Automatic landing
in Pitlab&Zbig FPV System

Overview

The automatic landing feature in the Pitlab&Zbig FPV System allows for safe and accurate model airplane landings without direct pilot involvement. It may be used in regular landings, but is also a great emergency aid in the case of reduced or no visibility (e.g. fog, darkness, drops of rain on camera lens etc.) or video link failure. In darkness and fog the ability to land in a classic way is limited due to the lack of visibility of the airplane from the ground – Pitlab's automatic landing system gets your plane back on the ground safely even in these difficult conditions. The auto landing functionality also gives you the ability to safely land at a distant runway in case of an emergency during long-range flight.

Automatic landing requires some conditions to be met in order to make it safe; all landings should always be performed with care and under the supervision of the pilot.

Automatic landing performs these steps:

1. The autopilot flies the airplane to the beginning of the approach path, reaching the proper altitude at the beginning of the approach path.
2. Flight continues along the approach path to the runway while keeping the correct course and downward glideslope.
3. The throttle is cut-off shortly before touch down.
4. The aircraft lands and rolls to a stop.

Note for airplanes with wheels: Automatic landing does not control rollout direction after touch down.

Automatic landing shares definitions and overall ideas with the OSD's **ILS** system for support of manual landing. Runway must be defined using the ILS system before automatic landings can be performed. Please see the document **ILS_in_Pitlab_OSD_en.pdf**, available on PitLab's web page for detailed information on creating and understanding runways .

Runways

The system allows for the definition and use of up to 8 different runways. Each runway is defined as the set of information necessary for proper landing. Runways may be defined using the OSD menus or the FPV Manager application. The properties required to define each runway are:

Touchdown point (TDP). The GPS position of the desired point where the airplane touches the runway surface. It should be at least several meters beyond the physical beginning of the runway (to allow for some margin of error in system accuracy). Beyond the *TDP* there must be enough free space for the airplane to loose speed and safely come to a stop after touching down. This point is defined in the FPV Manager application by dragging a defined runway around the map.

Runway AMSL. The altitude over mean sea level of runway surface. Distant runways may have different altitude than starting (base) point. This altitude is determined automatically during runway definition. This altitude is given by map provider when defining runways in FPV_manager, or taken from GPS when defining runway from OSD menu. For local (near) runways it is recommended to change runway altitude to base level in OSD menu **Runways->(selected runway)->AMSL** option.

Runway name. The two-letter shortcut name for the runway (e.g. NY or LA). This shortcut will be concatenated with the approach path course creating the unique runway identifier (e.g. NY054 or LA150) shown on the OSD screen when a runway is selected for landing. If the shortcut is omitted (empty) the system uses the generic **RW** symbol for the runway shortcut.

Approach path course. The airplane course in degrees (0 is traveling from south to north) when landing. This is a straight vector. Each defined runway has only one approach course (this is different from regular runways at airports). If your runway allows more than one approach course, you need to define several runways and select the proper one according to current needs or conditions (e.g. wind direction).

Glideslope angle. How steep the approach path should be in degrees from horizontal. This is dependent on the airplane's flight characteristics and local conditions (e.g. obstacles, like trees just before the runway). The smaller the glideslope angle, the more space that is required before and after the TDP for safely landing (due to limited accuracy of airplane positioning). This glideslope should be selected close to real airplane slope when gliding without power. To estimate glideslope you may check which distance your airplane may glide when loosing 10m altitude:

Distance	**glideslope**
47 m	12 deg
57 m	10 deg
51 m	11 deg
63 m	10 deg
71 m	8 deg
82 m	7 deg
95 m	6 deg
115 m	5 deg
145 m	4 deg
190m	3 deg

Runway width and length. These values are used only for proper visualization of the runway on the OSD screen. Distances are provided in meters. This information is not used in controlling the flight path.

