

A topographic map showing contour lines and a coastline on the left. A thick blue arrow points horizontally from the coast towards the right. A small circle with a crosshair is at the start of the arrow, and a yellow arrow points from this circle down and to the left. The background is a solid blue color with white contour lines.

# Global Positioning System (GPS) / Wide Area Augmentation System (WAAS)

Min Kim: OSM MCR, Alton, IL



# GPS Resources:

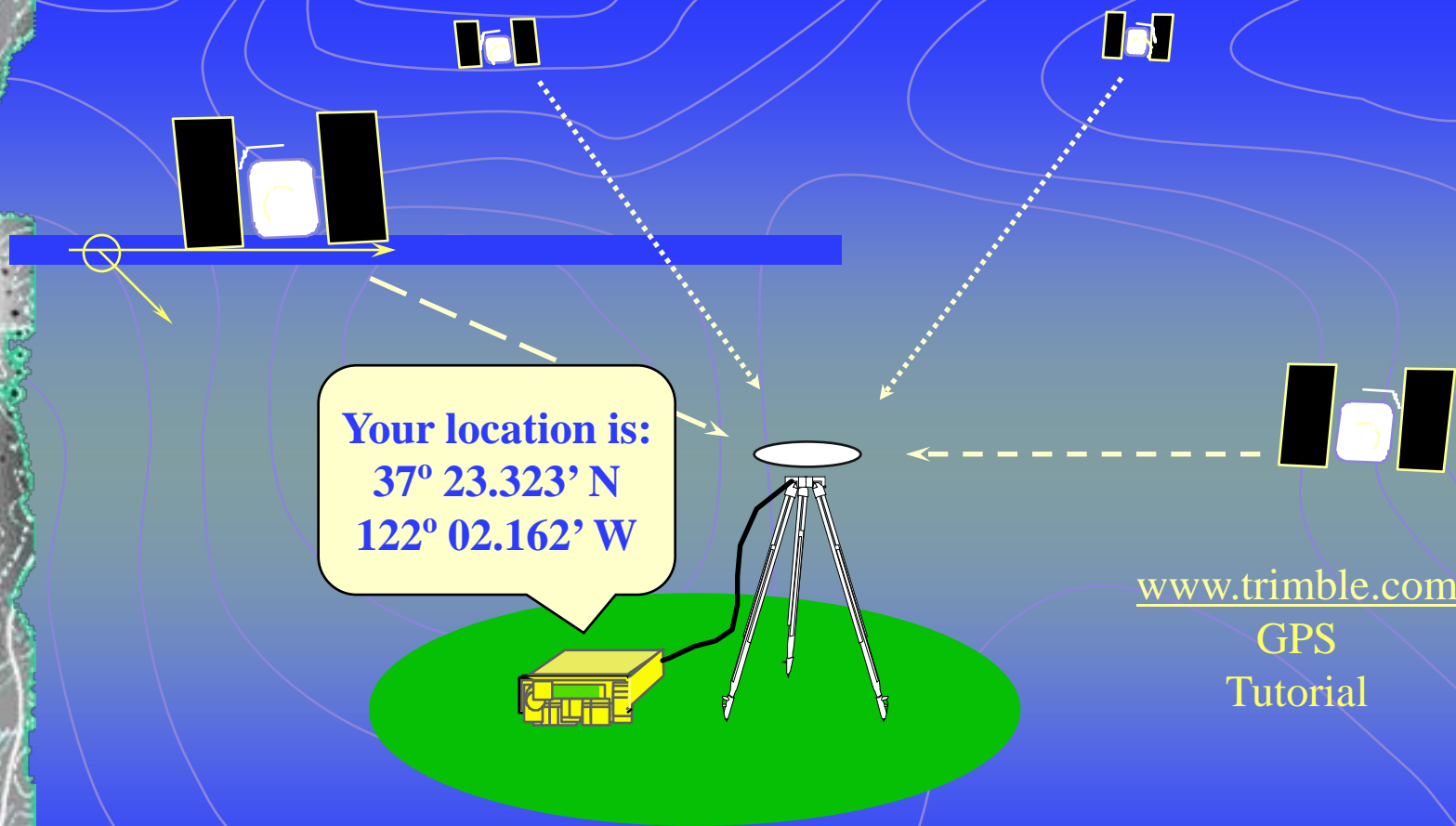
U.S. Coast Guard Support

