

# Sure-Path User Guide

## 1. The Sure-Path System

Sure-Path is a system for plotting the GPS positions of the buoys used for tournament water skiing and then using this information for tournament homologation and/or tracking the boat's position in real time through the slalom and jump boat lanes.

The standard system comprises the following hardware:

- 2 x RTK capable GPS receivers
- 2 x dual frequency GPS antennas
- 1 x Android device with GPS Data Collection app installed
- 1 x Android device with RTK Base app installed
- Various USB connection leads to interconnect hardware.

## 2. The Technology

Sure-Path uses a form of differential GPS known as Real Time Kinematic GPS (RTK GPS). As such the system is comprised of two GPS receivers, one remains in a fixed location and acts as a Base station, the other is free to move and is referred to as the Rover.

The Base receiver is programmed with, or self surveys, its position and from then on can generate correctional data based on the original surveyed position. In other words, at any particular time, its measured position is compared with its previously surveyed position and the difference becomes a correction value. With RTK GPS, the Base can also take into account, variations in the ionosphere and troposphere by measuring satellite carrier wave phase perturbations and it is this extra level of data that gives the system its cm level accuracy.

Correctional data from the Base is then transmitted to the Rover which is also taking its own positional readings. When the corrections from the Base are applied to the Rover's positional readings, its position RELATIVE to the Base becomes very accurate, typically +/- 1cm. It is important to realise that it is the "relative" position that is accurate rather than "absolute" position. Fortunately for water skiing, absolute position is not important since we only need buoy and boat positions to be accurate relative to each other and accurate geographical positions are not necessary. What is important is that once the Base has been surveyed and programmed, it should not be moved in much the same way that if you were surveying using a traditional Total Station and needed to take some readings a second time, its position must be the same as when the original readings were taken for them to have any meaning. The Rover needs to be within 10km (6.2 miles) of the Base for good results to be achieved.

It is worth noting at this point that government in certain parts of the world are setting up real time Base station networks (so called CORS networks) which are free (or relatively low

cost) to the public. In these circumstances, one only needs a Rover receiving correction data from such a network to achieve accurate positioning. Normally the Rover needs to be within 10km of the Base to achieve accurate results, however, with some of these CORS networks, sophisticated algorithms use data from the whole network to create a virtual base station which appears to be near enough to the Rover for good results.

### **3. Choosing a System Configuration**

There are various ways of getting error data from Base to Rover and at first, setting up may seem a little complicated. However, once you are clear what method you are going to use, it is in fact reasonably straight forward.

There are three main methods of data transmission:

- 3.1. Using a local radio modem pair to transmit data directly from Base to Rover.
- 3.2. The error data is transmitted from the Base to a remote online computer on which there is software which relays the data to the Rover. The connection between Base and Rover is therefore via the internet.
- 3.3. The error data is transmitted directly from the Base to the Rover via a local network (WiFi).

Each method has its advantages and disadvantages. The method you choose will largely depend on your site layout (ie position and size of obstacles to radio signals such as trees, line-of-site to all areas of the lake etc), access to a local network (WiFi) that has sufficient coverage to link Base and Rover, and of course, the availability of a cellular network.

Here is a discussion of the pros and cons:

- Option 3.1 - Using a local radio modem pair is perhaps the simplest to understand, however as anyone who has set up radio links for boat video in a tournament will know that getting sufficient range, link speed etc is often problematic. In tests we have found that using the excellent RF900 series radios from RFDesign (or equivalent) is almost a must since cheaper lower range radios are often just not man enough for the job. But even using these RF900s at a site in the UK near a large international airport (and powerful radar signals) the quoted 40km range was reduced down to about 400 metres!

Another problem is that using powerful radios can interfere with other radios links needed for video transmission at a tournament.

**Advantages:** Easy to understand; no need for internet access.

**Cons:** Powerful radios are expensive; possible interference with other sources of radio signals; multiple Rovers (feeding from one Base) harder to setup (albeit not impossible).

