SURVEYING FOR THE REAL ESTATE PROFESSIONAL

A "how to" article that details four computer programs aimed at solving your surveying problems.

by Wilbert L. White, CRE

Sometimes during a market investigation, you read a deed and the metes and bounds legal description goes all around the tract and fails to state the amount of land enclosed. The recorded plat of a subdivision will show all the calls around an irregular lot, but will fail to give you the land area. You receive a complete boundary survey which states the total land area however, there is a road going through the property with a canal alongside that isolates and nearly landlocks a small section. This part may have a different highest and best use, but the land area is not shown. These and many other situations arise that cause irritation and frustration to a real estate professional who does not have an engineering education with a course in surveying.

The advent of the electronic calculator, programmed with a magnetic stick, provides a solution to this problem. The Hewlett-Packard and Texas Instruments Companies make calculators with this feature, and they also provide surveying pacs or packages that work with their calculators for a rather small additional cost. I can go around a seven or eight-sided tract with a curve or two and calculate the area on my machine in about five minutes. The same problem would have taken half-a-day on a slide rule using the DMD (double-meridian-distance) method, and the results of the new method are more accurate.

This article will make you familiar with the programs and their operation, and it will tell you how to use the information supplied by a surveyor to solve problems the survey doesn't address. Without these programs, you might be forced to make an educated guess or hire a surveyor to solve the problem.

Application Packages

The application packages are based on the coordinate system of surveying. All of the points on a survey are shown as being a certain distance north (or south) of an arbitrary east-west line and a certain distance east (or west) of an arbitrary north-south line. Numbers that are south or west of these arbitrary lines will have a negative sign. This doesn't make any difference to the calculator, however it may cause you some confusion. This problem can be avoided if you assign the southwesterly corner of a smaller tract the coordinates: N-1,000, E-1,000. On larger tracts, the coordinates: N-10,000, N-10,000. will usually remain positive. By using the coordinate system it is easier and more accurate to plot the

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coordinates of the corners on graph paper than to use a protractor and scale if you need a sketch of the property.

The angles used in the program calculations are based on the azimuth system. Most surveys show the angle of deflection in degrees east or west from a north or south line. A line into the northeast or number 1 quadrant has the same azimuth as its angle of deflection (North 45° 35′ 16″ East has an azimuth of 45° 35′ 16″. It is entered as 45.3516.) The southeast quadrant is number 2, the southwest is number 3 and the northwest is number 4. If the angle of deflection and the quadrant number are entered, the program calculates the azimuth. The cosine of an azimuth in the northern hemisphere has a positive sign and one in the southern hemisphere has a negative sign. The sine of an azimuth in the eastern hemisphere has a positive sign and in the western hemisphere a negative sign. In the traverse program, the cosine of the azimuth is multiplied by the horizontal distance along the line and the result is added to the north coordinate of the first point to obtain the north coordinate of the second point. The product of the sine of the azimuth times the horizontal distance is added to the east coordinate of the first point to obtain the east coordinate of the second point.

Each manufacturer has a different system for entering data into their program and some program differences are necessary because of the various models produced by the same manufacturer. The program's key strokes must be followed exactly. Because of the limited memory in the calculator, the programs are unforgiving of any errors more than one point back in the traverse. The inverse program will allow you to go back to the last point if you make an error in data entry and then you can enter the correct data. Since a record of the coordinates is very important if you need a sketch of the property, a calculator with a tape printer or one that can be attached to a tape printer is preferred and will make a difference in the operating speed of the program.

DEFINITION OF TERMS

The *radius* is the distance from the center to the curve.

The *chord* is the straight line distance between the end points of the curve.

The *arc length* is the distance around the outside of the curve.

The *degree of curve* is the angle needed to have an arc length of 100′.

The *central angle* is the angle formed by the radius lines to the ends of the curve.

The *tangent* is the distance along the continuation of a tangent line from the point of beginning of a curve to its intersection with a continuation of a line that is tangent to the other end of the curve.