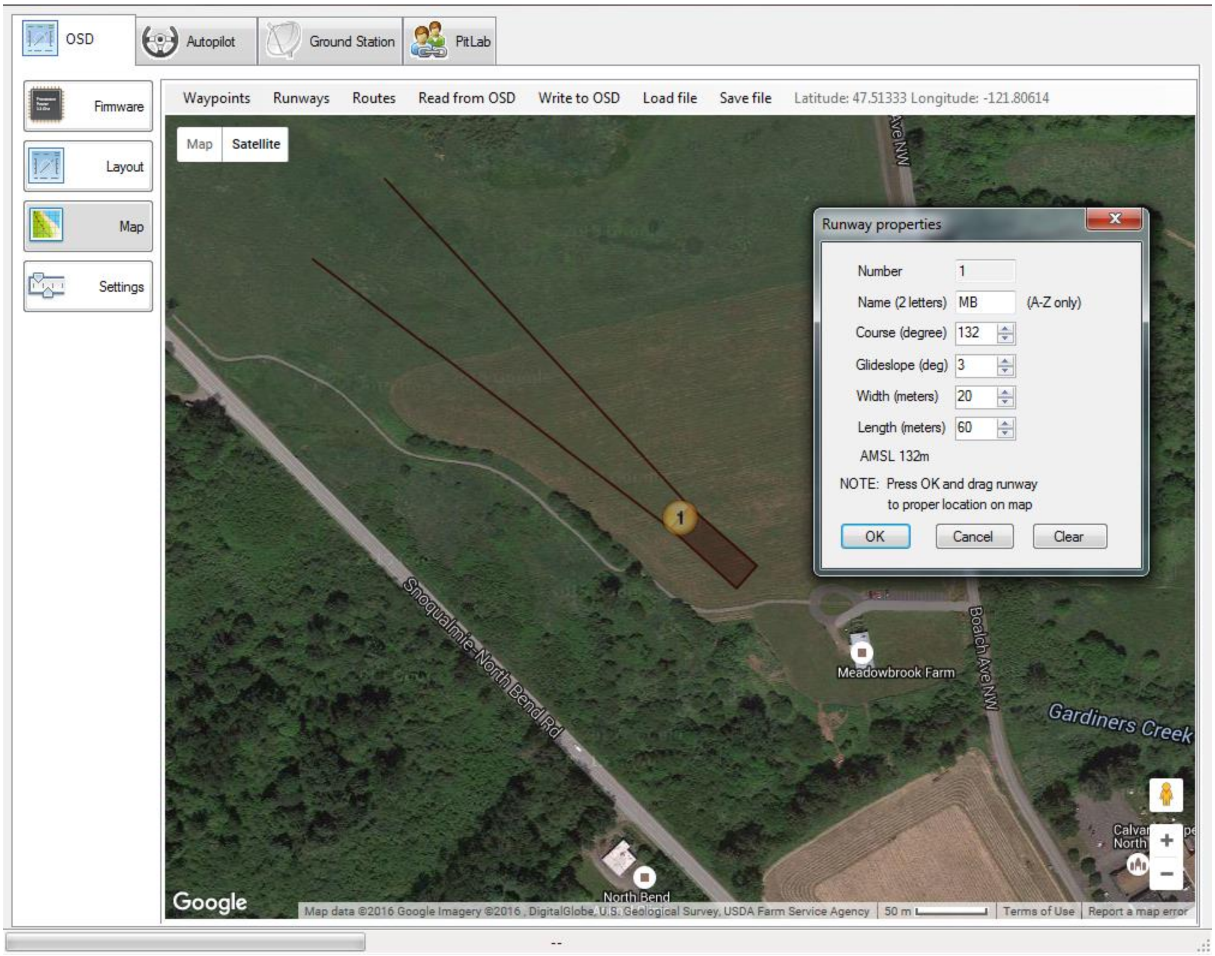

Figure 1 – Using the FPV Manager application to define a runway.

There are several other parameters that apply to all runways. These must be set using the OSD menu system, they cannot be set using the FPV Manager application. These parameters are:

Approach path length. Each automatic landing starts from a point along the approach path course at this distance out from the TDP. Along with the glideslope angle this length defines the point before the runway at a particular altitude where the airplane should begin the landing process (start approach to land).

Runway visualization. This determines how a runway will be shown on the OSD screen (radar). There are two options: **Proportional** – the runway is displayed on the OSD as a quadrilateral imitating a real runway, or **Small rectangle** – the runway is shown as a small rectangle, saving OSD screen space.

Path visualization. This determines how the approach path is shown on the OSD screen (radar). Three options are available: **None** – The approach path is not visualized at all (except as an asterisk on the radar screen at the beginning of the approach path), **Single** – The appraoch path is displayed as a single line, **Funnel** – Both left and right edges of the approach funnel are shown on the OSD screen.

