

NATIONAL  
COLLEGIATE  
**FM** 2007  
TECHNOLOGY  
CONFERENCE

# GPS: A Primer

*presented by*

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**EMH&T**

# GPS: A Primer

- GPS = Global Positioning System
- 24 Satellites in Orbit around Earth
- Each Broadcasts precise time and known location
- Receivers triangulate position



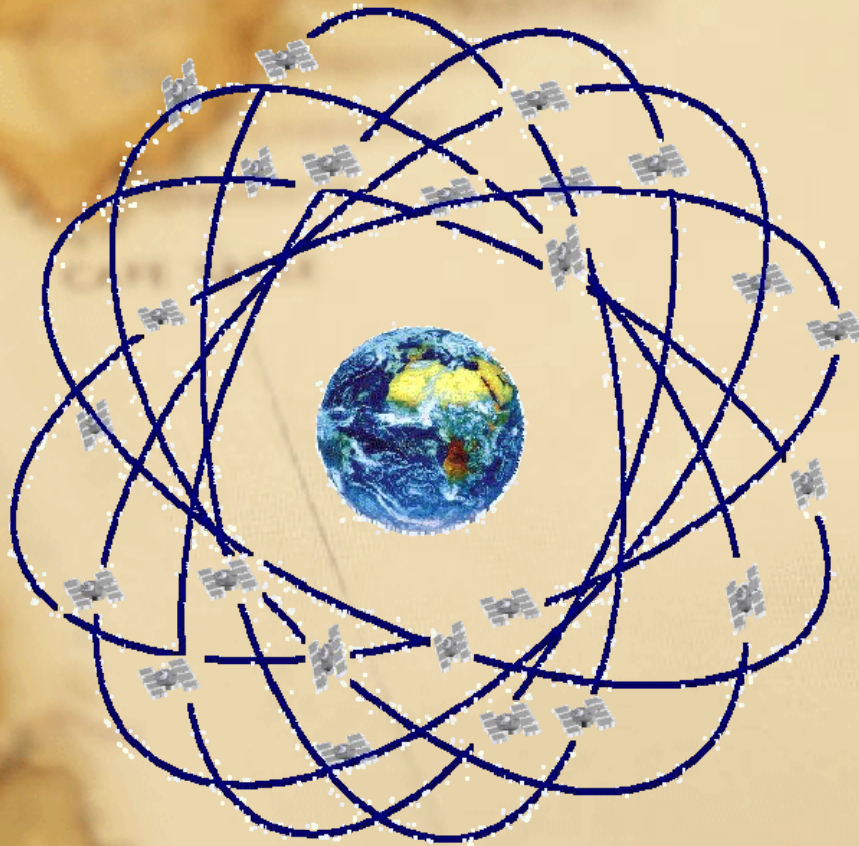


## By the way...

- “GPS” is an American system
- “GLONASS” is Russian
- “Galileo” is EU



# GPS Orbit

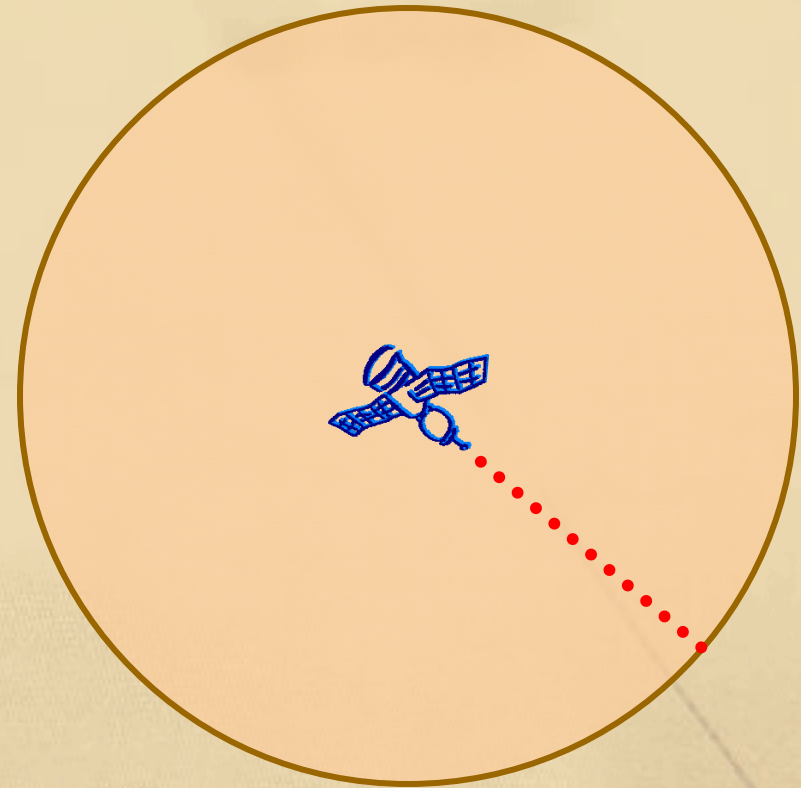


- About 12,000 miles above Earth
- 6 Circular Orbital Planes
  - Global Coverage
- Equipped with very precise atomic clocks