The *mid-ordinate* is the distance from the chord to the midpoint of the curve.

The *external* is the distance from the midpoint of the curve to the intersection of the two tangent lines.

If any two of these items are known including at least one of either the radius, degree of curve or central angle, the program will calculate the rest. In addition, the program will compute the areas of the *fillet, segment* and *sector.*

The *fillet* is the area enclosed by the outside of the arc of the circle and the extension of the two tangent lines.

The *segment* is the area enclosed by the chord and the arc of curvature. It is the area added for a curve to the outside and subtracted for a curve to the inside of a tract.

The *sector* is the area enclosed by the radius lines and the arc of curvature.

Four Software Programs

My surveying application pac contains 19 different programs and several are of a technical nature. I have only used four of them and they have taken care of my problems and more than justified their $35.00 cost. I use the following programs:

1. Traverse, Inverse and Sideshots,
2. Intersections,
3. Curve Solutions,
4. Predetermined Area.

The most frequently used program is the traverse, inverse and sideshots because it has the capability of calculating the effect of curves on the area of a tract. Since the data needed for curves is the most often neglected in a legal description, a discussion of the curves program is given.

Curve Solutions

There are two kinds of curves. All of the above pertains to tangent curves. There are three additional points to remember about tangent curves. One, the angle of deflection between a tangent line and the chord is half of the central angle. Two, the central angle is equal to the angle formed between the extension of one tangent line and a line to the point of intersection with the extension of the other tangent line. Three, the central angle between tangent lines never changes, but the length of the radius will change all of the other values.

On nontangent curves, it is helpful to know the distance and direction from one end of the curve to the center point in order to calculate the deflection of the chord if it is not given by the surveyor. Another solution to this problem is to start the traverse program at one end of the curve and traverse around to the other end of the curve. The inverse program will then close the survey.

Intersections Program

Another useful program is the intersections program. If you have a nonrectangular tract with a road coming up to a boundary line at some angle other than 90° and it appears logical to continue the road through the tract, the intersections program will tell you where it hits the other side. If you know the coordinates of two points and the calls or azimuths of lines leaving these points, this program will calculate the location of the point of intersection of these two lines. It will give you the azimuth and distance from each of the two known points to the point of intersection and the coordinates of the point of intersection.

If you have a line leaving a known point with a given azimuth which crosses a circle where you know the coordinates of the circle's center and radius, it will give you the location of the two points where the line crosses the circle. It also will give you the azimuth and distance from the first point to the point of intersection, the azimuth and distance from the center of the circle to the point of intersection and the coordinates of each of these points.

If you know the coordinates of the centers of two intersecting circles and the radius of these circles, it will calculate the points of intersection, show the azimuth and distance from the center of each circle to the points of intersection and the coordinates of each point of intersection.

Predetermined Area Program

Another helpful program is the predetermined area program. It operates with two different types of areas—a triangle and a trapezoid. When dealing with a triangle, you need to know the coordinates of the end points of a fixed line and the angle between the fixed line and a second line from one of these end points. The program will hinge a line from the other point until the desired area of the triangle is enclosed. It gives you the distance and direction from the first point, the distance and direction from the second point and the coordinates of the third point on the triangle

In the second predetermined area option, two sides of the trapezoid are parallel. The required information consists of the coordinates of the end points 1 and 2 on the base line and the bearings or azimuths of the lines leaving these end points. The program calculates the distance along each of these lines required to give the predetermined area with a line parallel to the base line. It also calculates the coordinates of the third and fourth points needed to form this trapezoid.

Traverse, Inverse And Sideshots Program

The program which I use the most is the traverse, inverse and sideshots. In the traverse mode you enter the bearing and quadrant number or the azimuth and then the horizontal distance. The program calculates the coordinates of the next point in the survey. It also calculates the area of a trapezoid formed by the base line, the two north-south lines and the side of the property. The area of this trapezoid is calculated by the formula: $A = (N_1 + N_2)(E_2 - E_1) / 2$. These areas are added to a memory location and the traverse is continued. The algebraic sum of these areas is the area enclosed by the traverse if you go in a clockwise direction. If you go in a counter clockwise direction, the solution will be negative, but the program changes it to a positive value.

