Dedalus autopilot

User's manual

Introduction

Thank you for purchasing Dedalus Autopilot. We have put our many year experience in electronics, automatics and control of model planes into this device.

Dedalus was designed to stabilize the flight and save your model in case you're out of your RC radio range, lose eye contact with the model or get stuck in the thermals and is pulled into clouds. When you lose control over the model, you can turn on automatic “return to base” function using spare channel on your transmitter. It is also highly recommended to program Fail-Safe mode in your receiver as to automatically switch to the said mode in case the receiver loses signal.

In addition, Dedalus can stabilize the model's flight, which is helpful when flying on the edge of visibility with the model becoming a small dot in the sky.

Small size (30 x 60 x 10mm) and less than 55g weight of the kit allows you to place it in almost every model. All basic airframe systems with T-tail, V-tail and tailless designs like delta or flying wing are supported. It may be useful for flight stabilization during air tow operations, to secure glider against escape into thermals or controlling fast flying models with a very short reaction time, where short moment of inattention results in the loss of the model.

What you find in the box?

A complete kit of Dedalus autopilot consist of following components:

- Main autopilot unit,
- GPS-GLONASS receiver (GNSS) with external magnetometer,
- Operator's panel with OLED display and keyboard,
- Set of connection cables.

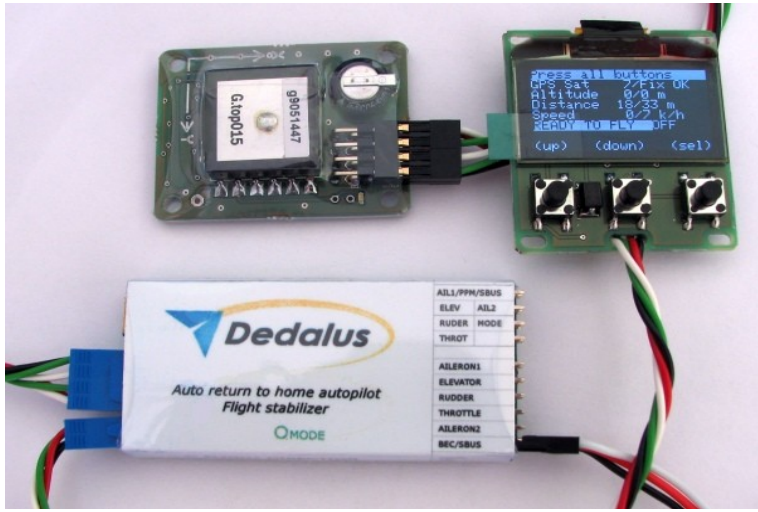


Figure 1 Dedalus Autopilot kit

The operator's panel can be connected and disconnected at any moment of autopilot work. Using it is not necessary, but it is useful to check GPS status and readiness to work. It also shows flight statistics and allows adjusting parameters in the field, without connecting to PC application.

Electrical connection

Electrical connection to GNSS module and to operator's panel is done using special polarized connectors, ensuring proper connection. Attention should be paid to polarization tabs on plug and socket when connecting these devices, particular attention to the 4-pin operator's panel connector.

Autopilot can be connected to a remote control receiver in two ways, depending on the characteristics of the receiver and the autopilot settings:

- Parallel connection where every channel is connected with separate wire.
- Serial connection (CPPM or SBus) where all channels are connected using one wire.

NOTE: Improper connection of power or external devices may cause damages that are not subject to warranty.

Parallel connection to receiver

Usual remote control receivers with separate outputs of all signals (parallel) are connected with the autopilot in such a way that the outputs of appropriate channels of the receiver are connected with the corresponding input channels of the Autopilot.

NOTE: Only first row has pin layout compatible with standard pin connection sequence in receivers (signal, power, ground). The remaining rows of connector has 2 inputs and ground on the lower pin.

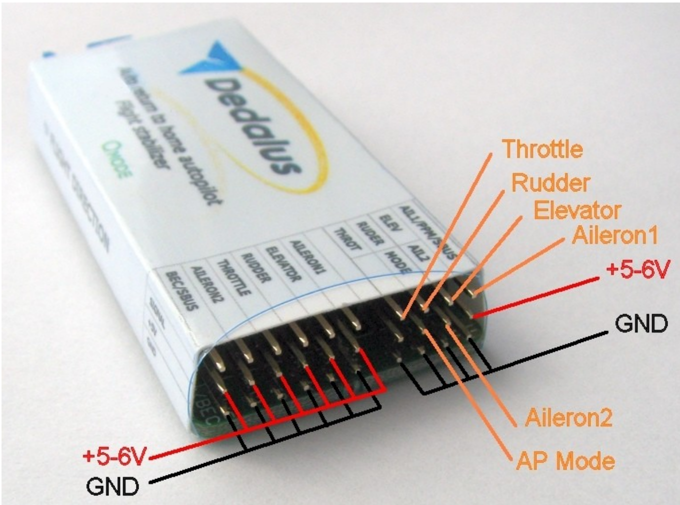


Figure 2 Autopilot inputs in parallel mode

The RC kits from different manufacturers may use different order of channels used for functions like ailerons, throttle, elevator or rudder. Pay attention to the order of receiver outputs and autopilot inputs while connecting channels.

