Smart Tether

User Manual

Software Version 6.3

KCF technologies

Revision 1

KCF Technologies, Inc.   336 South Fraser St., State College, PA 16801   www.kcftech.com   814.867.4097

1. CONTENTS

2. INTRODUCTION

The Smart Tether is a revolutionary tether-based underwater navigation technology in which all of the sensing elements are housed in the tether itself. This makes setup very quick and straightforward, and a new user can easily be up and running in a matter of minutes.

It is recommended that a new user read through the Connections, Shutting Down, and Basic Software Operation sections before attempting a mission. With that small amount of information you should be able to get the Smart Tether running and get comfortable with its operation. Once you are fluent with operating the Smart Tether, read on to the Advanced Software Features section to learn about the further capabilities of the Smart Tether.

With a small bit of training and only minor modification to your operating and tether tending techniques, the Smart Tether is a powerful navigation and positioning tool which can add great value to your underwater missions.

While the Smart Tether is designed to be simple and require minimal training, there is some technique involved in using the system, and training from a certified instructor can be highly beneficial to new users. To schedule training, please contact KCF Technologies.

3. CARE AND HANDLING OF THE SMART TETHER

The Smart Tether is designed to stand up to your most demanding missions. Following a few simple guidelines while handling your Smart Tether will help ensure that it is not damaged.

Avoid chafing or scraping the tether against rough or sharp surfaces, avoid stepping on the tether or placing heavy objects on it, and avoid bending it in a very tight radius or putting kinks into the tether.

In addition to these common-sense guidelines, additional care should be paid to the Smart Tether sensor nodes.

- Do not subject the sensor nodes to high bending loads, for instance by letting them get pulled taut over the edge of a pier, rail, or boat deck

- Do not subject the nodes to heavy loads by stepping or placing heavy objects on them

- Do not insert small objects into the pressure sensor hole in the sensor nodes. If the hole becomes encrusted with sand or other material and the pressure reading becomes incorrect, soak the node in fresh water and gently swish it back and forth to free the foreign material

- Avoid coiling the tether smaller than a 16" diameter

When winding the Smart Tether into a VideoRay Tether Deployment System (TDS) or other small-diameter reel, the connectors and nodes should be laid parallel to the axis of the reel as they are put onto the reel. If they are wound around circumferentially like the rest of the tether, they may experience severe bending loads and become damaged, or contact the inside of the Pelican case and get jammed. (*Note: For the VideoRay PRO 3 Smart Tether, a specific 12-wire TDS is required*)

4. CONNECTIONS

1. VideoRay PRO 3 System

a. Arrange the ultra-mobile PC (UMPC) as shown below. There is a folding stand on the back of the UMPC which allows it to rest directly under the VideoRay Integrated Control Box (ICB) screen. The power supply can be connected to the outlet in the ICB storage well if it is not already occupied by another accessory, using the included power adapter cable.

b. Boot up the UMPC by sliding the power switch on the lower left side downward. Continue with other steps while it is booting. The Smart Tether program will automatically open. Note: the VideoRay ICB's power outlet is only powered when the ICB power switch is turned on.

c. Connect the male 8-pin connector whip from the Smart Tether Control Box to the female 8-pin connector whip from the ICB (remove the ICB whip from the plastic cable clamp if necessary).

⚠️ **Warning:**

NEVER connect a PRO 3 Smart Tether Control Box to a PRO 4 VideoRay ICB. The PRO 4's higher voltage can damage the PRO 3 Smart Tether Control Box. A special Upconverter module must be used to connect a PRO 3 Smart Tether to a PRO 4 VideoRay. Contact VideoRay or KCF to obtain an Upconverter module.

Failure to follow the above warning may result in damage to the VideoRay or Smart Tether.

d. Connect the Smart Tether male 12-pin connector to the female 12-pin connector on the Tether Control Box.

Tip:

- *The 12-pin connector requires a firm push to install. Push the connector as far as you can, then thread the locking collar as far as you can, and repeat until none of the threads on the bulkhead connector are visible. If threads are visible, the connector may not be fully engaged and you may experience connectivity problems.*

e. Connect the USB cable from the top USB port of the UMPC to the Smart Tether Control Box.

Smart Tether

Tip:

- *It can be useful to run the USB cable behind the strut on the left side of the ICB to keep it tidy*

f.   Pull the USB GPS receiver out of the ICB and place it near where the Smart Tether enters the water, using the USB extension cords if necessary. Connect the USB cable to the port on the right side of the UMPC (behind the flap door) if not already connected.

Tips:

- *The GPS receiver has a magnetic base*

- *Moving the GPS receiver several feet away from the ICB may improve satellite reception*

- *The Smart Tether will work without a GPS receiver. If a receiver is not used, the software will use the baseline coordinates entered in the GPS menu (see Section 10.4). When operating from a fixed launch point, to avoid GPS error or drift, use the "Lock GPS Position" option in the GPS menu*

g. Connect the VideoRay ROV 8-pin male connector whip to the Smart Tether 8-pin female connector.

h. Install the terminating Smart Tether sensor node into the clear float block cap by gently pulling the bottom edges of the cap apart and sliding the node in from the rear.

i. Attach the strain relief wire from the ROV to the Smart Tether strain relief.

j. Ensure all connectors are fully inserted and locking collars are secure.

k. Turn on the ICB power switch. LEDs on Smart Tether Control Box and Smart Tether Nodes illuminate to indicate the Smart Tether system is powered.

Tip:

- *If Smart Tether Control Box LED is not illuminated, turn off ICB power switch, check (disconnect and reconnect) all connections, and try again.*
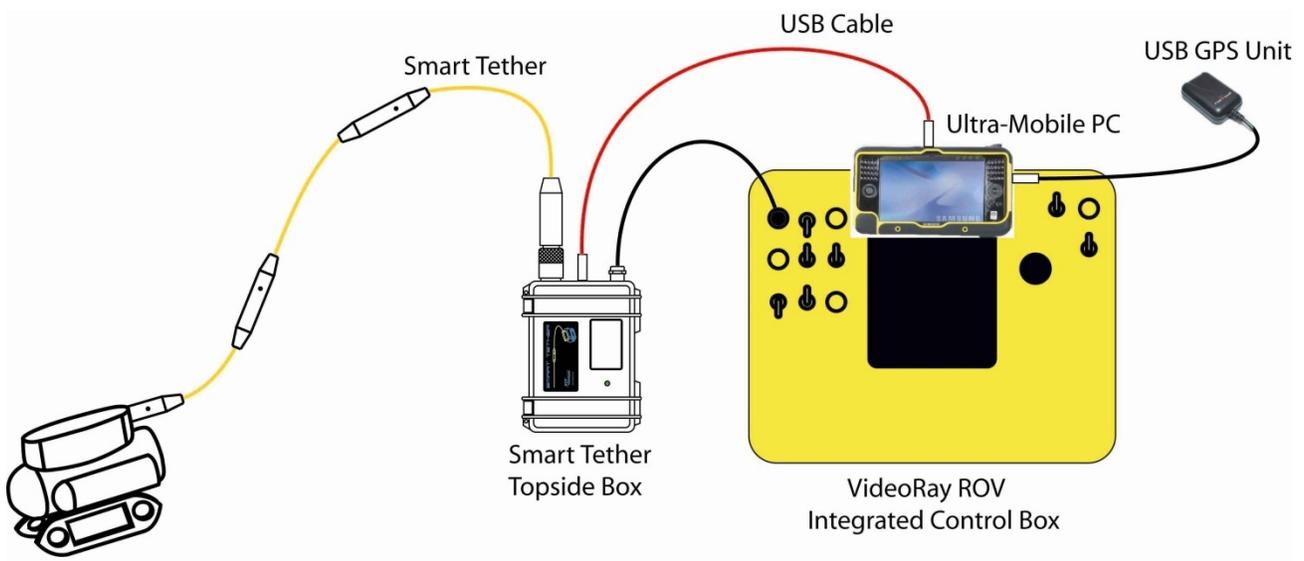

Warnings:

- **ALWAYS secure all connections BEFORE turning on ICB power switch**

- **ALWAYS turn off ICB power switch BEFORE loosening or disconnecting any connectors**

Failure to follow the above procedures may result in damage to the VideoRay or Smart Tether

Completed System Setup

2. VideoRay PRO 4 System

a. Simply connect the Smart Tether in place of your standard VideoRay tether between the Remotely Operated Vehicle (ROV) and Integrated Control box (ICB).

⚠️ **Warning:**

NEVER connect a PRO 3 Smart Tether Control Box to a PRO 4 VideoRay ICB. The PRO 4's higher voltage can damage the PRO 3 Smart Tether Control Box. A special Upconverter module must be used to connect a PRO 3 Smart Tether to a PRO 4 VideoRay. Contact VideoRay or KCF to obtain an Upconverter module.

Failure to follow the above warning may result in damage to the VideoRay or Smart Tether.

b. Pull the USB GPS receiver out of the ICB and place it near where the Smart Tether enters the water, using the USB extension cords if necessary. Connect the USB cable to a port on the computer or an accessory port in the ICB if not already connected.

