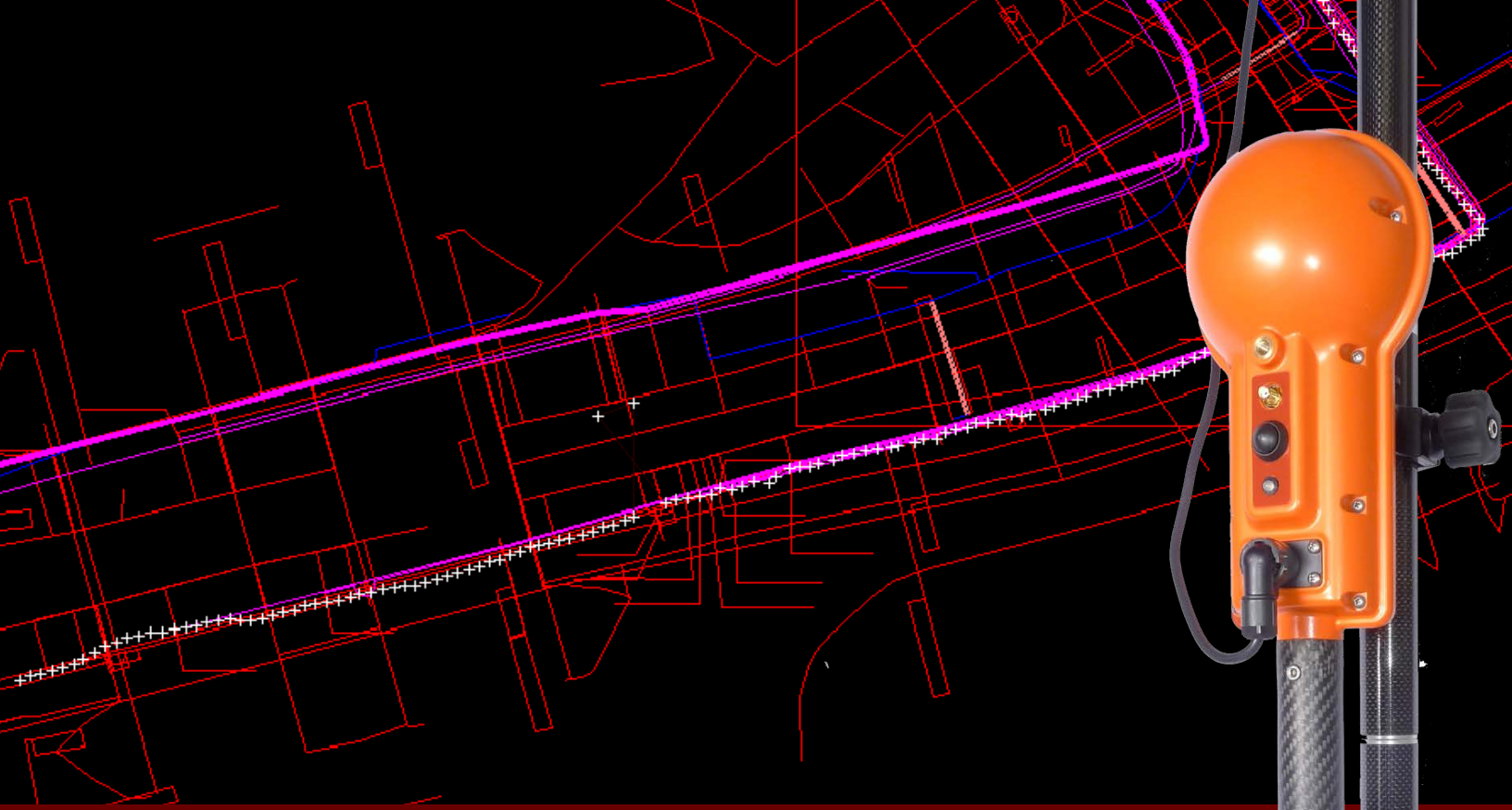

Underground Utility 3-D Survey

Product Brief

Spar 300
Spar 300 L1
Spar 300 RL1G1
Spar 300 RL1G1B
Utility Survey for Trimble Access™

Version 1.3

VIVAX METROTECH

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Geospatial Underground Utility Survey

REMOTE POSITION SENSING

In Line Mode, precise magnetic field measurements (regardless of orientation or relative position to the utility) permit model-based estimates of offset, depth, and impressed AC current. Sonde mode detects the offset, depth, and range to a battery-operated point source.

