



Utility Survey User Guide

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About This Guide

This user guide is a process-oriented, practical guide to using Optimal Ranging’s utility line tracking technology, including one or two spars, a sonde or transmitter, and a data collection device using Trimble Access with the Utility Survey application installed. The guide first presents step-by-step instructions to use Line and Sonde modes. These sections may be repetitive, since some steps are identical or similar in each mode. Use of two spars in both modes is discussed at the end.

Optimal Ranging makes available on its website a Reference Manual with more technical information on the hardware and systems, as well as advanced user topics. This manual is mentioned here when it can be a complement to the User Guide. The website also provides video tutorials for various aspects of utility mapping, including point measurements and feature coding, measuring offsets and spar separation, finding the utility peak, and using a transmitter or sonde.

Line Mode

The most common use of the Spar 300 Utility Survey application is to collect underground positions of a metallic utility line using a transmitted signal along the line. When coupled to an external Trimble GNSS receiver like the R6 or R8, accurate geospatial positions are logged in real-time to an open Job. Each point is optionally line coded with the horizontal and vertical confidence values, representing the combined overall accuracy of the position that results from tight integration of the locating and GNSS subsystems.



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Setup Instructions

This section provides a practical introduction to basic setup and use of Line Mode in Utility Survey in order to precisely map underground metallic cables or pipes by transmitting a signal along the line. **These instructions will mainly describe the process for use of a single spar**, though dual-spar methods may be referenced and the user directed to later sections for more detailed instructions.

Step 1: Construct the spar apparatus

Normally, the spar is affixed vertically to a range pole or cart, or mounted on a tripod. The black power button defines the top end of the spar and the “forward” (positive x) direction, so the spar should be oriented with the power button facing forward and away from the mounting apparatus. If mounted on a cart, the spar may need to be affixed to the side of the cart rather than the front, but still with the power button facing forward.

The GNSS rover should be positioned above the spar on the same pole. Utility Survey will locate the Spar based on the position of the GNSS rover, even if the pole is not held perfectly vertically. In the absence of a rover, the spar can be placed on a known geospatial position, but this limits the Spar’s mobility.

In many cases, a second spar can be used in Line mode to make more precise measurements on deeper utilities. The second spar can be free-standing and unlinked to the first, or, more likely, it might be affixed to an ATV or boat to be driven over a utility line. These mounting techniques and notes about them can be found in [Dual Spars in Line Mode](#).



Step 2: Set up the data collecting device

The computer device for data collection is typically a Trimble TSC3 with Windows Mobile or a Trimble Tablet. Verify that your data collector is correctly licensed for Utility Survey, using the About box from the Trimble icon at the top-left of the Trimble Access starting page. Install Utility Survey v1.x.x Setup.WM5.CAB (if using a TSC3 data collector) or Utility Survey v1.x.x Setup.Win32.TrimbleTablet.exe (if using a Trimble Tablet). If you are using a GNSS rover, confirm it is connected to the data collector and configured correctly as part of a Survey Style by entering “Settings” in Trimble Access.

For easy map-reading, face the data collector in the “forward” direction as defined by the spar’s power button.

Step 3: Set up the transmitter

Generally, the Vivax-Metrotech Loc-10Tx transmitter is supplied as part of the standard kit, but transmitters from a variety of manufacturers are supported. To make a direct connection using the Vivax-Metrotech transmitter, attach the red end of the transmitter’s cables to an aboveground metal point on the utility line, and the black end to a grounded metal stake. Frequencies can be toggled using the f key. More frequencies are available than can initially be toggled, and can be added to the list using the full frequency menu (keep pressing *i* to find it). The current can also be adjusted using the +/- keys.

In general, when choosing a frequency, keep in mind that lower frequencies are better when possible because they have less distortion in areas of high utility congestion. When the AC current on the targeted utility is low, it may be useful to increase the frequency, since the spar will be more sensitive at higher frequencies. For more information on setting up the transmitter when a direct connection is not possible, manipulating the transmitter’s controls, and troubleshooting, consult the Transmitter video tutorial and the Loc-10Tx User Handbook.



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Step 4: Connect the data collector to the spar

Insert the spar battery, and turn it on by pressing the power button for four seconds. The data collector may be connected using Bluetooth, or a USB cable if Bluetooth is nonfunctioning or unreliable (note that the cable locks to the spar upon a press, and unlocks with a counterclockwise twist).

The spar will have a Bluetooth ID in the format Spar-SSSS:PPP, where SSSS are the last 5 digits of the Spar's serial number, or Firefly-XXXX. In the latter case it is recommended you make a note on the Spar of its Bluetooth ID since you will need to select it later. The PIN to add a spar as a Bluetooth device is always 1234.

Note: if the cable is connected, that connection will be the default over the Bluetooth. To use the Bluetooth connection, you must disconnect the cable from the Spar.

Using a cable connection will require installation of a driver, either automatically or using the one included in the product package. On a tablet connected to the internet or a Windows Mobile device, the driver should install automatically when the USB cable is plugged in. In some cases, you may get a prompt for a driver name, in which case enter "ftdi_d2xx.dll". **On a Trimble Tablet**, the supplied driver may be used if it fails to automatically install over the internet. Once installed, a virtual COM port will be designated by Windows or can be determined using the Windows Device Manager. **For Windows Mobile devices**, the driver will be automatically installed. In this case a COM number will not be assigned, and the user should select "Cable" in the Spar Style dialog rather than a COM number (see Step 6).