- Option 3.2 - If both your Base and Rover can be given access to the internet then this is nearly always the better option compared to local radios and is the one recommended for Sure-Path. It is useful to think of the relay process happening in three stages:

- i The Base transmits the data to a server on the internet via the android phone, using the phone's internet connection. The phone's internet connection can either be via its own 3G/4G connection or via WiFi if it is available. So that multiple Bases can use the same server, Rovers choose which Base they want data from, and the data feed includes a name for the feed known as the "Mountpoint".
- ii The internet server receives data streams from one or more Base receivers and waits for Rovers to login and register which particular stream (Mountpoint) they wish to receive.

Commercially this is done using a data protocol known as NTRIP. Such online servers are known as NTRIP Casters and various companies provide this service on a subscription basis. In fact the CORS networks of Base stations mentioned earlier are in fact a network of NTRIP Casters. Sure-Path supports the use of such services but we have also developed our own data relay server and software which we can provide to customers at no extra cost for the foreseeable future.

- iii Rover(s) login to the server and register which Base data stream (Mountpoint) they wish to receive.

The android phone attached to the Rover receiver handles the connection to the server and the login process. The phone can do this either using its 3G/4G connection to the internet or via WiFi. It is of course unusual to find a water ski site with sufficient WiFi coverage over the boat path but this is slowly changing.

**Advantages:** No limit on distance between Base and Rover (other than the RTK 10km advisory limit); Easy to set up multiple Rovers receiving data from a single Base; If cell coverage is available it is generally more reliable than radio links; less risk of interference with other radio sources.

**Cons:** Relies on internet access and therefore if cell coverage is unavailable, would rely on a WiFi network which may also be unavailable.

- Option 3.3

If WiFi coverage between Base and the whole of the area in which the boat will travel is available, then the phone attached to the Base receiver can be put into

“server” mode. In this mode, multiple Rovers can connect to the Base and receive error data without any recourse to the internet and an online server.

The use of WiFi bridges and access points to provide coverage over a whole site is becoming increasingly feasible now with devices such as the Ubiquiti range becoming more and more affordable.

**Advantages:** No requirement for internet access; If all systems at a tournament use the WiFi network for data communications, then there is little chance of interference between systems. This is especially true of in-boat video transmitting back to shore and is the most common cause of problems at tournament.

**Cons:** Not many if set up properly but does involve a significant initial investment, not only in the WiFi network but also using IP based cameras which are generally more expensive than their analogue counterparts.

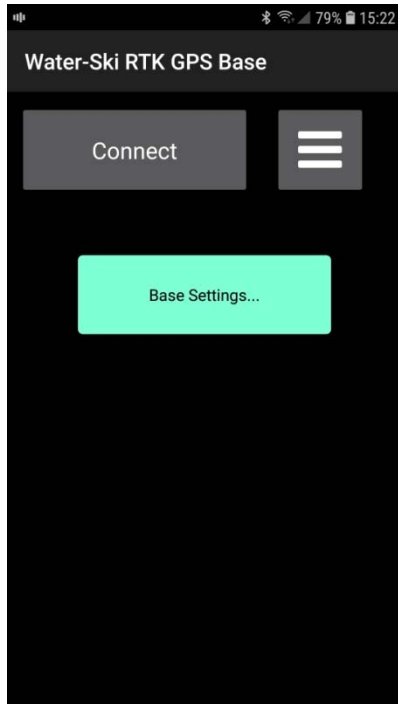
## **4. The Standard System Setup**

By default, Sure-Path uses option 3.2 as the standard method of getting Base error data to the Rover(s). Details of other options are described in later sections. Customers who have purchased a Rover kit for use with a CORS network, can skip to section 5.

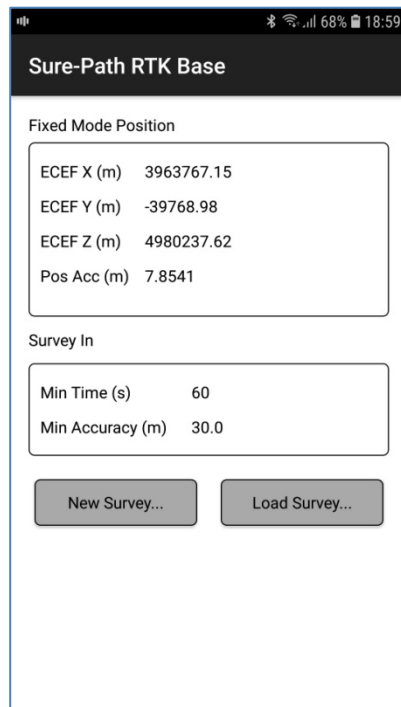
### **4.1 Configuring the Base Receiver**

In this section you are configuring the Base receiver so that it “self surveys” its position and remembers it for future correction data generation.