The inverse portion of the program gives you the azimuth and the distance between two points where their coordinates are known. I find it useful to close the survey on the last call with the inverse program instead of the traverse program; this forces a correct closing of the survey. The last azimuth and distance should be very close to those given by the surveyor or there is a mistake. After the survey has been closed, the program calculates the sum of the horizontal distances around the tract, the area enclosed in square feet and repeats the initial coordinates.

If there is a curved side on the parcel, you traverse or inverse from the beginning point'of the curve to the end point of the curve along the chord, insert the central angle in degrees, minutes & seconds and enter the radius. If the curve goes inside the tract, the radius is given a negative sign; if outside the tract, it is given a positive sign. The program then adds the area of the segment of the curve algebraically to the total area of the tract.

Lambert Grid Coordinates

Sometimes the surveyor's field notes gives the Lambert coordinates of the various points on the tract. The Lambert coordinate system treats a very large area as if the world was flat instead of curved. There are 68 of these zones covering the continental United States and Alaska. The United States Department of Interior Geological Survey Maps have a 10,000′ grid based upon one of these Lambert projection zones. There are marks on the edges of the quadrant map which show the number of feet north or east of the base lines of the zone in which the property is located. A straight edge placed on these reference marks allows you to measure the distances to the property in which you are interested. These distances added to or subtracted from the Lambert numbers on the edges of the map gives you the approximate Lambert grid coordinates of the property. Some of the local maps in our area use the geological survey quadrant map as their base. These have tic marks at 5,000 or 10,000 feet intervals which expedite the location of the property's grid coordinates.

One of the factors which helps explain the difference in adjusted market prices in an area is the distance from the central business district of the nearest major metropolitan area to the property. I have found that within various sectors, there is a correlation between the market price of the land and the distance from the center of a major metropolitan area. The amount of variation may change in different sectors with the effect more apparent on properties adjacent to major highways and freeways. If you know the Lambert grid coordinates of the center of your major metropolitan area, the inverse program will rapidly calculate the Lambert azimuth and the distance to the property you're investigating. The last number displayed on the inverse program for my calculator is the distance between the two points. By dividing this distance by 5,280', you get a close approximation of the mileage to the central business district. I find this method is easier than attempting to draw long radius curves on a small scale map where it may be difficult to accurately locate a property.

It is possible to use the Pythagorean theorem (the square of the hypotenuse = the sum of the squares of the two sides on a right triangle) to solve this problem. However, at about 18.9 miles you reach the accuracy limits of a nine-digit calculator.

By way of illustration, the intersection of Main & Walker in Houston is close to being the 100% corner. It has Lambert grid coordinates of north 717,500' and east 3,153,500'. The main entrance into the NASA Manned Space Center in Clear Lake has Lambert grid coordinates of North 646,000' and East 3,243,200'. The inverse program indicates that this property has a Lambert azimuth of 128° 33' 30" and that it is 114,710' or about 21.73 miles from the center of Houston. Lambert North at Main & Walker is about 4° east of true north. This indicates a call of South 55° 26' 30" East.