GEOSPATIAL POSITIONING

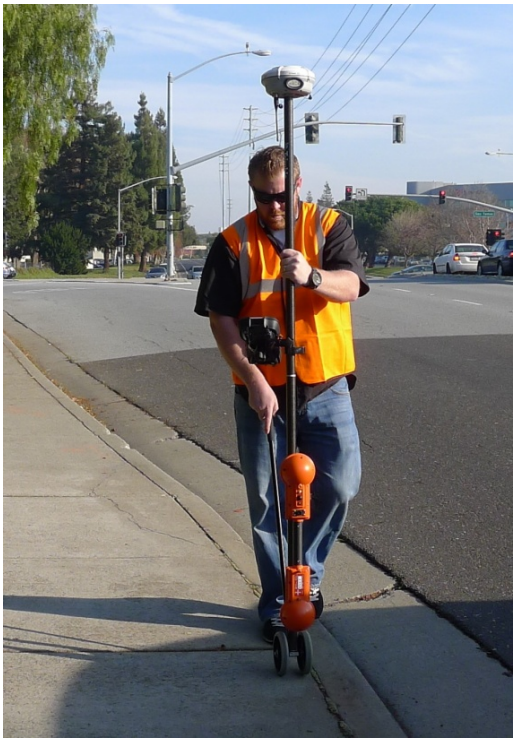
The Trimble Access-based Utility Survey software integrates seamlessly with Trimble GNSS receivers, merging measured offsets to the utility with the geospatial position of the aboveground spar. Elevation, Easting, and Northing are directly recorded in a Trimble Access "job" file. Each utility position may be logged upon command, or as a semi-automatic stream, and coupled with the estimated accuracy. Aboveground points can be measured and coded as per the normal field data collection process.

WIRELESS INTEGRATION

The system relies on Bluetooth and IEEE 802.15.4 wireless technology to integrate GNSS, the host computer, and dual-spar tracking modes.

SELF-ORIENTATION

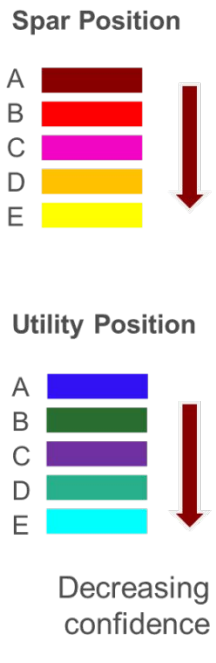
The Spar 300 includes on-board orientation sensors including a 3-axis digital compass, 3-axis accelerometer, and (optionally) a dual antenna RTK-based precision heading measurement.



Casual contact to the underground utility line is maintained during a survey. The system logs geospatial positions and expected error of the utility regardless of the perspective of the spar relative to the line.

Underground utility asset survey can now use the same trusted methods, and with similar quality metrics as for corresponding aboveground assets. The new Spar 300 is a precise utility surveying system that collects positions in your site coordinates, in a package that easily adapts directly to a range pole, ATV, riverboat, or push cart. With conventional handheld locating equipment, logging underground position information of pipelines, cables, and ducts has required cumbersome integration of GNSS receivers and locating equipment using special brackets and cables. Now, the Spar 300 continuously logs the utility depth and offset, along with statistical confidence and automatic offset calculations. Over a Bluetooth or USB link, the instrument outputs the 3-D positions to a Trimble TSC3 or Tablet for real-time display on the Trimble Access™ map, independent of its own perspective with respect to the utility or the GNSS antenna. When a complex locate scenario is encountered, as can occur when several utilities are co-located within a common right-of-way, the Spar 300 applies automatic tolerance masks to the position data, flagging these areas on the map.

Accurate utility infrastructure geopositioning leads to long term cost savings, since an electronic record is available when needed for repair and maintenance of the line.



Positions, with both horizontal and vertical precision, are continuously plotted in coordinates, and easily exported to the GIS, CAD, or modeling environment. The Utility Survey module for Trimble Access supports a variety of external Trimble GNSS receivers.

FieldSens Technology is based on the joint optimization of data from many sensors against a physical model of the magnetic field expected from a utility line. The method minimizes the need to bring the measurement equipment to specific points related to the utility cable or pipe in order to validate position. Using two 3-D magnetic field sensors, a triaxial accelerometer and digital compass, the Spar 300 estimates the 3-D offset and orientation angles to the underground utility regardless of its position in the radiated field.

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FieldSens View ↔ Trimble Access™

TRANSMITTERS

The Spar is compatible with many existing locating transmitters, and is offered with a optional Very Low Frequency transmitter for maximum accuracy in direct connect mode. Passive AC can be optionally traced.

FIELDSENS VIEW

Manages the Spar hardware, and performs the coordinate rotations that combine the Spar-centric offset measurements with the geospatial utility position.

