# Chapter 6 The Data Collection Process

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# 6. The Data Collection Process

# A. Project Control

P&S will conduct GPS observations for every project control network to establish horizontal control. Differential leveling will be performed between all survey monuments and flight line targets to establish vertical control. After the GPS and level data has been collected, the coordinate values for every project control point will be computed. The project control coordinates will then be distributed to the field office. These coordinates will serve as the basis for future survey activities, including but not limited to:

- Extendible and temporary monuments.
- Photo control surveys.
- Locating monuments for right-of-way retracement.
- Topography and utility surveys.
- Slope staking, blue topping and other construction related activities.
- Final quantity surveys.

# **1. Arbitrary Coordinates**

A GPS collected survey is not easily translated and rotated from an arbitrary coordinate system to the true coordinate system once it is established. Also, the accuracy of the manipulated GPS survey cannot be verified. Since every survey should be based on the P&S published coordinates, arbitrary coordinate surveys will no longer be accepted.

# 2. Data Collector File

After the coordinates for the project control network have been computed, a data collector file is generated. This file (\*.dc) is saved on the Falcon Data Management System where it is available for the field office. After the file has been successfully downloaded onto the TSC2, verify that the project control information is correct. This information includes the project name and section, project number, state plane zone, and datum adjustment factor (DAF).

A field check should also be performed by setting up on a control monument and checking the backsight distances and angles to adjacent monuments. Identify any differences between coordinate distances and field measurements larger than the allowable tolerances. Check the tolerances listed in Section VIII, Survey Standards, of the WYDOT Survey Manual. These differences should be reported to the State Photogrammetry & Surveys Engineer.

# 3. Extendible Control

Refer to Sections IV and V in the WYDOT Survey Manual for a guide on extending the project control network or replacing control points which have been damaged or destroyed.

# **B. Data Collector Settings**

When collecting survey data, it is important to verify that the settings discussed in Chapter 3 of this manual are entered correctly. These settings should always be checked at the start of a new job.

After a power outage, some settings in the TSC2 may default to the last entry. Other settings may default to the values defined in the survey style. Before collecting new measurements, settings such as instrument height, rod height, reflector type and offset, units, and PPM correction should be verified.

# 1. Date and Time

Set the date and time as accurately as possible. Refer to Chapter 3 of this manual for instructions.

# 2. Survey Units

The units on the data collector must be consistent with the control file and with the project criterion. Except for the rare metric project, most jobs utilize the U.S. Survey Foot.

# 3. File Name

Use the following standard format when naming a job file. Typical file names consist of a project number followed by a specific survey type and then a file extension.

# a. Survey Type

- SRV Project control survey.
- DTM Ground measurements used for earthwork computation and TIN files.
- UTL Utility survey.
- TOP Combination of planimetric and DTM data.
- PRO Profile survey.
- CNTL A project control file created by P&S for the data collector.
- GEO Geology survey.

# b. File Extension

- .dc A raw measurement file that has been downloaded from the data collector in a Trimble file format.
- .job A raw data file in a binary format. This file is created when the \*.dc file is downloaded.
- .bak A backup file created when the \*.dc file is opened with the Trimble DC editor.
- .edt A copy of the original \*.dc file that has been edited.
- .cor A coordinate file in a specific file format. The typical format is point number, northing, easting, elevation, feature code, and attribute. Refer to Chapters 8 and 10 in this manual for coordinate file requirements.

# c. Example

N345088UTL2.edt is the second utility survey collected on project N345088. This file is an edited copy of the original Trimble, N345088UTL2.dc file.

# 4. Feature Code List

Select the appropriate WYDOT feature code list at the start of a job. Refer to Chapter 4 of this manual for the current feature code list.

# 5. Control File

Coordinate values for the project control network are included in the control file created by P&S. This file is loaded onto the data collector and any project control point can be selected from the control file list as an instrument setup or backsight. When a control point is selected, the data collector displays the coordinate values (see Figure 6-6) for the setup. When creating a new job, link to a project control file as illustrated in Chapter 3 of this manual. Project control coordinates should not be manually entered to avoid key-in errors.

Occasionally, the instrument setup may need to be setup in a location that is not part of the project control network. In these situations, data collector rounds or resection procedures are used to establish the position of a new point. The Trimble data collector software uses a least-squares adjustment method to compute the coordinates.

# 6. Required Measurements

There are many conventional surveying methods used during the preliminary data collection process. It may be necessary to establish coordinates for an extendible control point or temporary control point prior to data collection. Performing multiple sets of observations from two or more known points are required to determine coordinates for these control points. For each measurement, the vertical angle, horizontal angle, and slope distance will be recorded by the data collector. The data collector compares the first set of measurements to subsequent sets to improve the accuracy of the extendible control points coordinates. Unlike control points, the collection of topographic features only require a single measurement from a known point.

The TSC2 term "rounds" refers to multiple measurements from an instrument setup to two or more survey points. The purpose of this procedure is to determine coordinates for an unknown point by making observations to known backsight points. Resection and sub-traverse procedures are forms of rounds. A resection establishes the coordinates of a point from an unknown instrument point to two or more known backsight points. A sub-traverse also establishes the coordinates of a point using measurements from a known instrument point.