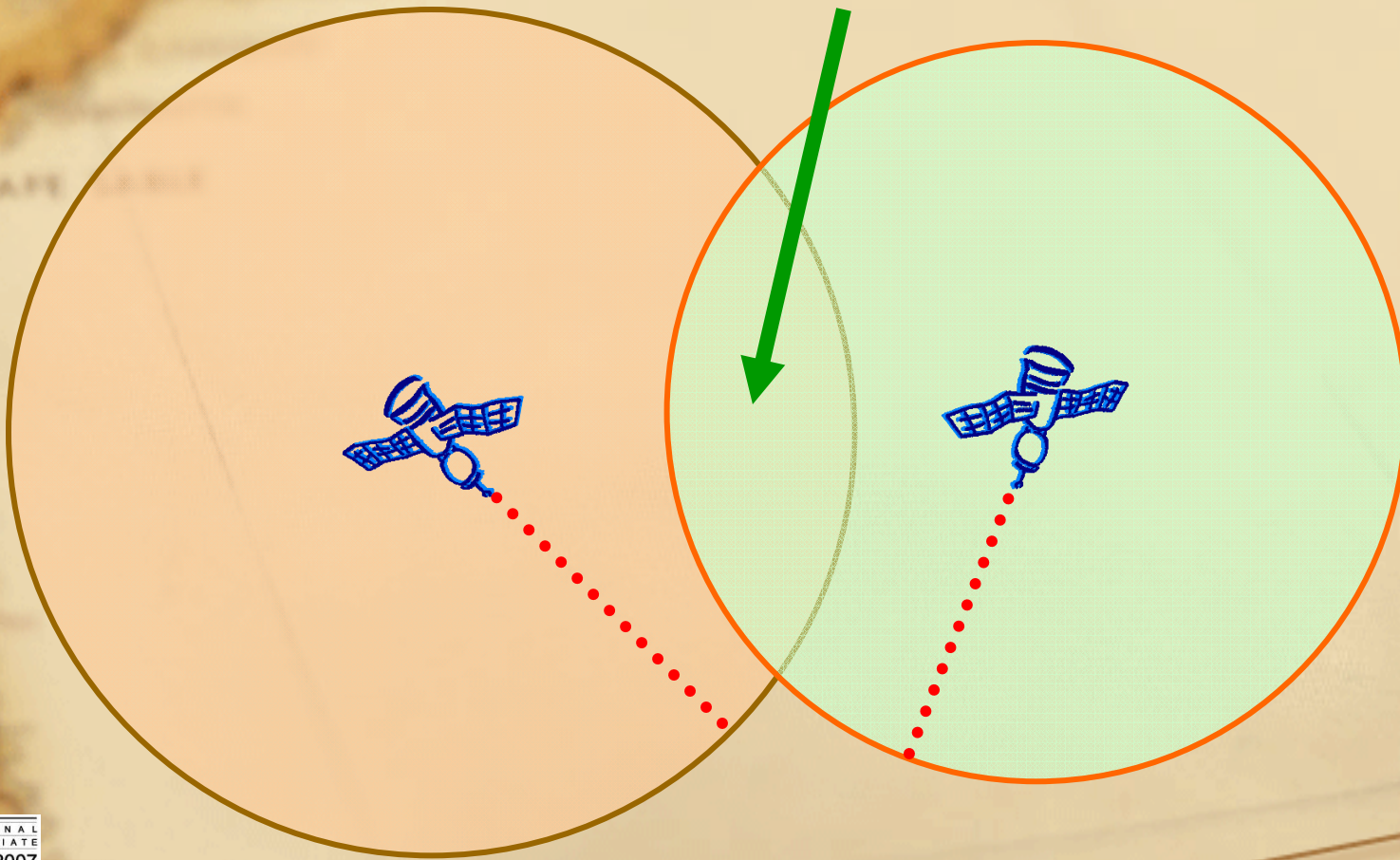
# It's about time...

- Distance =  
Velocity x Time
- Velocity is fixed at  
the Speed of Light
- Calculate signal travel  
*time* and distance is  
solved
- Location is  
somewhere within a  
sphere



# It's about time...

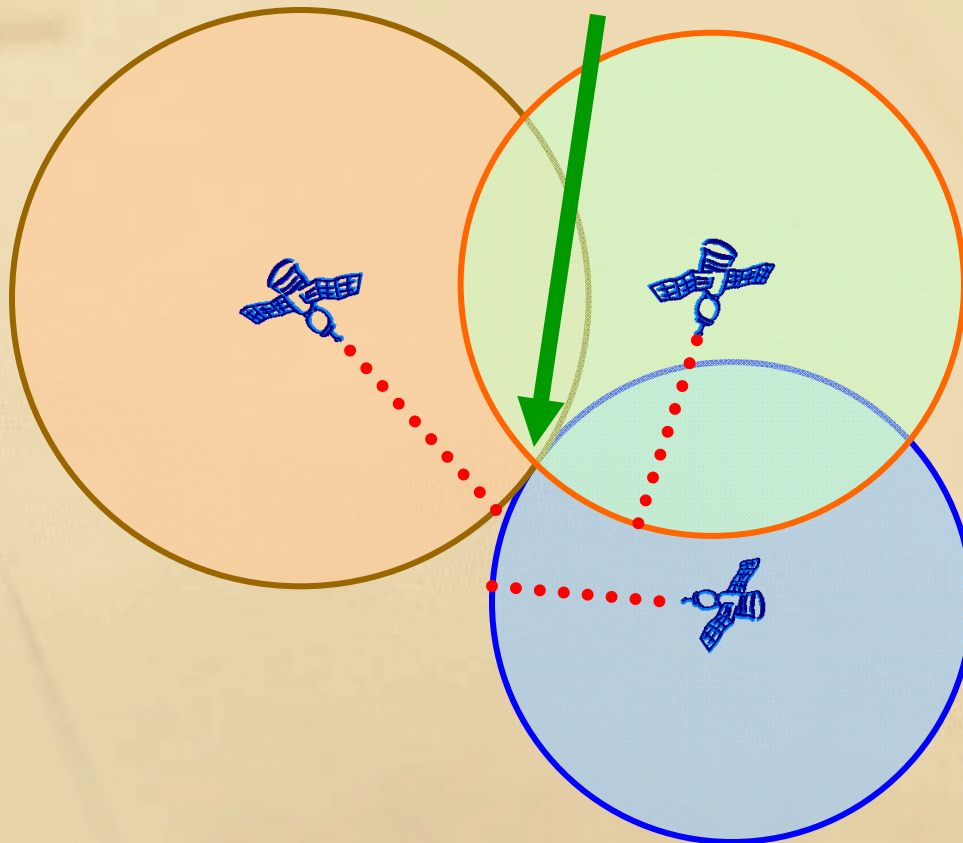
- A second distance can calculate an area...





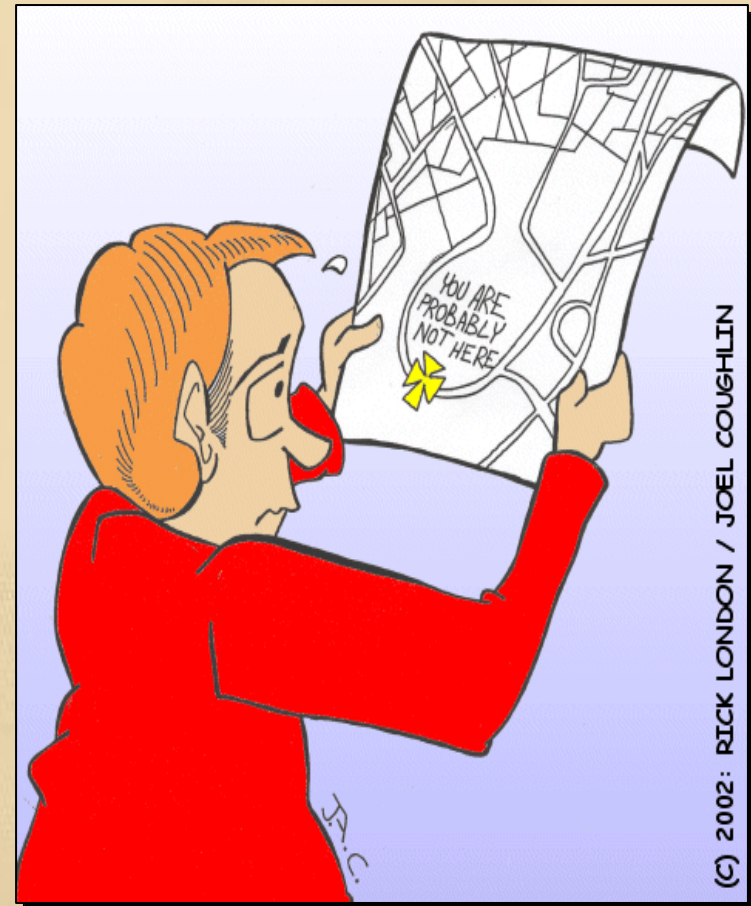
# It's about time...

