Vector Waypoints Manual

Version 0.7, Preliminary

1.1 Safety

Waypoints are an advanced Vector feature, intended for skilled and knowledgeable pilots. The waypoint support is presently in BETA, with limited testing.   Proceed with caution!

Use the waypoint feature ONLY if you understand and agree to the below:

- You are fully responsible for your model, even when it is flying in waypoint mode.

- You are responsible for determining whether an area is safe and legal for model flight. If you are not sure, don't fly there!

- Never program waypoints that could cause your model to fly near other aircraft or airports, over people, or anywhere else that could cause a hazard!

- Assume that your prop(s) can spin at any time, when waypoint mode is engaged!

 - If lost radio link is detected, waypoint navigation will stop and RTH will be activated, if RTH is configured correctly. Configure and test RTH before activating waypoints! Ensure there is a clear path to home from any point in the waypoint sequence!

- If a problem related to GPS or compass is detected, or if you lower your throttle or move your control stick, the Vector will at least temporarily switch to a manual flight mode, requiring immediate pilot interaction.

1.2 Terminology

Command – an instruction that causes the Vector's waypoint controller to perform a specific set of actions.

Session – a set of commands comprising a waypoint flight.

Click and drag – left clicking with the mouse, and moving the mouse pointer while continuing to hold down the left button.

1.3 Requirements

- Vector software version 12.03 or later, with Vector firmware version 2.10 or later, must be installed.

1.4 Limitations

During the beta, waypoints are presently limited as follows, for safety. After the beta, we plan on providing a means to set up your Vector without these limitations:

- Distance – the maximum distance allowed between the first waypoint and any other waypoint is approximately 1 mile (1.6 km).   This limitation also applies to the distance between the home position and all waypoints.
- Altitude – altitude is limited to under 400 feet (122 m).

1.5 Planned Additional Features

Please let us know what we're missing! A few of the planned additional waypoint related features are listed below. We do not have any timeline estimate for these:

- An internet connection is required when setting up waypoints.   We are investigating options for offline setup. Note that most mobile phones can be set up as internet "hot spots" at the field for your laptop (data rates may apply).