Step 5: Create a new Job

Enter "Utility Survey" from the home screen of Trimble Access. Then select "Job" and "New job" to create a new Job with a custom name. Select the correct coordinate system and units before accepting.

Note: some menus have multiple pages. Scroll between pages using the button on the lower right when it appears.

Step 6: Configure Spar Style

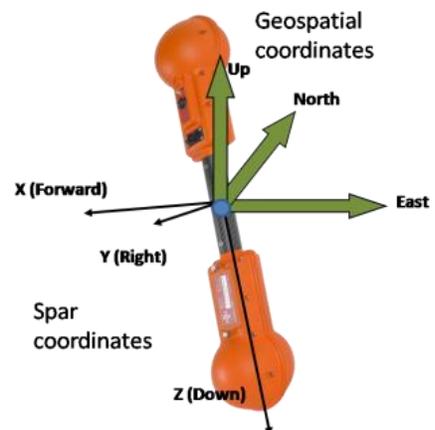
Go back to the Utility Survey screen and select "Style." On page 1, match the Frequency to what the transmitter is outputting, which you determined in Step 3. Different transmitters in the menu have different frequency options, so if your frequency isn't immediately visible, try a different choice in the Transmitter menu. On page 2 of the Style menu, select the correct COM port, which you determined in Step 4. This page also allows you to define the number of spars you will be using (default is 1). Further discussions of required settings for dual-spar mode can be found in [Dual-Spar Utility Mapping](#).

Step 7: Confirm GNSS rover precision

Back on the Utility Survey screen, select "Status" to confirm the GNSS rover is receiving within proper standards that you define (an accuracy range of centimeters or millimeters). If you are not using a GNSS rover, skip to step 8.

Step 8: Calculate offsets

Enter the "Line" screen from Utility Survey and click "Offsets." Here, measure the height of the Spar from the ground to the middle of the black handle and enter it as "Spar height" with units (can be metric or US system). Then, if necessary, enter the diameter of the utility line you will measure, and define whether to measure the depth to the top, center, or bottom of the line (the spar automatically measures to the center). Select the units you want to display.





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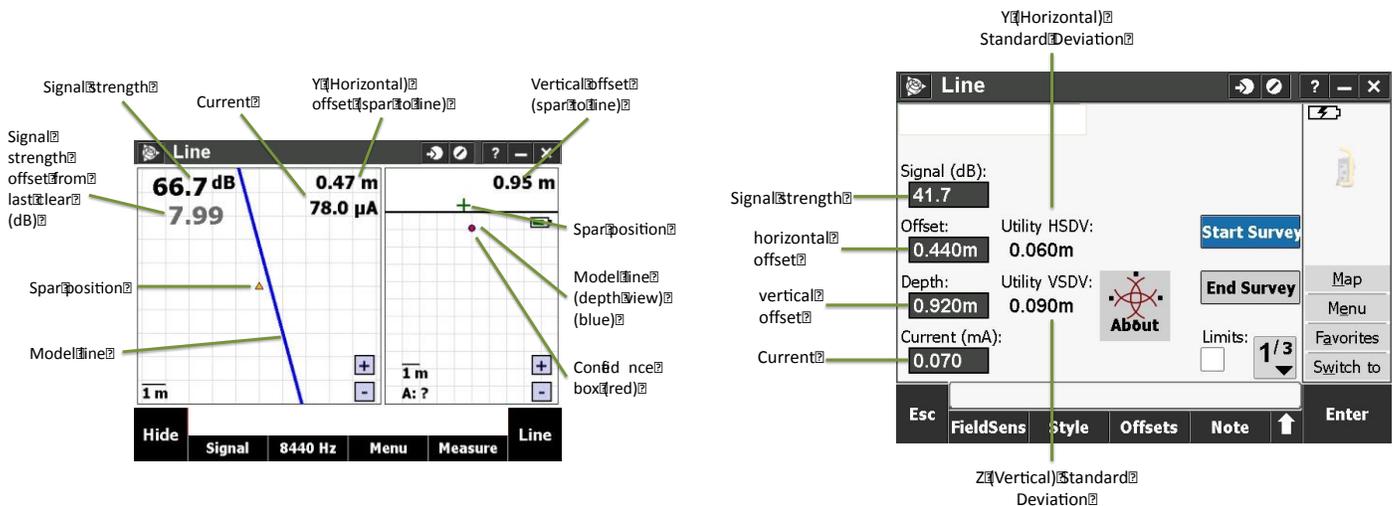
Next, set the x and y offsets of the spar to the antenna. Remember that the black power button defines the spar's forward direction. Spars use a right-handed coordinate system, in which forward is positive-x, right is positive-y, and down is positive-z. If the spar is 10cm in front of the pole (antenna), the base to antenna x-offset will be -10cm and the y-offset will be zero. If it is 10cm to the right of the antenna, the y-offset will be 10cm and the x-offset will be zero. Once you enter the offsets correctly, Utility Survey will always calculate the location of the spar based on the location of the antenna/pole. For a demonstration of calculating offsets in single- and dual-spar mode, see the Offsets tutorial video.

