GPS Fundamentals

Your location is:
37° 23.323' N
122° 02.162' W

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Global Positioning System

Your location is:
37° 23.323' N
122° 02.162' W

T
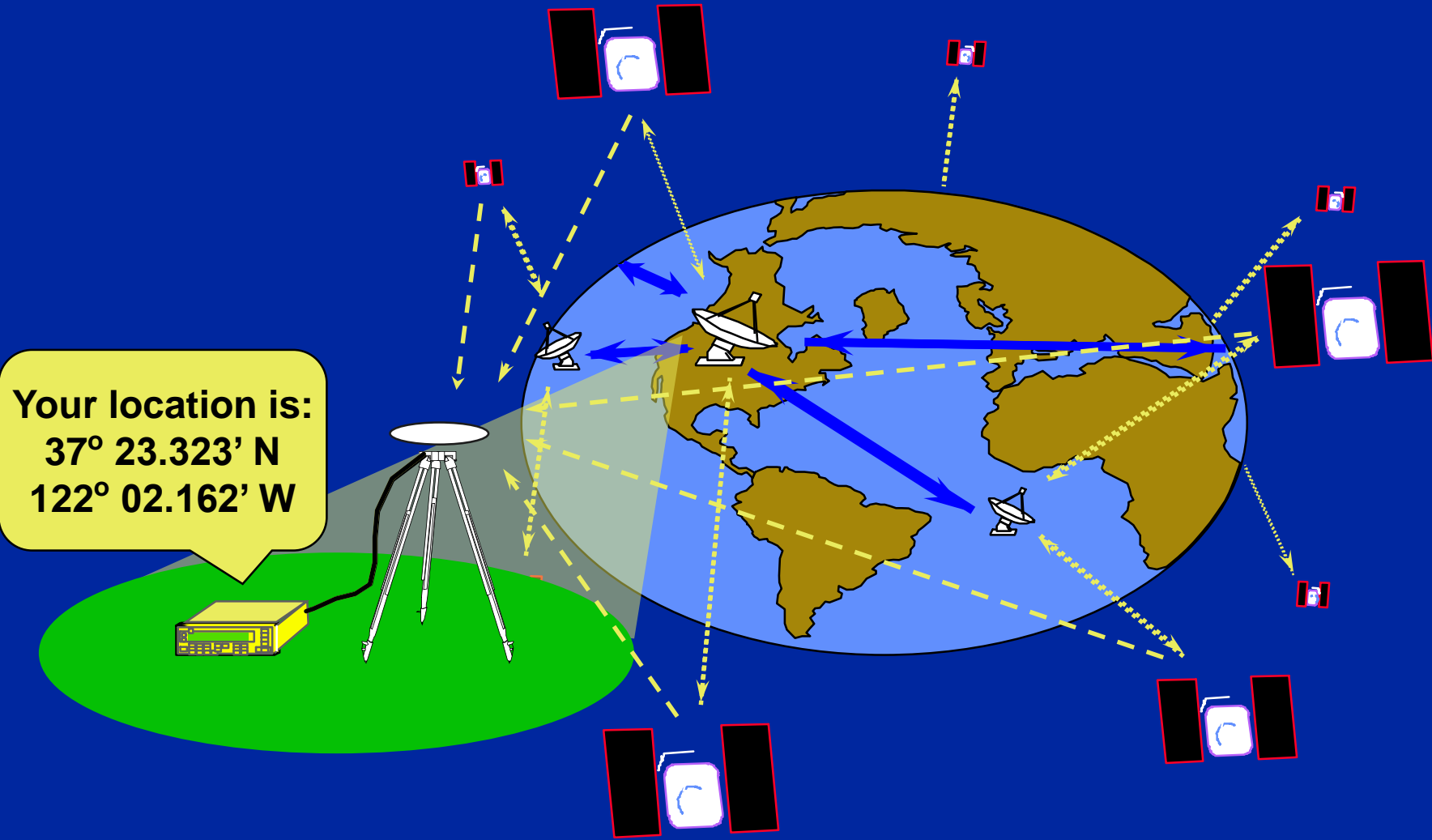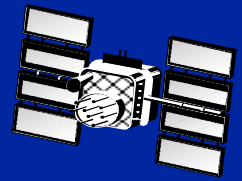
Satellite Signal Structure
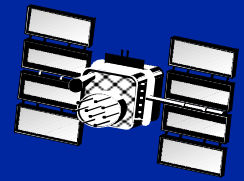
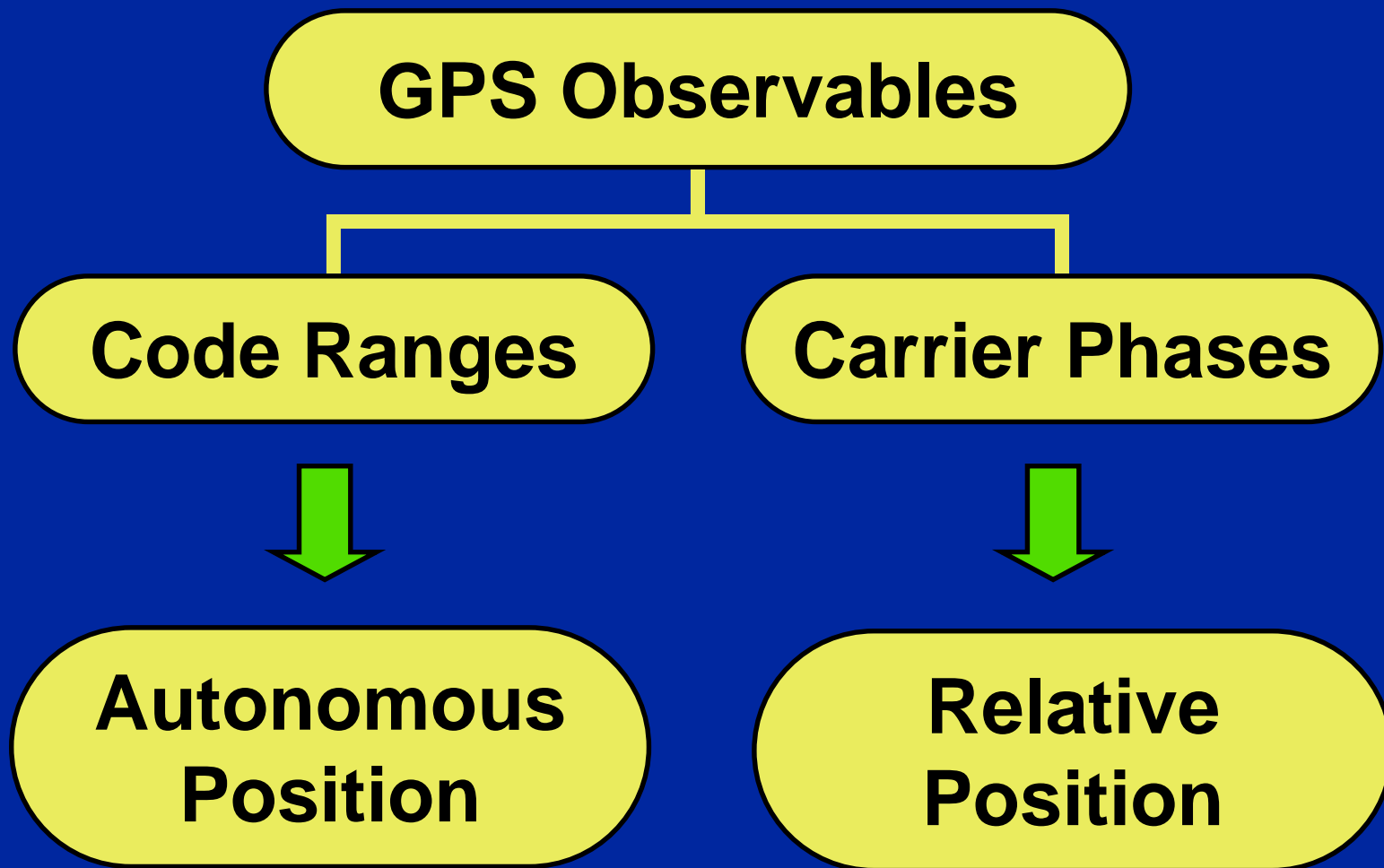| Carrier	L1	L2
Frequency	1575.42 MHz	1227.60 MHz
Wavelength	19cm	24cm
Code Modulation	C/A-code	-
	P(Y)-code	P(Y)-code
	NAVDATA	NAVDATA