- Takeoff and Land support for fixed wing

- Closed loop speed control for fixed wing

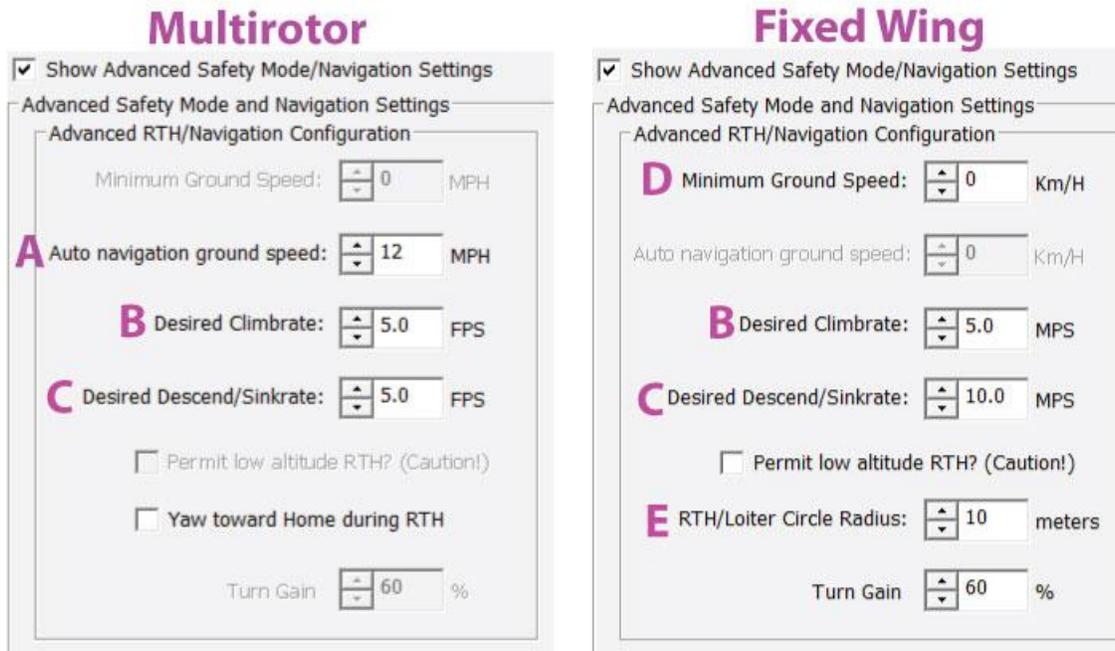- Camera control

1.6 Units of Measure

Distances and altitudes are configurable as described in the Vector manual.

1.7 Waypoint Setup

Waypoint commands are set up by navigating to the "Safety/Nav Setup" and "Waypoint Setup" tabs in the software.

1.7.1 Waypoint Related Settings on the Waypoint/Nav Setup Tab

Refer to the lettered indications on the diagram below:

A: The Vector attempts to maintain this ground speed during waypoint navigation and RTH.

B: The Vector attempts to honor this climbrate during waypoint navigation and RTH.

　　Note: This setting is NOT used for Takeoff commands.

C: The Vector attempts to honor this descend/sinkrate during waypoint navigation and RTH.

　　Note: This setting is NOT used during Autoland. Presently, Autoland speed is hardcoded to 1.5FPS/50cmS

D: If your fixed wing model is navigating waypoints or returning to home at a speed lower than specified ground speed (from the GPS), the Vector will use the 'Climb' throttle setting instead of the 'Cruise' throttle setting you specified in the wizard. This is useful if you are navigating in high wind.

E: This circling radius is used when no circling radius/direction is specified in individual waypoint commands, as well as for RTH.

1.7.2 The Waypoint Setup Tab

Refer to the lettered indications on the diagram below:
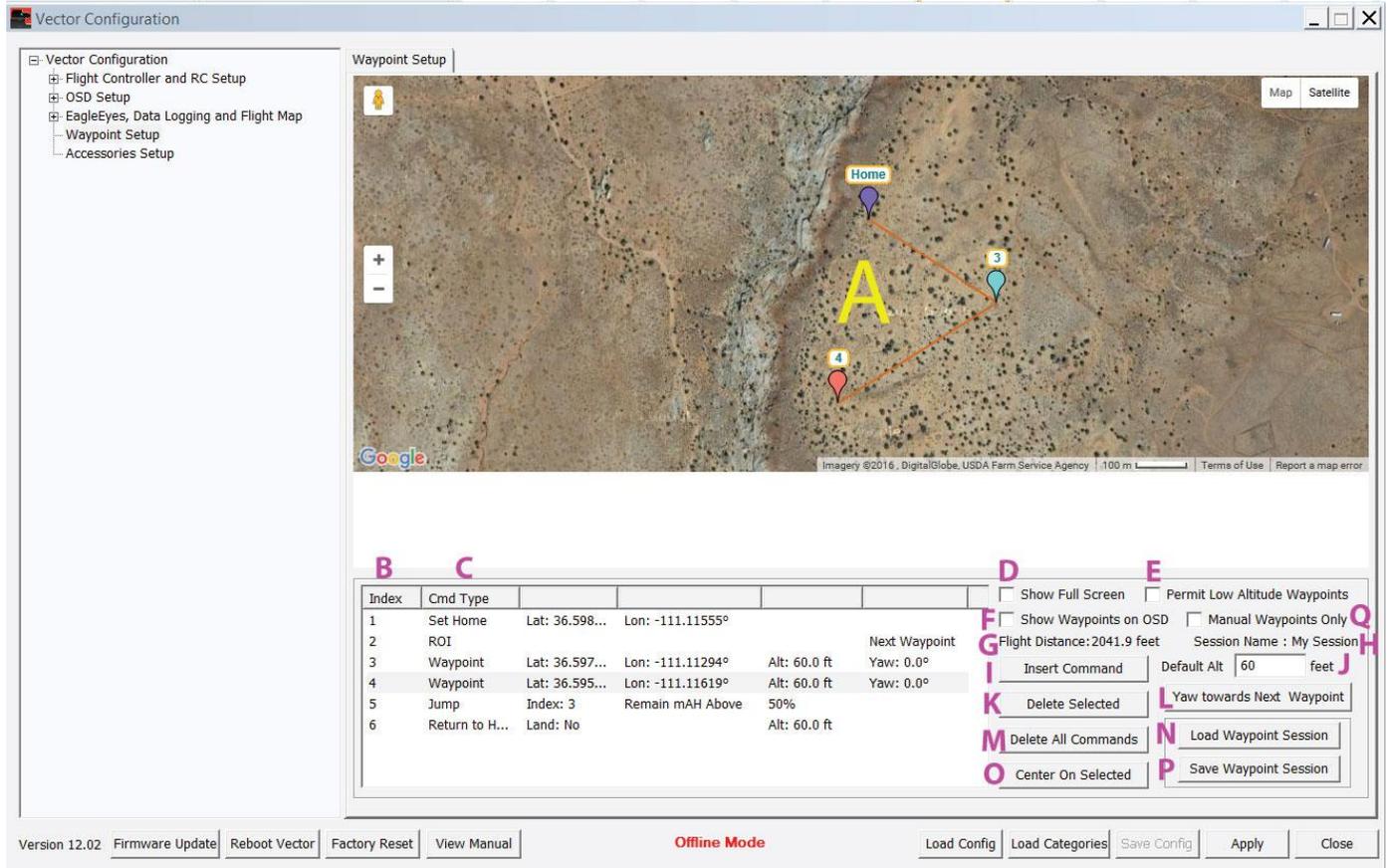
A: The waypoint map