In Table 6-1, the required number of measurements per instrument setup for specific surve	y
modes are listed below.	

Survey Mode	Required Measurements	Point Description	Point Numbers
Rounds	6	Project control points	0000-0299
	6	Extendible project control points	0000-0299
	6	Replacement project control points	0000-0299
	6	Traverse points	0000-0299
	6	Sub-traverse points	0000-0299
	2	Photo control flight line targets	0300-0399
	2	Photo control wing points	0400-0499
Resection	2	Auxiliary control points (i.e. rebar or railroad spike)	0000-0299
	2	Temporary control points (i.e. hub & tack)	0000-0299
	2	Bridge structure ties	1000-8999
Topography	1	Topography/DTM points	1000-8999
	1	Utilities	1000-8999
Editing	0	Renumbering or duplicating point(s) during office editing	9000-9999

Table 6-1. Required measurements.

# 7. Point Numbering

In the TSC2 data collector, each control point must have a unique point number within a job. This is necessary to avoid duplication and overwriting of points by Geopak. During general topography collection, auto-incrementing minimizes the chance of point number duplication. Table 6-1 illustrates specific point numbers for the observation of certain categories of points. Keep track of the point numbers used in a field book.

When manually numbering special category points and a point number is duplicated, the data collector alerts the instrument person. A verbal announcement "Out of tolerance" will be heard. Typically, the point is renamed with a unique point name to resolve the conflict.

# **C. Data Collection**

#### 1. Rounds

As previously mentioned, rounds are a conventional method of multiple observations to multiple points. At the survey controller main menu, tap on the *Survey* icon. Select *Station setup* from the *Survey* menu.



Figure 6-1. Station setup.

Set the *Pressure* and *Temperature* values and then tap *Enter*. Refer to Chapter 3 in this manual for more information on temperature and pressure settings. Tap the *Accept* button as indicated by the red oval to set the values.

<b>1</b> 2	Corrections		# ⊀	1:18	ok
- Cor	rections				90%
Pres	sure: 33inHg	Temperature: 36.0F			S ?
PPM 32	(Computed):	Curvature correc	tion:	Ŷ	-30 ?
Refr	action correction:	Refraction const	.:	Ma	аp
		0.142		Mei	nu
Show	corrections on startu	ıp:		Favor	rites
<b>⊻</b>				S <u>w</u> itc	h to
Esc				Acce	ept

Figure 6-2. Set atmospheric conditions.

At the *Station setup* screen, enter a point name in the *Instrument point name* field. A point name can also be selected from a pre-loaded project control file.

1	Station setu	p			- #* ·	ŧ	1:18	ok
Instru	ment point nar	ne:	Code:			7		90%
<b>E</b>			?					c
Instrur ?	ment height:	<b>.</b>					2	?
							Ŷ	-30 ?
							Ma	ıр
							Me	nu
							Favor	rites
							S <u>w</u> itc	h to
Esc				0	)ptions		Acce	ept

Figure 6-3. Instrument point settings.

Tap the arrow next to the Instrument point name field and select List.

🏄 Station setup	#	` ◀€	1:19	ok
Instrument point name:	List	h		90%
Instrument height:	<u>W</u> ildcard search Key in Eind			S ?
	Map selections	]	Ŷ	-30 ?
			Ma	ар
			Me	nu
			Favo	rites
			S <u>w</u> itc	h to
Esc	Option	s	Ent	er

Figure 6-4. Select List.

1	9	Select a p	oint		<b>**</b>	€	1:19	ok
Insl	Na	ame	1	Code		5		90%
Ц	С	5		PCPT@NII	DRR 5	μ	0	
Ins	$\Diamond$	6		PCPT@NII	DRR 6			3
4	С	7	1	PCPT@NII	DRR 7			f
	٠	8	1	PCPT@NI	DRR 8		<b>P</b>	-30
	٠	9	1	PCPT@NI	DRR 9			<i>r</i>
				-			<u>M</u> a	p
1						]	Mer	nu
							Favor	rites
							S <u>w</u> itc	h to
Es						1	Acce	ent
	-	Filter	Review	Page 🕇	Page 🕹		4	-P-(

Highlight the appropriate control point from the menu and tap Accept.

Figure 6-5. Control point list.

Enter a measured value in the *Instrument height* field, and tap *Enter* as indicated by the red oval.

📌 St	ation setu	p	- # <b>*</b> ₹	€ 10:	21 0	k
Instrume	nt point nan	ne: Code:			<b>1</b> 0	0%
6		▶ PCPT@NIE	DRR 6			
Instrume	nt height:					S
4.80		<b></b>		14		?
_ Instru	ment coor	dinates ———		_[	- 1	30 ?
Northin	g:	Easting:			<u>М</u> ар	
10050	)38.260sft	863374.68	lOsft		M <u>e</u> nu	I
Elevatio	)n: 220- <del>0</del>			F	<u>a</u> vorite	BS
3823.	32UST			S	<u>w</u> itch	to
Esc		[	Options	\$	Enter	2

Figure 6-6. Instrument settings.

