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Total Station Field Surveying: WPES, How Do I...? Quick Guide

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for

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Introduction

This document provides guidance for performing field surveys using a total station unit (TSU) and connected handheld data collector and for downloading collected point data.

WPES uses a Sokkia CX-series TSU and a data collector running Carlson SurvCE software. Minor differences in instrument set-up may arise if using a different TSU. Major differences in data collection procedures will occur if using a different data collection software.

Before leaving for field

1. Equipment list
    1.1. Total Station equipment:
        1.1.1. CX-105 Total Station Unit (TSU)
        1.1.2. TSU batteries, charged
        1.1.3. Carlson handheld Bluetooth data collector, charged
        1.1.4. Tripod
    1.2. Prism equipment:
        1.2.1. Prism(s) *must be matching pair with pole*
        1.2.2. Prism pole(s)
        1.2.3. Bipod(s)
    1.3. Additional equipment
        1.3.1. Field notebook
        1.3.2. Flags/Pins *for marking station locations*
        1.3.3. Orange nail polish *for discreetly marking station locations on hard surfaces*
        1.3.4. Magnetic compass
        1.3.5. Metric open-reel measuring tape
        1.3.6. GPS unit, charged
        1.3.7. Walkie talkies, charged
        1.3.8. Waders, life jackets *location-dependent*
2. Magnetic declination
    2.1. Record magnetic declination for survey area at ngdc.noaa.gov/geomag/calculators/magcalc.shtml

    Note: Magnetic declinations for Maine coast range from -14.75° to -16.5° (west declinations are negative).

Field operation

1. Instrument set-up
    1.1. Turn on GPS unit and place it at point where total station will be set up while unpacking other gear.

    Note: GPS unit should be allowed to sit for several minutes after acquiring satellites to improve accuracy of reading. This step is unnecessary if XYZ coordinates of point are known (e.g. you are occupying a survey control point).

    1.2. Set up tripod over initial point, with head (top plate) as level as possible and opening directly above point; make sure tripod feet are securely anchored in soil and slip joint clamps are locked.

    Note: Sight down through the hollow mounting screw to help center over point.

    1.3. Place total station unit on tripod head and secure using mounting screw.

    Note: Use both hands when carrying TSU – do not carry solely by handle. Tighten to finger tight – do not over-tighten.

    1.4. Perform gross leveling of instrument using bullseye level bubble on tribrach by making small adjustments to one tripod leg at a time; make sure to securely re-lock slip joint clamp before moving on to next leg.

    1.5. Turn on total station unit.

    1.6. If level bubbles do not appear on TSU screen, press "Shift" key on unit face until "TILT" appears over F2 key (and press that).

    1.7. Perform fine leveling of instrument using on-screen level bubbles by adjusting leveling foot screws on tribrach.

    *Note: The easiest way to do this is to align face of instrument with one of the three sides of the tribrach, then use *one* of the two foot screws along that side to level instrument in the Y direction and the third foot screw (at opposite vertex) to level instrument in the X direction.*

    1.8. Turn on laser plummet by pressing 'L-ON' (F2).

    If re-occupying an established point (mark on the ground), continue to step 1.9; otherwise place a flag/pin at laser dot and skip to step 1.11.

1.9. Loosen mounting screw and gently slide instrument until laser is directly on point; re-tighten mounting screw.

Note: Do not rotate tribrach while sliding instrument or it will go out of level.

1.10. Check level using on-screen level bubbles and repeat steps 1.7 and 1.9 as necessary until instrument is level and directly over point.

1.11. Turn off laser plummet and press 'OK' (F1).

2. Data collector set-up

2.1. Turn on data collector and open SurvCE program (Start menu).

2.2. Choose "Select New/Existing Job" from on-screen prompt.

2.3. Choose "Connect to last BT device" from on-screen prompt to connect data collector to total station unit.

Note: This prompt may appear at a different stage in the set-up process, and will reappear if collector goes to sleep.

2.4. **If creating a new survey job**:

2.4.1. Enter descriptive name in "Name" field at bottom of screen; tap green check mark (upper right).

2.4.2. "Job Settings" screen will open; if necessary, make changes to reflect job requirements (rare), then tap green check mark.

Note: By default, "Distance" = 'Metric', "Angle" = ' Degrees, Minutes, Seconds', "Zero Azimuth Setting" = 'North', "Projection" = 'UTM/WGS 84/UTM zone 19N 66-72W'.