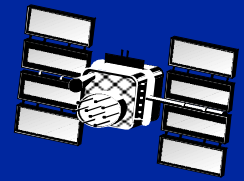C/A - *Coarse Acquisition Code*

P - *Precise Code (Y-Code when encrypted)*

NAVDATA - *Satellite health, satellite clock corrections, and ephemeris parameters.*
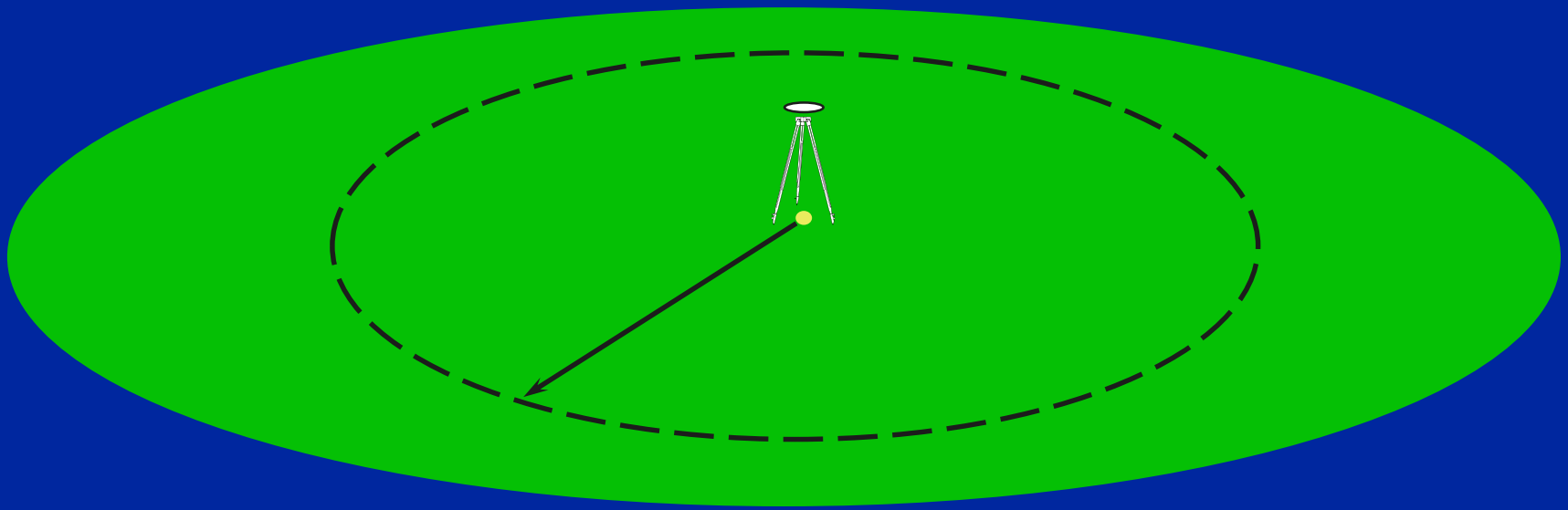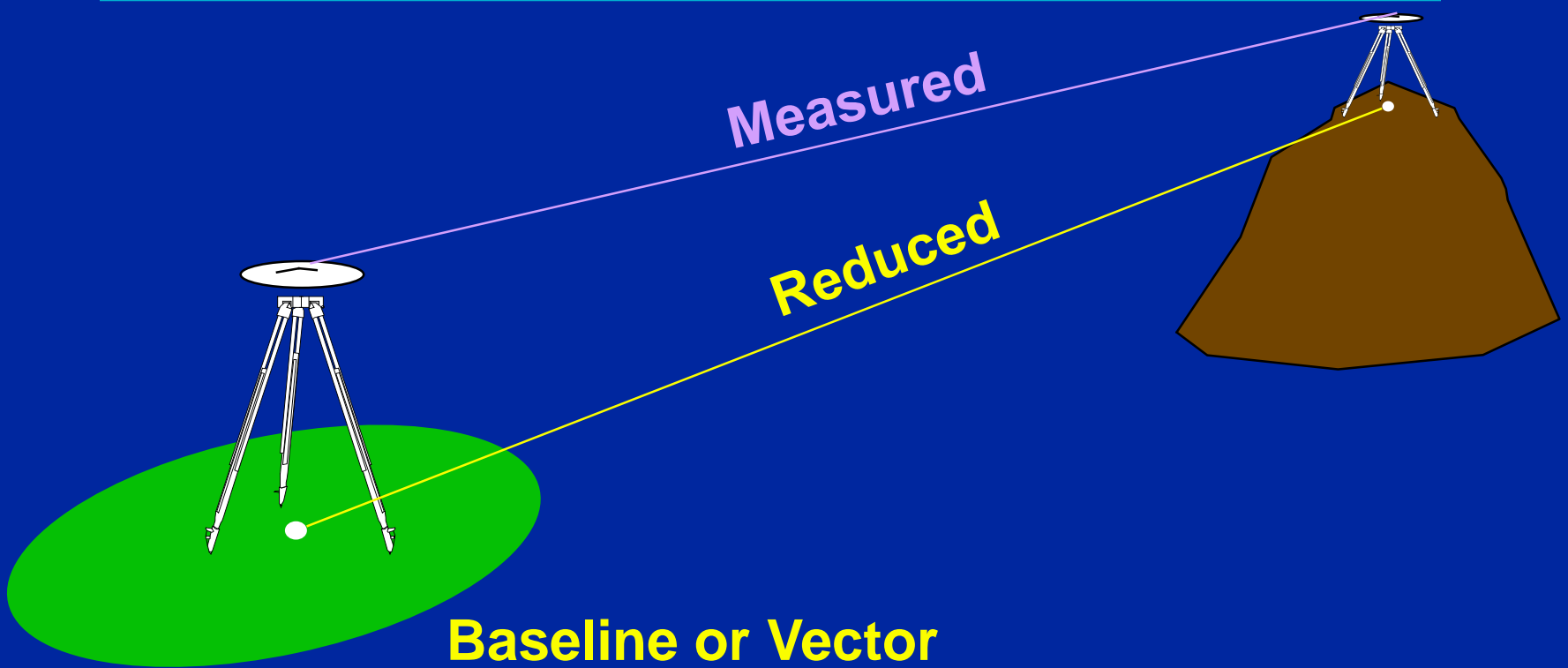
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What is Measured?

