JASON E. FOOSE, PS

the HP 35s calculator

A Field Surveyor's Companion

Part 7—Adjustment

The current price range of the HP35s is $50-$60 in the United States. In 1972 a new HP35 cost $395. Adjusting $395 to 42 years of inflation equates to about $2,200 according to internet fodder. Going backwards, $60 in 2014 bucks equates to about $10.75 in 1972. It's no big secret that electronics are really cheap now-a-days and who really cares? Well, I do! I'm teaching you how to wring every single dime out of a $60 dollar black box that is really worth $2,200. Our next few programs require your elbow grease to squeeze the lemonade out of the old black box.

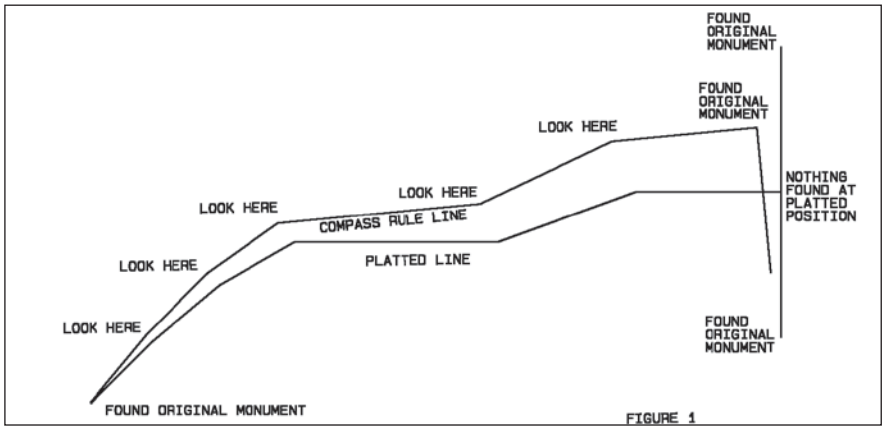

Figure 1

This Month's Program

Background

Why do we even bother to adjust our surveys if our modern measuring capabilities are ridiculously precise to begin with? Least squares network adjustment will resolve the most probable statistical value of measurements and positions. That type of adjustment truly improves consistency of expectations when comparing positional values. Positive applications include baseline networks and level networks. Contrary to our judicial function as boundary retracement surveyors, the objective of control work is resolving the most absolute positional value for a particular station. For example as in the NGS case the station mark itself is subordinate to the values assigned, adjusted, published, updated, and republished as the geodesy is refined. I really don't think that Michael Dennis and Dave Minkel sneak out at night with a hammer and bang every mark on the continent over a smidge. Of course not, they simply report the updated adjustment values which lend the appearance of a "floating" mark to us dirt surveyors. I can assure you that NGS marks are very static and don't "move"! However, when introducing NGS control into a network, the expectation is to adjust the physical measurement between control points to the known adjusted control values. That is somewhat contrary to our expectations as boundary retracement surveyors. We most often and comfortably report varying measurements between legal corners and place our emphasis on the evidentiary value of a position as controlling rather than the mathematically derived coordinate. *{If you feel any challenge to my last statement please unsubscribe from The American Surveyor. You are not practicing Land Surveying. You are engaging in some sub professional measurement exercise and you are a FRAUD!!!}.*

Our predecessors did not necessarily seek to resolve the most probable statistical value of a position but rather aimed to accurately identify the location of legal evidence. Their purpose for adjusting measurements was to promote consistency for retracement rather than a truly "most probable value". They measured linearly and thus they adjusted measurements linearly. According to "Surveying" by Davis, Foote, and Rayner circa 1928, *"Many surveyors, however, rely upon their own judgment, in large measure disregarding any established rule, and arbitrarily distribute the error in accordance with their estimation of the difficulties met in the field. Manifestly, if certain courses are over rough ground, the error of chaining these courses would be expected to be relatively large, and the correction to the observed distance should be correspondingly great; also when sights are steep and visibility is poor, larger angular errors would be expected than where conditions of observing are more nearly ideal, and hence in balancing the survey it is fair to assume that the larger changes in direction should be in the courses where conditions surrounding the observations were relatively unfavorable."* It should be apparent that the quest for the absolute mechanical position of a point is of little relevance in retracement work. However, employing the compass rule adjustment simply provides a consistent

method to distribute error through your measurements.