- The third distance can calculate a point...



# If it were a perfect World...

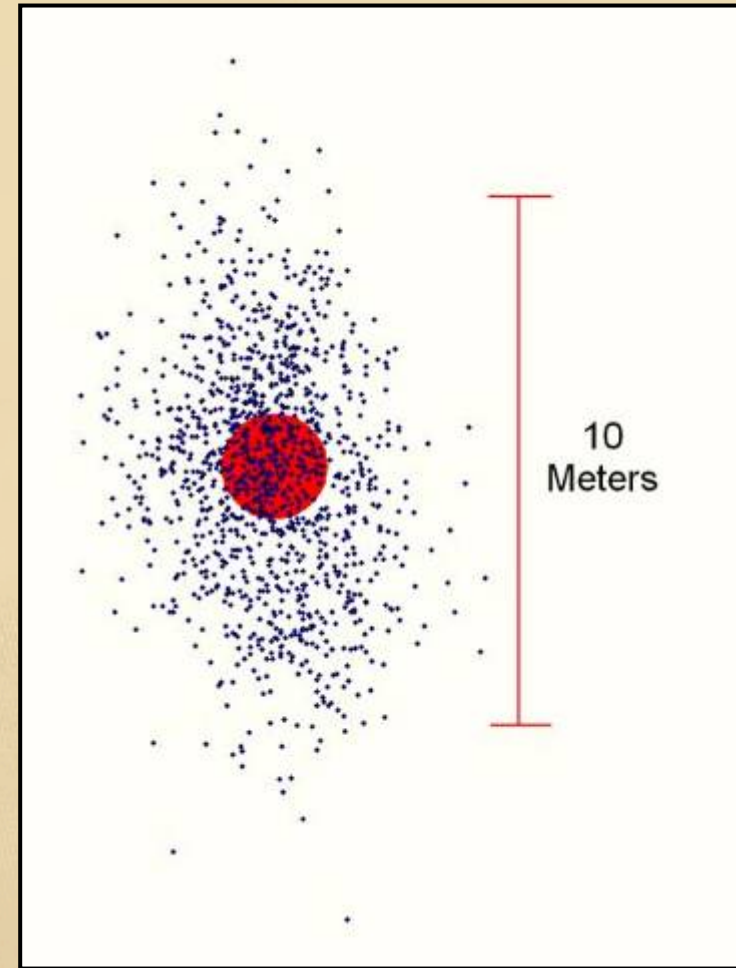
- Extremely precise clocks required
  - Average time from Satellite  $< 0.06$  sec
  - 1ns error = 1 ft
- Speed of Light
  - Not a constant
- Orbits change





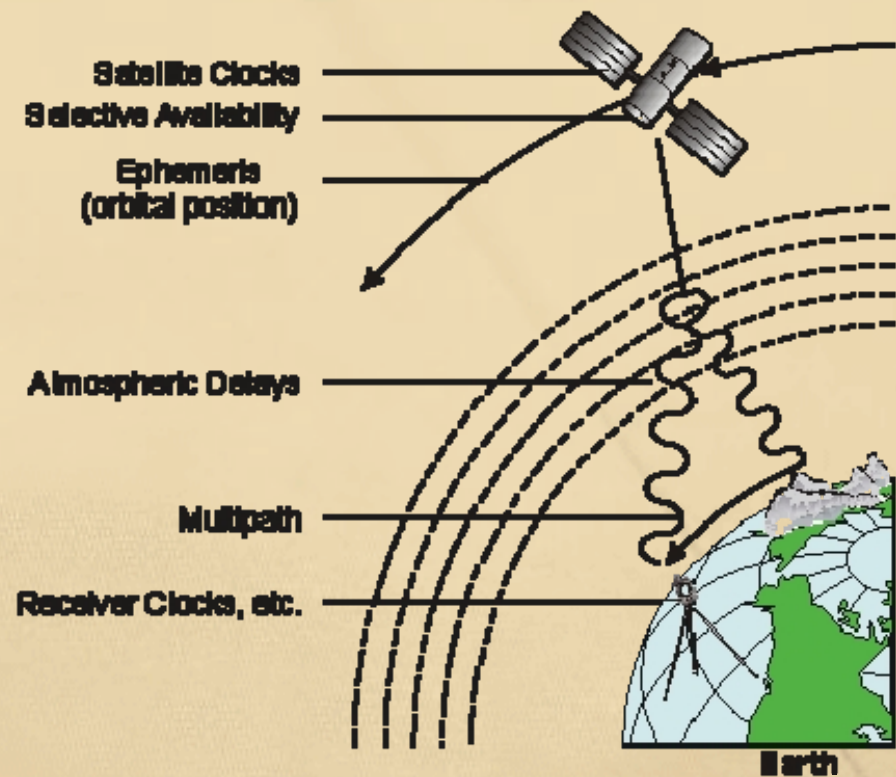
# If it were a perfect World...

- Each reading is slightly different
- Due to changing
  - Satellite location
  - Satellite DOP's & combinations
  - Varied clock errors
- Points are averaged



# GPS Error

- Satellite Clocks
- Selective Availability (SA)
- Orbital Errors (Ephemeris)
- Atmospheric
  - Delays & Signal Strength
- Multipath
- Receiver Clock