GPS Observables

Code Ranges

Carrier Phases

Autonomous Position

Relative Position
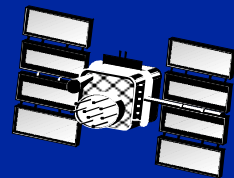
Code Range Results

Autonomous Position

+/- 100 m (330 ft) error (horizontal)

+/- 156 m (515 ft) error (vertical)

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Carrier Phase Results

Measured

Reduced

Baseline or Vector

(cm precision)

Azi = 212° 42' 49.8244"

Dist = 557.05307 m

ΔEll Ht = 4 .8751 m

OR

Δ X = -408.251 m

Δ Y = -84.830 m

Δ Z = -369.413 m

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ECEF Coordinate System

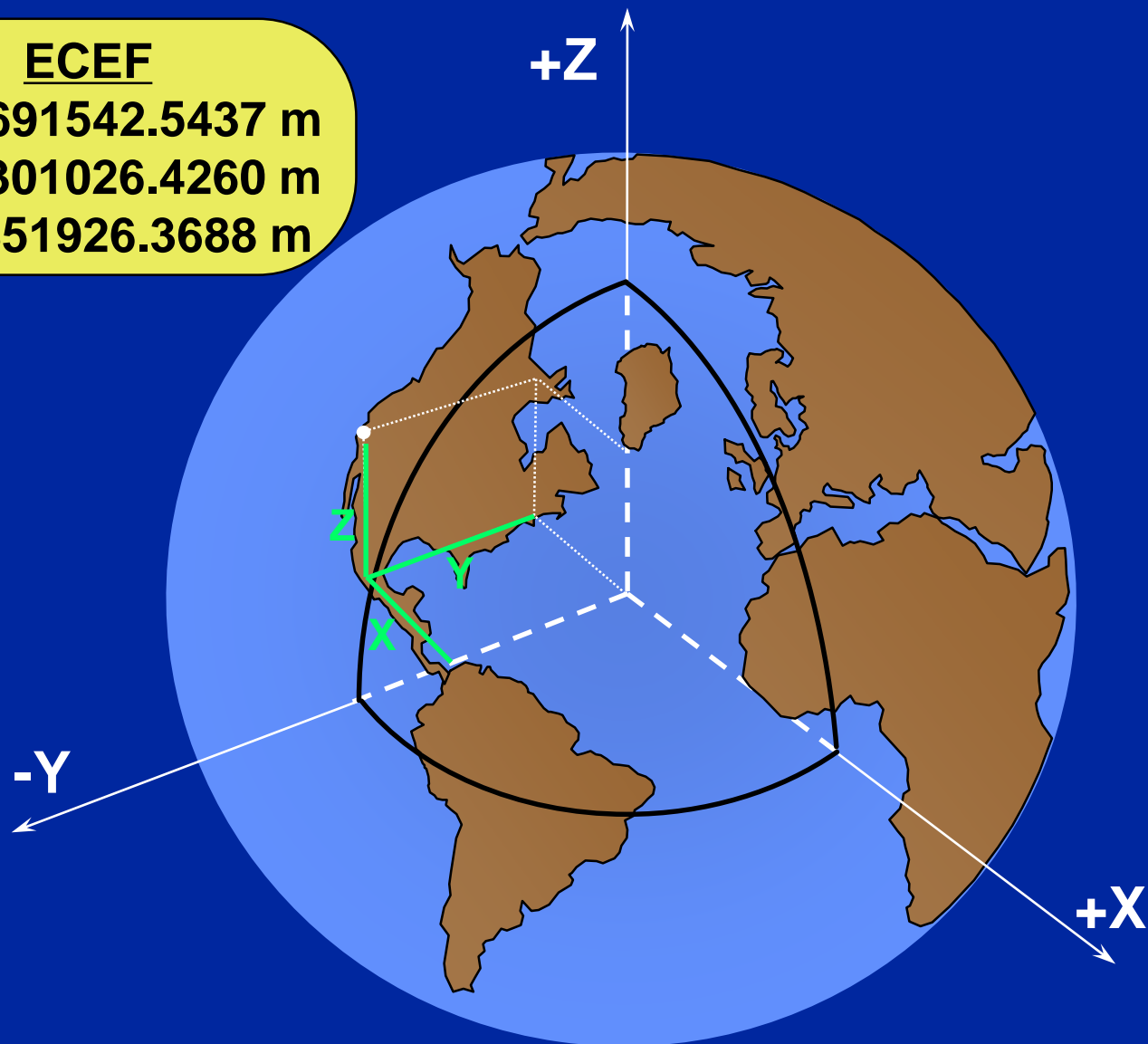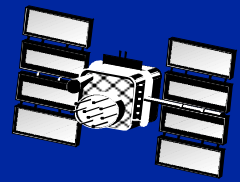**ECEF**
X = -2691542.5437 m
Y = -4301026.4260 m
Z = 3851926.3688 m

