The Global Positioning System
A Quick Overview

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Why is GPS such a big deal?

Sometimes it’s good to know where you are!!

Anyone who needs to keep track of their location, to find their way to a certain place, or know what direction and how fast they are going can utilize GPS.

GPS is great for:

Navigation
Recreation
Tracking
Surveying
Mapping

Countless uses of GPS: map, track, find, time

GPS is usable everywhere where it's possible to receive the signal

At Sea: used for navigation by boaters, commercial fishermen, and maritime shipping.

In the Air: used for navigation by general aviation and commercial aircraft.

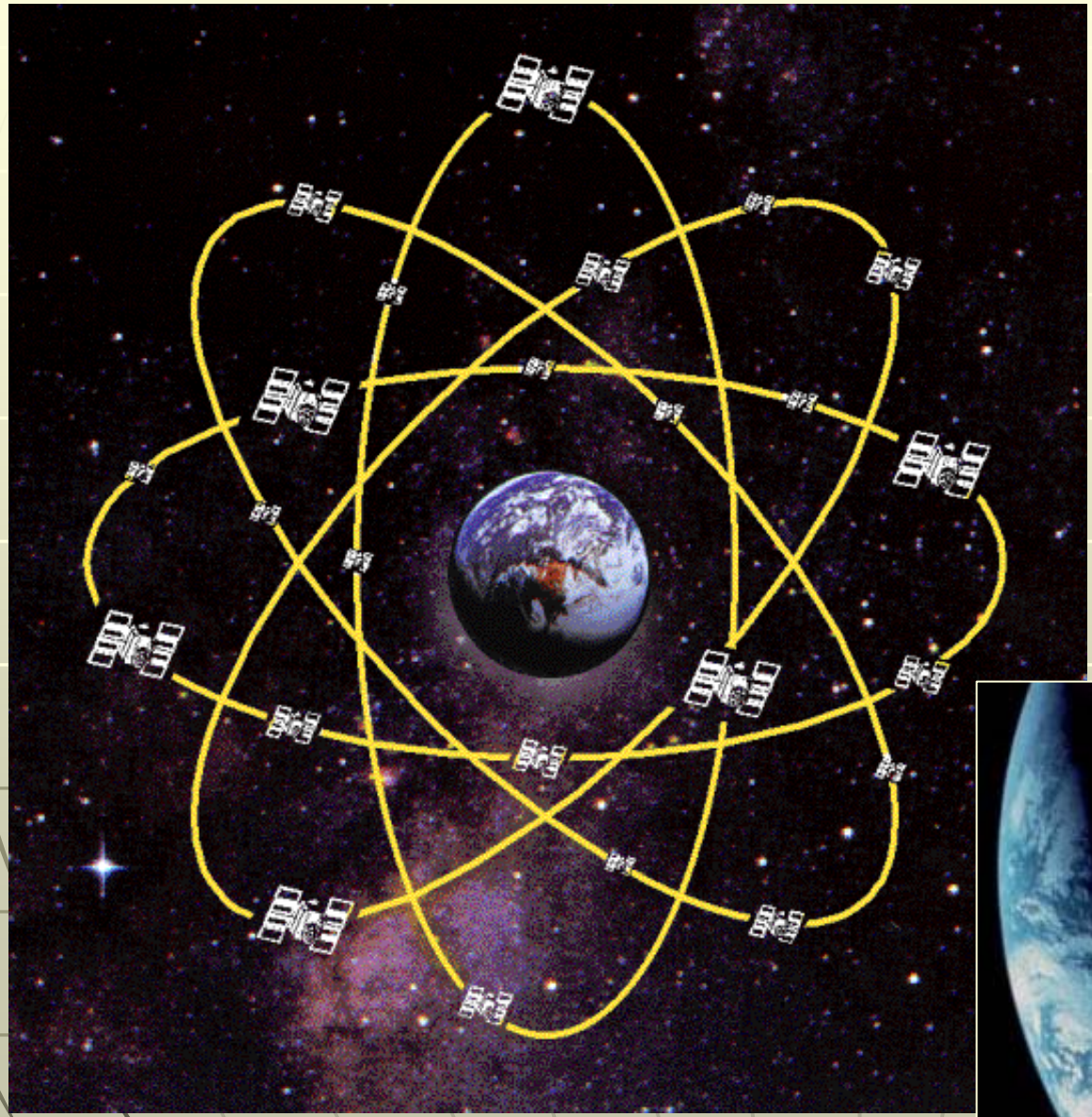
On Land:

- Recreational uses are as varied as the number of recreational sports: hikers, hunters, snowmobilers, mountain bikers, cross-country skiers,
- The scientific community uses GPS for precision timing capability and position information.
- Surveyors use GPS for its reduced survey time and incredible accuracy.
  - Mapping units cost a few thousand dollars with accuracies down to one meter.
  - Geodetic systems cost a little more but provide accuracies to within a centimeter.

GPS in vehicles:

- Systems provide emergency roadside assistance by transmitting your current position to a dispatch center.
- Navigation systems show your position on a street map and suggest the best route to a designated location.