If you are using a GNSS rover, ensure the Reference Frame is "relative" and move to Step 9. If you are not using the rover and have placed the spar on a known geospatial location, select "absolute." Then go back to the Line screen. A "Base Spar" button should have appeared; click it to enter the geospatial location of the spar yourself, choose it from a list, or measure it (requires GNSS rover).

Setting the correct Reference Frame and Offsets is crucial in dual-spar mode. For a discussion of these settings, turn to [Setting Spar Separation](#).

Step 9: Measure points manually

Click "Start Survey" from the "Line" screen and enter FieldSens. In FieldSens, the blue line indicates the position of the utility line (top view on the left; side view/depth on the right). A red box around the blue dot on the right or the yellow triangle (spar position) shows the confidence of the position measurement, and may increase or decrease in size. Depth of the utility is shown numerically at top right, and the offset (horizontal distance from the current spar position to the utility) is shown at top center. The strength of the transmitter signal (dB) is shown at top left.



Collect a Utility Line point by using the FieldSens View softkey "Measure", then "Utility Line (UL)". The point is recorded and automatically line coded. You may also choose "Utility Point (UP)," meaning the point is not line coded, or "Utility Peak (UK)," which measures a peak signal point and is explained further in the Model Fix video tutorial and Application Note AN100. The data for these points can be found in Point Manager (see Step 12). "Continuous Topo" mode will automatically measure points at set time or distance intervals that you select. To learn more about Continuous Topo mode, consult the Reference Manual.



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You have great flexibility to control the data that are recorded for each point measurement, in accordance with your survey. For more information on feature and attribute coding, see the Measuring Points video tutorial, Application Note AN101, and the Reference Manual.

Further points can be collected after moving the spar along the line. (Without a GNSS rover, this will require changing the geospatial location of the spar as in Step 8.)

Step 10: View the geospatial utility line position

Return to the “Line” screen. On the vertical menu to the right, click “Map.” Click the arrow pointing up on the bottom right corner, then click “Pan to,” then “Here” on the bottom menu. Zoom in and navigate the map using the “+/-” and handprint buttons on the bottom.

On the map you will see the points you measured with their corresponding codes to describe the confidence of the measurement. The letter codes range from A to E ratings; these ratings are color-coordinated to create a visual code in which darker sections of the utility line (dark blue, for example) mean a more confident measurement than lighter sections. More information on confidence coding can be found in the Reference Manual.

Step 11: View Point Manager and sync data

Return to the Utility Survey screen and select “Job,” then “Point Manager” (also accessible from “Favorites” on the Line panel). From this screen, you may view created points and notes, including metadata information. For more information on feature coding, see the Measuring Points video tutorial and the Reference Manual.

Now, export the data to open in Excel, use in Trimble Business Center, or map to a CAD file by returning to “Job” and selecting “Import/Export”, and then “Export Utility CSV”. The job will export to a file on the data collection device, and can be transferred into another computer program for manipulation. Your utility line is now mapped precisely in an absolute coordinate system.

Utility Line Locating Strategies

Finding the Signal Peak

The strength of the signal (dB) from the transmitter will be shown from the upper left corner of FieldSens. Higher signal readings will generally give better and more accurate position data. To aid in finding the peak of the signal, the smaller gray number below the signal reading (dB) shows the difference in signal since the last “clear.” To clear the difference to zero, click it. Clearing the difference and moving the spar will help to pinpoint the peak of the signal. Refer to the Model Fix video tutorial to learn how use the utility peak to determine whether signal distortion exists.

Finding the Line

After hooking up the transmitter, it can sometimes be difficult to find the utility line if you have no other reference for its approximate location. In this case, take the spar 10 meters (30 feet) away from the transmitter hookup site. Slowly walk in a semicircle around the hookup site, paying attention to the dB (signal strength) value. Do not stop walking just because the blue model line appears and stabilizes—it could be a case of signal bleedover or return current. The line you want will be defined by the highest dB value *and* a fixed blue model line.

Detecting line direction changes

The blue model line in FieldSens aligns itself with the magnetic field around the utility line; if that field changes direction, the line will also change direction. As you walk along the line, pay close attention to any shifts in the orientation of the blue model line, or a distinct enlargement of the red confidence box. At an indication of change,



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try standing to the left or right of the line or moving slightly forward and backward to watch the model indicators. You are more likely to see a clear shift in orientation of the model line if you are walking on the inside curve of the utility line as it bends.

High Utility Congestion and Distortion

In areas where there are a number of different utility lines in a small space, distortion of the signal may occur. Distortion may be present if the confidence box is asymmetrical on the left side of the line compared to the right, if the confidence box is extremely tall or wide, if the depth value makes major fluctuations, or if there are other irregularities in the model. Using the “Model Fix” function can help determine whether distortion exists (consult the Model Fix video tutorial). There are several strategies for dealing with distortion in congested situations (for more information, see Application Note AN100).

