SUBSITE®

GeoRanger Utility Scanner

Operator's Manual

CE UKCA

CMW®

Issue 1.0

Original Instruction

Safety Guidelines

⚠ WARNING Misuse of equipment can cause death or serious injury. Read and understand operator's manual and all other safety instructions before use.

Follow these guidelines before operating any jobsite equipment:

- Complete proper training.
- Read and understand operator's manual before using equipment.
- Wear personal protective equipment.
- In the US or Canada, call 811 (US) or 888-258-0808 (US and Canada). Also contact any local utilities that do not participate in the One-Call service. In countries that do not have a One-Call service, contact all local utility companies to have underground utilities located.
- Classify jobsite based on its hazards and use correct tools and machinery, safety equipment, and work methods for jobsite.
- Mark jobsite clearly and keep spectators away.
- Review jobsite hazards, safety and emergency procedures, and individual responsibilities with all personnel before work begins.
- Fully inspect equipment before operating. Repair or replace any worn or damaged parts. Replace missing or damaged safety shields and safety alert signs. Contact your Ditch Witch dealer for assistance.
- Replace missing or damaged safety signs.
- Use equipment carefully per the instructions in this manual. Stop operation and investigate anything that does not look or feel right.
- Contact your equipment dealer if you have any questions about operation, maintenance, or equipment use.

FCC Class A Compliance and Usage Limitations

This device complies with Part 15 Subpart B and Subpart F of the FCC Rules. Operation is subject to the following two conditions: (1) the device may not cause harmful interference, and (2) this device must accept any interference received including interference that may cause undesired operation.

FCC ID: 2AP78-US1 and contains RF Module FCC ID: Z64-WL18DBMOD.

Warning: Changes or modifications to this unit not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment. According to the FCC Rules Part 15 Subpart F, this device has several requirements and limitations for use. Specifically:

15.509:
(a) The UWB bandwidth of an imaging system operating under the provisions of this section must be below 10.6 GHz. (b) Operation under the provisions of this section is limited to GPRs and wall imaging systems operated for purposes associated with law enforcement, fire fighting, emergency rescue, scientific research, commercial mining, or construction. (1) Parties operating this equipment must be eligible for licensing under the provisions of part 90 of this chapter. (2) The operation of imaging systems under this section requires coordination, as detailed in §15.525.

15.521:
(a) UWB devices may not be employed for the operation of toys. Operation onboard an aircraft, a ship or a satellite is prohibited.

15.525:
(a) UWB imaging systems require coordination through the FCC before the equipment may be used. The operator shall comply with any constraints on equipment usage resulting from this coordination.

(b) The users of UWB imaging devices shall supply operational areas to the FCC Office of Engineering and Technology, which shall coordinate this information with the Federal Government through the National Telecommunications and Information Administration. The information provided by the UWB operator shall include the name, address and other pertinent contact information of the user, the desired geographical area(s) of operation, and the FCC ID number and other nomenclature of the UWB device. If the imaging device is intended to be used for mobile applications, the geographical area(s) of operation may be the state(s) or county(ies) in which the equipment will be operated. The operator of an imaging system used for fixed operation shall supply a specific geographical location or the address at which the equipment will be operated. This material shall be submitted to Frequency Coordination Branch, OET, Federal Communications Commission, 45 L St NE, Washington, D.C. 20554, Attn: UWB Coordination.

(c) The manufacturers, or their authorized sales agents, must inform purchasers and users of their systems of the requirement to undertake detailed coordination of operational areas with the FCC prior to the equipment being operated.

(d) Users of authorized, coordinated UWB systems may transfer them to other qualified users and to different locations upon coordination of change of ownership or location to the FCC and coordination with existing authorized operations.

(e) The FCC/NTIA coordination report shall identify those geographical areas within which the operation of an imaging system requires additional coordination or within which the operation of an imaging sys- tem is prohibited. If additional coordination is required for operation within specific geographical areas, a local coordination contact will be provided. Except for operation within these designated areas, once the information requested on the UWB imaging system is submitted to the FCC no additional coordination with the FCC is required provided the reported areas of operation do not change. If the area of operation changes, updated information shall be submitted to the FCC following the procedure in paragraph (b) of this section.

(f) The coordination of routine UWB operations shall not take longer than 15 business days from the receipt of the coordination request by NTIA. Special temporary operations may be handled with an expedited turn-around time when circumstances warrant. The operation of UWB systems in emergency situations involving the safety of life or property may occur without coordination provided a notification procedure, similar to that contained in §2.405(a) through (e) of this chapter, is followed by the UWB equipment user.

IC Compliance and Usage Limitations

This device complies with Canadian RSS-220, RSS-GEN and ICES-003. Operation is subject to the follow- ing two conditions: (1) the device may not cause harmful interference, and (2) this device must accept any interference received including interference that may cause undesired operation.

IC: 24078-US1 and contains RF Module IC: 451I-WL18DBMOD.

According to the RSS-220, Issue 1, Section 6.2, this device has several requirements and limitations for use. Specifically:

(a) This Ground Penetrating Radar Device shall be operated only when in contact with or within 1 m of the ground.

(b) This Ground Penetrating Radar Device shall be operated only by law enforcement agencies, scientific research institutes, commercial mining companies, construction companies, and emergency rescue or firefighting organizations.

(c) This device complies with Industry Canada licence-exempt RSS standard(s). Operation is Subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired Operation of the device.

Cet appareil est conforme aux normes canadiennes RSS-220, RSS-GEN et ICES-003. L'exploitation est au- torisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

IC: 24078-US1 et contient le module RF IC: 451I-WL18DBMOD.

Selon le RSS-220, Issue 1, Section 6.2, cet appareil a plusieurs exigences et limitations d'utilisation. Plus précisément:

(a) Ce dispositif radar à pénétration du sol ne doit être utilisé qu'en contact avec le sol ou à au plus 1 m du sol.

(b) Ce dispositif radar à pénétration du sol ne doit être utilisé que par des organismes d'application de la loi, des établissements de recherche scientifique, des sociétés minières commerciales, des entreprises de construction, et des organismes d'intervention d'urgence ou de lutte contre les incendies.

(c) Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

FCC/IC Radiation Exposure Statement

This equipment complies with the IC/FCC RF radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with a minimum distance of 20 cm between the radiator and any part of your body.

Cet équipement est conforme aux limites d'exposition aux rayonnements énoncées pour un environnement non contrôlé. Cet équipement doit être installé et utilisé en gardant une distance de 20 cm ou plus entre le dispositif rayonnant et le corps.

EU Declaration of Conformity

Hereby, Charles Machine Works declares that the radio equipment type GEORANGER GPR is in compliance with directive EU 2014/53/EU. The full text of the EU declaration of conformity is available by visiting **https://subsite.com/about-us/contact-us** or by emailing a request to **service@subsite.com**.

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1. Introduction

The GeoRanger Utility Scanner is the most flexible and comprehensive system on the market, with many features for locating pipes, conduits, vaults, defects such as voids, and other underground objects. The system includes a scanner unit with an integrated radar, odometer, and power line detector, and a tablet computer. It incorporates a wireless design to increase reliability and ease of use. There are several software options to support simple single line surveys and multi-line surveys with cross sections, depth slices, and 3D images of the subsurface.

Figure 1: GeoRanger Utility Scanner

The scan head contains a high frequency (750 MHz) GPR antenna for making shallow high-resolution surveys, a low frequency (350 MHz) GPR antenna for deep surveys, and a power line detector. The scan head also contains a GPS receiver that can provide global positional accuracy to one centimeter when using a reference data feed from either a reference base station or network. The scanner rides on a rough terrain cart with large wheels to make it easy to push on rough ground, and a floating suspension to keep the scan head in contact with uneven ground.

In addition to the standard system, there are several optional components available which are listed in Table 1. The hard-shell shipping case is recommended for units that will often be transported. When high accuracy GPS positioning is needed the GPS RTK 2W can be used at the job site, or a third-party NTRIP/CORS network can be used. The accuracy of the GPS RTK 2W can be enhanced with a subscription to PointPerfect™, which also increases the GPS RTK 2W usefulness as a tool for surveying above-ground evidence of subsurface utilities.

The Windows Tablet Kit is recommended for maximum compatibility, however users can provide a tablet computer of their choice, as long as it meets the specifications listed in Appendix B. For simple one-line surveys, an Android® or Apple® smart phone or tablet can be used with the Surveyor Mobile. A Windows tablet is required to record data, to perform multi-line surveys, or to perform surveys which use GPS positioning as these features are exclusive to Surveyor Pro.

ESSential Underground is a companion Windows application which provides advanced data processing, 3D visualization of the survey site, and report generation. Finally, users can publish reports and 3D views to the mobile devices of on-site field personnel using the Underground Aware service.

Component	Description
GeoRanger Utility Scanner	Wireless scan head with GPR, power line, and GPS sensors. Includes two battery packs and a dual-port battery charger. Includes a four wheeled cart with a floating suspension system to keep scan head close to the ground.
Windows Tablet Computer Kit	A rugged tablet PC with and mobile internet capability. A slim custom mount secures the tablet to the cart.
GPS RTK 2W	A dual-function GNSS (GPS) device which can be used as a above-ground survey tool or as a reference station to improve the GPS position accuracy of the GeoRanger Utility Scanner. See Section 5.4.1
Surveyor Pro	The Windows software used to operate the GeoRanger Utility Scanner. See Section 3.2 and Section 4.2
Surveyor Mobile	A mobile app (Android or Apple) used to operate the GPS RTK 2W (Section 5.3) or basic functions of the GeoRanger Utility Scanner (Section 5.2). See Section 3.1 and Section 4.1
PointPerfect™	PointPerfect™ improves accuracy of the GPS RTK 2W through assistance data streamed over the internet. This increases the accuracy of above-ground survey points, and enhances the assistance of the GeoRanger Utility Scanner position when the GPS RTK 2W and GeoRanger Utility Scanner are used with Surveyor Pro. See Section 5.4.1.1
ESSential Underground	Advanced software for generating comprehensive 3D site visualizations. Available via subscription. See Section 5.9
Underground Aware	Share and view survey data, reports, and 3D views from ESSential Underground to team members on site using their mobile devices. See Section 5.10
Mobile Internet Access	A cellular data connection is needed for downloading aerial maps and linking to GPS base station networks. Available via subscription in select areas for tablets supplied with GeoRanger Utility Scanner. See Section 2.2

Table 1: System components and their functions.

2. Mobile Internet Requirements

Note: The GeoRanger Utility Scanner and GPS RTK 2W require Wi-Fi to communicate. You will not be able to use Wi-Fi for internet access while connected (unless using a second Wi-Fi adapter connected by USB).

Some features of Surveyor Pro and Surveyor Mobile require a mobile internet access (also known as “data service”, “cellular data”, “mobile broadband”, etc.) during surveys. Mobile internet service is therefore recommended for optimal function.

2.1. Mobile Internet with Surveyor Mobile

Mobile internet service is required by Surveyor Mobile in order to use the following features:

- Satellite Imagery in Above-Ground Survey Mode
- PointPerfect™ GNSS Position Assistance in both modes (requires additional subscription)

Some low-cost tablets have only Wi-Fi and cannot use mobile internet, these tablets are therefore not recommended.

2.2. Mobile Internet with Surveyor Pro

Mobile internet service is required by Surveyor Pro in order to use the following features:

- Satellite Imagery
- PointPerfect™ GNSS Position Assistance (requires additional subscription)
- NTRIP/CORS Position Assistance (requires third-party subscription, see Section 5.4.2)

2.2.1. Mobile Internet Activation

Important: This does not apply to third-party Windows tablets. See Appendix B.

On tablets supplied with your GeoRanger Utility Scanner, and in select regions, mobile internet service may be available through SUBSITE Cloud Service. To check availability, start the mobile internet activation process using one of the methods shown in Figure 2. If neither method appears, your tablet is likely ineligible.

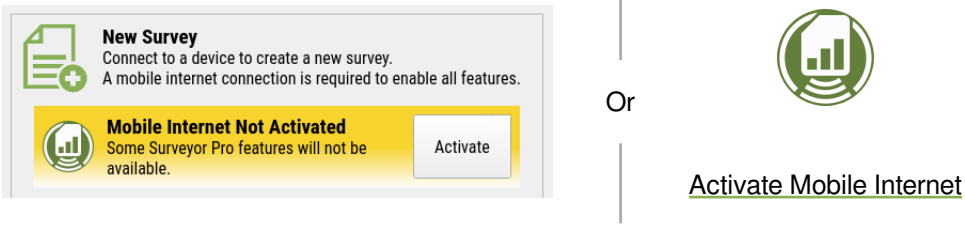

Figure 2: To activate mobile internet, touch the Activate button on the message in Surveyor Pro (left). Or if Surveyor Pro is not open, double-tap the icon on the desktop (right). If neither appears, your tablet is likely not eligible. Third-party tablets will not offer this feature.

2.2.2. Connecting Mobile Internet

On compatible tablets, if it is not connected already, Surveyor Pro will remind you to connect to mobile internet before beginning a new survey. Touch the Connect button shown on the message in Figure 3.

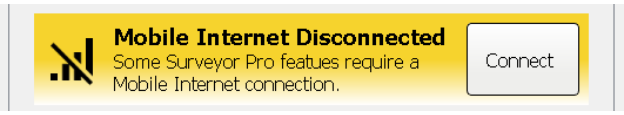

Figure 3: If this message appears, touch Connect before starting your survey.

3. Software Installation

3.1. Installing Surveyor Mobile

Surveyor Mobile is available on the Google Play® and the Apple® App Store®. Use any of the following to find Surveyor Mobile:

> **Note:** If your device does not meet the minimum Android or Apple requirements, Surveyor Mobile may not be listed in your platform's application marketplace: See Section 3.1.1 or Section 3.1.2 respectively.

1. Using your mobile device, scan the QR code on the top of your GeoRanger Utility Scanner.
   - If you have Surveyor Mobile installed, this should open it and begin connecting.
   - If you do not have Surveyor Mobile installed, you should be directed to web page which lists how to install it.
2. If that doesn't work or you don't have a QR code scanner, visit the following website on your mobile device:
   `https://app.esscloud.net`
3. Or, type the following phrase in the search bar of Google Play Store or Apple App Store:

   Earth Science Systems Surveyor

   Make sure you type the entire phrase exactly.

3.1.1. Android Requirements

> **Important:** The following Google applications need to be up-to-date, or Surveyor Mobile may not work:
>
> - Android System WebView
> - Google Play Services
> - Google Maps
>
> Make sure you have installed all available updates from Google Play before using Surveyor Mobile.

- Android 7.1 or later
  - Android 12 or later recommended
- 5 inch or larger display
  - Operation on smaller devices may be possible but is not supported.
- Wi-Fi 4 (also called 802.11n or "dual-band") or better.
- Mobile Internet (also called "Mobile Broadband", "Cellular Modem", "Cellular Data", etc.)
  - See Section 2.1
  - Optional for GeoRanger Utility Scanner
  - Strongly recommended for GPS RTK 2W
- Android System WebView version 90 or later
- Google Play Services version 24 or later

3.1.2. Apple Requirements

- iPhone X or later
- iOS version 16.7.6 or later recommended
  - Surveyor Mobile cannot be installed in iOS versions prior to 15.5.

3.2. Installing Surveyor Pro

Important: Standard data-rates apply: Connect your Windows tablet to Wi-Fi before updating or installing, as this will reduce the time required and avoid exceeding your mobile-internet download limits (if any).