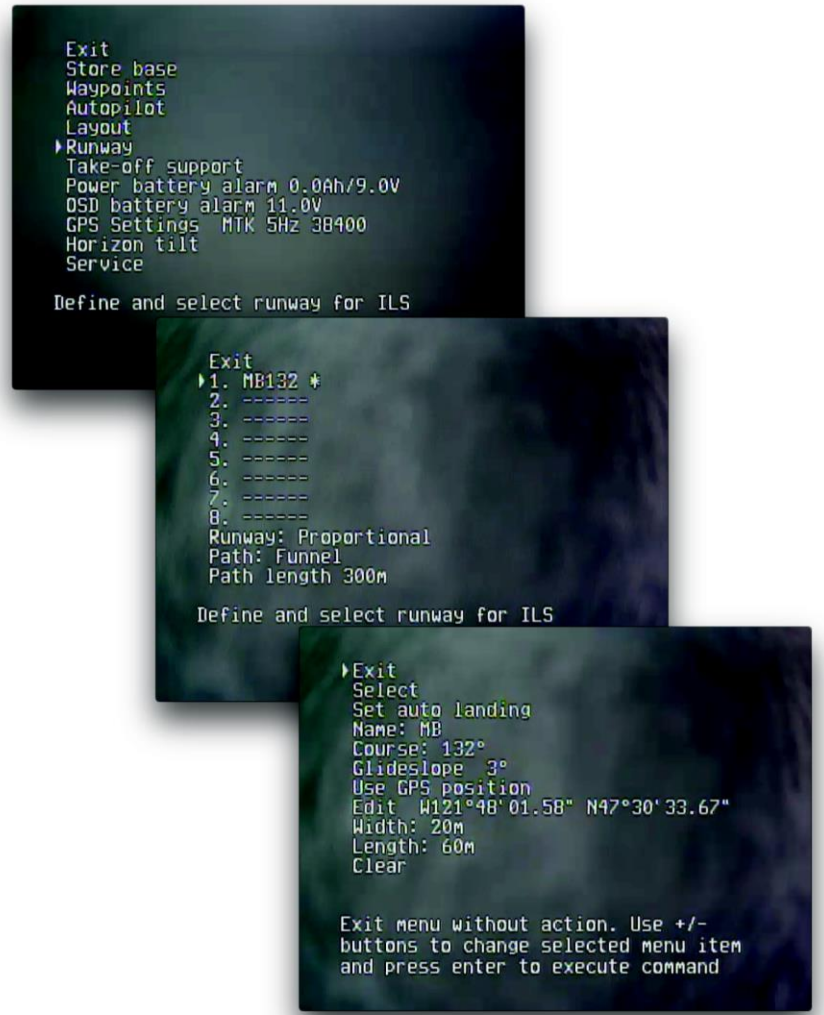

Figure 2 – Runway configuration menus in OSD

Approach to landing

When the automatic landing feature is turned ON, the autopilot will direct the airplane to a starting point on the approach path before the runway at the specified distance (as set in the **Runway->Approach path length** setting) at an altitude calculated from the specified approach path length and runway glideslope angle. This starting point is calculated according to the standard trigonometric formula: altitude = approach path length * tangent (glideslope angle). For example, given an approach path length of 600 meters (2000ft) and a glideslope angle of 5 degree the starting point for the landing will have an altitude of 52 meters (600m * tangent(5) ≈ 52m) (170 ft). The autopilot will fly the plane to the starting point, climbing or descending at a safe angle as necessary. If upon reaching the GPS position of the starting point the airplane is at a different altitude than the calculated target, it will circle next to this point until the desired altitude is attained.

After the plane has reached the required starting point, the autopilot will then start to fly towards the runway, gradually decreasing altitude and following the approach path. 15 meters before reaching the touchdown point or at altitude of 4m (whichever comes first), the autopilot will cut off the engine. This is important for airplanes without wheels (gliders, flying wings) to prevent broken propellers and avoid any other damage.

Note: It is important to set glideslope angle in runway definition close to airplane ability to glide, unless airplane may land before runway.

If during the landing process the pilot interrupts the landing procedure (by changing autopilot's mode from AUTO to STAB/OFF or by moving throttle UP), and then engages auto landing again, the autopilot will return the plane to the starting point and restart the entire landing procedure from the beginning.

Activation

Several steps are required to perform an automatic landing:

Before the flight, these steps must be completed:

1. Define at least one runway.
2. Define an OSD layout with an active ILS field. Refer to the document: ILS_in_Pitlab_OSD_EN.pdf for details.

