WEEK 5:

GLOBAL NAVIGATION SATELLITE SYSTEMS AND COORDINATE SURVEYING

Intro to GIS
Evan Lue, PhD

GNSS

Global Navigation Satellite Systems

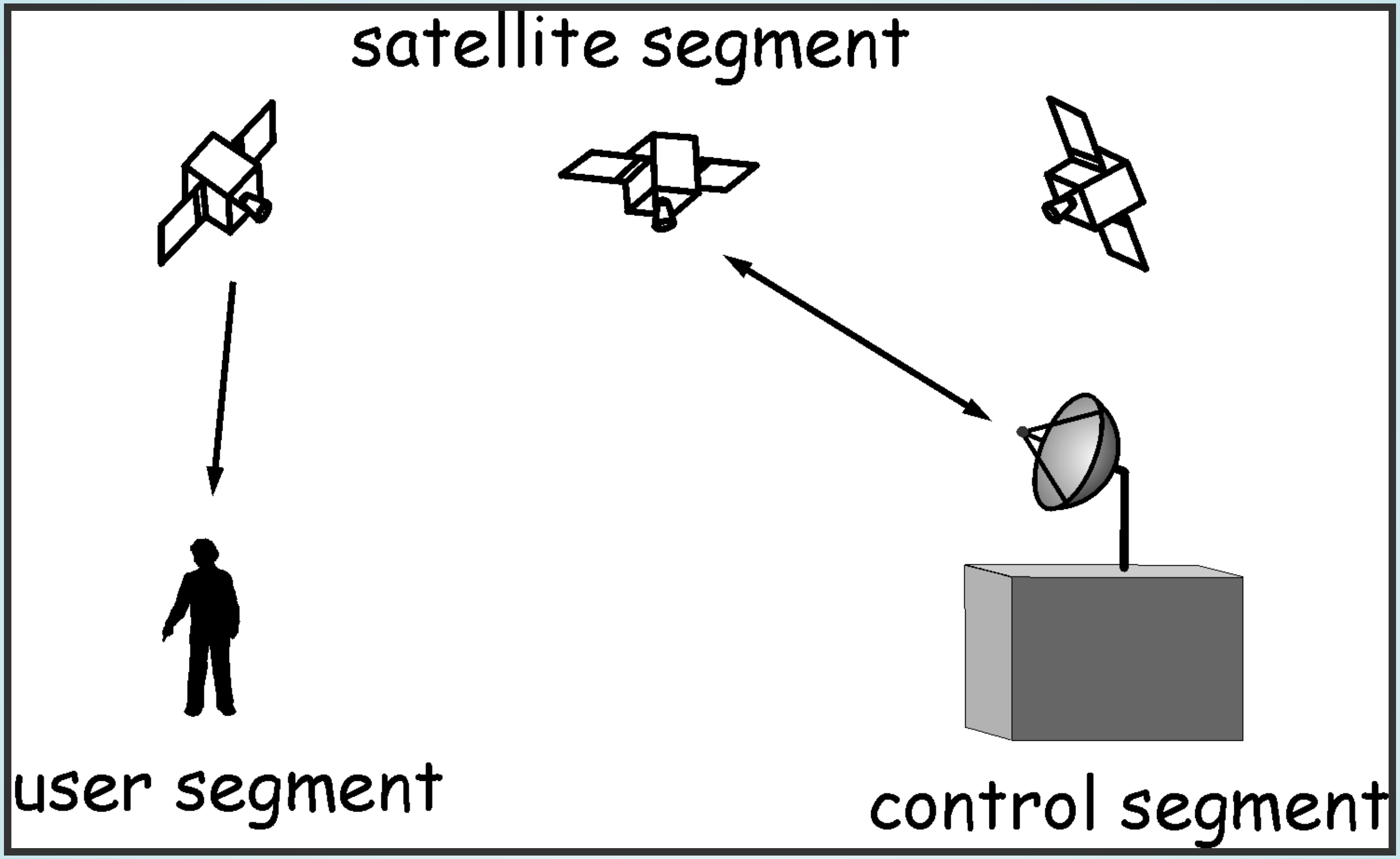
Bolstad 2012, Fig 5-1

GNSS SYSTEMS*

- GPS - USA - NAVSTAR Global Positioning System
- GLONASS - Russian Federation - Global Navigation Satellite System
- BeiDou - China - regional, global in development
- Galileo - EU - in development

*Yes, the last "S" in "GNSS" also stands for "Systems"

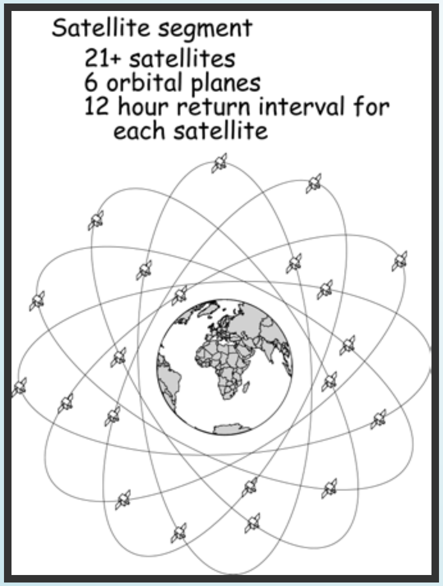
SEGMENTS

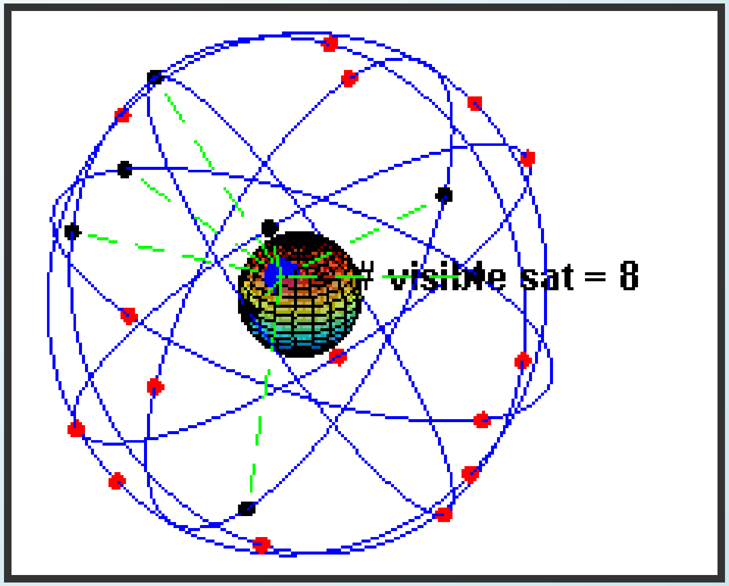


Bolstad 2012, Fig 5-2

GPS CONSTELLATION

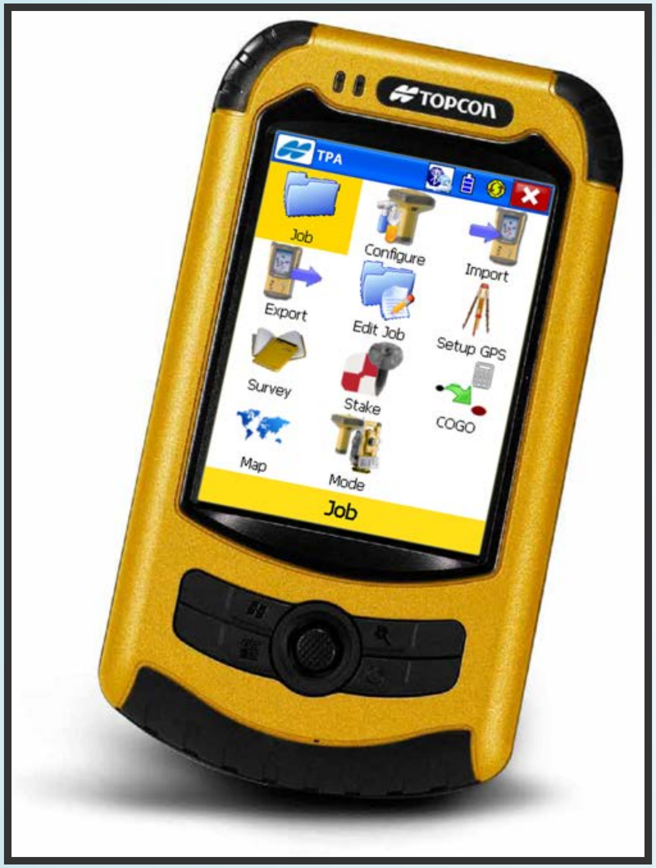
- Constellation - a collection of satellites working together
- 20,000 km above earth
- 2x daily, above horizon 8+ hrs per day
- The book suggests 4-8 satellites visible at any time
- 21 active + 3 spare, and some more