<http://www.navcen.uscg.gov>

National Geodetic Survey Support

<http://www.ngs.noaa.gov>

# GPS Fundamentals



# Space Segment

- **24 Satellites**

- **Orbit with a 55° rotation**

- **20,200 km orbit**

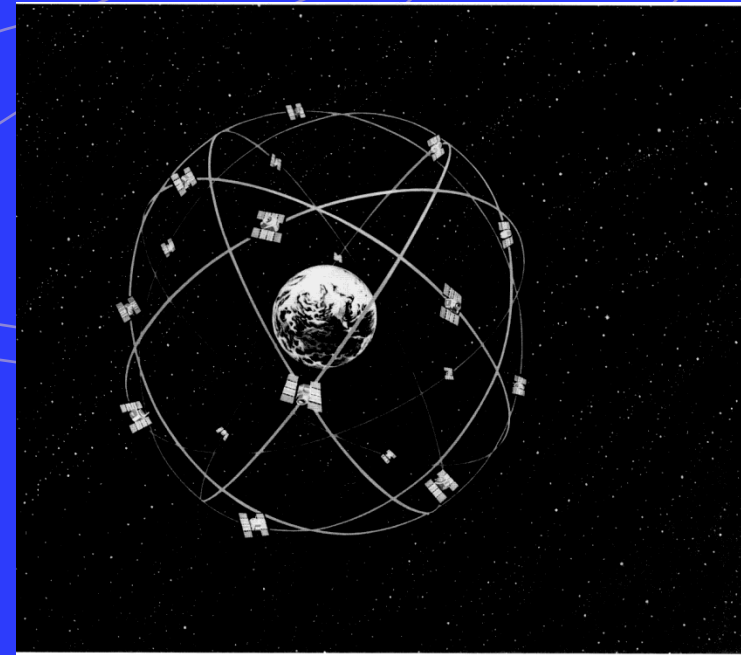
- **1 revolution in 12 hrs**

- **High Orbit For:**

- **Survivability**

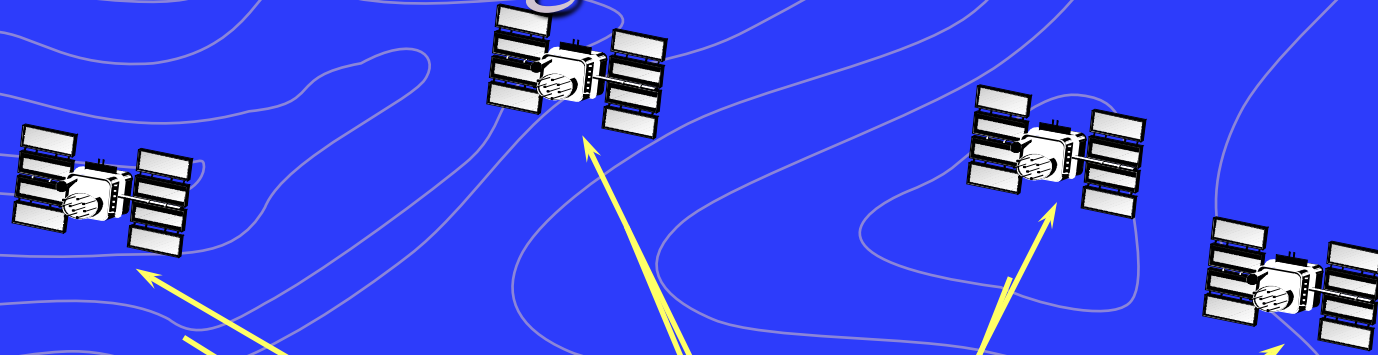
- **Coverage**

- **Accuracy**

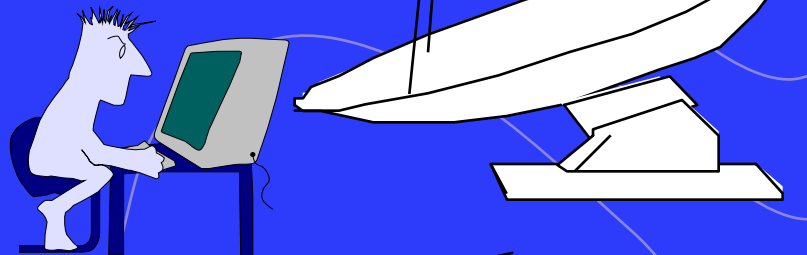


Copied from "GPS Navstar User's Overview"  
prepared by GPS Joint Program Office, 1984