Serial connection of the receiver

If you use a receiver equipped with serial PPM output (CPPM or SBus), connection of all channels to the autopilot can be made by a single signal 3-wire cable connecting grounds, +5V power and receiver output signal to autopilot input.

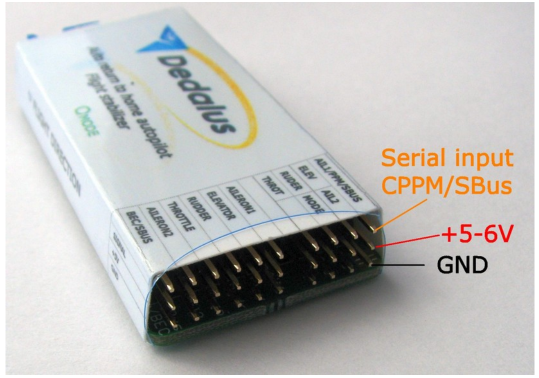


Figure 3 Autopilot inputs in serial mode (CPPM, SBus)

If you connect Serial PPM signal (CPPM), it is necessary to set this option up up with FPV_manager application on your PC. Please connect autopilot board to the computer (via USB). Then, in configuration application, choose the socket pin of the Serial Input PPM (CPPM) - Input 1, and assign channels of CPPM signal to corresponding functions of the autopilot.

In serial mode you can configure the unused PPM inputs as outputs for additional channels from CPPM signal (output Aux 2 to Aux 5, up to 11 channels total). This eliminates the need to purchase an additional CPPM decoder. In this case it may be necessary to build suitable cable with +5V power for powering the devices on these extra channels.

Connecting servos and motor controller

Autopilot directly controls servos and the electric motor speed controller (ESC) in the model. These devices must be connected to the appropriate terminals, according to their description.

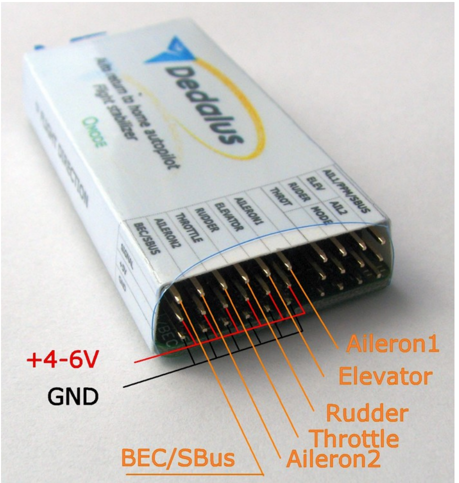


Figure 4 Autopilot outputs

The autopilot in stabilization and AUTO mode actively stabilizes the position of the model in response to external perturbations, like wind gusts or turbulence. Thus, is moves servos much more actively than human pilot does. This makes them consume significantly more power in flight. Thus, normally used linear voltage regulators that built in motor speed controllers are often unable to supply enough current to servos. This may cause brownouts or even damage the ESC. For this reason, we recommend the use of external switching controllers (UBEC) rated for 3A or more, depending on the size of the model and amount of servos used, or motor controllers with built-in pulse regulators. In the case of external UBEC please pull the red wire from the plug of motor controller and insulate it.

GNSS receiver connection

The GNSS receiver (actually GPS+GLONASS) is connected using dedicated cable to the blue 8-pin polarized connector on the front edge of autopilot. The right connector profile protect it against reverse connection. The GNSS receiver module should be mounted vertically with ceramic antenna pointing up. Don't cover it with conductive materials like metal or carbon, as they would block the signal reception. Non-conductive materials can be used to protect it against dirt and humidity. It can also be placed inside the fuselage, on account that it is not made of conductive materials, such as carbon fiber.

Sometimes external magnetometer built into GPS unit can be used instead of the one in the autopilot itself. In this case, the module should be mounted with X axis pointing in flight direction. The direction of the axis is marked on the module upper side. When using GPS or internal magnetometer as a source of heading info, mounting orientation has no meaning.

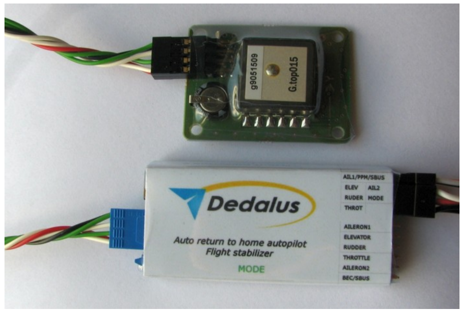


Figure 5 Connection if the GNSS receiver module

Location of autopilot board inside a model

Autopilot has an integrated inertial measurement unit (IMU), which allows determining the attitude of the autopilot board. By using this information the autopilot can maintain the level flight of the model.

However, in order for this information to be correct about model's attitude about the orientation of autopilot board in respect to the model must be correct. The autopilot board should be mounted in such way that at the stable level flight of the model, the autopilot board is horizontal and is facing the direction of flight.