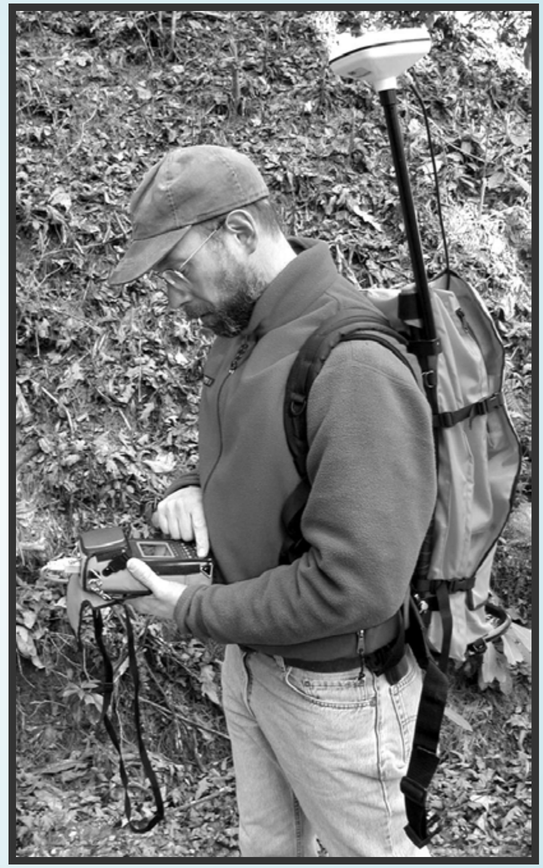




Bolstad 2012, Fig 5-3 and Wikimedia Commons

GNSS USER





Bolstad 2012, Fig 5-4

GPS SIGNALS

- Pseudorandom noise (PRN) - signals similar to noise, but consisting short segments of code.
- C/A code - Coded signal; coarse acquisition, PRN.
- P-code - Coded signal; Precision code, PRN.
- L1 - Carrier signal; C/A and P code.
- L2 - Carrier signal; P code.

Table 5-1 : GPS Signals

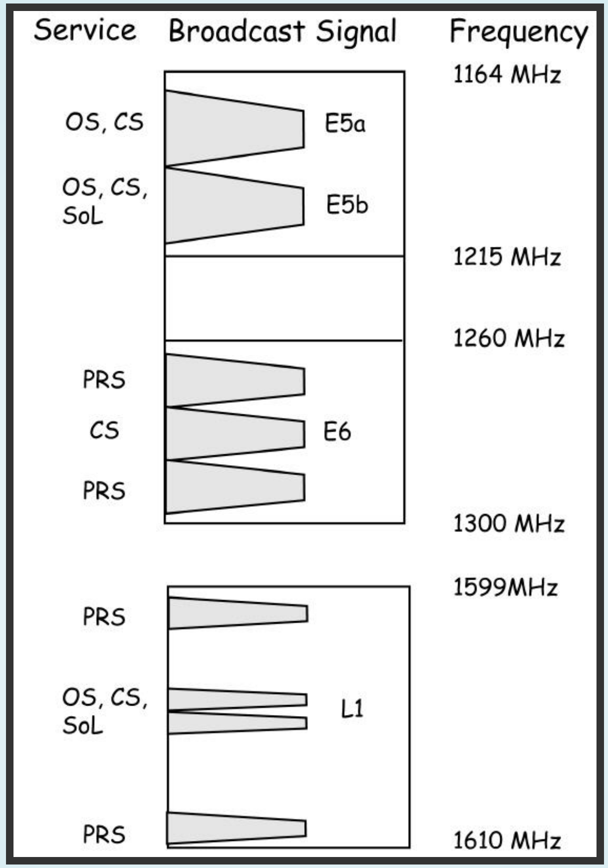
Name	Frequency (MHz)
L1, L1C	1575.42
L2, L2CM, L2CL	1227.6
L5	1176.45
P, M	10.23
C/A	1.023

Bolstad 2012, Table 5-1

GNSS TERMS

- Almanac - system info on time and status of a constellation.
- Ephemeris data - information on the position of satellites and their expectes positions.

BROADCAST SIGNALS

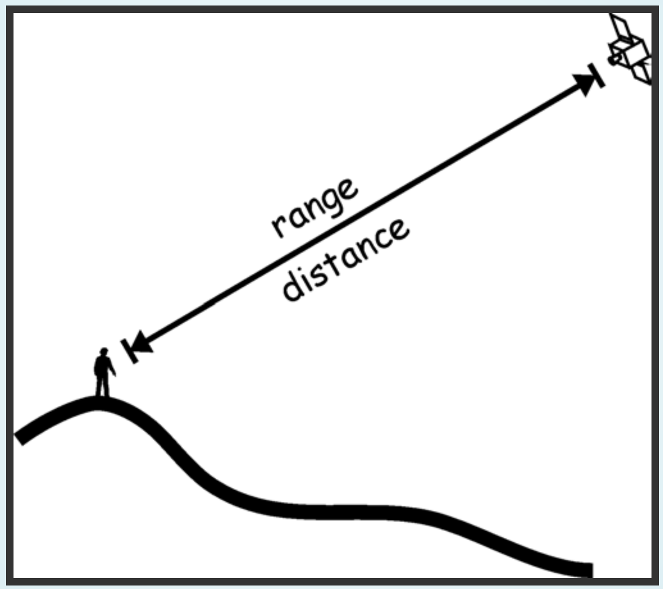


Bolstad 2012, Fig 5-5

RANGE

The distance between two objects.

Range = (speed of light) * (travel time)



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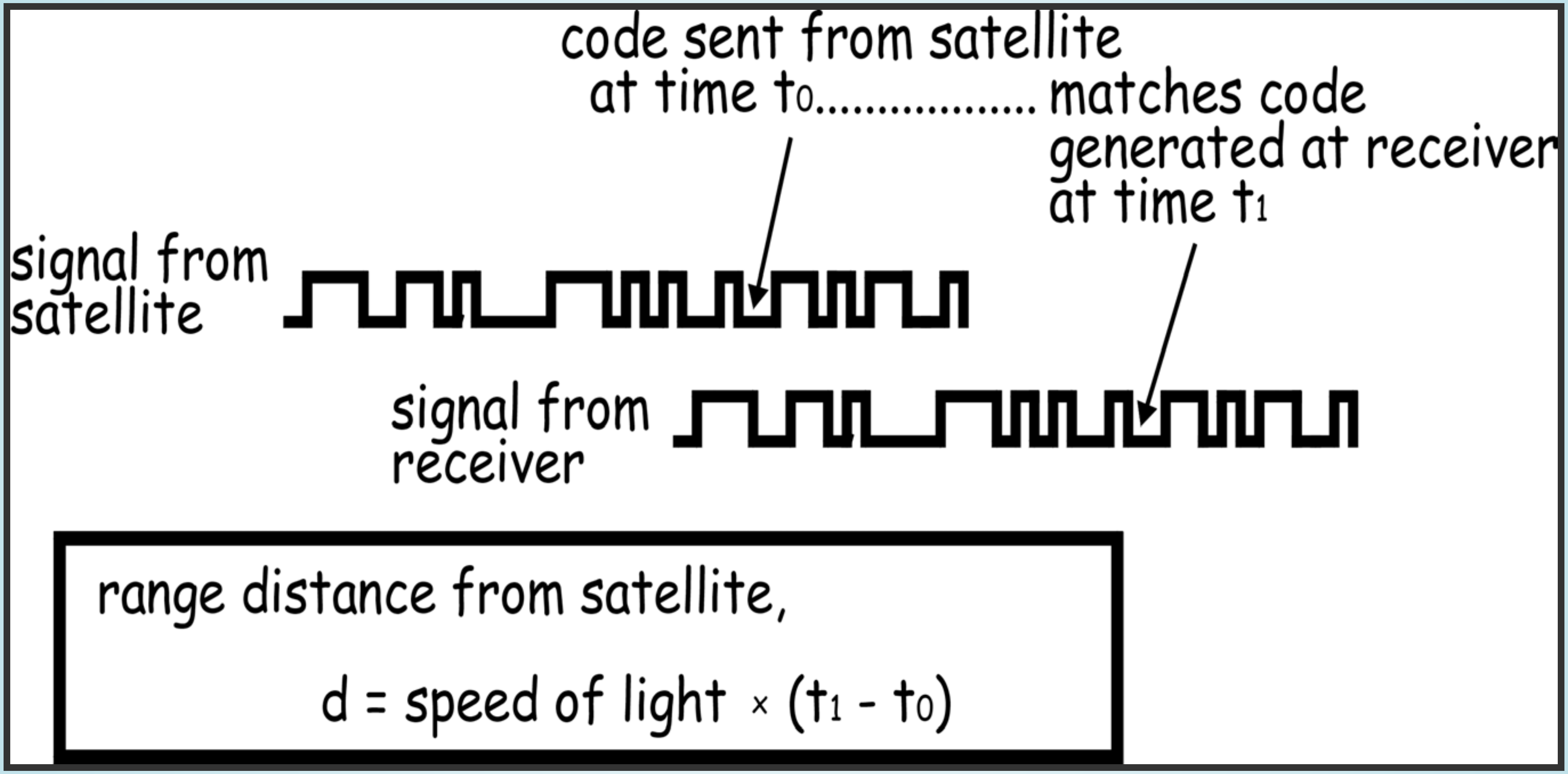
DECODED C/A SIGNAL