+Z

+X
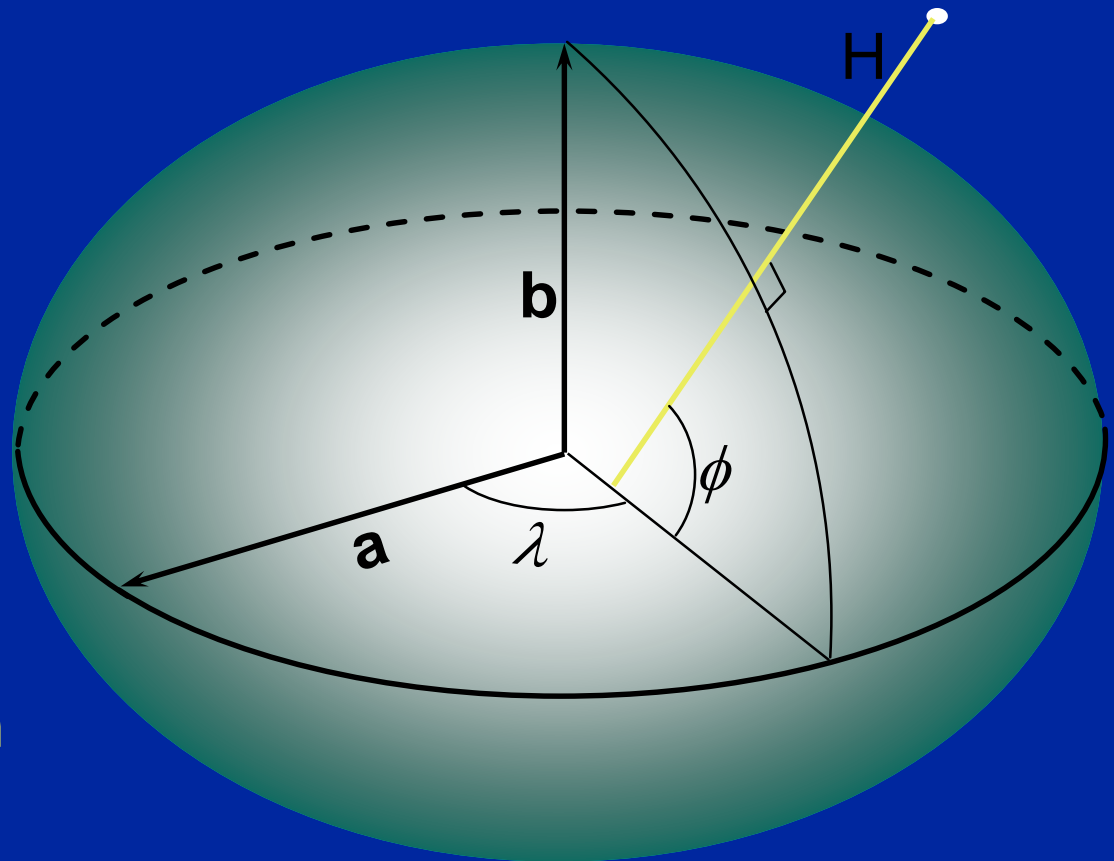
-Y

T
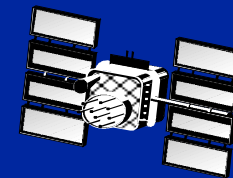
Reference Ellipsoid

a = semi-major axis

b = semi-minor axis

Flattening $f = \dfrac{(a-b)}{a}$

$\phi \equiv$ latitude

$\lambda \equiv$ longitude
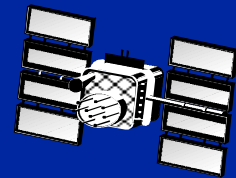
$H \equiv$ ellipsoidal height

