Navigator User's Guide

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Table of Contents

Introduction

The MLB Navigator is an autopilot system for model vehicles. With only a standard hand-held GPS unit, it can drive your car wherever you tell it to go. The basic idea is simple: program the car with where to go (waypoints) and how fast to go while getting there, and let it go. Your car has become a robot!

GPS Setup

The GPS should be configured to send the NMEA format sentences.
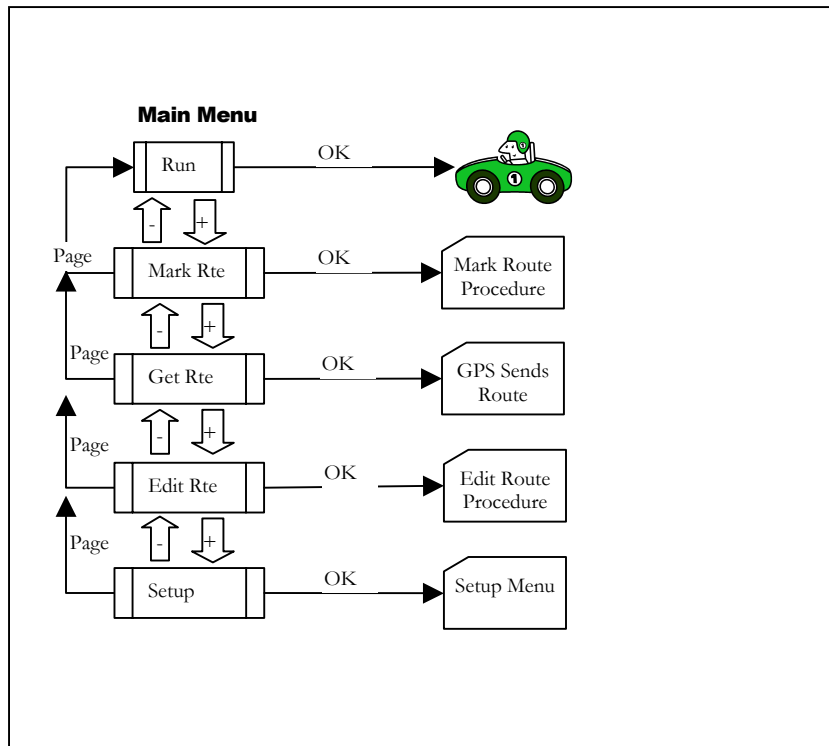
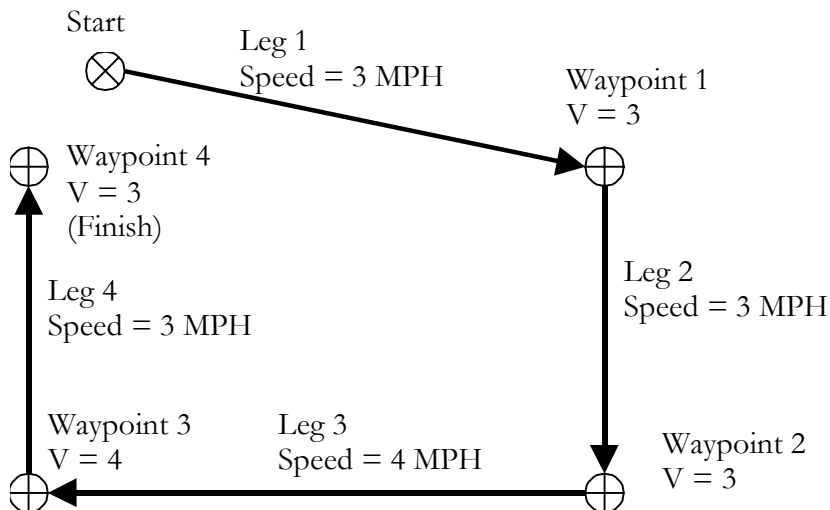## Main Menu

Figure 1: Main menu

When the Navigator is powered up, it shows the main menu, with "Run" selected. Pressing the OK button will send the car on the route programmed in memory. Pressing the + or – buttons selects the other menu options. Pressing the Page button

at any time brings you back to the "Run" option. Figure 1 shows the main menu options, and the button presses to change the options shown.