Compass Rule can logically be applied to aid in recovery of evidence when a consistent difference is noted between plat reports and observed measures. Where original subdivision lines were physically run the difference between the physical end points and the platted positions could be prorated through the line points. The thought being that accumulated field error was accepted on the ground but not accounted for on the plat. This computation may lead the retracement surveyor closer to the original evidence of the work as laid out on the ground. Frederick W. Boreman P.S. 6855 (Ohio) used to say "Jase, they're like clams. When one coughs, it gives them all away." (see **Figure 1**)

The benefits of least squares adjustments are negligible if not perhaps misleading (too good for the intended purpose) when applied to modern retracement survey work. The compass rule method is well suited to retracement efforts because of its simplicity and repeatability. It is quite a simple premise: any error is proportionally distributed to every measurement in a lineal set according to each measure's magnitude. Traversing is linear and stations are generally physically dependent upon only the adjoining stations. When measurements are made with consistency they are considered equal in weight so there's little if no need to apply any sort of arbitrary or statistical weighting.

Please do not hesitate to send any comments, concerns, questions, or criticism to *rls43185@gmail.com*.

The Program

Program B: Compass Rule Traverse Adjustment

This program is very dependent on the order and format of the traverse entry. The objective is to get the foresight point number to match the input leg number. The reasoning is that the program operates on a loop counter and requires sequential addressing with the order of the legs as entered. Traverse legs will be overwritten by the values of the computed coordinates as they are addressed to the same register. This may take some rearranging on your part or a change in field numbering discipline. Remember to enter azimuths/angles in decimal degrees. Final report of angles and azimuths is in DMS format.

Example Data and Running The Program

Create a traverse sketch and use field notes to construct a data table like the examples below. Raw coordinate values are listed to demonstrate differences but are not apparent while running the routine. Raw coordinates are computed by simply assuming the backsight azimuth of N35E between points 4 and 5 and simply running around the polygon. The program uses the statistical accumulator and registers. Access Σ registers through keystrokes **BRS** **-** for the "SUMS" menu.

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SETUP			INTERIOR ANGLE		
BACKSIGHT	OCCUPIED	FORESIGHT	ANGLE RIGHT COUNTER CLOCKWISE	FORESIGHT DISTANCE	LEG
4	5	1	159-32-25	330.25	1
5	1	2	76-31-45	600.23	2
1	2	3	89-01-01	598.21	3
2	3	4	89-58-46	330.43	4
3	4	5	125-00-48	325.89	5