Note: If you have already installed Surveyor Pro the update function is recommended over re-installing: Start Surveyor Pro, touch the Help menu, then touch Check for Updates.

For users supplying their own tablet computer (see Appendix B.), or if your Surveyor Pro installation is lost, follow these steps to install it:

1. Visit the following website:
   `https://subsite.esscloud.net`
2. Log in with your e-mail and password.
   - If you don't have an account, use the registration function to create one, then log in.
3. From the menu, choose Downloads
4. Locate the download called ESS Python and touch the Download button.
5. Wait for the download to complete.
6. Open the downloaded install program from your browser's Downloads menu.

   Important: The ESS Python installer must be completed before the Surveyor Pro installer can be opened.
7. Locate the download called Surveyor Pro and touch the Download button.
8. Wait for the download to complete.
9. Open the downloaded install program from your browser's Downloads menu.
10. You can now run Surveyor Pro by double-tapping the icon on your desktop.

4. Software Overview

4.1. Surveyor Mobile Overview

Surveyor Mobile is used to operate the GPS RTK 2W (see Section 5.3 and Section 5.4.1) and to perform basic single-line surveys using the GeoRanger Utility Scanner (see Section 5.2). To install Surveyor Mobile see Section 3.1.

4.1.1. Connecting to a Device

1. After opening Surveyor Mobile for the first time you will need to accept the End User License Agreement (EULA).
2. On Android devices you must grant “location” permission.
   - The “location” permission allows Surveyor Mobile to use Wi-Fi (your location is not actually used).
3. On newer Android devices you will asked to allow “notification” permission.
   - As of this writing, notifications are used only for background PointPerfect™ (see Section 4.1.3) and “GPR Assist” mode status (see Section 5.4.1).

> **Important:** Make sure your GPS RTK 2W or GeoRanger Utility Scanner have been turned on for at-least 20 seconds before attempting to add a device or connect to a previously connected device. See Appendix C.

Figure 4: Surveyor Mobile welcome screen (Wi-Fi signal indications are available only on Android).

4. To reconnect to a previously connected device, touch the Connect button below the device’s serial number.
   - Devices are listed in order from most-recently to least-recently connected.
5. To add a new device choose an option under the heading “Add Device Using”:
   - Touch QR Code to scan the QR code on the top (or back) of your device.
   - If you are unable to scan the QR code, touch Serial Number and carefully type in your device’s serial number.
   - On Android, compatible devices may be added automatically if their Wi-Fi signal is detected.

- If you are unable to connect after three attempts, refer to Appendix D.2. for additional troubleshooting steps.

6. Your device will ask you to allow Surveyor Mobile to connect Wi-Fi to the chosen serial number. Choose Allow or Connect:
   - On Apple devices you will be prompted for permission each time.
   - On Android devices you should only be prompted the first time you connect to a new serial number.
7. The first time you successfully connect your Apple device to a GPS RTK 2W or GeoRanger Utility Scanner, you will see a prompt similar to Figure 5:
   - It is important to choose Allow, as the GeoRanger Utility Scanner and GPS RTK 2W are “devices on your local network”.

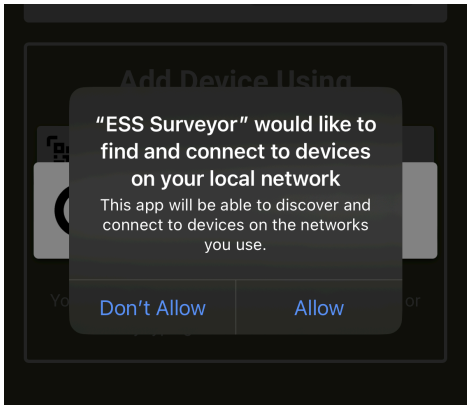

Figure 5: Local network permission prompt (Apple only).

   - If you choose Don't Allow Surveyor Mobile **will not function**, refer to the following Apple support article for more information: `https://support.apple.com/en-us/102229`
8. The GPS RTK 2W can operate in either of the two following modes:
   - Survey: An above-ground survey. See Section 5.3
   - GPR Assist: Used together with the GeoRanger Utility Scanner and Surveyor Pro: See Section 5.4.1
9. The GeoRanger Utility Scanner operation is limited in Surveyor Mobile compared to Surveyor Pro: See Section 5.2

4.1.2. Common Features

While the operation of the GPS RTK 2W (see Section 5.3 and Section 5.4.1) and GeoRanger Utility Scanner (see Section 5.2) are very different, there are a few common features to be aware of:

1. Navigation and options are on the menu accessed by touching the three parallel lines in the top left corner of your display: ☰
   - On large-screen devices (tablets) the menu may be visible along the left at all times.
2. While connected, the battery level of the connected device is shown in the top-right of the display.
   - Touch the battery symbol to see the estimated time remaining.
3. If the Wi-Fi connection is lost, a red Wi-Fi symbol replaces the battery indicator:
   - If necessary, replace the device’s battery with a fully charged one.
   - Ensure you are near the device and have not left its Wi-Fi range:
     - For optimal performance stay within 10 feet (3 meters) of the GeoRanger Utility Scanner.

- If you are in-front of the GPS RTK 2W (opposite the battery) see Figure 13 in Section 5.4.1.2 for maximum Wi-Fi range.
- If you are behind or to the side of the GPS RTK 2W stay within 3 feet (1 meter), as the Wi-Fi signal is weaker.

- Touch the red Wi-Fi symbol ( ), then touch Reconnect to restore your connection.

4. To disconnect and return to the welcome screen:
   a. Touch *(Menu)*
   b. Touch Disconnect

4.1.3. PointPerfect™ on Android Devices

Note: PointPerfect™ is utilized in Section 5.3 and Section 5.4.1.1. PointPerfect™ requires a subscription through SUBSITE Cloud Service and mobile internet service (see Section 2.1).

On most Android devices PointPerfect™ will continue operating in the background, even if you switch apps or lock your Android device (provided you remain in Wi-Fi range). Some Android manufacturers improve battery life by terminating background apps in non-standard ways: To reduce the chances of unexpected background termination, return to Surveyor Mobile at-least once every 10 minutes.

The following notification in Figure 6 shows that background assistance is operational.

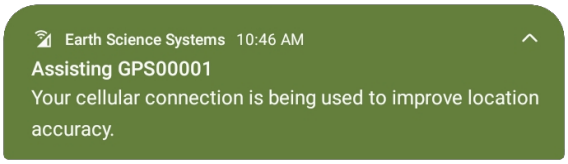

Figure 6: Background PointPerfect™ assistance notification.

Touch the notification to return to Surveyor Mobile. To stop background assistance, return to Surveyor Mobile, touch *(Menu)* then Disconnect. When in GPR Assist mode, background assistance will stop automatically once GPR Assist mode is fully operational (see Section 5.4.1.2).

4.1.4. PointPerfect™ on Apple Devices

Note: PointPerfect™ is utilized in Section 5.3 and Section 5.4.1.1. PointPerfect™ requires a subscription through SUBSITE Cloud Service and mobile internet service (see Section 2.1).

Apple devices maximize battery life and privacy by restricting background activity. In the case of Surveyor Mobile, this means communication with your GPS RTK 2W is only possible **while visible** on your device's display. "Locking" your Apple device display, or switching to another app, will interrupt the connection after **only a few seconds**. Interrupting the connection interrupts the continuous stream of PointPerfect™ data which the GPS RTK 2W requires in order to achieve maximum position accuracy.

- When using GPS RTK 2W with PointPerfect™, keep Surveyor Mobile visible:
  - **Do not "lock" your screen or switch apps.**
- If you must leave Surveyor Mobile, upon returning:
  1. Restore the Wi-Fi connection (see Section 4.1.2).

2. Allow at-least 60 seconds for previously-achieved GPS accuracy to return.

- If it is safe to do so, hold the GPS RTK 2W still Surveyor Mobile whenever Surveyor Mobile is not visible on your display:
  - In general, restoration of GPS accuracy will take longer if the GPS RTK 2W was moved while the connection was interrupted.

4.2. Surveyor Pro Overview

Surveyor Pro is used to operate the GeoRanger Utility Scanner, optionally with assistance from a GPS RTK 2W (see Section 5.4.1). To install Surveyor Pro see Section 3.2

1. After opening Surveyor Pro for the first time you will need to accept the End User License Agreement (EULA).
2. On some Windows 11 computers you may need to give Surveyor Pro permission to access your “location”. This is necessary in order to use Wi-Fi.
3. The Welcome tab is divided into left and right halves:
   - The left half allows connecting mobile internet, if so equipped (see Section 2.2).
   - The left half also contains options for connecting to a GeoRanger Utility Scanner to create a new survey:
     - Touch the serial number of your GeoRanger Utility Scanner, then touch Connect.
     - If your serial number is not listed, make sure your scanner has been turned on for at-least 20 seconds, or see Appendix D.2.
   - The right half allows opening previously created surveys, for review or reporting.
4. After connecting to a GeoRanger Utility Scanner, or opening a file, the Welcome tab is replaced by three tabs:
   - The Job Information tab:
     - Allows configuring all other tabs using named settings.
     - Allows entering or editing record-keeping information about the survey.
     - When creating a new survey: Sets in what folder the data is stored.
   - The Survey Plan tab:
     - Configures the type of survey: Free-form (see Section 5.5) or Grid (see Section 5.6)
     - Shows a virtual overhead view of the survey, with satellite view where available (see Section 2.2).
     - Shows numerical and status information along the top, with a battery indicator at the far right.
   - The GPR Scan tab:
     - Shows the GPR scan data and relative magnetic signal strength.
     - Allows marking a GPR target and fitting a hyperbola using the Markers and Depth button.
     - Optionally shows the overhead view from Survey Plan on the left side, allowing simultaneous viewing.
     - Shows numerical and status information along the top, just as in Survey Plan.
     - Contains controls for adjusting the plotting.
5. The Survey Plan and GPR Scan tabs both contain:
   - A battery indicator near the top-right. Touch the battery indicator to see the estimated time remaining.
   - A numerical indication showing the GPS status and estimated accuracy (rightmost). Touch the indicator to see detailed positioning status:
     - For enhancement using a GPS RTK 2W, see Section 5.4.1
     - For enhancement using NTRIP/CORS, see Section 5.4.2 and Appendix E.
6. The Start Line and Stop Line buttons in the top-right are used to create a new survey:
   - See Section 5.5 or Section 5.6 for examples of creating free-form or 3D GPR scans, respectively.

7. When a previously created file is open, the Replay button begins playing back the data, see Section 5.7.
8. The Survey Plan and GPR Scan tabs contain buttons on the left for creating basic exports and reports:
   - Advanced reporting options are available in ESSential Underground see Section 5.9.
   - See Section 5.8
9. To return to the Welcome tab, touch Disconnect or Close in the bottom-right.
10. To launch the new or opened survey in ESSential Underground for 3D analysis, touch Export to 3D.

5. Operation

Before starting a survey, remove any debris from the scan area and avoid areas with standing water. Then determine the area to be surveyed and which of the survey methods will be used:

1. A single-line GPR survey (See Section 5.2):
   - A simplified, but limited, GPR survey performed using Surveyor Mobile.
   - Generates a cross-section view versus distance by pushing the cart along the survey line.
   - Cannot be re-examined or combined with any of the following types.
2. A surface feature survey (See Section 5.3):
   - Optionally performed before a free-form GPR survey or a 3D GPR survey, to aid in their later interpretation.
   - Uses GPS RTK 2W with Surveyor Mobile to record the the locations of:
     - Above-ground evidence of buried utilities, such as water meters and man-hole covers.
     - Other landmarks related to the survey area, such as curbs.
3. A free-form GPR survey (See Section 5.5):
   - Uses GPS positioning to collect data using Surveyor Pro on a Windows tablet.
   - Lines can be of any shape, but enhanced-accuracy GPS is recommended so that the shape is stored accurately.
4. A 3D GPR survey (See Section 5.6):
   - Provides the most complete and highest resolution images.
   - A collection of survey lines are run on a crosshatch grid with a constant spacing between the lines.
   - Surveyor Pro on a Windows tablet provides an on-screen display that guides the surveyor to properly position the scanner while traversing each scan line (requires enhanced accuracy GPS).

The first step for any survey method is to perform the Hardware Assembly in Section 5.1.

5.1. Hardware Assembly

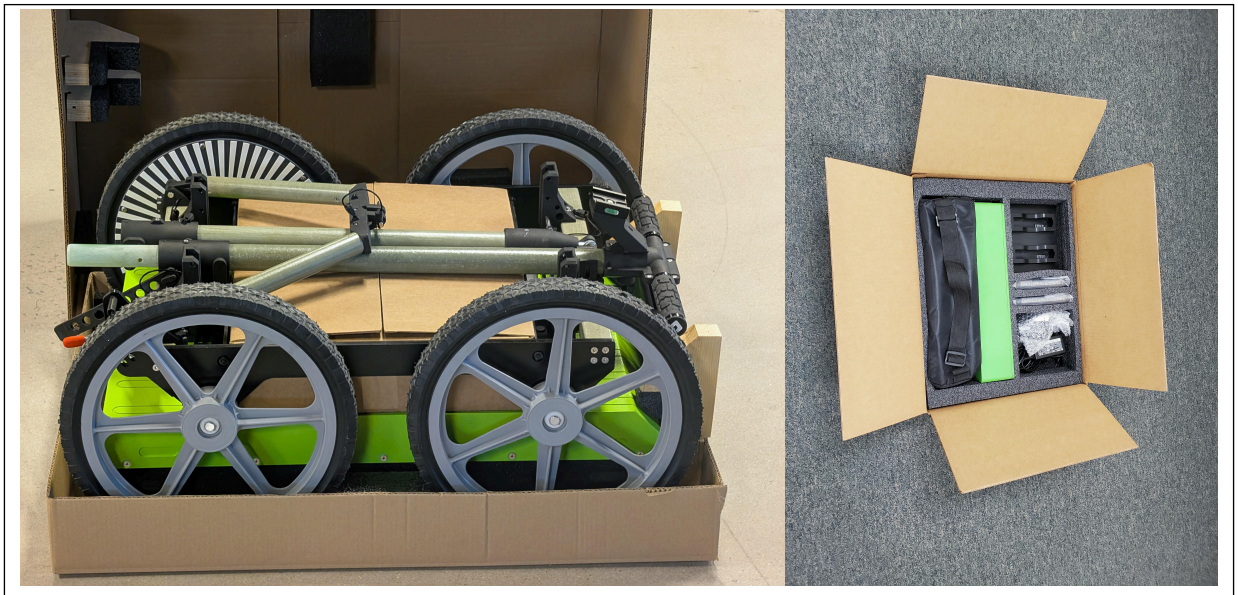

Figure 7: GeoRanger Utility Scanner packed in cardboard box (left). GeoRanger Utility Scanner accessory box, showing GPS RTK 2W and tripod, if so equipped (right).

5.1.1. Assemble Scanner Cart

Note: This section applies to both the cardboard and hard-shell containers, as they are internally similar.