💡 **Tips:**

- *The GPS receiver has a magnetic base*

- *Moving the GPS receiver several feet away from the ICB may improve satellite reception*

- *The Smart Tether will work without a GPS receiver. If a receiver is not used, the software will use the baseline coordinates entered in the GPS menu (see Section 10.4). When operating from a fixed launch point, to avoid GPS error or drift, use the "Lock GPS Position" option in the GPS menu*

c. Attach the strain relief wire from the ROV to the Smart Tether strain relief.

d. Ensure all connectors are fully inserted and locking collars are secure.

e. Turn on the ICB power switch. LEDs on the Smart Tether nodes illuminate to indicate the Smart Tether system is powered.
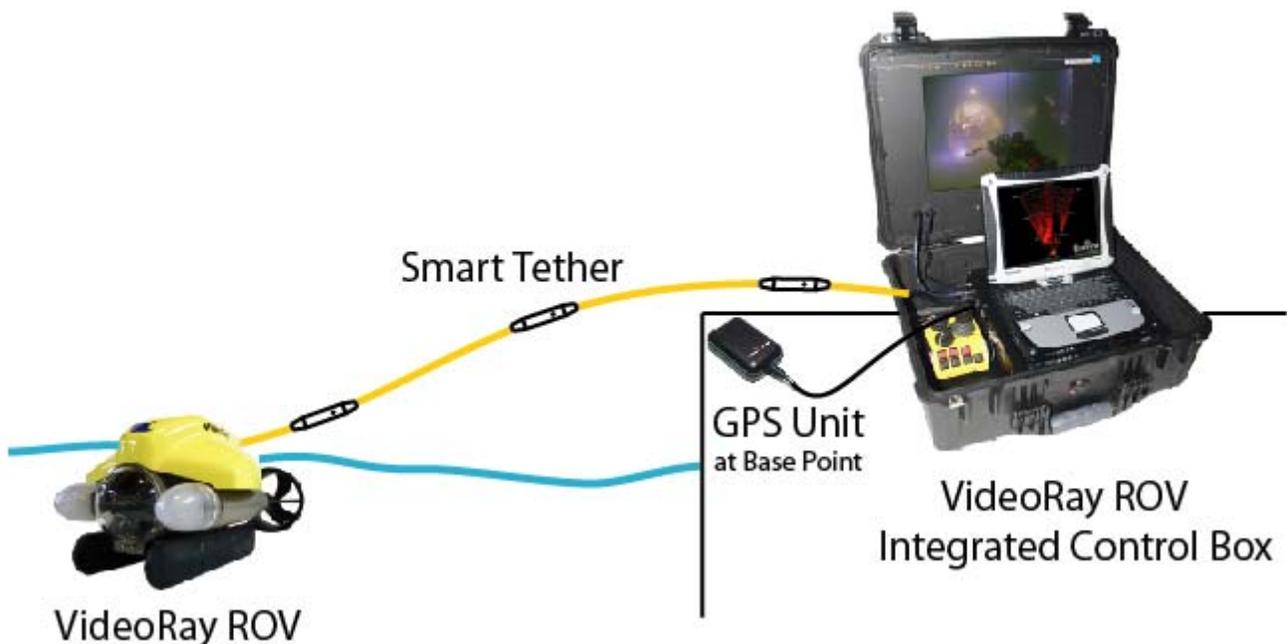

⚠️ **Warnings:**

- **ALWAYS secure all connections BEFORE turning on ICB power switch**

- **ALWAYS turn off ICB power switch BEFORE loosening or disconnecting any connectors**

Failure to follow the above procedures may result in damage to the VideoRay or Smart Tether

Completed System Setup

3. Smart Tether Basic System

The Smart Tether software may be used in Basic mode with a VideoRay PRO 4 system without having a Smart Tether. Connect the ROV as per VideoRay instructions, and connect the GPS antenna as shown if desired (see section 10.4). See Section 12 for special instruction on the use of Smart Tether Basic.

4. DiverNav System

a. Attach the terminating node of the Smart Tether to the diver's mask or to a hand-held camera or SONAR. The terminating node makes it possible to see which direction the diver or camera is facing so that topside crew can communicate directions to the diver more easily.

Tips:

- *If the terminating node is attached to the diver's mask, it is advisable to attach it pointing up at a 45-degree angle as shown below. This way, whether the diver is walking upright or swimming horizontally, the terminating node will be pointing the correct direction to give an accurate heading.*


Smart Tether Diver Heading Sensor
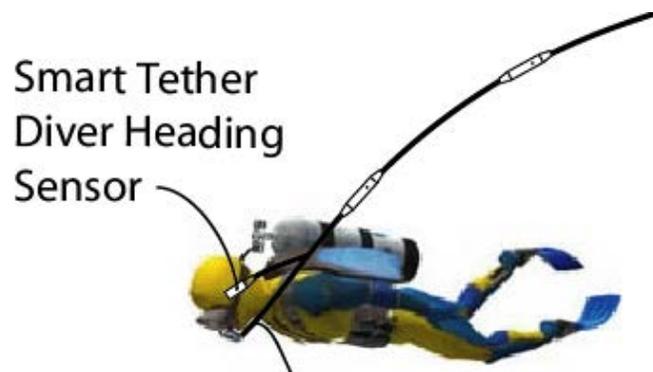
- *Additionally, the node should not be attached to a piece of ferrous metal, as this may disrupt the magnetometer reading and give an inaccurate heading measurement.*

b. Marry the DiverNav cable to the diver umbilical using tape or other convenient means.

c. Connect the DiverNav Control Box to a 120 VAC power source.

d. Connect the Smart Tether male 4-pin connector to the female 4-pin connector on the DiverNav Control Box.

e. Connect the USB cable from a USB port on the computer to the DiverNav Control Box.

f. Locate the GPS and place it near where the Smart Tether enters the water, using USB extension cords if necessary. Connect the USB cable to and available port on the computer.

 Tips:

- *The GPS receiver has a magnetic base*

- *The Smart Tether will work without a GPS receiver. If a receiver is not used, the software will use the baseline coordinates entered in the GPS menu (see Section 10.4). When operating from a fixed launch point, to avoid GPS error or drift, use the "Lock GPS Position" option in the GPS menu*

g. Boot the computer, select Smart Tether program from the Windows desktop.

h. Turn on the DiverNav Control Box power switch. LEDs on Divernav Control Box and Smart Tether nodes illuminate to indicate the Smart Tether system is powered.

Completed System Setup
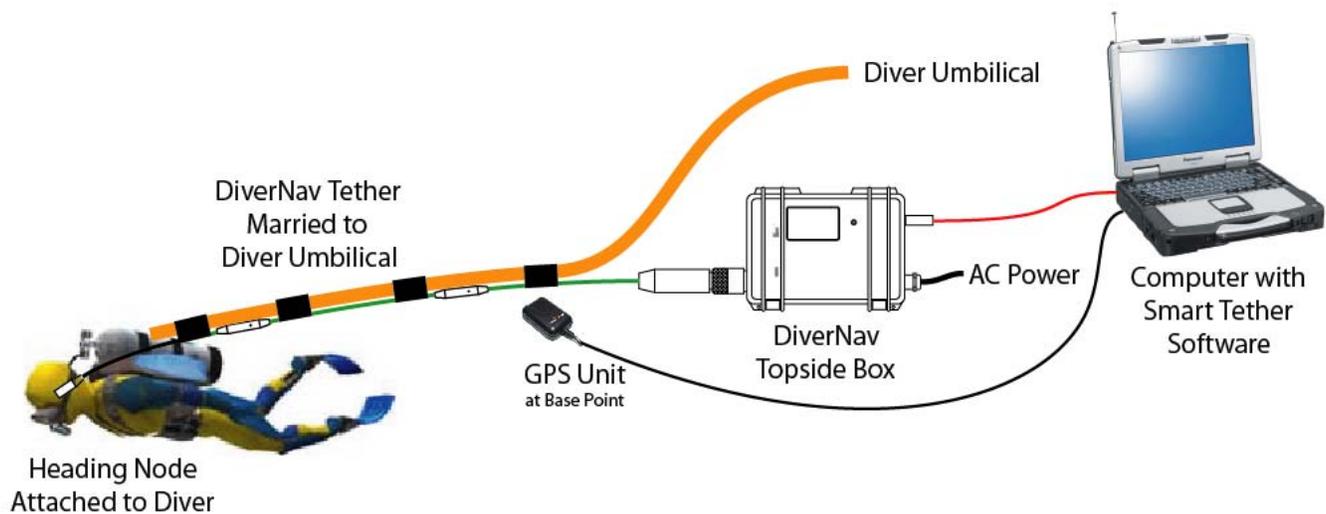
5. PRE-DIVE CHECKLIST

1. All systems powered on

2. Smart Tether sensor node LEDs lit

3. Smart Tether software opened and running (see section 4)

4. GPS fix acquired (if using GPS, see sections 4 and 10.4)

5. Pressure sensors zeroed (see section 9.5)

6. SHUTTING DOWN

When shutting down and packing up the system, the GPS receiver and cables can be stored inside the VideoRay ICB.

1. Press the "Stop" button in the Smart Tether Software

2. Close the Smart Tether software either by clicking the "X" button in the upper right corner or clicking "File → Exit". If you are ending your VideoRay Cockpit session, closing Cockpit will automatically close Smart Tether

3. Turn off the VideoRay and Smart Tether via the on/off switch on the ICB

Basic System Layout

The following image shows a top view of the general layout of the Smart Tether system. By measuring the shape of the tether, the Smart Tether calculates the position of the end of the tether relative to the Base Point which is specified by the user in global coordinates, thereby generating both relative and absolute coordinates of the end point of the tether. Any tether that is between the Operator Station (which can be arbitrarily located) and the Base Point is not used in the calculation, and is considered inactive. The tether between the Base Point and the end point is used, and is considered active. See section 7.3 and 10.5 for more information on how to tend the tether during use.
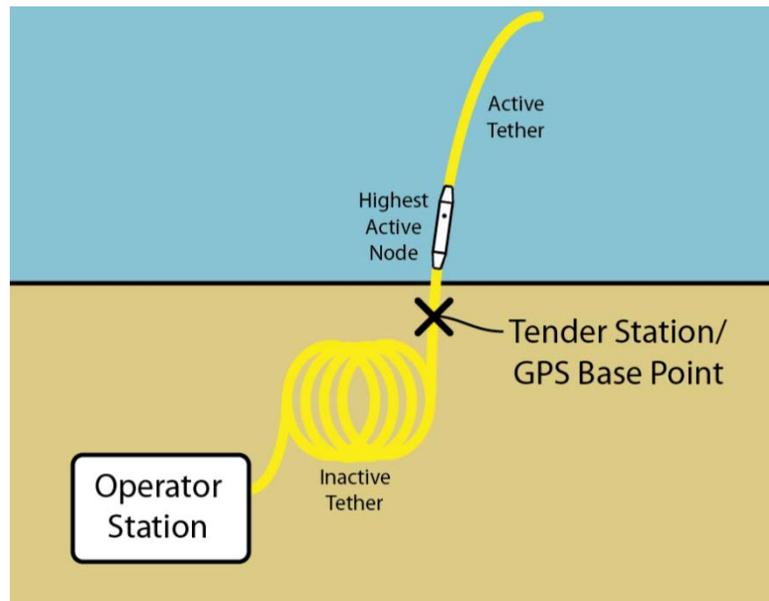

The Smart Tether software is designed to be simple from a user perspective. For basic operation, there are only a few buttons and features with which you need to be familiar. The user interface is designed for a touch-screen computer, so most of the features needed during normal operation are accessible by large buttons on the front panel of the software that can be pushed with the computer's stylus or your finger. This section details these basic functions and their operation. Sections 8 and 9 cover more advanced and specialized features of the Smart Tether software.

