USING GPS AND GIS TO ENHANCE PERFORMANCE OF A PORTABLE TELEMETRY SYSTEM

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ABSTRACT: Global Positioning System (GPS) and Geographical Information System (GIS) can assist with triangulation as a means of re-locating radio tagged animals. Locations of twenty five moose (*Alces alces*) fitted with radio telemetry collars were monitored using truck mounted telemetry equipment, GPS receivers, GIS software, and a portable computer. This paper explains how GPS can be used to calibrate antenna arrays on portable receiving stations and GIS to generate lines of triangulation on a portable computer in the field.

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A variety of techniques have been used to obtain positional data on wild animals fitted with radio transmitters. These include triangulation, both fixed station (Heezen and Tester 1967) and mobile (Cochran and Lord 1963, Verts 1963, Tester *et al.* 1964), and from fixed-wing aircraft (Fuller and Snow 1988), helicopters, and satellites. In recent years, GPS and GIS have found a variety of uses in wildlife management and research (Lynch and Shumaker 1995).

When a portable tracking unit is moved to a new location the degree disk must be adjusted to compensate for the orientation of the vehicle. Methods for doing this include parking in the same direction at each stop, using a magnetic compass (Hallberg *et al.* 1974), using known straight roads or fence lines (Verts 1963), sighting on surveyed markers (Hutton *et al.* 1976, Anderson and De Moor 1971), and using known landmarks (Hutton *et al.* 1976, Cederlund and Okarma 1988). Anderson and De Moor (1971) used a beacon transmitter to help calibrate their degree disk. Most of these methods are complicated by magnetic declination and difficulties in physically lining up a vehicle in reference to a landmark.

Yagi antennas used for animal tracking are highly directional; their greatest gain occurring when the front of the antenna is pointed toward the incoming signal. Biologists often assume that the front of their receiving antenna is pointing directly toward the transmitter when they record an azimuth. However, an antenna pattern is complicated by the existence of side lobes, back lobes and asymmetry of the main lobe (Moell and Curlee 1987). It is further complicated when two antennas with their respective imperfections are used in a null-peak array. Asymmetry in a telemetry receiving system is difficult to detect and can be large enough to induce unacceptable errors in azimuth readings.

I conducted a moose telemetry project in Alberta that required supplementing aerial with ground locations. This paper explains the use of GPS and a beacon to orientate the degree disk and correct the symmetry of a portable antenna array and the field use of a computer to generate lines of triangulation and determine areas of polygons produced when three lines of triangulation cross.

MATERIAL AND METHODS

During June 1994, 25 moose were captured by net gun and equipped with telemetry collars. The purpose of the project was to determine survival rates of female moose in an area where moose numbers were declining in spite of restrictive hunting seasons on females. The study area contained many secondary roads that enabled us to use a truck mounted portable receiving station to triangulate.

Moose transmitters were collar mounted, with frequencies between 150.800 and 151.800 megahertz (Wildlife Materials HLPM-22200-M). The beacon was a high output 3-stage unit (Wildlife Materials HLPM-39140-HDHI). The receiver was a Wildlife Materials Falcon V equipped with APS-164 scanner. The antenna system was mounted in the bed of a pickup truck and consisted of an antenna array fastened to a mast that passed through the centre of a 3m tower section. The mast was mounted on a ball bearing base that rotated 360 degrees. A pointer extended from the base above an adjustable degree disk. Cushcraft 4-element yagi antennas were trimmed to frequency and set up in a null-peak array. The entire system was mounted on a hinged platform that could be lowered during transit. The GPS was a hand held Garmin GPS 55 STD. The portable computer was a Toshiba T6600C with 486 processor and 32 megabytes of RAM operating under Windows 3.1. Software was MapInfo 3.0 and Quattro Pro 6.0.

Antenna Calibration

The high powered beacon was placed on a height of land so it could be received at all mobile tracking locations. The GPS was used to store the location of the beacon as a way point. At a tracking location, the "Go To" function of the GPS was used to determine the direction to the beacon in degrees. The GPS, set to true rather than magnetic bearing, provided distance and direction to the beacon. Next the telemetry receiver was tuned to the beacon frequency and the null-peak system used to point the antenna toward the beacon. The degree disk was then rotated so the pointer indicated the true azimuth as obtained from the GPS way point. This procedure correctly calibrated the degree disk and compensated for any possible asymmetry in the antenna array.