🏄 Station setup		# ◄ 1	:19	ok
Instrument point name:	Code:	[	<b></b> )	90%
5	PCPT@NIDRR	6	_	
Instrument height:				S
4.800sft			4.	.800
<sub>[</sub> Instrument coordinat	tes ———		<b>*</b>	-30 ?
Northing:	Easting:		Map	þ
1005038.260sft	863374.680sf	t  [	Mer	nu
Elevation:		F	= <u>a</u> vori	ites
3823.32UST		s	<u>w</u> itcł	n to
Esc	Opt	ions	Acce	pt

Tap the Accept button to set the instrument setup values.

Figure 6-7. Completed instrument setup.

Enter a point name in the *Backsight point name* field. The point may be selected from a preloaded project control file. Tap the arrow next to the *Backsight point name* field and select *List*. Next, enter a measured value in the *Backsight height* field and tap *Enter*.

<b>#</b> s	tation setu	IP .		- # ·	€	1:20	ok
Backsigl	ht point name	e: ▶	Code: PCPT@N Azimuth (C)	DRR 5		<b></b>	0 90%
5.490s	sft	<b></b>	351°17'4	8"		2	4.800
Method	:		_				-30
Avera	ged observ	ations	<b>•</b>			1	5.490
						Ŀ	<u>1</u> ap
						M	<u>e</u> nu
						Fav	orites
						S <u>w</u> it	tch to
Esc				Options	]	Er	nter

Figure 6-8. Backsight settings.

When the backsight settings have been completed, aim the instrument at the backsight target and tap the *Measure* button as indicated by the red oval when ready. The horizontal angle, vertical angle, and slope distance to the backsight will be measured.

f Station setup	## +€	1:20 ok
Backsight point name:	Code:	90%
5	PCPT@NIDRR 5	
Backsight height:	Azimuth (Computed):	📔 S
5.490sft k	351°17'48"	4.800
Method:		30
Averaged observation	ns 🔻	1 5.490
		Map
		M <u>e</u> nu
		F <u>a</u> vorites
		S <u>w</u> itch to
Esc	Options	Measure

Figure 6-9. Backsight measurement.

Review the measurement data and tap on the Store button as indicated by the red oval.



Figure 6-10. Store the measurement.

After the backsight measurement has been stored, the TSC2 announces "Station setup completed." The instrument is now ready to start the rounds procedure, select *Measure rounds* from the *Survey* menu.

<b>1</b> 2	Job: CN14	4063TOP1 🛛 🗱 ┥	€ 1:26 ok
•	Files	Station elevation Measure topo	90%
<u>s</u>		Measure codes Measure rounds Measure 3D axes Station and offset Stakeout	<u>M</u> ap M <u>e</u> nu F <u>a</u> vorites S <u>w</u> itch to
Exit		End conventional survey	Enter

Figure 6-11. Measure rounds.

When the correct backsight information is displayed, tap *Accept* to use it as the first point in the round.



Figure 6-12. First point in the round.

When the *Rounds Face 1* screen is displayed, tap the *Options* button as indicated by the red arrow.

🏄 Rounds - Face 1 (1/6) 🛛 🗱 📢	1:36 ok
Point name: Code:	90%
? ▶ ? ▶	
Method:	📔 S
Averaged observations 🔻	4.800
Target height:	30
5.490sft k	1 5.490
	Map
	M <u>e</u> nu
	F <u>a</u> vorites
	S <u>w</u> itch to
Esc End face Coptions	Enter

Figure 6-13. Select Options.

Key-in the appropriate number of rounds (red arrow) from Table 6-1 then tap *Enter*. Tap on the *Accept* button to set the value.

fe Options	₩ 4€	1:35 ok
Face order:	Number of rounds:	90%
F1 F2 🔻 🖵	b	
Observation order:	Automate rounds:	S 4 800
123 321 ▼		- 4.000
Skip obstructed foresights:		♀ -30 1 5.490
Set backsight:	Averaged observations:	<u>M</u> ap
Zero 🔻	5	M <u>e</u> nu
Measure dist on face 2:	1/3	F <u>a</u> vorites
▼		S <u>w</u> itch to
Esc		Accept

Figure 6-14. Number of rounds.

When the *Rounds Face 1* screen is displayed again, key-in a point name for the supplemental or temporary control point, feature code, and target height then tap *Enter*. Verify that the target offset is correct. Aim the instrument at the desired target and tap the *Measure* button when ready.

1	Rounds - I	Face 1 (	(1/6)	# ⊀€	8:46 ok
Point n	name:		Code:		100%
101		►	AUXC	•	
Metho	d:				📔 S
Avera	nged obse	rvation	s 🔻		4.800
Target	: height:				() -30
5.770	)sft	<b>.</b>			1 5.770
					<u>M</u> ap
					M <u>e</u> nu
					F <u>a</u> vorites
					S <u>w</u> itch to
Esc	Attrib	End fac	е	Options	Measure

Figure 6-15. Completed point information.

After the measurement is taken, the TSC2 announces "Observation stored." Tap *End face* as indicated by the red arrow when the points in the round have been observed once. The TSC2 announces "First face completed."

<b>#</b>	Rounds - Face 1	(1/6)	₩ 🗮	8:57 ok
Point n	name:	Code:		100%
?	•	?		
Metho	d:			📔 S
Avera	ged observation	IS 🔻		4.800
Target	: height:			(3) -30
5.770	lsft 📐			1 <b>T</b> 5.770
				<u>M</u> ap
				M <u>e</u> nu
				F <u>a</u> vorites
				S <u>w</u> itch to
Esc	End fa		Options	Measure

Figure 6-16. End face.