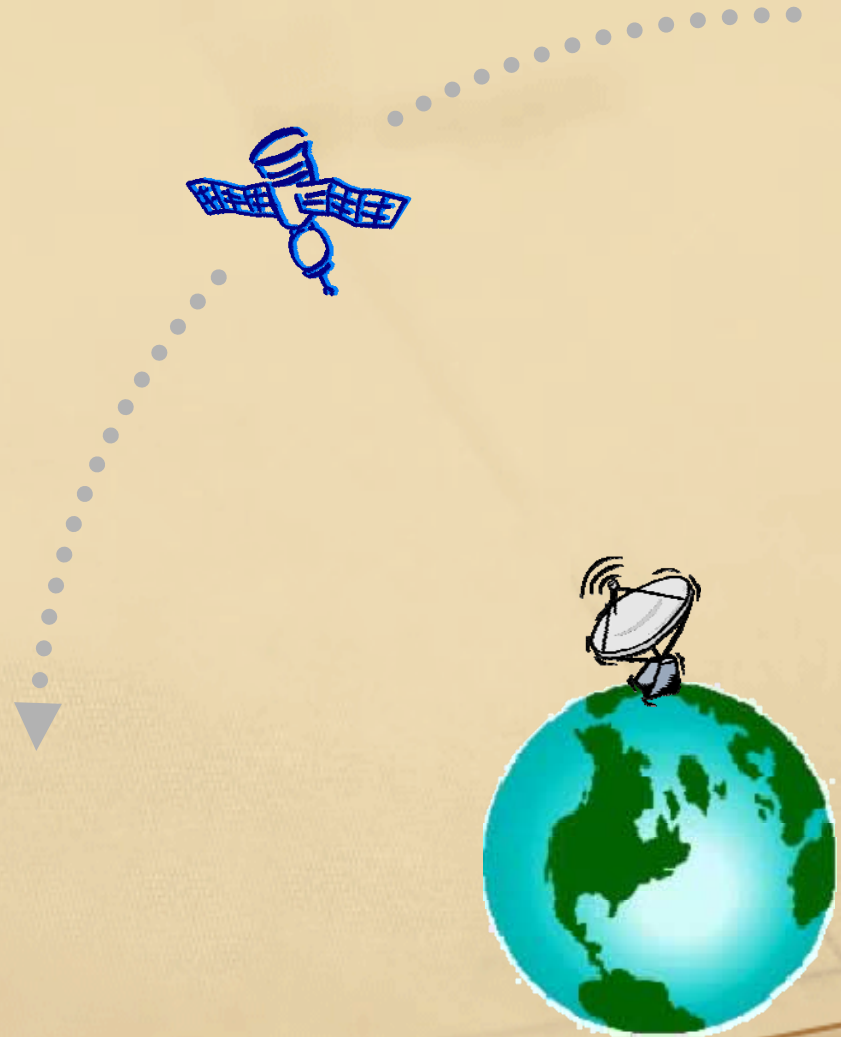


# GPS Error

- Satellite Clocks Minimal - atomic clocks
- Selective Availability (SA) Disabled - was upwards of 300 feet
- Orbital Errors (Ephemeris) 7 feet
- Atmospheric 13 feet
  - Delays & Signal Strength
- Multipath 3 feet
- Receiver Clock 13 feet

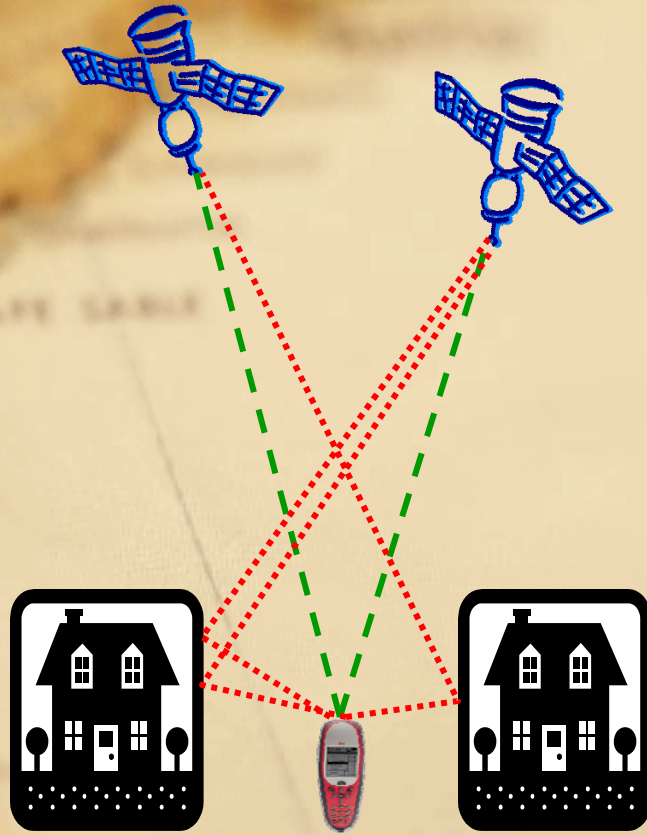
# Ephemeris

- Satellite location
- Monitored by DoD
  - Updated Constantly
- Almanac: all SV's
- Adjusted
  - Orbit
  - Altitude
  - Speed





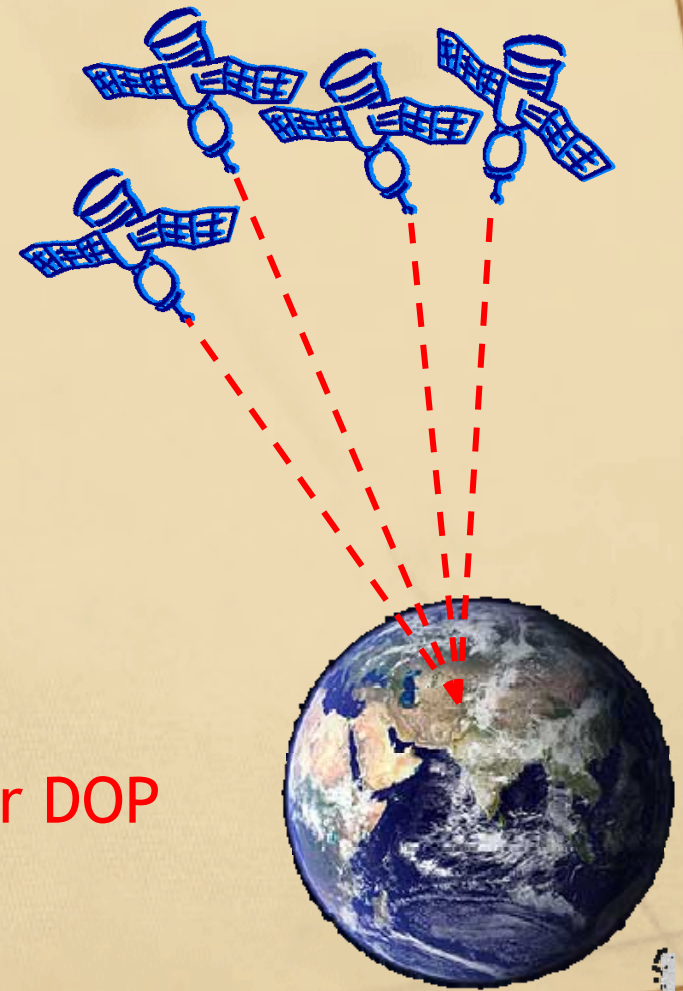
# Multipath



- Signal reflects off Objects
- Travels further and delayed
- Corrected with improved antenna and processors
- “First one wins”

# Dilution of Precision (DOP)

- Includes:
  - Horizontal (HDOP)
  - Vertical (VDOP)
  - Position (PDOP)
    - $\sqrt{\text{HDOP}^2 + \text{VDOP}^2}$
    - Generally below 6
  - Time (TDOP)
  - Geometry (GDOP)
    - $\sqrt{\text{PDOP}^2 + \text{TDOP}^2}$