WGS-84 Ellipsoid

a = 6378137.000000 m

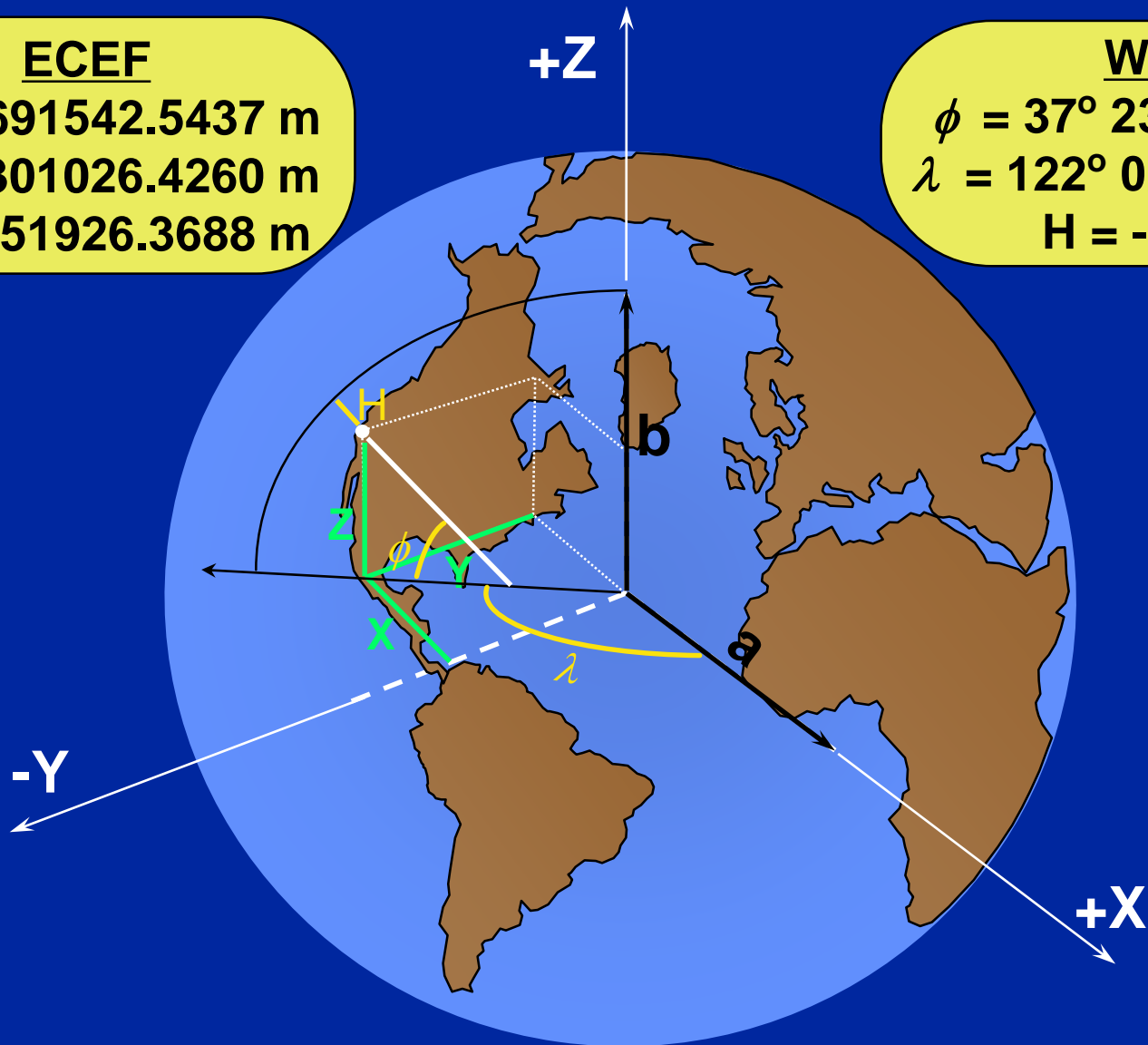b = 6356752.314245 m

1/f = 298.2572235630

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ECEF and WGS-84
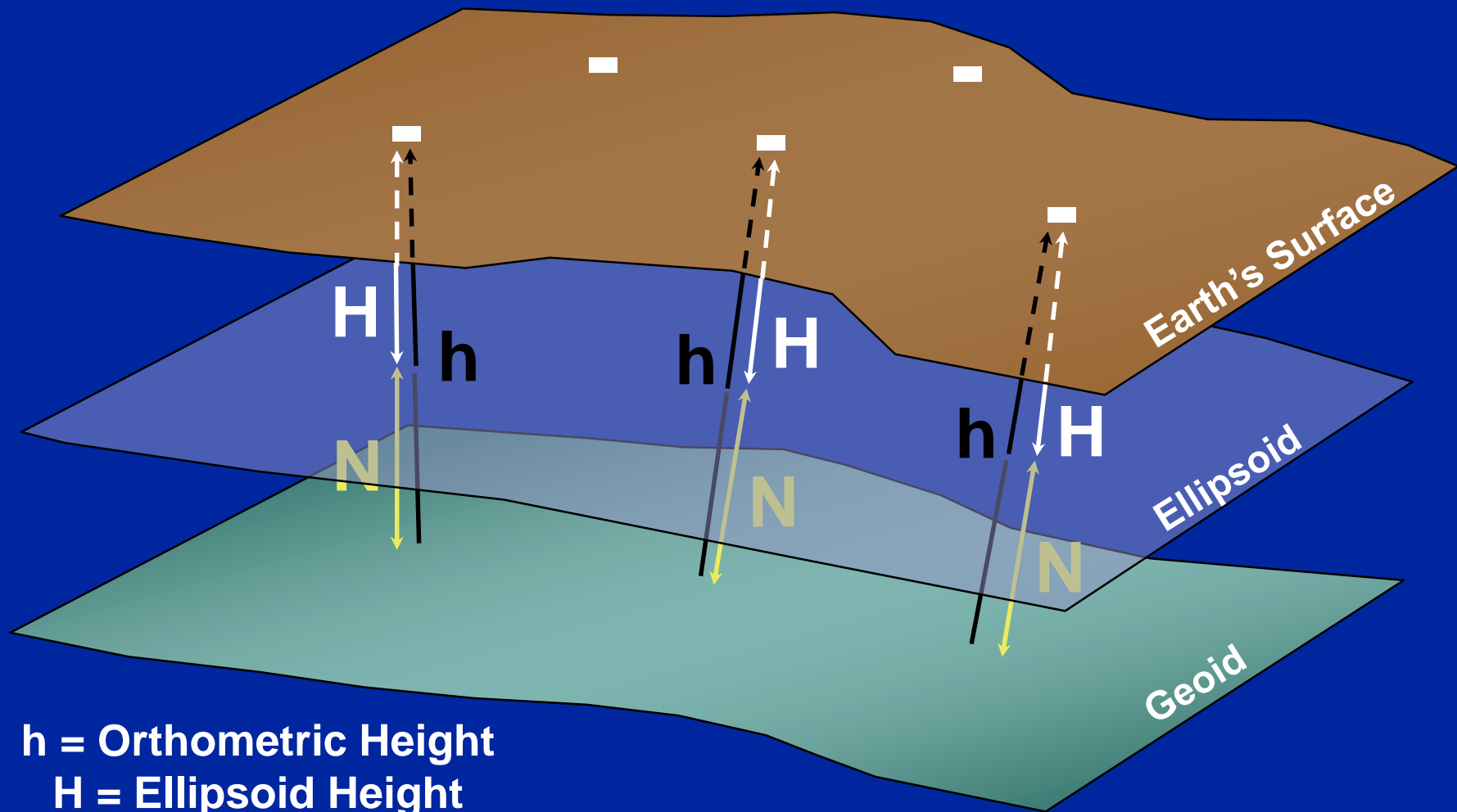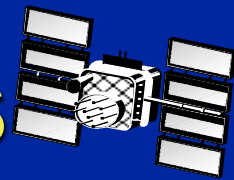
ECEF
X = -2691542.5437 m
Y = -4301026.4260 m
Z = 3851926.3688 m

WGS-84
ϕ = 37° 23' 26.38035" N
λ = 122° 02' 16.62574" W
H = -5.4083 m

+Z

+X

-Y

H

Z

Y

X

ϕ

λ

a

b

T

GPS Heights vs. Elevations

Earth's Surface

Ellipsoid
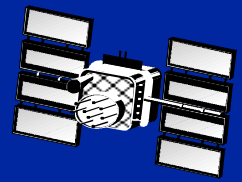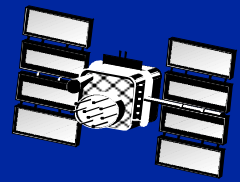
Geoid