2.4.3. "Enter Point Coordinates" screen will open; enter Easting, Northing, and ground elevation of TSU set-up point and tap green check mark.

*Note: **Ensure that GPS coordinates are in the same projection as set in the previous step, and that Easting and Northing are entered in the correct order**. If using UTM (preferred), Maine is in UTM zone 19. For the Maine coast, Easting is a 6-digit number in the range (350 000 : 650 000) and Northing is a 7-digit number in the range (4 770 000 : 5 000 000); Bryand GSC is at [19T 526260 4971320 (NAD83)].*

2.4.4. **If you will occupy or backsight to additional known control points during job**:

2.4.4.1. Tap "File" tab at upper left of screen.

2.4.4.2. Tap "3 Points".

2.4.4.3. Tap "Add".

2.4.4.4. Enter Easting, Northing, Elevation, Description; tap green check mark.

2.4.4.5. When all points have been added, tap red "back" arrow.

2.4.5. Tap "Survey" tab at upper left of screen.

2.4.6. Tap "1 Store Points".

2.4.7. "Store Points" screen will open.

2.4.7.1. Occupy Point: 1

2.4.7.2. Continue to step 2.5.

If continuing an existing survey job:

2.4.8. Select existing job file; tap green check mark (upper right).

2.4.9. Tap "Survey" tab at upper left of screen.

2.4.10. Tap "1 Store Points".

2.4.11. "Store Points" screen will open.

Note: "Single Setup" tab should be highlighted – tap it if not.

If establishing a new point for TSU location: set "Occupy Point" to an unused point number and continue to step 2.5.

If re-occupying a stored point with the TSU: set "Occupy Point" to number of stored point and continue to step 2.5.

2.5. "Store Points – Remote Benchmark Single Setup" screen

2.5.1. Instr. Height: use tape to find height from ground to notch at scope on side of TSU

2.5.2. Target Height: enter prism height

Note: For unbranded prism/pole combo, ensure pole adapter is correctly calibrated (see Appendix B*).*

2.5.3. Backsight Point, Backsight N Azi: continue to step 3.

3. Backsighting

3.1. Send assistant with prism/pole to backsight location.

Hold the pole still and level, please, kind assistant.

3.2. **If sighting from a new or re-occupied TSU location to a new backsight point:**

3.2.1. Set "Backsight Point" to an unused point number.

Note: For a new survey job, use "2".

3.2.2. Continue to step 3.3.

If sighting from a new TSU location to a stored backsight point:

3.2.3. Set "Backsight Point" to that point number.

3.2.4. Continue to step 3.3.

If backsighting from a re-occupied TSU location to a stored backsight point:

3.2.5. "Backsight N Azi" field will be locked.

3.2.6. Tap "Backsight" box (lower right) and skip to step 3.4.

3.3. Use magnetic compass to sight azimuth from TSU to backsight.

Note: Azimuth is angle measured clockwise from N (e.g. due west is 270°).

3.3.1. **If using a compass with adjustable declination**, adjust to survey area's magnetic declination then take azimuth reading to backsight; this is a true azimuth *(polar N = 0°).*

If using a compass without adjustable declination (most hand compasses), the azimuth reading is in relation to magnetic north rather than true north; to convert compass's reading to a true azimuth, add the survey area's magnetic declination to the magnetic azimuth.

(e.g. 86.5°(mag. az.) + [-15.3°](declination) = 71.2°(true az.)).

3.3.2. Enter true azimuth in "Backsight N Azi" field in data collector.

3.3.3. Tap "Backsight" box (lower right).

3.3.4. Tap "Continue" on "Backsight Method" screen.

3.4. Begin backsight with vertical clamp / fine adjustment screw on total station unit face pointing toward yourself (away from the backsight location) and scope pointing toward backsight; vertical and horizontal clamps should be unlocked.

3.5. Sight through scope to prism, focusing scope as necessary.

Note: You should be able to see + shaped reticles embedded in scope and radial reticles embedded in prism.

3.6. When prism is in scope crosshairs, lock vertical and horizontal clamps.

3.7. Use vertical and horizontal fine adjustment screws to center scope's crosshairs on center of prism.

3.8. Tap "Set Angle and Read" box on screen, and after a successful reading a message will pop up on screen directing you to reverse the instrument face.

3.9. Unlock vertical and horizontal clamps, rotate instrument 180° and plunge scope (flip it 180°), and repeat steps 3.5 – 3.7 to sight in on prism.