The main plot on the right side is the Navigation Window, showing the tether's shape and position. The black dot at the origin of the graph represents the Base Point the tether is deployed from (this can be either a fixed point or a moving boat). The yellow line represents the tether, and the subsequent black dots indicate the position of the sensor nodes. The current heading of the terminating node is indicated by the arrow on the end of the tether.

In the upper left corner of the screen is a side-view plot of the tether shape. This is a perpendicular projection of the overall orientation of the tether. This plot can be valuable in showing the depth of the various portions of the tether, and can help identify entanglements such as if the tether has been trapped underneath an obstacle.

In the lower left corner of the screen is a readout for the current position information. The end point's 3D coordinates are shown, as well as range and bearing from the Base Point.
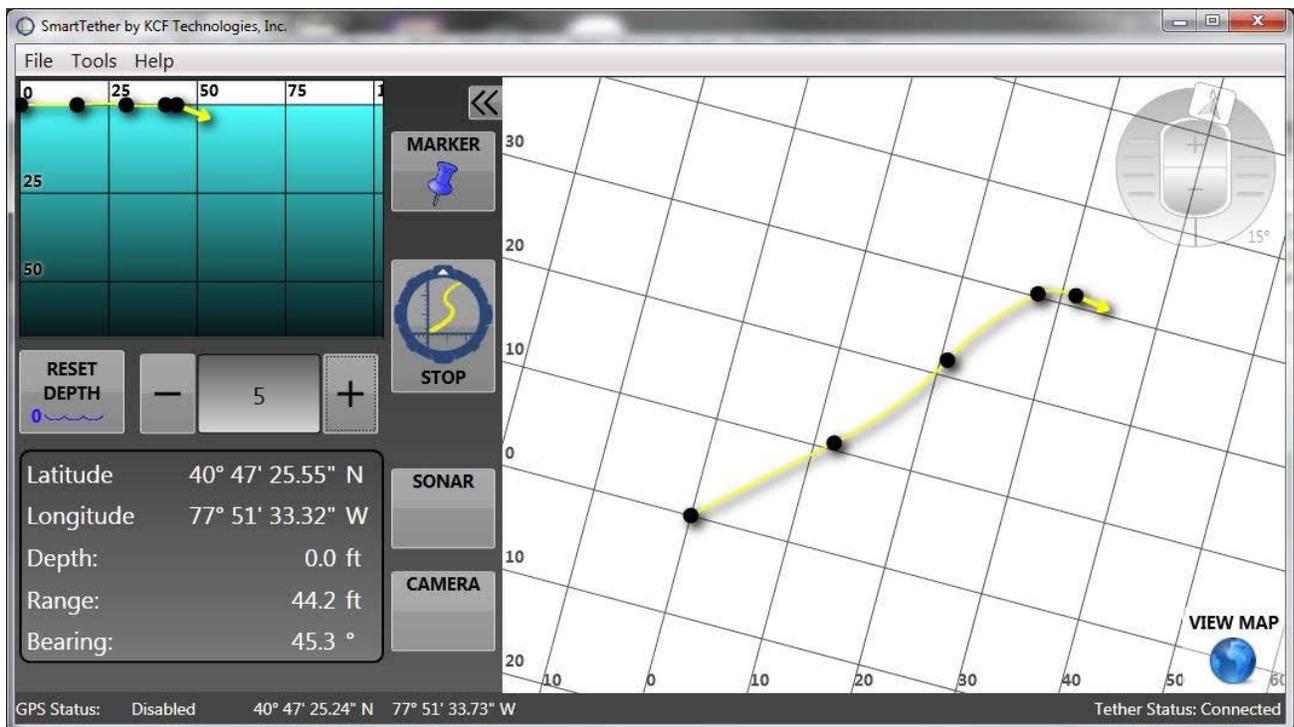
1. Open the Smart Tether software by clicking the Smart Tether icon from the Windows Start menu. When operated with a VideoRay PRO 4 system, the software may be launched from the VideoRay Cockpit launch bar.

2. To begin navigating, press the "Operate" button (always make sure the Smart Tether and ROV are turned on for 5 seconds before Operating to allow the sensors to boot up).

3. As the Smart Tether is tended and nodes enter or exit the water, adjust the software accordingly by pressing the gray "+" and "-" buttons to maintain the correct number of nodes in the water (see Section 10.5 and 11.2).

Tips:

- *The Smart Tether sensor nodes are marked with bands indicating their number, i.e. the number of nodes in the water, to help with this operation. Each narrow band (|) represents 1, each wide band (█) represents 5. For example if the last node to enter the water is marked █ |, it indicates that 6 (5+1) nodes are being used.*

- *Using extra tether: If the 6th and final node is in the water but more tether is still needed, you can increment the Smart Tether software in 5-foot (1-meter) increments as you add more tether. For this reason, it is advisable for the customer to mark the Smart Tether and any extension tethers in whatever way is most convenient for your application. Keep in mind there are 30 feet of tether past node 6 on the standard Smart Tether.*

- *Using the minimum amount of tether necessary to complete your mission helps to maximize the accuracy of the Smart Tether. Accuracy will be negatively affected by having large amounts of slack, unnecessary tether in the water. A person tending the tether and informing the operator of how many sensor nodes are in the water is most helpful.*

- *See section 11 for more details on piloting and tether tending techniques to maximize the accuracy of the Smart Tether.*

4. To end the operation, press the "Stop" button.

8. GOOGLE EARTH

The Smart Tether can display your scan history and markers in Google Earth, giving you a simple way to geo-reference your location relative to real landmarks.

1. Any time you would like to view your markers and scan history in Google Earth, click the "View Map" button in the bottom right corner of the Smart Tether top view plot.

2. Google Earth will automatically launch if it is not already open, and auto-zoom to your location for easy viewing of a snapshot of your current scan progress.

KCF Technologies, Inc. | 814.867.4097

www.smarttether.com | sales@kcftech.com
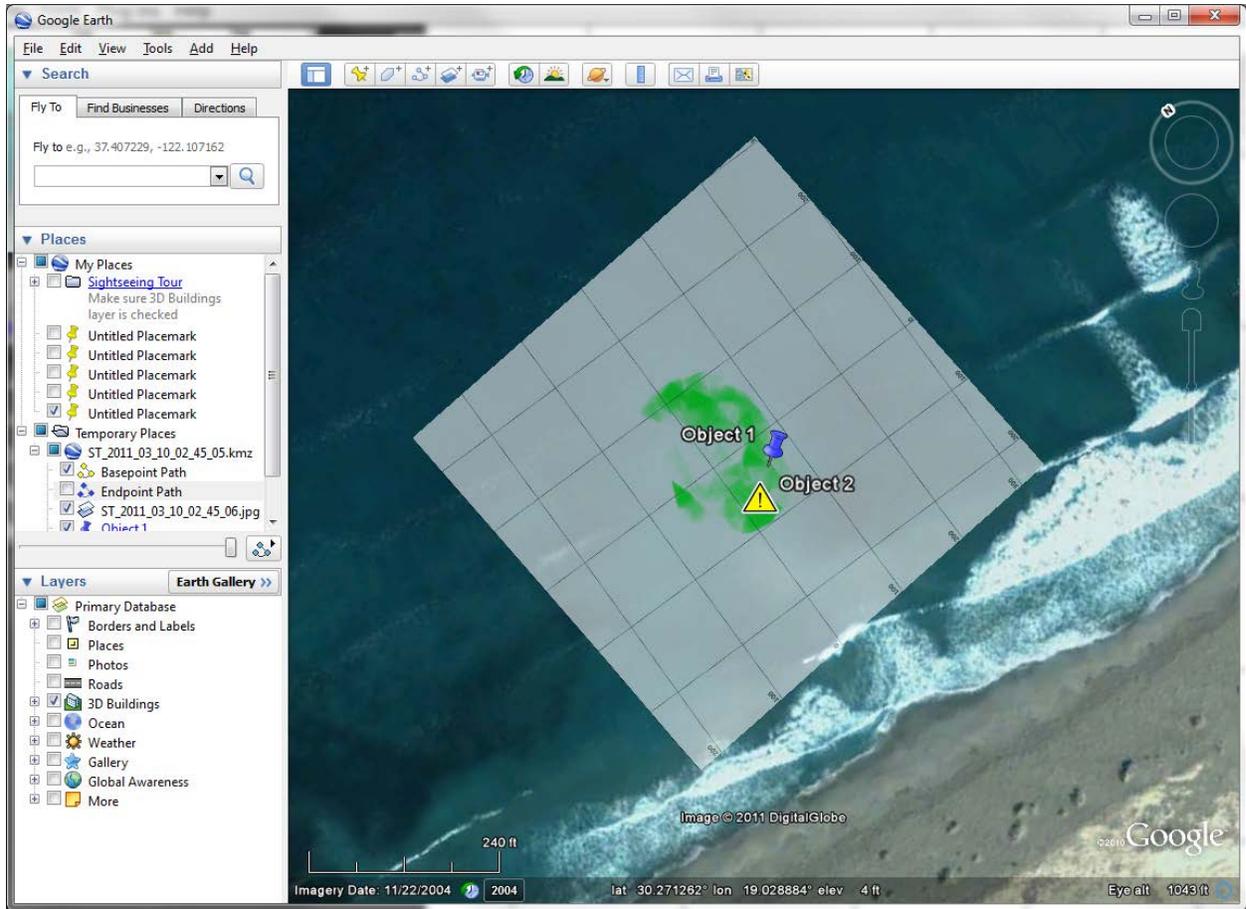
Smart Tether