The total station begins the Face 2 measurements by turning to the first target. The TSC2 prompts the operator to "Aim to target." Refine the aiming if necessary and then tap *Measure* when ready.

	Rounds - Face 2 (	1/6)	<b>;;; →</b> € 1	0:17 ok
Point n	ame:	Code:		100%
5		PCPT@N	DKK 5	
Method Avera	l: ged observations	•		4.800
Target 5.490	height: I <b>sft</b>			♀ _30 1 5.490
				<u>M</u> ap
				M <u>e</u> nu
				F <u>a</u> vorites
				S <u>w</u> itch to
Esc			Options	Measure

Figure 6-17. Face 2 measurements.

After the Face 2 measurements have been stored, the TSC2 announces "Round completed." After each round, the TSC2 displays the horizontal, vertical, and slope distance residuals. Tap the + *Round* button as indicated by the red arrow to begin collecting the next round.

<b>#</b>	itart					# ◄	€ 1	0:41	ok
Poi	nt	σHA		σVA		σSD			<b>D</b> 100%
¥ 5 ∀ 1	01 0	°00'00'' ° <b>00'02''</b>	0°( 0°(	00'01'' 00'02''	0.01 0.00	10sft )8sft			S 4.800
								Ŷ	-30 5.770
								P	<u>1</u> ap
								M	<u>e</u> nu
								Fav	orites
	7							S <u>w</u> it	tch to
Esc	+ Round	d Export	t	Details	Opt	ions		C	ose

Figure 6-18. End of round.

When the desired number of observations have been stored, the TSC2 displays the horizontal, vertical, and slope distance residuals. Tap *Close* as indicated by the red oval if these residuals are within the allowable tolerance. Refer to the WYDOT Survey Manual, Section VIII, Survey Standards.

<b>f;;</b>  9	itart			# ◄	(11:54 ok
Poi	nt	σHA	σVA	σSD	90%
\ <mark>∀ 5</mark> ∀ 1	02	D°00'00'' D° <b>00'02''</b>	0°00'04" 0°00'01"	0.017sft 0.010sft	S 4.800
					1 5.490
					Map
					M <u>e</u> nu
					F <u>a</u> vorites
					S <u>w</u> itch to
Esc	+ Roun	d Export	t Details	Options	Close

Figure 6-19. Close the round.

Tap *Yes* to save and exit the round.



Figure 6-20. Save and exit.

The TSC2 has now calculated and stored a position for the unknown point. Tap the *Survey* icon and select *End conventional survey*.

🏄 Job: CN1	4063TOP1 🛛 😂 ┥	<del>(</del> 2:33 ok
	à 🚅	■ 80%
Files	Station elevation Measure topo Measure codes	<ul> <li>₩ 4.800</li> <li>₩ -30</li> <li>11 5.490</li> </ul>
	Measure rounds Measure 3D axes	<u>M</u> ap M <u>e</u> nu
Survey	<u>S</u> tation and offset Stakeout	F <u>a</u> vorites S <u>w</u> itch to
Exit	End conventional survey	Enter

Figure 6-21. End conventional survey.

If topography is to be collected before moving the instrument, tap the Survey icon and select *Use last*. The total station will then use the last instrument setup for the survey. If topography collection is not needed at this instrument setup, move the total station to another location and select *Station setup*.



Figure 6-22. Use last.

# 2. Resection

The collection of a resection is a similar to the collection of a round. The difference being the instrument is set up on an unknown point and the backsight measurements are taken to two or more known points. Review Section V, Control Surveys, of the WYDOT Survey Manual for general procedures detailing the resection of extendible control. The resection should be performed in a separate job reserved for the establishment of project control points.

At the survey controller main menu, tap on the *Survey* icon. Select *Resection* from the *Survey* menu.

<b>#</b>	Job: CN14	4063TOP1	~ # ₹	2:39	ok
4		<b>N</b>	-		80% S ?
	<u>F</u> iles	<u>Key in Configu</u> Station setup	ration	Ŷ	-30 ?
	1 4	Station setup plus		Ma	ар
	1 1	Refine		Me	nu
			- Ma	Favo	rites
2				S <u>w</u> itc	h to
Exit				Ent	er

Figure 6-23. Resection.

Set the *Pressure* and *Temperature* values and then tap *Enter* (see Figure 6-2). Tap the *Accept* button to set the values.

Key-in the instrument point name, feature code, and height and tap the *Enter* button when complete. Verify that the target offset is correct. Select *Options* for further settings.

nesection		#‡ €€	2:41 ok
Instrument point name	e: Code:		80%
202	TCP	•	
Instrument height:			📔 S
5.010sft			10 5.010
Compute station eleva	ation:		♀ -30 1 ?
			<u>М</u> ар
			M <u>e</u> nu
			F <u>a</u> vorites
			S <u>w</u> itch to
Esc		Options	Accept

Figure 6-24. Instrument setup.