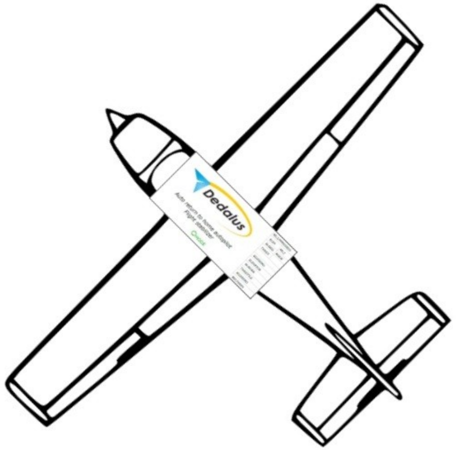


Figure 6 Correct locations of the autopilot inside the model

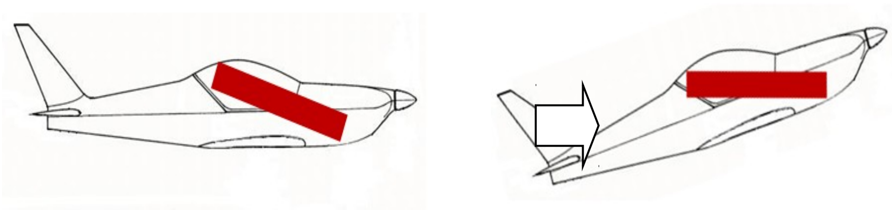


Figure 7 Impact of incorrect autopilot location on model flight

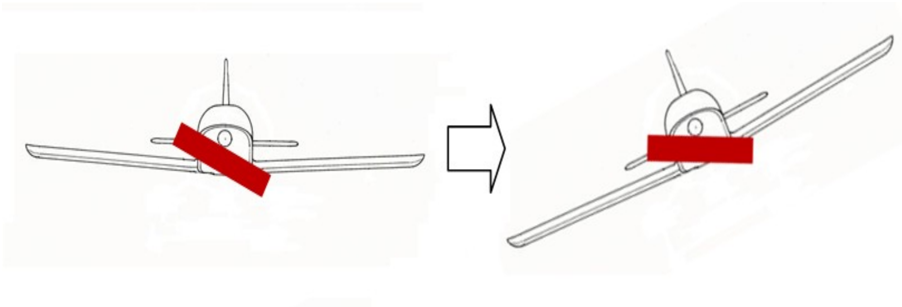


Figure 8 Impact of incorrect autopilot location on model flight

Small, on the order of few degrees autopilot orientation errors can be compensated in menu settings, **Settings->pitch cor.** for pitch and **settings->roll cor.** for roll. Perfect location (or perfect compensation) is reached when properly trimmed model flies straight and horizontal in autopilot OFF mode, and the attitude stays same when you turn stabilization on.

Autopilot board does not have to be fixed exactly in the model's center of gravity, other convenient places inside the model can be used.

Vibration protection

Autopilot should be protected against vibrations (which affects the position sensors: accelerometers and gyroscopes). If needed, you can use special dampers, sponge, thick double-sided tape or other methods. Dampers should dampen vibrations but still keep autopilot in correct orientation, and they should not resonate (do not use springs).

The vibration level can be checked with the engine running using FPV_manager.exe PC application.

The sensors and algorithms of the autopilot are designed to operate in presence of certain vibrations, but keep in mind that during the flight, there are additional loads (turbulence, the centrifugal force, etc.). Generally, the lower the vibration, the more accurate is the autopilot. You must therefore strive to achieve a minimum level of vibrations from the engine.

NOTE: Too high level of vibrations can cause model flying tilted or not straight in stabilization and autonomous flight modes.

Magnetic noise prevention

The autopilot and GNSS receiver board have magnetometers that used to measure Earth magnetic field and determine the magnetic course. Every magnetic field other than the Earth's can be an interference source. Try to avoid putting permanent magnets, such as for holding the canopy, closer that 20cm from the autopilot.

Electric wires, especially the ones conducting high currents for the motor should be arranged parallel to each other and tied together to prevent making magnetic loop during current flow.

The magnetometer sensor is placed on the autopilot board near the „a" character of the Dedalus logo. If you have to place wires near autopilot, place them near opposite side like on picture below.

