

Applied Geomorphology

Lecture 4: Total Station & GPS Survey Methods



Total Station

- Electronic version of Alidade
- Accurate to ± 3 ppm horizontal & vertical
 - 3×10^{-6} (5000 feet) = 0.2 inches



Total Station Advantages over the Alidade

- Calculations are processed internally so there are no post data collection calculations to process
- Accuracy is much better than alidade, and it is not shot distance dependent
- Results are stored in a data collector computer that can display results graphically
- Each individual ray shot can take as little as a few seconds to take- many more stations can be collected per day as compared to the alidade and plane table method



Total Station Disadvantages

- No plane table for sketching contours and/or contacts on a geologic map
- It may take 30 minutes to an hour to set up (level) the instrument before data can be collected
- Battery life on data collector computer can limit length of daily surveys



Total Station Surveys

- The initial XY coordinate system of the instrument is random- it must be calibrated to conform to geographic or magnetic north
- A “backsight” target is established north of the starting station position to calibrate coordinate system
- If two benchmarks or former station positions have known coordinates the relative positions can be used to calibrate coordinate system
- Because of the range and accuracy of the total station one instrument station may be sufficient for entire survey project



Integrating Alidade & T.S. Surveys

- To integrate an Alidade survey with T.S. data you must “grid” the alidade points based on the XY coordinates of two known points.
- Once grid lines are established on the alidade map each data point is read off as if the map were a sheet of graph paper.



Integrating Alidade & T.S. Surveys

- Campus Map Example using stations 1 & 2

St1 = 5000, 5000 (measured w/ T.S.)

St2 = 4984, 4744 (measured w/ T.S.)

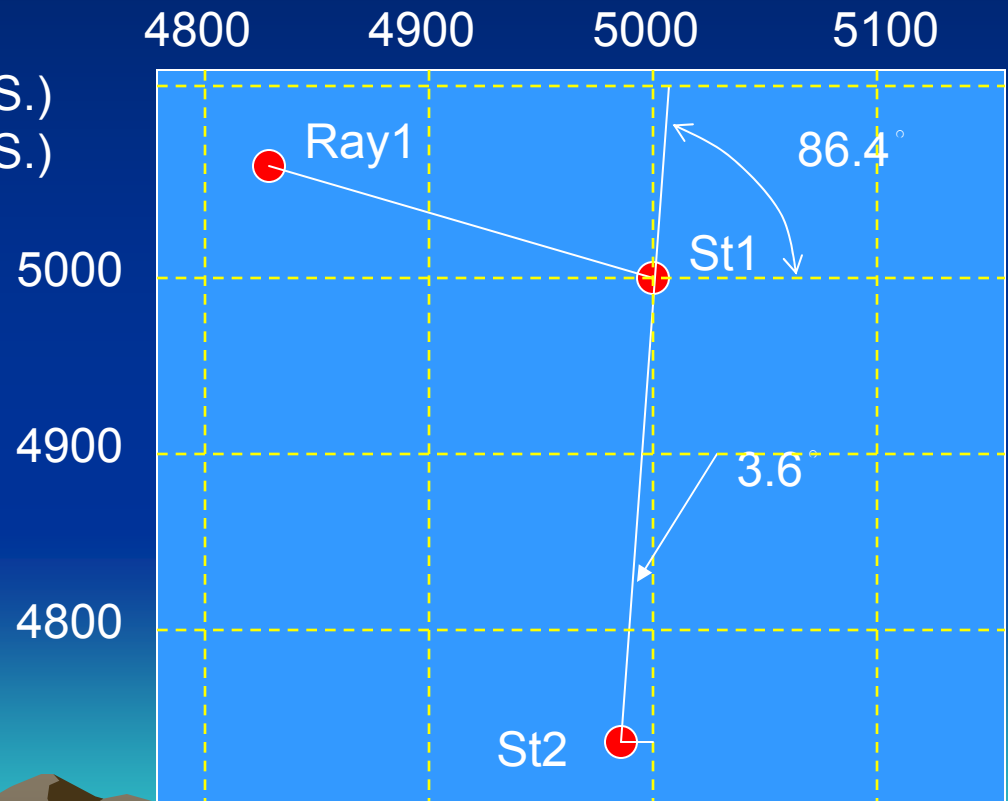
$\Delta x = 16$, $\Delta y = 256$

$\tan \alpha = \Delta y / \Delta x = 256/16$

$\alpha = 86.4^\circ$

Ray1 = 4819, 5067

(interpolated from grid)