GPS Facts



Satellite Constellation

28 Satellites
6 Planes,
55° Rotation
4/5 Satellites /Plane
12,536 mi Orbit
1 Revolution /12 Hrs

GPS Signal Structure

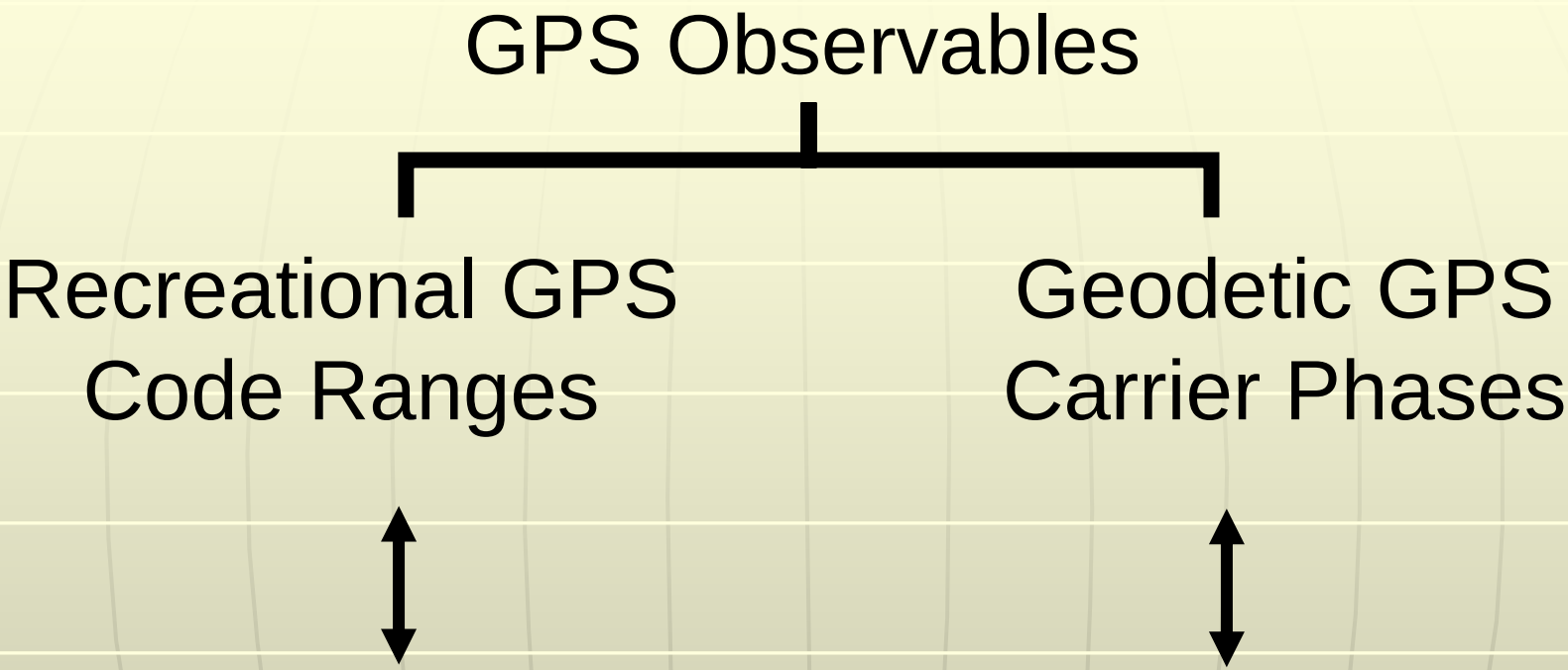
Carrier	L1	L2
Frequency	1575.42 MHz	1227.60 MHz
Wavelength	19cm	24cm
Code Modulation	C/A-code	-
	P or Y code	P or Y code
	Navigation Data	Navigation Data

C/A - Coarse Acquisition Code (available for civilians)

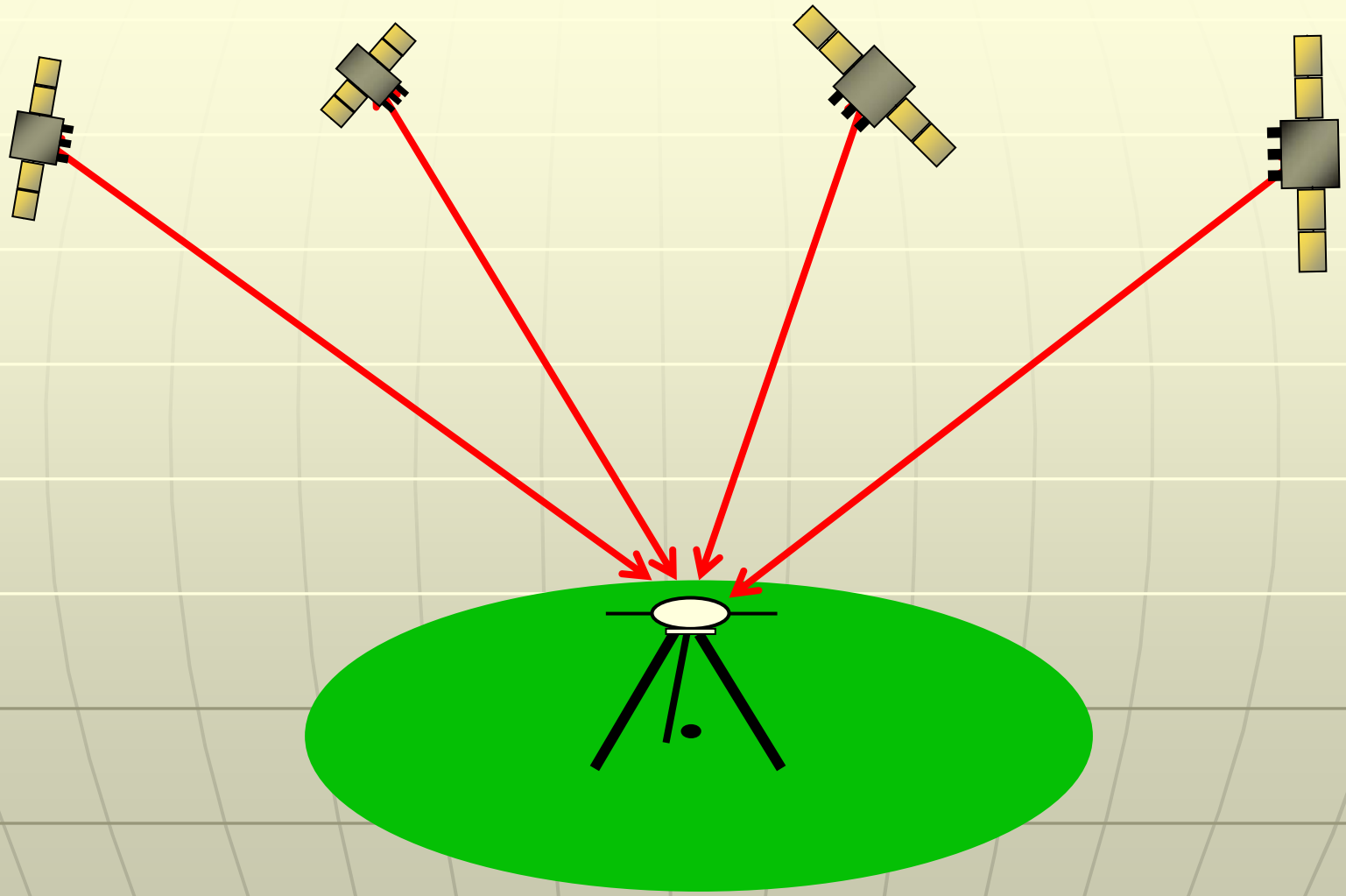
P or Y - Precise Code (military only)