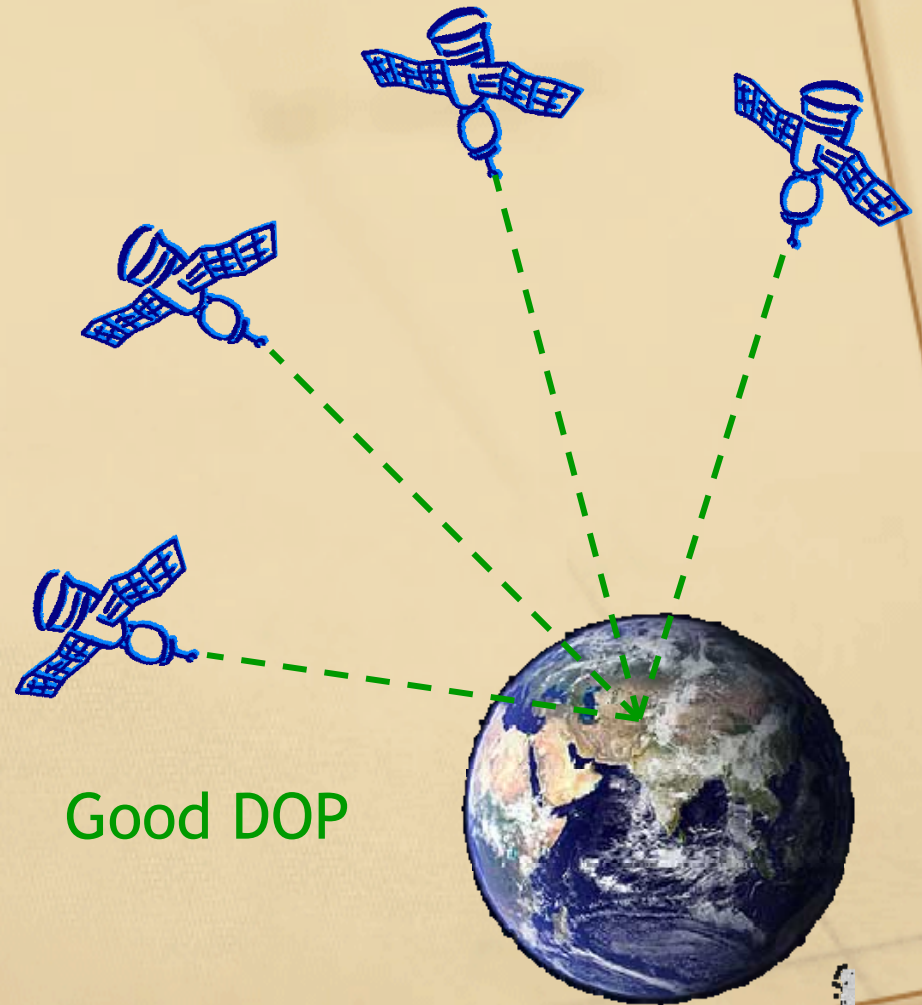


Poor DOP

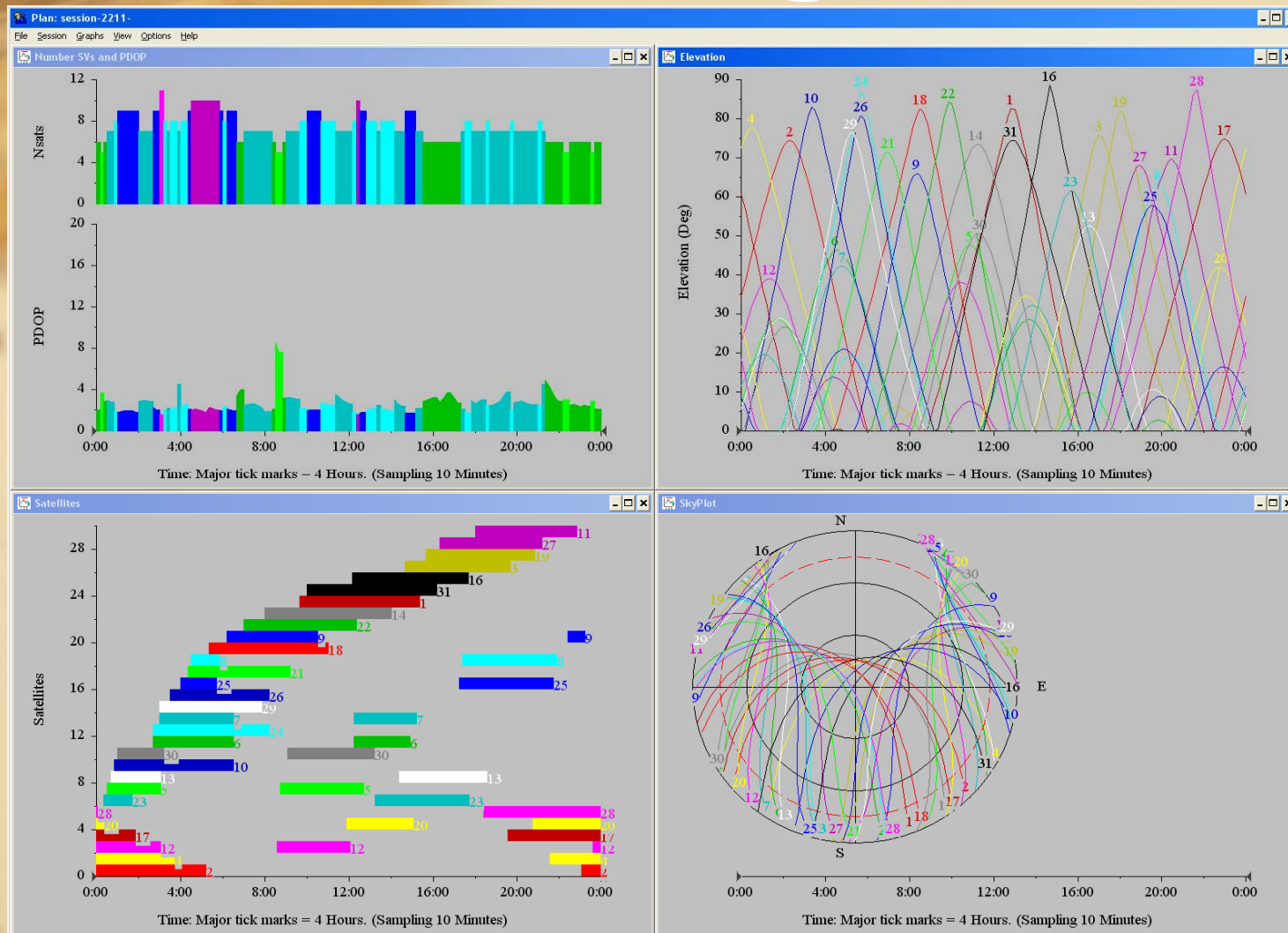


# Dilution of Precision (DOP)

- Includes:
  - Horizontal (HDOP)
  - Vertical (VDOP)
  - Position (PDOP)
    - $\sqrt{\text{HDOP}^2 + \text{VDOP}^2}$
    - Generally below 6
  - Time (TDOP)
  - Geometry (GDOP)
    - $\sqrt{\text{PDOP}^2 + \text{TDOP}^2}$