KEYSTROKE STEPS	RESULTANT DISPLAY	ACTION
XEQ GTO ENTER	Y-reg : X-reg : COMPASS RULE	Executes program {B} and displays program annunciator. "B" is for Bowditch.
R/S	Y-reg: X-reg: ANGL RT INTRNL	Annunciator/reminder to enter angles right, going counterclockwise, internal angles (as in "N-2x180").
R/S	Y-reg : A? X-reg : default value	Prompt for first angle. This is important because your first angle is actually your closing angle. Your occupied point is actually your last point in the traverse whereas your foresight (1st leg) is the measurement to your P.O.B. and closing point. Creating a sketch and table help to sort this out. You may find simply assuming a sequential point numbering scheme to be helpful. I can provide a simple "renumbering" program" upon request that enables you to reassign values consistent with your original point numbering schematic.
159.3225 YLS 8 R/S	Y-reg : D? X-reg : default value	Enter angle in DMS then convert to DD (159.5403) Prompt for foresight (leg) distance appears.
330.25 R/S	"RUNNING" then Y-reg: X-reg: LEG NUMBER	Annunciator for the foresight/leg number. This must begin with 1 and follow sequentially.
R/S	Y-reg : J? X-reg : default value	Prompt for leg number.
1 R/S	Y-reg : X-reg : END 1=Y 0=N	Annunciator to end loop. Enter 1 to complete the loop or 0 to enter another leg.
0 R/S	Y-reg : X-reg : ANGL RT INTRNL	Annunciator/reminder. This is the beginning of the next leg and follows the same steps.
R/S	Y-reg : A? X-reg : default value	Prompt for angle.
76.3145 YLS 8 R/S	Y-reg : D? X-reg : default value	(76.5292 DD) then Prompt for distance.
600.23 R/S	"RUNNING" then Y-reg : X-reg : LEG NUMBER	Annunciator for foresight/ leg number.
R/S	Y-reg : J? X-reg : default value	Prompt for point number.
2 R/S	Y-reg : X-reg : END 1=Y 0=N	Annunciator to end loop. Enter 1 to complete the loop or 0 to enter another leg.
0 R/S	Y-reg : X-reg : ANGL RT INTRNL	Annunciator/reminder. This is the beginning of the next leg and follows the same steps.
R/S	Y-reg : A? X-reg : default value	Prompt for angle.
89.0101 YLS 8 R/S	Y-reg : D? X-reg : default value	(89.0169 DD) then Prompt for distance.
598.21 R/S	"RUNNING" then Y-reg : X-reg : LEG NUMBER	Annunciator for foresight/ leg number.
R/S	Y-reg : J? X-reg : default value	Prompt for point number.
3 R/S	Y-reg : X-reg : END 1=Y 0=N	Annunciator to end loop. Enter 1 to complete the loop or 0 to enter another leg.
0 R/S	Y-reg : X-reg : ANGL RT INTRNL	Annunciator/reminder. This is the beginning of the next leg and follows the same steps.
R/S	Y-reg : A? X-reg : default value	Prompt for angle.
89.5846 YLS 8 R/S	Y-reg : D? X-reg : default value	(89.9794 DD) then Prompt for distance.
330.43 R/S	"RUNNING" then Y-reg : X-reg : LEG NUMBER	Annunciator for foresight/ leg number.
R/S	Y-reg : J? X-reg : default value	Prompt for point number.
4 R/S	Y-reg : X-reg : END 1=Y 0=N	Annunciator to end loop. Enter 1 to complete the loop or 0 to enter another leg.
0 R/S	Y-reg : X-reg : ANGL RT INTRNL	Annunciator/reminder. This is the beginning of the next leg and follows the same steps.
R/S	Y-reg : A? X-reg : default value	Prompt for angle.
125.0048 YLS 8 R/S	Y-reg : D? X-reg : default value	(125.0133 DD) then Prompt for distance.
325.89 R/S	"RUNNING" then Y-reg : X-reg : LEG NUMBER	Annunciator for foresight/ leg number.
R/S	Y-reg : J? X-reg : default value	Prompt for point number.