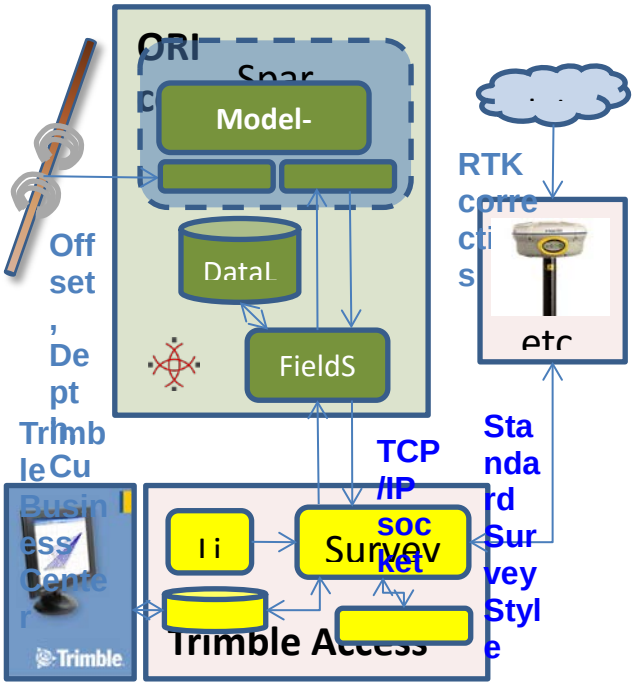
MODEL OPTIMIZATION

The Spar includes a numeric processor that performs many iterations per positioning result, wherein each represents the best match of the measured sensor data to a physical model of the magnetic field. A unique model is used for each of the two main targets (Line or Sonde) detected by the Spar 300.

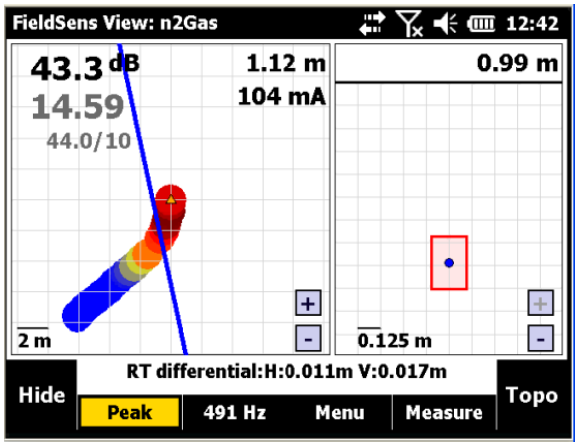
TRIMBLE ACCESS

Designed to fully support everyday field data collection, including topographic surveys, staking, control and more; Trimble Access offers a familiar easy-to-use interface to ensure a short learning-curve. Trimble Access for General Survey supports the full range of Trimble GNSS and optical sensors, plus robotic radio connections. Simply choose the Trimble controller that best meets your surveying needs.

Spar Hardware and model-based FieldSens software integrate seamlessly with Trimble GNSS receivers and robotic total stations within an Access-based workflow. Any external GNSS receivers supported by existing Survey Styles can be used in a Spar measurement. Trimble S- and VX-series total stations are supported, as are the controller platforms Trimble TSC3, GeoXR, and Tablet.



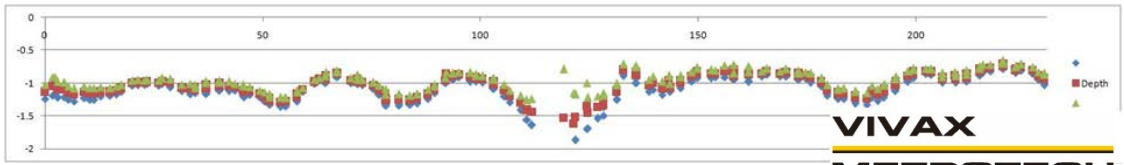
FieldSens View provides control and monitoring of the locating subsystems of the spar. With both bird's eye and down-line views, it's easy to collect 3-D utility positions simply by "walking the line". With the Spar 300's revolutionary positioning ability from arbitrary offset positions, accurate mapping is possible even when the spar can't be brought over the utility. The user need only be reasonably close, and the system automatically applies all offsets and ensures logged points meet desired tolerances.



Trimble Access™ handles base map display, data collection in a point database, line coding, local coordinate transformation, GNSS receiver control, and data export. In addition, customized utility reports can be developed to adapt the system to your particular company's data collection conventions. Local coordinate systems in use throughout the world are supported, and where unique requirements exist, custom coordinates can be configured using built-in transformations. All existing Survey Styles are supported.

Map Views are particularly valuable during data collection, to validate the position of the incoming points compared to already mapped utilities, or the as-built positions. Continuous Topo points based on time and/or distance intervals, coupled with auto-tolerancing of the merged utility offset and GNSS positions, provide a very efficient mechanism for collecting line data. After the measurement session, Trimble Access supports field editing of the dataset, or alternatively, synchronization of the data with Trimble Business Center and online servers.