- i. Install the white dome topped GPS antennae in a suitable position where it has a clear view of the sky (ideally in all directions and down to 15 above the horizon) and where it can remain undisturbed, either permanently or at least for the duration of the tournament.
- ii. Using the supplied antenna lead, connect the GPS receiver marked “RTK\_BASE\_XXXX” to the antenna.
- iii. Using the supplied USB OTG adapter, connect the “base” phone to the Base receiver. This will also power the receiver.
- iv. The RTK Base app usually starts automatically when the USB is plugged in and once it has started, click the “Base Settings” button.

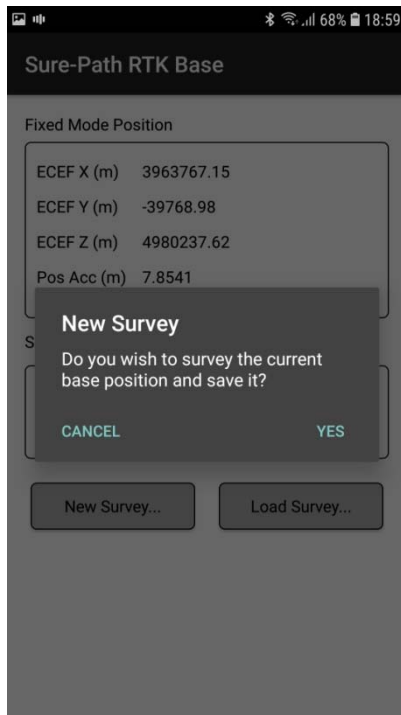


If all is well, the dialog below will slide in.



- v. Click the "New Survey" button.

- vi. A prompt dialog will appear as follows:



- Click “Yes” to have the Base receiver do a “self survey” and save those location settings in the receiver itself. This can take a minute or two depending on whether the receiver is doing a cold start etc.
- vii. The app will let you know when the survey has completed successfully and you will be prompted to choose a name for the survey file. This is so that you can move the base from site to site and be able to retrieve surveys without having to redo a self survey each time. Whilst this makes life convenient, it is also important in that every time the base does a self survey, any mapping of the slalom or jump course done under that survey have to be redone whilst if a survey is loaded from file and the antenna position is the same, the previous mappings work fine. Once saved, click the phone’s “back” button to exit the Base Settings dialog.
- viii. Unplug the USB OTG cable to depower the receiver.
- ix. Power the Base receiver either from a standard micro USB power adapter or from a USB power pack.

The Base receiver is now setup but is not yet linked to the online server.

#### 4.2 Connect the Base phone to the Base receiver using Bluetooth

When supplied, the Base phone and Base receiver will already be “Bluetooth paired”, but here is the procedure should you need to redo it. In the phone’s Settings, select Bluetooth, then “Pair new device” (ensure the Base receiver is powered up). The receiver’s Bluetooth ID is marked on the label on the underside of the receiver and when it appears in the list of available devices, click it to start pairing. If you are prompted to enter a PIN code, use “1234”. After pairing is complete, the device will appear to disconnect and instead move to the list of “available devices”. **This is normal!**

In the phone app, click the menu button (top right with 3 horizontal bars). Click “Bluetooth Device” and select the newly paired Bluetooth device, even if it appears to be already selected.

### 4.3 Check/Set the remaining Settings

Use the below template to check the Settings. The actual Mountpoint and Password will not be the same as displayed and will have already been setup for you before shipping the system so it is worth noting them for future reference.



Use the phone’s back button to close the Settings menu.

### 4.4 Start transmitting Base error data

In the phone app, click the “Connect” button. The app will first establish a Bluetooth connection to the Base receiver and when that is successful, it will connect to the online server and start transmitting error data to it.

There are two progress bars displayed. The upper one shows data being received from the Base receiver. The lower one shows transmitted data to the online server.