- If possible, try lowering the frequency and increasing the current on the transmitter.
- Examine the model on both sides of the utility line—one side may be more stable and accurate than the other in certain distortion cases.
- A dramatic drop in current could mean that there has been a line split or you have begun following the wrong line

Low/High Signal Strength

Signal strength should optimally stay between 30 and 60 dB. When the signal strength is too high, lower the current on the line. When the signal strength is too low, the blue model line will be unstable or jump around erratically. In this case, consider the following:

- Check if there is enough current being output from the transmitter and experiment with a higher current if possible.
- Try a higher frequency if possible, being aware that higher frequencies are more susceptible to distortion.
- The transmitter may have a weak grounding because of dry ground or a poor connection. Refer to the Transmitter video tutorial for guidance on connections and grounding.
- The utility line may be buried too deep for the spar to get a position solution. Using two spars may yield significantly greater range if there is sufficient signal strength at each spar, and if field distortion is low.

Sonde Mode

Sonde mode is useful for precisely identifying the positions of underground conduits, clay or plastic pipes that can accept a sonde on a pushrod, or tunnels in which an underground sonde (battery operated magnetic dipole antenna) can be geospatially tracked and mapped. Two spars can be used for more precise calculations or in challenging environments. Each spar can be loaded with an internal RTK GNSS to facilitate automatic baseline calculations, multi-spar synchronization, and precise orientation.

Setup Instructions

This section provides a practical introduction to basic use of a single-spar system and its Trimble Access software in order to precisely map underground non-metallic conduits, tunnels, sewers and clay pipes using a sonde pushed or pulled through the pipe. **These instructions will mainly describe the process for use of a single spar**, though dual-spar methods may be referenced and the user directed to [later sections](#) for more detailed instructions.



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Step 1: Construct the spar apparatus

Normally, the spar is affixed vertically to a range pole or cart, or mounted on a tripod. The black power button defines the top end of the spar and the “forward” (positive x) direction, so the spar should be oriented with the power button facing forward and away from the mounting apparatus. If mounted on a cart, the spar may need to be affixed to the side of the cart rather than the front, but still with the power button facing forward. Since the sonde is usually changing position in sonde mode, the most popular setup for the spar is a static mount on a tripod. However, a mobile mount on a cart or pole will also work.

The GNSS rover should be positioned above the spar on the same pole. Utility Survey will locate the spar based on the position of the GNSS rover, even if the pole is not held perfectly vertically. In the absence of a rover, the Spar can be placed on a known geospatial position, but this limits the spar’s mobility.

In many cases, a second spar can be used in Sonde mode to make more precise measurements on deeper utilities. The second spar can be free-standing and unlinked to the first, which is the most likely situation in Sonde mode. These mounting techniques and notes about them can be found in [Dual-Spars in Sonde Mode](#).



Step 2: Set up the data collecting device

The computer device for data collection is typically a Trimble TSC3 with Windows Mobile or a Trimble Tablet. Verify that your data collector is correctly licensed for Utility Survey, using the About box from the Trimble icon at the top-left of the Trimble Access starting page. Install Utility Survey v1.x.x Setup.WM5.CAB (if using a TSC3 data collector) or Utility Survey v1.x.x Setup.Win32.TrimbleTablet.exe (if using a Trimble Tablet). If you are using a GNSS rover, confirm it is connected to the data collector and configured correctly as part of a Survey Style by entering “Settings” in Trimble Access.

For easy map-reading, face the data collector in the “forward” direction as defined by the Spar’s power button.

Step 3: Set up the sonde

In this case, the transmitting device will be the battery-operated sonde. Install the battery in the sonde and make note of its frequency (included in the documentation for the sonde).

Step 4: Connect the data collector to the spar

Insert the spar battery, and turn it on by pressing the power button for four seconds. The data collector may be connected using Bluetooth, or a USB cable if Bluetooth is nonfunctioning or unreliable (note that the cable locks to the spar upon a press, and unlocks with a counterclockwise twist).

The spar will have a Bluetooth ID in the format Spar-SSSS:PPP, where SSSS are the last 5 digits of the Spar’s serial number, or Firefly-XXXX. In the latter case it is recommended you make a note on the Spar of its Bluetooth ID since you will need to select it later. The PIN to add a spar as a Bluetooth device is always 1234.

Using a cable connection will require installation of a driver, either automatically or using the one included in the product package. On a tablet connected to the internet or a Windows Mobile device, the driver should install automatically when the USB cable is plugged in. In some cases, you may get a prompt for a driver name, in which case enter “ftdi_d2xx.dll”. **On a Trimble Tablet**, the supplied driver may be used if it fails to automatically install over the

Note: if the cable is connected, that connection will be the default over the Bluetooth. To use the Bluetooth connection, you must disconnect the cable from the Spar.



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internet. Once installed, a virtual COM port will be designated by Windows or can be determined using the Windows Device Manager. **For Windows Mobile devices**, the driver will be automatically installed. In this case a COM number will not be assigned, and the user should select “Cable” in the Spar Style dialog rather than a COM number (see Step 6).

Step 5: Create a new Job

Enter “Utility Survey” from the home screen of Trimble Access. Then select “Job” and “New job” to create a new Job with a custom name. Select the correct coordinate system and units before accepting.