Tips:

- *The Smart Tether Google Earth export makes compact KMZ-format files which can easily be emailed or used as a concise summary of your mission. These files are saved in the folder "KCF Technologies\Smart Tether\KMZ Files" in the "Documents" folder ("My Documents" in Windows XP).*

- *A KMZ file is created whenever either the "View Map" or "Stop" button is pressed, ensuring you have easy access to the results of each operation.*

- *Scan history snapshots exported from Smart Tether become "Temporary Places" in Google Earth and can be viewed and manipulated in the tree on the left side of Google Earth just like any other Google Earth object. You may hide or show individual items by checking or unchecking the item in the tree.*

- *The Smart Tether Google Earth feature will work without an internet connection, but new satellite imagery cannot be downloaded without an internet connection. Previously-viewed satellite images are retained in Google Earth's image cache until the cache fills. Thus, it is advisable to log on to the internet and view the target area at maximum zoom-in in Google Earth before the operation so that accurate satellite imagery will be available in the field during the operation.*

9. ADVANCED SOFTWARE FEATURES

1. Scan Tools

The Smart Tether software can show a representation of the area scanned by various imaging hardware you may be using underwater, such as a camera or SONAR held by a diver or mounted to an ROV. The scan tools buttons toggle between showing only the tether, showing the current Camera or SONAR field of view, or showing the Camera or SONAR scan history. A mode is selected by pressing either the Camera or SONAR button multiple times to toggle through each option.
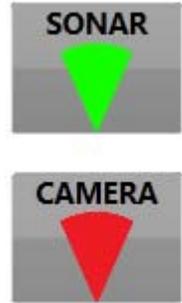
a. Field of View

A single cone shape indicates field of view mode. In field of view mode, the Smart Tether software will show you the current field of view.

b. Scan History:

Multiple cone shapes indicate scan history mode. In scan history mode, the Smart Tether software will show you all the area that has been covered by either device during the current scan. This can be helpful in ensuring you have covered an entire scan area. The scan history colored area gets darker the longer you remain in an area, so an area that is lightly colored may have only been briefly scanned, while a darkly-colored area indicates a more thorough inspection. The scan history will be cleared whenever the tether operation is stopped and restarted.

2. **Markers**

Adding markers or waypoints to the screen can be very helpful in navigating or reacquiring a target. At any time, simply press the "Add Marker" button near the top of the screen. A new window will pop up allowing you to enter marker data. To mark the current location, simply select the marker type you prefer, enter a title for the marker and click "OK"; the current location is already pre-loaded in the latitude and longitude fields. To mark a different location, e.g. a known GPS point you'd like to navigate to, enter the title, replace the pre-loaded coordinates with your desired location, and click "OK", and the marker will be placed at the location you enter. If you enter invalid coordinates the field will turn red to indicate you need to make a correction before clicking "OK".

Tips:

- *You may edit or delete an existing marker by clicking on the marker while it is visible in the Navigation Window*

- *Push-pin style markers indicate the marked location with the tip of the push-pin. Other marker icons are centered over the marked location*

3. Zoom and Rotate

Use the control in the upper right corner of the Navigation Window to zoom and rotate the map. Press the plus button to zoom in and the minus button to zoom out. Press on the right side of the button to rotate the image clockwise and the left side to rotate the image counter-clockwise. The current map rotation angle is displayed in the lower right.
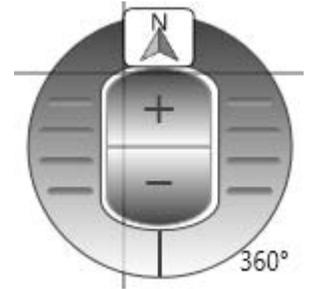
Tips:

- *Press and release quickly for small zoom/rotate changes or hold the buttons down for a continuous zoom/rotate*

- *When zooming with scan history enabled, it may become necessary for the Smart Tether software to redraw the scan history in order to display it clearly. There may be a slight flicker as the history is redrawn*

4. Panning

By default, the Base Point of the Smart Tether is centered in the middle of the Navigation Window. The Base Point can be moved, if desired, by clicking on the Navigation Window and dragging the Base Point to the new desired location. The Smart Tether software will not allow the Base Point to leave the window to ensure that the tether is always visible.

5. Depth Reset

Over time, the pressure sensors may get slightly out of calibration. If this happens, remove the entire Smart Tether from the water and press the "Reset Depth" button, and click "Yes" to confirm the Smart Tether is out of the water (at atmospheric pressure). As a pre-dive check, it is a good idea to Reset Depth before putting the Smart Tether in the water to ensure all sensors are zeroed (this calibration is *not* performed automatically at startup, so that if power is interrupted while the tether is at depth, the calibration is not lost).

6. Data Output

Smart Tether position data can be exported to different hardware or software via serial connection, either through a physical port or through third-party virtual port software. Data is exported as a NMEA GPGGA string. This data can be useful for incorporating Smart Tether data into other mapping or mission management software, or for overlay in other software, such as SONAR or video displays. See Section 10.7 for instructions on how to configure the output. To set up a

connection between separate software applications on the same computer, use a third-party virtual COM port software to set up virtual ports and then select one of those ports in the pull-down menu.

7. Data Storage

Any time the Smart Tether software is operating, all available data is being stored to the hard drive. All raw data is stored by default in the folder "KCF Technologies\Smart Tether\Data Files" in the "Documents" folder ("My Documents" in Windows XP). This data is stored in .csv format and contains, among other data, GPS location of the Base Point and end point in a NMEA standard GPGGA format. The first line within these data files contains a header that explains the meaning of each field.

10. TOOLS MENU

A number of useful, but less critical features are available via the tools menu.

1. Base Maps

This feature allows a nautical chart or other image to be placed in the background of the Smart Tether Navigation Window, making it possible to continually geo-reference the Smart Tether's position and tether shape data in real time.
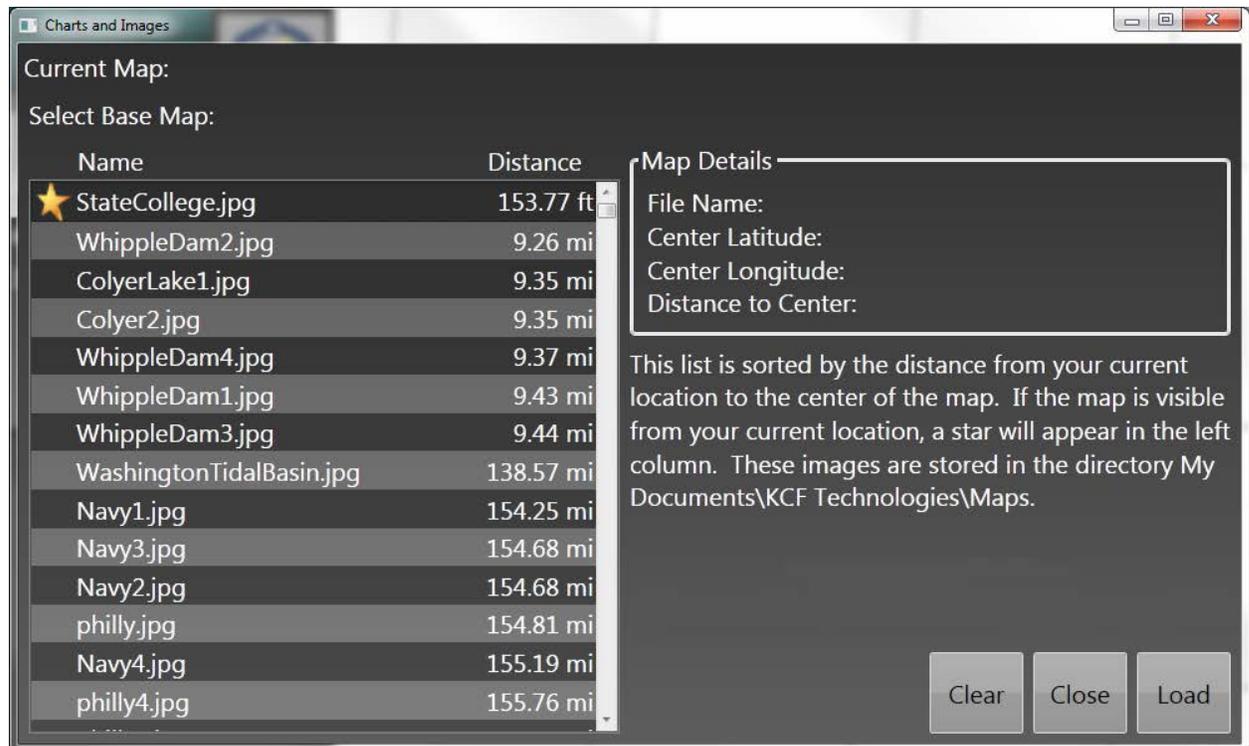
Smart Tether software will scan the folder "KCF Technologies\Maps" in the "Documents" folder ("My Documents" in Windows XP) for raster based imagery. While scanning, a progress bar will be visible in the lower right-hand corner of the screen. Once scanning completes, any valid charts or images found will be displayed in the left side of the window order by distance from current location. If a map is visible from the current operating location, it will be marked with a star as shown above.

a. Loading a base map

- Select the file name from the list by clicking on the desired map

- Click on the Load button

- The image will load within the Navigation Window

b. Clearing the base map

- To clear the base map from the Navigation Window, press the Clear button from within the Base Maps window.

Tips:

- *Make sure the selected map has a star by its name. If there is no star, verify that the GPS has a fix or the correct Base point is entered into the Smart Tether software (See Section 10.4)*

- *If a map doesn't show up in the list as expected, verify that it is properly located within the folder KCF Technologies\Maps in the "Documents" folder ("My Documents" in Windows XP). If it is in the correct location, it may be in a format incompatible with the Smart Tether software*

Smart Tether software can read most raster based charts and images. These are normal images that have been geo-referenced and contain information regarding their geographic location. Depending on the image format, sometimes the geographic information is contained within the image file itself, or sometimes additional, companion files will be required.