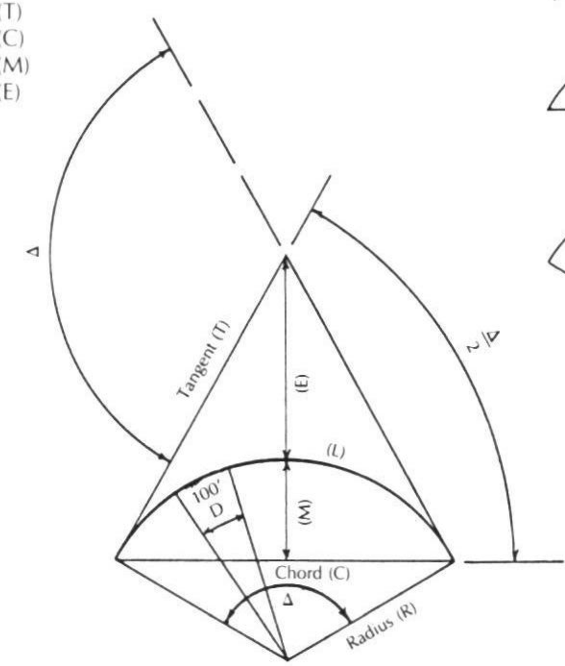
Another use of the traverse program, is to calculate the area of a large shopping center, industrial building or warehouse. Most drafting is done using angles of 90°, 60°, 45°, 30° and sometimes 15°. You don't have to use the actual directions. The front of the building is assumed to have an east-west or north-south orientation. You can traverse around the perimeter to find the area. However surveyors are careful about the boundary of a tract. If the building is in the middle of the tract and there is no possibility of a boundary encroachment, they may not be as careful. Surveyors and appraisers tend to measure a building differently.

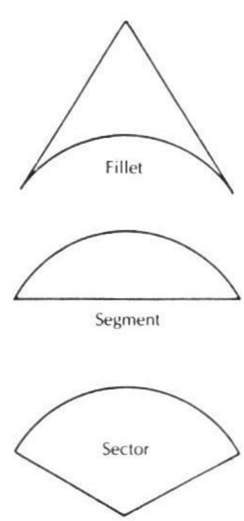
The program calculates dimensions to 0.0001 feet. I haven't seen the surveying crew assembled which can make measurements this accurate. The results you obtain from these programs should compare closely to those obtained from the surveyor. However, the programs do not make you a surveyor. They are capable of relieving the frustration from inadequate information on a survey. The purpose of this article is to point out those programs which appear to be most useful to the real estate practitioner and to review the fundamentals of their use. Surveying programs are also available for the various types of desk top computers. These programs apply the same basic principles faster, with more accuracy but at a larger expense.

The following diagrams have a sample problem showing the traverse, inverse and side shots program and the curve solutions needed in the traverse problem. A copy of the tape printout obtained while solving the problem is shown on the left side of the diagrams.

Curve Solutions
Sample Problem
(Tape Printout on Left)

200.0000	T	Radius (Entered)	(R)
28.3852	Z	Degree of Curve	(D)
64.5252	Y	Central Angle	(Δ)
226.4781	Z	Arc Length	(L)
127.1228	T	Tangent	(T)
214.5700	Z	Chord (Entered)	(C)
31.2104	Y	Mid-Ordinate	(M)
36.9814	Z	External	(E)
0.0000	T		
22647.8134	Z	Sector	
4539.2213	Y	Segment	
2776.7389	X	Fillet	





Traverse, Inverse & Sideshots
Sample Problem
(Tape Printout on Left)

1.0000	***	Point of Beginning
1000.0000	***	Initial North
1000.0000	***	Initial East
28.1523	***	Azimuth
256.4200	***	Distance
2.0000	***	Point
1225.8645	***	North
1121.3938	***	East
116.1705	***	
321.0000	***	
3.0000	***	
1083.7154	***	
1409.2039	***	
195.3144	***	
403.6700	***	
4.0000	***	
694.7811	***	
1301.1316	***	
337.4127	***	
256.8300	***	
5.0000	***	
932.3871	***	
1203.6379	***	
288.2203	***	
214.5691	***	
6.0000	***	
1000.0000	***	
1000.0000	***	
-4539.2022	***	Segment Area
214.5691	T	Chord
226.4778	Z	Curve Length
64.5252	Y	Central Angle
-200.0000	X	Radius
1464.3978	***	Sum of Horizontal Distances
90748.0150	***	Area in Square Feet
21.0215	***	Closing Error Azimuth
2.785677655-07	***	Error Distance
7.0000	***	Point of Beginning
1000.0000	***	
1000.0000	***