# Control Segment

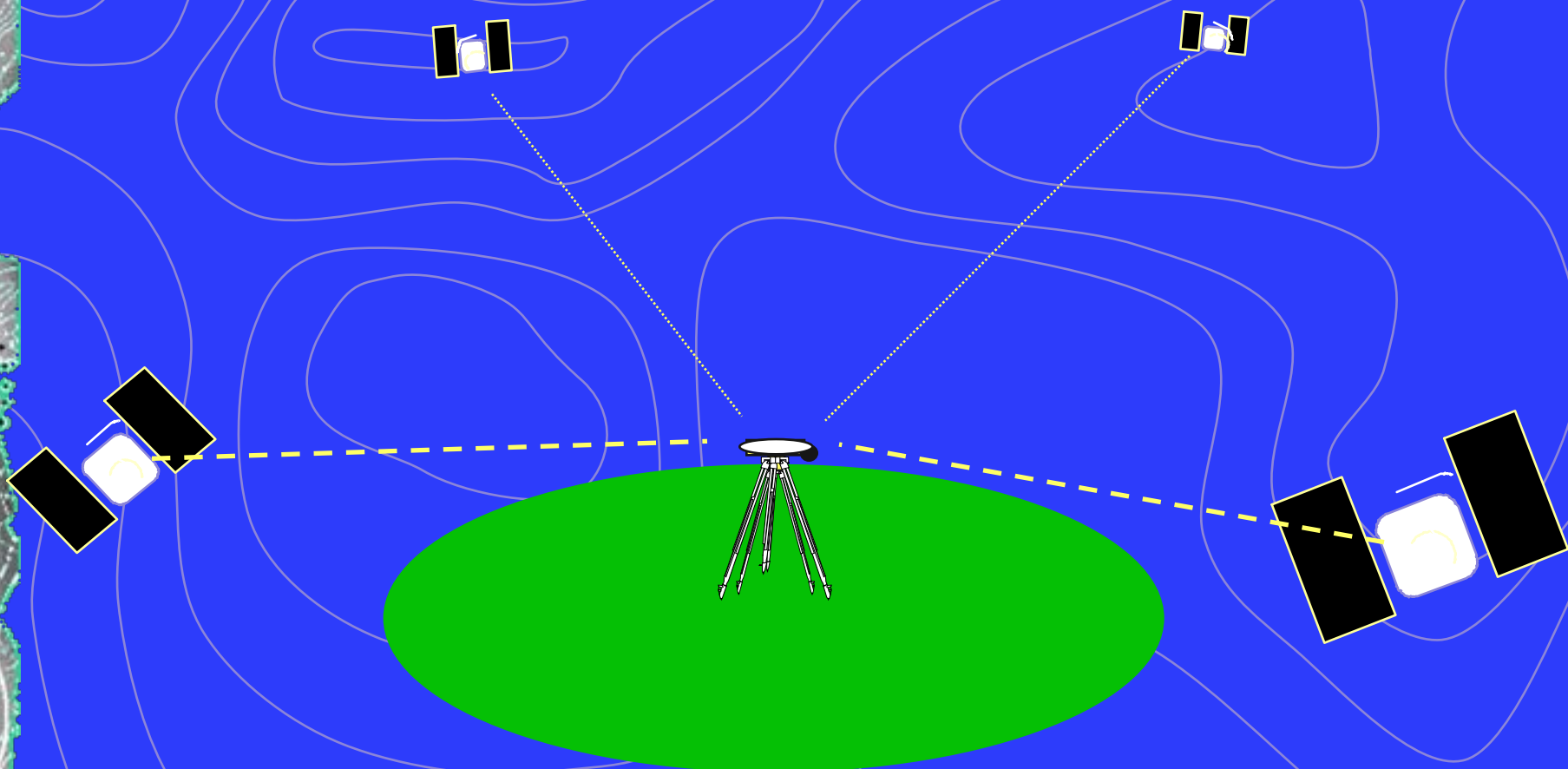


**Transmits information**  
**Receives information**



# How Does GPS Work? By Trilateration

**Distance D = Speed of Light x Time**



# User Segment

Power Grid  
Interfaces



Personal Navigation



Trucking &  
Shipping



Surveying &  
Mapping



Communications --  
Network  
Synchronization  
and Timing



Aviation



Recreation



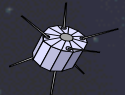
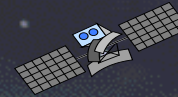
Railroads