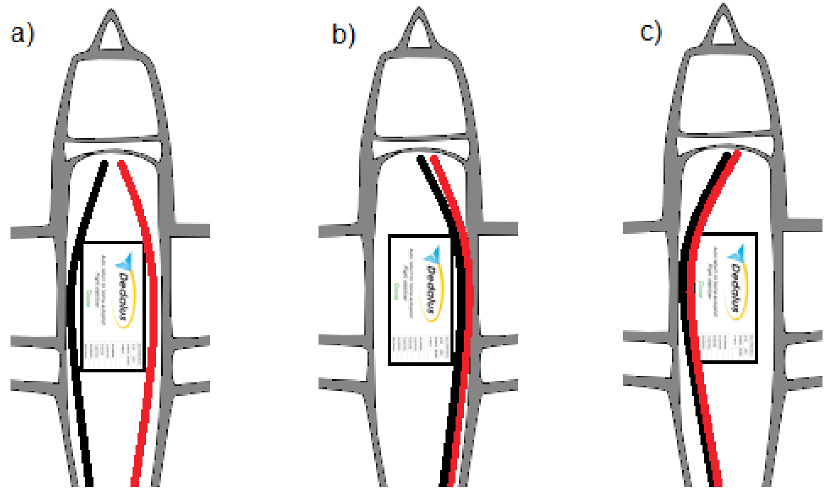


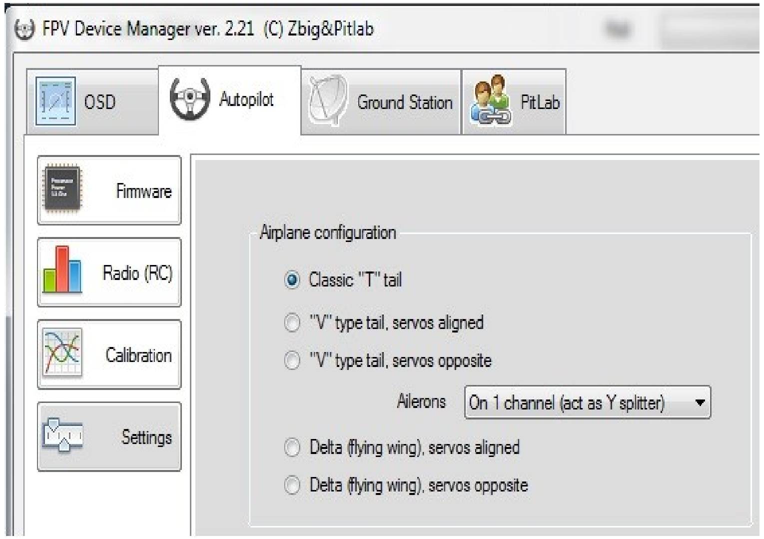
Figure 9 Way of placing current wires in the model: a) worst possible – big loop, b) better – without a loop but still close to the sensor, c) optimal.

Reverses and alignment of servos

Adjusting RC apparatus for controlling a particular model means setting correctly reverses and mixers so that the control stick movement causes correct control surface deflection. In the same way it is necessary to set the autopilot up for a specific model to ensure proper control of autonomous model flight.

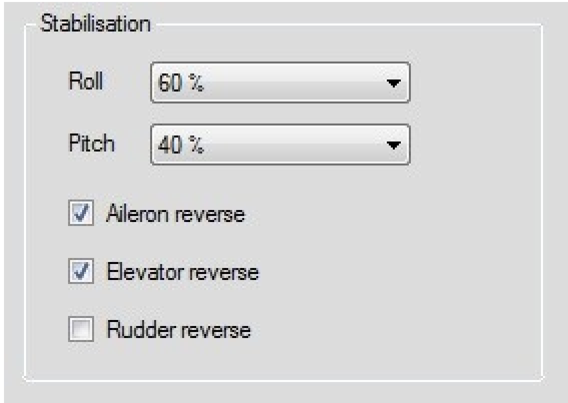
NOTE: Model configuration can be done using FPV_manager.exe application on PC or with keyboard and display. Simplest way of configuration is to run menu command **Settings->Easy Setup.**

The first step is to select the type of model tail.



When one stick is attached to two servos and two control surfaces (delta, V-tail, flaperons), we can choose between two options of servos concurrency, (**aligned**) and (**opposite**), depending on whether for the proper control the opposite – or non-opposite movement of servos is required.

In the second step set correct value of reverse for every control surface in the **Stabilization** panel.



Check the proper servo alignment and reverse mode can be done after turning on the STAB mode, observing the behavior of the control surfaces to the movements of the model. When alignment and reverse mode are positioned properly, the control surfaces must deflect in the direction needed to return model to level flight.

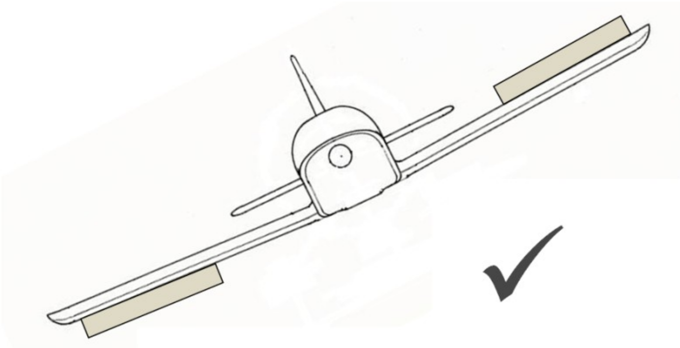


Figure 10 The correct setting of concurrency and servos reverses

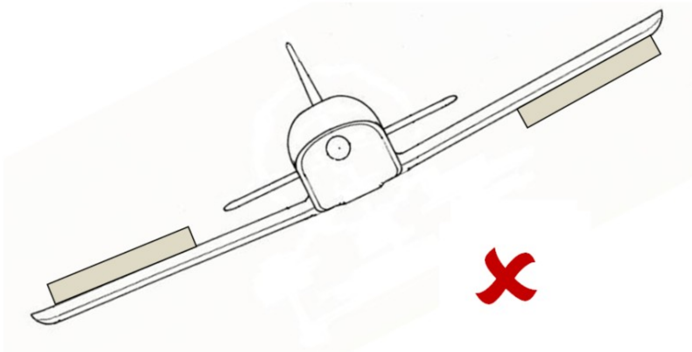


Figure 12 Incorrect setting of the reverse (correct concurrency setting)