Navigation Data - ephemeris parameters (satellite orbits), satellite clock corrections and satellite health

Low and High Precision GPS



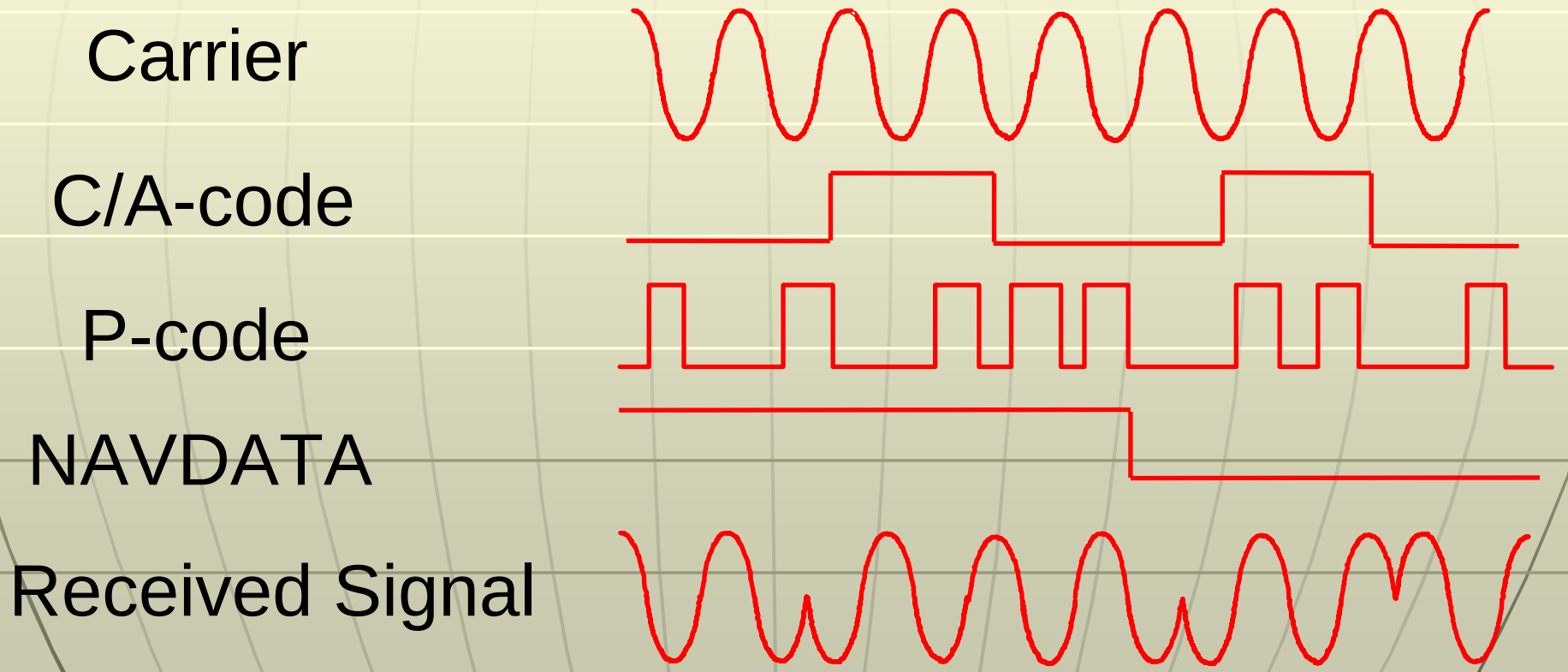
Control Points in the Sky



Distance = Speed of Light x Time

The GPS Signal

Based on the phase of the electromagnetic signal carrying the timing codes and NAVDATA