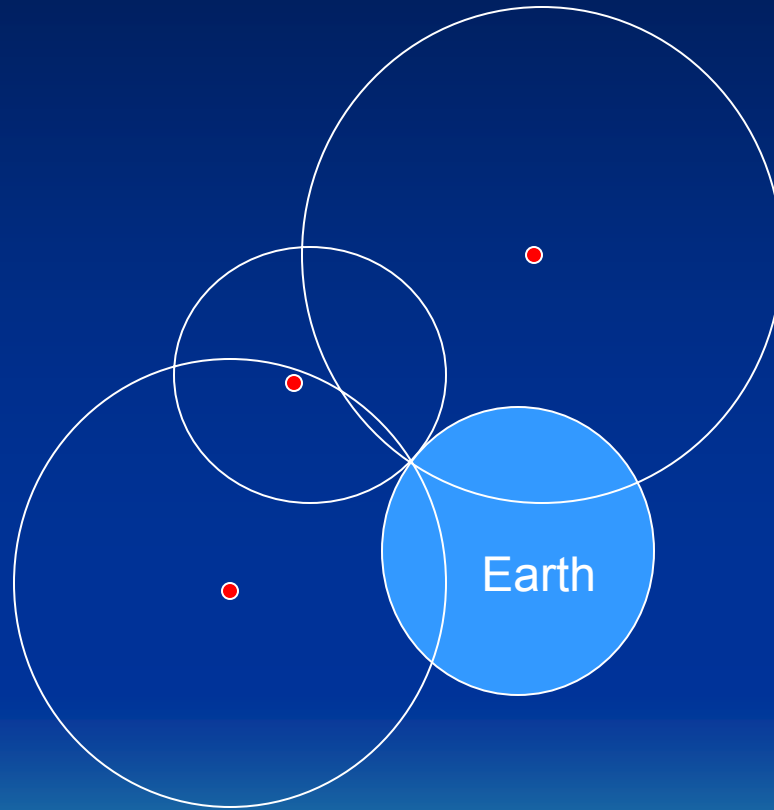


GPS Surveys

- Global Positioning System
- Constellation of 24 satellites orbiting at 50,000 km altitude
- At a given point on the earth at least 4 satellites can be tracked by receiver simultaneously
- 3 satellites plus the earth define a range of possible positions; the 4th satellite timing is used to arrive at a consistent position



Earth- GPS Satellite Geometry



GPS Satellite Characteristics

- Contain a very accurate atomic clock
- Orbit at a high altitude so that no friction with the atmosphere is possible, resulting in a very predictable orbit
- Broadcast signal contains the position of the satellite, and the time the signal was broadcast
- Satellites are maintained by the Military and NASA



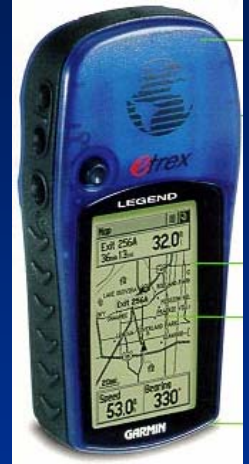
GPS Error Sources

- SA: selective availability
- Atmospheric heterogeneity
- Clock Error
- **Multipath Error (largest source of error)**
- PDOP: position dilution of precision
- Because of satellite geometry z accuracy is usually 1.5 to 2 times that of horizontal map accuracy



GPS Receiver Types

- Autonomous
 - Hand held receivers with built-in antenna (\$150 - \$500)
 - Receiver and external antenna (usually as a backpack or harness) combo (\$500 - \$5,000)
- Base Station (Survey Grade; Real-Time Kinetic) (\$20,000 to \$50,000)
 - Receiver and PDA data collector
 - Base station receiver with differential correction beacon broadcast



Typical GPS Accuracy

- Low-end autonomous: 5m (with differential beacon)
- High-end autonomous: 2m (with differential beacon)
- RTK: 1cm



