

# Navigation modes

---

*in the Pitlab & Zbig FPV system*

## Table of Contents

- Table of Contents.....1
- Overview .....1
- Base point navigation.....3
- RTH Return To Home .....4
  - Altitude Modes in RTH .....5
- Takeoff .....6
- Circling at GPS point.....7
- Auto hold course and altitude .....7
- Manual waypoint navigation.....8
- Autonomous waypoint navigation .....9
- RTR – Return to Runway .....9
- Manual landing with ILS.....10
- Automatic landing with ILS.....11
- Route.....11
- Navigation modes summary.....12

## Overview

The phrase “Navigation Mode” or simply Navigation as used in the Pitlab & Zbig FPV System refers to a specific type of autopilot behavior and the accompanying information presented on the OSD screen to support that behavior. The autopilot behavior may include manual, assisted or fully automated flight control to a location or along a route. The information displayed on the OSD includes course direction, distance, and altitude; these can be relative to a particular GPS point such as the base (home) position, a destination point, a temporary target or a waypoint. During flight a pilot can change navigation points and the system will provide guidance to the next selected point, either manually or automatically.

The types of navigation points used in system are:

- **Base** – The starting point (home position)

- **RW** – The currently selected runway in manual flight
- **Land** – The beginning of the approach path and then the runway in autonomous landing
- **WP** – Waypoints
- **(\*)** – An ad hoc circling point
- **Route** – A path of travel following a set of vertices
- **HOLD** – A temporary, virtual point 5km ahead in autonomous hold course and altitude mode

These navigation points may be selected in several ways, either manually or automatically:

- By using the AP mode switch on the RC transmitter
- If in AUTO mode, by selecting a throttle level
- By using the OSD menu system (using the OSD mode switch on the transmitter)
- By making an OSD layout change (using the OSD mode switch on the transmitter)
- By the RC system going into failsafe (RC link failure or beyond RC range)

The Autopilot has 4 modes of operation:

- **OFF** – full manual flight, where the pilot controls the airplane as if there is no autopilot. All controls pass directly from the RC receiver to the control surfaces and throttle.
- **STAB** – manual flight with stabilization, where the autopilot assists the pilot with easier control of the airplane’s position, avoiding unexpected movements caused by turbulence or wind.
- **TAKE** – a sub mode of STAB with additional climbing support for fast, controlled takeoffs.
- **AUTO** – autonomous flight, where the autopilot takes full control of the airplane. It has many sub-modes, each with different autopilot behaviors.

In the PitLab system, a **navigation point** determines **where** you want to fly, and the **autopilot mode** determines **how** you want to fly there.

The combination of all navigation points together with the autopilot modes makes for many different system states and different system behaviors as summarized in the following table:

OSD Display	Flight Behavior
<b>Auto, (*)</b>	The autopilot performs an <b>AUTO Circle</b> at a given GPS point
<b>Auto, Hold</b>	The autopilot controls Auto altitude and course <b>Hold</b> (for 5 km)
<b>Auto, Wp X</b>	The autopilot controls flight to <b>Waypoints</b>
<b>Auto, Route</b>	The autopilot controls flight through a <b>Route</b>
<b>Auto, Base</b>	The autopilot controls Auto <b>RTH</b> - Return to home (base or starting point)
<b>Auto, RWxxx</b>	The autopilot controls Auto flight to <b>RTR</b> - Return to runway
<b>Auto, Land</b>	The autopilot controls an Auto <b>Landing</b>
<b>Stab/Off RWxxx</b>	OSD displays information for a manual or stabilized <b>ILS</b> landing.
<b>Stab/Off, Base</b>	OSD displays information for flying to the <b>Base</b> location manually or with stabilization
<b>Stab/Off, Wp X</b>	OSD displays information for manual or stabilized flight to a <b>Waypoint</b>
<b>Stab/Off, Route</b>	OSD displays information for manual or stabilized flight through a <b>Route</b>
<b>Stab, TAKE</b>	The autopilot provides assistance for a stabilized <b>Take-off</b>

Additionally, some Auto modes may have several different phases during flight (e.g. in auto landing mode the autopilot first flies to the beginning of an approach path at a given altitude, then follows the approach path, then cuts the engine at a low altitude, and finally touches down).