# When to go?





# Differential Correction

Base Station



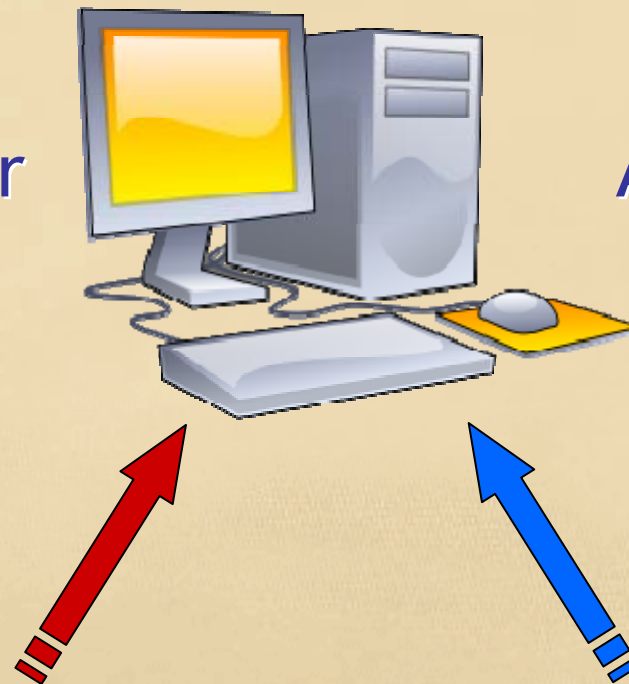
Rover



# Differential Correction

Known Position  
All Satellites  
Calculate Error

Unknown Error  
Compare to Base  
Apply offset Error



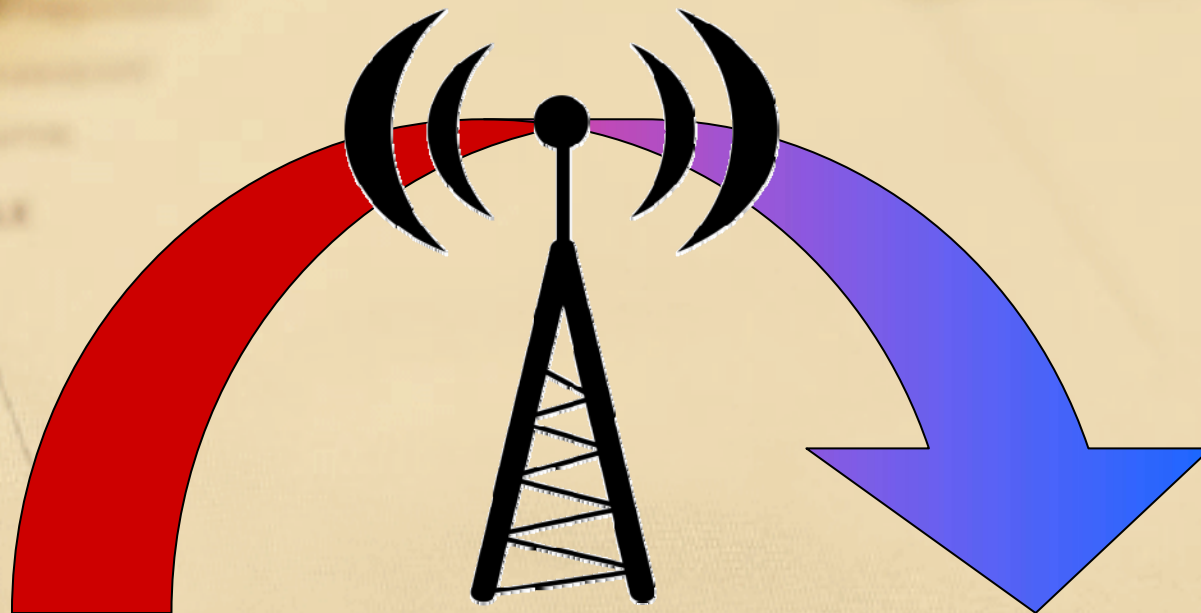
Base Station

"Post Processing"

Rover



# Differential Correction



Base Station



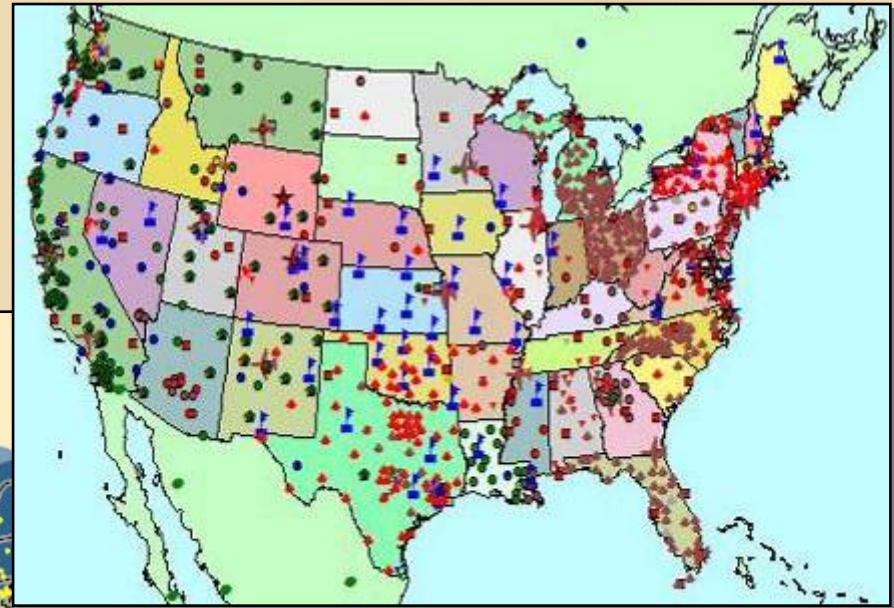
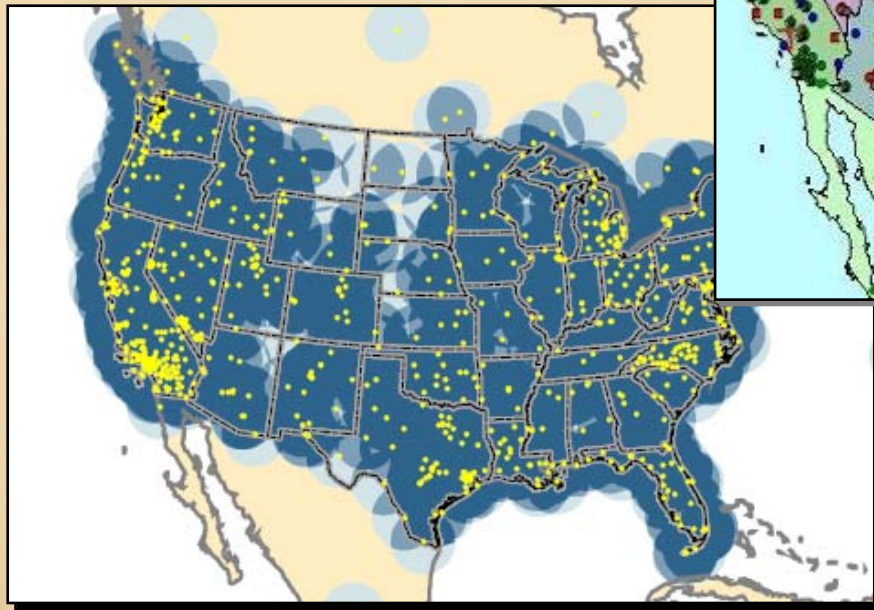
“DGPS”  
“RTK”