During flight, these steps must be taken to prepare for the automatic landing:

1. Select an OSD layout that displays the ILS field.
2. Select a runway for the automatic landing using the OSD menu **Runway->(selected runway)->Set** for **auto landing**.

    Note: At this point after automatic landing has been prepared, failsafe (loss of RC control) will engage the current auto landing procedure instead of regular RTH mode.

To start the automatic landing procedure during flight:

1. Select AUTO mode for the autopilot
2. Move the throttle stick to minimum.

The OSD will confirm the activation of the auto landing procedure by showing **↑Land** in the navigation field.

Replacing regular RTH mode with auto landing is very important for long range flights and allows the Autopilot to safely land on a distant (backup) runway when there is no possibility of returning safely to home (e.g. empty battery, strong wind). In such cases remote manual landings are almost impossible since when flying at very low altitudes at a distance, video and even RC signals are likely to be lost, triggering RTH mode. Without a runway selected for an automatic landing the Autopilot would take over and attempt to fly back home. If instead the pilot has selected a predefined backup runway and engages AUTO mode (or just turns the transmitter off forcing RTH) the automatic landing procedure will take place at the specified distant runway.

Accuracy

The accuracy of the automatic landing algorithm depends on many factors, including the accuracy of the Autopilot's sensors, the airplane's characteristics and local conditions during landing.

GPS accuracy (horizontal positioning) depends on many factors such as clouds, moisture in the air, sun activity and electromagnetic noise (EMI) from other devices on the airplane or near the runway. The accuracy of the GPS can be several meters in good conditions and up to thousands of meters (or more) in bad conditions. This is a major contributor to the accuracy of the flight path during landing and the precision in hitting the touchdown point.

Altitude accuracy (vertical positioning) depends mainly on the sensor used for altitude measurements. This data may come from the GPS or the altimeter. Because of the low vertical accuracy of the GPS (usually worse than horizontal accuracy) it is **not** recommended as the altitude source. The air pressure based altimeter has good initial accuracy (+/- 1 meter), but its measurements are sensitive to air pressure changes (such as when the weather changes rapidly) and its accuracy may be reduced after a long flight. In such cases the altitude error may be several meters, but will still be far better than altitude measurements based on GPS readings.

Flight control accuracy results from internal algorithms controlling airplane position, overall airplane characteristics (how strong it reacts to steering surfaces, proper wing geometry, etc.), and current Autopilot settings. These can introduce additional error in airplane positioning during flight.

Weather conditions like strong winds, thermal currents and turbulences caused by trees or other obstacles may cause problems with keeping an airplane on the proper course and altitude.

The result of these inaccuracies is that the airplane may touch down at a point different from the one set in the runway definition (as the touchdown point, TDP).

Horizontal inaccuracy simply results in an offset in any direction from the ideal chosen TDP; that's why TDP should be set as far from any obstacles as possible, allowing extra space before the TDP, and on both sides of the TDP.

Vertical inaccuracy also causes a horizontal offset of the TDP, but only in the direction of the airplane's course (along the runway). For example if a plane is over a target TDP point but still has an altitude of 2 meters (6ft) altitude, given a glideslope of 5 degrees, the plane will glide for another 23 meters (75ft) before touching down ($2m \div \tan(5°) \approx 23m$). The lower the glideslope angle, the longer the distance until the airplane touches down. A similar calculation can be used when the airplane is below the ideal approach path (at a lower altitude), but in this case the airplane will land before the ideal TDP. Because these slight deviations in altitude have relatively large effects on the touchdown point along the runway, overall automatic landing accuracy is typically lower in the direction of the runway than it is across it.

The current firmware takes into account altitude (AMSL) of a runway when ILS system is active and airplane is close to runway (closer than approach path length +200m to runway) , or automatic landing is activated. System automatically switches from base-relative altitude into runway-relative altitude. In this case OSD fields showing altitude has additional underline to inform about runway-relative altitude.