If only the upper progress bar shows activity, then it means that there is data coming from the Base receiver, but there is a problem connecting to the online server. Check that there is internet connectivity available to the phone, either via 3G/4G or via WiFi.

If all is good, then the Base phone and Base receiver are all set up. You are now ready to set up the Rover(s).

### 4.5 Setting up the Rover

Connect the rover antenna (black device marked Ublox) to the Rover receiver using its own lead. The antenna also needs to be on a “ground plane” which to the uninitiated is simply a metal plate at least 10cm in diameter. Later this plate will be the metal disk that is part of the pylon mount but for now, it is the metal disk that is on the collapsible colander (supplied) which is used for mapping buoys (section 5). The Ublox antenna has a small magnet on its underside to enable it to be attached to the disk.

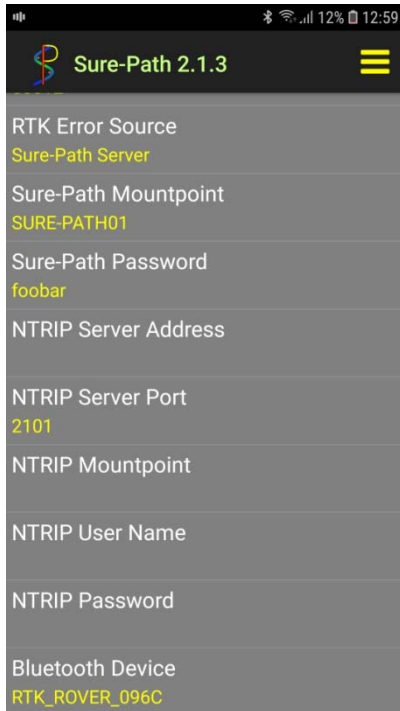


Connect the Rover receiver to power using its USB A plug (some newer receivers have a USB mini socket and are supplied with a separate USB A to USB mini lead). This can be from a USB power outlet in the boat, a USB power pack or a USB power adapter connected to the boat’s battery.

The Rover phone comes already Bluetooth paired with the Rover receiver. Refer to section 4.2 if this needs to be done again. Like the Base receiver, the Rover receiver is labelled with its Bluetooth ID on the underside.

In the Rover phone app, click the menu button (three bars at the top right) and click “GPS & Network Settings...”. Scroll to the bottom and ensure that the Rover receiver is shown as the Bluetooth Device.





As for the Base, the Mountpoint and Password will have already been set for you and they will be the same as for the Base.

Use the phone's back button to close the menu.

Click the Connect button (upper left). The phone will first establish a Bluetooth connection to the receiver and start to receive GPS position data.

Once connected to the receiver, the phone will then connect to the online server in order to start receiving correction data from the Base. If this is successful, the phone will pass the correction data to the receiver via the Bluetooth link.

The receiver's status will be displayed in the following sequence:

**"No RTK Fix" => "GPS" => "DGPS" => "RTK Float" => "RTK Fix"**

If correction data is not being received from the Base, then the status will only get as far as "GPS". Another indicator of whether correction data is being received is the "Age" display. This should cycle round from around 0.5 to 3.0. If it says "Null" or ceases to change, it is likely there is no data coming in from the server.

If correction data is present, the status will very quickly go to "DGPS", then to "RTK Float" and will then take a little longer to achieve "RTK Fix" (typically anywhere between 10 and 60 seconds). The Rover's position relative to the Base will **ONLY** be cm level accurate when "RTK Fix" mode is achieved.

If the Rover is still in "RTK Float" mode after a few minutes, check the following:

- i. It cannot be stressed enough that if the Base antenna is in an ideal position, the job of the Rover becomes much easier. Ideally the Base antenna has a clear view of the sky **in all directions down to 15 degrees above the horizon.**

Achieving this may entail mounting the antenna on a pole to elevate its position above surrounding obstacles such as buildings or trees.

- ii. The Base antenna is not close to any vertical surfaces such as the wall of a building.
- iii. The Base has done a “self survey” as part of its setup (see section 4.1.vi).
- iv. The Base is transmitting data to the online server, ie the Base phone has internet access and the lower progress bar is showing activity.