h = Orthometric Height
H = Ellipsoid Height
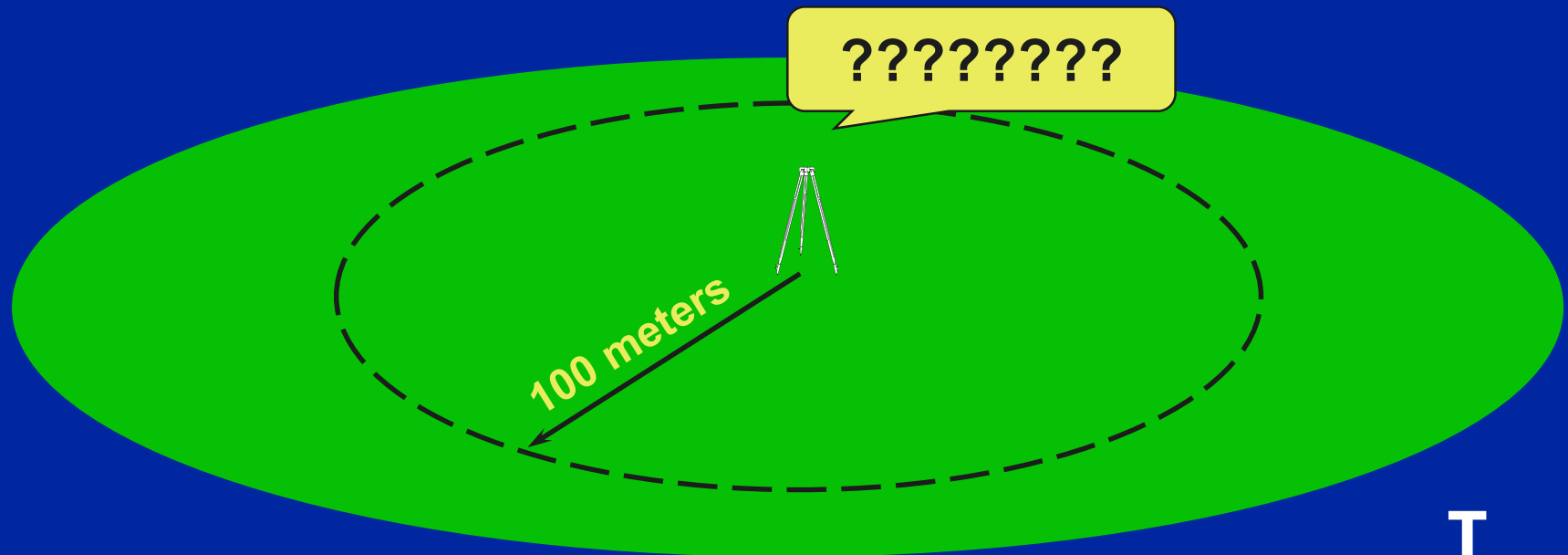N = Geoid Height

$$h = H - N$$

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Errors Sources in GPS

- **Selective Availability (SA) and Anti-Spoofing (AS)**
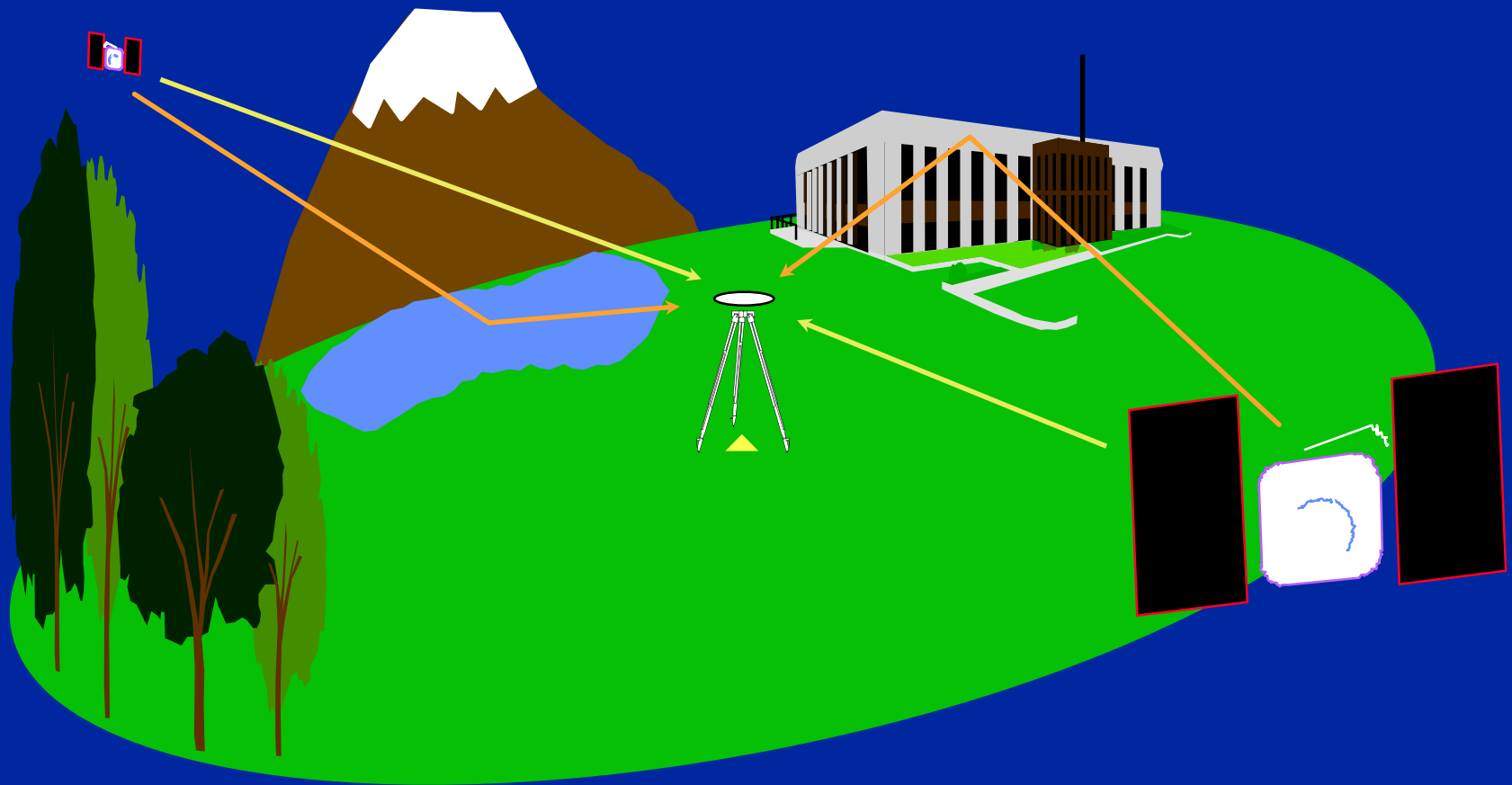
- **Multipath**