Rover



# Differential Correction

- National Public Base Station Network





# Types of GPS

- Recreational Grade  
 $\pm 30 - 100$  feet
- Mapping Grade  
 $\pm 1 - 3$  feet
- Survey Grade  
 $< 0.04$  feet (1 cm)

Vertical 2-5 times  
horizontal accuracy

# Types of GPS

- Recreational Grade  
 $\pm 30 - 100$  feet
- Mapping Grade  
 $\pm 1 - 3$  feet
- Survey Grade  
 $< 0.04$  feet (1 cm)

Purchased for  
\$100-800



# Types of GPS



- Recreational Grade  
 $\pm 30 - 100$  feet
- Mapping Grade  
 $\pm 1 - 3$  feet
- Survey Grade  
 $< 0.04$  feet (1 cm)

Purchased for  
\$3,000-5,000+

# Types of GPS

- Recreational Grade  
 $\pm 30 - 100$  feet
- Mapping Grade  
 $\pm 1 - 3$  feet
- Survey Grade  
 $< 0.04$  feet (1 cm)

Purchased for  
\$15,000-50,000++





# Types of GPS

- Recreational Grade  
 $\pm 30 - 100$  feet
- Mapping Grade  
 $\pm 1 - 3$  feet
- Survey Grade  
 $< 0.04$  feet (1 cm)

What do you get?

Better clocks, receivers, filters,  
processors.

The background of the slide features a close-up, slightly blurred image of a vintage-style compass and an old map. The compass is in the upper left corner, showing cardinal and intercardinal directions. The map below it shows some geographical features and text, including "CAPE SABLE".

# Types of GPS

- Recreational Grade  
 $\pm 30 - 100$  feet
- Mapping Grade  
 $\pm 1 - 3$  feet
- Survey Grade  
 $< 0.04$  feet (1 cm)



# So what can you do with it?

- Tree - Horticulture Inventory
- Ponds - Streams
- Historical - Archeological



# Utilities

- Manholes
- Storm Drains
- Sprinkler Heads
- Power / Light Poles
  - Not to “locate” underground utilities!





# Planimetric

- Building Corners
- Walls
- Trails - Footpaths
- Bike Racks
- Benches - Bus Stops
- Signage



# Emergency Management

- GPS is also for Navigation
- Hydrants
- Emergency Call Boxes
- Valves

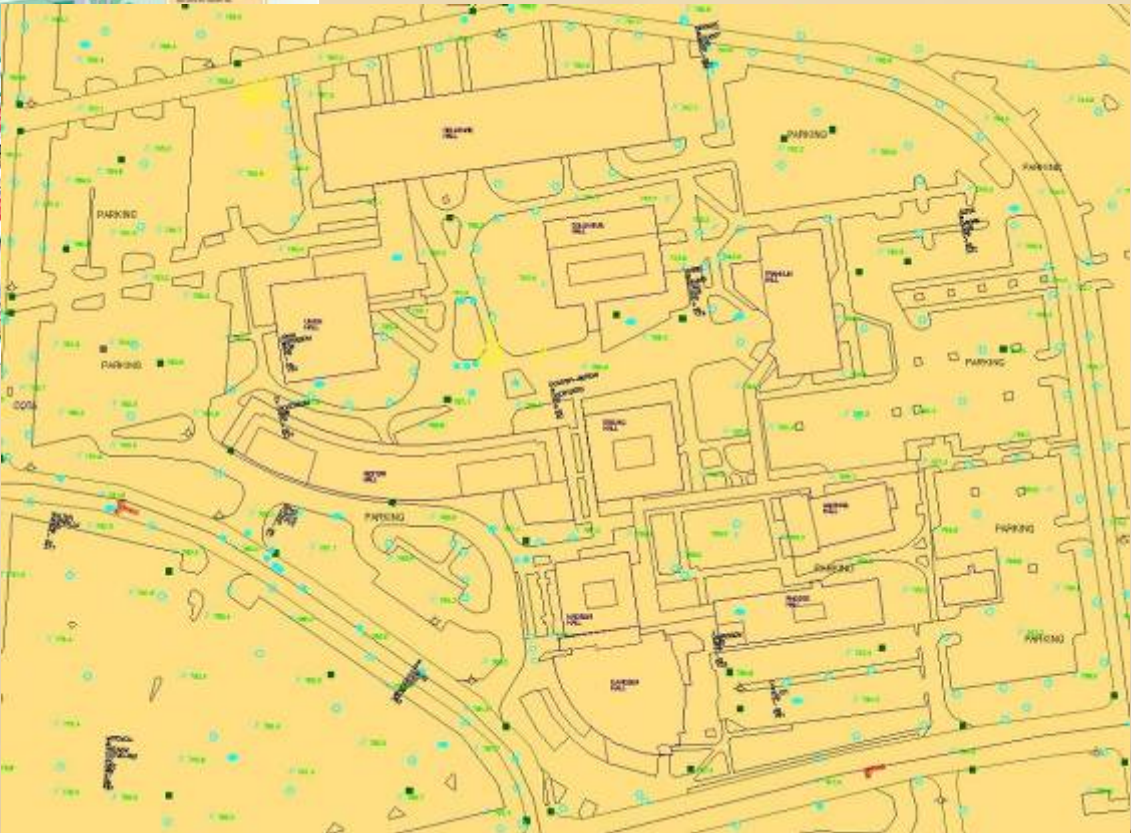




# Attributes

The screenshot shows the TerraSync software interface. At the top, there's a blue header bar with the TerraSync logo. Below it, a menu bar includes 'Data', 'Collect', 'Options', and 'Log'. The main window displays a form for '1 Insp 1'. The form includes fields for 'Date' (6/29/2007) and 'Time' (9:58:42 am). A section titled '>>>> COVER:' contains several fields: '\*Shape:' (set to 'Circular'), '\*Diameter-Width (in):' (-1), 'Length (in):' (-1), '\*Material:' (empty), and '-> Type ->:' with sub-fields for '\*Solid:', '\*Vented:', '\*Gasketed:', '\*Bolted:', and '\*Locking:'. Below this is a 'Pick Holes:' section with '\*Num Pick Holes:' (-1), '\*Width (in):' (-1.0), '\*Length (in):' (-1.0), and '\*Type:'. The 'Vent Holes:' section includes '\*Num Vent holes:' (-1), '\*Vent hole dia (in):', and '\*Frame fit:'. A '-> Condition ->:' section has fields for '\*Cracked:', '\*Broken:', '\*Missing:', '\*Corroded-Pitted:', and '\*Missing bolts:'. At the bottom, there's a 'Cover comments:' text area and a prompt '>>>> GOTO INSP 2:'.