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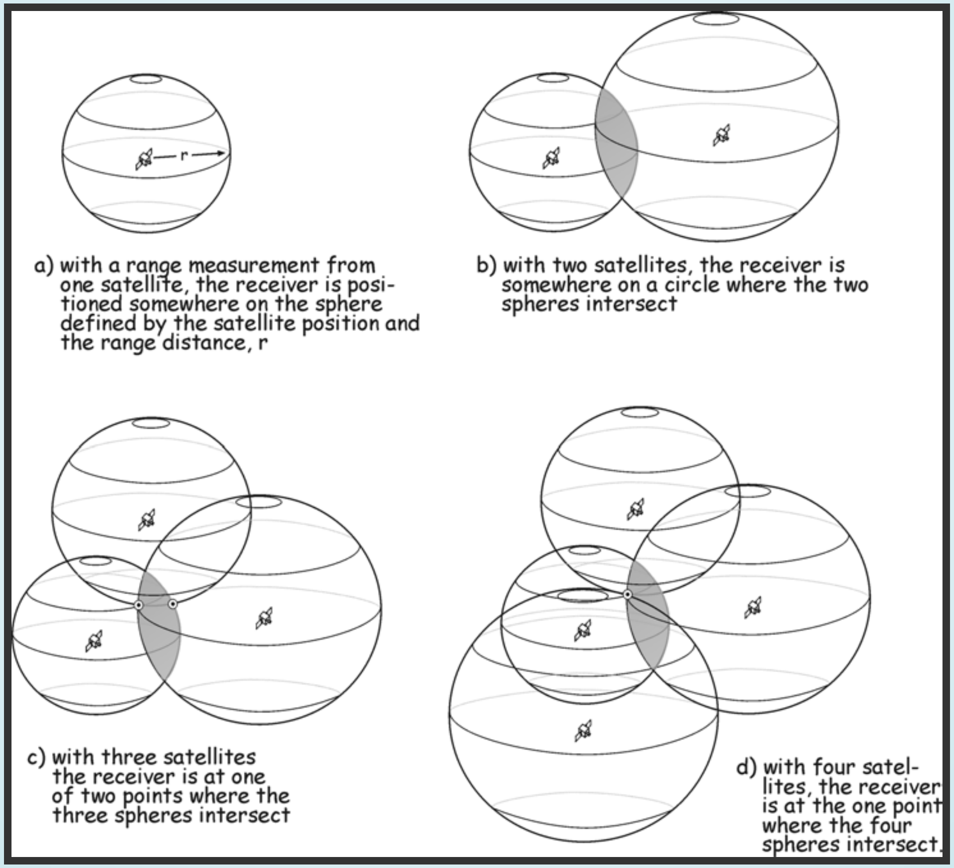
RANGE MEASUREMENTS CONT.



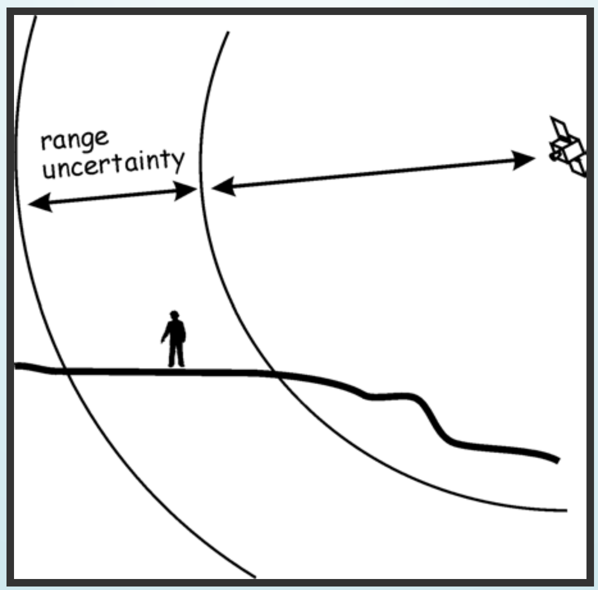
Bolstad 2012, Fig 5-8

RANGE UNCERTAINTY

Ionospheric/Atmospheric Delays - varied speed traveling through the ionsphere/atmosphere.

Dual Frequency - Some receivers collect from multiple GNSS signals and remove ionospheric errors.

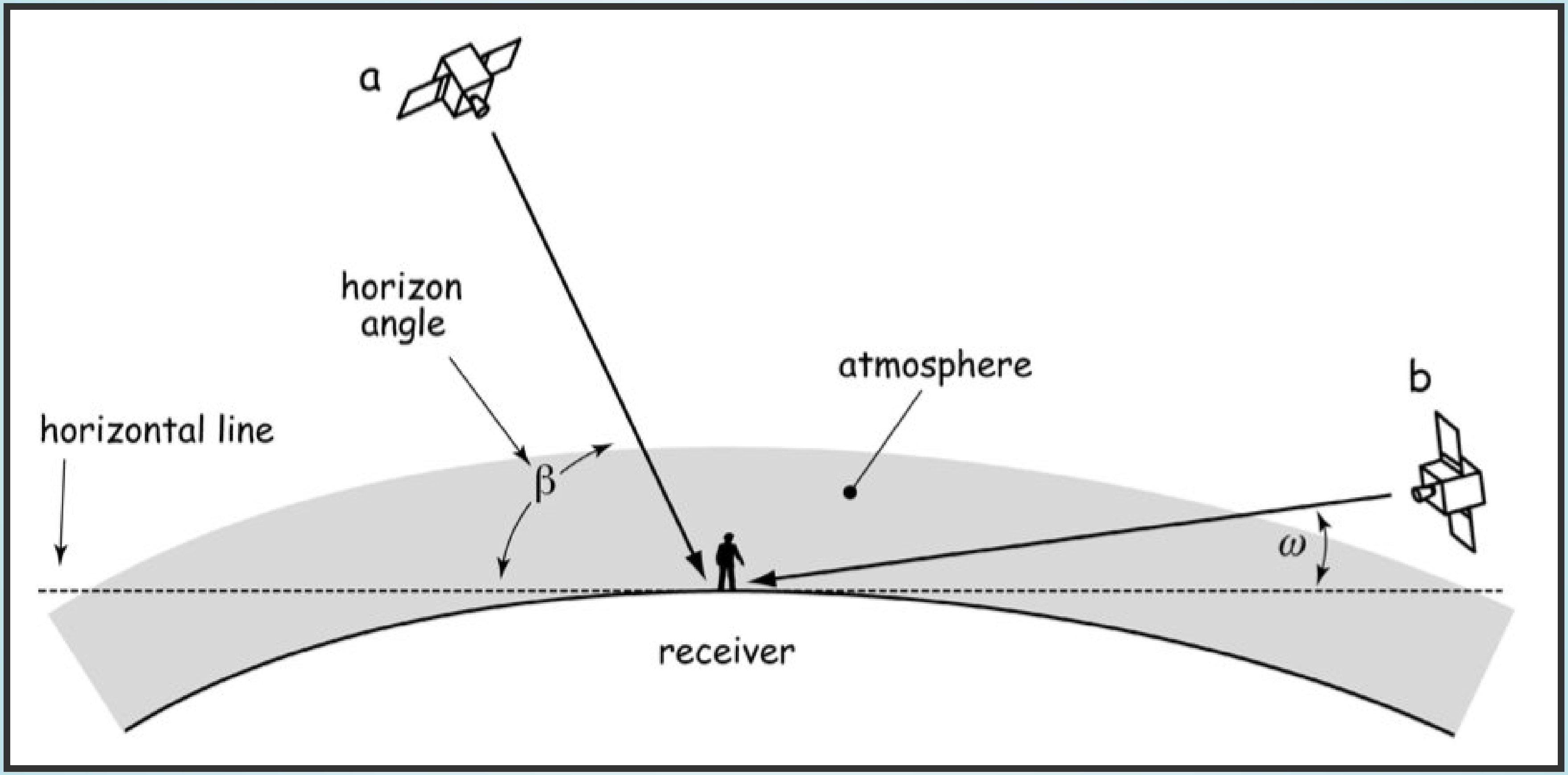
Multipath - Signals reflected off of objects; take longer to reach the object and are weaker.