The GeoRanger Utility Scanner's cart disassembles for transport or storage. Follow the steps below to assemble it:

1. Open the container (see Figure 7).
2. Unfold the diagonal brace.
3. Pull the rubber strap near the back of the scanner to release it, and free the handlebar assembly and strut.
4. Remove the handlebar assembly by firmly pulling the handlebars up while holding down the square cart frame.
5. Set the handlebar assembly aside.
6. Unfold the remaining strut and remove the accessories box (see Figure 7) and set it aside.
7. Refold the strut and diagonal brace, then lift cart out of the box and set it aside.
8. Grasp the scanner by placing one hand around each of the black hanger bars on the top of the housing.
9. Carefully lift the scanner from the shipping case and set it near the cart.
10. Roll the cart so that it is over the scanner: The diagonal brace should be over the rear of the scanner (the end with the battery door).
11. Retrieve the handlebar assembly from Step 5 and insert it into the open end of the strut.
12. Rotate the handlebar assembly so that the triangle on the handlebar assembly matches the triangle on the top of the strut. See Figure 8.
13. Insert the pin attached to the strut through the upper hole on the strut (Figure 8 shows this pin installed).
    - You may need to rotate the handlebar assembly slowly to allow the pin to align.
14. Lift the diagonal brace up to meet the bottom of the strut assembly.

15. Align the top of the diagonal brace to one the the positions (A, B, C or D) shown in Figure 8.
    - Your choice of position controls the final handlebar height off the ground.
    - In general, taller surveyors should select latter positions.
16. Insert the pin attached to the diagonal brace through both the top of the brace and the position selected in Step 15.
17. Refer to Section 5.1.2 to attach the scanner to the cart.

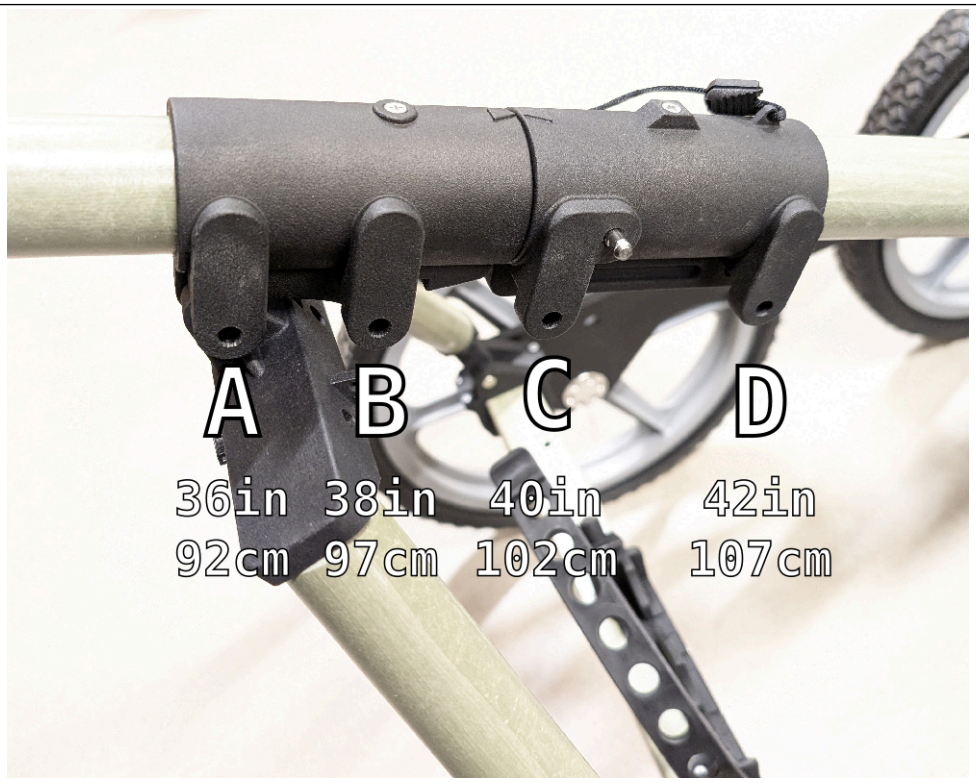

Figure 8: Your choice of pin position sets the handlebars to the indicated height above the ground.

5.1.2. Assemble GeoRanger Utility Scanner

The GeoRanger Utility Scanner is suspended beneath the cart by four slotted arms and two elastic cords. This arrangement allows the scanner to “float” under the cart and stay in contact with uneven ground. Follow the steps below to attach the scanner to the cart:

1. Roll the cart (assembled in Section 5.1.1) over the scanner.
    - Make sure that the handlebars are on the same end as the battery door.
2. Choose one of the grooved brackets on the cart, and remove the locking pin.
3. Below the bracket, rotate up the slotted arm on the top of the scanner, and place it in the groove on the cart.
4. Install the pin, through both the bracket and the slotted arm, into one of the three positions on the bracket:
    - For surveys on flat clear ground, such as parking lots, use the lowest position.
    - For rougher terrain, use higher positions if necessary to avoid collisions at the front of the scanner.
5. Repeat from Step 2 for each of the three remaining arms.
    - All four brackets should use the same height setting.
6. Using two hands, press down on the front black elastic cord, until it touches the scanner.

7. Push the cord under the hook on the scanner and release.
8. Repeat from Step 6 for the rear elastic band.
9. On the rear of the scanner, locate the black battery door.
10. Turn each of the black tabs on the battery door one-quarter turn counterclockwise to release the door.
11. Pull the battery door down and out of the way.
12. Insert a fully charged battery with the grooved-face up, and the grooved edge toward the front of the scanner.
    - A fully charged battery will show five black squares in the window on one end.
    - Make sure the battery is inserted fully, it will not seat fully if inserted incorrectly.
13. Flip the battery door up and press it against the scanner housing, then turn each black tab one-quarter turn clockwise to secure it.
14. Firmly press the power button located on the center of the rear of the scanner.
    - The power button should illuminate green. If it does not, refer to Appendix D.1.
    - The GeoRanger Utility Scanner indicates a few different states using blink patterns explained in Appendix C.

5.1.3. Assemble Tablet Mount

The tablet mount (if so equipped) uses a slim clamp to attach to the Windows Tablet Kit to the cart. (The tablet mount is not compatible with third-party tablets.) It allows the operator to keep their hands on the handlebars while surveying a line using Surveyor Pro.

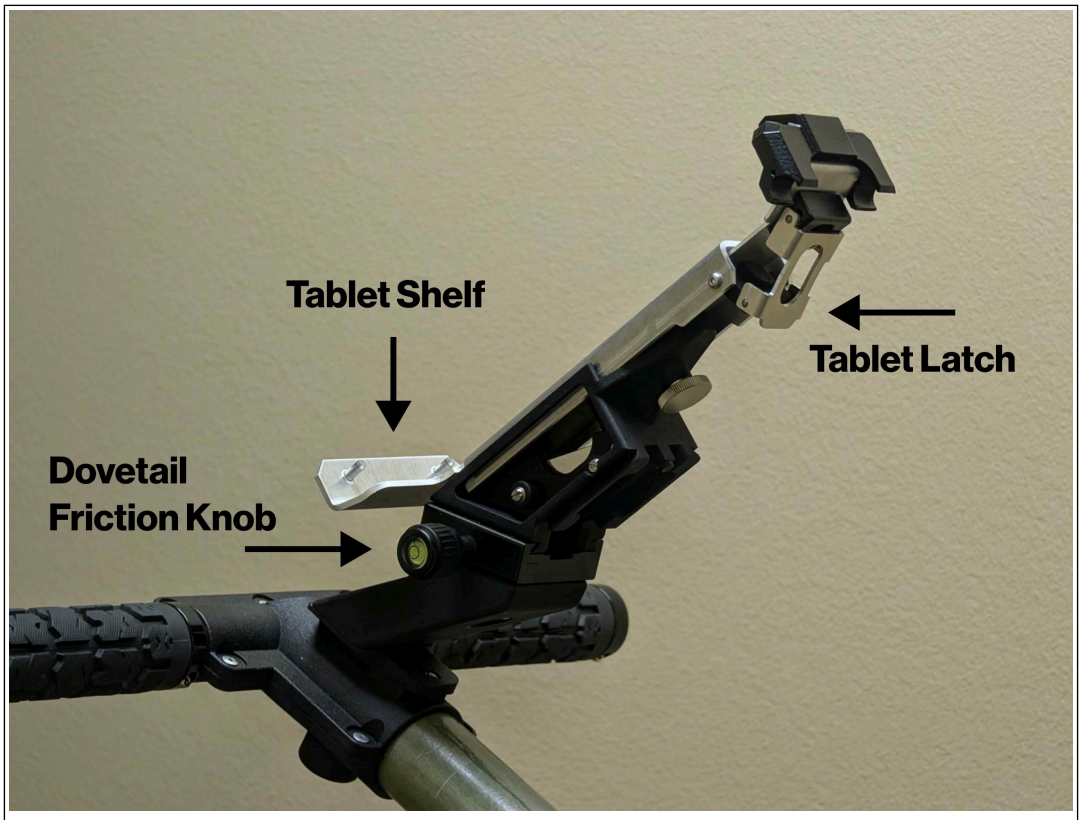

Figure 9: The tablet mount attached to the cart, showing the tablet latch in the open position.

1. Locate the dovetail mount. It is centrally located above the handlebars of the cart.
2. Locate the knob on the right of the dovetail mount and turn it counterclockwise to open the dovetail jaws.

3. Insert the mating base of the tablet mount, then turn the dovetail knob clockwise until the mount is secure.
4. Pull the tablet latch on the back of the tablet mount toward the front of the scanner to unlock the upper half of the clamp, as shown in Figure 9.
5. Place the top of the tablet under the upper part of the clamp.
6. Align the holes in the bottom of the tablet to the pins on the tablet shelf (see Figure 9), then lower the tablet to the shelf so that the pins are inserted into the tablet.
7. Press the top of the clamp down, making sure the lip of the top clamp wraps over the front of the tablet.
8. Push the tablet latch toward the back of the tablet until it lies flat.

5.1.4. Assemble Smartphone Mount

The smartphone mount (if so equipped) uses a spring-loaded clamp to attach most smartphones to the cart. It allows the operator to keep their hands on the handlebars while performing a single-line survey (Section 5.2) using Surveyor Mobile.

1. Locate the dovetail mount. It is centrally located above the handlebars of the cart.
2. Locate the knob on the right of the dovetail mount and turn it counterclockwise to open the dovetail jaws.
3. Insert the mating base of the smartphone mount, then turn the dovetail knob clockwise until the smartphone mount is secure.
4. Place your smartphone against the lower jaw.
   - Your smartphone will only fit in “landscape” orientation: This is the only orientation supported by a single-line survey (Section 5.2).
5. Shift your smartphone left or right to avoid either jaw pressing any buttons, such as power or volume.
6. Lift the upper jaw and wrap it over the top of your smartphone so that your smartphone is gripped from both the top and bottom.
   - Large cases may need to be removed in order to fit the clamp.

5.1.5. Assemble GPS RTK 2W (Base Station and Survey Tool)

1. Remove the GPS RTK 2W from the accessories box shown at the right of Figure 7.
2. Remove the tripod from the accessories box:
   - As of this writing it is immediately adjacent to the GPS RTK 2W.
3. Remove the tripod from the tripod bag, and rotate each leg 180 degrees to unfold them.
4. Twist each of the rings along each of the legs until they are loose.
5. Pull each leg until it is fully extended.
6. Twist each of the rings along each of the legs again until they are tight.
7. Locate the knob on the side of the dovetail mount at the top of the tripod and turn it counterclockwise to open the dovetail.
8. Place the mating dovetail of the GPS RTK 2W into the tripod dovetail.
9. Turn the knob from Step 7 clockwise until it is tight and the GPS RTK 2W is secure.
10. Unfasten the battery door of the GPS RTK 2W and insert a fully charged battery.
    - The door can only be closed if the battery is inserted in the correct direction.
11. Secure the battery door.
12. Firmly press the power button to the urn the GPS RTK 2W on.
13. Proceed with either of the following operations:
    - Perform an above-ground survey, see Section 5.3.
    - Set up the GPS RTK 2W to assist your GeoRanger Utility Scanner and increase it’s location accuracy: See Section 5.4.1.

5.2. Perform a Single-Line GPR Survey

Important: Surveyor Mobile GPR features are limited. Only Surveyor Pro fully utilizes all GeoRanger Utility Scanner features, see:
- GPR survey (Section 5.5)
- 3D GPR survey (Section 5.6)

The GeoRanger Utility Scanner can be used with Surveyor Mobile on an Android or Apple device for rapid GPR surveys, however they have several important limitations:

- Surveyor Mobile GPR surveys **do not** use GPS.
- Surveyor Mobile GPR surveys can only be exported as a PDF or PNG:
  - They **cannot** be reviewed, edited or merged with other surveys.
- Surveyor Mobile GPR surveys **cannot** mark multiple targets.
- The maximum line length is significantly shorter than in Surveyor Pro.

To take a single-line survey:

1. If you have not already, install Surveyor Mobile (see Section 3.1).
2. Setup your GeoRanger Utility Scanner cart (see Section 5.1.1).
3. Attach your GeoRanger Utility Scanner to the cart (see Section 5.1.2).
4. Attach your smartphone mount to the cart (see Section 5.1.4).
5. Ensure the GeoRanger Utility Scanner is turned on.
6. Launch Surveyor Mobile as you would any other app on your mobile device.
7. Connect Surveyor Mobile to the GeoRanger Utility Scanner (see Section 4.1.1).
8. Once connected, place your smartphone in the smartphone clamp (see Section 5.1.4):
   - The smartphone display will automatically remain on and locked in “landscape” orientation until you disconnect.
   - If you have difficulty connecting refer to Appendix D.2.

   Note: In most cases Surveyor Mobile will preserve your survey if you switch apps or take a call during your scan. If it is safe to do so, avoid moving the GeoRanger Utility Scanner during interruptions, as upon returning to Surveyor Mobile this may replace parts of your scan or create unwanted gaps.

   Interruptions of more than a few seconds may cause loss of the Wi-Fi connection, to reconnect see Section 4.1.2.
9. Move the GeoRanger Utility Scanner to the beginning of your scan line:
   - This will become the “zero” position of your scan.
10. Surveyor Mobile contains a menu on the left-side of the display which is normally hidden:
    - Touch the three parallel lines in the upper-left corner () to open the menu.
    - The menu scrolls vertically access a large number of options and controls.
    - Your survey’s measurement units are selectable on this menu.
11. Near the top of the menu, touch the Clear & Restart button:
    - The GPR scan will be cleared and the horizontal position (displayed in the upper-right) will be reset to zero.