Raster based charts may be obtained or created from several sources. In the United States raster-based navigational charts are freely available for all navigable waters. These may be downloaded, free of charge from the NOAA website at: http://www.charts.noaa.gov/RNCs/RNCs.shtml. These charts may be downloaded for individual regions, states, or the entire country.

Raster based satellite imagery may also be purchased from commercial vendors. There are several reputable vendors which can be found on the internet.

Raster based images may also be obtained from Google Earth using free third party software like Shape2Earth, a plug-in for the open source GIS software MapWindow. (http://shape2earth.com/default.aspx) These tools allow you to export images from Google Earth and save them in a geo-referenced, raster based format. Please make sure to check with Google Earth's terms of use as their satellite imagery may not be free to use for all purposes.

2. Markers

a. Save Markers

Markers may be saved at any time during an operation. You will be prompted for a location to save the markers too. They will be saved to a standard KMZ file format and may be opened in Google Earth for viewing. Markers will also be automatically be saved to a KMZ file when the Stop button is pressed to end the operation. These automatically generated files are stored in

Smart Tether

KCF Technologies\Smart Tether\KMZ Files in the "Documents" folder ("My Documents" in Windows XP).

b. Recall Markers

Use this function to recall markers from previously-saved files. This can be very useful in resuming a scan from an earlier operation, or if you operate in the same area frequently and have various features marked to establish a reference frame for the region. You will be prompted to select the file to recall.

c. Clear Markers

This will delete all the markers from the Navigation Window.

3. Units

Change the on-screen display of the latitude and longitude coordinates and measurement units to suit your preference.
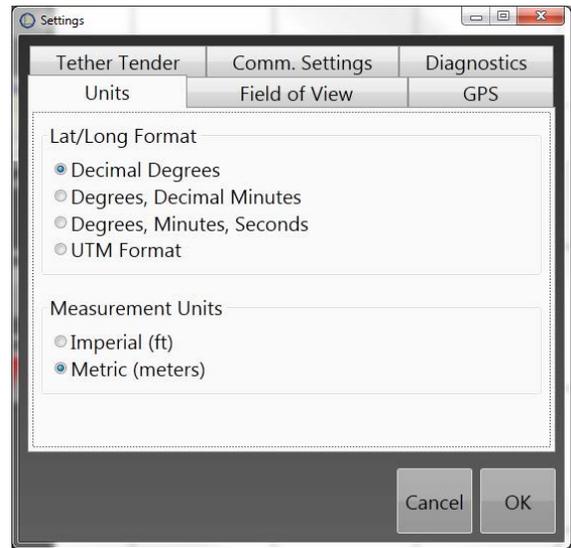
4. GPS

To enable GPS functionality, check the "Enable GPS" checkbox. Smart Tether will then display a list of available GPS devices as well as an "Auto" option. Selecting "Auto" will cause the software to automatically connect to the first GPS device that it detects. If multiple GPS devices are present on the system, select the desired device from the list. Alternately, if no GPS is present, uncheck the "Enable GPS" box and enter your current location in the Basepoint Coordinates box that will appear.
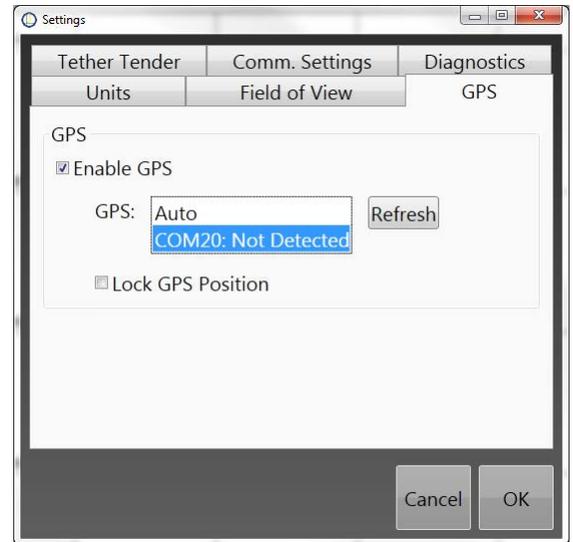
Tips:

- *Checking the "Lock GPS Position" checkbox will cause the software to monitor the GPS reading for 30 seconds, determine the average location based on the last 30 seconds and lock the Base Point to the calculated position. This can be very useful when operating from a fixed location as it will prevent normal GPS drift from affecting operation. When operating from a moving vessel, leave the GPS position unlocked.*

- *If no GPS is used, it is important that the "Enable GPS" box is unchecked and a reasonable location is entered into the Basepoint Coordinates. Try to make sure that, at most, the Baseline Coordinates are no more than 100 miles (160 kilometers) from the operating location. Smart Tether software automatically compensates for variations in the earth's magnetic field by using the location from either the GPS or the Baseline Coordinates. If no GPS is used and the Baseline Coordinates are significantly wrong, position accuracy may suffer.*

5. Tether Tending

Select the tether tending mode. This is the method by which the Smart Tether software tracks the amount of tether that has been deployed. See Section 11.2 for more information on the different options.
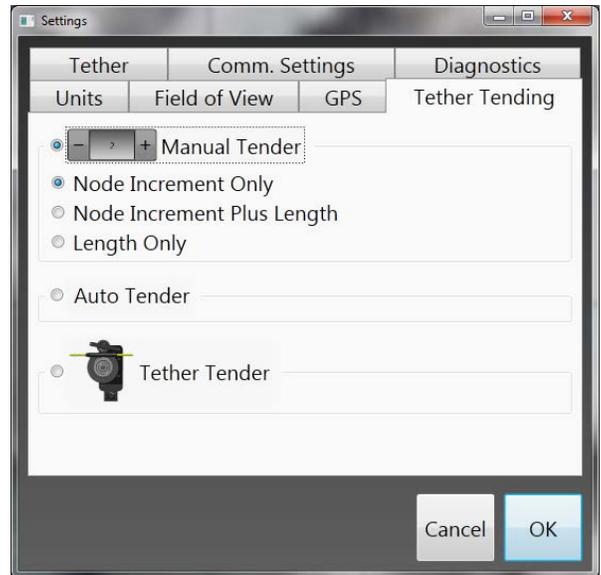
6. Tether Configuration

Select the type of tether that will be used. Only choose Custom if you have a custom tether and have received a custom tether configuration file for your tether.

For DiverNav systems, up to three individual tethers may be connected in series. Each tether is marked with a specific color. Select the color of each tether segment from the drop down lists, making sure that they are shown in the correct order between the diver and computer. When less than three tether segments are used, select "None" from the corresponding list. The example at right shows a system with a single green tether.

At the bottom of the screen are advanced settings which shouldn't normally be changed.

KCF Technologies, Inc. | 814.867.4097

www.smarttether.com | sales@kcftech.com
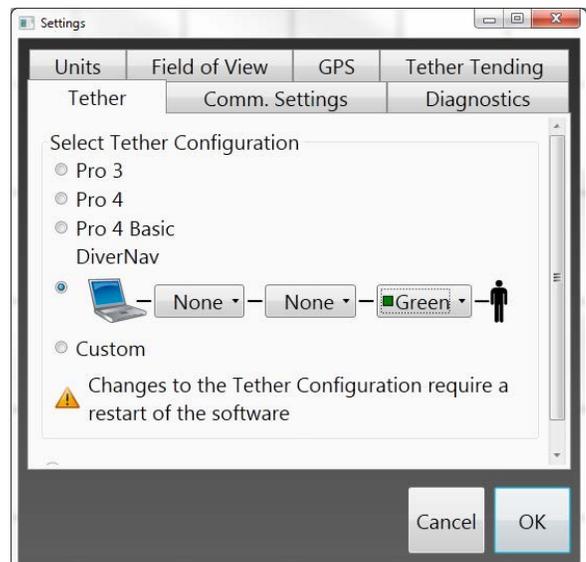
7. Communication Settings

Communication settings are adjusted on this screen. For VideoRay PRO 3 or DiverNav systems, the correct port will be indicated with an *. For a VideoRay PRO 4 system, the Smart Tether port should always be set to COM16. If "Enable Real-time Output" is checked, Smart Tether will output the current ROV position to the serial port that is selected from the list. This output will be in standard NMEA format and will appear as a standard GPS device.
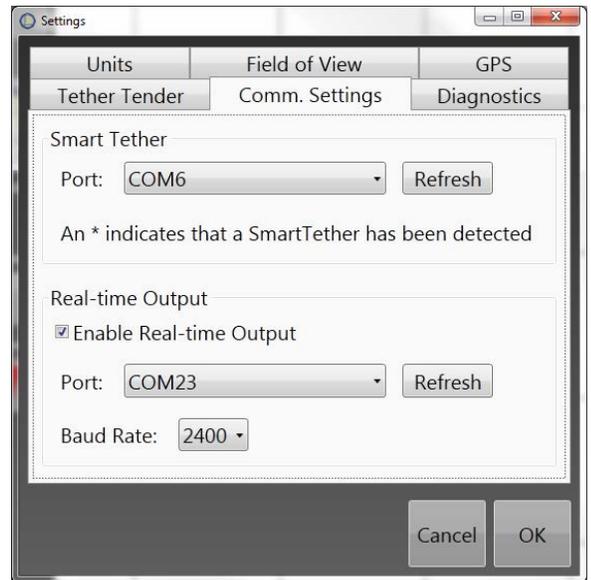
8. Field of View

Change the angle and distance of the Camera and SONAR unit's field of view. Use this feature to adjust the size of the view cone to accurately represent the equipment you are using, so that you get a realistic representation of the area covered during a scan.
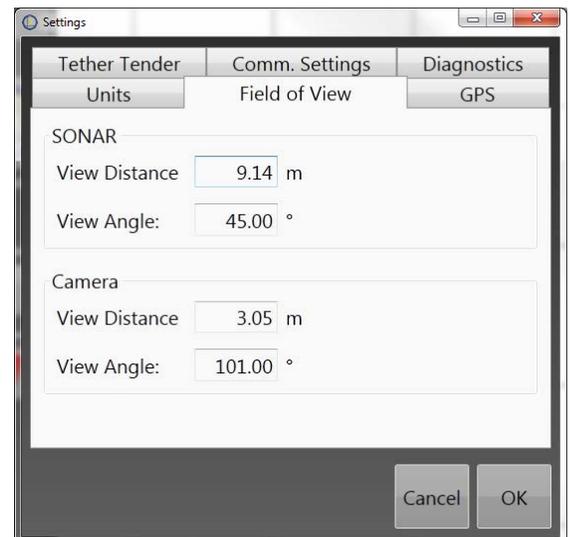
9. Diagnostics

This menu is primarily used to diagnose and troubleshoot issues with the physical Smart Tether hardware and should not be required under normal operating conditions.