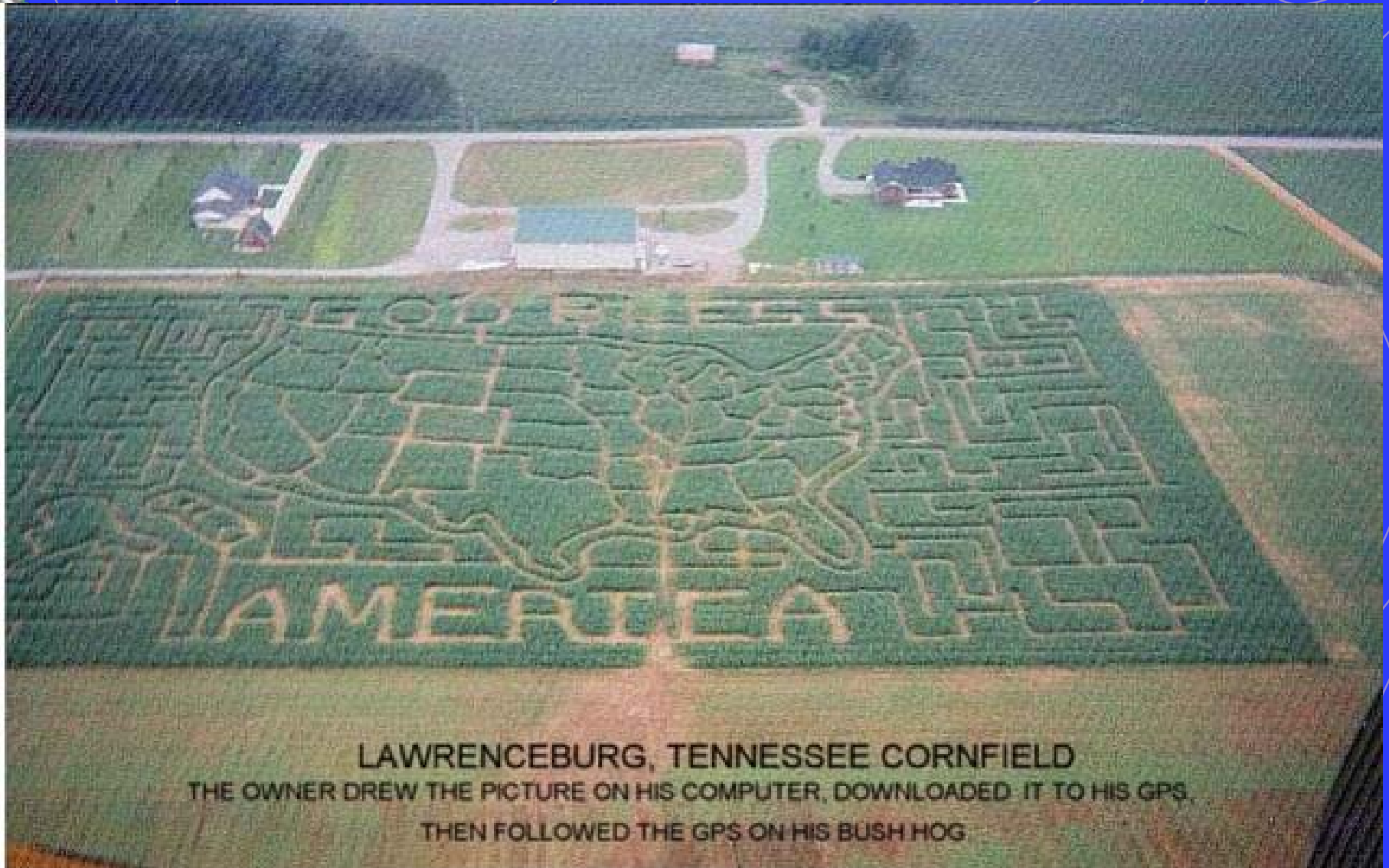
Fishing &  
Boating



Off shore  
Drilling



Satellite Ops --  
Ephemeris,  
Timing



**LAWRENCEBURG, TENNESSEE CORNFIELD**

**THE OWNER DREW THE PICTURE ON HIS COMPUTER, DOWNLOADED IT TO HIS GPS,  
THEN FOLLOWED THE GPS ON HIS BUSH HOG**