Setting up a Route

Before you can send the car off on a mission, you must tell it where to go. The path the Navigator will follow is called its Route. The route consists of the waypoints that the car will visit in order, and the speed it will drive on each leg between waypoints. The car will drive a straight line between waypoints, and will drive the speed for the waypoint while it is heading for the waypoint. The first leg of the route is from the car's current location (wherever you start it from) to the first waypoint. The subsequent legs are between consecutive waypoints.

The sample route below would be a good first route to program. Make the horizontal legs (like between wpt 2 and wpt 3) around 50 feet, and the vertical legs (like between wpt 1 and wpt 2) around 30 feet. Leave at least 20 feet around any waypoint free of obstacles—most GPS receivers are no more accurate than 25-30 feet under the best conditions, so the car may be off course by this much at any time.

Start
Leg 1
Speed = 3 MPH
⊗
Waypoint 1
V = 3
⊕

Waypoint 4
V = 3
(Finish)
⊕

Leg 2
Speed = 3 MPH

Leg 4
Speed = 3 MPH

Waypoint 3
V = 4
⊕
Leg 3
Speed = 4 MPH
Waypoint 2
V = 3
⊕

There are 3 ways to program a route into the Navigator autopilot: Marking a route by walking the route and pressing a button at each waypoint, editing the route by changing the latitude and longitude and speed for each waypoint, and downloading a route created in the handheld GPS.

Mark a Route

Marking the route is the quickest way to enter a simple route. The user walks the route carrying the car and presses the OK button at each waypoint. Before pressing OK, use the +/- buttons to set the desired speed for the leg. Press Page instead of OK to end the route.

Step 1. From the main menu, use the +/- buttons until "Mark Rte" is shown on the display. Press OK.

Step 2. The computer will make sure the GPS is communicating properly, then show the speed for waypoint 1. Use the +/- buttons to adjust the speed for the first leg.

Step 3. Carry the car to the first waypoint. Press the OK button to take this location and the displayed speed.

Step 4. Continue to mark the waypoints in this fashion until you have reached the end of the route. On the last waypoint press the Page button instead of OK to end the route. If you forget and hit OK first, don't worry, you can have consecutive waypoints with the same location without affecting the operation of the vehicle. Don't forget to enter the proper speed for each waypoint.

Edit Routes

Editing a route is a slow way to create a route from scratch, but is quite useful for modifying an existing route, for example if one waypoint is a little off from where you intended, or if you want to change the speed of a leg of the route. It is tedious in that you must step through the latitude, longitude and speed for each waypoint.

Step 1. From the main menu, use the +/- buttons until "Edit Rte" is shown on the display. Press OK.

Step 2. The number of waypoints for the current route will be shown. Use the +/- buttons to change the number of waypoints if desired. Press OK when the correct number is shown.

Step 3. The longitude of the first waypoint will be shown, labeled "X1". The format is signed degrees with signed decimal minutes. A negative sign means West longitude, positive numbers are East longitude. For example "X1 = -122 -3.456" is 122 degrees 3.456 minutes West longitude. Use the +/- buttons to change this to the proper longitude for the waypoint. Each button press moves the waypoint 10 feet, to the east for +, to the west for -. Press OK when the correct longitude is shown on the display.

Step 4. The latitude of the first waypoint will be shown, labeled "Y1". The format is signed degrees with signed decimal minutes. A negative sign means South latitude, positive numbers are North latitude. For example "Y1 = 37 1.987" is 37 degrees 1.987 minutes North latitude. Use the +/- buttons to change this to the proper latitude for the waypoint. Each button press moves the waypoint 10 feet, to the North for +, to the South for -. Press OK when the correct longitude is shown on the display.

Step 5. The speed for the waypoint is shown, labeled "V1". The units are miles per hour. This is the speed the car will drive while heading for the waypoint you just edited. Use the +/- buttons to increase or decrease the speed until the desired speed is shown on the display. Press OK to edit the next waypoint.

Step 6. The next waypoint's longitude will be displayed (X2, X3, etc). Continue to edit each waypoint as described in steps 3-5 until each waypoint has the correct latitude, longitude and speed.

Pressing Page during the edit process is the same as pressing OK.

Using a Route from the GPS

Setting up a route on the handheld GPS allows you to save routes that you use often and download them to the Navigator. The route is downloaded to the Navigator before starting the car on its way.