Set the number of required measurements (red arrow) from Table 6-1, then tap the *Accept* button. When the data collector returns to the *Resection* screen, tap on the *Accept* button (see Figure 6-24).

fe Options	₩ 4€	2:42 ok
Face order:	Number of rounds:	80%
Observation order: 123 321 ▼	Automate rounds:	S 5.010
Skip obstructed foresights:		♀ -30 1 ?
Set backsight:	Averaged observations:	<u>M</u> ap
Zero 🔻	5	M <u>e</u> nu
Measure dist on face 2:	13	F <u>a</u> vorites
▶		S <u>w</u> itch to
Esc		Accept

Figure 6-25. Number of rounds.

Enter the point name, feature code, and target height for the first known point. Aim the instrument at the backsight and tap the *Measure* button when ready. After the measurement is taken, the TSC2 announces "Observation stored."

<b>**</b>	Resection -	Face 1		<b>₩</b> 4€	2:44 ok
Point n	name:		Code:		80%
29		•	PCPT@PI	_HR 29 🕨	
Backsig 🖌	ght:				S 5.010
Metho	d:				(3) -30
Avera	aged observ	ations	-		1 <b>I</b> 4.770
Target	: height:				Map
4.770	)sft	<b>.</b>			M <u>e</u> nu
					F <u>a</u> vorites
					S <u>w</u> itch to
Esc				Options	Measure

Figure 6-26. First resection backsight.

Enter the point name, feature code, and target height for the second known point. Aim the instrument at the foresight and tap the *Measure* button when ready. After the measurement is taken, the TSC2 announces "Observation stored."

🏄 Resection - Face 1 🛛 🗱 •	(€ 2:49 ok
Point name: Code:	80%
233 ► PCPT@PLHR 28 ►	
Backsight:	S S
	= 5.010
Method:	🤣 –30
Averaged observations 🔻	1 4.440
Target height:	Map
4.440sft	M <u>e</u> nu
	F <u>a</u> vorites
	S <u>w</u> itch to
Esc Options	Measure

Figure 6-27. Second resection backsight.

The TSC2 displays the horizontal, vertical, and slope distance residuals. Tap on the + *Point* button as indicated by the red arrow to include additional measurements (if needed) to another known point for the resection. Tap *End face* when all points have been observed once. The TSC2 announces "First face completed."

<b>#</b>	itart						#	K	7:52	ok
Point	t		ΔHA		ΔVA		ΔSI	)		<b>D</b> 100%
K 29		-0°0	0'00"	0	)°00'02''	-0.	015sf	t	0	F
K 28	l	0°0	0'00"	-0	)°00'03''	-0.	018sf	t	2	5.010
									<b>%</b>	-30 4.440
									N	<u>1</u> ap
									M	<u>e</u> nu
∆ HA	VAS	D	•						F <u>a</u> v	orites
	ſ	l							S <u>w</u> it	tch to
Esc	+ Pc	pint E	ind fac	e	Details	Opt	tions		Re	sults

Figure 6-28. Add point or end face.

The total station begins the Face 2 measurements by turning to the first target. The TSC2 prompts the operator to "Aim to target." Refine the aiming if necessary and then tap *Measure* when ready.



Figure 6-29. Face 2 measurements.

After the second measurement in each round has been stored, the TSC2 announces "Round completed." The TSC2 will then display the horizontal, vertical, and slope distance residuals. Tap the + *Round* button to begin collecting the next round in the resection process. When the desired number of observations have been stored, Tap the *Results* button (red oval) to review the horizontal, vertical, and slope distance residuals. If the residuals are within the allowable tolerances as shown in the WYDOT Survey Manual, Section VIII, Survey Standards, then continue.

<b>**</b>	itart				#	┥€	8:15	ok
Point	t	ΔHA		ΔVA	Δ5	SD		<b>D</b> 100%
<mark>≥ 29</mark> ∀ 28	]	-0°00'00'' 0°00'00''	-	0°00'00" 0°00'01"	-0.014s -0.016s	sft sft		S 5.010
							Ŷ	-30 4.440
							N	<u>1</u> ap
							M	<u>e</u> nu
∆ HA	VAS	D 🔻					Fav	orites
							S <u>w</u> it	tch to
Esc	+ Ro	und Std. D	)ev	Details	Options	]	Re	sults

Figure 6-30. End of round.

The TSC2 has now calculated positional coordinates for the point in the resection. Tap on the 1/2 button as indicated by the red arrow to view the results on page 2.

<b>f</b> a	Resection results		# ▲€	8:17	ok
Point r 202	iame:	Code:	•		<b>¢ 100%</b>
Northir 5773	ng: 4 <b>8.028sft</b>	Easting: 690560.426sf	t		S 5.010
Elevati 4720	ion: .449sft			Ŷ	-30 4.440
				M	<u>l</u> ap
Star	ndard errors ——			Mg	<u>e</u> nu
σNo	rth:		10	Favo	orites
0.00	U7 SIL		>'~	S <u>w</u> it	ch to
Esc		Opt	ions	st	ore

Figure 6-31. Resection results, page 1.