B: The Command Index column of the waypoint command table

C: The Command Type column of the waypoint command table

D: When clicked, the waypoint map will be displayed in full screen mode. Hit ESC to exit full screen mode.

E: When clicked, low altitude waypoint navigation will be enabled. Enable this option only if you need your model to fly low to the ground during waypoint navigation.   CAUTION: enabling this option greatly increases the likelihood that your prop(s) will spin on the ground when waypoint mode is enabled!

F: When clicked graphical "birds-eye" view graphical waypoint icons will be displayed on the OSD screen, when Waypoint flight mode is selected. See description of graphical waypoints later in manual.

G: Flight distance indicates the approximate total distance between the first and last waypoint. Flight distance does not factor in Jump instructions.

H: The Session name is set when a waypoint session is either saved or loaded.

I: Click this button to insert a Waypoint Command after the presently selected command.

J: Each time a waypoint is added, the system will set its altitude to this default value. You can edit the waypoint altitudes later as needed, to override the default.K: This button deletes the selected command.L: (multirotor only) This button inserts a Yaw To Next Waypoint ROI command, which causes the multirotor to always point to the next waypoint in the sequence. This can be overridden with another ROI command in another command slot. The ROI behavior is changed at the time that the given ROI command gets executed.

M: This button deletes all commands.

N: Click this button to load a previously saved waypoint session from disk.

O: Clicking this button causes the map to be centered on the selected Waypoint Command.

P: Click this button to save the present waypoint session to disk.

Q: Click this checkbox if you want to only fly manual (graphical) waypoints. When this box is checked, the distance range check for waypoints is disabled. Note that when this box is checked, non-manual waypoint navigation is disabled in the Vector.

1.7.3 Using the Waypoint Map

1.7.3.1 Adding Commands via the Map

Clicking on the map adds a new command, of type Waypoint. The commands can then be moved by click and drag.

Note: a maximum of 50 commands are allowed in a single Vector Waypoint session.

1.7.3.2 Commands shown on the Map

The Waypoint Map shows only those commands that have a latitude and longitude. Additionally, if the command is a navigation type (Waypoint, Take Off, Land/Disarm, etc.) the command will be linked to other navigation commands, via lines, in the order they appear in the table. Waypoints that are not navigated to (like Set Home and ROI) are not linked.