3.10. Tap 'OK' and the total station unit will take a second reading.

3.10.1. If a message pops up on screen warning that the difference in angles is outside tolerance, tap 'No' and return to step 3.4.

3.11. When "Set Report" page appears on screen, tap green check mark .

3.12. When "Backsight" page appears on screen, tap green check mark.

3.13. When "Store Point" popup appears on screen, change description to 'BS' and tap green check mark.

3.14. After completing backsight process, the view will automatically change to the "Store Points" screen, which shows a map view of the survey job. This screen can also be accessed by tapping the "Survey" tab and tapping "1 Store Points".

Note: For each visible point, the black number above the point is the point number, the blue number to the right of the point is the point's elevation, and the green text below the point is the point's description.

3.15. **Before making any other readings after backsighting, return instrument to original orientation** (scope facing backsight, clamp/screw toward yourself), **<u>then</u> turn to next target** (step 4 or step 5).

4. Side shots

Note: "Side shots" are points measured without relocating the TSU. For a typical site survey where the TSU is set up with a commanding view of the area, most or all measurements will be side shots.

4.1. Send assistant with prism/pole to point.

Good work, assistant. We appreciate you. Keep the pole level, please.

4.2. Place flag/pin at point.

4.3. Sight in total station unit on prism (see steps 3.5 – 3.7).

4.4. Tap the large 'R' at top left of screen to read angle and distance.

4.4.1. A marker with a '?' above it will appear on the map. **If it appears 180° from where it should be, ensure you followed step 3.15 after backsighting**. Readings can be taken as many times as you wish without storing the point.

4.5. If you are satisfied with the reading, give the point a description and tap the large 'S' at top left of screen to store the point.

4.5.1. Common point descriptions include:

TW – thalweg (deepest point of stream channel cross-section)

REW, LEW – right and left edges of water

BB, BoB – bottom of bank

TB, ToB – top of bank

XS1 – prefix for cross-section 1

RPIN, LPIN – pin or flag at end of cross section on river right or river left

INST – generic label for location of an instrument (level logger, etc)

5. Traversing

5.1. To traverse to a point, sight in on the prism as in steps 4.1 – 4.3, then tap the large T at top of screen.

Note: The TSU will read and store the location of the prism/pole.

5.2. When "Move to Traverse" screen appears, tap "Move Now".

5.3. "Store Points – Remote Benchmark Single Setup" screen will appear.

5.3.1. Occupy Point: the number of the point you are traversing to.

Backsight Point: the number of the point you are traversing from.

Both fields should be correctly autofilled.

5.3.2. Tap 'Backsight'.

5.4. Break down TSU and tripod (steps 6.3 – 6.4) and set up over point you are traversing to (steps 1.2 – 1.11).

*Note: **NEVER** pick up and move tripod while TSU is still attached, even for short distances. This will damage the instrument.*

Before moving either TSU or prism pole, be sure each location is flagged/pinned. You must precisely re-occupy these locations.

5.5. Send assistant with prism/pole to occupy the point you are traversing from.

5.6. Backsight to point you are traversing from (steps 3.4 – 3.12, 3.14 – 3.15).

Note: Once complete, you can take additional side shots (step 4) and/or traverse to another point (step 5).

6. Finishing a job

6.1. Once all points have been measured, tap red 'X' at top right of data collector screen to leave "Store Points" map page, tap "File" tab, then tap "0 Exit". The data collector can now be powered down.

6.2. Power down total station unit.

6.3. Unlock vertical and horizontal clamps – the instrument should be able to turn freely on both axes.

6.4. Unscrew mounting screw and remove TSU from tripod.

Note: Use both hands when carrying TSU – do not carry solely by handle.

6.5. Replace scope cover and return TSU to case.

6.6. Break down and store prism/pole, tripod, and other gear.

Post-survey tasks

1. Equipment storage
    1.1. Return all equipment to equipment room.
        1.1.1. Return data collector, TSU battery, GPS unit, and walkie talkies to charging stations.
        1.1.2. Hang wet waders and/or life jackets to dry.
    1.2. If surveying was completed in damp or humid conditions, allow TSU to sit open to indoor air before storing in closed case.