Tap the <i>Store</i> button to save	the point and its coordinates.
-------------------------------------	--------------------------------

<b>1</b> 8	Resection results		#: ▲€	8:18	ok
σEas	st: D3eff	σ Elevation:			¢ 100%
σ Ori 0°0	entation correction: 0'02''	0.00431			S 5.010
L				₽.	-30 4.440
				M	ap
				Me	inu
			20	Favo	orites
			Z'~ *	S <u>w</u> ite	ch to
Esc		Opt	ions	Sto	ore

Figure 6-32. Resection results, page 2.

Tap the Survey icon and select End conventional survey.

🏄 Job: CN14063TOP1 🛛 🗱 📢 3:21 🛛 ok								
		80%						
		📔 s						
	Station elevation	\$ 5.010						
<u>F</u> iles	Measure topo	🔇 –30						
	Measure codes	1 4.440						
🔰 🔬	Measure rounds	Map						
/ 🕅 🐺	Measure 3D axes	M <u>e</u> nu						
	Station and offset	F <u>a</u> vorites						
<u>S</u> urvey	<u>S</u> takeout	S <u>w</u> itch to						
Exit	End conventional survey	Enter						

Figure 6-33. End conventional survey.

A resection performed on a newly monumented control point is referred to as an auxiliary point (AUXC) and is typically intended to become part of the project control network. Resections are also used to determine coordinates for temporary control points (TCP) such as a hub & tack for short term collection or stake out purposes.

Before auxiliary points become a permanent part of the control network, they are imported into MicroStation using Geopak Survey. The Geopak Survey program uses the least-squares method of adjustment and may calculate slightly different coordinates than the TSC2 derived coordinates. For P&S mapping purposes, the coordinates calculated from the Geopak Survey adjustment will be used for any auxiliary points. The new point and its coordinates are added to the project control (\*.dc) file.

# 3. Topography

At the survey controller main menu, tap on the *Survey* icon and select *Station setup* from the *Survey* menu (see Figure 6-1). Tap the *Survey* icon again and select the *Measure topo* function.

Al Job: CN1	4063TOP1 🛛 😂 🛋	€ 3:21 ok
	Ctation clouation	80%
<u>F</u> iles	Measure topo	-30 11 4.440 Map
1	Measure rounds Measure 3D axes Station and offset	Menu Favorites
<u>S</u> urvey Exit	<u>Stakeout</u> End conventional survey	S <u>w</u> itch to Enter

Figure 6-34. Measure topo.

At the *Measure topo* screen, the number for the topo measurement in the *Point name* field will typically start at 1000. The *Code* setting defaults to the previous measurement and may need to be changed. The *Target height* setting also defaults to the previous measurement. Tap on the target icon as indicated by the red arrow to select a backsight target.

<b>**</b>	Measure to	ро		<b>#                                    </b>	1:43 ok
Point n	name:	Code	1		80%
1000		► GRD	)		
Metho	d:				📔 S
Avera	aged observ	rations 🔻			1.010
Target	: height:			~	(3) -30
4.440	)sft	<b>b</b>		~	1 4.440
					<u>M</u> ap
					M <u>e</u> nu
					F <u>a</u> vorites
					S <u>w</u> itch to
Esc		Check	Opt	tions	Measure

Figure 6-35. Measure topo.

Use the stylus to select the appropriate target, height, and prism offset.

P	1easure t	оро			÷	<b>* ⊣</b> € 1	l 1:44 ol	ĸ
Point n	ame:		C	iode:			80	%
1000			0	GRD				
Method	l:						1	S
Avera	ged obse	rvatior	IS .	•			5.01	0
Target	height:		1	Target 1	4.4	40sft	-30mm	
4.440	sft	<b>b</b>		Target 2	7.0	100sft	+10mm	
							Map	_
							Menu	
							Favorite	s
							S <u>w</u> itch t	0
Esc	2	Chec	k ]	[	Optic	ons	Measure	9

Figure 6-36. Select backsight target.

Once the measure topo settings have been edited, tap the *Options* button to view additional settings.

<b>#</b> #	Measure to	оро		#‡ ◀€ 1	1:45 ok
Point n	name:		Code:		80%
1000			GRD	•	
Metho	d:				📔 S
Avera	nged obser	vations	s 🔻		10 5.010
Target	: height:				+10
7.000	)sft	<b>b</b>			2 <b>1</b> 7.000
					<u>M</u> ap
					M <u>e</u> nu
					F <u>a</u> vorites
					S <u>w</u> itch to
Esc	Γ	Check		Options	Measure

Figure 6-37. Measure topo settings.

Review the additional settings at the *Options* screen. The *Auto point step size* setting is typically set to "1." This setting helps manage point numbers and avoid duplication. If the *View before storage* box is checked, the operator is able to review each measurement and change incorrect settings (e.g. incorrect rod height or feature code) before it is stored. When the *Prompt for attributes* box is checked, the data collector will prompt the operator for attributes associated with the selected code. When it is not checked, the prompts are not displayed.

🏄 Options	#‡ ◀€ 1	0:43 ok
Measure display:	Auto point step size:	100%
HA VA SD (raw) 🛛 🔻	1	
View before storage:	Prompt for attributes:	5.010
Measurement mode:	Averaged observations: 5	2 +10 2 7.000
Auto F1/F2:	Measure dist on face 2:	<u>M</u> ap
	✓	M <u>e</u> nu
Autolock off for offsets:	12	F <u>a</u> vorites
		S <u>w</u> itch to
Esc		Accept

Figure 6-38. Options settings.