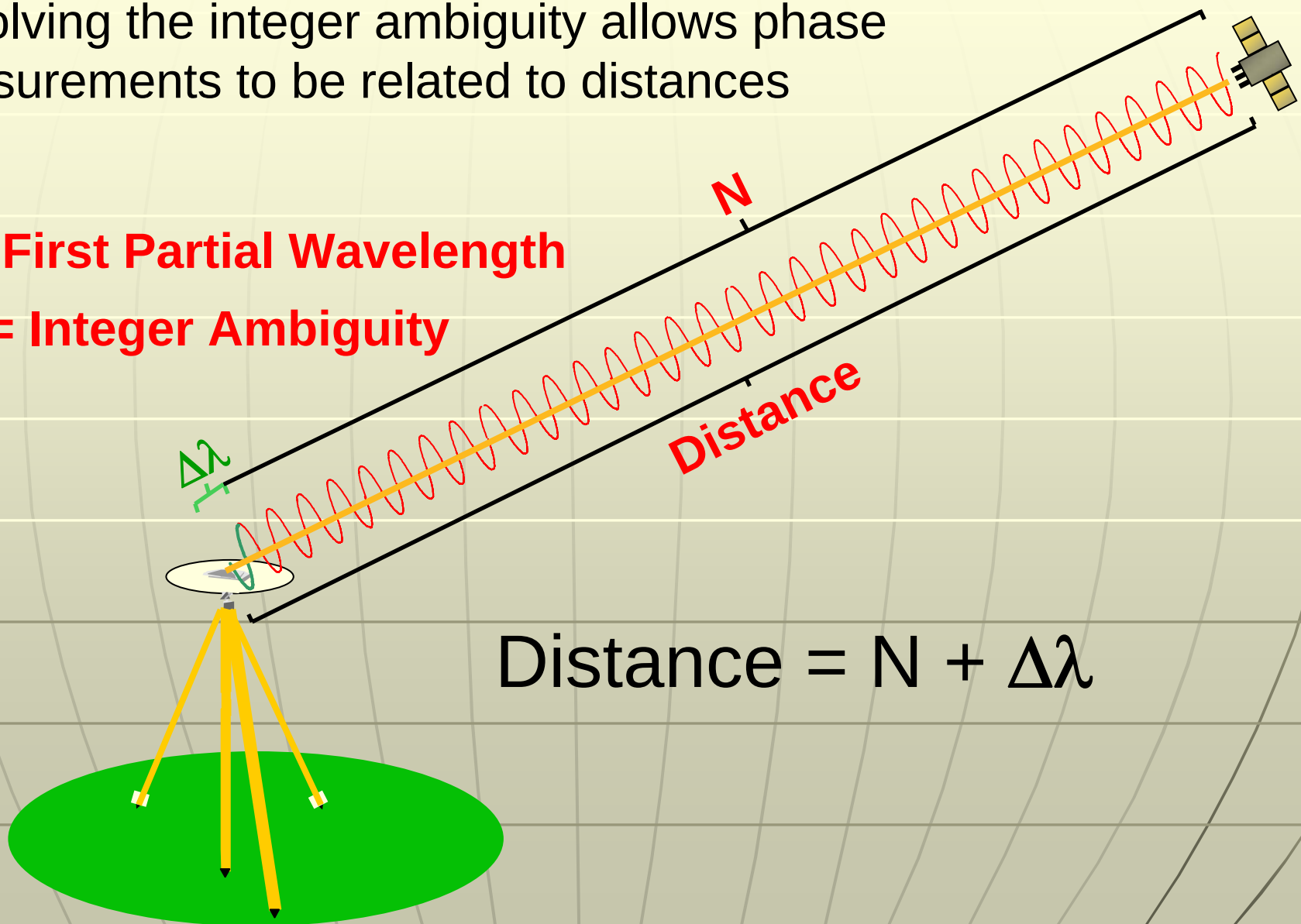


Counting Wavelengths
(aka - Integer Ambiguity)

Resolving the integer ambiguity allows phase measurements to be related to distances