*Note: AUTO (autonomous flight) and Stab (Stabilized) modes are available only when flying with both an OSD and Autopilot (the complete PitLab set).*

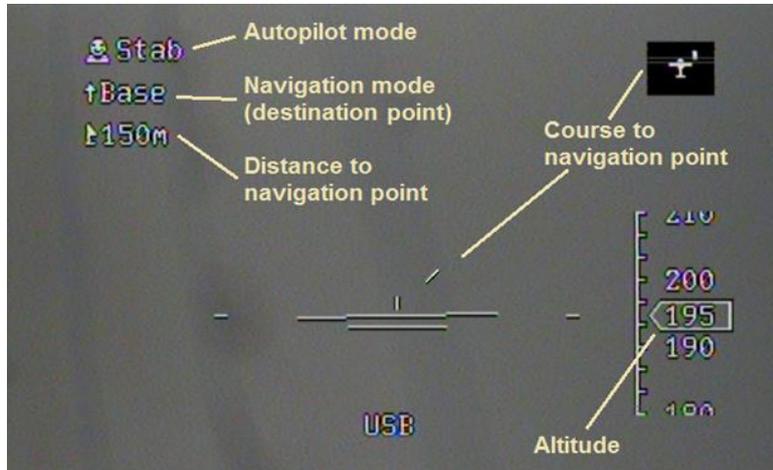


Figure 1 – Simplified OSD screen with navigation relative fields

All data shown on the OSD screen is **airplane relative** not **base relative**. The OSD graphics are displayed from the position of the pilot in the airplane (like in real full-scale airplanes), NOT from the position of a pilot sitting on the ground. This means, for example, that the course indicator shows where the base location is relative to the airplane's current course and position, not from the position of where the FPV pilot is on the ground. The same applies to waypoint locations and ILS navigation information. At first this may seem strange, but it really is the most natural approach. After several flights everything becomes obvious and the FPV pilot feels like he or she is actually sitting inside the airplane, not on the ground.

When defining an OSD screen layout using the FPV Device Manager application, the Autopilot mode will be shown in the field called "Autopilot info" and the navigation mode name will be displayed in the "Navigation mode" field.

## Base point navigation

Navigation to the base point is the default navigation mode after system startup in all manual modes (OFF/STAB and TAKE) and in autonomous RTH mode. In this mode, the OSD shows the distance and course to the base. Base point mode allows for the easiest recognition of the airplane's actual location relative to the FPV pilot's location, and safe return to the starting point. The base position is set automatically when the system first obtains valid GPS coordinates at startup or when the "Store base" command is executed from the OSD menu.

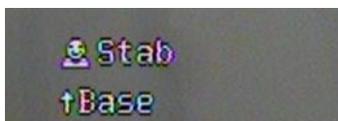


Figure 2 – Navigation to base point in manual (STAB) mode

## RTH – Return To Home

In RTH mode the autopilot will autonomously fly back to the base (home) point. In this mode the OSD shows the distance and course to the currently defined base. This mode allows safe, autonomous return to the starting point if the RC link is lost. The pilot can also invoke RTH directly by activating AUTO/RTH mode.

In order to directly activate Auto RTH mode (autonomous flight to the base point):

- Change autopilot mode to AUTO (using the autopilot mode switch on your transmitter).
- Move throttle stick to low position (PPM pulse below 1250 microseconds or below ¼ throttle).

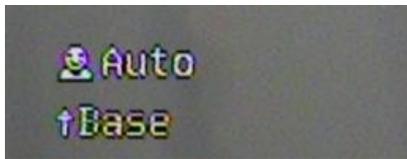


Figure 3 – OSD display when navigating to the base point in autonomous (RTH) flight

The Autopilot activates RTH mode automatically when there is no signal from the RC receiver. In this case the Autopilot mode field on the OSD will blink and show both **Auto** and **-RC** messages.