Real-time Triangulation

We used MapInfo to generate lines of triangulation and to determine the area of the error polygon produced when three lines of triangulation crossed. At each mobile station, we entered the location of the station (from the GPS unit) into MapInfo. Next, we used the beacon to orient the degree disk on the antenna system. Finally, we used the antenna system to obtain the true azimuth to the moose from our mobile station. We repeated this procedure from two additional locations and used the three azimuths to calculate the error polygon, an indication of the accuracy of triangulation. To plot the azimuths in MapInfo, we first converted to UTM coordinates. Latitude and longitude cannot be used because 1 degree of latitude is not equal in length to 1 degree of longitude. After conversion to UTM we used standard trigometric functions to calculate azimuth lines and the error polygon (Fig. 1).

Some of the angles formed when lines of triangulation crossed were less than optimal for precision radio tracking. White (1985) indicated that precision of the estimate of a

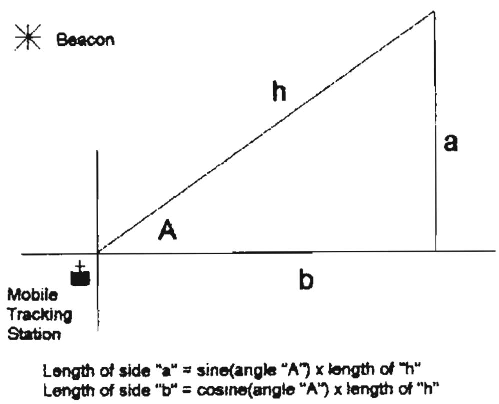

Fig. 1. Diagram of a right triangle showing how sine and cosine can be used to calculate lengths of sides "b" and "a" when angle "A" and the length of the hypotenuse "h" are known.

radio location is a function of distance between receiving towers, precision of the bearings, and angle of intersection of two bearings. Locations are most precise when the bearings are at 90 degrees (White 1985). We discarded lines that created sharp angles and obtained additional readings on a moose until lines crossed at better angles and polygons formed by three lines of triangulation were less than 0.5 km^2.

Site selection for mobile tracking stations was another key to precision radio tracking. Our system worked best on high ground where we were above tree level or in clearcuts on the tops of hills. In heavily forested areas we tried to select high ground next to a meadow, pond or lake. Stands of very large trees near our site always produced distortions. The key to successful radio triangulation is high ground (Moell and Curlee 1987). Garrott *et al.* (1986) reported on the accuracy of four 3-tower triangulation systems .

We used several techniques to increase our efficiency in the field. A template in Quattro Pro was used to convert the current location and an azimuth to a triangulation line. We used look-up tables on locations used often. A battery operated 8-hour timer was used to turn the beacon off at the end of the day, making it unnecessary to retrieve the beacon after the radio tracking session. Details of the techniques used to increase efficiency are available from the author.

DISCUSSION

All of the telemetry equipment, the computer and GPS worked well for us. The "T-switch" on the APS-164 scanner caused the unit to generate tones proportional to the strength of the incoming signal and was especially helpful for detecting nulls. The beacon was overpowering at times, making it difficult to listen to moose transmitters on frequencies close to that of the beacon. This problem could be minimized by selecting a beacon frequency distant from that of any of the moose transmitters.

The Garmin GPS 55 did not provide satellite orientation data and could not be differentially corrected for improved accuracy. Mobile locations were within 100 m 95% of the time. Increased accuracy is possible with real-time differential GPS, or by post-processing the mobile locations later. Our project did not require that level of precision, therefore the uncorrected data provided by the Garmin GPS 55 was adequate.

Further work with this technique is needed to better understand the accumulative effect of using non-differential GPS to locate the mobile tracking station (3 times), azimuth to moose (3 times), and the error polygon from triangulation (1 time). Those interested in using the technique should consider switching to differentially corrected GPS and conduct accuracy tests using transmitters in known locations.

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