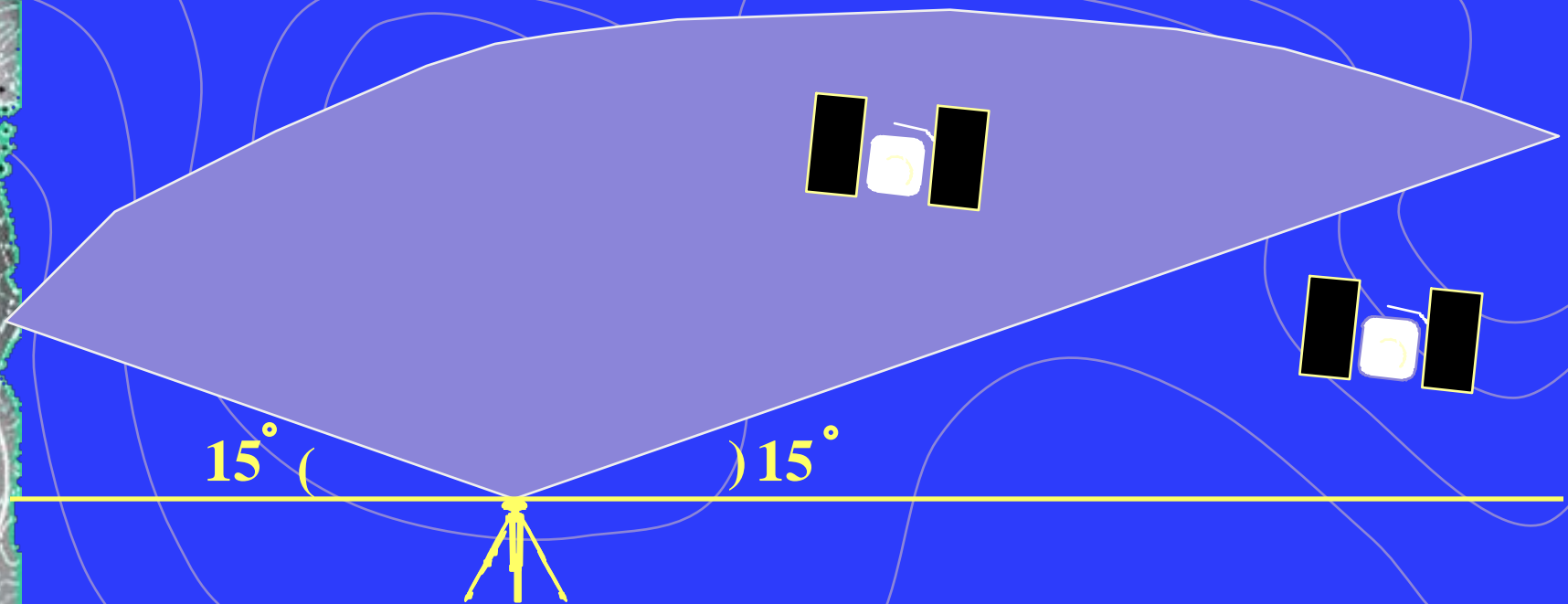




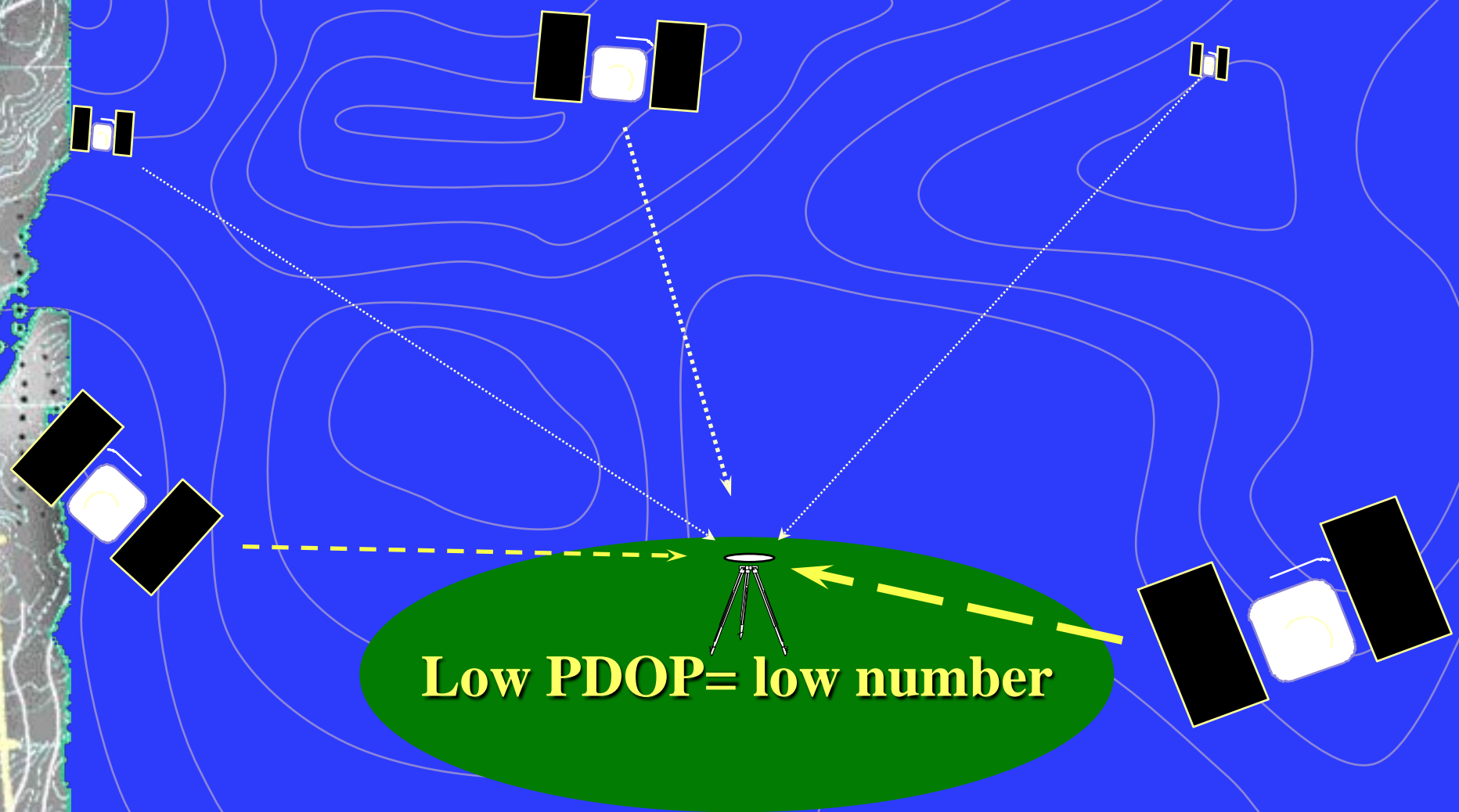
# Some GPS Terms

# Elevation Mask

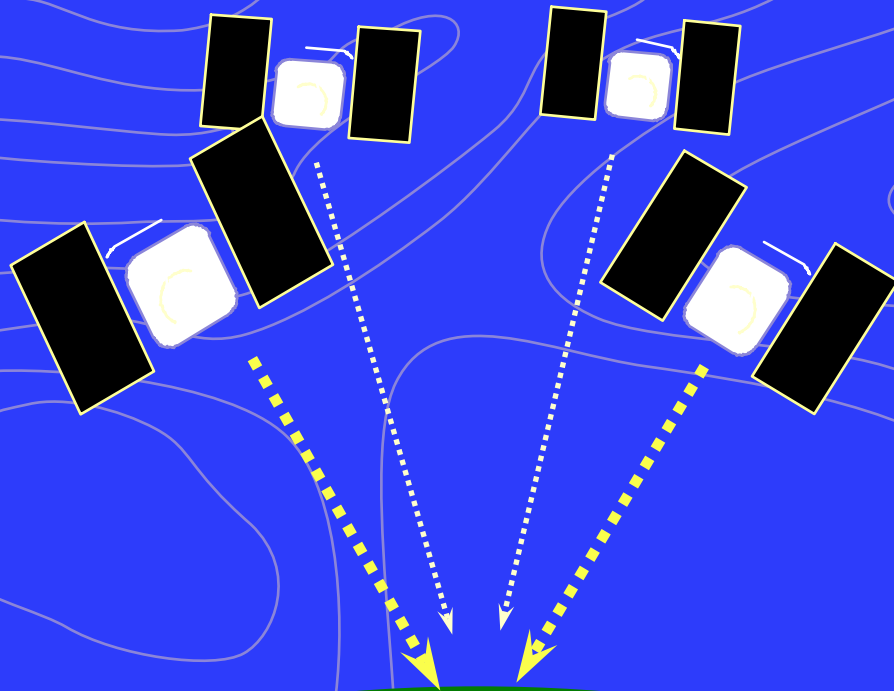
- The elevation above the horizon at which a receiver can use a satellite to calculate a GPS position