Figure 4 – OSD display of Autopilot mode field in the case of RC failure or signal loss

RTH mode can also be activated when the RC receiver is out of range or the transmitter stops sending a valid signal (e.g. transmitter failure or low battery). Using this feature requires that the RC receiver's **failsafe** feature be configured so that when triggered, it forces the receiver's output channels to set **Auto** mode and **throttle low**.

*Note: To avoid any unexpected behavior in the case of RC link loss, the OSD menu RC channel should be set to the neutral position during failsafe. Other channels are unimportant for the autopilot system but of course the pilot should properly set the receiver's failsafe outputs for flaps, landing gear, head tracker, etc. depending on an individual plane's setup.*

Note: If you are using an LRS relay system with two sets of transmitters and receivers, it is critical that failsafe be set on both receivers. It is common for pilots flying long range to use their hand-held radio transmitter to send the RC signal to a short-range receiver (1 in Figure 5) on a tall mast. There, the short-range receiver is hard-wired to an LRS transmitter and the RC control is relayed to the LRS receiver on the plane (2 in Figure 5). When using this type of setup, for maximum safety in case of RC problems, both receivers (1) and (2) must have proper failsafe settings.

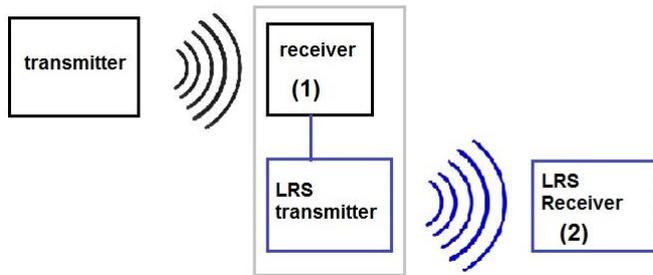


Figure 5 – RC link with retransmission and LRS

Refer to your RC and LRS system manuals for failsafe setting procedures.

## Altitude Modes in RTH

In Auto/RTH mode the autopilot not only keeps the plane on a course to the base, but also controls cruising altitude using the throttle and elevator. The altitude during Auto/RTH is set based on settings made in the **OSD->Autopilot->Altitude** submenu. There are three types of options for determining the autopilot’s altitude control behavior in an RTH situation.

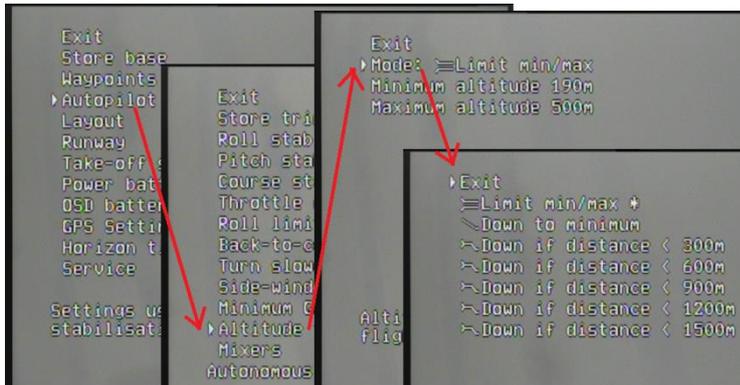


Figure 6 – Altitude settings menu structure for RTH mode

Altitude Mode **Limit min/max**: In this mode the autopilot keeps the airplane within given altitude limits **Minimum** and **Maximum**. If the airplane is below Minimum altitude when RTH is invoked, the autopilot will increase the plane’s altitude until the airplane reaches the specified minimum and then maintain that altitude while flying toward the base point. This behavior is used to avoid obstacles such as trees or buildings on the route home. If the airplane is above the specified Maximum altitude, the autopilot will immediately decrease the plane’s altitude until the airplane reaches the maximum altitude and then continue flying to the base at this altitude. By flying at a maximum altitude, the likelihood of regaining the lost RC link is improved due to a clearer line-of-site. Also, the plane may be visible sooner if flying at a higher rather than lower altitude. If the airplane is between the specified minimum and maximum altitudes when RTH is invoked, the autopilot will keep the plane at the current altitude during the flight back home.