Depth Profile with error bounds (meters)



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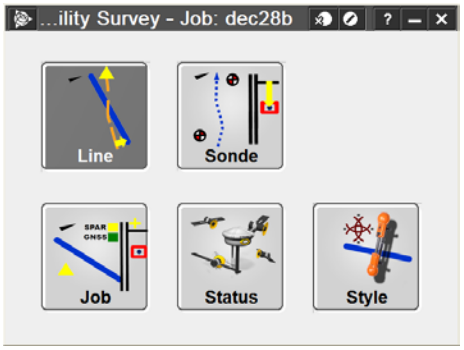
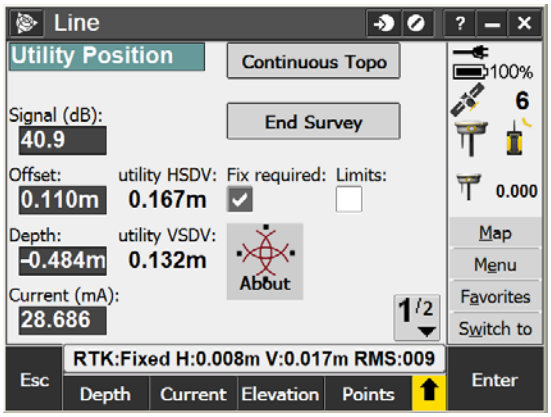
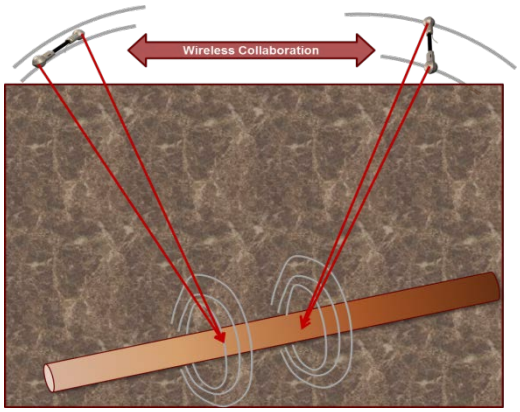
Utility Line Positioning



Single Spar measurements are obtained for over ranges up to 3m, but can be reduced in areas of significant distortion. Often distortion can be mitigated by traversing the spar over the top of a facility, verifying that both the depth and expected error provide consistent positioning results. Areas of high distortion will cause the confidence to quickly erode, and choosing a perspective from the side of the distorting influence can lead to improved results.





Dual-Spar measurements effectively extend the vectoring capability of the spar by increasing the baseline distance between magnetic sensors. Rather than a fixed ½ meter separation between measurement points, the baseline can be increased to up to 10 or 15 meters. As long as sufficient signal from the utility target can be detected at each spar, the sensors on each spar are combined to improve detection accuracy and confidence. The spars must include a synchronization option either using a cable or using internal GPS timing hardware, both of which are available at the time of order.

Fixed Mount dual-spar setups work just like a single spar system, but extend the range of the system for deep targets, as long as the signal is strong enough at each spar measurement position onsite distortion is low (as is often the case for long distance pipelines and underwater cables). This permits custom fixtures to be developed for a variety of vehicles to mount a dual-spar system.

RTK-GNSS

The Spar 300 is the first utility mapping system that optionally integrates a professional grade RTK (real-time kinematic) GNSS component. The RTK-based RL1G1 configuration (L1 frequency, GPS+GLONASS constellations) is recommended for Dual-Spar systems, for accurate and automatic moving baseline measurements, removing the necessity for a separate aboveground positioning system. When the Spar baseline is fixed, the L1-GPS configuration is required for wireless Dual-Spar synchronization. For the simplest Dual-Spar setups, a synchronization cable is available.

MULTI-ANTENNA HEADING

Again with respect to Dual-Spar measurements, an optional two-GNSS antenna true heading measurement results in improved accuracy of underground static point positions, or dynamic sonde tracking, using ORI-supplied magnetic dipole transmitters.

RTK NETWORKS

RTK Networks are available in many urban areas of the world. With a 3G enabled Trimble TSC3 or Tablet, the spar can access these data streams for RTK corrections. All industry standard formats are supported, including RTCM 2.3, 3.0, and CMR+, in either direct IP or NTRIP formatted packets.

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Sonde Tracking

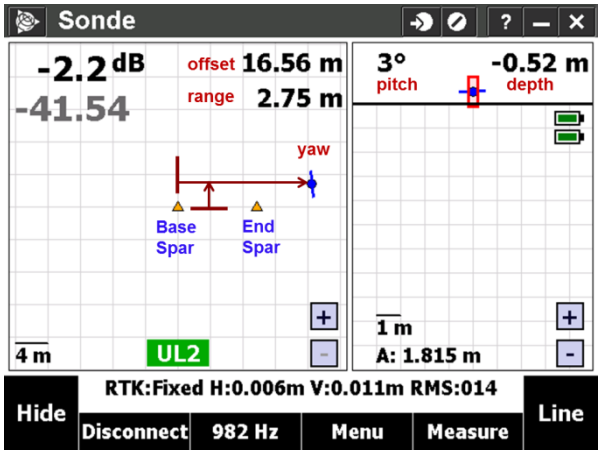
SONDE TRANSMITTERS

Sonde transmitters placed within pipes and ducts can be tracked in 3-D geospatial coordinates at ranges up to 24 m using a dual-spar system. This mode is useful when validating directional drilling bores, or mapping plastic pipes, conduits, tunnels and underwater pipelines in rivers, bays, and estuaries without using marine grade equipment. Coordinates of the tracked sonde are presented in real-time, both in profile and map views.