1.7.4 Waypoint Command Navigation Behavior

This section describes specific behaviors of the Vector's waypoint controller.

1.7.4.1 GPS Fix Requirements

During waypoint navigation, the GPS fix quality must be at least as good as specified in the "GPS Fix Quality" settings on the Compass and Sensor Setup tab in the software.

If the fix quality falls below the specified requirements at any time, the following occurs:

- If there is still a fix, waypoint navigation will continue for up to 5 seconds, waiting for the fix to improve to the specified quality. If it does not improve after 5 seconds, RTH Safety mode will be invoked, until the user switches into a non-Waypoint Mode.

- If there is no GPS fix at all, waypoint navigation will pause (initiating 2DH flight mode) up to 2.5 seconds, waiting for the fix to return, and improve to the specified quality. If it does not return after 2.5 seconds, Land Safety Mode will be invoked. If the GPS subsequently reacquires a fix, RTH Safety Mode will be invoked, until the user switches into a non-Waypoint Mode.

When GPS quality issues occur, the appropriate error message(s) will appear in the OSD notification area.

1.7.4.2 Loiter Circle Radius

For fixed wing operations involving loiter, the circle radius used is specified in one of two ways:

1. The circle radius/direction specified in the "Radius" waypoint command field is always used, if one has been specified. Clockwise is positive.

2. The "RTH/Loiter Circled Radius" setting on the Safety/Nav Setup tab is used, if no loiter radius has been specified in the waypoint and a climb, descent, or delay action is required. If no loiter radius is

specified and the model would reach the specified altitude before reaching the specified location and no Delay command follows the current one, the aircraft will fly straight through the target location before loading the next command.

1.7.4.3 Fixed Wing Speed and Altitude Control during Waypoint Navigation

For fixed wing, when flying to a waypoint, the Vector will attempt to reach the altitude specified in the waypoint while in transit, but will be limited by the "Desired Climbrate" and "Desired Sinkrate" settings on the "Safety/Nav Setup" tab in the software.   Note that these settings also control the speeds used during RTH.

If the plane reaches the specified latitude and longitude before reaching the specified altitude, the Vector will loiter (circle) the plane while ascending or descending, as needed. See the section above for information on the circle radius used.

Fixed wing speed control during waypoint navigation is presently not implemented, but is planned for later. The Vector uses the "Cruise" throttle setting you specified during the Receiver Analysis Wizard, and will also attempt to honor the "Minimum Ground Speed" setting on the "Safety/Nav Setup" tab in the software.

1.7.4.4 Multirotor Speed and Altitude Control during Waypoint Navigation

For multirotors, the Vector will attempt to honor the horizontal and vertical speeds specified in the "Auto navigation ground speed", "Desired Climbrate", and "Desired Descend/Sinkrate" settings on the "Safety/Nav Setup" tab in the software.   Note that these settings also control the speeds used during RTH.

However, the Vector will limit the horizontal or vertical speed, as necessary, so that it arrives at the specified altitude when it reaches the specified latitude and longitude.   For example, when flying between two waypoints, if the climbrate is set too low for the multirotor to reach the specified altitude when traveling at the specified ground speed, it will fly at a slower ground speed.

1.7.4.5 Waypoint Arrival Detection

The Vector will consider a waypoint arrival to have occurred whenever the model is either 33 feet/10 meters from the waypoint, or within 2 seconds of estimated arrival at the waypoint.

Note that wind opposing the direction of travel could cause aircraft to never reach waypoint, if your speed settings are too low.   In this case, the Vector will continue to attempt to reach the waypoint, unless the user takes action, or an issue occurs.

1.7.4.6 Behavior at Final Waypoint

When the model reaches the final waypoint in the session, the Vector will loiter at that location, until the user takes action.

The message "Loitering at last waypoint" will appear briefly in the OSD notification area.