Altitude mode **Down to minimum**: In this mode the autopilot flies to home controlling altitude so the minimum altitude is reached at the base point. In terms of battery consumption, this is likely the most economical way of flying back home. When this option is chosen, if the airplane is below the specified minimum altitude, the autopilot will immediately increase the plane’s altitude to the minimum and then maintain this altitude while flying toward the base point. If the airplane is above

the specified minimum altitude, the autopilot will decrease altitude proportionally to the distance to the base in order to reach the minimum altitude when the airplane arrives at the base point. The autopilot in effect flies a straight path from the current altitude to a point "Minimum altitude" above the currently defined base. At times, this may involve lowering the throttle to the lowest position and gliding.

Altitude mode **Down if distance less than...** : In this mode, regardless of the current altitude, the autopilot will change altitude to reach the specified maximum altitude and then fly toward the base at that maximum altitude. When the distance to the base is less than the specified distance, the autopilot will fly down to the selected minimum altitude in the same way it would in **Down to minimum** mode, i.e. in a straight line. This allows you to avoid very high obstacles such as power lines, factory chimneys and hills when flying back home.

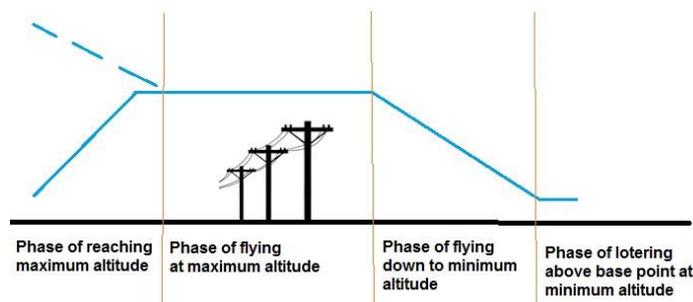


Figure 7 – Auto RTH flight in "Down if distance" mode

In all **RTH modes**, after reaching the base point the autopilot will fly in a figure-8 pattern with the base point at the center. The autopilot will repeatedly attempt to hit this center point at the required altitude, then make a turn, alternating the turn direction each time.

The radius of each turn depends on the autopilot settings, airplane characteristics, wind speed and wind direction.

*Note: The default autonomous flight destination point (including in failsafe conditions) can be changed from the base to a selected runway in ILS/RTR (Return To Runway) or LAND (automatic landing) mode.*

## Takeoff

Takeoff is a modification of Manual STAB mode and is not associated with a particular navigation mode; it may be used with manual Base, Waypoint or Route mode. In this mode the autopilot will control the climb speed and angle, stabilizing the airplane to avoid any unexpected changes in position or course, while still allowing the pilot to manually control the airplane at any time. This mode should be activated before takeoff when the airplane is still on the ground. For a full description of Takeoff mode please refer to the manual "**Takeoff Support in Pitlab FPV System**" available in PDF format on the Pitlab website.

In order to activate Takeoff mode:

- change autopilot mode to STAB (using the autopilot mode switch on your RC transmitter)

- Use the OSD control switch to select the OSD menu command **Takeoff support->Activate takeoff now**

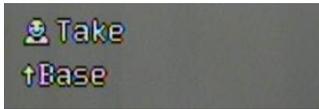


Figure 8 – Takeoff mode

To set the system so takeoff mode is the default mode every time the system is powered-up, set the OSD menu option **Takeoff support->Takeoff on startup:** to **Yes**.

## Circling at GPS point

When this mode is activated the airplane's current GPS position is stored internally and the autopilot will circle around this point in an approximately 100 meter (330 foot) radius. In this mode, the course and distance displayed on the OSD are relative to the currently stored temporary GPS point. The autopilot maintains at least the current altitude, but if the airplane is able to climb at the current throttle setting (e.g. high fixed throttle or strong thermal currents), the autopilot allows the plane to increase in altitude. This may be useful for gliding and climbing in thermals until the wind moves the upward thermal current to a different location.

