction & Motivation

- What is a Point Cloud?
  - A set of vertices in a 3D coordinate system, usually defined by X, Y & Z coordinates
  - Most often created by 3D laser scanner
  - The scanner records millions of 3D points as the laser beam sweeps over a scene or object
  - The point cloud represents the points that the laser scanner has measured



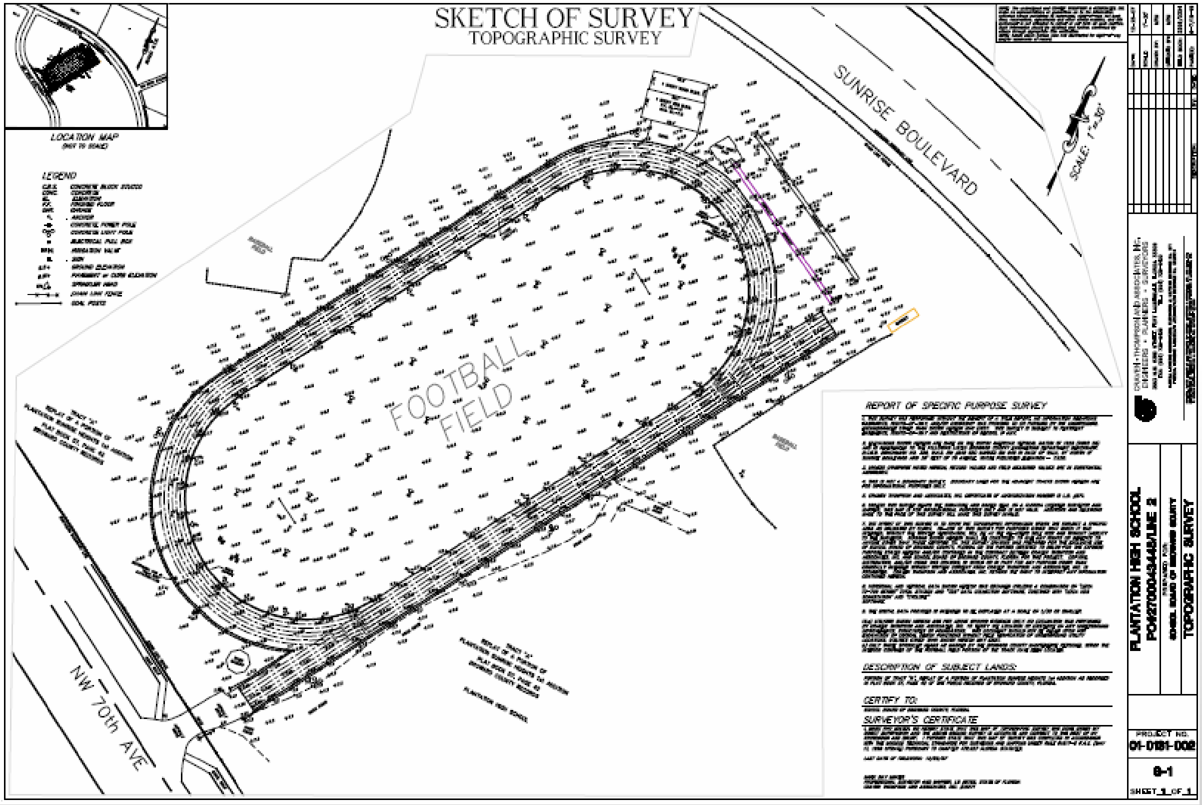
Laser Scan Point Cloud, Plantation High School. Source: Craven Thompson & Associates, Inc., Fort Lauderdale, FL

Benefits of Point Cloud Data:
- Speed of data capture
- Remote acquisition & measurement
- High point density data
- Provides direct measurement capability
- Overlay with imagery for 3D visualization

How do you take a Point Cloud …

Introduction & Motivation

And end up with a Final Deliverable?



Topographic Survey, Plantation High School. Source: Craven Thompson & Associates, Inc., Fort Lauderdale, FL

Why Civil 3D?

- Leading software used by the civil/survey industry
- 3D Model Space Design
  - Objects maintain their relationships to other objects in the design
  - Dynamic updating

Lasers & Surveying

LASER

- An acronym for Light Amplification by Stimulated Radiation

Electronic Distance Measuring (EDM)

- Used by many surveyors in the 1970's for measuring long distances & setting control points for surveys
- Measures distance only (no angles)

HP3800B Distance Meter. Manufacture Date: 1969. Dates of Use: 1970's. Source: NOAA

Total Station

- Electronic instrument capable of measuring distance & angles
- Includes electronic data collection

Topcon ET-1 Total Station. Manufacture Date: 1985. Dates of Use: 1980's. Source: NOAA

Leica TPS1200+ Total Station. Manufacture Date: Current. Dates of Use: In use today. Source: Leica Geosystems

Lasers & Surveying

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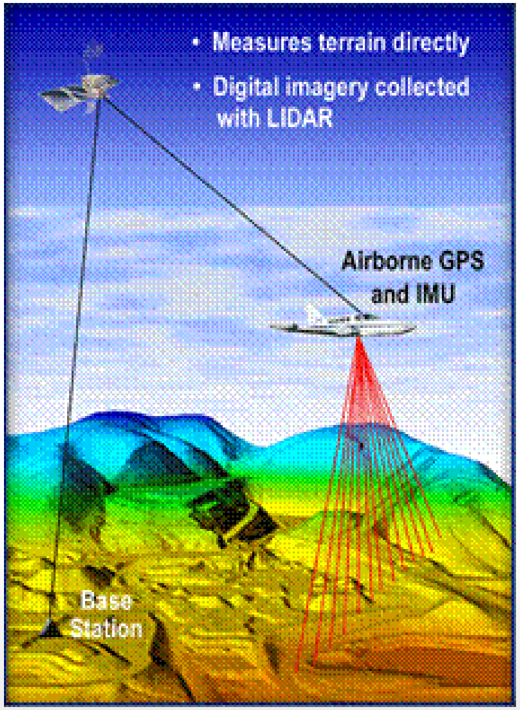

Illustration showing the components for an aerial lidar system. Source: Spatial Resources

Aerial Lidar

Aerial Lidar System includes:

GPS

IMS (Inertial Measurement System)

Scanning Laser transmitter-receiver

LIDAR

- An acronym for Light Detection and Ranging

Static

Ground-based static laser scanner mounted on a tripod. Source: Nobles Consulting Group

Dynamic (Mobile Mapping)

Sporting two lidar sensor heads, the rooftop mobile scanning system collects data while traveling at posted speeds.

Ground-based mobile laser scanning system. Source: Professional Surveyor Magazine

Terrestrial (Ground-Based) Lidar

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Thank you for your attention