Differential Correction Beacons

- A GPS receiver is permanently fixed at a known benchmark
- A correction factor that accounts for the differential between the actual and calculated position is continually broadcast on the FM radio band from the benchmark
- In theory any errors generated by PDOP or atmospheric conditions can be eliminated by a GPS receiver that applies the correction factor
- Multipath errors are not eliminated by differential beacons (DGPS)

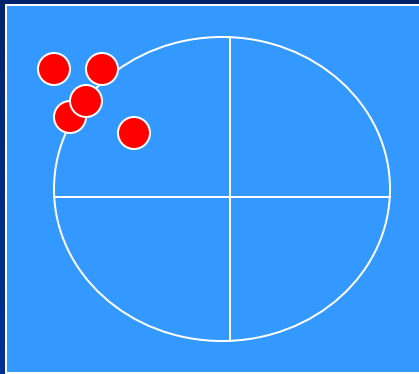


GPS Accuracy & Precision

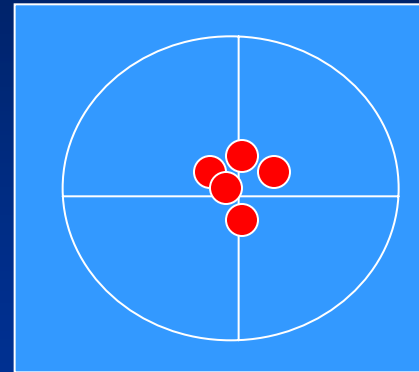
- Precision is the reproducibility of the measurement
- Accuracy is how close the measured position is to the actual location