Step 6: Configure Spar Style

Go back to the Utility Survey screen and select “Style.” On page 1, match the Frequency to what the sonde is outputting, which you determined in Step 3. Different transmitters in the menu have different frequency options, so if your sonde frequency isn’t immediately visible, try a different choice in the Transmitter menu. On page 2 of the Style menu, select the correct COM port, which you determined in Step 4. This page also allows you to define the number of spars you will be using (default is 1). Further discussions of required settings for dual-spar mode can be found in [Dual-Spar Utility Mapping](#).

Step 7: Confirm GNSS rover precision

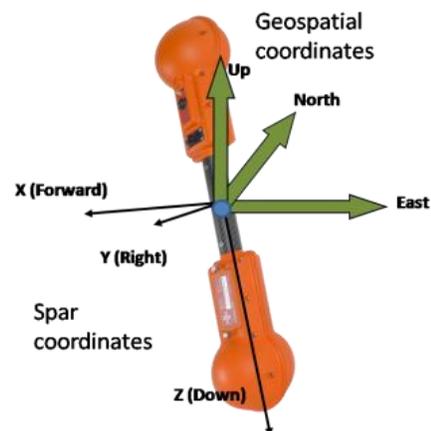
Back on the Utility Survey screen, select “Status” to confirm the GNSS rover is receiving within proper standards that you define (an accuracy range of centimeters or millimeters). If you are not using a GNSS rover, skip to step 8.

Step 8: Calculate offsets

Enter the “Sonde” screen from Utility Survey and click “Offsets.” Here, measure the height of the spar from the ground to the middle of the black handle and enter it as “Spar height” with units (can be metric or US system). Then, if necessary, enter the diameter of the utility line you will measure, and define whether to measure the depth to the top, center, or bottom of the line (in a large utility line, the sonde most often will rest at the bottom). Select the units you want to display.

Note: some menus have multiple pages. Scroll between pages using the button on the lower right when it appears.

Next, set the x and y offset of the spar to the antenna. Remember that the black power button defines the spar’s forward direction. Spars use a right-handed coordinate system, in which forward is positive-x, right is positive-y, and down is positive-z. If the spar is 10cm in front of the pole (antenna), the base to antenna x-offset will be -10cm and the y-offset will be zero. If it is 10cm to the right of the antenna, the y-offset will be 10cm and the x-offset will be zero. Once you enter the offsets correctly, Utility Survey will always calculate the location of the spar based on the location of the antenna/pole. For a demonstration of calculating offsets in single- and dual-spar mode, see the Offsets tutorial video.



If you are using a GNSS rover, ensure the Reference Frame is “relative” and move to Step 9. If you are not using the rover and have placed the spar on a known geospatial location, select “absolute.” Then go back to the Sonde screen. A “Base Spar” button should have appeared; click it to enter the geospatial location of the spar yourself, choose it from a list, or measure it (requires GNSS rover).



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Setting the correct Reference Frame and Offsets is crucial in dual-spar mode. For a discussion of these settings, turn to [Setting Spar Separation](#).

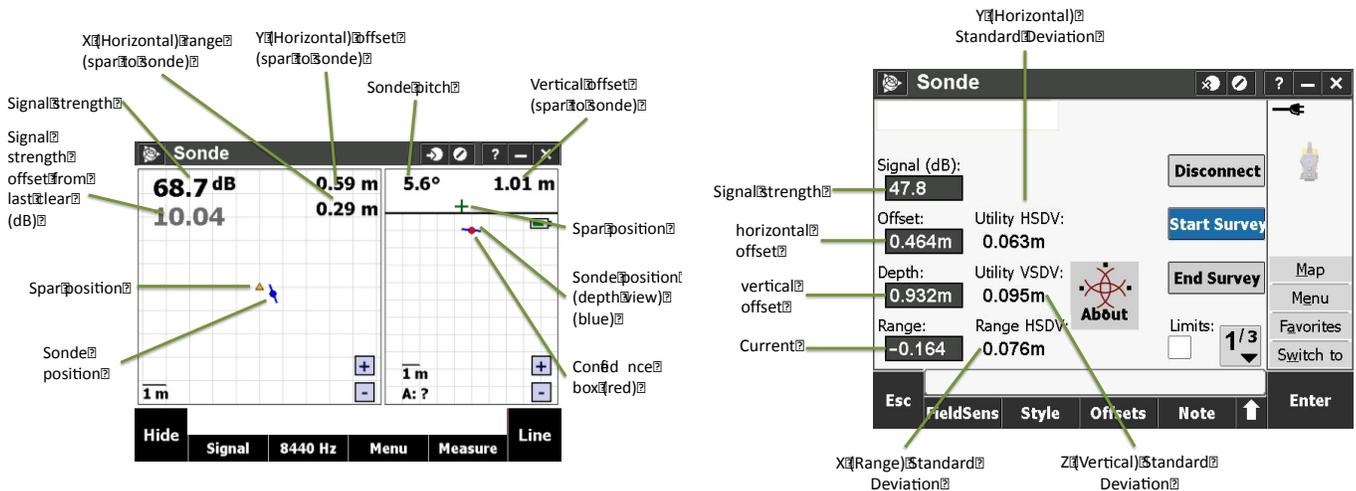
Step 9: Calibrate and install sonde

Go back to the “Sonde” screen and select “FieldSens, then “Menu.” Select “Calibrate Sonde,” then “In Front of Spar.” Imagine a circle around the upright spar, then place the sonde in front of the spar with its long side along a tangent of that circle. Ensure the height of the spar is entered correctly on the calibration menu, then start the calibration.