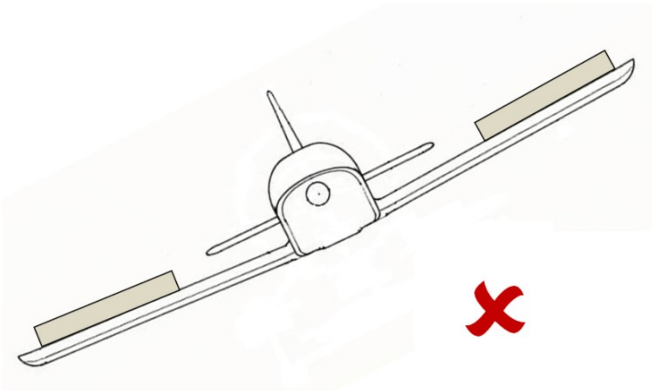


Figure 11 incorrectly set servos concurrency

Since the rudder is not used for the stabilization of flight, it is not possible to set its reverse on the basis of observation of the reaction of the model to movements. Therefore, after any change to reverse of the rudder the autopilot moves the rudder like to the right for about 1 second. If you see the rudder turn left after the change of the reverse setting, it means that the setting is incorrect.

Easy Setup

The simplest way of correct configure the model is use the menu command **Settings->Easy Setup**. The wizard helps setting all parameters (servos alignment, mixers, reverses) in 4 simple steps by asking for moving sticks in your transmitter and confirming it by keyboard click.

The **Easy setup** should be run only after correct connection and configuration of input RC channels.

NOTE: To avoid surprising deflections of the control surfaces during calibration (if no mixers set yet), set the autopilot mode to OFF. Autopilot mode does not affect the settings are correct, only to swing them when the wizard is running.

On the every step of wizard you should move the correct transmitter's stick in accordance with the information on the screen and confirm the position with [**Next**] button while holding the stick in that position.

After completing all steps, the screen will display detected model configuration.

In order to verify the settings, turn the STAB mode on and, while, leaving the sticks in the neutral position, tilt the model with the right wing down. Right aileron should deflect downward and left upward "preventing" this movement of the model. Then lean model nose down, keeping the wings horizontal. The elevator (or elevon for the delta) should deflect up, leveling the model.

Autopilot modes

Autopilot mode control is done by a three-position RC channel connected to the **MODE** input as follows:

- Channel at minimum (PPM pulse duration less than 1.2 ms): **OFF** - autopilot off (pass the signal through directly from receiver to servos without any modifications).
- The center-channel (pulse duration 1.3 ms to 1.7 ms): **STAB** - stabilization mode
- Channel for maximum (pulse duration more than 1.8 ms): **AUTO** - autonomous flight

Actual autopilot mode is displayed on last line of OLED screen.

NOTE: To automatically return the model to the starting point in case of lost RC signal, the fail-safe mode in the RC receiver should set correctly the **MODE** control channel to maximum value (pulse > 1.8ms).

Turning the autopilot off

In the OFF mode, all RC input signals are transmitted to the output without any interference (except for disregarding false PPM pulse outside the acceptable range of 0.8 ms to 2.3 ms).

If the autopilot is connected to only one aileron signal (input # 1 "aileron 1"), the autopilot transmits the same signal on both ailerons outputs - works as a "Y" cable, making it easy to control two servos from one RC channel.

STAB mode - stabilization of the model

Stabilization of model is used in order to prevent unexpected or uncontrolled changes of model attitude, both as reaction to control inputs and to wind gusts. It is also useful when a model is very responsive to stick deflection, which could end up in stalling the model, a spin or flipping over and, consequently, loss of control and crash. Proper configuration of stabilization mode is also required for the correct operation in autonomous flight mode.

When model attitude becomes different than the desired one, stabilization system causes appropriate control surface deflection to eliminate these deviations. Proportionality of control surface deflection in relation to the position deviation is defined by **Stabilization** menu setting, adjustable independently for **roll** and **pitch**.