11.   PILOTING AND TENDING TECHNIQUES

1. Proper Techniques

The Smart Tether changes your underwater tether from being simply a necessary umbilical into being a valuable measurement tool. As with any tool, good technique is required to obtain the best possible results. The following are some basic tips on how to perform your underwater operations in order to improve the accuracy of the Smart Tether position calculation. By being mindful of the general layout of your tether, not only will you increase the accuracy of the Smart Tether, you will also help avoid time-consuming tether entanglements.

The Smart Tether software uses an intelligent curve-fitting algorithm to determine the tether shape based on the discrete orientation data collected from the sensor nodes. In order to maintain reasonable accuracy in a wide variety of tether configurations, the algorithm takes into account certain assumptions about how the tether should be handled. When these assumptions are violated by driving the tether in an unusual configuration, the position accuracy of the Smart Tether suffers.

In general, using the minimum amount of tether necessary to complete your mission helps to maximize the accuracy of the Smart Tether. Accuracy is also helped by keeping the Smart Tether in a straight line or large, sweeping curves. Accuracy will be negatively affected by having large amounts of slack, unnecessary tether in the water or having a lot of tight zig-zags or coils in the tether. A person tending the tether and informing the operator of how many tether nodes are in the water is most helpful.
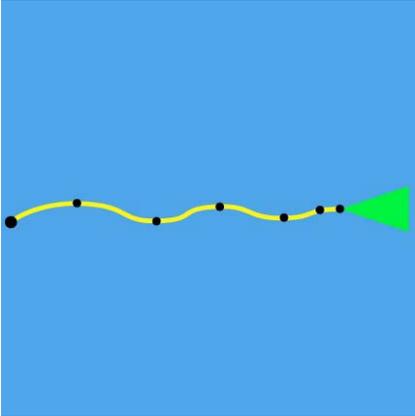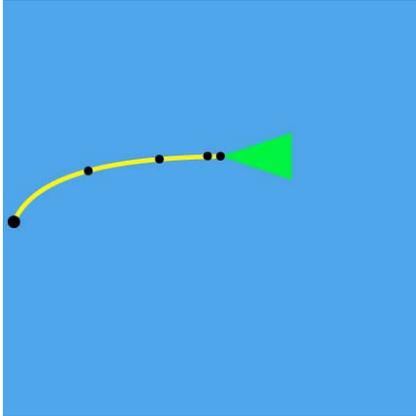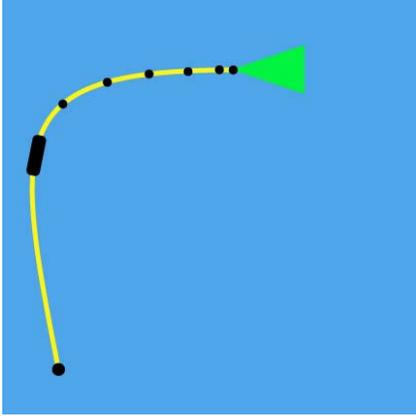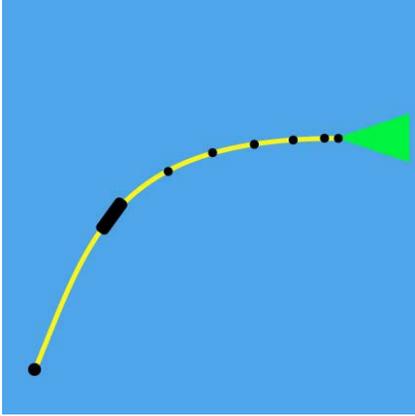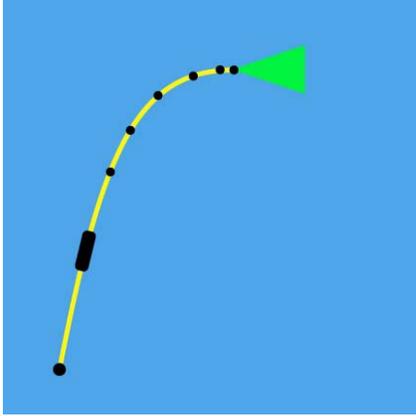
Also, the diver, ROV pilot, and/or tether tender should avoid allowing a lot of curvature in the tether between the launch point and the first Smart Tether node in the water. The first node should basically point directly away from the launch point. Similarly, when using the Smart Tether Extension, the extension should go roughly in a straight line away from the launch point toward the area of operation. It should not go off a long distance in another direction and then double back.

The following table illustrates some example situations that would reduce the Smart Tether's accuracy, and provides improved alternative techniques.

Tips:

- *These techniques apply to the full Smart Tether system. For Smart Tether Basic see Section 12*

| BAD OPERATION	BAD SOFTWARE RESULT	GOOD OPERATION
X	Smart Tether software assumes more gentle curves and plots end point too far away. This is exaggerated if nodes happen to be generally aligned, as illustrated	✓
Tether has several zig-zags and tight curves		Use less tether (fewer sensor nodes) and operate in a more gentle curve
X	Smart Tether software assumes smooth curve from first Smart Tether node to launch point	✓
Smart Tether Extension not extended in general direction of first Smart Tether node		Use less tether and keep Smart Tether Extension in line with beginning of Smart Tether

Smart Tether

✗
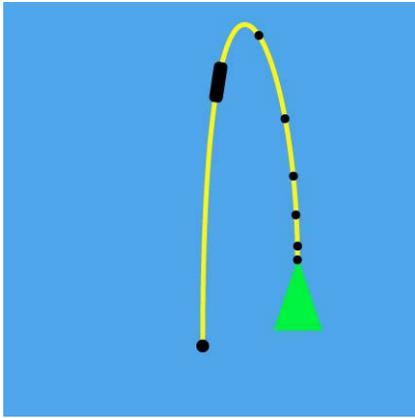
Smart Tether Extension stretched out in one direction, Smart Tether doubled back, e.g. for a pier inspection
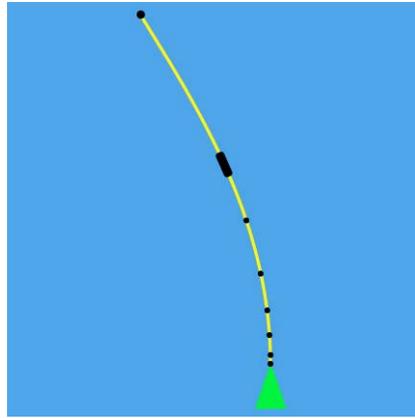
Smart Tether software assumes smooth curve from first Smart Tether node to launch point and causes a large position error


✓

Use less tether (fewer sensor nodes) and operate in a more gentle curve

✗
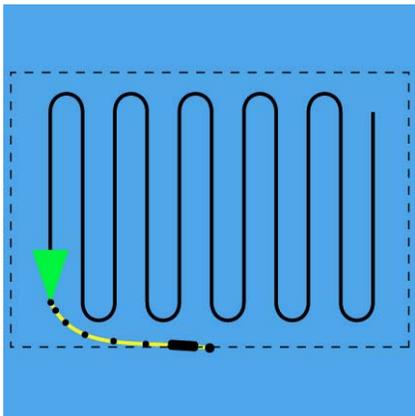
Rectangular scan pattern from fixed point

A large rectangular pattern will require constant tether tending to avoid the "doubling back" situation shown above, and will result in poor accuracy and low confidence that the area has been completely covered.

Using an arc pattern instead means the tether only needs to be tended occasionally, and the tether can be kept virtually straight, giving excellent accuracy. An arc pattern also allows more area to be covered with the same tether length.

✓
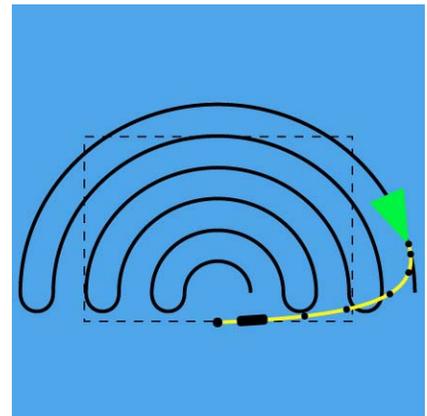
Arc scan pattern from fixed point

2. Tether Tending Modes

The Smart Tether software must correctly track the length of tether that is in the water in order to make accurate measurements. This can be accomplished by either manually indicating to the software the length of tether that is in the water or by using an automatic counter like the Tether Tender.

a. Manual Tender

Manual tether tending can be done using one of the following three options:

- Node Increment Only

  In Node Increment Only mode, the software tracks the number of nodes in the water. Each time a node on the tether is deployed or retrieved, the "+" or "-" button must be pressed to indicate the number of nodes in the water.

- Node Increment Plus Length

  In Node Increment Plus Length, the software tracks both the number of nodes plus the length of tether beyond the highest active node. When a node is deployed or retrieved, use the upper "+" and "-" buttons to indicate the number of nodes in the water. Additionally, when more or less tether is deployed beyond the node, use the lower "+" and "-" buttons to indicate the length of additional tether that is in the water. This method will generally be the most accurate of the Manual Tender modes.

- Length Only

  In Length Only mode, the software tracks the length of tether in the water. Whenever tether is deployed or retrieved, the "+" or "-" button must be pressed to maintain the corresponding length of tether that is in the water. Depending on the units of measure, each press of the button increments the deployed length by 5 feet or 1 meter.

b. Auto Tender

In Auto Tender mode, Smart Tether attempts to determine which nodes are in the water by monitoring the pressure reported at each node.