Bolstad 2012, Fig 5-9

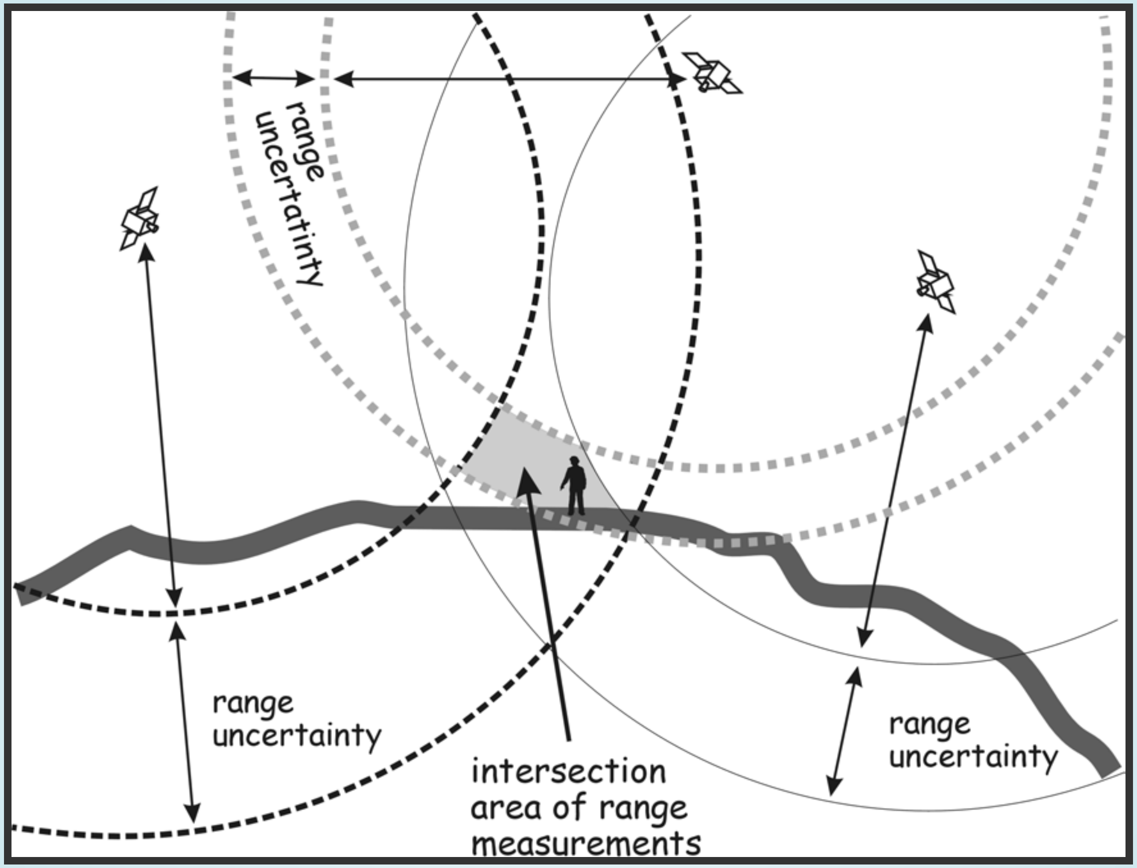
THE HORIZON

More atmosphere to pass through.



Bolstad 2012, Fig 5-10

POSITIONAL ACCURACY



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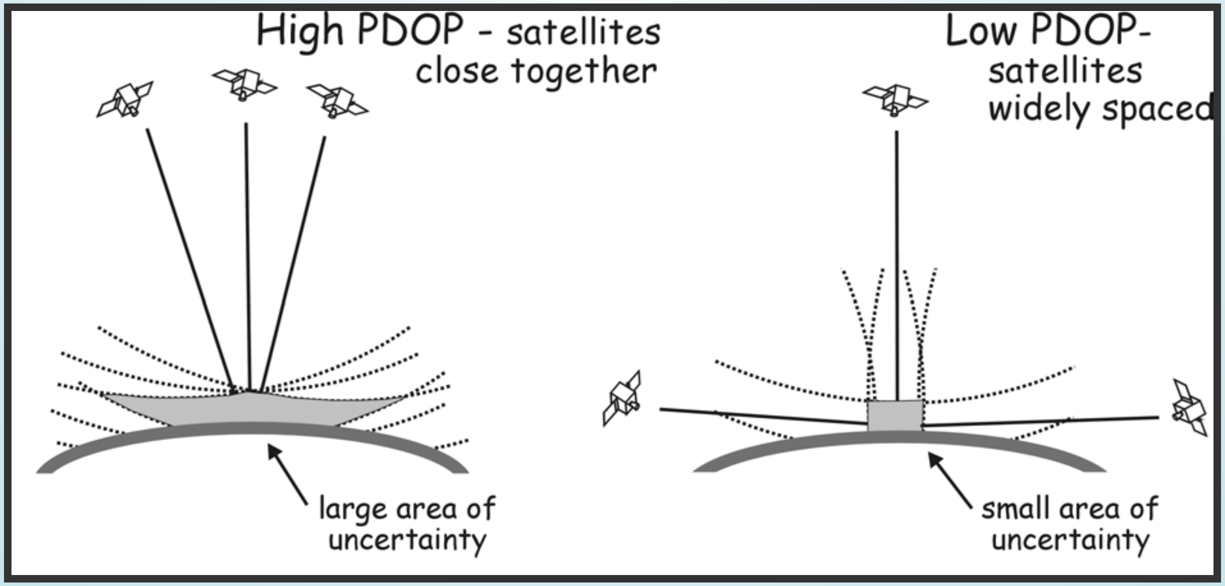
DILUTION OF PRECISON (DOP)

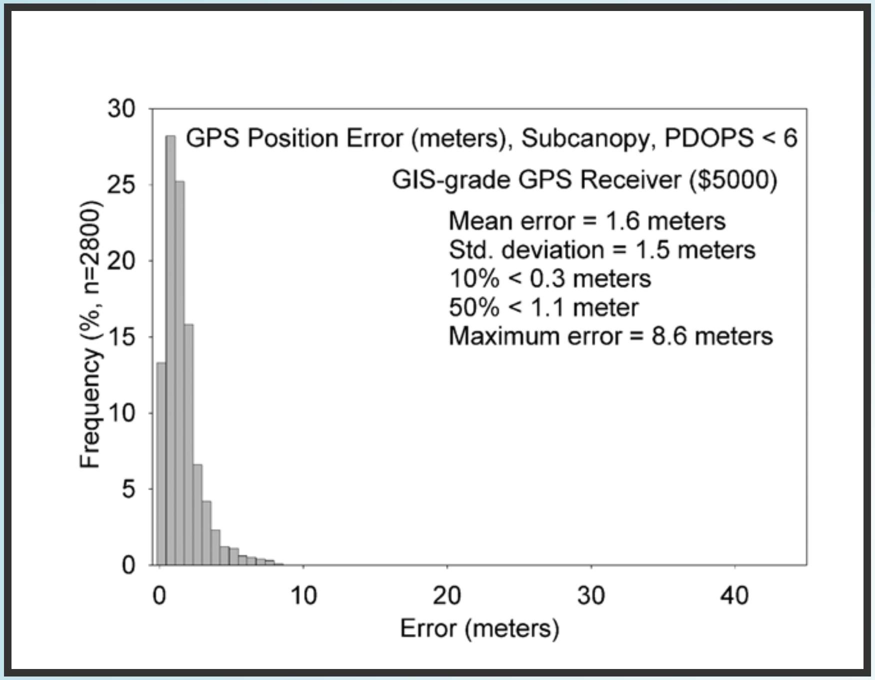
Describes effects of satellite location on precision.