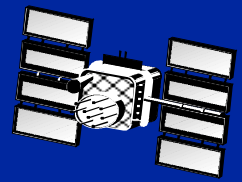- **Ionospheric Noise**

- **Human Error**

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SA and AS

- **Selective Availability (SA)**
  - **Clock dither**
  - **Ephemeris error**
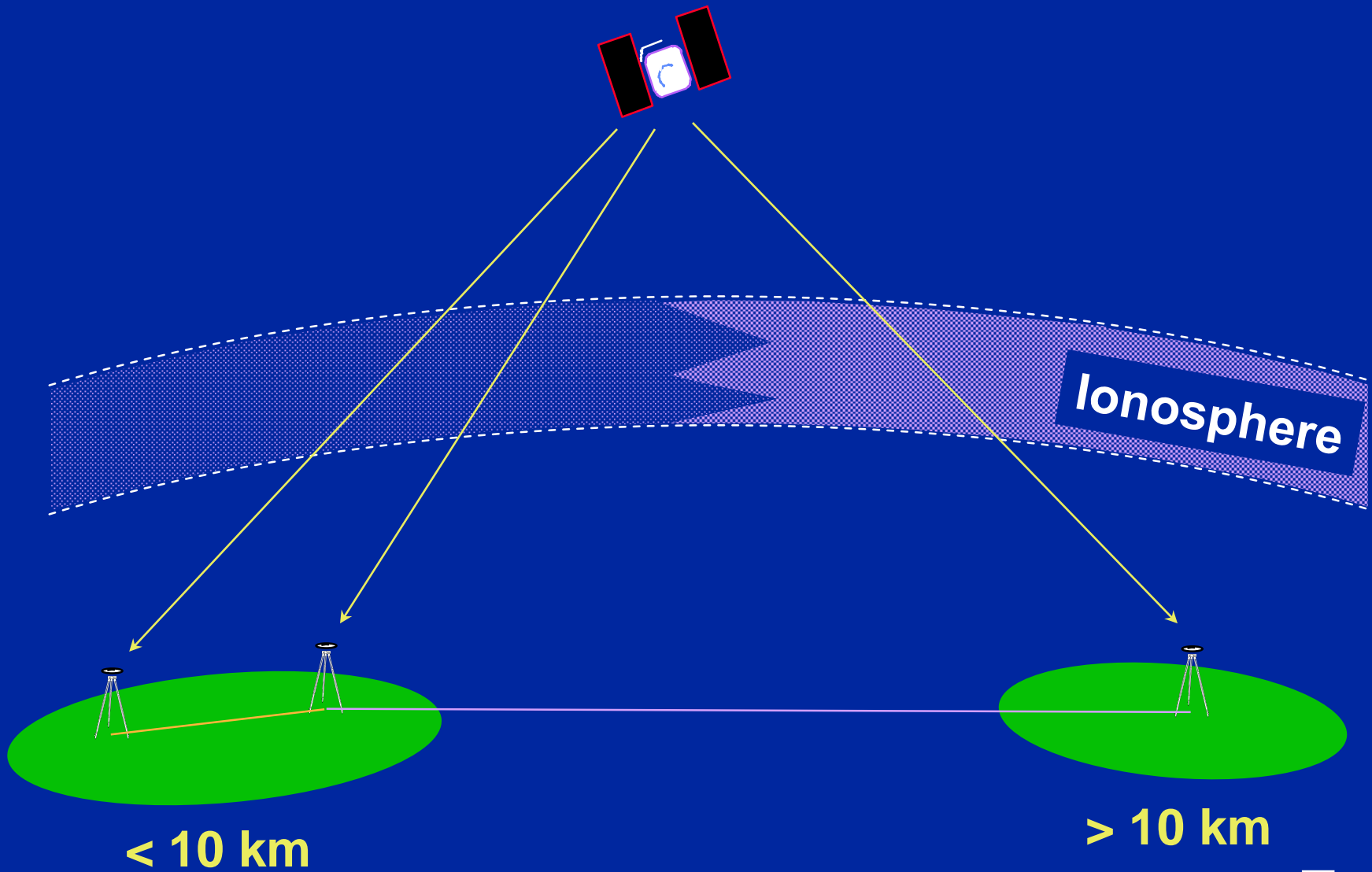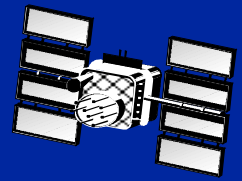- **Anti-Spoofing (AS)**
  - **Encryption of the P-code signal**
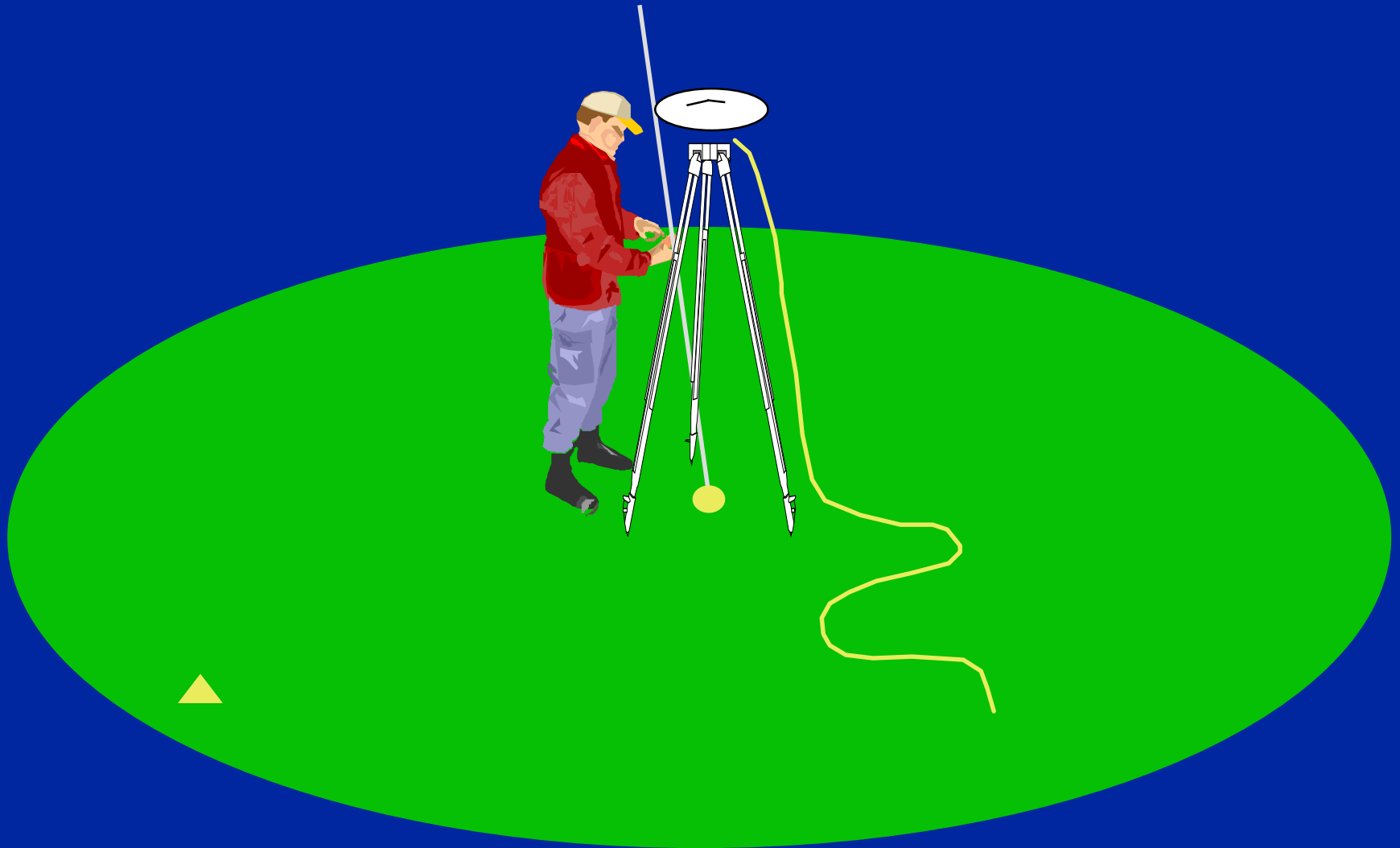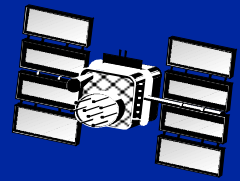
????????