12. Push the GeoRanger Utility Scanner forward at a gentle even pace: GPR scan data will fill the display from left to right.
    - The display scrolls automatically when nearing either edge: Use the Pause button to suspend GPR data collection and automatic scrolling.
    - A colored bar along the bottom indicates the relative strength of magnetic fields which may indicate electrical power cables.
13. Surveyor Mobile collects data from both GeoRanger Utility Scanner GPR antennas simultaneously, but only displays one at a time:
    - Touch ☰ *(Menu)*, then touch Antenna A or Antenna B to choose which is displayed.
    - The “B” antenna is physically behind the “A” antenna (see the color coded lines on the top of the GeoRanger Utility Scanner), and as a result data from “B” is plotted behind “A”.
14. The GeoRanger Utility Scanner battery level is shown in the top-right of the display. See Section 4.1.2.
15. To estimate the depth to a target:
    a. Touch ☰ *(Menu)*, then touch Mark Hyperbola.
    b. Surveyor Mobile will show an image demonstrating marking an example hyperbola. Touch Continue.
    c. Touch the top of a hyperbola in your scan.
    d. Surveyor Mobile will show the GPR scan from the location you touched and overlay a dashed hyperbola on it:
        (i) Swipe the image up, down, left or right to align the peak of the dashed line to the peak of the hyperbola in your scan.
        (ii) Touch the buttons on the right of the display to change the shape of the dashed hyperbola to match the shape of the hyperbola in your scan. See also Appendix A.
        (iii) Touch and hold the display to temporarily hide the dashed line.
        (iv) Repeat the steps above until both the location and shape are matched, then touch Continue.
    e. Surveyor Mobile will show the horizontal position, depth and dielectric computed from your input in the previous steps.
        - Touch Accept to use the computed dielectric for the remainder of your scan.
        - Surveyor Mobile can only mark one hyperbola per scan: If you repeat this process your previous selection will be lost.
16. While marking a hyperbola, the scan is paused automatically. Touch the blinking yellow Resume button to continue the scan.
17. To save images or reports:
    a. Touch ☰ *(Menu)*, then touch Export Plot.
    b. Choose the format of the export:
        - Report: A minimal PDF report.
        - Image Only: A PNG image is saved. This is best suited for inserting into a word processor at a later time.
    c. Touch Continue:
        - Enter a file name, if desired.
        - If Report was chosen, choose “Letter” (US) or “A4” (International) paper size.
        - If Report was chosen, a very brief description may be entered and will appear in the margin of the PDF.
    d. Touch Save PDF Report or Save Image:

- When doing this for the first time you will be prompted to allow Surveyor Mobile to store files on your device.
- Surveyor Mobile will store the PDF or PNG to your smartphone's Documents folder.
- Surveyor Mobile will display the PDF or PNG using your smartphone's default application for the respective format. This typically includes options for sharing the file, such as by e-mail.

18. To take a new scan, repeat from Step 9.
19. If you are finished with GeoRanger Utility Scanner:
    a. Touch ☰ *(Menu)*
    b. Near the top choose Disconnect.
20. Turn off GeoRanger Utility Scanner, remove the battery, disassemble the cart and store the system safely.

5.3. Perform an Above-Ground Survey

Important: A subscription to PointPerfect™ for your GPS RTK 2W is strongly recommended. Without PointPerfect™ the surface feature points **may be too inaccurate to aid in the later interpretation of GPR data.**

Note: Surveyor Mobile uses PointPerfect™ automatically when:
1. Your Android or Apple device has a working mobile internet connection, see Section 2.1.
2. The GPS RTK 2W you are using is subscribed to PointPerfect™ in SUBSITE Cloud Service. (Surveyor Mobile does not need your account information.)

An above-ground survey is used to virtually mark the GPS locations of evidence of subsurface utilities, which can aid in the later interpretation of GPR scans. Performing an above-ground survey, prior to either a free-form survey (Section 5.5) or 3D survey (Section 5.6), ensures virtual markings are automatically included into either GPR survey. To perform an above-ground survey:

1. Assemble the GPS RTK 2W (see Section 5.1.5).
2. Open the battery door, insert a fully charged battery, and close and secure the battery door.
3. Firmly press the power button to turn on the GPS RTK 2W.
4. If you have not already, install Surveyor Mobile (see Section 3.1).
5. Launch Surveyor Mobile and connect to the GPS RTK 2W (see Section 4.1.1).
6. Once connected you will see the mode selection and the checklist for the current mode:
   - Touch "Survey" to ensure the GPS RTK 2W is in above-ground survey mode, as shown in Figure 10.

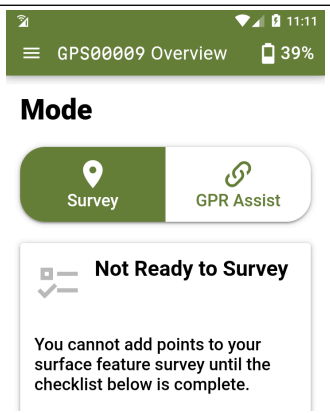

Figure 10: Surveyor Mobile showing the GPS RTK 2W overview in above-ground survey mode.

7. Scroll down to see the checklist for this mode. Each checklist item needs to be completed before surface features can be added. Checklist items include:
   - Setting the tool height, this measured from the ground to the base of the GPS RTK 2W enclosure.
   - Allowing PointPerfect™ to achieve acceptable accuracy (if subscribed and mobile internet is available, see Section 2.1).

   Important: When using PointPerfect™, **you cannot lock your iPhone or iPad or switch apps** as this will suspend Surveyor Mobile and in turn interrupt PointPerfect™, causing a loss of position accuracy. See Section 4.1.4 for more information.

   Note: On most Android devices PointPerfect™ will continue operating in the background. See Section 4.1.3 for more information.

8. Surveyor Mobile will remind you if the points currently stored in the GPS RTK 2W are more than 8 hours old:
   - If the old points are still relevant to your survey, simply ignore this reminder to retain them.
   - To delete all points, touch `Start New Survey` button at the top of the overview page (or use the `Delete All` button in the points list).
   - All points in the vicinity will be automatically included in your Surveyor Pro GPR survey (when Section 5.4.1 is followed), regardless of age.

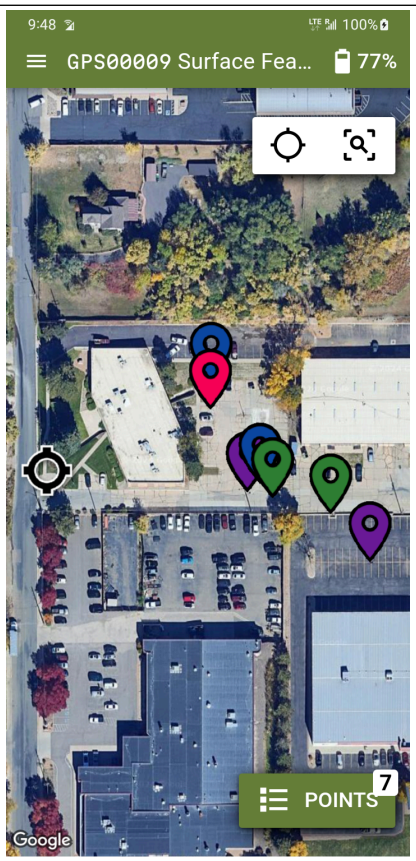

Figure 11: Surveyor Mobile above-ground survey map view. Touch ☰ *(Menu)* and choose Overview to return to the checklist and mode selection.

9. When the checklist indicates you are ready to add points, touch View and Add Points.
   - A satellite view map will be displayed, as in Figure 11 (requires mobile internet, see Section 2.1).
   - The cross-hairs indicate the GPS RTK 2W current position.
   - Colored markers show any locations currently in the GPS RTK 2W memory.
   - Touch the Points button in the bottom-right of the display to view points as a list.
   - Touch a colored marker to see a point's details, or to edit or delete it.
   - There are two buttons for controlling the view in the upper-right corner:
     - The cross-hair button (left) zooms to the GPS RTK 2W current position.
     - The box zoom button (right) adjusts the view to make all points in memory visible simultaneously.
10. Locate a surface feature of relevance to your GPR survey, such as a water meter.
11. Place the GPS RTK 2W over the feature.
12. Touch the Points button.
13. Locate the category of the new feature, and touch the Add button at the right of the category.
    - The Add button will not be available if you are not ready to survey, return to the checklist and complete it first.
    - The categories and their colors are predefined to be consistent with subsurface utility engineering (SUE).

14. Enter a name for the feature, then touch Add Point.

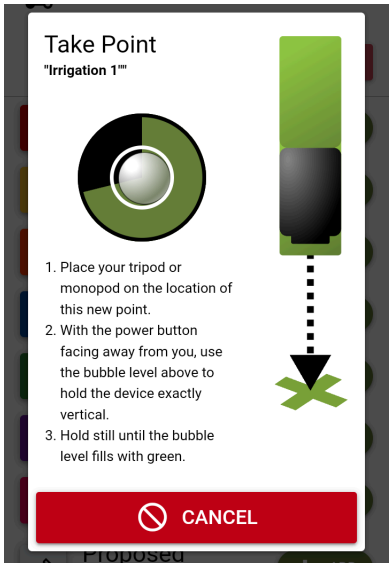

Figure 12: An example of taking a point, showing the on-screen bubble level centered and with its background showing just under 75% completion.

15. While holding the the GPS RTK 2W so that the battery door faces you, use the on-screen bubble level to ensure that the tripod and GPS RTK 2W are plumb: See Figure 12.
16. When the on-screen bubble is within the white circle, hold the GPS RTK 2W still until the background of the on-screen bubble level fills with green.
17. Once sufficient data is collected, the prompt in Figure 12 will close and the point will be added to the survey map.
    - Touch the new marker on the map to see its details, modify its name or type, or delete it.
18. Repeat from Step 10 for any other above-ground features which may be relevant.

> **Note:** All collected points are transferred into your Surveyor Pro GPR survey automatically when the GPS RTK 2W is used to assist your GeoRanger Utility Scanner survey (see Section 5.4.1).
>
> Collected points remain stored in your GPS RTK 2W, and continue to be added to Surveyor Pro surveys, until you delete them.

19. If no more points are desired, **proceed immediately** to GPR Assist mode (Section 5.4.1.2) **without disconnecting**, as this can significantly reduce the total setup time when using PointPerfect™.

5.4. Enhancing GeoRanger Utility Scanner GPS Accuracy

Note: Only Surveyor Pro utilizes GPS. This section does not apply to Surveyor Mobile.

Enhancing the GeoRanger Utility Scanner's GPS position accuracy is strongly recommended when performing free-form (Section 5.5) or 3D (Section 5.6) GPR surveys. Without an enhanced-accuracy position, some features of Surveyor Pro will be unavailable or have little utility.

The GeoRanger Utility Scanner GPS position accuracy can be enhanced using a GPS RTK 2W (Section 5.4.1) or using an NTRIP/CORS reference station or subscription to NTRIP/CORS network (Section 5.4.2).

5.4.1. Position Enhancement Using GPS RTK 2W

The GeoRanger Utility Scanner position accuracy can be enhanced by receiving assistance directly from a GPS RTK 2W over Wi-Fi. When GPS RTK 2W is used without PointPerfect™, the GeoRanger Utility Scanner survey may be shifted in comparison to other precision GPS systems (see Table 2). To reduce the shift, PointPerfect™ can be used to improve the accuracy of the reference position used for assistance (see Section 5.4.1.1).

5.4.1.1. PointPerfect™ Enhancement

Note: Surveyor Pro and Surveyor Mobile use PointPerfect™ automatically when:

1. Your smartphone or tablet has a working mobile internet connection, see Section 2.
2. The GPS RTK 2W you are using is subscribed to PointPerfect™ in SUBSITE Cloud Service.
   - Your account information is not necessary because the service is linked by serial-number.
3. PointPerfect™ disconnects automatically once `GPR Assist` mode is fully operational.

When the GPS RTK 2W is in `GPR Assist` mode, the GPS accuracy of the GeoRanger Utility Scanner will be improved even without PointPerfect™. However, combining GPS RTK 2W and PointPerfect™ will maximize the agreement of GeoRanger Utility Scanner position data with GPS data from other systems. See Table 2.

	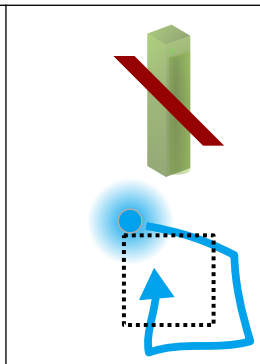	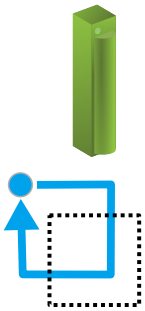	
GeoRanger Utility Scanner GPS Assistance	None	GPS RTK 2W	GPS RTK 2W with PointPerfect™ Subscription
Mobile Internet	Not Necessary		**Required**
GPS RTK 2W GPR Assist Mode	*N/A*	GPR Assist mode may require additional time to start.	Fastest startup time.
Absolute Position Accuracy	**Poor agreement:** Data will be difficult or impossible to combine with other systems.	Shape is correct, but survey has **unpredictable shift**.	**Best agreement:** Survey positions should combine well for most applications.
Free-Form Surveys	**Distorted**	Survey path taken is faithfully captured.	
3D Surveys	**Difficult:** Requires manual measurement and marking.	3D surveys can be performed with **no manual measurement or markings**. Simply follow the on-screen grid in Surveyor Pro.	

Table 2: Effect of different assistance components on GPS position data (blue) if moving the GeoRanger Utility Scanner along a hypothetical square (dotted line). *For illustration only. Not to scale. Performance varies with site conditions and other factors.*

5.4.1.2. Setup for GeoRanger Utility Scanner Assistance

The GPS RTK 2W can improve the position accuracy of the GeoRanger Utility Scanner when:

1. Located in a corner of your survey area and aimed toward the center of that area (see Figure 13).
2. Configured to connect your GeoRanger Utility Scanner by entering your scanner's serial number.
3. Set to GPR Assist mode.
4. Allowed sufficient time and view of the sky to establish a reference position.

Assistance is provided by a Wi-Fi link between the GPS RTK 2W and GeoRanger Utility Scanner. The GPS RTK 2W is equipped with a long-range Wi-Fi antenna to maximize the usable survey area (see Figure 13). Like all Wi-Fi devices, usable range will be reduced or blocked by any object between the GPS RTK 2W and GeoRanger Utility Scanner. Obstructions containing metal, such as buildings and vehicles, may block the signal entirely.

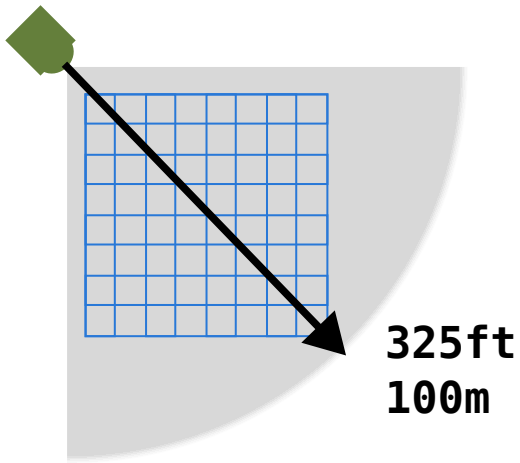

Figure 13: Recommended GPS RTK 2W placement and usable assistance area (shaded gray). Note that the GPS RTK 2W's Wi-Fi signal is emitted primarily from its rounded face, and so should be aimed toward the center of the GeoRanger Utility Scanner survey area (blue grid). **The usable area will be reduced by any obstructions, such as buildings or vehicles.** *Not to scale.*

Note: Immediately after your final above-ground survey point (from Section 5.3), **begin from Step 10 without disconnecting Surveyor Mobile.** This will reduce the total setup time in most cases.

To set up GPS RTK 2W to assist your GeoRanger Utility Scanner:

1. Assemble the GPS RTK 2W as explained in Section 5.1.5.
2. Ensure the legs of the tripod are fully extended and are spread out for stability.
3. Locate a safe position for the GPS RTK 2W:
   - Select a location where the GPS RTK 2W **will not be moved**.
   - Select a location near the corner of your GPR survey, see Figure 13.
   - Avoid locations where vehicles will frequently pass between the GPS RTK 2W and your survey area.
   - Avoid buildings and vehicles where possible.
   - Avoid dense tree-cover where possible.
4. Set the tripod in a safe position meeting the requirements in Step 3.
5. Rotate the tripod so the rounded face is aimed at the center of your intended GPR survey area (Figure 13).
6. If on uneven ground, shorten one or more legs to ensure the base-station is upright.
7. Attach a weight to the spring-loaded hook located under the apex of the tripod:
   - A weight should be attached even if the weather is calm, in windy conditions use a heavier weight.
8. Install Surveyor Mobile if you have not already, see Section 3.1.
9. Open Surveyor Mobile and connect it to the GPS RTK 2W, using one of the following methods:
   - At the bottom of the welcome screen under "Add Device Using", touch QR Code, then scan the barcode on the back of the GPS RTK 2W.
   - At the bottom of the welcome screen under "Add Device Using", touch Serial Number, then carefully type the serial number displayed on the back of the GPS RTK 2W.
   - On Android devices, the GPS RTK 2W will usually be detected automatically by its Wi-Fi signal: Simply touch the Connect button next to its serial number.