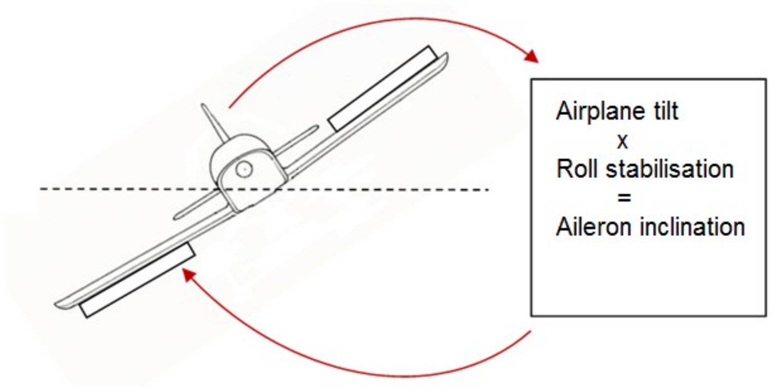


Figure 13 Illustration of operation of banking stabilization algorithm

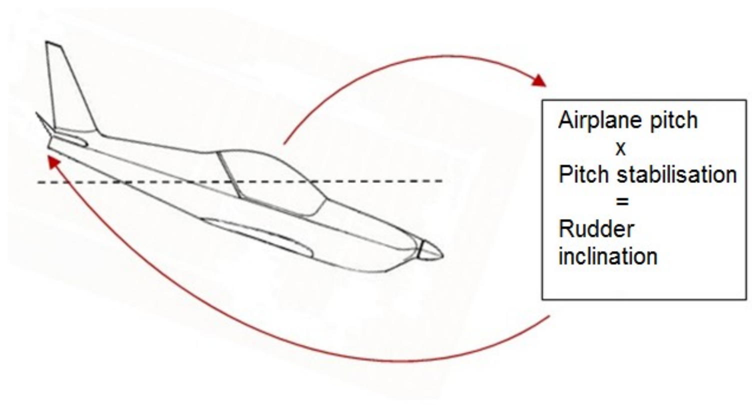


Figure 14 Illustration of operation of inclination stabilization algorithm

The correct setup of the stabilization model is necessary for autonomous mode of the autopilot to work.

The value of the **roll** stabilization force should be set to the highest value at which the model is still flying steadily without falling into oscillation. Too high a value is indicated by rapid rocking of the wings, especially at high speed.

Too low **roll** stabilization force could prevent proper flight in AUTO mode (unstable flight, too small or too great banking of model during turns).

The **pitch** stabilization force should be set so that the diving model, gets back to the level flight without oscillating, and after zeroing the throttle it soars without deceleration and stall. After increasing throttle it should slowly gain altitude, but not pitch up rapidly.

Small values of **pitch** stability may cause phugoid long-period vertical oscillations of the model and too rapid climb when applying throttle.

Too high inclination stabilization force can cause quick, short oscillating up and down, especially at higher speeds, and also cause stall of the model without engine power, and poor ascending on power (model accelerates, without ascending), causing problems in autonomous flight.

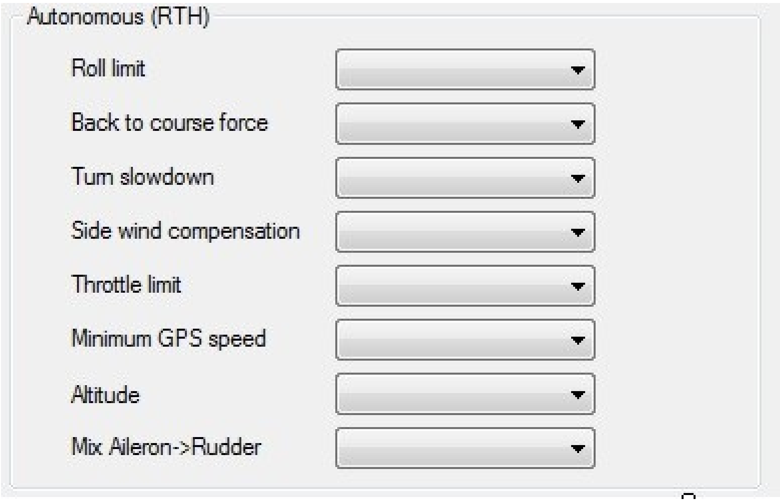
Autopilot in stabilization mode does not hold directly the setpoint direction of flight, but by keeping the level of the model largely eliminates the unplanned deviations from the current model course.

AUTO mode -automatic return to start place

In autonomous mode, the autopilot controls the model flight on its own, maintaining the correct attitude and altitude, as well as preventing too rapid model banking, which could cause loss of control (framing the wing, corkscrew, etc.).

Banking limit

In order to maintain control over the model it is necessary to determine the maximum safe allowed model banking during maneuvers in autonomous mode. Settings are made in **FPV_manger** application in A**utonomous (RTH)** panel, or in **Autonomous->Roll limit** menu:



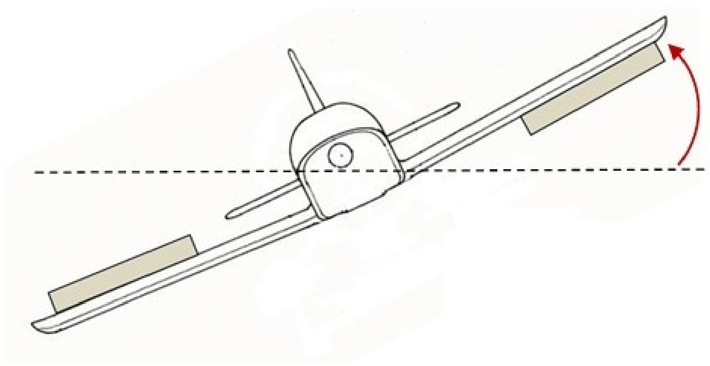


Figure 15 ***Maximum banking of the model in autonomous flight***

Too small value of the maximum banking increases turn radius, or may even impede turning in strong wind. Too large values can cause cause the loss of altitude during the turn or may even lead to stall, and cause significant deviation of the course provided by the GPS from the real course of the model, so the model will zigzag when flying to the base.