WALKOVER-FREE TRACKING

Either single or dual spars can be used to track sonde transmitters, with tracking range being the most important reason to use a dual spar system. For all but the smallest and least powerful plumbing sondes, the tracking range of a single spar system is 3 meters. For a dual-spar system, the strength of the sonde is the key determinant. ORI offers a range of sondes at several frequencies that can be tracked at up to 24 meter (80 feet) range. Sondes are rated in terms of tracking range, which also determines the maximum separation of the two spars. Lower frequencies are less susceptible to distortion due to underground eddy currents, while higher frequencies offer greater tracking range. All ORI sondes are level-stabilized and do not require calibration. Check with ORI regarding compatibility of sondes from other manufacturers.

Sonde Tracking permits accurate positioning in GPS-Denied locations without having to maintain a position over the peak signal. Depth, offset, and range measurements are automatically converted to Easting, Northing, and Elevation. The position of the spar relative to the underground target is completely arbitrary, and permits positioning in inaccessible areas. Examples include tracing a conduit under a major highway without traffic control, capturing duct positions under a building, a tracking a robot in a tunnel of unknown extent. ORI's model based method offers unparalleled performance and a completely new method of collecting accurate underground positions.



External GNSS or Total Stations are used to site the spar placements aboveground. The underground survey then can take place over a line section within the tracking radius specified by the sonde in use. A simple rule is that the radius of the tracking range is equal to the spar separation distance, as measured from the midpoint of the spars. This permits using the dual-spar system to track underground sonde transmitter positions under deep foliage cover or near buildings, as long as the spars can be accurately sited. Collecting Spar "control" positions can even be done as a separate operation, and those points imported into the Trimble Access job for use during the tracking operation.

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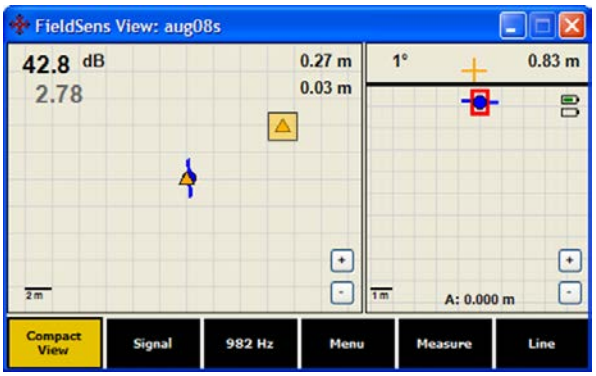
Dual-Spar Sonde Tracking

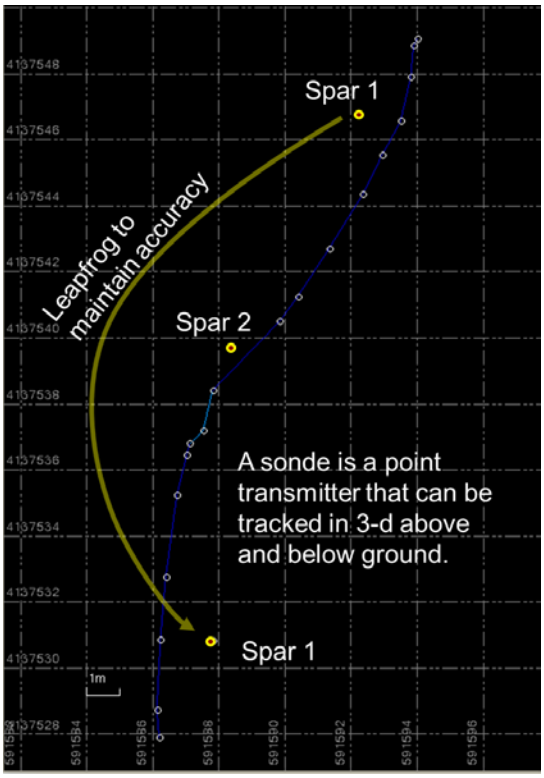
TEST HOLE SURVEY

Both single and dual spars can be used for qualification of utility depths, as an aid in the decision of where to use so-called “Test Holes”, i.e., vacuum or hydro-excavated holes that expose the utility for confirmation of precise elevation. By performing a sweep over the area from one side of the utility to the other and monitoring the consistency of the depth and confidence, a determination of the quality of the detected position is obtained. This can be very useful in determining the best use of resources allocated for physical exposure of the utlity. In difficult areas where magnetic field distortion is present, the confidence region presented by FieldSens View is a guide to where is the best location to record the point (see ORI Application Note 100).