1.7.4.7 Low Battery Autoland

The Low Battery Autoland feature is not active during waypoint navigation, except when the multirotor is loitering on the final waypoint. In this situation, the Vector will attempt to land the multirotor.

1.7.5 The Command Table

1.7.5.1 Adding Commands to the Table

Waypoint commands are added to the command table clicking the "Insert Command" button, or clicking on the map.   To add a command at a specific point in the table, click the Index field of the waypoint preceding the insertion point, then click the "Insert Command" button.

1.7.5.2 Changing the Command Type

Click on the "Cmd Type" table column for the new command, to change the command type, if necessary. Commands are added initially as type "Waypoint."

1.7.5.3 Changing Command Order in the Table

Commands can be reordered in the table by clicking and dragging the Command Index number.

1.7.6 Command and Parameter Reference

The information below describes the available commands, and available options for each supported command.

⚠ Note that most navigation commands will result in both horizontal and vertical navigation, which will occur even at ground level if the "Permit Low Altitude Waypoints" option is enabled!

1.7.6.1 Waypoint Command

The Waypoint command causes the system to navigate to the specified position (latitude, longitude and altitude).

When the Vector begins navigation to a waypoint, the message "Navigating to Waypoint X" will appear briefly in the OSD notification area, where X represents the waypoint index.

Parameters:

- Lat: The Lat field specifies the target latitude for the command, in DDD.DDDDD format. A positive value represents North, and negative represents South.
- Lon: The Lon field specifies the target longitude for the command, in DDD.DDDDD format. A positive value represents East, and negative represents West.
- Alt: The Alt field specifies the target altitude for the command.   The target altitude must be above about 60 feet (18 meters), unless the 'Permit Low Altitude Waypoints' is enabled.
- Yaw: (multirotor) The Yaw field specifies the direction the multirotor should face when navigating to the specified location.   This field is ignored if there is an active ROI command. Values are in degrees, clockwise is positive. (East = 90.0, West = 270.0, etc)
- Radius: (fixed wing) The Radius field specifies the circling radius to use, if loitering is necessary. If set to "0," and loitering is not necessary, the model will fly straight through the target point before loading the next waypoint command. If set to "0" and loitering is necessary, the "RTH/Loiter Circle Radius" will be used instead. A positive radius indicates clockwise rotation, and a negative radius indicates a counter-clockwise rotation.

1.7.6.2 Delay Command

The Delay command causes the model to loiter at its present position, for the specified number of seconds. Normally, Delay commands are added immediately after waypoint commands, to cause the model to loiter at that waypoint's position.

When the Vector begins executing a delay, the message "Waypoint delay secs: X" will appear briefly in the OSD notification area, where X represents the specified delay time in seconds.

⊥ Fixed wing models will loiter at the radius and direction specified in the last executed waypoint command.

If the radius of the previous waypoint command was 0, the "RTH/Loiter Circle" setting on the Safety/Nav Setup tab is used.

Parameters:

- Time: The Time parameter specifies the length of time, in seconds, to delay.

1.7.6.3 Jump Command

The Jump command results in command execution continuing at the specified command index, if the specified condition is TRUE. If the condition is FALSE, the Jump command has no effect and the next command will immediately be executed.

When the Vector begins executes a Jump command, the message "Jumping to waypoint X" will appear briefly in the OSD notification area, where X represents the specified jump index.

Parameters:

- Index: The Jump Index specifies the next command to execute, if the specified condition is TRUE.

  The following conditions can be programmed to trigger a jump:
- Loop Count: The Loop Count condition specifies the number of times the jump will occur. Once the jump command has been executed more times than specified, the jump will no longer occur. The counter is cleared when waypoint execution is (re)started.
  Note: Only three (3) Loop Count type Jump commands can be inserted into a Waypoint Session.
- Remain mAH Above: The jump will occur if the remaining mAH percentage is ABOVE the specified value. Total pack mAH must be set correctly for proper operation!
- Cell Volts Above: The jump will occur if the present pack PER-CELL voltage is ABOVE the specified value. The system divides the present voltage by the number of cells to determine cell voltage.
- Remain mAH Below: The jump will occur if the remaining mAH percentage is BELOW the specified value. Total pack mAH must be set correctly for proper operation.
- Cell Volts Below: The jump will occur if the present pack PER-CELL voltage is BELOW the specified value. The system divides the present voltage by the number of cells to determine cell voltage.