Good Satellite Geometry =



# Poor Satellite Geometry



**Poor PDOP= high number**

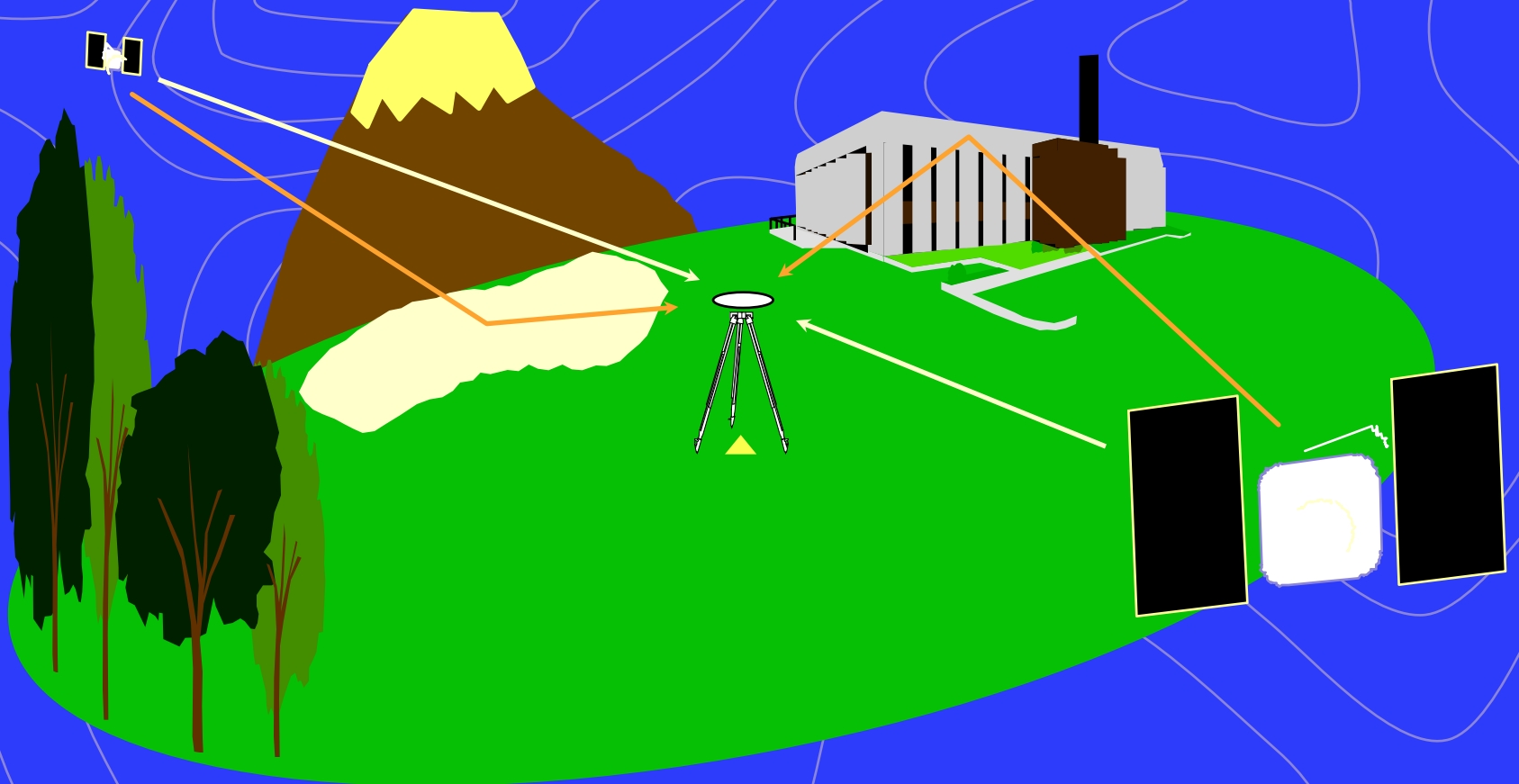


# Sources of Error

# Obstruction

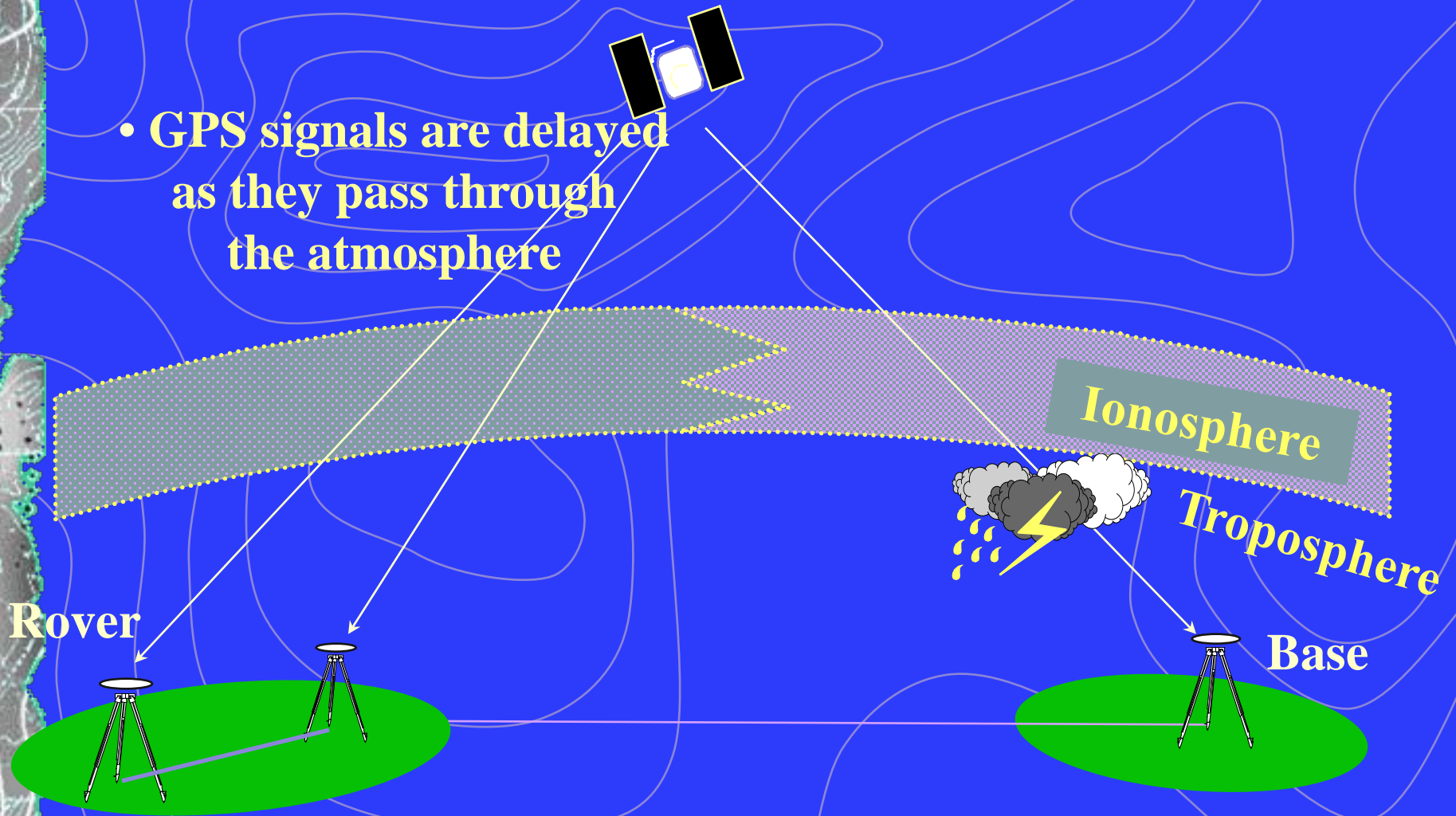


# Multipath



# Atmospheric Delay

- GPS signals are delayed as they pass through the atmosphere





**Post-processed differential – Geo XT**

**1 – 5 m**

**Real-time- WAAS**

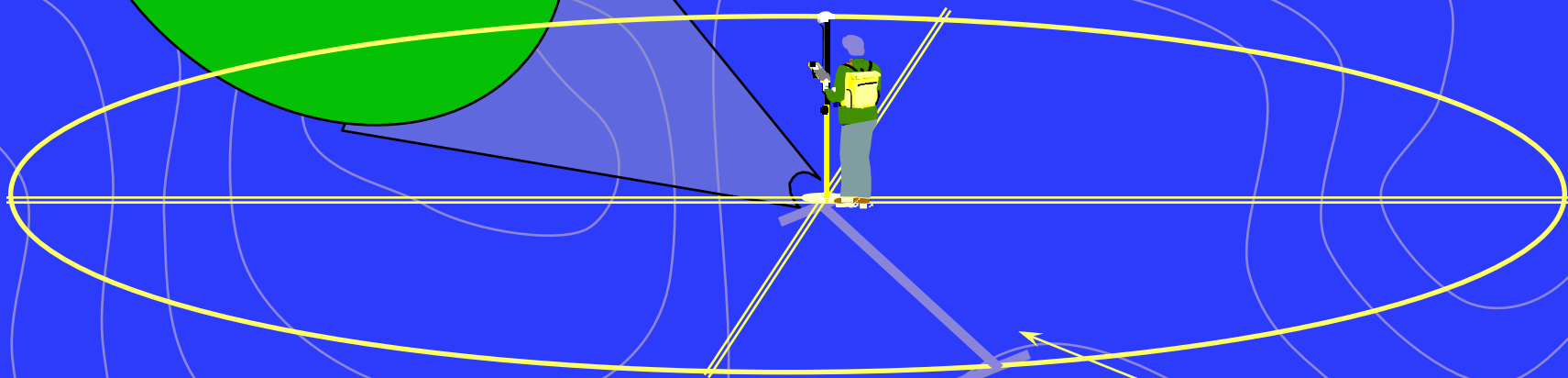