$\Delta\lambda$ = First Partial Wavelength

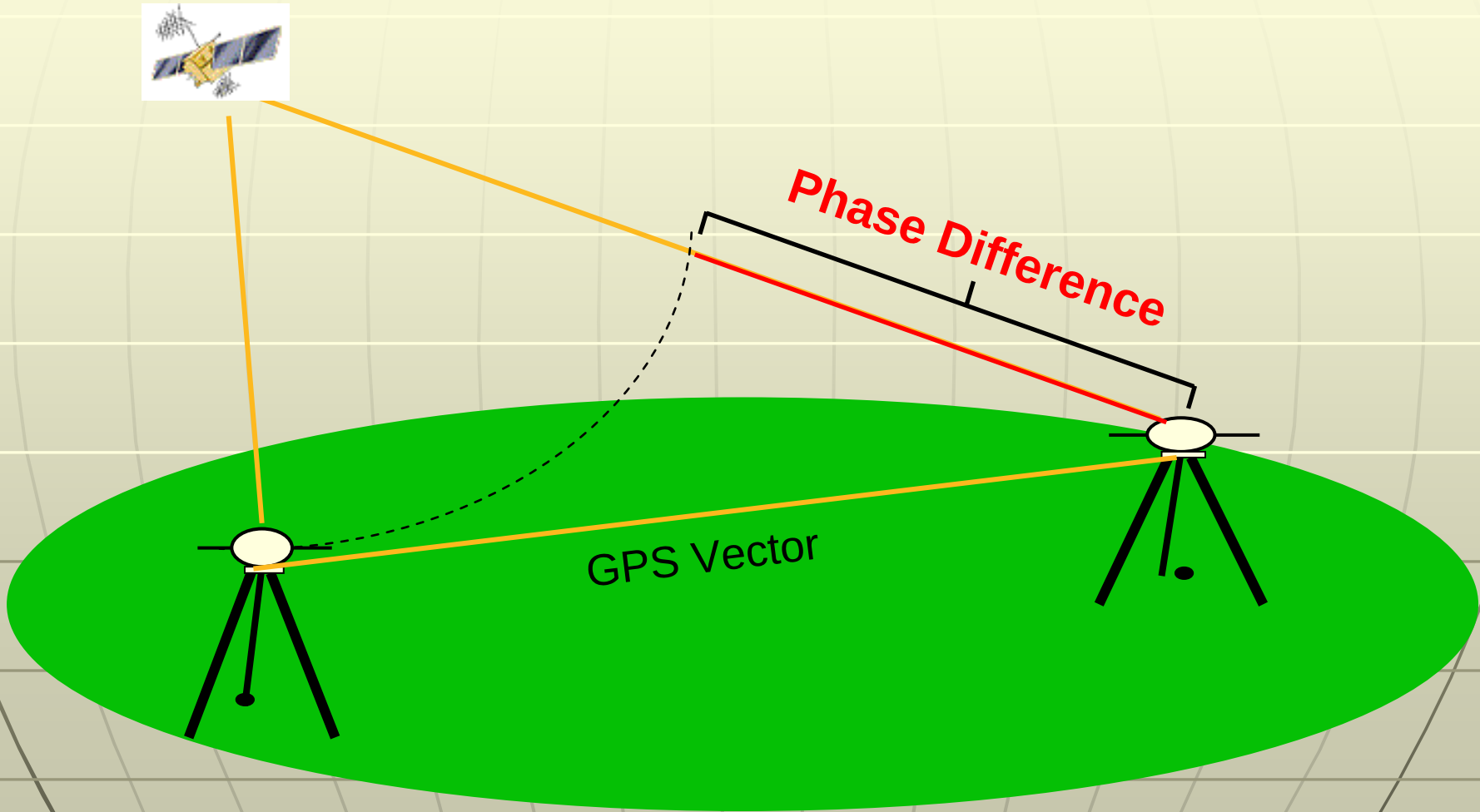
N = Integer Ambiguity



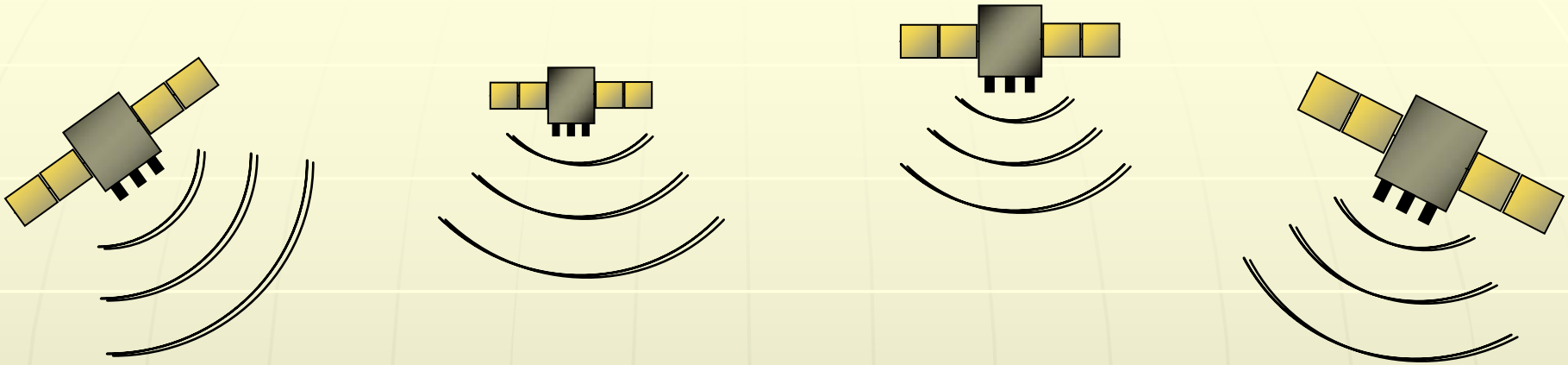
$$\text{Distance} = N + \Delta\lambda$$

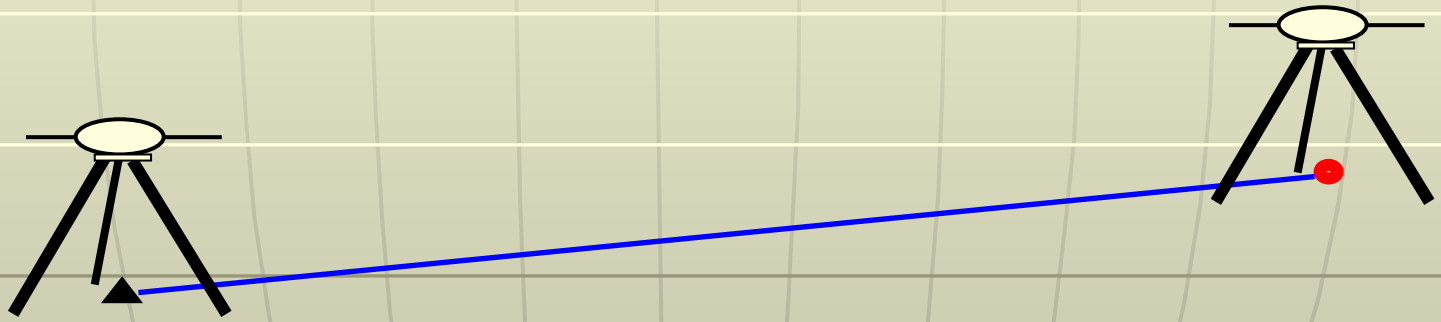
Carrier Phase Differencing

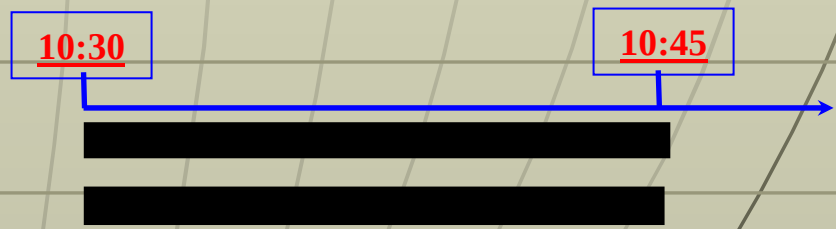
$$\textbf{Distance} = \frac{\textbf{Phase Difference}}{2\pi}\lambda = \left(\Delta\lambda_1 - \Delta\lambda_2\right) + \lambda_1\left(N_1 - N_2\right)$$