STATIC POINT CONFIRM

Sondes can also be used to statically confirm the position of a single underground point. Sometimes, in an underground tunneling application, a laser based positioning system will have a limited backsight, and be susceptible to progressive errors as the boring tool moves further along the planned path. Using a stationary sonde, the dual-spar system includes a static mode that enables multiple aboveground spar positions to be combined into a single high quality underground position estimate.





RTK Moving Baseline completely removes the need to site the spars prior to sonde tracking. In this scenario, the two spars employ an embedded Trimble MB-100 RTK-GNSS module (L1, GPS+GLONASS) to determine the 3-D baseline distance automatically. This permits the aboveground spars to be leapfrogged down the line without needing independent survey of the spar positions. Once the baseline is fixed (centimeter accuracy), the system continues to track the underground sonde continuously after the reposition of either spar. During the period that the system converges to a fix, the baseline accuracy is displayed (yellow region). With an external RTN Network correction applied to the Base Spar, the combined dual-spar system is fixed geospatially.

Mechanical	ORI Part No.	Dimension (L x D), mm	Frequency (Hz)	Advantage	Power Source	Battery Life	Max Range, meters	Max Range, feet
General purpose	SONDH982	180 x 53	982	Low distortion	9V alkaline	4 hour	8	25
	SONDH8440	180 x 53	8440	Medium range	9V alkaline	4 hour	12	40
Non-metallic duct	SONDS8440	152 x 22	8440	Small size	3.7V Li-Ion	4 hour	12	40
	SONDL8440	305 x 22	8440	Long range	3.7V Li-Ion	4 hour	24	80
	SONDR512	320 x 32	512	Low distortion	3.7V Li-Ion	4 hour	18	60
Metallic conduit	SONDR32	320 x 32	32	Low attenuation	3.7V Li-Ion	4 hour	8	25
	SONDE32	320 x 32	32	Low attenuation	12V external	indefinite	11	35

Dual-Spar Survey Style	External GNSS Trimble R4/R6/R8		External GNSS Trimble R4/R6/R8		None (Internal RTK)	
Spar Part No.	300 (base spar) 300 (end spar)		300 L1 (base spar) 300 L1 (end spar)		300 RL1G1B (base spar) 300 RL1G1 (end spar) †	
Internal GNSS	None		L1 GPS		L1 RTK GPS + GLONASS	
Synchronization method	Tethered cable		GPS PPS		GPS PPS	
Mode	Line	Sonde	Line	Sonde	Line	Sonde
Spar baseline	Relative XYZ (manual)	Absolute ENU (single shot)	Relative XYZ (manual)	Absolute ENU (single shot)	Absolute ENU (continuous, automatic)	

†Model 300 RL1G1B may also serve as an End Spar

Synchronization options require either a cable that connects the two spars, or the presence of a GNSS board in the spar.

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3-D CAD Interface

SURVEY ARCHIVAL

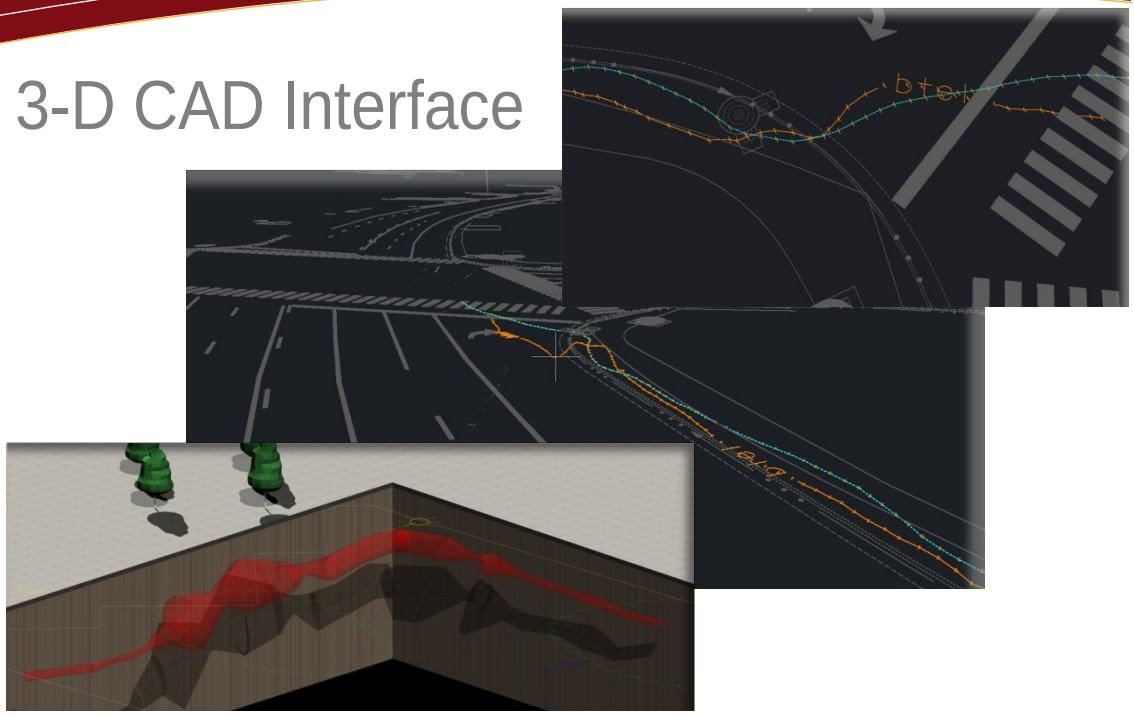
FieldSens collects measured utility positions and attributes in a Trimble .job file, allowing post analysis and review. Export of geospatial position and depth information in AutoCAD .dxf or ASCII .csv formats can occur from the field, or later in the office using Trimble Business Center. A special .csv export is directly compatible with Autodesk's Civil3D software. Industry standard raster and vector map formats are supported for base maps (.dxf, .shp, .jpg, .bmp).