In the Auto Tender setup, there are two values which can be adjusted. The "Deployed Depth" value determines the depth at which Smart Tether determines that the node is now deployed in the water. The "Retracted Depth" value determines the depth at which Smart Tether determines that a deployed node has been retracted from the water.
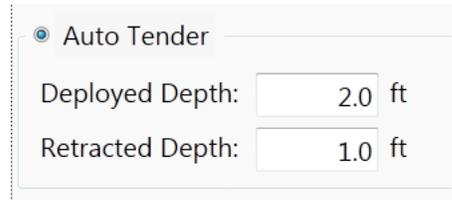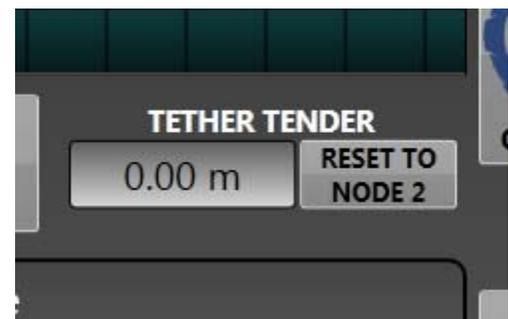
Tips:

- *Be sure that the Deployed depth is greater than the Retracted depth*

- *Smart Tether nodes can sense variations in depth of roughly 6" (0.15m). Make sure that there is at least 6" (0.15m) between the deployed and retracted values*

- *Typical values will be a deployed depth of 2' (0.6m) and a retracted depth of 1' (0.3m)*

c. Tether Tender

The Tether Tender is a counter that automatically tracks the length of tether that is deployed into the water. This is more accurate than the Manual Tender options and relieves the operator from having to constantly monitor tether length.

Use the following steps to use the Tether Tender:

- Connect a USB cable between the Tether Tender and the computer

- Select Tether Tender from the Tether Tending menu (See Section 10.5) and press OK

- From the main window, the tether tending area should show "Tether Tender" with a length of 0

- Place the second node on the wheel of the tether tender and press the button "Reset To Node 2". This will reset the length to reflect the length of tether between the 2nd node and the end point

- Run the tether through the Tether Tender and see that the length changes in the window

Tips:

- *If it is more convenient to reset the length to a node other than node 2, go to the Tools > Tether Tending menu and select the desired node from the list under the Tether Tender section. This can be useful if a reset needs to be done during an operation with the tether already deployed. (See Section 10.5)*

- *On PRO 3 and PRO 4 systems, node 2 is the first node after the ROV*

12. SMART TETHER BASIC

Smart Tether Basic is an introductory mapping and location marking tool that can be used to supplement a PRO 4 ROV without the use of the Smart Tether hardware. Smart Tether Basic uses the standard Smart Tether orientation board installed in the VideoRay Pro4 ROV, the ROV's depth sensor, and the extended tether length to approximate the location of the ROV by drawing a straight line from the base point to the ROV.

This method of approximation has significant limitations for accurate positioning purposes, but if the limitations are understood and the ROV is correctly operated, it can be very useful for mapping and marking approximate locations. Smart Tether Basic is also ideal for accurately tracking the base location, maintaining a geo-referenced situational awareness during an operation, and documenting results.
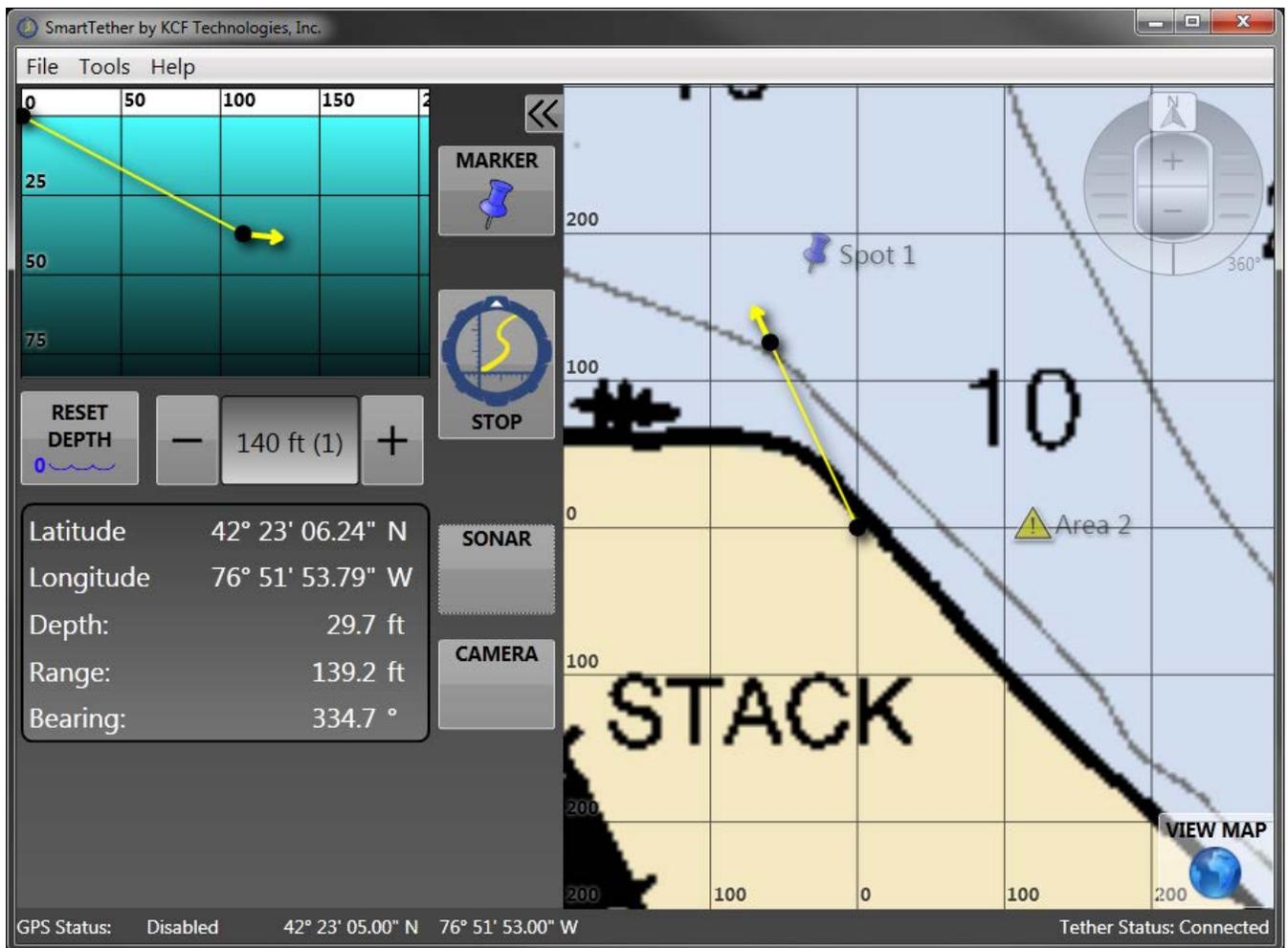
Smart Tether

Tips:

- *Without the complete Smart Tether hardware, Smart Tether Basic provides only a rough estimate of the ROV location. This estimate can be affected by many factors (tether tension, wave action, etc.) that Smart Tether Basic will not be able to compensate for.*

- *For accurate positioning, consider purchasing the complete Smart Tether hardware and upgrading to the full Smart Tether software. A full Smart Tether system, complete with Smart Tether hardware can provide positioning accuracy of +/- 2% of the tether length.*

The Smart Tether Basic software comes with all the features of the standard Smart Tether system. This includes markers, background maps, kmz outputs, etc.
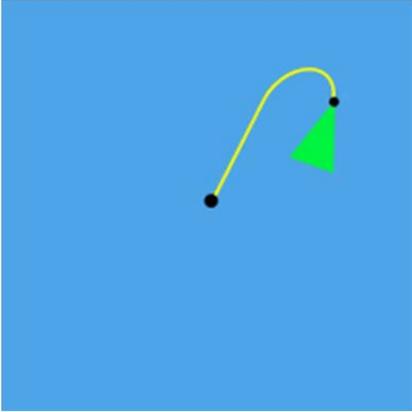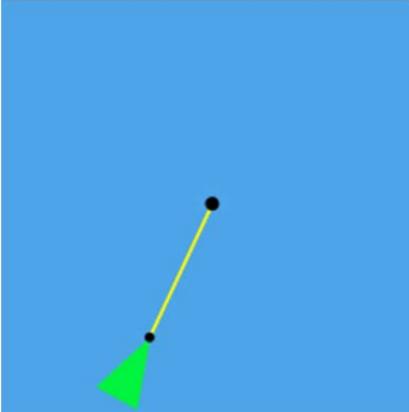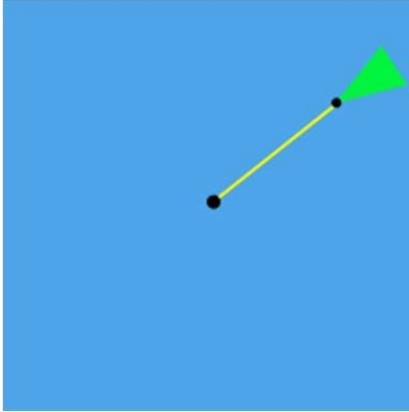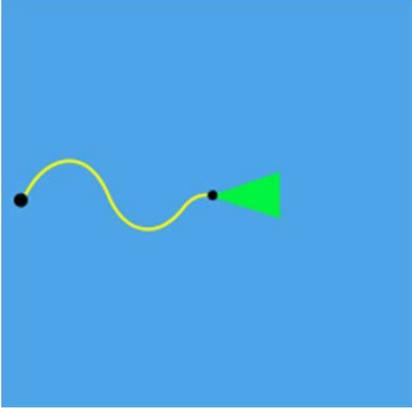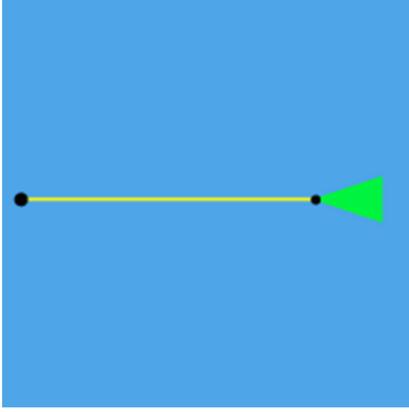
The only limitations to the Smart Tether Basic software are the following:

a. The only option in the Tether Configuration window is Pro 4 Basic. (see Section 10.6)

b. Tether tending options are limited to Length Only or using the Tether Tender. (see Section 10.5)

Due to the limitation of only using the orientation sensor in the ROV, Smart Tether Basic makes certain assumptions when estimating ROV location. The two key assumptions are:

a. There are no curves or bends in the tether. The software assumes the tether is in a straight line from the base point to the ROV.

b. The ROV is oriented away from the base point.