NOTE: For models with a large agility (large aileron deflections) or with lower stabilization force set it may be necessary to decrease the limit of the banking angles.

Force of getting back on course

When the model is in the autonomous flight and the current heading is different from the desired the autopilot performs a turning maneuver in order to return to the right course. Accuracy of staying the course, and the deflection of the ailerons and rudder in case of deviation from the course is defined by menu parameter **Autonomous->back to course**. This is illustrated in figure:

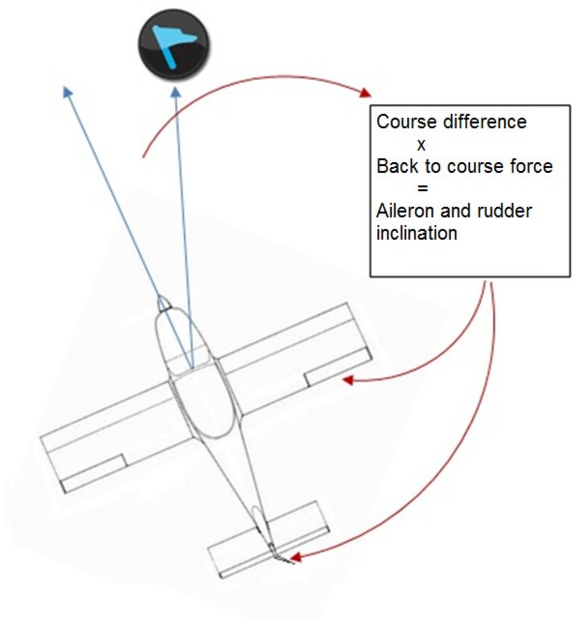


Figure 16 I*llustration of the algorithm to maintain the course*

The greater the deviation of the course, the stronger the deflections of ailerons and rudder that cause getting back on course. This means that if deviation of the course is high, then also the turning speed of the model is high, and with getting closer to the expected course the speed of turn decreases.

If this value is too low, the model will be turning slowly and will not be coming to the course to the base. Too high a value causes the model to perform a quick turn also when the deviation from the course is low, so that the model significantly exceeds the course and oscillates around the course flying zigzag.

Mixer aileron->direction

Turn of the model is generally obtained by ailerons, but it is also possible to add steering with the rudder. This is done by the mixer set **Aileron->rudder**. In models with ailerons its use and value is at the discretion of the pilot. Too large values of the mixing can cause excessive model banking in relation to the value of the banking limit set in autopilot menu.

NOTE: in aerobatic models where the ailerons turn the model very slowly, the values of aileron-direction mixer should be high, and the banking value limit should be small.

The slowdown the turn

Since small values of the maximum model banking can cause problems in the event of strong winds, it is necessary to use average values of the banking limit, aided by dynamic constraint (slow down) of the turn speed, which prevents problems with GPS course.

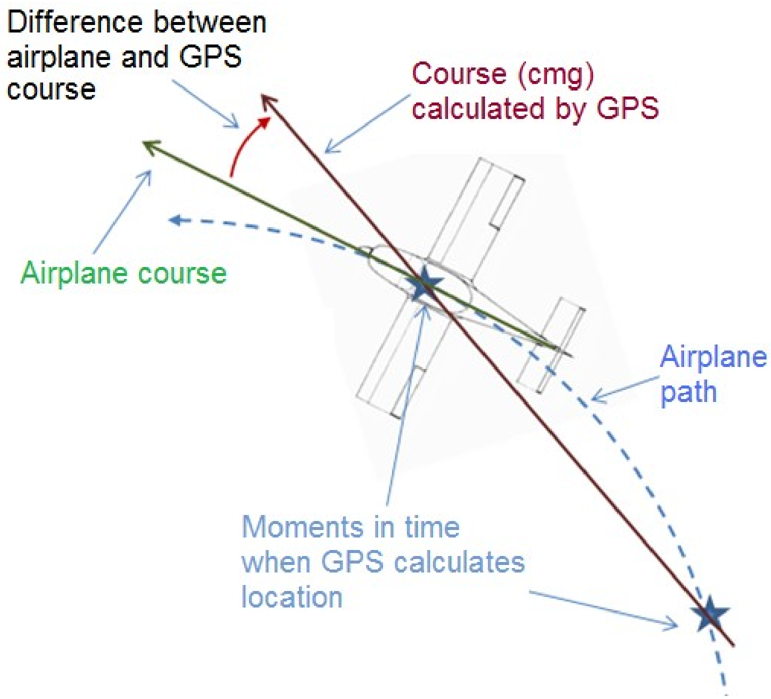


Figure 17 *The error of indication of the course during a quick turn GPS model*

The slowdown in turn can be set in the menu **Autonomous->Turn slowdown**.