Static Surveying

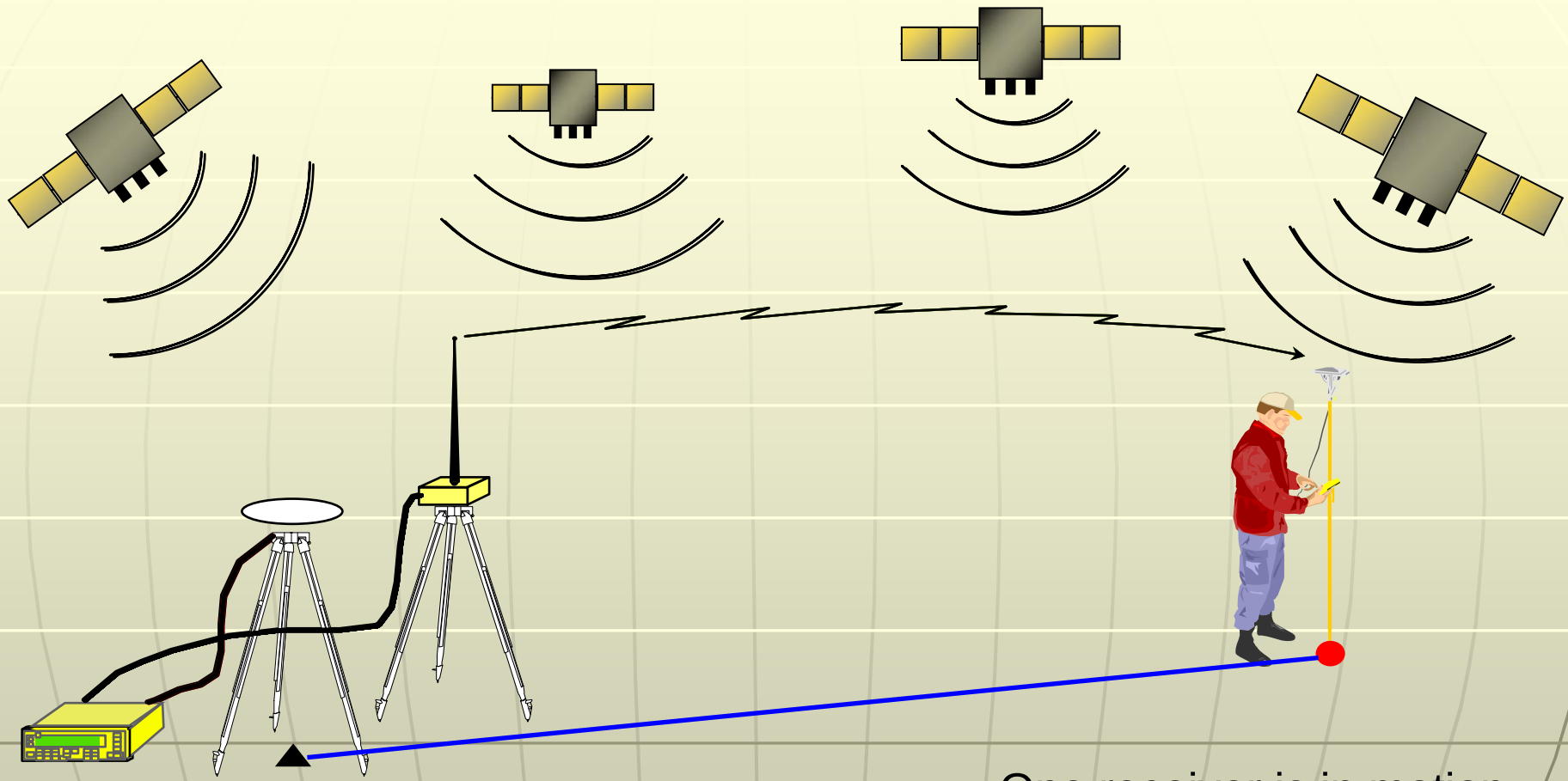






Both receivers are held immobile on points until there is sufficient data to determine coordinates

Real Time Kinematic (RTK) Surveying



One receiver is on a known location while measurements are made

One receiver is in motion while measurements are made

GPS Error Sources

Atmospheric Conditions

The ionosphere and troposphere both refract the GPS signal. This causes the speed of the GPS signal in the ionosphere and troposphere to be different from the speed of the GPS signal in space.

Ephemeris Errors/Clock Drift/Measurement Noise

GPS signals contain information about satellite orbital positions and the rate of clock drift for the broadcasting satellite. The broadcast data may not exactly model the true satellite motion or the exact rate of clock drift. Distortion of the signal by measurement noise can further increase positional error.

Selective Availability

Selective Availability (SA) is the intentional alteration of the time and ephemeris signal by the Department of Defense. Fortunately, positional errors caused by SA can be removed by differential correction and SA has been turned off since May 1, 2000.

Multipath

Multipath is caused by the GPS signal bouncing off a reflective surface before it reaches the GPS antenna. Multipath is difficult to correct even in high precision GPS units and is a serious concern to the GPS user.

GPS Error Budget

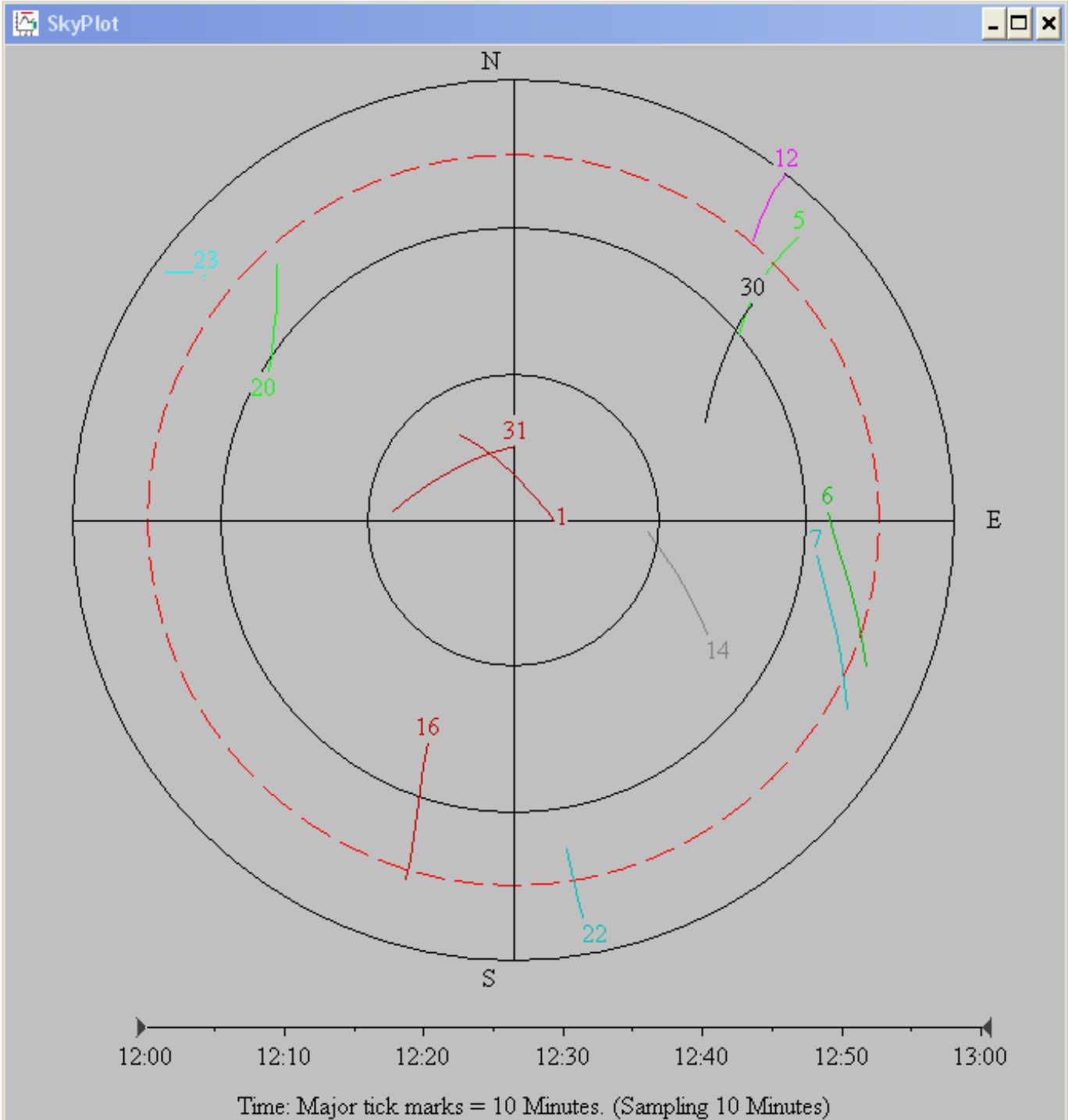
Source	Uncorrected Error Level
Ionosphere	0-30 meters
Troposphere	0-30 meters
Measurement Noise	0-10 meters
Ephemeris Data	1-5 meters
Clock Drift	0-1.5 meters
Multipath	0-1 meter
Selective Availability	0-70 meters