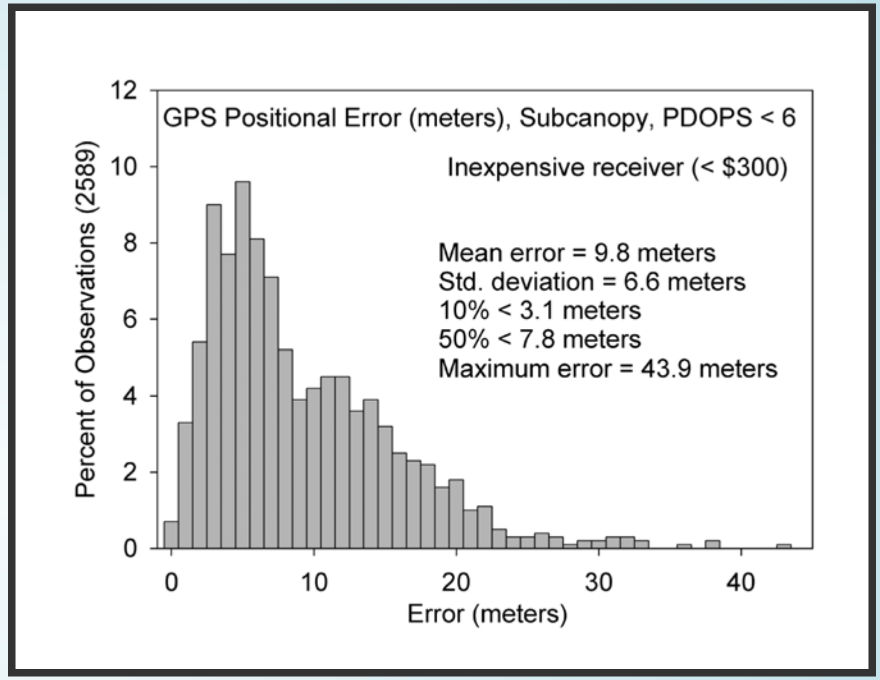
- PDOP - Position (3D). Lower is better, 1-5 is good.
- Also: HDOP (Horizontal), VDOP (Vertical), TDOP (Time), GDOP (Geometric)



Bolstad 2012, Fig 5-12

GPS ERROR





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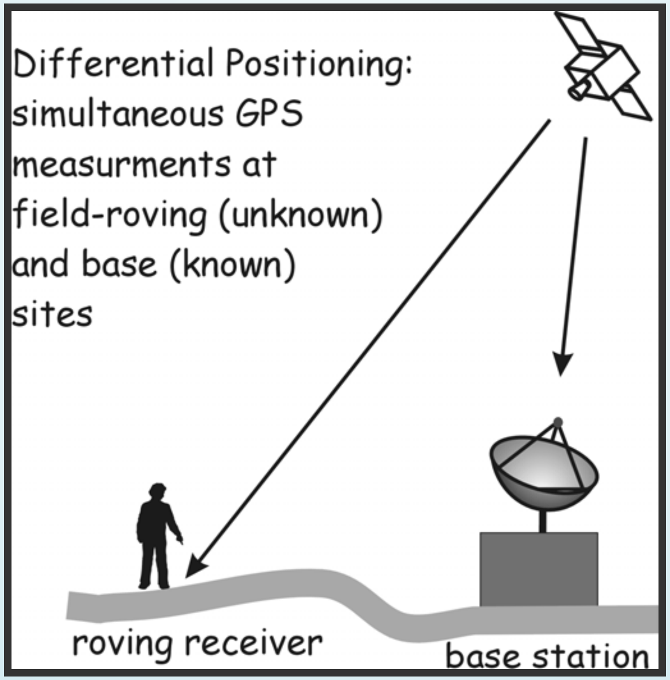
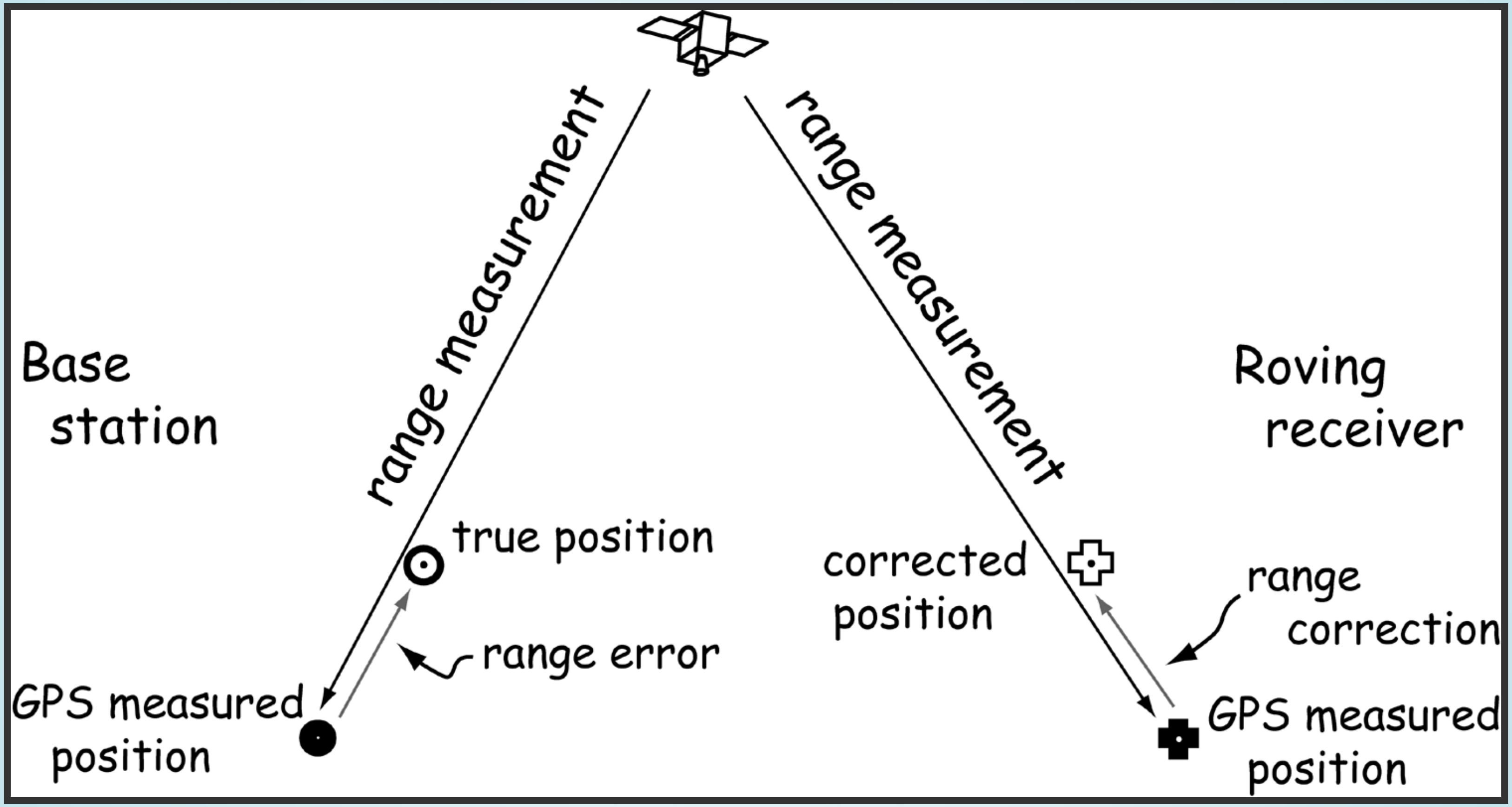
DIFFERENTIAL GNSS POSITIONING

- Differential Positioning - Using one or more receivers.
- Base Station - A receiver at a known location.