<b>#</b>	Measure t	оро				<b>4</b> € 1	1:46	ok
Point n	name:		Code:					> 80%
1052			CULS			►		
Target <b>7.000</b>	: height: I <b>sft</b>	<b>.</b>						S 5.010
							<b>P</b> 2	+10 7.000
							N	<u>1</u> ap
	Horizontal a	ngle:		127	7°25'4	5"	M	enu
▶  \	vertical ang	le:		89	9°55'2	2"	Fav	– orites
2	5lope distar	ice:		35	2.407	sft	S <u>w</u> it	tch to
Esc	Attrib	Read			Option	s	_St	tore

Review and edit (if necessary) the code and target height.

Figure 6-39. Review measurement.

Key-in the feature code attributes, tap on the *Enter* button, then the *Accept* button. Tap on the *Store* button at the *Measure topo* screen (see Figure 6-39). After the measurement is stored, the TSC2 announces "Observation stored."

🏄 CULS	# ◀€ 1	1:48 ok
Туре:		80%
СМР	]	
Size:		S 5.010
24"		- 0.010
		2 +10 2 7.000
		<u>М</u> ар
		M <u>e</u> nu
		F <u>a</u> vorites
		S <u>w</u> itch to
Esc	Options	Enter

Figure 6-40. Feature attributes.

# **D. Check Shots**

# 1. Backsight

During the topo collection process, a backsight check shot is recommended. It should be done at least hourly or more frequently when conditions make the setup stability suspect. At the completion of any topo measurement, tap the *Check* button as indicated by the red arrow.

🏄 Measure topo		$\not \equiv \not \in I$	1:49 ok
Point name:	Code:		50%
Averaged observation			S 5.010
Target height: 7.000sft			♀ +10 2 7.000
			<u>М</u> ар
			M <u>e</u> nu
			F <u>a</u> vorites
			S <u>w</u> itch to
Esc Chec	< Turn Op	otions	Measure

Figure 6-41. Backsight check.

At the Check shot screen, tap on the Chk BS button as indicated by the red arrow.

🏄 Check shot 🗱	<b>4</b> € 11:50 ok
Point name: Code:	50%
?	•
Method:	📔 S
Averaged observations 🔻	🕊 5.010
Target height:	🔇 +10
7.000sft k	2 <b>1</b> 7.000
	<u>M</u> ap
	M <u>e</u> nu
	F <u>a</u> vorites
	S <u>w</u> itch to
Esc Chk BS Turn Option	s Measure

Figure 6-42. Check shot.

The instrument turns back to the current backsight and is ready for the measurement.

<b>f</b> y	Check ba	ksight			0:45 ok
Point n	iame:	C	ode: PCPT		30%
Metho	d:		_		S S
Avera	nged obse	rvations	•		<b>5.010</b>
Backsig	ght height:				30
4.440	sft	<b>b</b>			1 4.440
					<u>М</u> ар
					M <u>e</u> nu
					F <u>a</u> vorites
					S <u>w</u> itch to
Esc					Measure
2.70	Attrib	Chk topo	Turn	Options	

Figure 6-43. Backsight measurement.

# a. Small Residuals

Once the measurement has been taken, the *Check backsight* screen displays the residuals (misclosures) between the check measurement and the original backsight measurement. The main residual values,  $\Delta H Dist$ . and  $\Delta V Dist$ ., are within the red box.

🏄 Check backsight		# ₩	1:51 ok
Point name: 28	Code: PCPT@P	LHR 28	30%
Action: Store and reorient 🔻			S 5.010
∆ H.Angle: 0°00'02''	∆ H.Dist: 0.019sft		♀ -30 1 4.440
∆ V.Angle: -0°00'03''	∆ V.Dist: <b>0.016sft</b>		Map Menu
∆ S.Dist: - <b>0.016sft</b>		1/2 ▼	F <u>a</u> vorites S <u>w</u> itch to
Esc			Store

Figure 6-44. Backsight check residuals.

After reviewing the residual values tap on the down arrow to view a list of possible actions. For small residual values, select the *Store as check* option. If the residual values are larger than expected, check the instrument and backsight setups. Ultimately, it is up to the operator to determine if the check shot is acceptable before continuing with the survey.

🏄 Check backsight	# +€	1:52 ok
Point name:	Code:	30%
Action: Store and reorient	PCPT@PLHK20	S 5.010
Discard Rename	∆ H.Dist: <b>0.019sft</b>	♀ _30 1 4.440
Store as check	Δ V.Dist:	<u>M</u> ap
Store and reorient	0.016sft	M <u>e</u> nu
Δ S.Dist:	12	F <u>a</u> vorites
-0.01051	∎.≃ ▼	S <u>w</u> itch to
Esc		Store

Figure 6-45. Store as check.

Tap on the *Store* button at the *Check backsight* screen. After the measurement is stored, the TSC2 announces "Observation stored."