To activate Auto Circling mode:

- Change autopilot mode to AUTO (using the autopilot mode switch on your transmitter).
- Move the throttle stick to its maximum position (PPM pulse above 1750 microseconds or between more than  $\frac{3}{4}$  throttle).

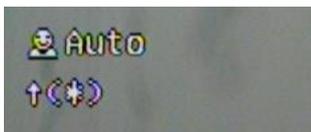


Figure 9 – OSD screen in Auto Circling mode

In Auto Circling mode the pilot may change the circling direction by moving the aileron stick to the maximum left or right position until the direction has changed. When the circling direction is changed, the center point remains unchanged.

## Auto hold course and altitude

Auto HOLD mode is used to fly in a straight course at the current altitude. For safety reasons, after 5 kilometers (3 miles) of autonomous flight the autopilot will circle at that GPS endpoint while maintaining the same altitude.

In order to activate Auto HOLD mode:

- Change autopilot mode to AUTO (using the autopilot mode switch on your transmitter).
- Move the throttle stick to the middle (half) position (PPM pulse between 1250 and 1750 microseconds or between  $\frac{1}{4}$  and  $\frac{3}{4}$  throttle).

- If waypoints navigation mode was previously set, it will need to be deactivated by setting HOLD mode again (OSD menu **Waypoints->Auto/Mid: Hold course & altitude**).

*Note: After system startup waypoints are inactive and the default behavior for Auto + throttle mid is HOLD mode.*

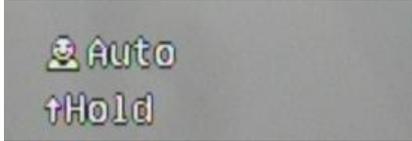


Figure 10 – OSD information in Auto Hold mode

In Auto HOLD mode the autopilot keeps the current flight altitude unless the current altitude is less than the configured minimum altitude for autonomous flight (set in OSD menu **Autopilot->Altitude->Minimum Altitude**). In that case, the autopilot will increase altitude to the minimum and maintain that minimum during flight.

In Auto HOLD mode the autopilot attempts to maintain the airplane's course (a straight path travelling over the ground), not the airplane's heading. In case of a side wind, the airplane's heading may change to compensate for drift caused by wind. This is commonly known as "crabbing."

During HOLD mode deflecting aileron and elevator sticks more than 30% will change flight altitude and flight course. Aileron sticks changes flight course, and elevator stick changes flight altitude. The more stick is deflected, the faster altitude or course is changed. As long as sticks is deflected new course or altitude is shown on OSD screen replacing "HOLD" text.

After each stick deflection (course/altitude change) autopilot will prolong 5km safety distance.

## Manual waypoint navigation

In this mode the OSD will guide the pilot to a waypoint by displaying the distance and course to that point. When the airplane flies within 60 meters (200 feet) of the waypoint, the current waypoint is changed to the next defined waypoint and navigation continues to this next waypoint. When the last waypoint is reached, the navigation display remains on this last waypoint.

In order to activate manual waypoint mode:

- Select a waypoint from the OSD menu **Waypoints->(selected waypoint)->Start flying from this waypoint**.
- Change autopilot mode to STAB or OFF (using the autopilot mode switch on your transmitter).

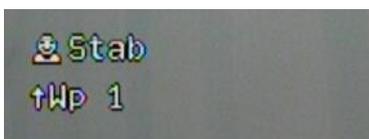


Figure 11 – Manual waypoints navigation mode

To deactivate Waypoint navigation mode, execute the OSD menu option **Waypoints->Auto/Mid:**. After that this option will change from **Auto/Mid: Fly through waypoints** (current mode) to **Auto/Mid: Hold course & altitude** (default mode after startup).

## Autonomous waypoint navigation

In this mode the autopilot will guide the airplane to the selected waypoint. When the plane flies within 60m (200 feet) of the waypoint, the current waypoint is changed to the next defined waypoint and the autopilot resumes flying to that next waypoint. When the last waypoint is reached, the autopilot will circle above the GPS position of that last waypoint.