KEYSTROKE STEPS	RESULTANT DISPLAY	ACTION
5 R/S	Y-reg : X-reg : END 1=Y 0=N	Annunciator to end loop. Enter 1 to complete the loop or 0 to enter another leg. We have returned to our first occupied station and have completed the loop of 5 traverse legs. Select "1" at the next prompt to complete (end) the traverse.
1 R/S	Y-reg : X-reg : SUM OF ANGLES	Annunciator for the sum of the angles in the polygon.
R/S	Y-reg : default value X-reg : 540.0445	Sum in X-reg DMS format.
R/S	Y-reg : X-reg : PERIMETER	Annunciator.
R/S	Y-reg : 540.0445 X-reg : 2,185.01	Perimeter distance in X-reg. Sum is bumped up to Y-reg.
R/S	Y-reg : X-reg : PER ANGLE	Annunciator for the angular surplus/deficiency required to balance angles.
R/S	Y-reg : X-reg : -0.0057	In *DMS*. Negative values represent excess to be subtracted..
R/S	Y-reg : X-reg : RUN CLOSURE	Annunciator beginning the closure function.
R/S	Y-reg : N? X-reg : default value	Prompt for POB northing coordinate. POB is point #5 in this scenario and the same as the first occupied point on our table.
5000 R/S	Y-reg : E? X-reg : default value	Prompt for POB easting coordinate.
5000 R/S	"RUNNING" then Y-reg : X-reg : BACKSIGHT AZ	Annunciator for the backsight azimuth of the first setup. In this scenario it is an assumed direction between points 5 and 4. The BACKSIGHT AZ is always an assigned direction between the last two points of the traverse.
R/S	Y-reg : A? X-reg : default value	Prompt for 360 degree north azimuth in DD. YLS 8 added below for emphasis.
35 YLS 8 R/S	"RUNNING" then Y-reg : X-reg : MISCLOSURE	Annunciator for misclosure. The sceen may display "running" for an extended period of a minute or so.
R/S	Y-reg : X-reg : 1 UNIT IN X	Annunciator for precision ratio.
R/S	Y-reg : 1 X-reg : 2,762	1 unit in 2,762 units. Y-reg=1 X-reg=2,762.

KEYSTROKE STEPS	RESULTANT DISPLAY	ACTION
R/S	Y-reg : X-reg : ADJUSTMENT	Annunciator for adjustment routine.
R/S	Y-reg : X-reg : STORE POINT	Annunciator for point storage loop. This process requires user keystrokes but could be automated. The user can review coordinates during the routine.
R/S	Y-reg : J? X-reg : default value	Prompt for 1st point number and Point Number 1. Sequential order must be observed or the coordinates generated within the routine could be overwritten.
1 R/S	Y-reg : (1)= X-reg : 4,680.20 *i* 4,917.12	Point 1 adjusted coordinates. This is generated from point 5 coordinates 5000*i*5000, the backsight azimuth of N35E, the adjusted angle of the 1st leg, and dispersed error.
R/S	"RUNNING" then Y-reg : X-reg : STORE POINT	Annunciator/reminder.
R/S	Y-reg : J? X-reg : default value	Prompt for sequential store point.
2 R/S	Y-reg : (2)= X-reg : 4,669.13 *i* 5,517.15	Point 2 adjusted coordinates.
R/S	"RUNNING" then Y-reg : X-reg : STORE POINT	
R/S	Y-reg : J? X-reg : default value	
3 R/S	Y-reg : (3)= X-reg : 5,267.15 *i* 5,517.46	Point 3 adjusted coordinates.
R/S	"RUNNING" then Y-reg : X-reg : STORE POINT	
R/S	Y-reg : J? X-reg : default value	
4 R/S	Y-reg : (4)= X-reg : 5,267.06 *i* 5,186.98	Point 4 adjusted coordinates.
R/S	"RUNNING" then Y-reg : X-reg : STORE POINT	
R/S	Y-reg : J? X-reg : default value	
5 R/S	Y-reg : (5)= X-reg : 5,000.00 *i* 5,000.00	Point 5 adjusted coordinates and closure.
R/S	Y-reg: X-reg: DONE	R/S to exit.