🏄 Check backsight	<b>₩ +</b> €	2:16 ok
Point name:	Code:	30%
28 Action: Store as check 🗸	PCPT@PLHK28	5.010
∆ H.Angle: 0°00'02''	∆ H.Dist: 0.019sft	♀ -30 1 4.440
∆ V.Angle: - <b>0°00'03''</b>	∆ V.Dist: 0.016sft	<u>M</u> ap M <u>e</u> nu
∆ S.Dist: - <b>0.016sft</b>	<b>1</b> <sup>/2</sup> ▼	F <u>a</u> vorites S <u>w</u> itch to
Esc		Store

Figure 6-46. Store backsight check.

# b. Large Residuals

Occasionally, very large horizontal or vertical residuals are encountered. These residuals are an indication of a potential setup problem. In these situations, the error source is typically linked to movement of the instrument or backsight during the topo collection. This movement may have been gradual or may have been caused by a bump to the tripod.

When a very large residual is discovered, it is important to check the measurements of previously collected topography. These checks will determine the extent of the instrument movement on the entire collection. It may be necessary to abandon the collected data that has occurred since the last backsight check with small residual values.

Tap on the down arrow and select *Discard* from the drop down menu.

🏄 Check backsight	₩ ₩	3:40 ok
Point name: 28	Code: PCPT@PLHR 28	<b>=</b> > 30%
Action: Store as check 🛛 🔻	]	S 5.010
Discard Rename	Δ H.Dist: <b>0.158sft</b>	♀ -30 1 4.440
Store as check Store and reorient	∆ V.Dist: 0.097sft	<u>M</u> ap M <u>e</u> nu
∆ S.Dist: 0.434cff	12	F <u>a</u> vorites
0.13481		S <u>w</u> itch to
Esc		Store

Figure 6-47. Discard.

Tap on the *Esc* button as indicated by the red circle. The backsight measurement may be retaken to check the residuals once more. If the residuals are still questionable, it is up to the operator to determine how to resolve the issue.

🏄 Check backsight	<b>₩</b> +€	3:40 ok
Point name: 28	Code: PCPT@PLHR 28	30%
Action: Discard 🗸		S 5.010
∆ H.Angle: -0°00'16"	∆ H.Dist: <b>0.158sft</b>	♀ -30 1 4.440
∆ V.Angle: -0°00'18''	∆ V.Dist: 0.097sft	<u>M</u> ap M <u>e</u> nu
∆ S.Dist: 0 134eff	1/2]	F <u>a</u> vorites
0.134310	<b>1</b> <sup>−</sup> ▼	S <u>w</u> itch to
Esc		Store

Figure 6-48. Retake measement.

The operator may tap the *Chk topo* button as indicated by the red arrow to check previously stored topography shots.

	Check ba	ncksight			0:45 ok
Point r	ame:	C	ode:		30%
28 Mother	<b>.</b>	,	νCPT		
Avera	u: aged obs	ervations	•		5.010
Backsig	ght height	:	_		
4.440	isit	·			Map
					M <u>e</u> nu
					F <u>a</u> vorites
		Л			S <u>w</u> itch to
Esc	Attrib	Chk topo	Turn	Options	Measure

Figure 6-49. Chk topo.

# 2. Topography

At the *Check shot* screen, enter the point number of a previously stored topography measurement in the *Point name* field. A field diary will be useful to find an easily identifiable feature. Take a new measurement to that point. Review and edit (if necessary) the target, target height, and prism offset. Any topo check measurements out of tolerance should be replaced with the new measurements based upon a corrected orientation.

1	Check sho	ot		# ◄	2:32 ok
Point n	name:	(	Iode:		30%
1050			CULS	•	
Metho	d:				📔 S
Avera	iged obse	ervations	•		1.010
Target	height:				🚯 +10
7.000	lsft	<b>b</b>			2 7.000
					<u>М</u> ар
					M <u>e</u> nu
					F <u>a</u> vorites
					S <u>w</u> itch to
Fsc			-		Moasuro
LSC	Attrib	Chk BS	Turn	Options	

Figure 6-50. Check topo.

# **E. Collection Guidelines**

# 1. Safety

Safety should be the primary objective during the planning and execution of WYDOT surveys. Areas which should cause special concern include but are not limited to:

- High traffic areas.
- Overhead electrical lines or other electrical devices that could come into contact with the surveyor or the surveying equipment.
- Bodies of water including lakes, rivers, and steams.
- Bridges, cliffs, or steep embankments where falls could occur.

# 2. Instrument/Backsight Setup

During the instrument setup process, one of the adjacent monuments is typically used for a backsight target. To minimize misclosures in the horizontal or vertical angles, choose the monument furthest from the instrument. For example, a 0.05 ft. sighting error (half the width of a target range pole) at 500 ft. is equal to a horizontal angle offset of 21 seconds. While a 0.05 ft. sighting error at 800 ft. is equal to an angle offset of 13 seconds. However,

extremely long sighting distances (i.e. greater than 1500 ft.) may degrade the surveyor's ability to accurately sight on the target.

# 3. Topography Collection

When collecting topographic surveys, measurement distances should not exceed 800 ft. The shot interval between topographic measurements along a feature (e.g. EPS, EP, FLC, or TBC) should not exceed 25 ft. Also, when collecting DTM shots the grid distance should not exceed 25 ft. Avoid measurements when obstacles interfere with the line of sight from the instrument to the target. Examples of obstacles are vehicles, signs, highway delineators, buildings, vegetation, and terrain.