Survey data download

1. Equipment list
    1.1. Carlson handheld data collector
    1.2. USB Mini-A or USB Mini-B to USB A data transfer cable
    1.3. Computer(s) with:
        1.3.1. Windows Mobile Device Center

        This service was broken on Windows 10 operating systems, but workarounds to get it running properly exist – see e.g. www.accuratedata.com/wordpress/index.php/2017/08/02/.

        1.3.2. Carlson X-Port software

        Available as a free download at www.carlsonsw.com/support/software-downloads/.

2. Accessing raw data
    2.1. Turn on Carlson data collector and connect it to computer using data transfer cable.
    2.2. Open Windows Mobile Device Center and click "Connect without setting up your device".
    2.3. Under "File Management" tab, click "Browse the contents of your device"; a new File Explorer window titled "Pocket_PC" will open.

    Note: If this window does not automatically open, manually open a File Explorer window and navigate to "Pocket_PC" under "This PC".

    2.4. Open the " \ " folder.
    2.5. Open the "Program Files" folder.
    2.6. Open the "SurvCE" folder.
    2.7. Open the "Data" folder.
    2.8. Sort files by Name to find the files for your survey job and copy them to a new folder on your computer or flash drive.

    Note: There will be up to five files for each job: CRD File, Setup Information, NOT File, RW5 File, and System File.

    2.9. Windows Mobile Device Center can now be closed and Carlson data collector disconnected from computer and powered down.

3. Processing data using Carlson X-Port

3.1. Open Carlson X-Port software.

3.1.1. If Registration Wizard pops up, choose "Register Later" radio button under Registration Options tab and click Next.

3.2. In Carlson X-Port window, click File > Open RW5 File.

3.2.1. Navigate to location of saved survey files and open your .rw5 file.

3.2.2. A spreadsheet showing instrument starting location, backsight setup, and distances and angles to survey points will open in the top half of the Carlson X-Port window.

3.3. **If you entered a true azimuth for the backsight in the field (or otherwise do not care about azimuth)**:

3.3.1. Click File > Open CRD File to open coordinate file.

3.3.2. A list of survey points with Point #, Easting, Northing, Elevation, and Description should open in the bottom half of the Carlson X-Port window.

3.3.2.1. **If this occurs**, skip to step 3.5.

If these data do not appear, continue to step 3.4.

If you entered a magnetic azimuth for the backsight in the field and need to adjust for magnetic declination:

3.3.3. Find magnetic declination for survey area at ngdc.noaa.gov/geomag/calculators/magcalc.shtml

Note: Magnetic declinations for Maine coast range from -14.75° to -16.5° (west declinations are negative).

3.3.4. In the "SetAzi" cell in Carlson X-Port window, subtract magnetic declination from cell value.

(e.g. 86.5°(mag. az.) - [-15.3°](declination) = 101.8°(SetAzi))

Note: This is the opposite direction from the action you would have taken in the field to convert magnetic azimuth to true azimuth.

3.4. In Carlson X-Port window, click Process (Compute Pts) > No Adjust.

3.4.1. When Process Options popup opens, ensure "Report SideShots" is checked and click OK.

3.4.2. When Traverse Points popup opens, click OK.

3.4.3. When Process No Adjust Results popup opens, close it.

3.4.4. A list of survey points with Point #, Easting, Northing, Elevation, and Description will open in the bottom half of the Carlson X-Port window.

For reasons unknown, X-Port will often place the backsight (Pt 2) directly north of the starting point during this processing step despite calculating correct coordinates for all other points [If you adjusted the SetAzi value during step 3.3, it will be directly to the magnetic north – note that in this case, the Easting for Pt 2 will not *be identical to that of Pt 1, which may make it more difficult to spot]. If this occurs, the backsight coordinates can be corrected during step 3.7.*

3.5. In Carlson X-Port window, click Tools > Export Point Data > Text/ASCII File.

3.5.1. When Export Point Data popup opens, change Coordinate Order check box to "Pt# East North Elev Desc" and click OK.

3.5.2. Enter a save location and file name and click OK to save comma separated text file.

3.6. Navigate to the text file in File Explorer and open it using Notepad or equivalent.

3.6.1. Insert the following string above the first row:

PtNo,Easting,Northing,Elevation,Description

3.7. **If you have no further edits to make to the file**:

3.7.1. Save and close text file.

If you processed points (step 3.4) and the backsight is in the incorrect location:

3.7.2. Return to Carlson X-Port window.

3.7.3. **If you entered a true azimuth for the backsight in the field**:

3.7.3.1. Set "SetAzi" cell to 0.

If you entered a magnetic azimuth for the backsight in the field and need to adjust for magnetic declination:

3.7.3.2. Set "SetAzi" cell to the additive inverse* of the magnetic declination.

*(*a.k.a the negative or opposite) (e.g. SetAzi = 15.3° if magnetic declination = [-15.3°]).*

3.7.4. Repeat step 3.4.

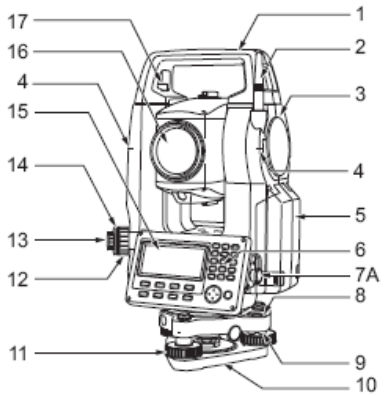
3.7.5. Copy the correct Easting and Northing for the backsight point (only) to update the appropriate line in the text file.

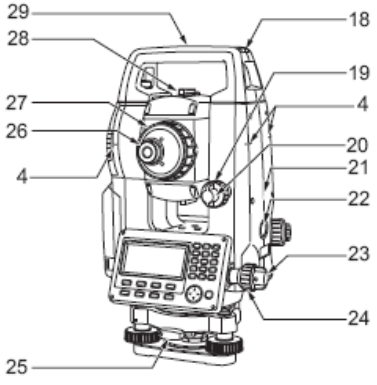
3.7.6. Save and close text file.

Appendix A

Parts of the total station unit (TSU)

● **CX Series**



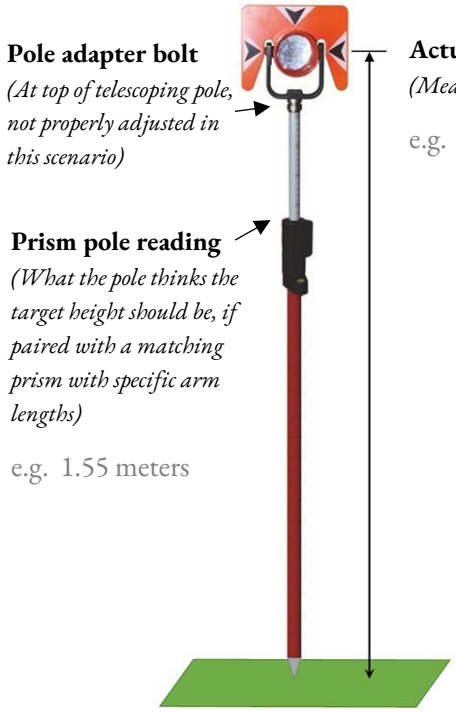


1 Handle
2 *Bluetooth* antenna
3 External interface hatch (USB port)
4 Instrument height mark
5 Battery cover
6 Operation panel
7A Serial connector
7B Combined communications and power source connector
8 Circular level
9 Circular level adjusting screws
10 Base plate
11 Levelling foot screw
12 Optical plummet focussing ring
13 Optical plummet eyepiece
14 Optical plummet reticle cover (12-14: Not included on instruments with laser plummet ( ))
15 Display unit
16 Objective lens (Includes Laser-pointer function)
17 Handle locking screw
18 Tubular compass slot
19 Vertical fine motion screw
20 Vertical clamp
21 Speaker
22 Trigger key
23 Horizontal clamp
24 Horizontal fine motion screw
25 Tribrach clamp
26 Telescope eyepiece screw
27 Telescope focussing ring
28 Sighting collimator
29 Instrument center mark
30 Plate level
31 Plate level adjusting screw

From Sokkia CX series Operator's Manual (see WPES Lab Resources Google Drive or us.sokkia.com/content/cx-user-manual for full document).

Appendix B

Prism height calibration with pole adapter



Our original prism pole is meant to be paired with a prism that measures 14 cm tall from base to prism center. However, our original prism only measures 10 cm from base to center, resulting in a 4 cm discrepancy between actual target height and prism pole reading if the pole adapter is not adjusted.

To calibrate, the threaded pole adapter bolt at the top of the telescoping prism pole must be unscrewed until actual target height matches the prism pole reading (in this case, a 4 cm extension). When the pole adapter is at the correct length, the lower check nut should be screwed down to lock the adapter in place.