Place the sonde in the utility line. Generally, a sonde can be pushed or pulled through the line, with the spar making measurements at different points along the way. For guidance on how to move the sonde, see [Moving the Sonde](#). For more information on other methods of sonde calibration and when to calibrate, see [Sonde Calibration](#) and the Sonde Calibration video tutorial.

Step 10: Measure points manually

Click “Start Survey” from the “Sonde” screen and enter FieldSens. In FieldSens, the blue dot with a line through it indicates the position and orientation of the sonde (top view on the left; side view/depth on the right). A red box around the blue dot or the yellow triangle (spar position) shows the confidence of the position measurement, and may increase or decrease in size. Depth of the utility is shown numerically at top right, and the x- and y-offsets (horizontal distance from the current spar position to the sonde) is shown at top center. The strength of the sonde signal is shown at top left.



Collect a Utility Line point by using the FieldSens View softkey “Measure”, then “Utility Line (UL)”. The point is recorded and automatically line coded. You may also choose “Utility Point (UP),” meaning the point is not line coded, or “Utility Peak (UK),” which measures the peak signal of the sonde after it is determined by maximizing the displayed signal strength. (This function is present for compatibility of the spar to conventional sonde locating equipment. Using the spar’s model based positioning method, it is not necessary to find the aboveground peak signal strength of a belowground sonde.) The data for these points can be found in Point Manager (see Step 12). “Continuous Topo” mode will automatically measure points at set time or distance intervals that you select. To



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learn more about Continuous Topo mode, consult the Reference Manual. Continuous Topo measurements are possible in Sonde mode, but do not often make sense since it is the sonde that moves.

You have great flexibility to control the data that are recorded for each point measurement, in accordance with your survey. For more information on feature and attribute coding, see the Measuring Points video tutorial, Application Note AN101, and the Reference Manual.

Further points can be collected after moving the sonde, and/or the spar if necessary for signal strength or confidence. (Without a GNSS rover, moving the spar will require changing its geospatial location as in Step 8.)

Step 11: View the geospatial utility line position

Return to the “Sonde” screen. On the vertical menu to the right, click “Map.” Click the arrow pointing up on the bottom right corner, then click “Pan to,” then “Here” on the bottom menu. Zoom in and navigate the map using the “+/-” and handprint buttons on the bottom.

On the map you will see the points you measured with their corresponding codes to describe the confidence of the measurement. The letter codes range from A to E ratings; these ratings are color-coordinated to create a visual code in which darker sections of the utility line (dark blue, for example) means a more confident measurement than lighter sections. More information on confidence coding can be found in the Reference Manual.

Step 12: View Point Manager and sync data

Return to the Utility Survey screen and select “Job,” then “Point Manager” (also accessible from “Favorites” on the Line panel). From this screen, you may view created points and notes, including metadata information. For more information on feature coding, see the Measuring Points video tutorial and the Reference Manual.

Now, export the data to open in Excel, use in Trimble Business Center, or map to a CAD file by returning to “Job” and selecting “Import/Export.” The job will export to a file on the data collection device, and can be transferred into another computer program for manipulation. Your utility line is now mapped precisely in an absolute coordinate system.

Sonde Locating Strategies

Sonde Calibration

Sonde calibration can be performed in three ways: in front of the spar (placing the sonde with its side along a tangent of a circle around the spar), below the spar (placing the sonde on a level surface directly underneath the spar, as in a manhole), or by keying in the calibration value for the sonde. Optimal Ranging sondes all have calibration values, though other sondes may not. Depending on the location of the spar when it is time to calibrate or recalibrate, one calibration method may make more sense than another.

Always calibrate the sonde at the beginning of a project, or when it has a new battery. Optimal Ranging sondes generally have a battery life of approximately 4 hours, and the output level is very stable over that time. When ORI sondes are placed within non-metallic conveyances, recalibration may not be required between changes in batteries. Other sondes may not be output controlled and require recalibration at different times. When any sonde is placed within an enclosure that contains some metal, a sonde calibration must be performed. Even concrete manholes and drains often have significant metallic content which may affect the output level of the sonde. Recalibration can also be a possible solution to worsening results or a weakening signal from the sonde, though other factors could also be affecting these results. For more information on sonde calibration, see the Sonde Calibration tutorial.



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Moving the Sonde

There are a number of methods to move a sonde through a pipe.

- Push the sonde with a rod, metal or snake;
- Pull the sonde on a string (especially if there is a string in place to do so);
- Mount the sonde on a robotic probe that can move the sonde mechanically.

Choosing the Sonde Frequency

Sondes come in a number of frequencies, a list of which can be found on the Optimal Ranging website or in the Reference Manual. In general, lower frequencies produce less distortion and thus a cleaner signal; however, lower frequencies also produce less signal strength and thus are not always possible. Sondes at greater depths will generally require higher frequencies.