10. At the top of the “Overview” in Surveyor Mobile touch GPR Assist to change to the GPR Assist mode, see Figure 14.

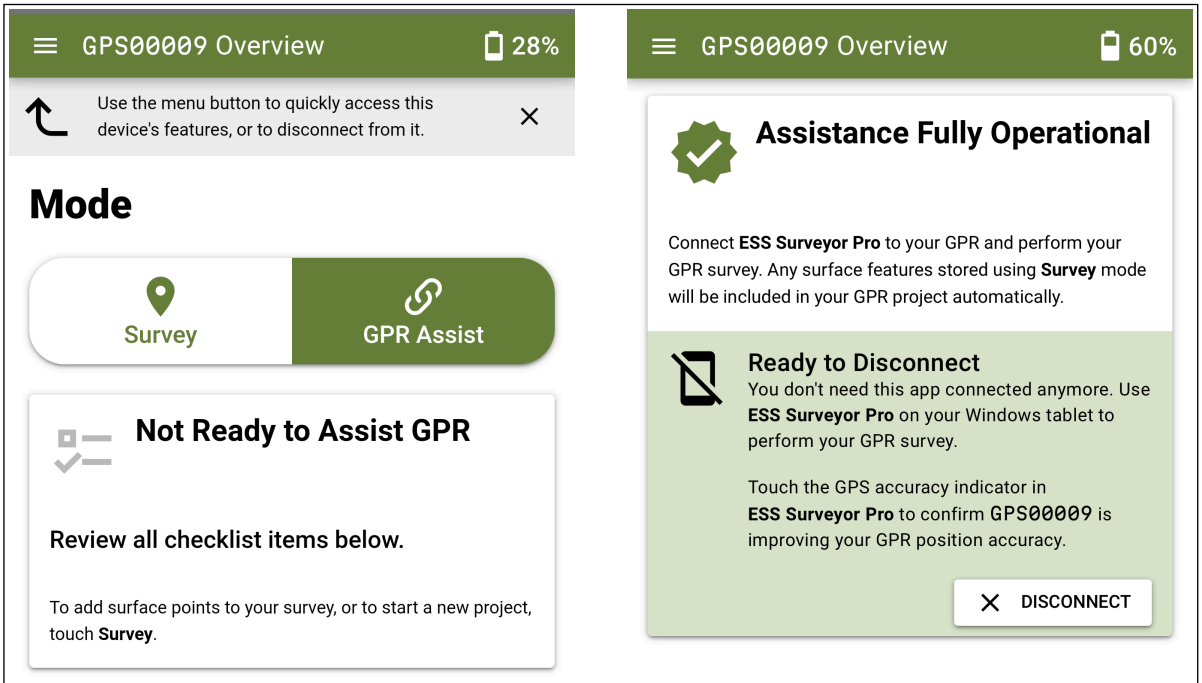

Figure 14: The Surveyor Mobile Overview, showing “GPR Assist” mode enabled, but not ready (left). And fully operational (right). In both cases, scroll down to see the checklist.

Important: Moving the GPS RTK 2W will distort GeoRanger Utility Scanner GPS positions or cause position enhancement to fail completely. **The GPS RTK 2W cannot be moved after Step 10.** If it is, refer to Section 5.4.1.3.

11. Once in “GPR Assist” mode, scroll down and review any checklist items which remain outstanding.
12. **Keep your Android or Apple device connected until the checklist is fulfilled.**

Important: When using PointPerfect™ you must not “lock” your iPhone or iPad, or switch to other apps until GPR Assist mode is fully operational. If Surveyor Mobile is not continuously visible on your display, **the setup time will be increased and the accuracy of the reference position will be degraded**. See Section 4.1.4

Note: It is typically safe to lock Android devices or use other apps, as long as you stay near the GPS RTK 2W or in the shaded area in Figure 13. See Section 4.1.3.

13. While waiting for GPR assistance to become fully operational, you can assemble your cart (Section 5.1.1), your GeoRanger Utility Scanner (Section 5.1.2) and tablet (Section 5.1.3).
14. Turn on your GeoRanger Utility Scanner and place it in front of the scanner (in the gray shaded area in Figure 13).
15. If you have not already, configure the GPS RTK 2W to connect to the the serial number of your GPS RTK 2W using the first item on the checklist. The GPS RTK 2W will remember this setting until you change it.

16. Once the GPS RTK 2W has had enough time, and if all items on the checklist are fulfilled, you should see the message on the right of Figure 14.
    - PointPerfect™ will stop automatically, as it is no-longer required.
    - On Android you will also receive a notification, if you have enabled them (see Section 4.1).
17. Disconnect your Android or Apple device, as it is no longer necessary.
18. Proceed with a free-form or 3D survey using Surveyor Pro, see Section 5.5 or Section 5.6 respectively.

5.4.1.3. Resetting GPS RTK 2W Assistance

If your GPS RTK 2W is disturbed during setup or during your GPR survey, you will have to start your GPR survey over again, and reset the GPS RTK 2W reference position:

1. End your GPR survey in Surveyor Pro by touching the Disconnect button in the bottom right.
2. Re-secure the GPS RTK 2W in a safer or the same location.
3. Reconnect Surveyor Mobile as in Step 9 of Section 5.4.1.2.
4. Touch the Survey button to leave GPR Assist mode.
5. Wait 10 seconds.
6. Return to “GPR Assist” mode by proceeding from Step 10 of Section 5.4.1.2.
7. Complete the remaining steps in Section 5.4.1.2 as before.
8. Proceed with a free-form or 3D survey using Surveyor Pro, see Section 5.5 or Section 5.6 respectively.

5.4.2. Position Enhancement Using NTRIP/CORS

Surveyor Pro supports enhancing GeoRanger Utility Scanner position accuracy using a stream of data received over the internet. This enhancement method has the following requirements:

- A mobile internet connection, on the Windows tablet, during your Surveyor Pro survey (Section 2.2).
- A third-party subscription to an NTRIP/CORS network or third-party hardware.
- The stream must meet certain requirements, which may require GNSS technical knowledge.
- Compatibility and technical support is limited.

NTRIP/CORS has a complex setup process and technical requirements: See Appendix E.

5.5. Perform a Free-Form GPR Survey

Free-form surveys allow the most flexibility and are often used for “first-look” reconnaissance surveys. Surveyors can collect GPR data along a path (or paths) of any shape, with little prior planning, while still allowing targets of interest to be virtually marked with a GPS position. The disadvantage of free-form surveys is they are less comprehensive than 3D surveys (Section 5.6), which also prevents creation of depth-slices in ESSential Underground (Section 5.9).

> **Important:** Enhanced-accuracy GPS is strongly recommended, see Section 5.4.
>
> Without GPS accuracy enhancement, the GPS positions may be to inaccurate for some applications, and the shape of the path may be distorted.

1. If using a GPS RTK 2W for enhanced GPS accuracy, set it up first: See Section 5.4.1.
2. Assemble the cart (Section 5.1.1).
3. Attach the GeoRanger Utility Scanner to the cart (Section 5.1.2).
4. Attach the tablet (Section 5.1.3) to the cart.
5. Insert a fully-charged battery into the GeoRanger Utility Scanner and firmly press the power button (Section 5.1.2).
6. Wait for the GeoRanger Utility Scanner power button to double-blink, then return to solid green.

- Blink codes are explained in detail in Appendix C.
- If you experience difficulty see Appendix D.1.

7. Double-tap the GPR Surveyor Pro icon on your desktop.
   - If you don't have this icon, install Surveyor Pro using the instructions in Section 3.2
8. For full functionality, a mobile internet connection is required, see Section 2.2.
9. Surveyor Pro will look Wi-Fi signals from GeoRanger Utility Scanners, which may take a few seconds.
   - If does not find your GeoRanger Utility Scanner see Appendix D.2.
10. Touch your scanner's serial number in the list, then touch Connect.
11. Enter the job site information into the Job Information tab.
12. If desired, touch Manage Configurations to save this information.
    - Alternatively, load a previously entered configured to save time and reduce entry errors while on the job site.
13. Use the Data Folder button to select a directory for storing data files.
14. Touch Meters or Feet to set the units system for the survey.
15. Touch the Survey Plan tab to apply changes and continue.
16. If using NTRIP/CORS, verify that it is configured before continuing. See Appendix E.
    - Perform the NTRIP/CORS compatibility test again if you are surveying in a new geographic area. See Appendix E.2.
17. On the left, touch the Survey Plan button.
18. Under "Grid Type", touch Freeform Lines.
19. Under "Positioning System" touch Odometer and GPS.
20. The area visible as satellite imagery will adjust based on the number next to "Survey area length (X)":
    - Touch the number next to "Survey area length (X)" to enter an approximate size of your survey.
21. Touch the Survey Plan button again to apply the settings.
22. Check your GPS position accuracy, displayed as the rightmost number at the top of the Survey Plan tab (to the left of the battery indicator).
23. If your GPS accuracy is worse (greater) than 0.5 meters (or 1.6 feet) (or if no number is displayed):
    - Touch the GPS position accuracy to check for errors, such as a missing GPS RTK 2W.
    - If using a GPS RTK 2W, verify that it is set up correctly by referring to Section 5.4.1
    - If using CORS/NTRIP, verify that it is set up correctly by referring to Appendix E.
24. Move the scanner to the desired start position.
25. Press the Start Line button, located near the top right of the screen, but keep the scanner still.
26. Wait for a "Please Wait..." message to appear, then disappear, accompanied by two beeps. The Start Line button will appear selected (green background).
27. Push the the GeoRanger Utility Scanner forward at a steady gentle pace.
28. Touch the GPR Scans tab to see the collected GPR data.
29. The GPR Scans tab collects data from both GeoRanger Utility Scanner GPR antennas simultaneously, but only displays one at a time:
    - Touch Plot Settings, then touch Antenna A or Antenna B to choose which is displayed.
    - The "B" antenna is physically behind the "A" antenna (see the color coded lines on the top of the GeoRanger Utility Scanner), and as a result data from "B" is plotted behind "A".
30. The GeoRanger Utility Scanner battery level is shown in the top-right of the display. Touch the battery indicator to see the estimated time remaining.
31. If the GPR Scans tab shows a target of interest, use the following steps to mark it:

a. Touch Markers and Depth
b. Touch New
c. Touch the location of the top of the target.
d. On the left, set the “Description” and “Type” of the target by touching the fields.
e. On the left, adjust the “Dielectric” up or down using the + and - until the blue hyperbola matches the hyperbola in the GPR data. See also Appendix A.
f. To save the changes touch Done.
g. Repeat as necessary for additional targets.

32. To end the survey, or to start another free-form shape at a different location, touch Line End.
33. Surveyor Pro will automatically advance to the next line number.
    - Targets can be added or adjusted on the most recent line using Step 31.
34. Take any additional free-form lines as desired by repeating from Step 25.
    - To re-take a line, touch the line-number indicator and adjust the current line number, before touching Start Line: The previously taken line of the same number will be lost.
35. Once all desired lines are taken:
    - Generate any maps or reports, see Section 5.8.
    - Open the survey in ESSential Underground using the Export to 3D button in the lower right corner. See Section 5.9.
    - End your survey using the Disconnect button in the lower right corner.
36. Press and hold the GeoRanger Utility Scanner power button until the green light turns off.
37. Remove the GeoRanger Utility Scanner battery, disassemble the cart and store the system safely.
38. Press and hold the GPS RTK 2W power button until the green light turns off.
39. Remove the GPS RTK 2W battery, remove and refold the tripod, and store the system safely.

5.6. Perform a 3D GPR Survey

A 3D GPR Survey requires additional time, but collects a more comprehensive GPR scan than a free-form survey. ESSential Underground has more advanced analysis tools for 3D datasets than for free-form, see Section 5.9. When using enhanced-accuracy GPS, a modest amount of planning is required as compared to free-form. If enhanced-accuracy GPS is unavailable, the surveyor must the manually measure and mark a grid on the ground (or floor), configure Surveyor Pro to this grid, then follow the these markings carefully.

Important: Enhanced-accuracy GPS is strongly recommended, as this allows on-screen steering and avoids manual grid measurement. See Section 5.4.

When the GPS accuracy is worse than 0.15 meters (0.5 feet) (or if Odometer mode is chosen in Step 19), Surveyor Pro will only measure distance from the point where the Start Line button was pressed, and therefore the on-screen grid **cannot be used for steering**.

1. If using a GPS RTK 2W for enhanced GPS accuracy, set it up first: See Section 5.4.1.
2. Assemble the cart (Section 5.1.1).
3. Attach the GeoRanger Utility Scanner to the cart (Section 5.1.2).
4. Attach the tablet (Section 5.1.3) to the cart.
5. Insert a fully-charged battery into the GeoRanger Utility Scanner and firmly press the power button (Section 5.1.2).
6. Wait for the GeoRanger Utility Scanner power button to double-blink, then return to solid green.

- Blink codes are explained in detail in Appendix C.
- If you experience difficulty see Appendix D.1.

7. Double-tap the GPR Surveyor Pro icon on your desktop.
   - If you don't have this icon, install Surveyor Pro using the instructions in Section 3.2
8. For full functionality, a mobile internet connection is required, see Section 2.2.
9. Surveyor Pro will look Wi-Fi signals from GeoRanger Utility Scanners, which may take a few seconds.
   - If does not find your GeoRanger Utility Scanner see Appendix D.2.
10. Touch your scanner's serial number in the list, then touch Connect.
11. Enter the job site information into the Job Information tab.
12. If desired, touch Manage Configurations to save this information.
    - Alternatively, load a previously entered configured to save time and reduce entry errors while on the job site.
13. Use the Data Folder button to select a directory for storing data files.
14. Touch Meters or Feet to set the units system for the survey.
15. Touch the Survey Plan tab to apply changes and continue.
16. If using NTRIP/CORS, verify that it is configured before continuing. See Appendix E.
    - Perform the NTRIP/CORS compatibility test again if you are surveying in a new geographic area. See Appendix E.2.
17. On the left, touch the Survey Plan button.
18. Under "Grid Type", touch Grid.
19. Under "Positioning System" touch Odometer and GPS.
    - If conducting a survey indoors or with a poor sky view, choose Odometer.
20. Specify the size of the grid by touching the numbers next to "Survey area length (X)" and "Survey area width (Y)":
21. Touch the Survey Plan button again to apply the settings.
22. Check your GPS position accuracy, displayed as the rightmost number at the top of the Survey Plan tab (to the left of the battery indicator).
23. If your GPS accuracy is worse (greater) than 0.5 meters (or 1.6 feet) (or if no number is displayed):
    - Touch the GPS position accuracy to check for errors, such as a missing GPS RTK 2W.
    - If using a GPS RTK 2W, verify that it is set up correctly by referring to Section 5.4.1
    - If using CORS/NTRIP, verify that it is set up correctly by referring to Appendix E.
24. Move the GeoRanger Utility Scanner to the corner of your scan grid as follows:
    - The grid extends **forward** for "Survey area length (X)" feet or meters (from Step 20) from this location.
    - The grid extends **to the right** for "Survey area width (Y)" feet or meters (from Step 20) from this location.
25. Press the Start Line button, located near the top right of the screen, but keep the scanner still.
26. Wait for a "Please wait..." message to appear, then disappear, accompanied by two beeps.
    The Start Line button will change to selected (green background).
27. Push the the GeoRanger Utility Scanner forward at a steady gentle pace:
    - If enhanced-accuracy GPS is not available or not working, steer to stay on the line you have marked on the ground or floor.
    - If GPS position accuracy is 0.15 meters (0.5 feet) or better:
      - For the first line, steer the GeoRanger Utility Scanner in a straight line. The grid will automatically align to your heading.