Program Listing

B001	LBL B
B002	SF 10
B003	EQN "COMPASS RULE"
B004	CLΣ
B005	CLVARS
B006	FIX 4
B007	EQN "ANGL RT INTRNL"
B008	INPUT A
B009	INPUT D
B010	Σ+
B011	RCL D
B012	RCL A
B013	XEQ C001
B014	EQN "LEG NUMBER"
B015	FIX 0
B016	INPUT J
B017	R▼
B018	STO (J)
B019	FIX 0
B020	EQN "END 1=Y 0=N"
B021	x=0?
B022	GTO B006
B023	FIX 4
B024	EQN "SUM OF ANGLES"
B025	Σy
B026	>HMS
B027	STOP
B028	FIX 4
B029	EQN "PERIMETER"
B030	Σx
B031	STOP
B032	FIX 4
B033	EQN "PER ANGLE"
B034	CF 10
B035	EQN ((n-2)*180-Σy) ÷n
B036	STO F
B037	>HMS
B038	STOP
B039	SF 10
B040	EQN "RUN CLOSURE"
B041	CF 10
B042	EQN 0.001*(J-1)
B043	STO L
B044	EQN 1+0 STO J *Note:* STO appears as a right arrow in EQN
B045	INPUT N
B046	INPUT E
B047	RCL E
B048	RCL N
B049	XEQ P001
B050	x<>y
B051	XEQ C001
B052	STO C
B053	STO B
B054	SF 10
B055	EQN "BACKSIGHT AZ"
B056	INPUT A
B057	RCL A
B058	RCL F
B059	RCL (J)
B060	ARG
B061	+
B062	RCL A
B063	+
B064	RCL (J)
B065	ABS
B066	x<>y
B067	STO A
B068	XEQ C001
B069	STO (J)
B070	RCL C
B071	+
B072	STO C
B073	RCL A
B074	180
B075	ENTER
B076	R▼
B077	x<y?
B078	GTO B081
B079	STO + A
B080	GTO B084
B081	+/-
B082	+
B083	STO A
B084	1
B085	STO + J
B086	ISG L
B087	GTO B057
B088	RCL E
B089	RCL N
B090	XEQ P001
B091	x<>y
B092	XEQ C001
B093	+/-
B094	STO + C
B095	RCL C
B096	ABS
B097	Σx
B098	FIX 0
B099	SF 10
B100	EQN "MISCLOSURE"
B101	x<>y
B102	÷
B103	1
B104	SF 10
B105	EQN "1 UNIT IN X"
B106	x<>y
B107	STOP
B108	EQN "ADJUSTMENT"
B109	CF 10
B110	EQN 0.001*(J-2)
B111	STO L
B112	EQN 1+0 STO J
B113	EQN 1+0 STO G
B114	RCL (J)
B115	FIX 2
B116	RCL C
B117	Σx
B118	÷
B119	RCL (J)
B120	ABS
B121	x (multiply)
B122	STO Z
B123	RCL (J)
B124	RCL Z
B125	+/-
B126	+
B127	RCL B
B128	+
B129	STO B
B130	SF 10
B131	EQN "STORE PNT"
B132	FIX 0

B133	INPUT J
B134	RCL B
B135	FIX 2
B136	STO (J)
B137	VIEW (J)
B138	CF 10
B139	1
B140	RCL + G
B141	STO G
B142	STO J
B143	ISG L
B144	GTO B115
B145	SF 10
B146	EQN "DONE"
B147	RTN

Jason Foose is the County Surveyor of Mohave County Arizona. He has been licensed for ≈ 441,504,000 seconds...no wait, 441,504,001 seconds...no wait, 441,504,002 seconds...

Did You Know?

Do you actually know the name of the division symbol? You know, the minus sign wedged between a colon? Well apparently Bill Gates forgot to put it in my Microsoft Office Suite so I set sail in that ocean of knowledge we call the internet. I found that the division symbol is named "obelus" and is available in MS Windows through keystrokes Alt+0247 on the keypad ÷ there, see I just did it! I'll do it again ÷ this is fun ÷ oh, BTW, sorry Bill I stand corrected!

Polecat of the Month

Mark E. Hummel, hailing from a certain un-named city holding six Superbowl titles and the rings to prove it, pointed out that Line I021 of the January 2015 Inverse Routine should include the keystroke EQN. Mark Hummel's great catch is second only to Franco Harris' Immaculate Reception in Iron City lore. Thanks Mark for pointing it out!