- While you're collecting location, collect data!
- Pull-down menus
- Valid Values - Ranges
- Required Fields





# Ground Control



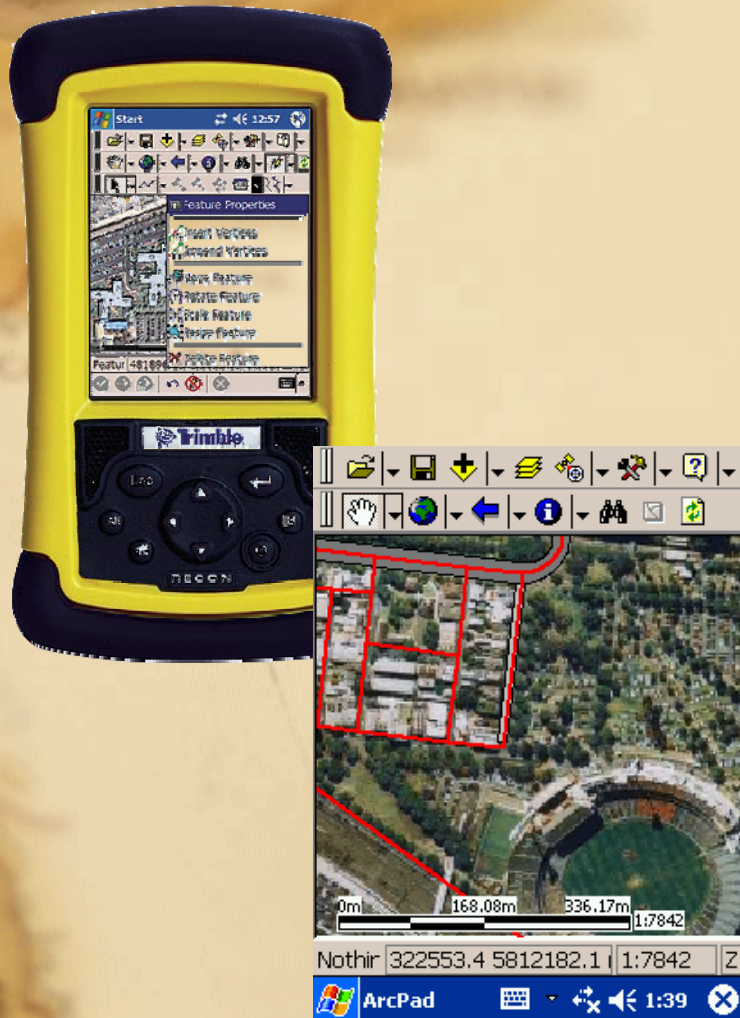
# Cool Tools you can Use!



July 21, 5:43 pm: The nerds meet the geeks



# ESRI ArcPad™



- Mini-GIS Integrates with GPS
- Draw, edit
- Enhanced menus, attribute collection
- Works with many Systems
- Customizable

# Laser Rangefinder

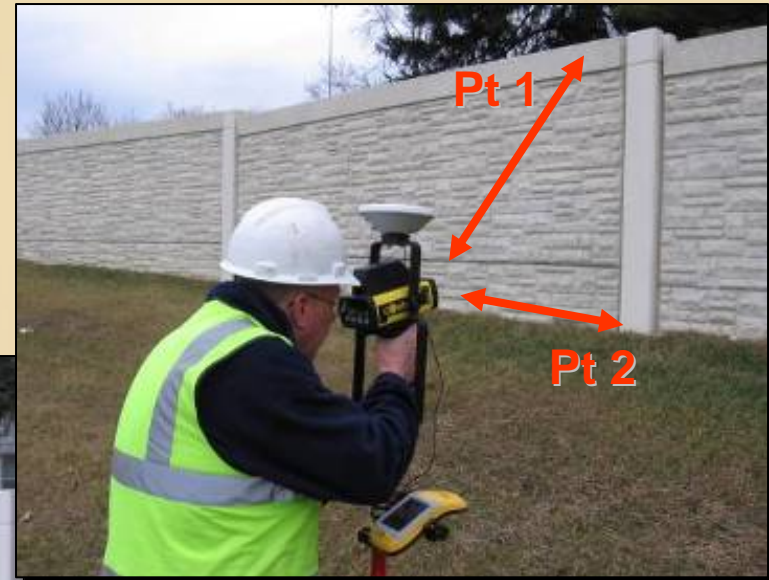
- Remote Positions
  - Under Canopy or Overhang
  - In Trees





# LaserCraft™ Rangefinder

- Remote Positions
  - Under Canopy or Overhang
  - In Trees



- Remote Measurements
  - Horizontal
  - Vertical

# Ricoh GPS Camera

- GPS Ready
- Data Embedded in Digital Image
- “Talks” with Bluetooth enabled GPS and Rangefinders







# GPS: A Primer

## *References:*

- ArcPad, ESRI. <http://www.esri.com/software/arcgis/arcpad/index.html>
- Contour XLR, LaserCraft, Inc. <http://www.lasercraftinc.com>
- “General Information on GPS,” U.S. Coast Guard Navigation Center. <http://www.navcen.uscg.gov/gps/default.htm>
- “Global Positioning System: The Role of Atomic Clocks,” National Academy of Science. <http://www.beyonddiscovery.org/content/view.article.asp?a=458>
- “Global Positioning System Overview,” Peter H. Dana, The Geographer's Craft Project, Department of Geography, The University of Colorado at Boulder. [http://www.colorado.edu/geography/gcraft/notes/gps/gps\\_f.html](http://www.colorado.edu/geography/gcraft/notes/gps/gps_f.html)
- Ricoh Corporation. <http://www.ricohsolutions.com/geo/>
- Trimble, Inc. <http://www.trimble.com/gps/index.shtml>

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# GPS: A Primer

*Thank you! Questions?*

For more information or a copy of this presentation,  
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