1.7.6.4 Return to Home Command

The Return to Home command causes the model to fly to the home position, at the specified altitude. Note that the Return to Home command is different than the Return to Home safety feature, and does not honor the altitude or RTH mode related settings on "Safety/Nav Setup" tab in the software.

When the Vector begins executes an RTH command, the message "Returning to Launch" or "Returning to Launch and Land" will appear briefly in the OSD notification area.

Parameters:

- Alt: The Alt field specifies the fly-home altitude to use during RTH.   The altitude must at least 60ft (about 15 meters), unless the 'Permit Low Altitude Waypoints' checkbox is checked.
- Land (multirotor only) – Set this to Yes to have the multirotor land and disarm when home is reached.

1.7.6.5 Set Home Command

The Set Home command causes the GPS home latitude and longitude to be set to the specified location, so long as the specified location is within approximately 500 feet/152 meters of the actual location where the GPS gets its first good fix.

At the field, if the Set Home command executes successfully, the message "Using Waypoint 1 as Home" will appear briefly in the OSD notification area. If the specified home location is too far from the actual GPS location of the aircraft when a fix is first acquired, the home location will be set to the current GPS location.

Note 1: The altitude is zeroed when the Set Home command is executed.

Note 2: The Set Home command must be the first command in the sequence.

Parameters:

- Lat: The Lat field specifies the target latitude for the command, in DDD.DDDDD format. A positive value represents North, and negative represents South.
- Lon: The Lon field specifies the target longitude for the command, in DDD.DDDDD format. A positive value represents East, and negative represents West.

1.7.6.6 ROI Command

The Region of Interest (ROI) command causes the multirotor to yaw toward the specified region (either a specific location, or the next waypoint).   The ROI command remains in effect until another ROI command is executed.

When the Vector executes an ROI command, the message "Region of Interest set" will appear briefly in the OSD notification area.

Parameters:

- An ROI command of type Next Waypoint causes the model to yaw toward the next waypoint. The model will continue to yaw toward the next waypoint as waypoints are navigated, until another ROI command is executed.
- An ROI command of type Location causes the multirotor to yaw toward the specified position, throughout waypoint navigation, until another ROI command is executed.   The Lat and Lon parameters specify the location position.
- An ROI command of type None cancels the last ROI command. Until another ROI command is executed, the Yaw field of all position type waypoint commands will be honored while navigating.

1.7.6.7 Takeoff Command

The Takeoff command causes the model to leave the ground and navigate to the specified position. This command allows waypoint navigation to start at ground level, even if "Permit Low Altitude Waypoints" is left unchecked.

If you plan to start waypoint navigation near the ground, add the Takeoff command before any other navigation commands in the session, since the Takeoff command should cause the multirotor to climb vertically before horizontal navigation occurs.

⚠ If you initiate waypoint mode with the multirotor on the ground and do not have a Takeoff command as the first navigational command, the multirotor may start lateral movement before gaining sufficient altitude! This may cause your multirotor to "skip" or bounce on the ground and possibly flip over!"

The multirotor must be armed, and the throttle moved to at least 33% up, before the Takeoff command will execute.

The multirotor will first ascend vertically to about 49 feet (15 meters).   Then, it will begin both horizontal and vertical flight to the commanded position.

When the Vector begins executing a Takeoff command, the message "Navigating to Waypoint X" will appear briefly in the OSD notification area, where X represents the Takeoff command index (normally 1).