To set up a route on the GPS, you must refer to the user's guide for your GPS model. In general, you must define the waypoints for the route, then link them in sequence to create the route. There are software packages that let you set up a route on a computer and download it into the GPS. Oziexplorer is one such program, Topo USA is another. They allow you to carefully plan your route when necessary.

Because GPS routes do not have speed data associated with them, you must embed the speed command in the name of the waypoint. At the end of the name for the waypoint, append a "V" with the speed in miles per hour. For example, a waypoint named "firstpt" would become "firstptV3" to command a 3 MPH speed for the leg. There can be other "V"s and numbers in the name if desired, only the last V and number will be used (for example a waypoint named V13ghV3 will have a speed of 3). Do not put anything after the number for the speed.

There are some shortcuts to the speed command. If there is no "VXX" speed command embedded in the name, the waypoint will be assigned the speed of the previous waypoint. If the waypoint is the first waypoint and has no speed command, a speed of 3 MPH will be used. That way if you want to run the course with a constant speed, you only need to embed the speed command in the first waypoint, or not at all for 3 MPH.

Once the route is created on the GPS, you must activate the route on the GPS. Refer to the GPS user's guide for instructions here. This will start the GPS transmitting the route data using the NMEA protocol.

To download the route in the car, make sure that the route has been activated, then go to the "Get Rte" menu and press OK. After a few seconds, the name of the route (as named on the GPS) will be displayed with the number of waypoints. Then each waypoint will be read, and the name and speed displayed as they are downloaded. Watch the display as the route is downloaded to make sure that the sequence is correct.

Let it Go!

Now that you've got a route set up, you can let the car go!

From the main menu, press the +/- buttons until "Run" is displayed. Press OK. The Navigator will pause until it receives valid GPS data, then count down for 5 seconds to give you time to position it. The first second of motion is in a slow straight line to let the GPS compass settle. From then on the car will do its best to drive the course and hold the specified speed. The first leg of the course is a straight line from wherever you pressed "OK" to the first waypoint of the route (at the speed defined for the first waypoint).

While the car is driving, it will display some information on its LCD screen. It will display the number of the waypoint it is currently heading for, and it will display the distance to that waypoint, in feet. dE is how many feet east of the waypoint the car is, while dN is how many feet north of the waypoint the car is. The car has reached the waypoint when dE and dN are zero. Try carrying the car around the route using this information and maintaining the correct speed!

If the car hits an obstacle and stops, the throttle will be advanced continuously to try to reach the programmed speed. Be careful if the car gets stuck, if you unstick it, it will take off at a high speed, so be sure it is aimed into open space with room to slow down and turn.

If at any time you wish to stop the car during the route, simply press the Page button and the car will return to the main menu with the motor stopped.

After the car finishes its route, it will stop. Sometimes, due to GPS inaccuracy, after it has stopped it will receive information from the GPS that it has moved away from the final waypoint and it will circle around to try to get back to the finish. It's a good idea to press Page after the car has stopped to make sure that it won't start moving again.

Car Setup

There are several steps involved in installing the Navigator in a car. It is helpful, but not entirely necessary, to have a radio control system for the car and an extra servo. To set up the car, use the +/- buttons from the main menu until "Setup" is displayed and press OK. This will bring you to the setup menu. Using +/- and OK will select the different setup options.

Steering0: Steering0 is used to center the steering. From the setup menu, use the +/- buttons until "Steering 0" is displayed, and press OK. The steering will be centered, and a number displayed that corresponds to the steering center position (meaningless units). Use the +/- buttons until the car rolls in a straight line, then press OK to exit the menu. The values are saved as soon as you press + or -, even if you turn the power off before pressing OK.

Throttle 0: Throttle 0 is the stop point for the throttle: the throttle setting at which the car will not move. From the setup menu, use the +/- buttons until "Throttle 0" is displayed, and press OK. The throttle will be set to the stop point, and a number displayed that corresponds to the stop point. Use the +/- buttons to adjust the stop point, then press OK.

Steering limit: Steering limit allows you to calibrate the steering on the car. This is an important step as the accuracy of the navigation algorithm depends on this calibration. From the setup menu, use the +/- buttons until "Steering limit" is displayed, and press OK The car will be steered for a circle. Adjust the steering using + and – until the car steers a circle to the right with a 10 foot diameter. Using a radio to control the throttle can make this adjustment easier, but you can push the car around if you do not have a radio available. ***Make sure that the car turns to the RIGHT!!!***

Throttle limit: Throttle limit sets full throttle on the speed control. From the setup menu, use the +/- buttons until "throttle limit" is displayed, and press OK Be careful as the throttle will go to full when you press OK. Use the +/- buttons until the throttle is at full, then press OK. Some speed controls have LED lights to indicate full throttle, which makes this setup step easier.