**1 – 5 m**

**Autonomous**

**<15 m**

**★ horizontal only**

**Accuracy**

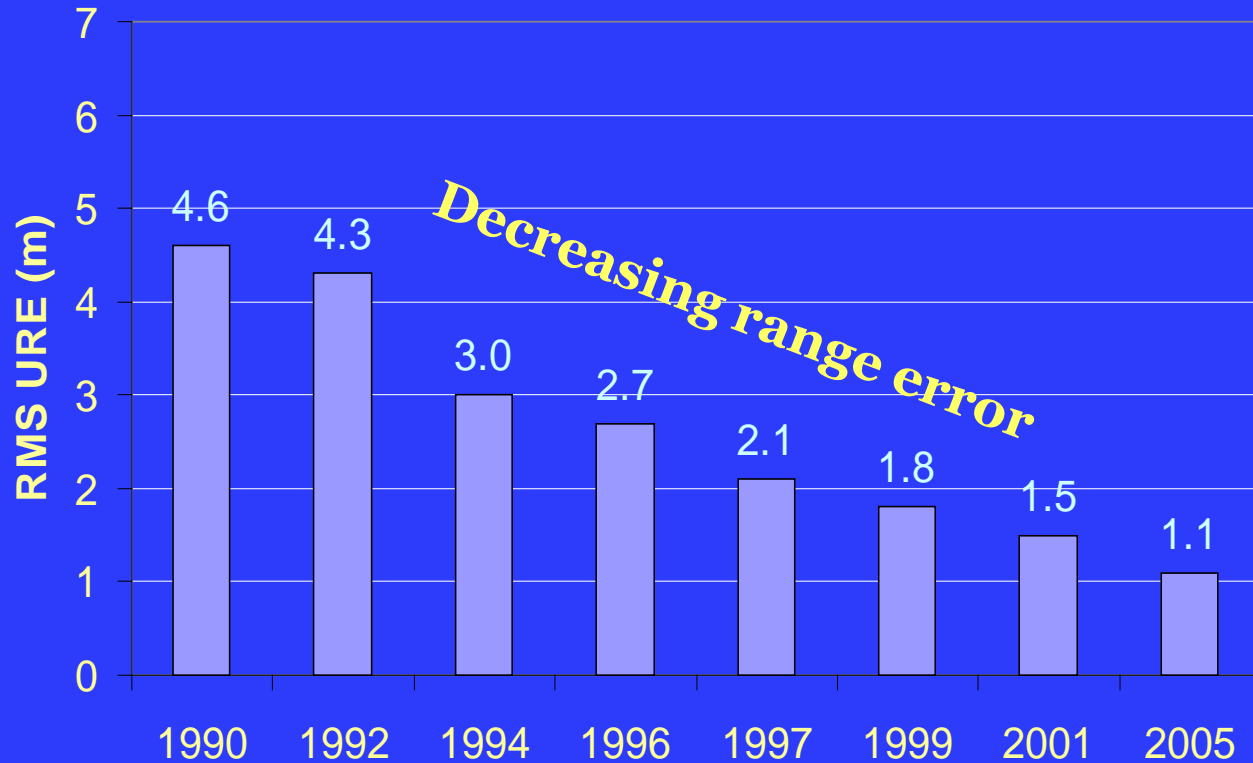


# Vertical Accuracy

- 2 to 5 times larger than horizontal accuracy



# GPS Single Frequency Performance



Signal in Space RMS URE: Root Mean Square User Range Error

A vertical strip on the left side of the slide shows a topographic map of a coastline. The map features contour lines, a road network, and a yellow line indicating a specific path or boundary. The background of the slide is blue with white contour lines.