- Lat: The Lat field specifies the target latitude for the command, in DDD.DDDDD format. A positive value represents North, and negative represents South.
- Lon: The Lon field specifies the target longitude for the command, in DDD.DDDDD format. A positive value represents East, and negative represents West.
- Alt: The Alt field specifies the target altitude for the command.   The target altitude must be above about 60 feet (18 meters), unless the 'Permit Low Altitude Waypoints' checkbox is checked.
- Yaw: (multirotor) The Yaw field specifies the direction the multirotor should face when navigating to the specified location.   This field is ignored if there is an active ROI command.

1.7.6.8 Land/Disarm Command

⚙ The Land/Disarm command causes the model to land and disarm, after reaching the specified position (latitude, longitude, and altitude).

When the Vector executes a Land/Disarm command, the message "Landing" will appear briefly in the OSD notification area.

The Land/Disarm command will cause the model to descend from its specified position, even if "Permit Low Altitude Waypoints" is not enabled, allowing for automatic landing regardless of this setting.

- Lat: The Lat field specifies the target latitude for the command, in DDD.DDDDD format. A positive value represents North, and negative represents South.
- Lon: The Lon field specifies the target longitude for the command, in DDD.DDDDD format. A positive value represents East, and negative represents West.
- Alt: The Alt field specifies the target altitude for the command.   The target altitude must be above about 60 feet (18 meters), unless the 'Permit Low Altitude Waypoints' checkbox is checked.
- Yaw: (multirotor) The Yaw field specifies the direction the multirotor should face when navigating to the specified location.   This field is ignored if there is an active ROI command.

1.8 Flying Waypoints

1.8.1 Troubleshooting Problems

We want to help you to track down any issues you encounter during the waypoints beta.   But, we need as much of the below information as possible to be able to do this:

- Flight logs (.FDR and .GLF files) – make sure you clear the recorder's buffer before each flight, and make sure you download data immediately if a problem is encountered.
- Waypoint session (.WPT file) – save your waypoint session before making changes to it, if a problem is encountered.
- Configuration setting (.TXT file) – save your configuration before making changes, if a problem is encountered.
- Inflight video, showing the OSD – try to record your flights using an onboard or ground based DVR.

Please open a support ticket with us at http://ticket.eagletreesystems.com with as much of the above information as you have, when reporting waypoint issues.

1.8.2 Setting up your Mode/Submode Switch

Waypoint mode is triggered by specifying the "Waypoint" mode on either your Mode or Submode Switch. When the switch is moved to that position, Waypoint mode is triggered.

⚠️ Always assume that the prop(s) may spin when the switch is moved to the Waypoint mode position!

1.8.3 Waypoint Display on the OSD

1.8.3.1 Graphical Waypoint Display

To display a "birds-eye" graphical view of the waypoint session on the OSD screen when Waypoint flight mode is selected, check the "Show Waypoints on OSD" checkbox on the Waypoints setup tab in the GUI. Note that when this box is checked, the RADAR radius setting will be automatically adjusted each time Apply is clicked, so that all waypoints will be visible on the OSD screen.

Note 1: This setting is different than enabling graphical waypoints in the advanced OSD setup page. When those waypoints are enabled, they will display on the OSD all the time, rather than just when Waypoint flight mode is selected. If you are seeing graphical waypoints all the time, you need to turn off waypoint display on the advanced OSD setup.

Note 2: After changing graphical waypoint/RADAR settings from the OSD stick menus, it's necessary to reset the home position or reboot the Vector before these changes will be applied to the OSD display.

1.8.3.2 Distance to Next Waypoint Readout

To display the distance to the next waypoint, under the Distances section of the Advanced OSD Screen Setup tree view, add the "Distance to Waypoint" readout to the OSD screen.

1.8.4 Starting a Waypoint Session

1.8.4.1 Throttle Position

When flying waypoints, if a problem related to GPS or compass is detected, the Vector will at least temporarily switch to 2D With Hold flight mode. So, it's strongly recommended that your throttle be left in an appropriate "Cruise" position while the Waypoint session is executing.

For multirotors, since rapid descent could occur if the throttle is below the midpoint when not in Waypoint mode, it is recommended to keep the throttle at its midpoint during waypoint navigation.