For a speed control that was set up using a radio, you might find it easiest to plug a spare servo into the receiver for the radio and note where full throttle is on the servo. Then plug the servo into the Navigator and adjust the throttle limit to match the radio's full throttle by matching the servo position. This way you can avoid the drama of running the car full throttle on the bench, and you can revert to radio control on the car without resetting the speed control stops.

If the car gets away from you while running full throttle, keep pressing Page until the motor is stopped, or turn the car off. Changes you make are saved as the +/- buttons are pressed, so no calibration will be lost if you power down suddenly.

Throttle gain: Throttle gain is a way to adjust the throttle control from the Navigator to allow for faster and slower cars. If the car attains its commanded speed sluggishly, you may want to experiment with increasing the gain. If the car's speed oscillates, first too fast then too slow then too fast etc., you should decrease the throttle gain. Faster cars will have a smaller throttle gain than slower cars.

From the setup menu, use the +/- buttons until "Throttle gain" is displayed, and press OK Adjust the gain a little at a time according to the above instructions, and test the car on a representative route. Changes on the order of 10% to 50% of the previous gain are appropriate, depending on how sluggish or oscillatory the speed control is.

Setup ESC: Most R/C car electronic speed controls (ESC's) can be reprogrammed to match your radio's limits. You can use this feature instead of programming the throttle0 and throttle limits if it is easier. The "Setup ESC" function will set the throttle to full forward, full reverse and stop, so you can program the ESC. It is recommended that you disconnect the motor from the speed control for this setup, or the car may drive away!

From the setup menu, use the +/- buttons until "Setup ESC" is displayed, and press OK. The throttle will be at the Stop position. Press + to set the throttle to full forward (lift the wheels off the ground!), or press – to set the throttle to full reverse (the Navigator will never set the throttle to reverse). Pressing any button when in forward or reverse will set the throttle to stop.

Hints

Once it's changed, it's saved: Routes and setup parameters are saved to permanent memory as the display is updated. That means that even if you switch off the power before pressing the OK button on a change the change is saved. There is no "Undo" feature, so be careful when in edit and setup modes. It is also a good idea to write down the calibration numbers that are displayed so that you may re-enter them in case some buttons accidentally get pressed by an unknowledgeable user.

Press Page to stop a moving car: At any time while the car is driving the route, pressing Page will stop the car. You can also use the power switch to turn the car off without losing the route, since it is stored in permanent memory.

GPS Accuracy: Most GPS units will display an estimate of their accuracy. For repeatable results, we recommend that the accuracy be better than 30 feet. Less accurate GPS positions will cause the car to drive a route that may be shifted by the amount of the GPS error.

Speed Limits: There are no software imposed speed limits on the routes used by the Navigator, but there are practical limits. The faster the car moves, the less accurate the navigation will become as it takes more distance to turn the car around and the car can move farther between GPS position updates. For the most accurate navigation, speeds in the neighborhood of 3 MPH are recommended. 5 MPH is fine for more open areas where there is room to make wide turns. Note that 5 MPH is faster than most people walk, so following the car becomes quite tiring. Anything faster than 10 MPH will probably result in wide turns and inaccurate navigation. If you wish to experiment with high speeds, first set up a route at a lower speed and test the route. Then use the "Edit Rte" menu to adjust the speed on the route incrementally.

Voltage Limits: The navigator computer is designed to run on 5 Volts power. Some car ESC's (like the duratrax evader) make 5 volts for the servos and radio, and the navigator will be wired to draw power directly from the ESC. Many other car ESC's create 7 volts for the servo. If the Navigator is wired directly to these ESC's it will burn out. A voltage regulator is required for ESC's that provide more than 5 Volts of power. Your Navigator may be wired for 5 or 7 volts (with or without a regulator), and must always be used with the correct voltage, or it will become damaged. Please contact MLB if you are unsure whether you have a 5 volt or 7 volt navigator computer *before* connecting it to a new ESC.

Servo Connections: The servo connectors are labeled on the top of the circuit board, while the servos plug into the bottom. Carefully peer under the LCD to find the labels.