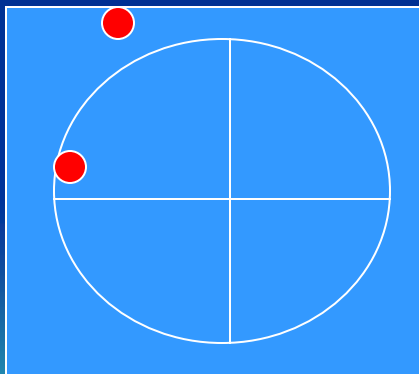
Concept of Precision & Accuracy



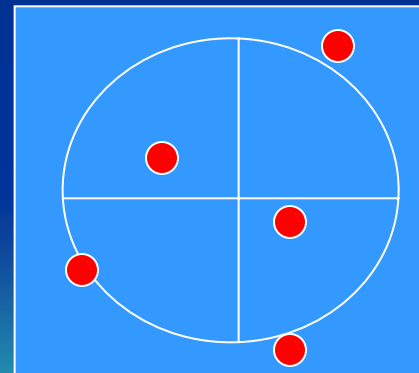
Good precision,
Poor accuracy



Good precision,
Good accuracy

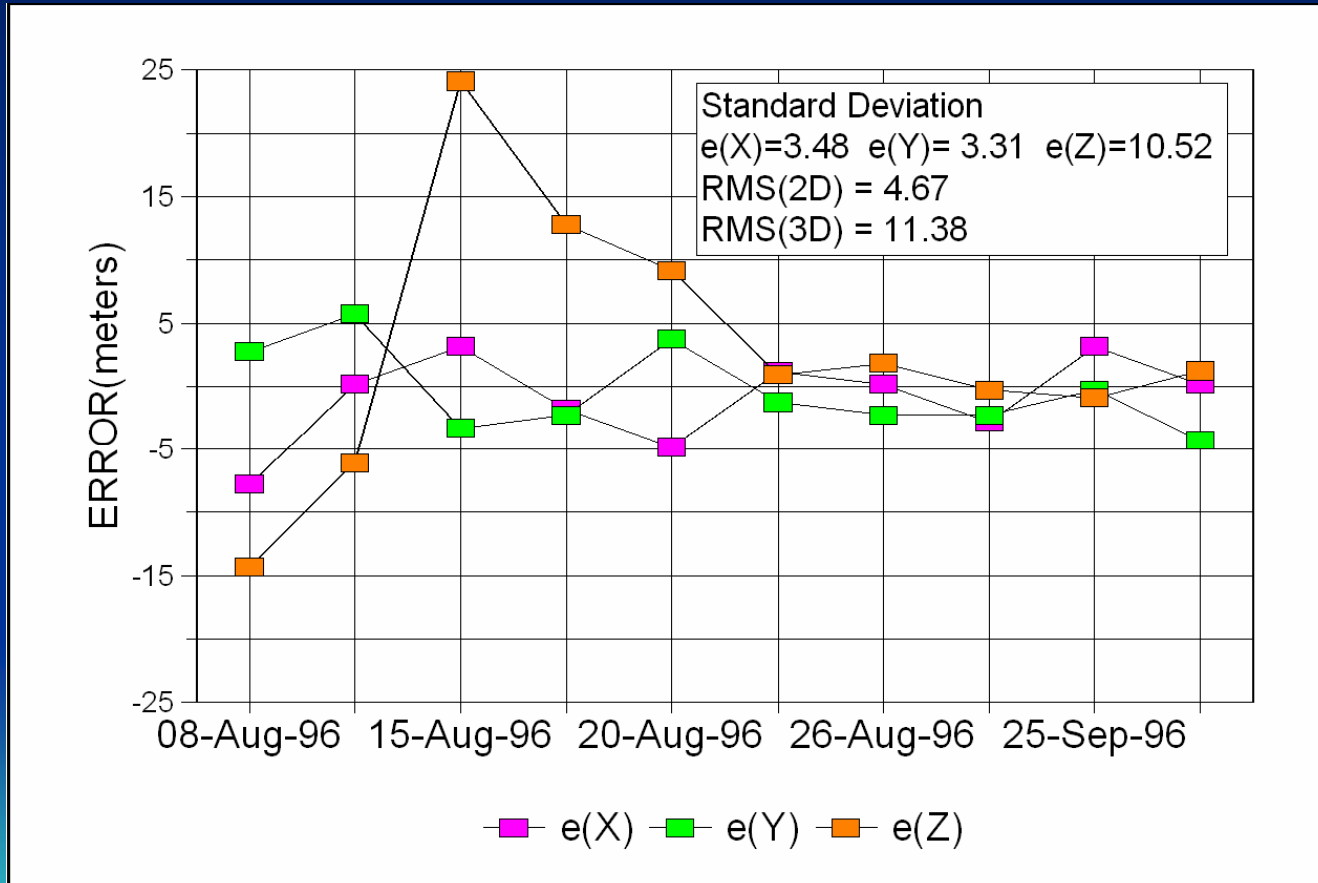


Poor precision,
Poor accuracy



Poor precision,
Good accuracy

Accuracy & Precision cont.

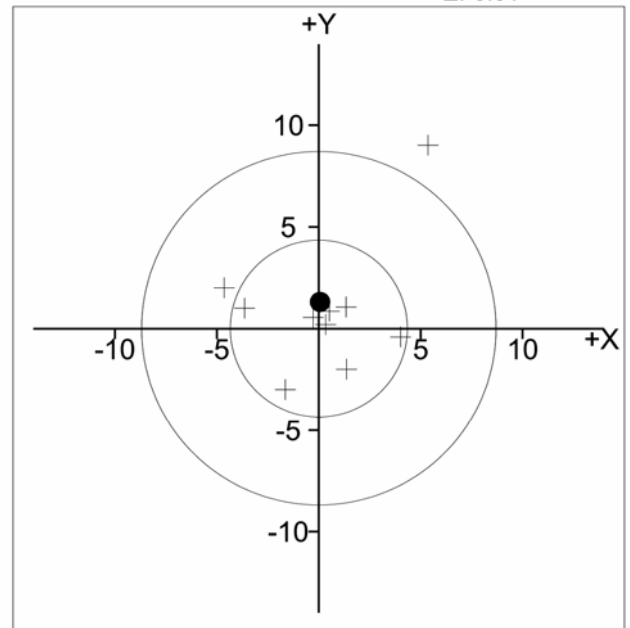


GPS RMS Values

- RMS: root mean square
- $RMS = \sqrt{\Sigma(d)/N}$ where d = distance from actual position

Rockwell/Accupoint
PID: BH3177
RMS(2D): 4.35
RMS(3D): 6.91

ERROR AVERAGES
X: 0.06
Y: 1.31
Z: -0.01



Lecture Test 1 Review

- Take home test
- Contour problem
- Topographic profile
- Alidade data reduction (use spreadsheet)
- Surfer contour problem
- Relational fraction (RF) problems
- Pace and Compass problem