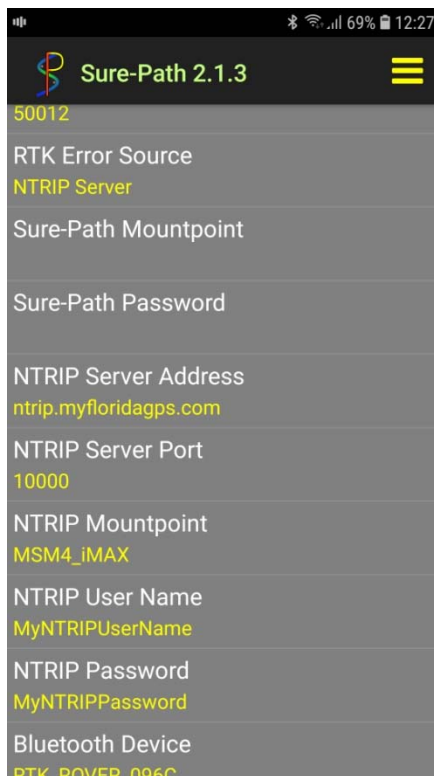
Once the Rover is in “RTK Fix” mode, the system is working and you are ready to survey the slalom or jump course.

## **5. Rover Setup when using a public CORS network**

If there is a Government provided network of base stations available for little or no cost, then you do not need to run and maintain a Sure-Path base station. The Rover can connect directly to the public network via a communication technology known as NTRIP. You will need to register for an account to login and use the network and as part of the registration process you will choose (or will be given) an “NTRIP User Name” and an “NTRIP Password”. These need to be entered into the Sure-Path Rover settings.

### **5.1 Configuring the Rover**

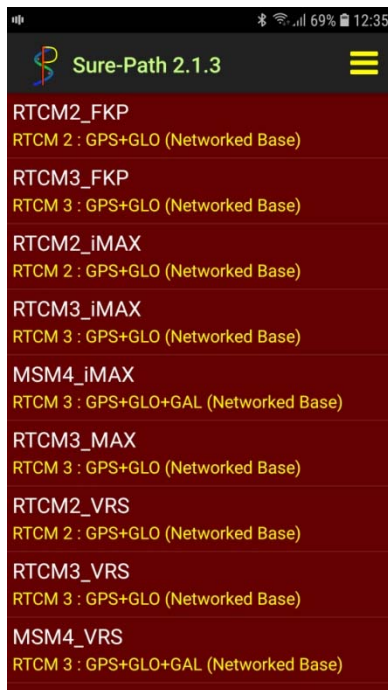
Start the Sure-Path app and open the menu (three bars top right). Then select “GPS & Network Settings”. The following example is for the Florida DOT network.



The settings that need to be entered/checked are:

- RTK Error Source: NTRIP Server
- NTRIP Server Address: Provided by the network

- NTRIP Server Port: Provided by the network
- NTRIP Mountpoint: Once the previous settings are correct, clicking this entry will bring up a list of possible data feeds.



You should choose an entry that is a) “Networked” and b) that uses as many satellite constellations as possible. In this example, “MSM4\_iMAX” is a Networked feed and utilises GPS, GLONASS and GALILEO satellite constellations. Some networks will also use the BEIDOU constellation. Another possible choice would have been “MSM4\_VRS”.

- NTRIP User Name: The User Name you have registered.
- NTRIP Password: The NTRIP Password you have registered.

Once all settings are in, exit the menu and return to the app’s main screen.

## 5.2 Starting the Rover

Connect the rover antenna (black device marked Ublox) to the Rover receiver using its own lead. The antenna also needs to be on a “ground plane” which to the uninitiated is simply a metal plate at least 10cm in diameter. Later this plate will be the metal disk that is part of the pylon mount but for now, it is the metal disk that is on the collapsible colander (supplied) which is used for mapping buoys (section 5). The Ublox antenna has a small magnet on its underside to enable it to be attached to the disk.



Connect the Rover receiver to power using its USB A plug (some newer receivers have a USB mini socket and are supplied with a separate USB-A to USB-mini lead). This can be from a USB power outlet in the boat, a USB power pack or a USB power adapter connected to the boat's battery.

The Rover phone comes already Bluetooth paired with the Rover receiver. Refer to section 4.2 if this needs to be done again. The Rover receiver is labelled with its Bluetooth ID on the underside.