    - After the first line, use the on-screen grid to steer so that the blue dot stays on the current grid line (shown in red).
  - To see the cross-sectional GPR scan, touch the GPR Scans tab.
    - On the left touch the Map View button so that you can continue steering while simultaneously seeing GPR scan data.
28. The GPR Scans tab collects data from both GeoRanger Utility Scanner GPR antennas simultaneously, but only displays one at a time:
  - Touch Plot Settings, then touch Antenna A or Antenna B to choose which is displayed.
  - The “B” antenna is physically behind the “A” antenna (see the color coded lines on the top of the GeoRanger Utility Scanner), and as a result data from “B” is plotted behind “A”.
29. The GeoRanger Utility Scanner battery level is shown in the top-right of the display. Touch the battery indicator to see the estimated time remaining.
30. If the GPR Scans tab shows a target of interest, use the following steps to mark it:
  a. Touch Markers and Depth
  b. Touch New
  c. Touch the location of the top of the target.
  d. On the left, set the “Description” and “Type” of the target by touching the fields.
  e. On the left, adjust the “Dielectric” up or down using the + and - until the blue hyperbola matches the hyperbola in the GPR data. See also Appendix A.
  f. To save the changes touch Done.
  g. Repeat as necessary for additional targets.
31. The line will end automatically when you continue some small distance past the end of the current grid line.
  - The end of the line is accompanied by a pair of beeps, and the Start Line button will return to its previous unselected state.
32. Surveyor Pro will automatically advance to the next line number.
  - The grid will highlight the next line number.
  - Targets can be added or adjusted on the most recent line using Step 30.
33. Navigate the scanner to the start of the highlighted line, then repeat from Step 25.
  - To re-take a line, touch the line-number indicator and adjust the current line number, before touching Start Line: The previously taken line of the same number will be lost.
34. When all lines in the configured grid (Step 20) have been taken:
  - Generate any maps or reports, see Section 5.8.
  - Open the survey in ESSential Underground using the Export to 3D button in the lower right corner. See Section 5.9.
  - End your survey using the Disconnect button in the lower right corner.
35. Press and hold the GeoRanger Utility Scanner power button until the green light turns off.
36. Remove the GeoRanger Utility Scanner battery, disassemble the cart and store the system safely.
37. Press and hold the GPS RTK 2W power button until the green light turns off.
38. Remove the GPS RTK 2W battery, remove and refold the tripod, and store the system safely.

5.7. Replaying GPR Surveys

Important: Only Surveyor Pro surveys can be replayed.

Replaying GPR data can be helpful for re-examining plots and generating new reports. To replay data, follow the instructions below:

1. Double-tap the GPR Surveyor Pro icon on your desktop.
2. The right half of the Welcome tab lists recently collected surveys, if your survey is listed:
   - Touch it, then to replay it touch Open Selected.
   - Touch it, then to open it in ESSential Underground, touch Export to 3D
   - To open a survey which is not listed, touch Browse for File... then locate it on your computer.
3. Surveyor Pro will prepare the play back the file, when it is ready you will see the message in Figure 15.

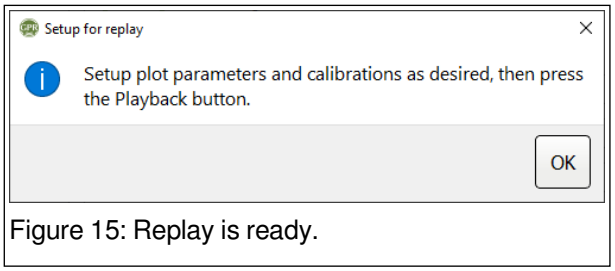

Figure 15: Replay is ready.

4. Touch the GPR Scans tab.
5. Touch the Plot Parameters button.
6. Adjust any plot parameters as desired.
7. At the right of the Surveyor Pro window, touch Playback button.
   - The selected survey line(s) will be replayed into the plots.
   - Playback can take a long time for large surveys, touch the Cancel button to stop playback.
8. If desired, adjust any GPR targets.
9. If desired, export any reports or maps using the Generate Report or Generate Map buttons.
   - Advanced analysis, reporting and export options are available in ESSential Underground.
   - To open your Survey in ESSential Underground touch the Export to 3D
10. To return to the Welcome tab, touch Close File button.

5.8. Maps and Reports

> **Note:** Surveyor Pro contains only basic reporting functions.
>
> For flexible analysis and reporting ESSential Underground is recommended, see Section 5.9.

Maps and reports can be created in Surveyor Pro either at the end of a survey, or while replaying data (see Section 5.7):

- There are two reporting options on the left of the Survey Plan tab:
  - Touch Generate Report to create PDF containing the job information and map view.
  - Touch Generate Map create an image file or KML file containing the map view.
- There are two reporting options on the left of the GPR Scans tab:
  - Touch Save Image to create an image file (e.g. PNG file) containing the current GPR scan view and its targets.
  - Touch Generate Report to create PDF containing the current GPR scan view and its targets.

For more reporting options, use ESSential Underground, see Section 5.9.

5.9. ESSential Underground

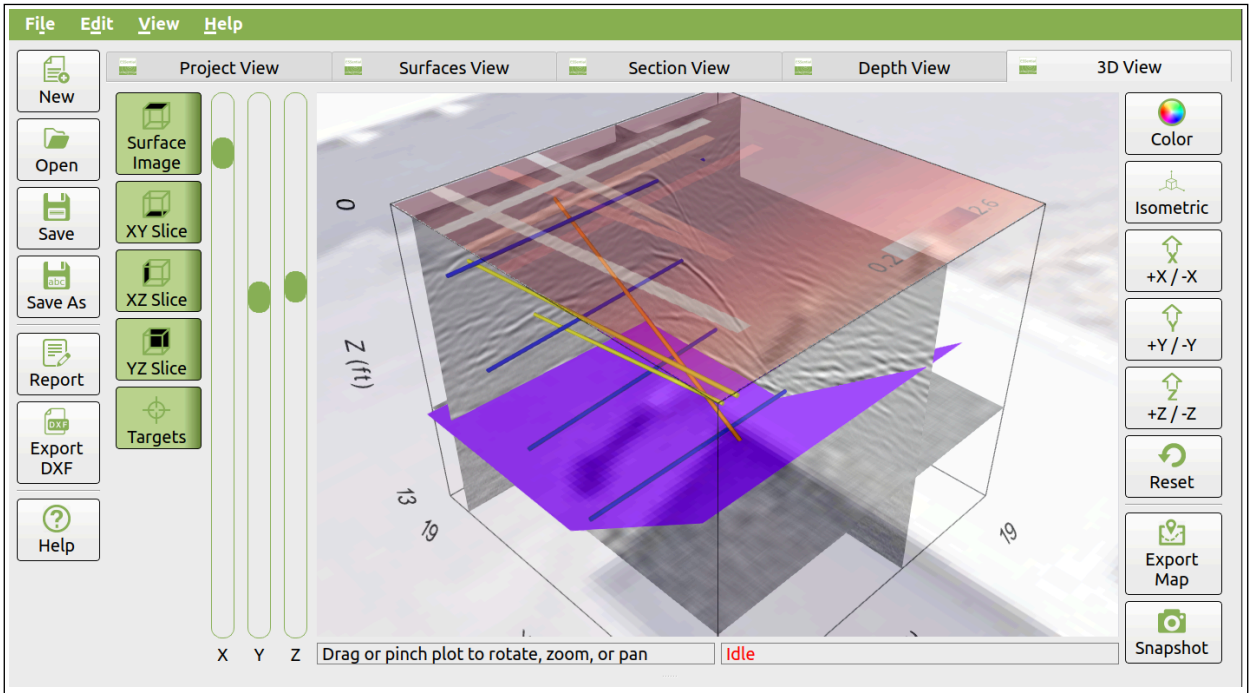

Figure 16: A 3D visualization of Surveyor Pro GPR data.

ESSential Underground is a companion application to Surveyor Pro which contains many useful features:

- Combine data from multiple sources:
  - One or more Surveyor Pro surveys.
  - Data from SUBSITE UtiliGuard® locators.
  - GPS RTK 2W above-ground surveys.
- Place 3D pipes based on GPR scans and position data from GPS RTK 2W and locators.
- Create PDF reports in the field using touch-friendly modular interface.
- Export 3D visualizations to multiple formats:
  - KML (Google Earth/ArcGIS Earth)
  - DXF (AutoCAD)
  - Share Directly to Underground Aware (requires additional subscription)

ESSential Underground is subscription software, available in your SUBSITE Cloud Service account.

5.10. Underground Aware

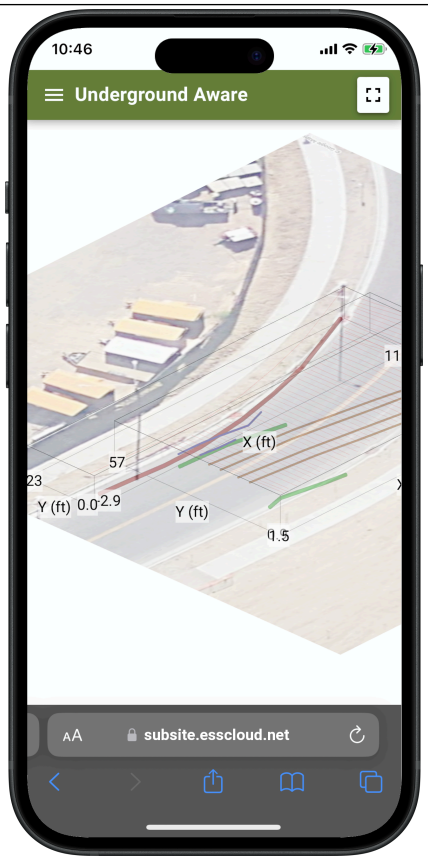

Figure 17: Share interactive 3D visualizations to anyone with a modern smartphone and mobile internet or any other device with a modern web-browser.

Underground Aware is an add-on subscription service which allows sharing of reports and visualizations directly from ESSential Underground:

- Just send a link: No app installation or log-in needed by recipient.
  - Control access by using separate links for different recipients.
  - Revoke a sharing link at any time.
  - Links automatically expire at the date and time you choose.
- Share additional reports and data: PDF, DXF, CSV, Images
- Interactive 3D visualizations with no app installation:
  - Modern Smartphones: Android or Apple
  - Modern Desktop Web-Browsers: Chrome, Edge, Firefox, Safari

Uploading data to Underground Aware requires both a subscription to ESSential Underground and to Underground Aware.

5.11. Charging Batteries

There are two rechargeable batteries in the system that provide sufficient power for operation over a full day. The battery in the scanner unit provides power for about 8 hours. A second battery is provided so that surveying can continue after the first is depleted. Additionally, the tablet battery will provide 5-8 hours of continuous operation, depending upon screen brightness settings. A dual bay battery charger is provided

that can simultaneously charge both batteries from a single power connection. The GPS base station also uses a rechargeable battery that provides more than 8 hours of continuous operation. The system is designed to be charged overnight so that all the batteries are ready for use the next day.

To charge the batteries, follow these steps.

1. Press and hold the power button on the scanner until the power light turns off.
2. Remove the battery from the scanner unit and place it in one of the charger's bays.
3. Place the spare scanner battery in the other bay.
4. Plug the main charger power cable into 120/220 VAC mains power.
5. The charge indicator lights will turn green when each of the charge cycles have completed.
   - A fully discharged battery may require 8 hours to fully recharge.
6. Charge the tablet with the included charging brick and cable.
7. The GPS Base Station also uses removable batteries, the chargers for both devices are interchangeable.

5.12. System Care and Cleaning

Keep the GeoRanger Utility Scanner clean and free of debris. The scan head can be cleaned with water and a mild detergent. The small round window on the rear left of the unit should be kept clean, do not use abrasives to clean it.

5.13. Remote Desktop Training

For training and demonstration purposes, the system can be configured so that the tablet's desktop can be shared to a remote office where a trainer or presenter is located. Since the tablet computer's internal Wi-Fi is used to connect to the GPR system, a different means of connecting to the internet is needed to provide remote desktop sharing. This can be accomplished using the tablet's internal cellular data modem, if so equipped, or an external USB Wi-Fi dongle to connect to a local Wi-Fi internet connection. The instructions below use an external USB Wi-Fi dongle.

1. Identify a Wi-Fi access point that is provided by your office or a tethered cellular phone. Insert the Wi-Fi dongle into the USB port on the side of the tablet. On the task bar, press the Wi-Fi network icon, then at the top of the menu select the "Wi-Fi 2" adapter and then select the proper Wi-Fi internet connection. Network adapter Wi-Fi will be left to connect to the GPR system.
2. The trainer or presenter will call the equipment operator's office or cellular phone and ask for the screen sharing code from the operator. The equipment operator will start the AnyDesk application and then provide the remote support ID over the phone. The trainer or presenter can now see and use the tablet computer to demonstrate how to operate the system.
3. When the training session is complete, simply exit from the AnyDesk application and remove the Wi-Fi dongle.

6. Theory of Operation

The GeoRanger Utility Scanner uses ground penetrating radar (GPR) to characterize the surface beneath the sensing unit. The GPR sends a low-energy impulse of electromagnetic (EM) energy towards the surface. Some of this energy penetrates into the subsurface and some is reflected back towards the sensor unit. The amount of reflected energy depends on the contrast in dielectric constant and electrical conductivity of the soil and embedded objects. By measuring the travel time of these waves, the depth to the reflectors can be determined in a manner analogous to a fish finder. By moving the scanner over the surface and detecting objects beneath it, a 2D or 3D cross section of the subsurface can be obtained. High frequency radar waves (i.e. 750 MHz) provide better spatial resolution than lower frequency radar waves, but they attenuate more quickly as they travel through the subsurface, resulting in a maximum object detection depth of about two feet. Lower frequency radar waves (i.e. 350 MHz) are able to penetrate more deeply (to about 20 feet) but do not provide subsurface images with as much detail.