# "Free" Real-time GPS Correction Options

- **Continuously-Operating Reference Stations (CORS)**
- **Wide Area Augmentation System (WAAS)**

# CORS OVERVIEW

- Network contained 1,300 sites as of March 2009
- Growing at rate of 200 sites per year
- Run by National Geodetic Survey
- Designed to meet post-processing requirements for
  - Positioning
  - Navigation

# What is the WAAS (Wide Area Augmentation System)?



WAAS Augments The GPS Constellation To Meet The Necessary Integrity, Availability, Accuracy, And Continuity For Use In All Phases Of Flight.

# Wide Area Augmentation System (WAAS)



- WAAS consists of:
  - 2 Geosynchronous Satellites
  - 25 Reference Stations
    - More being added in Canada/Mexico
  - 2 Master Stations
  - 3 Uplink Stations

# How does WAAS work ?

- Two master stations, located on either coast, collect data from the 25 GPS satellite reference stations and create a GPS correction message.
- The corrected differential message is then broadcast through geostationary satellites.
- The information is compatible with the basic GPS signal structure, which means any WAAS-enabled GPS receiver can read the signal.

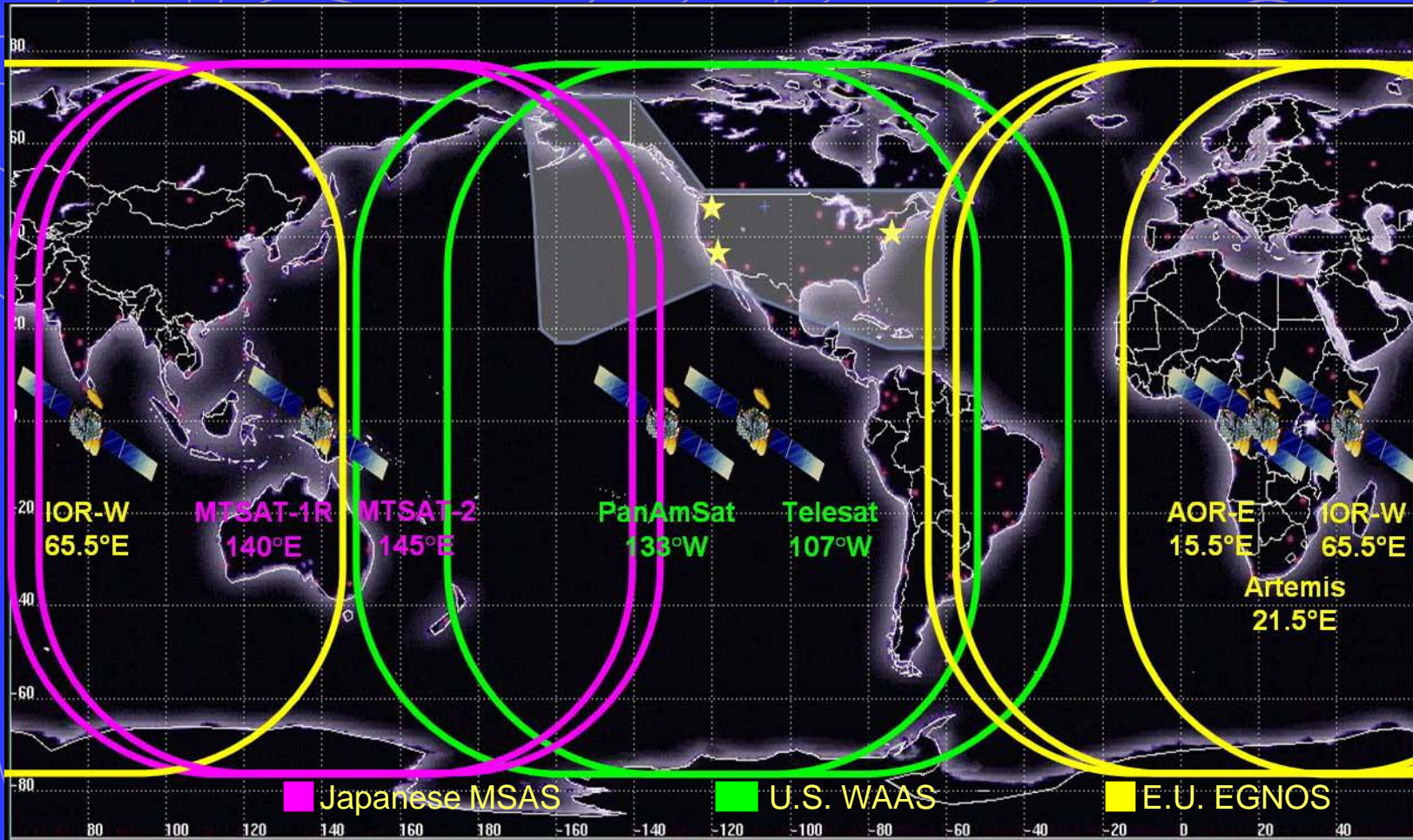


A vertical strip on the left side of the slide shows a topographic map of a coastal region, likely the Gulf of Mexico. It features contour lines, a coastline, and some urban areas. The map is partially obscured by the blue background of the slide.

# WAAS Limitations

- Satellites are geostationary at low latitude
- Resulting low sky elevations for mid-to high latitude observers
- Need unobstructed line of sight

# GPS Space-Based Augmentations



QUESTIONS ?