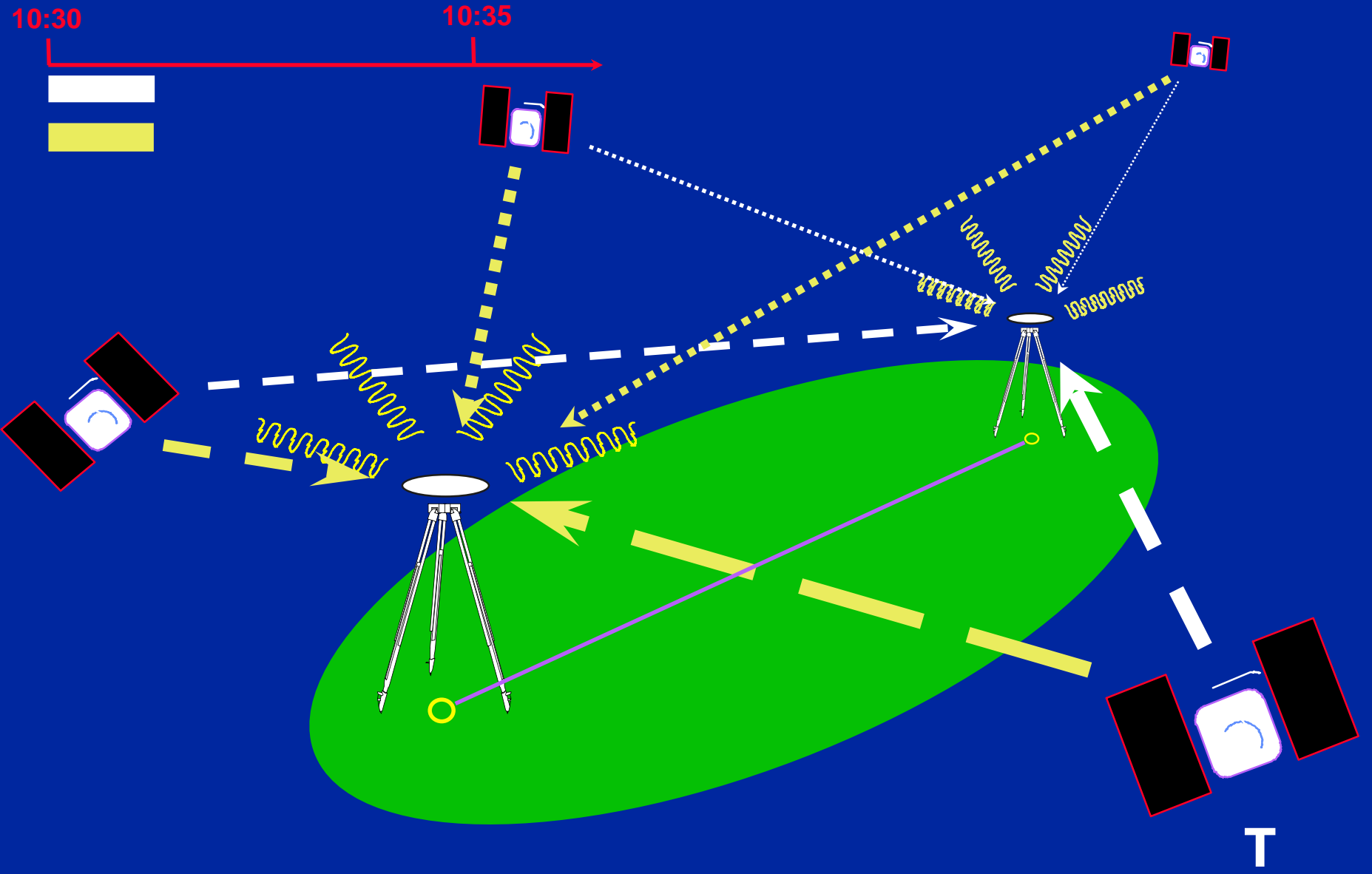100 meters

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Multipath

Ionospheric Effects

Ionosphere

< 10 km

> 10 km
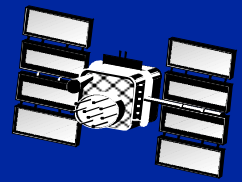
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Human Error

Survey Requirements
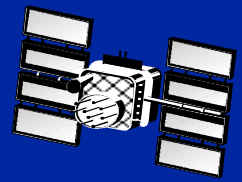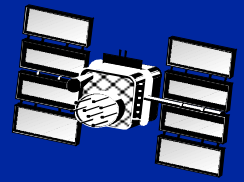
10:30   10:35
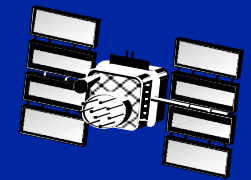
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Summary

- **There are three segments to GPS. All must be working to use GPS.**

- **There are 2 GPS signals, L1 and L2.**

- **Code Range measurements result in autonomous positions with several meter precision.**

- **Carrier Phase measurements result in relative positions with centimeter precision.**

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Summary (cont.)

- **GPS results are in reference to an ECEF coordinate system and the WGS-84 ellipsoid.**

- **Errors in GPS can be minimized by planning and utilizing proper surveying techniques.**

- **At least 4 SVs are required to determine a position or survey with GPS.**

- **At least 2 receivers are required to survey with GPS.**

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Questions?

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