RETURN ON INVESTMENT

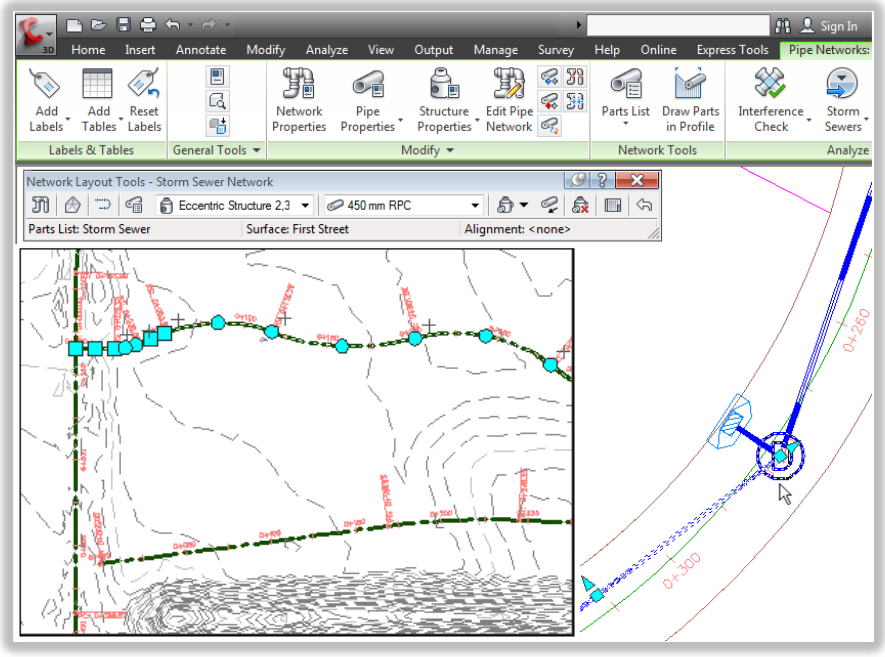
FieldSens Utility Survey provides a convenient platform for utility surveying, without the necessity of manually positioning the system over the target line. The volume and quality of position data is far greater than is practically obtained using existing methods. This saves time and effort, reducing the cost of underground utility data collection.

TURNKEY OR OEM

For most users, Utility Survey is deployed as a turnkey application, and is fully integrated with Trimble Access. OEM versions of the Spar hardware system are supported for custom NMEA 0183 applications. Additionally, a marine version of the Spar known as the FieldSens Underwater Rig is available, certified to 50 meter depths.



Confidence can be represented as a cloud around the target utility. This permits a quick look at segments of the utility survey that suffer from increased error due to magnetic field distortion, poor signal, or excessive distance between the spar and the targeted line. In the top two images, the 3-D spar position is plotted in relationship to a surveyed underground telephone line. Droops and twists in the offset and depth may be real, or can also be caused by field distortion (see ORI application note 100). Without inspection of the confidence attributes, the viewer of the plot does not know. Trimble Access Utility Survey records the horizontal and vertical accuracy for every utility position. A more sophisticated graphical representation of the utility position can make use of this confidence information. The third image above exposes the position confidence for a surveyed underground power cable by varying the diameter of the cable as a function of the measured confidence. Distortion is caused by the direction change of the cable (at the right angle bend). When the spar had to be walked around obstructing vegetation (modeled in the image as green shrubs), reduced confidence also resulted. Thus the spar's ability to annotate the data with confidence can provide designers actionable information regarding the position accuracy.