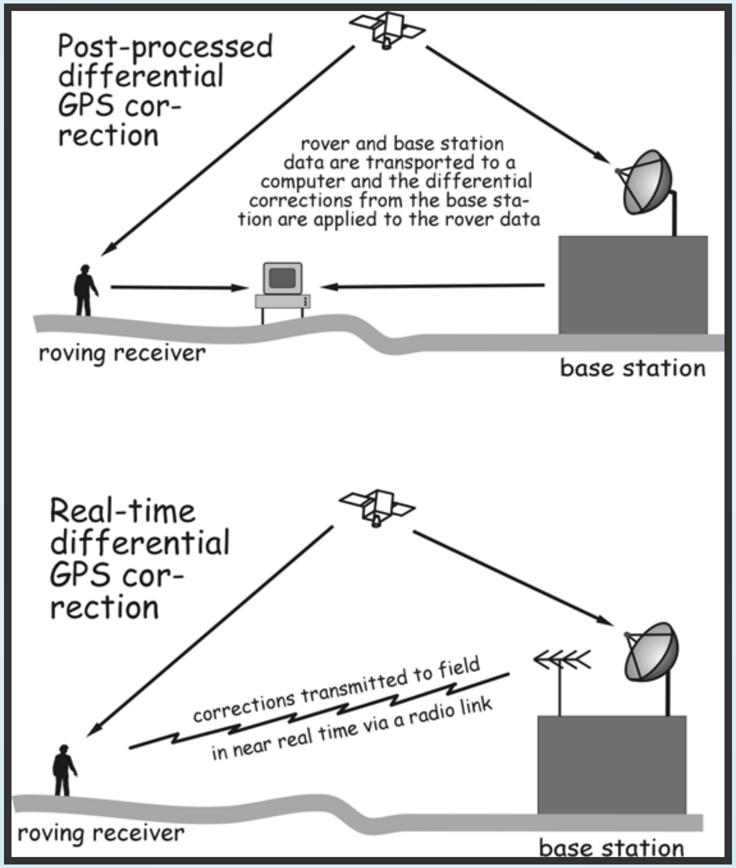
Bolstad 2012, Fig 5-14

DIFFERENTIAL CORRECTION



Bolstad 2012, Fig 5-15

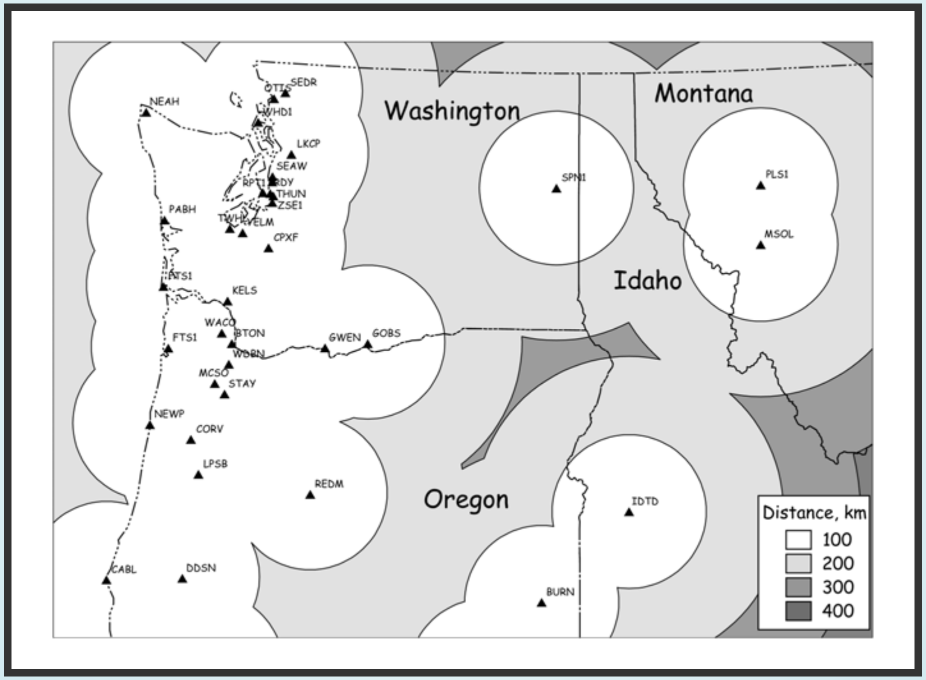
REAL-TIME VS. POST-PROCESSING



Bolstad 2012, Fig 5-16

GPS RADIO BEACONS

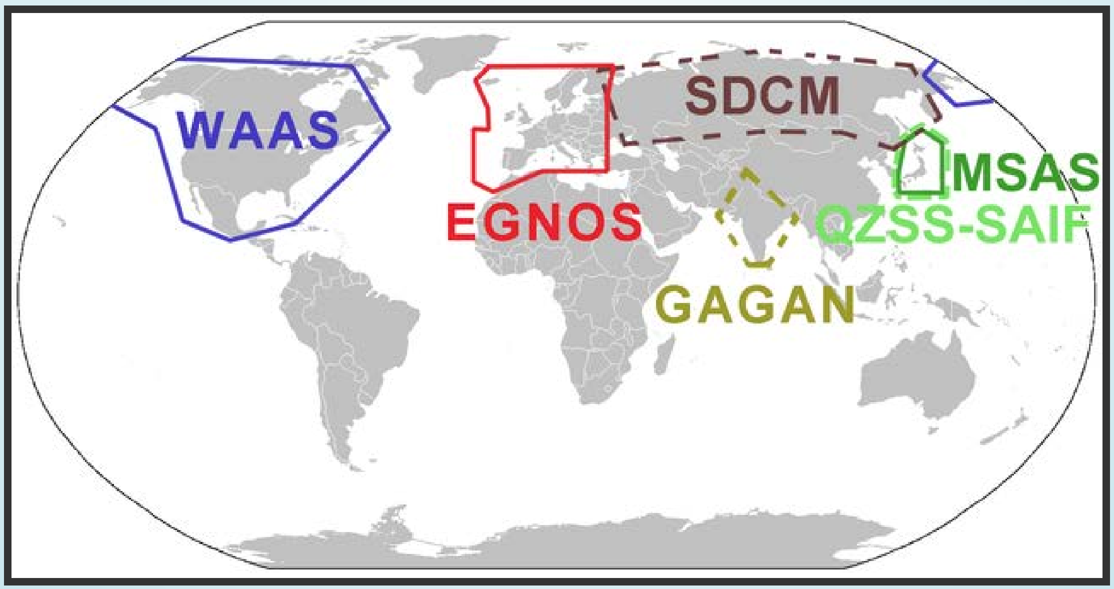
- Radio beacons - broadcasted signal correction.
- Beacon receivers - a GPS must have a beacon receiver to use the radio beacons



Bolstad 2012, Fig 5-17

SATELLITE-BASED AUGMENTATION SYSTEMS (SBAS)

The Wide Area Augmentation System (WAAS) administered by the FAA is the most common example.

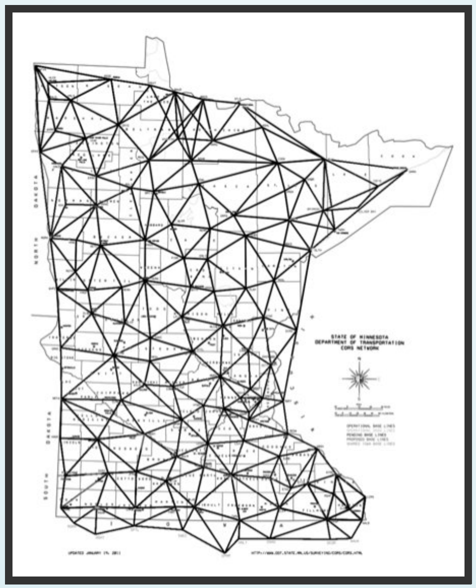


"SBAS Service Areas" by Persimplex

REAL-TIME KINEMATIC (RTK)

Dual-frequency solution reducing ionospheric delays.

Virtual Reference Station (VRS) - A roving receiver is never too far from a base station.



Bolstad 2012, Fig 5-18

DATUM WARNING

Remember that a transformation is needed when using different datums. GPS is based on WGS84. Many GPS devices can account for geographic coordinate systems.

OPTICAL/LASER SURVEYING

Plane surveying - horizontal surveying on a planar (flat) surface.

Bolstad 2012, Fig 5-19

SURVEYING INSTRUMENTS

Assuming a flat surface; plumb lines are perpendicular to the surface.

Surveys are under a few tens of kilometers. The distance error over 10 km is 0.72 cm.

Bolstad 2012, Fig 5-20

HOW IT'S DONE

Distances and directions are measured from survey stations. Traverses are series of connected lines that mark the beginning and end of a point. Coordinate geometry (COGO) is used to calculate coordinate locations. Traverses may be open (start and end are different) or closed (end at start).

