12.S56 GPS: Where Are You?
Fall 2008

12S56 Seminar 3 September 29 – October 6, 2008

Topic

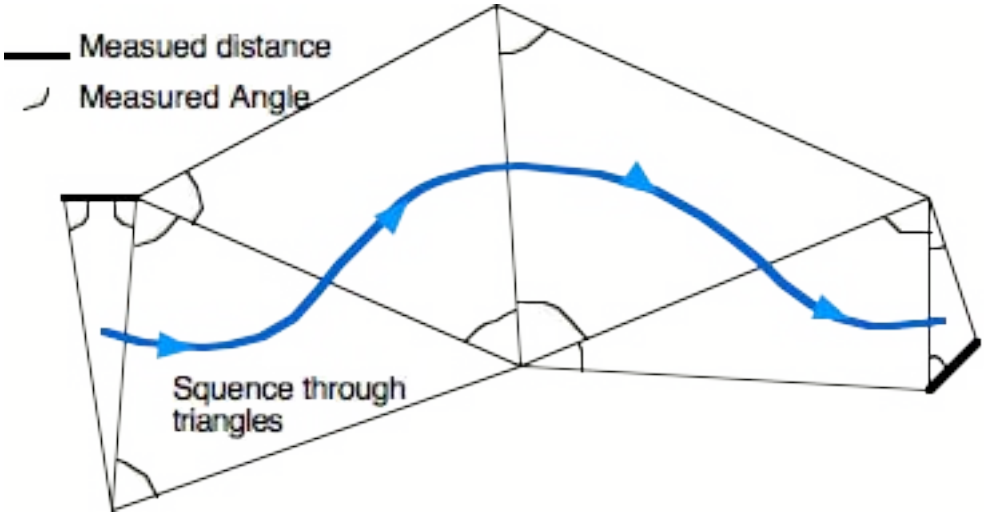
Discussion of results and techniques used to. How do you measure position without gravity? Geometric systems that use distance measurement. How to do this? How do you make maps and what is significance?

Primary Aim

Basic aim of this contrast the different types of coordinate systems: Gravity field based and geometric ones and look at how distances are measured.

Discussion

How would we measure distances over large distances? Especially further than we can see? Over short distances we can use a tape measure but how to measure further.
Triangulation: Measure base of triangle and the angles to another point. Keep making the triangles larger. (Method developed by Snell in the 1500ís).



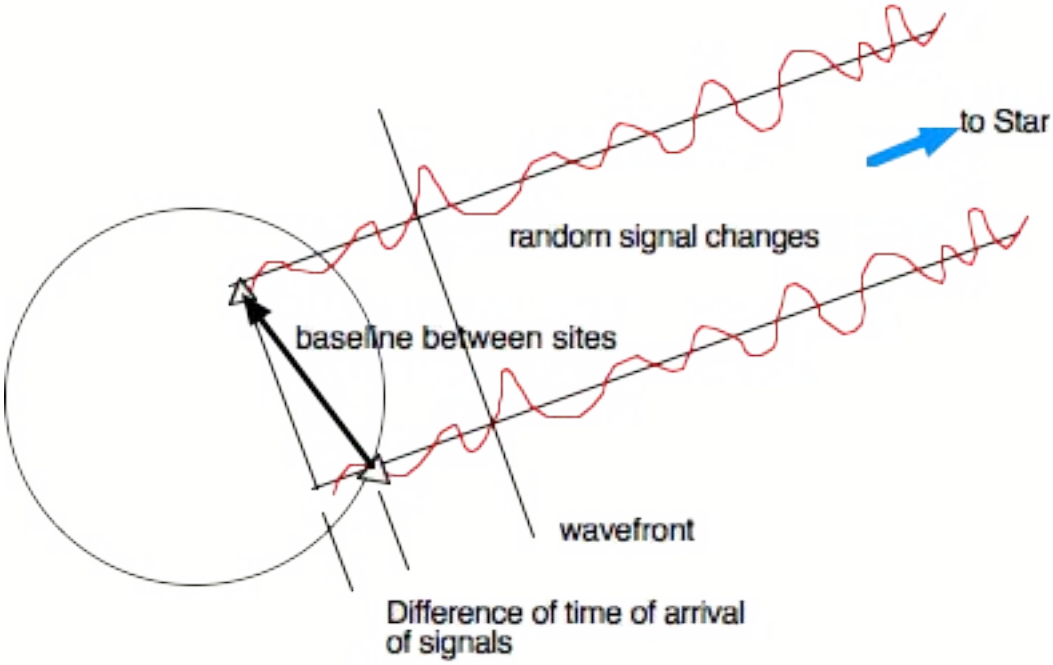
In reality all angles are measured and there is a problem in the “horizontal” angles at each point are measured relative to local gravity and so this system is really a mix of geometric and gravity based systems.

By the 1950ís it was possible to measure the distance s directly using Electromagnetic Distance Measurement (EDM) but still these distances need to be projected to a level surface.

A global distance measuring system: Can you measure the distance to a star? Yes: Can you measure it from different locations sufficiently accurately that you can tell where the sites are? Usually astronomical distance measurements are parallax (uses the orbit of the Earth around the

run, brightness of objects (calibrated with parallax to nearby objects) and velocity of motion (Hubble's constant and the expanding universe). None of these techniques have enough accuracy to tell use where the stations are but we can change the question and find out where the stations are.

Rather than measure the distances to the star from two different locations, the difference in distance between to sites is measured. Technique called very long baseline interferometry (VLBI) and shown in figure below.



If two sites record signals from a stellar object (in VLBI normally strong radio emitters called quasars), and the clocks at the two sites are synchronized then the recorded signals can be cross-correlated in the difference of the arrival times of the signals measured,
Measurement to a single object determines only one component of the baseline, perpendicular to the direction to the source. As the Earth rotates, the projected component of the baseline changes and so this component can be measured relative to the rotation axis of the Earth. At least one other star is needed to get all the components of the baseline.

When the stars are at an infinite distance, these measurements are insensitive to the translation of the system but are very good for obtaining the relative coordinates of the sites. What would need to changed to get coordinates relative to center of mass of the Earth?

Map making: Techniques such as triangulation and VLBI (and even GPS) are too expensive to make maps with. (Too many points would be needed). Most maps are made from aerial photography using ground points determined by geodetic methods for control of the images. Stereographic photographs are taken so that height information can also be obtained. With digital photography, digit maps can be directly mad. Although currently most digit maps (for car navigation systems) are made by digitizing paper maps.