7. Specifications

- 750 MHz bi-static radar antenna
- 350 MHz bi-static radar antenna
- Magnetic field sensor for detecting power lines or tracer signals
- Dimensions: 25.5W x 34L x 17H inches (64.8 x 86.4 x 17.8 cm) including folded cart
- Shipping container dimensions: 28 x 37.5 x 21 inches (71.1 x 95.3 x 53.3 cm)
- Weight of scanner and cart: 67.6 lbs (30.6 kg)
- Operating temperature: 15 to 120°F (-10 to 50°C)
- Operating altitude: 0 to 6500 ft (2000 m)
- Durable construction with IK08 impact protection and IP65 ingress protection

8. Data File Format

Note: This section applies exclusively to Surveyor Pro

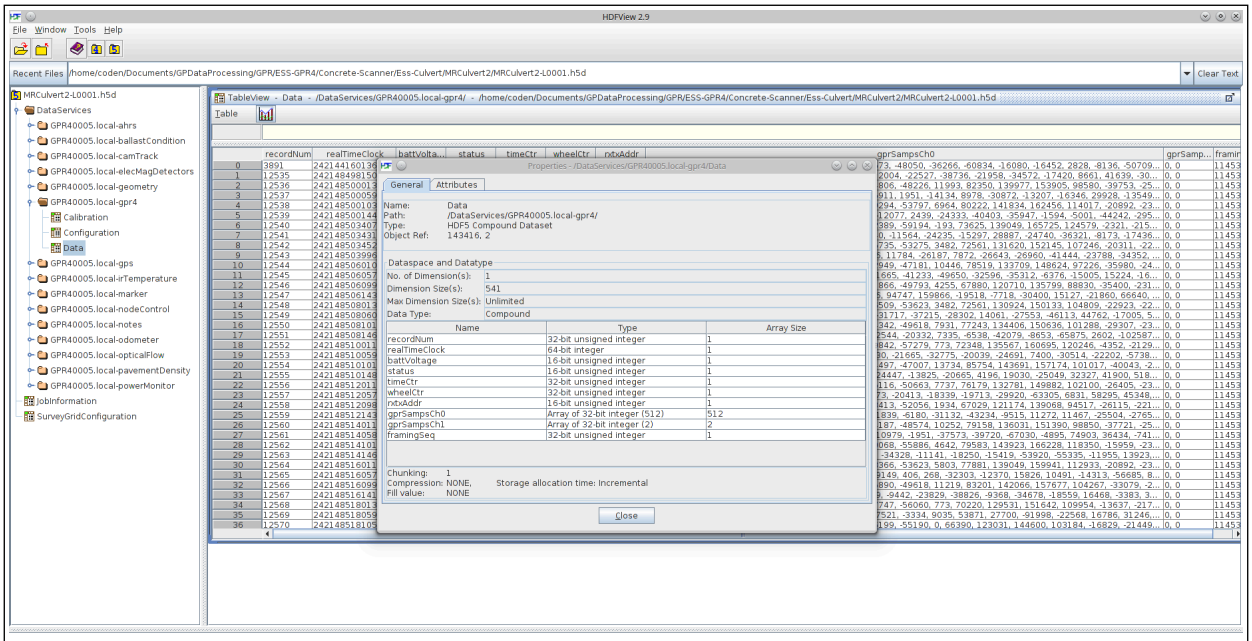

Figure 18: HDFView showing the contents of an “H5D” file recorded by Surveyor Pro.

Data recorded by the active ranging system are stored using the HDF5 file format. HDF5 allows storage of large datasets in complex data structures. In addition to the data stored in an HDF5 file, the files provide all of the data type and format information needed for reading the data. A helpful utility for quickly browsing HDF5 file is the HDFView utility, freely available from the HDF5 Group (**`https://www.hdfgroup.org/downloads/index.html`**). The HDF5 Group provides free software interfaces for HDF5 in most popular computer languages including Fortran, C, Java, Python, and Matlab. Figure 18 shows HDFView with the contents of an “H5D” file recorded by the Surveyor Pro. On the left is a tree structure that lists the datasets in the file. The JobInformation dataset contains information about the jobsite. There is a folder for each data server (e.g., gpr4, odometer, gps, etc.), and each folder contains configuration information and data. As shown below, the detailed format of each dataset is included in the file. This self-describing feature of HDF5 files along with the open software interfaces allows the data to be easily read by user-developed software.

A. Dielectric Estimation

The velocity of radar waves must be known in order to convert time-of-flight to depth. The velocity changes with the dielectric constant of the soil according to:

$$v = \frac{c}{\sqrt{\varepsilon}}$$

where v is velocity, c is the speed of light in a vacuum, and ε is the dielectric constant. ε may be estimated by fitting a hyperbola to a hyperbolic reflection shape from a subsurface pipe. Fitting a hyperbola is accomplished by:

- In Surveyor Mobile, touch ☰ *(Menu)* then touch Mark Hyperbola.
- In Surveyor Pro, on the GPR Scans tab, touch Markers and Depth then New.

In both Surveyor Mobile and Surveyor Pro, the user adjusts the shape of an overlaid hyperbola to the hyperbolic reflection in their GPR scan. This fitting process estimates ε, which in-turn adjusts the vertical depth axis of the GPR scan. Table 3 lists some typical dielectric constants for common materials.

Material	Dielectric (ε)
Air	ε = 1
Dry concrete/indoor/mature - Dry soil	ε = 4
Damp concrete/outdoor - Damp soil	ε = 6.5
Moist concrete/outdoor/young - Moist soil	ε = 9
Wet concrete/outdoor/young - Wet soil	ε = 16
Saturated concrete/outdoor - Saturated soil	ε = 25

Table 3: Typical dielectric constants of building materials

B. Windows Tablet Computer Requirements

- Microsoft Windows®: Version 10 or 11.
  - Enterprise edition recommended.
- Wi-Fi 4 (also called 802.11n or “dual-band”) or better.
- Mobile Internet (also called “Mobile Broadband”, “Cellular Modem”, “Cellular Data”, etc.)
  - A compatible cellular data service subscription is also required.
  - See Section 2.2 for features of Surveyor Pro which require this.
- Processor: 8th Generation Intel® Core i5 or better.
  - 12th Generation or later recommended.
- Display resolution: 1920x1080 or higher.
- RAM: 8 GB minimum (16 GB recommended).
- Storage: 128 GB minimum solid-state drive.

C. GeoRanger Utility Scanner LED Indications

The GeoRanger Utility Scanner power button will blink in one of a few different ways to indicate its state:

1. Double blink (two blinks, a brief delay, then repeat):
   - Occurs during startup to indicate that the Wi-Fi will soon be ready.
   - Wi-Fi is ready once the power button returns to solid green.
2. Solid green:

- Wi-Fi is ready for connection from Surveyor Mobile or Surveyor Pro (if proceeded by double blinking).

3. Slow blink (1 second on, 1 second off):
   - At least one device running Surveyor Mobile and/or Surveyor Pro is connected.
4. Fast blink (approximately twice per second):
   - Low battery warning (regardless of whether Surveyor Mobile or Surveyor Pro is connected).

D. Troubleshooting

D.1. Power LED Does Not Illuminate

If after installing the battery, and pressing the power button firmly, the ring around the power button does not illuminate:

1. Open the battery door and remove the battery.
2. Return the battery to the charger and plug the charger into mains power.
3. Allow the battery to charge until all five black squares are visible (and not blinking) in the rectangular window on the end of the battery. If the battery does not show five solid squares after charging for 8 hours, try another battery.
4. With the grooved side of the battery facing up, insert the battery into the scanner until it seats firmly, then tilt the door up and turn both tabs one-quarter turn clockwise.
5. Press the power button firmly.
6. If this does not resolve the problem, contact your support representative.

D.2. Cannot Connect to Scanner

1. Close Surveyor Pro or Surveyor Mobile if they are running.
   - Close Surveyor Pro by touching the Disconnect button the bottom right of the window.
   - Close Surveyor Mobile by touching the  *(Menu)* button in the top left of your display, then touch Disconnect.
2. Turn each of the black tabs on the battery door one-quarter turn counterclockwise to release the door.
3. Flip the door down and out of the way.
4. Remove the battery by pulling on its tab.
5. Return the battery to the charger and plug the charger into mains power.
6. Allow the battery to charge until all 5 black squares are visible (and not blinking) in the rectangular window on the end of the battery.
   - If the battery does not show 5 solid squares after charging for 8 hours, try another battery.
7. With the grooved side of the battery facing up, insert the battery into the scanner until it seats firmly.
8. Tilt the door up and while holding the door seated against the enclosure turn the black tabs one-quarter turn clockwise to secure the door.
9. Press the power button firmly.
10. Check that the ring of the power button illuminates green immediately. If it does not, refer to Appendix D.1.
11. Observe the power button carefully, in less than 15 seconds it should begin to blink in a repeating pattern of two blinks with a brief delay between each pair of blinks.
    - If after 15 seconds the power button does not blink, press and hold the power button until the green light goes off. Then firmly press the power button again. Observe the power button carefully for 30 seconds, if it never blinks, contact your support representative.
12. After blinking for at-most 15 seconds, the power button should return to solid green.

- If after 30 seconds the power button never stops blinking, press and hold the power button until the green light goes off. Then firmly press the power button again. Observe the power button carefully for 45 seconds, if it begins to blink but never stops, contact your support representative.

13. If the power button goes dark refer to Appendix D.1. and try different batteries. If this does not resolve the problem, contact your support representative.
14. Confirm that a Wi-Fi signal is being broadcast by GeoRanger Utility Scanner:
    a. With a Windows tablet, start Surveyor Pro and allow 30 seconds for your serial number to appear in the left half of the display.
        (i) If this does not work, from the Windows Start menu touch the power button, then choose Shutdown (not Restart).
        (ii) Allow the tablet to remain off for 10 seconds, then start it again and start Surveyor Pro again.
        (iii) If your serial number still does not appear contact your support representative or try the following step.
    b. With your Android smartphone or iPhone, go to your phone's Wi-Fi settings.
        (i) Turn your phone's Wi-Fi off, then wait 10 seconds, and turn it back on.
        (ii) Look for your scanner's serial number in the list of visible Wi-Fi networks.
        (iii) If it is not visible, continue looking for it in the list, you may need to scroll to find it.
        (iv) If you cannot find your scanner's serial number, try a different phone.
        (v) If no device is able to see the scanner's serial number, contact your support representative.
15. If using Surveyor Pro:
    a. Touch your scanner's serial number, then touch Connect.
    b. If you see an error message try again.
    c. If you are unable to connect after three attempts contact your support representative.
16. If using Surveyor Mobile:
    a. Scroll to the bottom of the welcome screen and under "Add Device Using" touch Serial Number.
    b. Carefully type the serial number printed on the back of GeoRanger Utility Scanner, and then touch OK.
    c. If it does not connect, try these steps again. You may need to try more than once.
    d. If you are still unable to connect, contact your support representative.

D.3. Line Position Does Not Change

Important: Do not use any abrasives or harsh chemicals to clean GeoRanger Utility Scanner as this will damage the plastic.

If, while recording a line in Surveyor Pro or while connected to the scanner with Surveyor Mobile, the line position indicator does not change while pushing the scanner forward:

1. If using Surveyor Pro, make sure:
    - That you have started a line.
    - That the line has not ended automatically (which occurs after exceeding the programmed line length).
    - That you are still connected to GeoRanger Utility Scanner, indicated by the Wi-Fi symbol with a green check-mark on it.
    - That the scanner is not over a metallic or conductive surface, see 4.3.3 No Data Displayed.
2. If using Surveyor Mobile, make sure:
    - That the scan is not paused, which is indicated by a flashing yellow Resume button.
    - That the scanner connection has not been lost, indicated by a Wi-Fi symbol with a slash through it and a red background in the top right corner of your display.

3. If this does not resolve the problem: Use a wet cloth to the small circular window near the rear of the left side of the GeoRanger Utility Scanner. If necessary use a gentle detergent such as dish soap to clean it (do not use an abrasive).
4. If this does not resolve the problem: Use wet cloth to clean the black-and-white stripes on the inside of the left-rear wheel.
5. If this does not resolve the problem, contact your support representative.

D.4. No Data Displayed

In some cases, powering-on GeoRanger Utility Scanner while it is over a metallic surfaces, conductive objects, or surfaces which contain conductive elements (such as reinforced concrete) can temporarily prevent startup of the radar system:

1. Move the scanner to a non-conductive surface and allow 30 seconds for the radar system to begin working.
2. If this does not resolve the issue, press and hold the power button until the power light goes dark, then after waiting 10 seconds, power on the scanner again.
3. If this does not resolve the issue refer to Appendix D.3.

D.5. Power Line Not Detected

GeoRanger Utility Scanner is equipped with a magnetic sensor which is designed to detect electrical power cabling. Not all electrical cabling can be detected:

1. The ability to detect electrical cabling is intended only to augment the information in a GPR scan.
   - A GPR target may still be an electrical cable, even if there is no magnetic signal from it.
2. Only electrical cabling which is both energized and supplying current can be detected by the magnetic sensor in the GeoRanger Utility Scanner.
   - Cabling which is carrying little or no power (because, for example, all loads are switched off) cannot be detected by magnetic sensors, even if it is “energized”.
   - De-energized cabling cannot be detected by magnetic sensors.
3. Not all electrical cabling produces a detectable magnetic field, even when carrying current.
   - This can be due to shielding (such as metal conduit) or due to the twisting of the conductors, or other factors.
4. GeoRanger Utility Scanner is designed to detect electrical cabling which crosses the scan line from left-to-right or right-to-left.
   - If the scan line is parallel to electrical cabling, that cabling may appear very weak, or may be undetected.
   - Perform your scan as grid to increase the likelihood of detecting electrical cabling.

D.6. Power Line Detected Without GPR Target

While the magnetic signals from electrical cabling below the scanner will generally appear stronger, GeoRanger Utility Scanner cannot differentiate overhead electrical cabling or overhead power lines from cabling below the scanner.

1. Check that the magnetic signal is not coming from above the scanner.
2. In some areas there may be a very high background magnetic signal.
   - In these areas the power line detector will not be useful.

E. NTRIP/CORS

The GeoRanger Utility Scanner utilizes an integrated dual-band (L1/L2) quad-constellation (GPS, GLONASS, Galileo, BeiDou) GNSS receiver. Under most conditions this receiver's accuracy can be improved either by using a GPS RTK 2W local reference station, or by streaming NTRIP/CORS assistance data over the internet. Surveyor Pro can stream corrections from standard RTCM 3 mount-points (or VRS systems) using the NTRIP 1 or NTRIP 2 protocol.

An automated compatibility test (which occurs as the last step of Section E.2.) can produce a compatibility score for a particular set of settings used in a particular geographic area. The automated compatibility test cannot detect all configuration errors, see Appendix E.3.

Important: A test failure indicates that your settings cannot be used in your current geographic location. Note however that a high compatibility score does not guarantee that the GeoRanger Utility Scanner position accuracy will be enhanced.