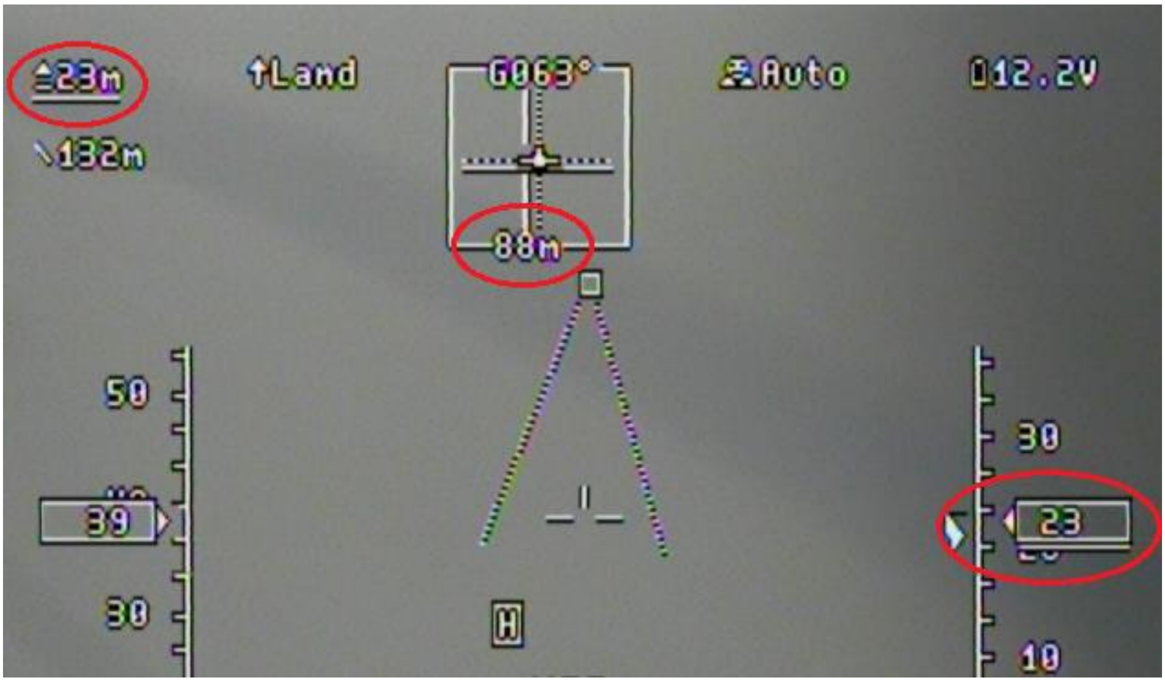

Figure 3 - Runway relative altitudes and runway altitude offset

NOTE: This is very important to store accurate base altitude at the beginning of the flight (when GPS accuracy is the best and HDOP value is less than 1.2) , to get proper altitude difference between base and runway. The difference (error) in altitudes will cause additional positioning errors along the runway.

We recommend using higher glideslope angles in these cases.

When landing on local (near) runway it is recommended to change runway altitude to base level in OSD menu **Runways->(selected runway)->AMSL** option. This avoids unnecessary positioning error caused by base and/or runway altitude inaccuracy. In this case all altitudes are base-relative.

he automatic landing feature in the present firmware cannot be set to autonomously control the deployment of retractable wheels nor does it have automatic flap control (for low airspeed approaches). These functions can only be engaged manually by the pilot with a remote-control switch. For this reason, they must be set to engage in failsafe mode to function correctly. This is especially important for remote landings, where the RC will lose radio signal and go into failsafe mode when it gets close to the ground preventing the pilot from manually deploying these functions.

Safety

Accuracy of auto-landing feature depends on GPS accuracy, so before engaging the auto-landing feature, check the current number of satellites used by the GPS, and overall GPS accuracy (HDOP). These values are displayed in the GPS field on the OSD screen. Avoid defining runway or storing base using auto-landing when the number of satellites is low (5-6 for GPS system or even more for GLONASS), or when the HDOP value is greater than 1.5 (the higher HDOP, the lower accuracy).

Take care when using the auto-landing feature after very long flights (several hours) or when the weather changes rapidly (before a storm) as the air pressure may change drastically.

Use the auto-landing feature in areas free of nearby obstacles like trees, utility poles, buildings etc.

Take special care in bad weather conditions: strong side winds, strong wind gusts, turbulences, fog, darkness, etc.

Always supervise automatic landings – be ready to stop the automatic procedure and take manual control of the airplane at any time.

We advise defining and activating the automatic landing feature during the entire length of long-range flights. That way if you lose RC control or the video link, your airplane will still safely land in a known place (a backup runway) and you will avoid the dangerous situation of your plane crashing at an unknown and arbitrary location after the battery is depleted.

When landing on a distant airfield always take into account the altitude difference between your base point and the distant runway.

We wish you many safe landings with our FPV System.

Pitlab & Zbig.