In order to activate autonomous waypoint mode:

- Select a waypoint from the OSD menu **Waypoints->(selected waypoint)->Start flying from this waypoint.**
- Change the autopilot mode to AUTO (using the autopilot mode switch on your transmitter).
- Move the throttle stick to the middle (half) position (PPM pulse between 1250 and 1750 microseconds or between  $\frac{1}{4}$  and  $\frac{3}{4}$  throttle).

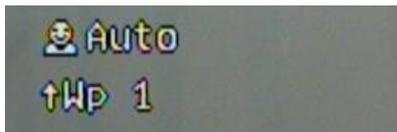


Figure 12 – Autonomous flight in waypoints mode

To cancel (deactivate) Waypoint mode, execute the OSD menu option **Waypoints->Auto/Mid:**. After that this option will change from **Auto/Mid: Fly through waypoints** (current mode) to **Auto/Mid: Hold course and altitude** (default mode after startup).

If you change the throttle stick position to a different position (max or min), the mode will change to circling or RTH/RTR accordingly.

When in this mode, switching the autopilot mode switch from AUTO to STAB/OFF will change from autonomous into manual waypoint navigation mode.

## RTR – Return to Runway

This mode is similar to RTH (Return To Home) mode, but instead of returning to the starting point (the base), the autopilot will guide the airplane to a selected runway, and then loiter above the TDP (Touch Down Point) defined for that runway. The autopilot will not land autonomously, but will maintain altitude above this point until the FPV pilot takes control of the airplane, or until the battery dies and the airplane eventually glides to a touch-down close to the runway. This mode is useful in an emergency when the base (starting) point is not suitable for an emergency landing, but the runway is. This may also be used in case of problems during long range flight. In this situation the pilot can define a new runway on the fly using the OSD menu **Runways->(selected runway)->Use current GPS position**, select it for RTR and then turn off the transmitter, pack his belongings and

drive to this GPS point to (hopefully) pick up the airplane from the ground nearby, or (even better) take manual control of the airplane if it is still flying over this emergency runway.

In order to activate Auto RTR mode:

- Select an OSD layout with the ILS field active.
- Select a runway from the OSD menu **Runways->(selected runway)->Select**
- Change autopilot mode to AUTO (using the autopilot mode switch on your transmitter)
- Move the throttle stick to the low position (PPM pulse below 1250 microseconds or below ¼ throttle)

*Note: This autopilot mode setting and throttle position are the same as used for normal failsafe. This allows this mode to be maintained even when the RC transmitter is turned off.*

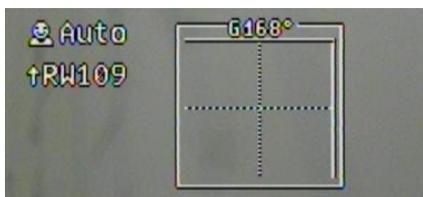


Figure 13 – Auto RTR mode with ILS field active

When RTR mode is active, changing the autopilot mode from Auto to Stab or Off allows for manual landing with the ILS feature.

## Manual landing with ILS

This mode allows the pilot to land on a predefined runway using the ILS feature and perform a safe landing even in darkness, fog, or the case of a camera failure. The approach and landing are displayed on the OSD according to previously stored parameters such as an approach azimuth and glideslope angle. For a full description of the ILS feature please refer to the manual “**ILS\_in\_Pitlab\_OSD**” available in PDF format on the Pitlab website. In this mode distance and course are displayed relative to the GPS position of the beginning of the runway.

In order to activate ILS manual landing mode:

- Choose an OSD layout with the ILS field active.
- Select a runway using the OSD menu **Runways->(selected runway)->Select for ILS navigation target.**
- Change the autopilot mode to STAB or OFF (using the autopilot mode switch on your transmitter).

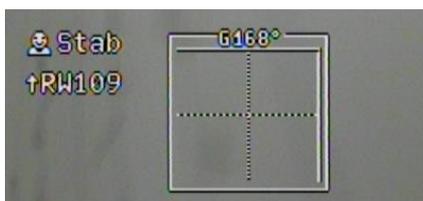


Figure 14 – Manual landing with ILS mode

When manual ILS landing mode is active, changing the autopilot mode to AUTO will change the navigation mode to RTR (Return To Runway).