To achieve the most reliable estimates of location when using Smart Tether Basic, it is important to reduce or eliminate slack in the tether and point the ROV away from the base point. Use the illustrations below as a guide.

BAD OPERATION	BAD SOFTWARE RESULT	GOOD OPERATION
✗ ROV is not oriented away from the base point	Smart Tether Basic assumes the tether is straight. ROV will be incorrectly located.	✓ Keep the tether straight and the ROV oriented away from the base point for more accurate location estimates
✗ Too much slack in the tether	Smart Tether Basic assumes that there are no curves in the tether. The ROV is incorrectly located further from the base point than it actually is.	✓ Keep the tether straight and the ROV oriented away from the base point for more accurate location estimates
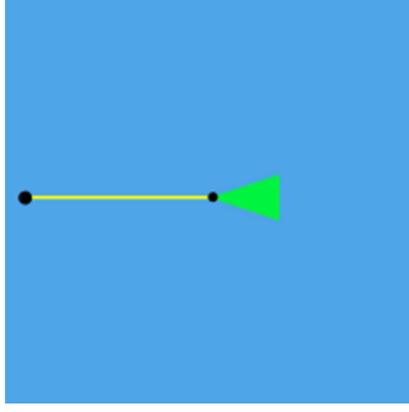
Smart Tether

1. Extension tethers

The PRO 4 Smart Tether utilizes similar construction to VideoRay's PPT tether, so VideoRay tethers can be used as extensions between the Smart Tether and the VideoRay ICB. It is not recommended to use a VideoRay PPT tether as an extension for the Smart Tether, as the thin wire diameter may result in reduced voltage and poor ROV performance.

2. Using a PRO 3 Smart Tether with a PRO 4 VideoRay

If you previously purchased a PRO 3 Smart Tether and are upgrading to a PRO 4 ROV, you can still use your PRO 3 Smart Tether. Please contact your VideoRay dealer to purchase an Upconverter module which will adapt the 12-pin PRO 3 Smart Tether to your new 8-pin PRO 4 hardware.

Warning:

NEVER connect a PRO 3 Smart Tether Control Box to a PRO 4 VideoRay ICB. The PRO 4's higher voltage can damage the PRO 3 Smart Tether Control Box. A special Upconverter module must be used to connect a PRO 3 Smart Tether to a PRO 4 VideoRay. Contact VideoRay or KCF to obtain an Upconverter module.

Failure to follow the above warning may result in damage to the VideoRay or Smart Tether

14. SOFTWARE TROUBLESHOOTING

1. Communications

If the Smart Tether experiences communications problems and begins to give error messages, the following basic troubleshooting procedures should rectify the problem.

1. Press "Stop" in the Smart Tether software

2. Close the Smart Tether Software

3. Turn off the ICB

4. Check (disconnect and reconnect) all connections: Smart Tether to ROV, Smart Tether to ICB, and USB cable from ICB to Toughbook

5. Turn the ICB back on and wait 5 seconds. Retry software operation

6. If problems still persist, check that the Smart Tether and GPS (if installed) are assigned to the correct COM port. The COM ports specified in the Tools menu (see section 10.7) must match the COM ports found in the Windows Device manager (accessed by clicking Start → Control Panel → System → Hardware → Device Manager → Ports (COM & LPT)

   a. The "Sealevel RS485" device is the Smart Tether COM port and the "Prolific USB-to-Serial Comm Port" device is the GPS COM port
   b. To change COM ports, double-click the device under Ports (COM & LPT), then select Port Settings → Advanced, and change the COM Port Number in the drop-down menu. Click OK if a warning appears about port sharing, then click OK to apply the changes and return to the Device Manager

7. Retry the Smart Tether Software

8. If the above steps do not solve the problem, shut down and restart the Toughbook and ICB before trying again

Smart Tether

2. Error Messages

a. Error connecting to the Smart Tether

The following error message indicates a problem with the COM port setup:


Possible Causes:

- USB cable not connected from Smart Tether Control Box to computer (solution: check cable connection)

- COM port in General Settings menu does not match COM port installed in Device Manager (solution: check COM port configuration, see Item 6 above)

- VideoRay PRO 4 Only: Virtual ports not assigned correctly: A pair of virtual ports must be assigned to handle communication between Cockpit and Smart Tether. For instance, assign ports 15 and 16 as a pair, then assign 15 in the VideoRay Cockpit configuration file and 16 in the Smart Tether General Settings (call VideoRay for assistance)

- USB cable damaged (solution: try a different USB cable)

- Damaged Smart Tether Control Box (solution: call VideoRay or KCF)

b. The following nodes are not responding

The following error message indicates a problem with the Smart Tether communication:
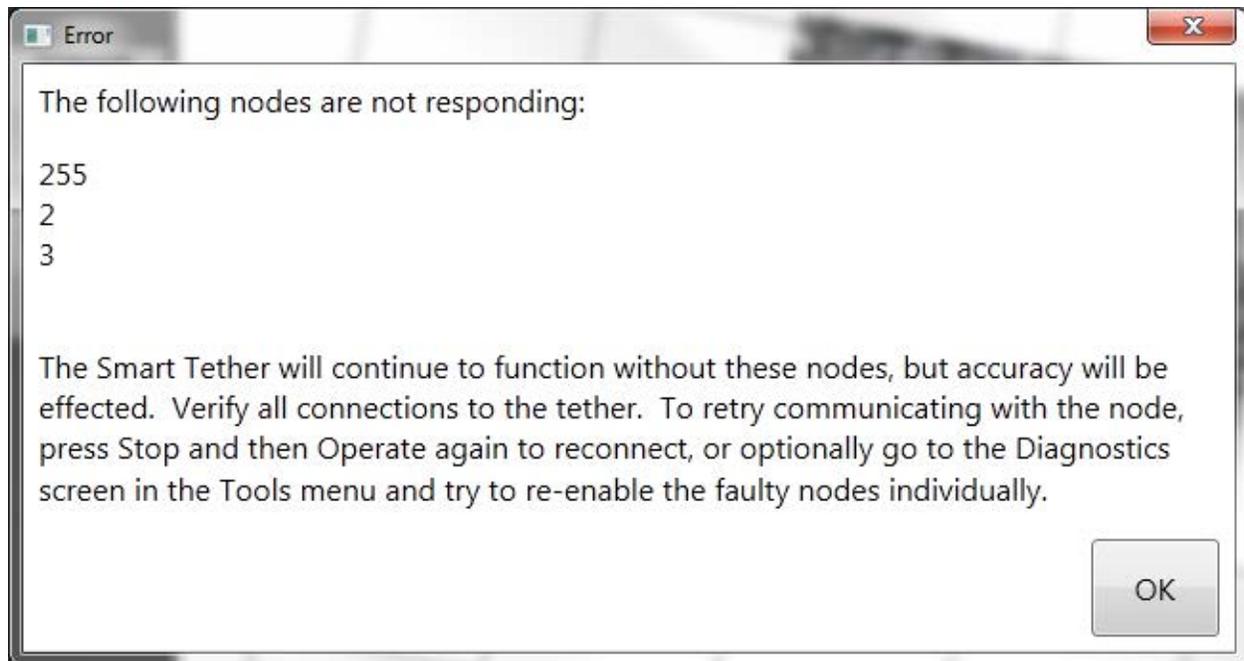
This error means that the software was unable to communicate properly to one or more nodes on the tether. This may indicate an instantaneous communication glitch which will clear up on its own, or it may indicate an actual problem. When this occurs, the affected nodes will be disabled and will no longer operate and tether accuracy will be affected. To re-enable a node, either press the stop button and then restart tether operations or enable the node in the Tools > Diagnostics menu.

Possible Causes:

- Smart Tether not connected to ICB (solution: check connection)

- Smart Tether not turned on (solution: check all connections and turn on power switch)

- Damaged Smart Tether (solution: call VideoRay or KCF)

- VideoRay PRO 4 Only: Virtual ports not assigned correctly: A pair of virtual ports must be assigned to handle communication between Cockpit and Smart Tether. For instance, assign ports 15 and 16 as a pair, then assign 15 in the VideoRay Cockpit configuration file and 16 in the Smart Tether General Settings (call VideoRay for assistance)

- Corrupted VideoRay Cockpit Configuration File (solution: call VideoRay)

- Corrupted Smart Tether Configuration file (solution: call VideoRay or KCF)

15. TRAINING / CERTIFICATION

The Smart Tether is designed to be simple and user-friendly, allowing new users to quickly get up and running. Many users will be able to operate the system adequately with no training. However, as with any task or system, it can be highly beneficial to receive training from an expert. KCF offers an intensive full-day Certification Training program which covers everything from basic operation to advanced techniques. This course can improve your organization's navigational capabilities and add value to your Smart Tether and VideoRay system.

To learn more about KCF's Smart Tether Certification Training, contact KCF at 814.867.4097 or sales@kcftech.com.

16. SERVICE AND SUPPORT

KCF offers a Service and Support agreement for repair or replacement of your Smart Tether equipment in the event of damage or malfunction. The Service and Support agreement also entitles you to certain upgrades to the Smart Tether software, as well as priority technical support.

To learn more about KCF's Smart Tether Service and Support program, contact KCF at 814.867.4097 or sales@kcftech.com.