Click the Connect button (upper left). The phone will first establish a Bluetooth connection to the receiver and start to receive GPS position data.

Once connected to the receiver, the phone will then connect to the online server in order to start receiving correction data from the Base. If this is successful, the phone will pass the correction data to the receiver via the Bluetooth link.

The receiver's status will be displayed in the following sequence:

**"No RTK Fix" => "GPS" => "DGPS" => "RTK Float" => "RTK Fix"**

If correction data is not being received from the CORS network], then the status will only get as far as "GPS". Another indicator of whether correction data is being received is the "Age" display. This should cycle round from around 0.5 to 3.0. If it says "Null" or ceases to change, it is likely there is no data coming in from the network. If this is the case, check the Rover phone for internet connectivity. This entails checking things like the SIM card is active and has a valid data plan; that the phone's "Mobile Data" is enabled; that the phone's APN settings are correct etc.

If correction data is present, the status will very quickly go to "DGPS", then to "RTK Float" and will then take a little longer to achieve "RTK Fix" (typically anywhere between 10 and 60 seconds). The Rover's position relative to the Base will **ONLY** be cm level accurate when "RTK Fix" mode is achieved.

If the Rover is still in “RTK Float” mode after a few minutes, check the following:

- i. The Rover antenna is on a ground plane (metal plate) if required.
- ii. The antenna has a reasonable view of the sky, ideally in all directions.

Once the Rover is in “RTK Fix” mode, the system is working and you are ready to survey the slalom or jump course

## **6. Surveying (mapping) the Slalom or Jump courses**

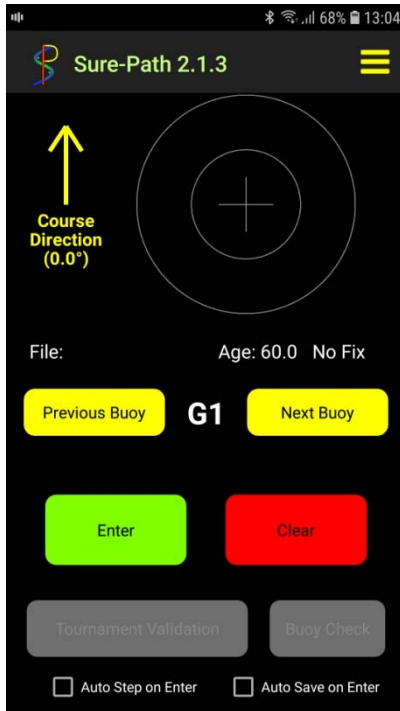
Before Sure-Path can track the boat’s position in the slalom or jump courses, it first needs to know where the course is. The GPS position of certain buoys need to be marked and recorded. For slalom, we use the four buoys marking the entrance and exit gates. For jump, we use the ST buoys and one other pair further along the course, ideally the ET15 and ET19 buoys.

To facilitate mapping the course, if you haven’t done so already, mount the Rover antenna on the metal plate on the supplied collapsible colander (the underside of the antenna is magnetic and so sticks to the metal plate without any other means of fastening). The colander is used upside down like a hat on a buoy so that the antenna is effectively held over the centre of the buoy’s position. For accuracy, ensure the antenna is central on the metal plate. Also supplied is a telescopic “selfie stick” which attaches to the rim of the colander using the stainless nut supplied. The stick can then be used to hold the colander over the side of the boat to reach the buoy without the boat coming too close. Obviously care must be taken to just rest the colander on the buoy without applying any sideways force that might move the buoy out of position.

*Picture here ....*

### **6.1 Mapping the Slalom Course**

In the Rover app, click the “Survey Slalom” button and the following screen displays:



The two yellow buttons select which buoy to survey and the ID displayed between the two yellow buttons indicates which buoy we are surveying. The IDs are the same as used in Emmanuel Lion's homologation software "[Waterski Homologation](#)".