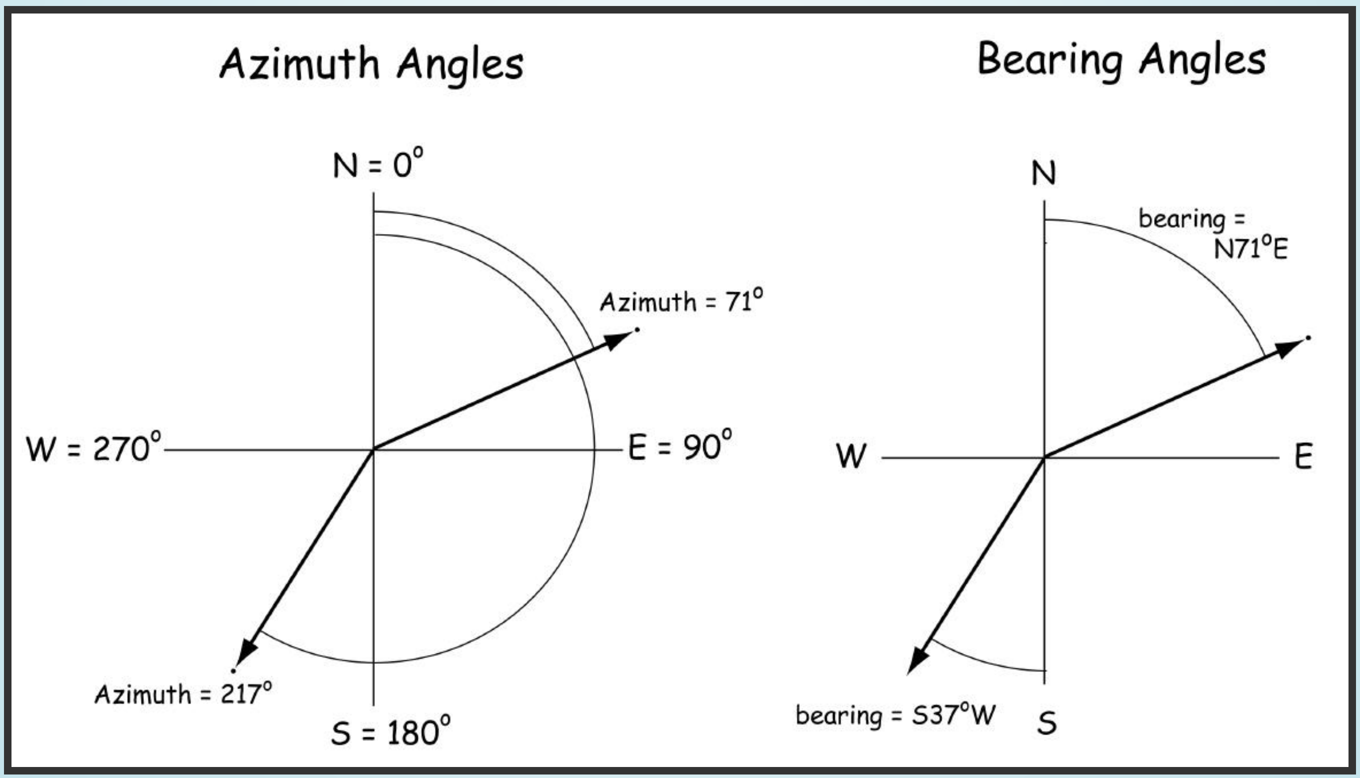
EXAMPLE COGO DESCRIPTION

"The starting point is a 1-inch rod that is approximately 102.4 feet north and 43.1 feet west of the northeast quarter of the southeast quarter section of section 16 of Township 24 North, Range 16 East, of the 2nd Principal Meridian. Starting from the said point, thence 102.7 feet on a bearing north 72.3 degrees east, to a 1-inch iron pipe; thence 429.6 feet on a bearing south, 64.3 degrees east to a 2-inch iron pipe..."

AZIMUTH AND BEARING

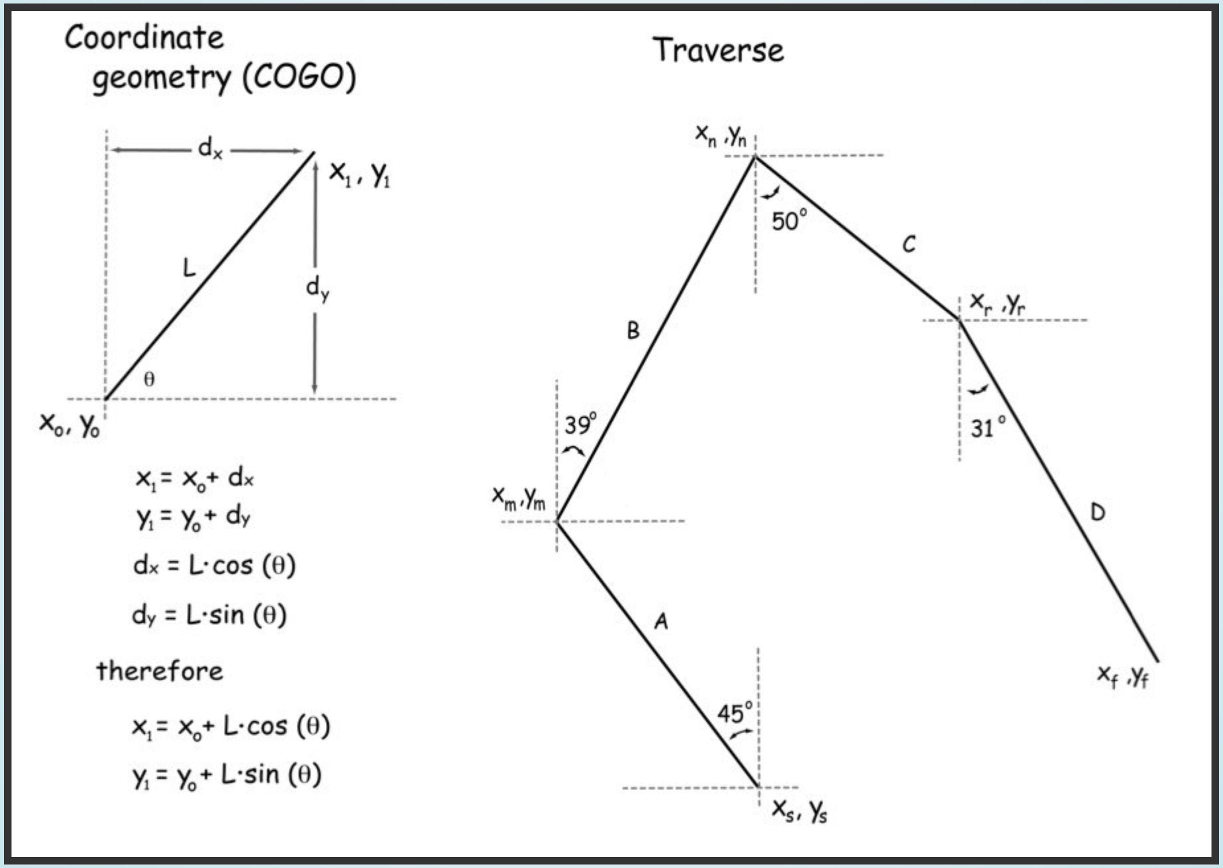
Azimuth - Measured clockwise from North.

Bearing - Measured relative to North or South with the turning direction specified.



Bolstad 2012, Fig 5-21

COORDINATE GEOMETRY (COGO)