Tree Canopy – The New Hampshire Wild Card

Expected Accuracies

Source	Accuracy Level
Autonomous Positioning	5-10 meters
WAAS Corrected	2-5 meters
Beacon Diff. Corr.	1-3 meters
Local Diff. Correction	0.5-1.5 meters
Geodetic	
Static or Kinematic	1-5 centimeters

& we still have those trees



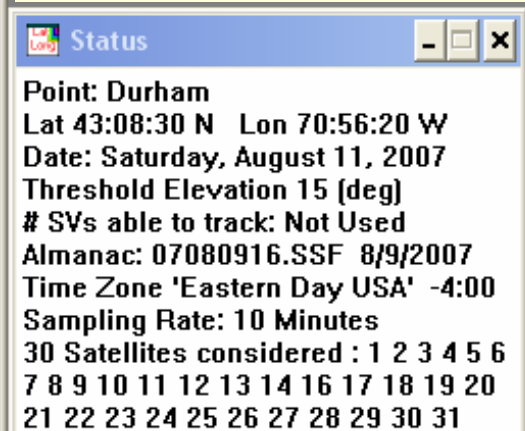
SV locations

Noon to 1 pm
August 11, 2007

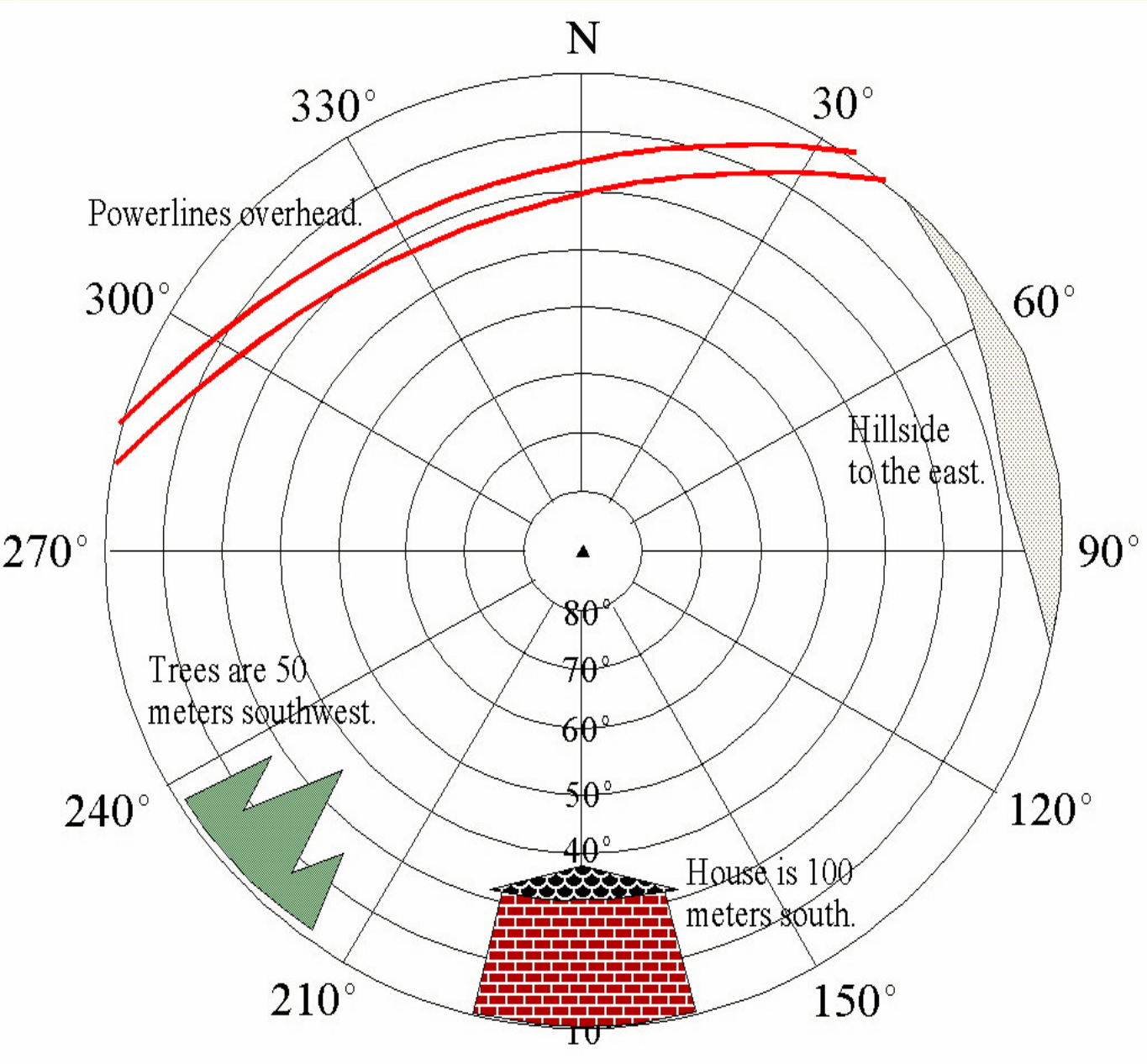
SV path is along arc toward SV #

8 SVs generally available at this time **If** we have a clear view of the sky

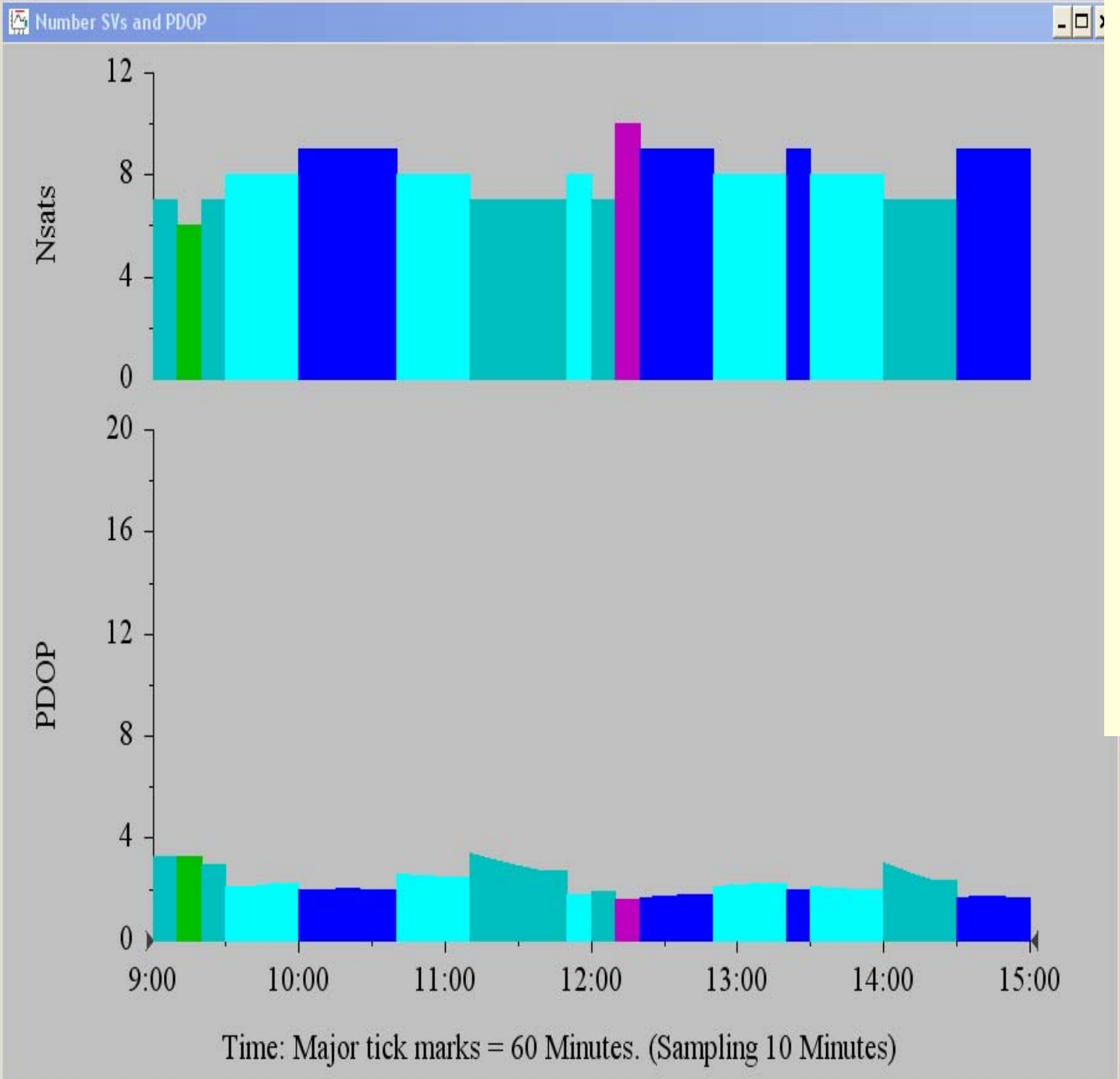
SVs 1, 6, 7, 14, 16, 20, 30, 31



GPS Obstruction Diagram

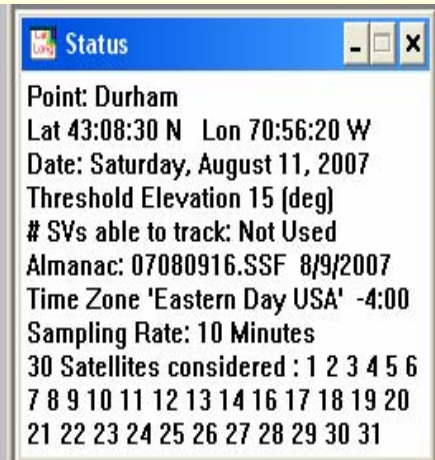


Be aware of obstructions when planning a project and collecting GPS data



Number of available SVs

Common sense would indicate that GPS data collection would be optimum when the most satellites are available.
Sometimes



Settings to Check on YOUR GPS

Read the Manual!!!

We don't give any extra points for being too cool to ***Read the Manual***.

Position Format:

- Hddd.ddddd^{o} latitude / longitude in decimal degrees
- Hddd^{o}mm.mmm' latitude / longitude in degrees, decimal minutes
- Hddd^{o}mm'ss.s" latitude / longitude in degrees, minutes, decimal seconds
- US National Grid
- UTM – Universal Transverse Mercator – West of longitude 72^{o} in Zone 18, East of longitude 72^{o} in Zone 19
- State Plane Coordinates – New Hampshire, Transverse Mercator, Zone 2800

Settings to Check on YOUR GPS

Map Datum

- NAD 83 – preferred
- WGS84 – very close to NAD83 but not exactly the same +/- 1 meter

Coordinate Units

- US Survey Feet (by statute, NOT the International Foot)

Distance/Speed

- Your choice, I use US Feet when walking, Miles when driving

Elevation

- Same as Coordinate Units

Read the Manual!!! We still don’t give any extra points for NOT reading the Manual.


DANGER
POWER LINE
SOMEWHERE
AROUND HERE