E.1. Technical Requirements

- NTRIP version 1 or 2
  - "Basic" authentication only
  - No encryption
- RTCM 3
  - RTCM 3.4 recommended
  - RTCM 3.1 is compatible but not recommended
- NMEA GGA regularly transmitted unless specifically forbade by the mount-point table
- Detectable error messages (if followed by connection closure):
  - RTCM 1029
  - HTTP-style

In order to be compatible with the GeoRanger Utility Scanner the messages transmitted by the mount-point should be consistent with Table 4:

RTCM Message Type	Recommendation
RTCM 1001 L1-only GPS RTK observables	**Not Recommended** Although technically compatible, these messages tend to indicate the older RTCM3.1 system which is unlikely to provide sufficient accuracy improvement.
RTCM 1002 Extended L1-only GPS RTK observables	
RTCM 1003 L1/L2 GPS RTK observables	
RTCM 1004 Extended L1/L2 GPS RTK observables	
RTCM 1005 Stationary RTK reference station ARP	**Required** One of these messages must be transmitted. If both are missing the compatibility test will fail.
RTCM 1006 Stationary RTK reference station ARP with antenna height	
RTCM 1007 Antenna descriptor	Optional
RTCM 1009 L1-only GLONASS RTK observables	**Not Recommended** Although technically compatible, these messages
RTCM 1010 Extended L1-only GLONASS RTK observables	

RTCM Message Type	Recommendation
RTCM 1011 L1/L2 GLONASS RTK observables	tend to indicate the older RTCM3.1 system which is unlikely to provide sufficient accuracy improvement. Check other mount-points for better compatibility.
RTCM 1012 Extended L1/L2 GLONASS RTK observables	
RTCM 1033 Receiver and Antenna Description	Optional
RTCM 1074 GPS MSM4	**Recommended** One of these three messages should be present for optimal function.
RTCM 1075 GPS MSM5	
RTCM 1077 GPS MSM7	
RTCM 1084 GLONASS MSM4	**Recommended** One of these three messages should be present for optimal function.
RTCM 1085 GLONASS MSM5	
RTCM 1087 GLONASS MSM7	
RTCM 1094 Galileo MSM4	**Recommended** One of these three messages should be present for optimal function.
RTCM 1095 Galileo MSM5	
RTCM 1097 Galileo MSM7	
RTCM 1124 BeiDou MSM4	**Recommended** One of these three messages should be present for optimal function.
RTCM 1125 BeiDou MSM5	
RTCM 1127 BeiDou MSM7	
RTCM 1230 GLONASS code-phase biases	**Recommended**

Table 4: RTCM message type compatibility. For each **Recommended** block, the presence of a message from that block increases the compatibility score.

E.2. Setup

Using NTRIP/CORS requires the following steps:

1. Create an account with an NTRIP/CORS provider who has service in the area you intend to survey.
   - With some providers this can be done by visiting their website.
   - Some accounts can be created for free, and others require payment.
2. Obtain the username and password for the provider's NTRIP service.

   Important: The username and password which you used to create your account are **often different** than the username and password which you need to use for your NTRIP/CORS configuration.
3. Determine the host for the NTRIP/CORS caster service:
   - This will either be a string of letters and dots, like website address, or an IP address which looks like "127.0.0.1".
   - It is often different from the website where you registered.
   - Your NTRIP/CORS provider may have multiple options, in which case you need to select the host which is most appropriate for your geographical area and satisfies Appendix E.1.
4. Determine port number of the NTRIP/CORS caster service:
   - Sometimes this will be 8080 or 2100, but it could be any of a large range of numbers.
   - Your NTRIP service may have multiple options, in which case you need to select the port which is most appropriate for your geographical area and satisfies Appendix E.1.

5. Determine a mount-point which is both geographically nearby your survey area and compatible with Appendix E.1. Depending on your provider, mount-points may be physical or virtual:
   a. Physical: The choice of mount-point determines both the message format and which physical reference station provides the corrections stream:
      (i) You will need to use the provider's map to choose a mount-point.
      (ii) The mount point should be as close as possible: The value of a mount point's assistance decreases with distance.
      (iii) Mount points more than 20 miles (32 km) away are not likely to improve accuracy at all.
   b. Virtual Reference Station (VRS): The choice of mount-point determines the message format produced by the server.
      (i) Upon connecting the NTRIP/CORS server will use your current location to synthesize optimal corrections messages as though a reference station were near you.
      (ii) You must ensure that your geographic location is inside the NTRIP/CORS provider's supported area.
      (iii) Some VRS systems will produce compatible data, even if you are not inside the supported geographic area. While this data will appear compatible, it will not enhance accuracy.
      (iv) Other VRS systems will respond with an error message: If Surveyor Pro detects a known error message format, it will display it in the GPS status window.
6. Open Surveyor Pro.
7. Power on your GeoRanger Utility Scanner outdoors, in an open area, and no more than 1 mile (2 km) from your intended GPR survey area.

   Important: The compatibility test results are specific to your current geographic location: Settings which work in one area may fail in another, and settings which fail in one area may succeed in another.

8. Open the GPS Settings dialog, either by selecting GPS Settings from the File menu, or by touching the GPS Settings button on the Survey Plan tab.
9. Enter the host, port, username, password and mount-point selected in steps 2 through 5.
10. Touch OK. An automated compatibility test will be performed using the current location of your GeoRanger Utility Scanner. See Appendix E.3.
11. If you receive a low compatibility score or failing compatibility test result, consult the NTRIP/CORS provider's documentation and Apppendix E.1. and try a different mount-point, different host, or different port.
12. If you receive a passing compatibility score, allow the GeoRanger Utility Scanner to operate for some time and observe the reported GPS position accuracy.

    Important: If the GPS position accuracy does not improve, there may be a problem with your configuration which is not detectable by the automated test. See Table 5 for problems which cannot be reliably detected.

13. If the reported GPS position accuracy is sufficient for your application, proceed with a free-form or 3D survey (Section 5.5 or Section 5.6 respectively).

E.3. Automated Compatibility Test

Important: A high compatibility score does not guarantee that the GeoRanger Utility Scanner position accuracy will be enhanced. A low compatibility score or a test failure indicates that your settings cannot be used in your current geographic location. Test results depend on the GeoRanger Utility Scanner's current location, settings which succeed in one geographic area may fail in another.

The table below lists several potential problems with your NTRIP/CORS configuration, and whether each problem can be detected by the automated compatibility test. **Undetectable problems will generally result in otherwise-unexplained lack of improvement in reported GPS position accuracy.**

Problem	**Detectable (Assuming GeoRanger Utility Scanner Connection and GPS Signal)**
Incorrect hostname and/or port.	Yes
Incorrect username and/or password.	Yes
Non-existent mount-point.	Yes
Mount-point stream has no data.	Yes: Can occur in some systems when the mount-point is offline.
Mount-point stream is not RTCM 3 (or is corrupted).	Yes
Mount-point RTCM 3 stream does not contain compatible messages.	Yes
Mount-point RTCM 3 stream contains only legacy "observables" messages. (See Table 4)	Yes: A low compatibility score will be returned.
Physical (non-VRS) mount-point is too far from your location.	**No**: This problem cannot be reliably detected, choose mount-point carefully.
VRS mount-point: Your location is outside the VRS network.	**No**: Some servers return data in the correct format, despite being outside the network, which prevents automatic detection of this problem. (Some other networks return a detectable error message.)

Table 5: NTRIP/CORS problem detectability.

F. Batteries

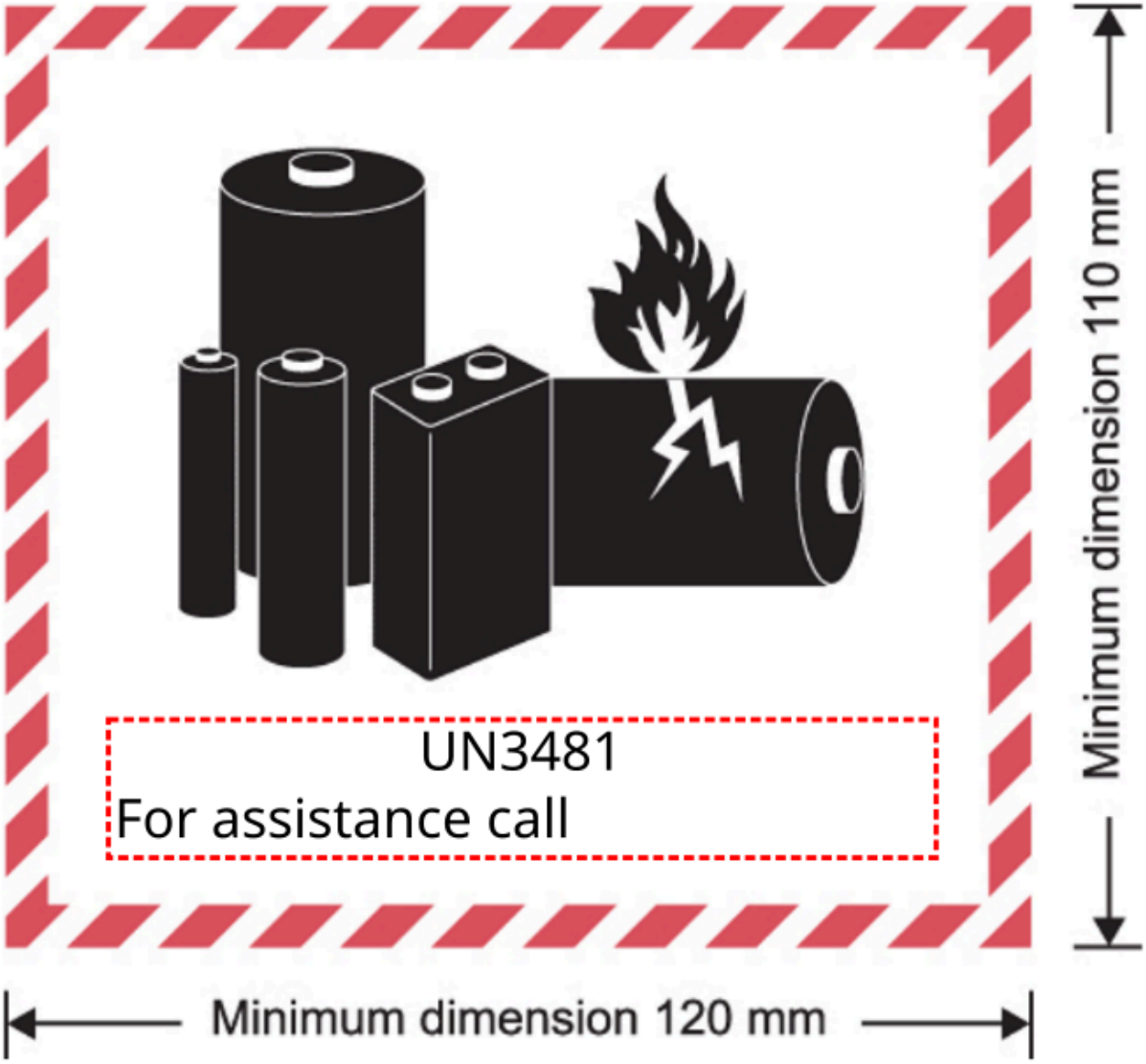

Figure 19: Typical shipping label requirement. Add your phone number after “For assistance call”.

The GeoRanger Utility Scanner and GPS RTK 2W use lithium ion batteries. To insert or change the battery, twist the thumb tabs on the battery door 1/4 turn counter-clockwise and open the battery door. Remove the existing battery by pulling the small tab on the battery. Insert the new battery with the terminals on the top and front of the battery. Close the battery door and latch by pushing the thumb tabs forward and turning 1/4 turn clockwise until they latch. For transportation purposes, their shipment falls under UN3481. They can be shipped via air on both passenger and cargo planes, or via standard ground transportation. The following label must be present on the outside of the shipping container.

F.1. Technical Support

Technical support is provided by Subsite® between the hours of 7:00 AM and 5:00 PM CST at 1-800-846-2713, Internationally at +1-580-572-3700, or by email at **productsupport-ok@subsite.com**.

F.2. Storage and Disposal

Store and dispose of batteries properly. See the battery manufacturer's instructions for more information.

G. Support

Procedure

Notify your dealer immediately of any malfunction or failure of Subsite Electronics equipment.

Always give model, serial number, and approximate date of your equipment purchase. This information should be recorded and placed on file by the owner at the time of purchase.

Return damaged parts to dealer for inspection and warranty consideration if in warranty time frame.

All repairs must be done by an authorized Subsite Electronics repair facility. Repairs done elsewhere will void warranty.

Resources

Publications

Contact your dealer for publications and videos covering safety, operation, maintenance, and repair of your equipment.

Training

For information about on-site individualized training, contact your dealer.

H. Warranty

Electronics Limited Warranty Policy

Subject to the limitation and exclusions herein, free replacement parts and labor will be provided when a unit fails due to a defect in material or workmanship within one (1) year of first commercial use. (See exceptions below for specific products.) Defects shall be determined through inspection by Manufacturer or authorized repair centers. An inspection must occur within thirty (30) days of the date of failure of the product or part by Manufacturer or its authorized repair facility. Manufacturer will provide the location of its inspection facilities or its nearest authorized dealer upon inquiry. Manufacturer reserves the right to supply remanufactured replacement parts under this warranty as it deems appropriate. Each warranty repair carries the remainder of the factory warranty or ninety (90) days, whichever is longer, for all repaired components and labor.

Product Warranty Exceptions

- HDD guidance beacons, Locate Beacons and Accessories, carry a six (6) month warranty.
- HDD guidance beacons, M-Series and T-Series, carry a three (3) year 750 hour warranty.
- All Used (Cosmetic) Electronics products sold from Manufacturer carry a six (6) month warranty from date of sale to dealer

Exclusions from Product Warranty

- All defects or damages caused by misuse, abuse, improper installation, alteration, neglect, modification, lack of maintenance, or uses
- All defects or damages caused by misuse, abuse, improper installation, alteration, neglect, modification, lack of maintenance, or uses other than those for which the products were intended.
- All defects, damages, or injuries caused by improper training, operation, or servicing of products in a manner inconsistent with manufacturer's recommendations.

- All batteries, which are considered consumable and therefore not covered under this warranty.
- All damaged plastics are considered to be the result of misuse or neglect unless Manufacturer has determined otherwise.
- All repairs or attempted repairs by non-certified repair facilities or personnel will void the warranty.
- All incoming duties and freight charges.
- Manufacturer reserves the right to make changes in design and/or improvements to products from time to time, and user understands that Manufacturer shall have no obligation to upgrade any previously manufactured product to include any such changes.
- In no event shall Manufacturer or its agents, assigns, or parent company be liable for any indirect, special, incidental, or consequential damages or for any cover, loss of information, profit, revenue, or use based upon any claim by user for breach of warranty, breach of contract, negligence, strict liability or any other legal theory. In no event shall Manufacturer liability exceed the amount user has paid for the Manufacturer product.
- Manufacturer will not be responsible for loss of accessories or loss or erasure of data storage media.
- Should it be determined that applicable law prohibits enforcement of any provision of this Warranty Policy, then to the extent it is necessary to comply with the applicable law, this Warranty Policy shall be deemed amended.
- This Warranty Policy shall be the entire agreement between Manufacturer and the Purchaser. Any statements that purport to be different than or modify or expand the terms set forth in this written policy are not effective for any purpose. ANY IMPLIED WARRANTIES, INCLUDING WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR USE ARE EXPRESSLY DISCLAIMED. IN NO EVENT SHALL SUBSITE ELECTRONICS, THE CHARLES MACHINE WORKS, INC., OR ANY AUTHORIZED SERVICING AUTHORITY BE RESPONSIBLE FOR ANY LOSSES, INCLUDING CONSEQUENTIAL AND INCIDENTAL DAMAGES, EXCEPT AS EXPRESSLY PROVIDED HEREIN.

Service and Repair

Units repaired at Manufacturer’s location or an authorized service center will carry a 90-day warranty on all replaced components/parts and labor commencing on the date of repair. HDD guidance beacons, M-Series and T-Series repairs: If a lower assembly is replaced on any T-Series beacons, the 750-hour count will start over at zero (0) hours. The warranty years will continue from date of product registration.

M-Series beacons: M-Series beacons are not repairable. Warranty assessments can only be done at an authorized Subsite Electronics repair center. If found to be defective, Authorized Service Center may replace with new beacon. M-Series and T-Series beacons that are past the three (3) year warranty will have a 90-day repair warranty.

Extended Warranty

Consult your local Subsite dealer for extended warranty options.

Warranty Details

For information regarding this warranty policy, contact Subsite Product Support at (800)846-2713 ext. 1; mail us at 1950 W. Fir, Perry, OK 73077; or contact your local dealer.

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