Point Measurement Methods

The way you choose to measure points will ultimately depend on your specific situation—depth of utility line, number of spars, difficulty of terrain, etc. However, generally, a “leapfrog” strategy of moving the spar can be effective in sonde mode. In this case, keep the spar in a set location and make as many quality measurements of a moving sonde as it is possible to make. Then “leapfrog” the spar over the sonde to where it gets a strong signal, and begin moving the sonde towards the spar again.

Continuous Topo measurements, while possible in sonde mode, may not make sense in most situations, and manual measurements will be the standard.

Dual-Spar Utility Mapping

Dual-spar mode can be used with both Line and Sonde mode in Utility Survey to achieve greater position accuracy and increase the range of positioning, such as when a utility line is located at a greater depth. The two spars’ sensors, farther apart than a single spar’s sensors are, serve to create a larger angle to measure changes in the circular transmitted signal, and compute these measurements to find the position the same way a single spar does.

Setting Up the Dual-Spar System

Base and End Spars

The two spars can be set up using any standard mounting apparatus, the most common being either a utility pole or a tripod. The black power button defines the “forward” direction. If you are using Ashtech RTK-enabled spars, one of the spar’s model numbers will end in a “B”; this spar is the Base spar, which will interact with the data collecting device. Using a cable connection, either spar can be a Base spar. If you will be using a GNSS rover to map in geospatial coordinates, the rover should be installed directly above the Base spar.

The second spar is the End spar, which will interact only with the Base spar. The End spar must always utilize a dongle to distinguish it—either the dongle supplied in the hardware package or the dongle-end of the cable. The dongle or cable is plugged into the End

Note: If you need to re-set the spars by quickly pressing the black power button (without holding it), be sure to re-set the Base spar first and then the End spar.



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spar's 10-pin I/O connector. Then, when the End Spar powers up (or is reset) it will look for a Base spar at a defined network ID with which to connect.

Spar Synchronization

Spars utilizing Ashtech GNSS boards will synchronize using GNSS time signals when turned on. The green flashing light on each spar will flash a ½ the normal rate when the spar is synchronized. In the absence of Ashtech boards, the Base and End spars must be connected together using a special cable (part number SPARSYNC). This permits a maximum separation of 4 meters, but in all other respects provides the same synchronization performance as does the satellite-based synchronization based on the Ashtech boards. However, dual-spar systems that rely on the SPARSYNC cable are not capable of automatic baseline estimation via the RTK moving baseline option, which is only available for the Ashtech boards.

Spar Networking

Dual-spar measurements require the same network ID (known as PID) and wireless channel number to be resident in non-volatile memory of each spar prior to use. By default, spars are set to a factory default configuration (PAN ID 56863 and channel number 11). If multiple dual-spar systems are being used within a few hundred meters or so of each other, these values should be reprogrammed. Optimal Ranging supplies a PC based utility (Windows 7) to set these values in each spar. Any PAN ID from 0 to 65535 can be chosen, as long as this number is the same for both the Base and End spars. The channel number refers to the IEEE 802.15.4 channel designation for the 2.4 GHz wireless link. Channels 11-26 are valid, and the PC utility supports a channel noise measurement in case there is interference encountered for the currently chosen channel. For more information, and specific instructions on how to set the spar PAN ID and channel number for dual-spar networking, please refer to the Utility Survey Reference Manual.

Setting up Utility Survey for Dual-Spar mode

Enter Utility Survey's "Style" screen. On page 1, set the frequency based on the transmitter (for Line mode) or sonde (for Sonde mode) that you are using. On page 2, set the COM port to the one established between the data collecting device and the Base spar when you connected using either the USB cable or Bluetooth. Then, set the "Spars in network" field to 2.

Setting Spar Separation

Create a new job or select a previous one, enter Line or Sonde mode depending on your project, and view the FieldSens screen. The screen will read "Waiting for Spar Separation." Back on the Line/Sonde screen, select "Offsets." From the dropdown menu "Spar separation," you will need to select Relative, Absolute, or Moving Baseline. These three options are described below.

Offset measurements can be complicated when using two spars. For more help with setting spar separation and offsets, see the Spar Separation tutorial video.

Choosing the distance between the spars for the most accurate measurement is a process of experimentation. Generally, a greater distance between spars will allow for a deeper measurement, but the spars have an approximate maximum range of 24m (80ft) between them. Signal strength, field distortion, and spar-to-spar communication issues will also affect how far apart the spars can be to get an accurate measurement. You might begin with a greater distance between the spars, and shorten or adjust it according to the signal strength and confidence as seen in FieldSens.