## Automatic landing with ILS

In Automatic landing mode the autopilot performs the entire landing procedure. The autopilot flies to the beginning of a runway's approach path, circles there while attaining the proper altitude (and proper glideslope angle), then follows the approach path toward the runway, cutting off the engine at a low altitude and finally landing on the runway. All navigation information displayed on the OSD (distance, course) is initially relative to the beginning of the approach path, but changes to be relative to the touch down point once the final runway approach begins.

For a full description of the automatic landing feature please refer to the manual "**Automatic landing in Pitlab FPV System**" available in PDF format on the Pitlab website.

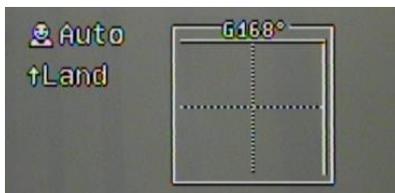


Figure 15 – Auto landing with ILS

In order to activate Automatic landing mode:

- Activate an OSD layout with the ILS field active.
- Select a runway for automatic landing from the OSD menu **Runways->(selected runway)->Select for auto landing**.
- Move the throttle stick to the low position (PPM pulse below 1250 microseconds or below ¼ throttle).

*Note: When automatic landing is active, RC failsafe and RC failure conditions will also activate automatic landing. This allows for safe landing on a distant airfield with no RC link present near the remote runway.*

## Route

In manual Route mode the system will guide the pilot (and in Auto mode the autopilot will fly autonomously) through a predefined set of GPS points in a way similar to waypoint mode – but routes are more advanced than waypoints. The system allows for the definition and use of up to 10 routes and each route may consist of up to 127 points (vertices). Additionally, a route is visualized on the OSD radar screen as a set of consecutive lines rather than single points. During flight, the OSD navigation information (distance, course) is relative to the next vertex on the route.

For a full description of the Routes feature, please see the manual "**Routes in PitlabAndZbig FPV System**" available in PDF format on the Pitlab website.

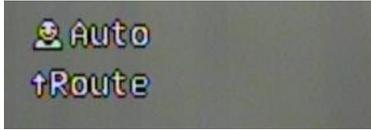


Figure 16 – Auto follow route mode

To activate manual route mode:

- Change autopilot mode to STAB or OFF (using the autopilot mode switch on your transmitter).
- Select a route using the OSD menu **Waypoints->Routes->(selected route)->From beginning** or **From nearest vertex**.

In order to activate Auto route mode:

- Select a route using the OSD menu **Waypoints->Routes->(selected route)->From beginning** or **From nearest vertex**.
- Change autopilot mode to AUTO (using the autopilot mode switch on your transmitter).
- Move the throttle stick to medium (half) position (PPM pulse between 1250 and 1750 microseconds or between ¼ and ¾ throttle).

## Navigation modes summary

Name	AP mode	Throttle	ILS layout	Runway	Waypoint	Route	Distance and course
Circle	AUTO	Up	x	x	x	x	Base
Hold	AUTO	Mid	x	x	No	No	Base
Waypoint	AUTO	Mid	x	x	Selected	No	Waypoint
Route	AUTO	Mid	x	x	No	Selected	Vertex
RTH	AUTO	Down	No	No	x	x	Base
RTR	AUTO	Down	Yes	Selected	x	x	Runway
Landing	AUTO	Down	Yes	Set for auto landing	x	x	Beginning of approach path then runway
Base	STAB,OFF	x	No	x	No	No	Base
Runway	STAB,OFF	x	Yes	Selected	No	No	Runway
Waypoint	STAB,OFF	x	x	x	Selected	No	Waypoint
Route	STAB,OFF	x	x	x	No	Selected	Base
Take	STAB,OFF	x	x	x	x	x	Base

x – not important

*We wish you many safe flights with our FPV System.*

*Pitlab & Zbig.*