Bolstad 2012, Fig 5-22

3D LASER SCANNERS

Bolstad 2012, Fig 5-23

TYPES OF RECEIVERS

Bolstad 2012, Fig 5-24

FIELD COLLECTION

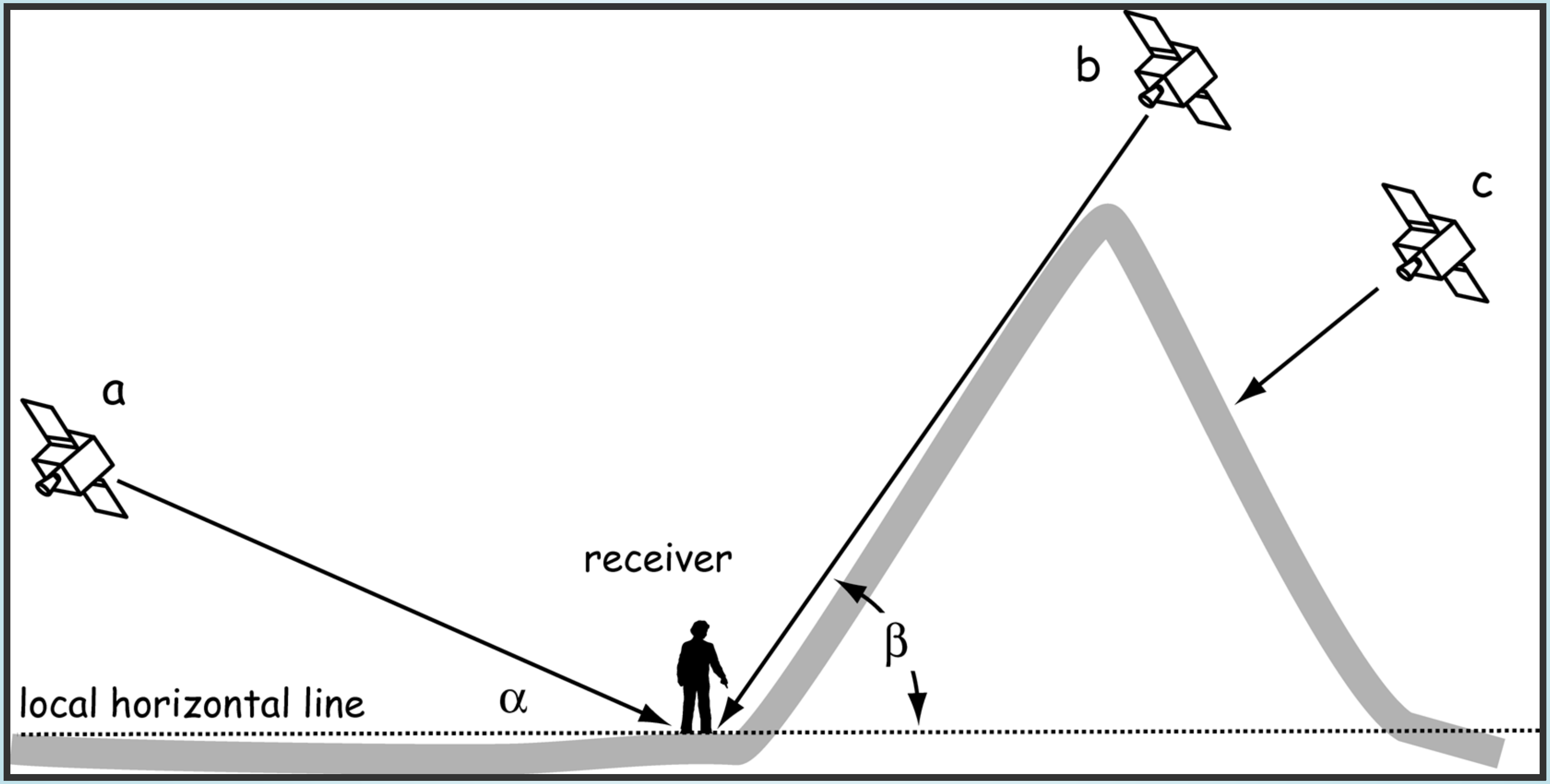
Bolstad 2012, Fig 5-25

FEATURE EDITING

Bolstad 2012, Figs 5-26 and 5-27

VISIBILITY IN THE FIELD

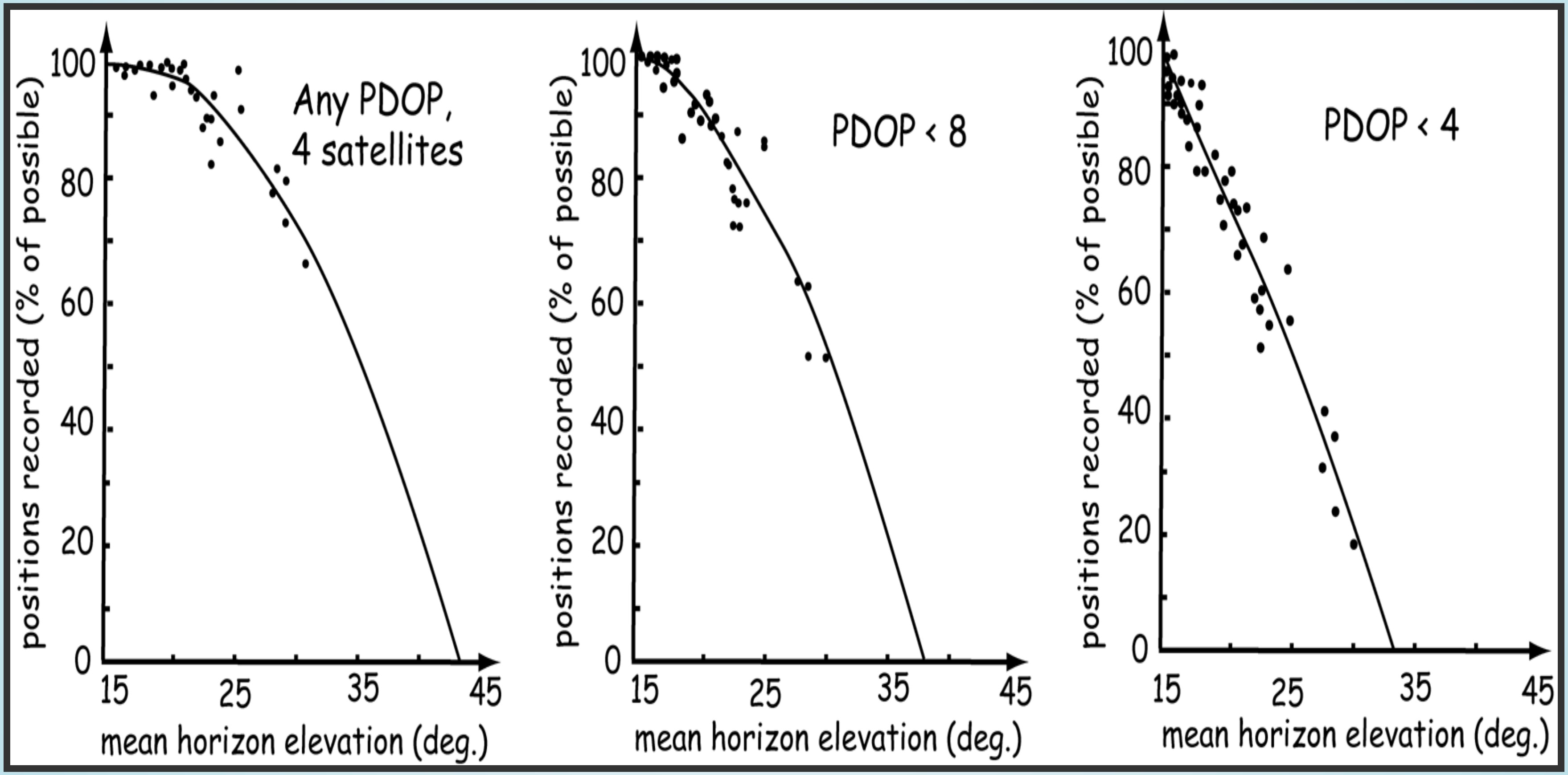
Uneven terrain obstructs sky views.



Bolstad 2012, Fig 5-28

PDOP VS. HORIZON ANGLE

The more sky you see, the better your precision.



Bolstad 2012, Fig 5-29

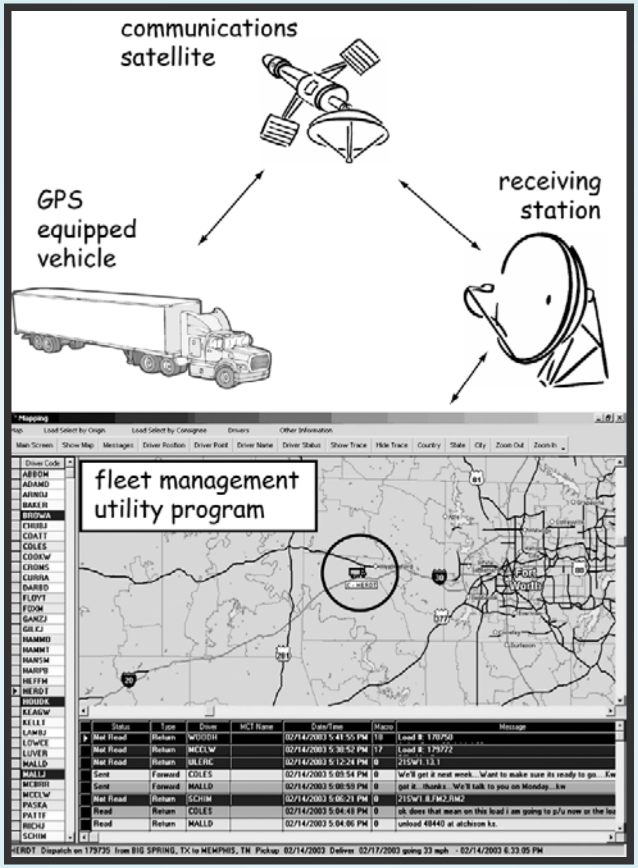
ADDITIONAL TOOLS

Rangefinder - Remotely calculates position and distance.

Range pole - A pole to mount an antenna on.

Bolstad 2012, Fig 5-30

REAL-TIME TRACKING

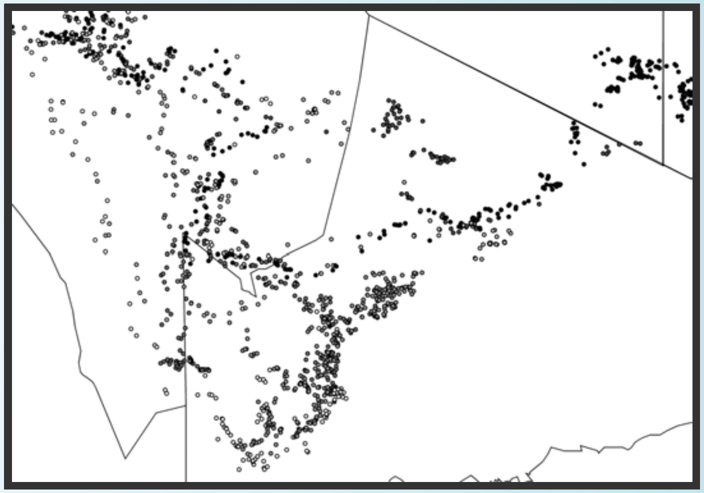


Bolstad 2012, Fig 5-31

WILDLIFE TRACKING

Radio telemetry - Transmitting and receiving radio units.

More and more, GNSS can be used for this.



Bolstad 2012, Figs 5-32, 5-33, and 5-34