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Spar 300 Specifications

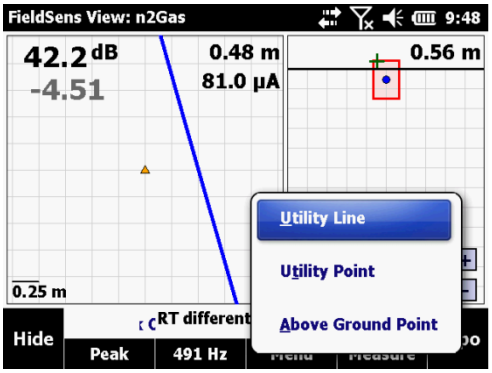
INFORMATION QUALITY

An electromagnetic (EM) detection instrument like the Spar 300 that focuses on the use of magnetic field emanated from an underground utility cannot be the only tool in the surveyor's or subsurface utility engineer's toolbox. By offering integrated geospatial positioning, a measure of position confidence in addition to a simple mark on the ground, and the ability to combine measurements from two spars to greatly expand the range over which the model-based positioning method can work, the Spar system provides actionable information. Civil engineers who need subsurface utility models for design, utility owners who are building GIS databases, contractors or construction supervisors that must deal with existing utility infrastructure can gain from the additional information provided by these enhancements.

REPRESENTATIVES

Optimal Ranging products, including the Spar 300 and accessories, are represented in most regions by Trimble. Please contact ORI or use Trimble's dealer locator at Trimble Access for Integrated Surveying, http://www.trimble.com/survey/Trimble-Access-IS.aspx.

FieldSens technology is based on US patents 7057383 (and foreign equivalents), 7356421, and several pending applications.



FieldSens View provides a local position reference relative to the underground line, with a graphical depiction of the overall error. The vertical and horizontal extents of the red box define the 1-σ accuracy.

Conventional Utility Locate

- Directional indication provided by a Left-Right deflection of a needle or signal strength bar graph
- Utility positioning requires the user to maintain position over the line
- Fast display update provides constant feedback of the peak signal strength
- Depth calculation is possible only when the receiver is held vertically over the line
- Method provides no confidence metrics

FieldSens Utility Mapping

- Receiver is rigidly affixed to a structure holding a professional GNSS antenna
- Casual contact to the centerline position is maintained, with no assumed perspective
- Modest display rate, because the line position is constantly known in 3-D
- Depth information is continuous and independent of the receiver orientation
- Confidence (precision) metrics are always available

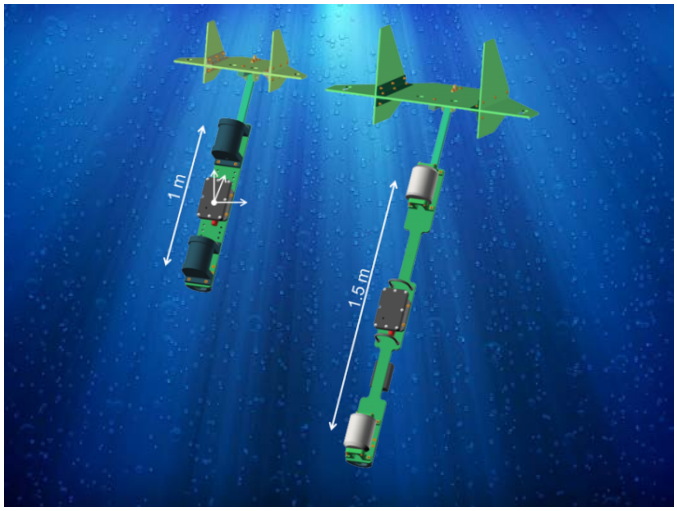
Specifications	(see Spar 300 Family Datasheet for details)
Operating Frequency	32, 50, 60, 98, 100, 120, 128, 491, 512, 577, 640, 982, 1520, 8192, 8440, 9820 Hz
Sensitivity (491 Hz)	500 µA to 10 A at 1 meter
Sensitivity (9820 Hz)	25 µA to 500 mA at 1 meter
Magnetic Heading	±1 degree static
Depth Accuracy (1-σ)	5% of depth relative to spar (typical)
Depth Range	3 meters (single-spar), 15 meters (dual-spar)
Horizontal Accuracy (1-σ)	5% of radial distance relative to spar (typical)
Continuous Positioning Rate	1 Hz geospatial, 5 Hz relative location
Geographic Accuracy (3-D)	≤ 5cm RTK Fix, depending on reported depth and centerline accuracy

Specifications subject to change without notice.

Spar 300 Specifications

are fully described in the datasheet. Compatible transmitters are listed, as are important features available in the Trimble Access Utility Survey module.

The user manual and datasheet are both present on Optimal Ranging's website, where setup dialogs related to the data collector are fully described. Look for training videos and announcements of additional supported languages.



Model-based positioning is the basis for the Spar 300 and related products, like the FieldSens Underwater Rig shown at left. In a similar way that GNSS works to position aboveground points, ORI's mission is to provide enhanced positioning accuracy in difficult, GNSS-denied environments.

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