For slalom these are:

- G1 = right hand entrance gate buoy
- G2 = left hand entrance gate buoy
- G3 = right hand exit gate buoy
- G4 = left hand exit gate buoy

With the correct buoy selected, rest the Rover antenna on the buoy. Check that "Fix" is still displayed just above the right hand yellow button. Click the Enter button to mark the buoy's position. If "Auto Step on Enter" is checked, the app will automatically move on to the next buoy. Repeat the above procedure until you have at least surveyed G1, G2, G3 and G4. If you are using Sure-Path to homologate the course prior to competition, you would of course do all the ski and boat buoys as well.

Open the system menu (3 dots at the top right) and select "Save File As...". Choose an appropriate filename and click OK.

For Boat Lane Tracking, exit "Survey Slalom" and click the "Boat Lane (Slalom)" button. Then open the menu and click "Select Course...". Choose a course you have already surveyed.

You are now ready to track the boat's path through the slalom course (Section 6).

## 6.2 Mapping the Jump Course

For jump the labels are pretty much self explanatory. The buoys used for boat lane tracking are ST15, ST19 plus one pair of the later buoys in the course, ie MT15 & MT19 or ET15 & ET19 or EC15 & EC19. Ideally, use the ET15 & ET19 buoys. If your EC buoys have been set accurately, then you could use those instead.

Follow the same process as for mapping the slalom course saving the resulting file.

**Note** that jump course files are saved to a different storage area to the slalom course files and therefore slalom and jump courses with the same filename will not clash with each other.

Note that whilst mapping the slalom or jump course, it is a good idea right at the beginning to save to a suitable filename even though you have no buoy position data yet. Then if “Auto Save on Enter” is checked, the data will be saved to file automatically every time the “Enter” button is clicked. Thus if the app crashes for any reason whilst mapping the course, you will not have to start from scratch again after restarting the app.

## 7. Tracking the Boat Path in the course

Remove the Rover antenna from the colander and mount it in the boat. The ideal position for the antenna is as close as possible to the ski pylon and at the same height as the rope attachment point. Obviously it should also be in the centre of the width of the boat. Sure-Path is supplied with a pylon mount that will fit all pylons from 2” to 2.5” diameter.

The receiver itself can be placed anywhere out of the way in the boat. This could be in the glove compartment or under the front passenger seat. Take care however not to “pinch” the antenna lead in ducting it from the antenna to the receiver. If the lead is compressed, it can change its impedance and reduce the quality of the GPS signal.

The Rover phone can be mounted on the windscreen (mount not supplied) or be placed anywhere convenient for the user.

After starting the app in the Rover phone, click the “Boat Lane (Slalom)” button or the “Boat Lane (Jump)” button to enter boat lane tracking mode.

For slalom, Sure-Path will automatically track and display the boat’s position relative to the boat lane whenever the boat is within the boat lane AND the boat speed is above the “Boat Threshold Speed” (set in the system menu) AND the boat is after 60 metres before the entrance gates and before 7 metres after the exit gates. At the end of the course, the app saves the boat path to file and displays a summary of the boat path data in a popup panel. This data includes the boat’s deviation when the skier is at each buoy and the required cumulative deviations (used for possible record passes).

Click the panel to hide it at any time. Once the panel is hidden, you can scroll back through the graphic and see from the breadcrumb trail the complete boat track through the course.

The boat lane graphic uses a colour scheme as follows:

- The blue area represents the width of the boat lane

- The green area represents the allowed boat deviation tolerance. For (Record Capability) slalom this is a 40cm (15.75") wide band. For jump, the allowed tolerance is +- 40cm (+-15.75") giving an 80cm (31.5") wide green band.

Note that for jump, prior to the boat pass, the driver would usually select the "split" that the skier has requested. This moves the green band left or right by 30cm, 60cm or 90cm (1ft, 2ft or 3ft approximately).

To view a previously saved boat track, click the "Load..." button. The files are stored in folders for each date and the filename shows the date and time the track was originally created. Once loaded, the boat track is displayed as a breadcrumb trail. Click the "Replay" button to display an animated replay of the boat path.

When the boat starts a new pass, any previously displayed path will automatically be removed and the new path displayed in real time.

## **8. Onshore Viewing of Boat Path Data**

[Onshore Viewing - Sure-Path GPS Boat Lane Tracking](#)

## **9. Integration with Scoring Software**

[Integration with Scoring Software - Sure-Path GPS Boat Lane Tracking](#)

## **10.**