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<p>Relative (XYZ) Spar Separation</p>	<p>In Relative mode, the location of the End spar will be expressed in xyz coordinates relative to the position of the Base spar. In Offsets, enter the xyz coordinates to show the location of the Base and End spars in relation to their antennas (tripod or pole). Then, fill in the fields for End Spar (x, y, z) by manually measuring the distances. Remember to enter these positive or negative values always in relation to the Base spar, using a right-hand coordinate system (forward=pos-x, right=pos-y, down=pos-z).</p> <p>Enter these values and return to the Line/Sonde screen, where a “Base Spar” button should have appeared. From here, enter the geospatial position of the base spar by keying it in, selecting it from a list, or measuring it (requires GNSS rover). The “code” for this point should be “SPAR,” already part of the ORI.fxl feature library.</p>	<p>Main Applications:</p> <ul style="list-style-type: none"> - To make measurements using spars mounted on a moving vehicle with a fixed and constant offset between them - To make a single point/line measurement on easy terrain without moving the spars (as in measuring the point that a line emerges from under a river)
<p>Absolute (ENU) Spar Separation</p>	<p>Absolute mode assumes you have access to geospatial coordinates for the positions of both the Base and End spars, for example, if they are situated on already-mapped locations or in range of a total station. In this case, enter the Base and End spar-to-antenna coordinates in the Offsets screen, then return to the Line/Sonde screen, where “Base Spar” and “End Spar” buttons should have appeared. Enter the geospatial positions of both spars by keying them in, selecting them from a list, or measuring them (requires GNSS rover). The “code” for these points should be “SPAR,” already part of the ORI.fxl feature library.</p>	<p>Main Applications:</p> <ul style="list-style-type: none"> - To make measurements on easy terrain where you have marked aboveground geospatial positions, with infrequent spar movement (a “leapfrog” strategy) - To make measurements near a total station
<p>Moving Baseline</p>	<p>Moving Baseline mode requires no measurements or entries from the user, but does requires a GNSS rover and satellite visibility to ascertain the position of the Base spar, and the presence of the RTK option for both Ashtech boards installed in the Base and End spars. When this is true, the position of the End spar relative to the Base spar is automatically determined. The Base spar position can either be determined from an active Trimble Access survey style (with external Trimble R-series receiver), or by enabling the “Internal RTK” option for network RTK corrections to be sent to the Base spar. To use this mode, ensure that your rover’s readings and settings are correct in the Trimble Access main menu, and that the RTK connection is live between the spars (see “Base and End Spars”).</p>	<p>Main Applications:</p> <ul style="list-style-type: none"> - To make measurements without a fixed mounting device in any kind of terrain



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Using Two Spars in the Field

FieldSens with Two Spars

Having set the separation of the two spars, you should now be able to view in FieldSens the visual representation of the position of the utility line or sonde. Measure points as usual, remembering that offsets and positions may need to be adjusted when you move one or both spars.

Relative Spar Separation on a Fixed Mount [Line Mode]

In Line mode, while two spars each be mounted separately and utilize RTK to measure their offset, it can often be useful to mount the spars on a vehicle or boat with a fixed XYZ offset between them. In the case of mounting on a vehicle, be careful not to place the spars too close to the signal noise created by the sparkplug. Relative spar separation measurements are more manageable in this case, when the offset from base to end spar remains constant even if the vehicle or boat moves. Mounted on either side of an ATV, for example, the spars could be arranged so as to only have a y-offset, with zero x- and z-offsets. However, take care to mount the spars exactly vertically, because tilting a base spar also tilts its internal reference frame, possibly creating other unintended offsets for the end spar.



Orientation of Spars

In Line mode, when placing the spars in relation to the utility line, there is only one orientation that will be impossible to get a reading. This is when the line created by the two spars is exactly parallel to the utility line. In this configuration, the two spars receive an identical value from the circular signal transmitted down the line, and are unable to calculate a position.

In Sonde mode, the spars can be placed in any orientation. As a guideline, it often makes sense to orient the spars such that the sonde will move roughly from spar to spar, then “leapfrog” one of the spars ahead of the other when necessary. This orientation makes the most sense in Absolute separation mode, and does not always apply. Whatever the spar orientation, the goal is to minimize the confidence box around the sonde.

Static vs. Continuous Measurements

Measuring a single static point—for example, the point at which a utility line emerges from under a river—can be done with two spars in static positions, as when mounted on tripods. In this situation, Moving Baseline spar separation would be recommended, since the spars will be in independent positions; however, Relative or Absolute separation may be possible in certain situations especially on easy terrain.

In other situations, a continuous measurement along the length of a deeply buried utility line is necessary. In this case, in Line mode it is recommended to mount the spars in a fixed configuration on a moving vehicle—for example, a spar affixed on either side of an ATV or boat. This would open the possibility for using Relative spar separation, since the end spar will always have the same offsets from the base spar. In Sonde mode, a “leapfrog” strategy would make more sense, moving the spars to follow the sonde as it passes through the pipe. Moving Baseline or Absolute separation would make most sense in this case.

Dual-Spar Range

Sondes come with different programmed frequencies and different ranges, the largest range being 24m (80ft). The two spars, similarly, can be trusted up to 24m apart.



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In Line mode when measuring a deeply-buried utility line, the further apart the two spars are placed, the larger the angle of measurement when receiving the circular signal from the utility line. With a larger angle, the spars can measure to a greater depth. However, this is limited by the range between the spars (functional up to 24m or 80ft apart) and the strength of the transmitter signal from a very deeply buried line. Within the range limits of the spars, try different frequencies and spar locations to optimize signal strength.

In practice, in many urban settings the presence of signal distortion due to electromagnetic coupling will limit the range of the dual-spar system. The best results are achieved in rural settings in which deep utilities are present under rivers, or in directionally bored conduits that have few neighboring lines.