If, during waypoint navigation, your throttle position is moved to below about 33% up, Waypoint mode will pause, returning control to the pilot and placing the Vector in Loiter Mode temporarily.

For fixed wing, if the throttle position is reduced to below about 15% up, the waypoint navigation will continue but, for safety, the Vector will command the throttle to be at its "throttle off" position. This should normally stop the propeller from spinning. So, the model will ultimately crash land unless throttle is increased! The message "Safety check fail, throttle off" will appear in the OSD notification area if this event occurs.

1.8.4.2 Initiating Waypoint Mode

⊥ When your model is flying at a safe altitude, with the throttle stick moved to at least 15% up, move the Mode Switch to the "Waypoint" position to begin waypoint navigation.

Note that if "Permit Low Altitude Waypoints" was NOT checked when waypoints were configured, the following may cause the throttle to shut off during Waypoint mode:

- Waypoint mode is triggered below about 32 feet (10 meters).
- During waypoint navigation, the plane descends below about 32 feet (10 meters).

Also, note that if your airspeed (or ground speed, if the pitot tube is not in use) is less than 3MPH/5KPH during Waypoint mode, the throttle will shut off.

The message "Safety check fail,throtle off" will appear in the OSD notification area if any of these conditions is detected.

⚜ When your multirotor is armed and at a safe altitude, and the throttle is moved to above 33% up, moving the Mode Switch to the "Waypoint" position will trigger waypoint navigation.   If ground takeoff is desired, make sure your first navigational command is the "Takeoff" command. Then arm the multirotor, switch to Waypoint Mode, and move the throttle at least 33% up to start the waypoint sequence.

When Waypoint mode is triggered, the message "Waypoint navigation started" will appear briefly in the OSD notification area.

1.8.5 Pausing and Aborting Waypoint Navigation

1.8.5.1 Pausing Waypoint Navigation

Waypoint navigation will pause if one of the following events occurs:

- The Vector detects a problem with the GPS or compass. 2D with Hold flight mode will be entered, and waypoint navigation will resume at the current command if the GPS issue quickly corrects itself (see the GPS Fix Requirements section above).

⊥ For fixed wing, if the control stick is moved (excluding rudder and throttle). 2D with Hold flight mode will be entered, and waypoint navigation will resume at the current command once the control stick is released.

⚜ For multirotors, if the control stick is moved (excluding rudder), or the throttle is reduced to below 33% up. 2D with Hold flight mode will be entered, and waypoint navigation will resume at the current command once the control stick is released, and the throttle is moved to above 33% up. Note that if this movement occurs during a Land/Disarm command, waypoint mode will be aborted, and the flight mode must be changed from Waypoint mode to another mode, then back to Waypoint mode, in order to restart the Waypoint mission.

- The flight mode is changed to a GPS Mode (such as Loiter) via the Mode or Submode Switch. Waypoint navigation will resume at the current command if the mode is switched back to type Waypoint.

When Waypoint mode is paused, the message "Pausing waypoint navigation" will appear briefly in the OSD notification area.

When Waypoint mode is resumed, the message "Resuming waypoint navigation" will appear briefly in the OSD notification area.

1.8.5.2 Aborting Waypoint Navigation

Waypoint navigation will be aborted if one of the following events occurs. Once waypoint navigation is aborted, retriggering waypoints with the Mode or Submode Switch will result in waypoint navigation restarting at the first waypoint command.

- The Vector detects a problem with the GPS or compass, which continues longer than described in the GPS Fix Requirements section above.
- The flight mode is changed to a non-GPS Mode (such as 2D with Hold) via the Mode or Submode Switch.
- RTH or Failsafe Safety mode is triggered for any reason.   Note that this does not apply to the Return to Home waypoint command.
- Other Vector detected problems may abort waypoint navigation.

When Waypoint mode is aborted, the message "Waypoint navigation aborted" will appear briefly in the OSD notification area.

1.8.5.3 Landing

Never attempt to manually land your model in Waypoint Mode! Always switch to a different mode before landing.