NOTE: When using the magnetic heading it is not necessary to slow down the bend more, as the used magnetometer has a sufficient speed and precision of operation, even with a stronger heel and high-speed turns.

Compensation of crosswinds

If some factor, such as crosswind (but also bad trimming or bad position compensation of autopilot) causes the model is still relegated from the course and does not pull to the course to the base, this error is constantly monitored and if it does not disappear, the autopilot is steadily increasing aileron deflection to compensate for this error. It takes a relatively long time (up to several seconds or even longer) and makes systematic "pulling" the autopilot to the correct course.

Compensation is selected at the discretion of pilot, keeping in mind that too high a value may result in exceeding the line of the course by the model and a slow return to the course (or zigzag flight or a slow change in the course), because the adjustment changes slowly.

Maintaining altitude

Maintaining the altitude of the autonomous flight is performed depends situation. If the model is above the limit the model use elevator to descend.

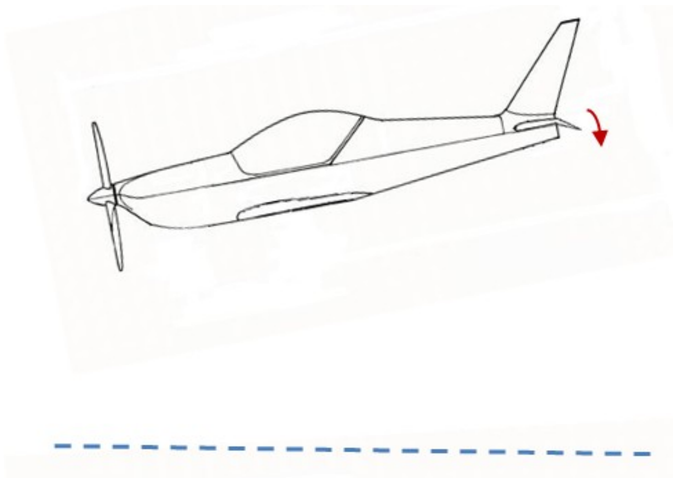


Figure 18 ***The use of the elevator during descent from a high altitude***

If the model is below requested altitude then autopilot expects that model flying would climb at after increasing throttle. The autopilot doesn't force ascend by using elevator to prevent stall and loss of control.

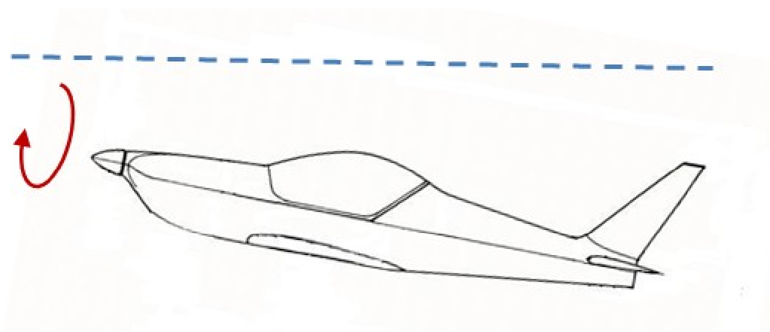


Figure 19 ***Ascending of the model on engine flight***

Throttle limit

The Autopilot use constant level of throttle during autonomous flight set by parameter **Throttle**. Value set in this parameter should ensure ascend the model above terrain obstacles like a trees or descending thermal currents. Value of throttle should be set experimentally, taking in account lower voltage of discharged main battery.

Reducing throttle allows for a more economical flight and limits the maximum cruise speed in models with a powerful engine. It also decreases the risk of overheating the motor or speed controller (ESC) during the autonomous flight after a long tour on some setups.

Saving the trimmers

Before the first flight, and after each change of trim settings, save new trim offsets corresponding to level flight of the model. Use this option in the menu **Store->Store trims**.

Saving the trimmers is important from the point of view of the autopilot, as in AUTO mode the autopilot takes over the role of RC transmitter and needs to know the PPM signal values (modulation of servos) corresponding to free flight in a straight line, with no banking and level flight. Changing the trim without saving it in the autopilot will result in banking and turning of model in STAB mode, and a worse operation during autonomous flight (asymmetric turns and, in extreme cases, stall or problems with maintaining altitude).

As usually, changing the trim settings can be done both on the ground and in flight. Trimming the model in flight should be made in OFF mode (with stabilization off) in order to correctly observe the behavior of the model in free flight.

The GPS course

GPS determines the course on the basis of the position of the model calculated in the consecutive points in time. So it is always the actual direction of movement of the model, including leeway angle caused by the wind pushing the model sideways. This is called the Course Made Good (CMG). Autopilot uses GPS course to fly to the base in a straight line, along the shortest route. However, side wind may push the model off this course. Thus, this drift must be compensated. This deviation may be up to about 90 degrees, with a very strong wind. For the pilot who observes view from a camera mounted on the model for the first time, this can be a surprise and may cause confusion, because the model gives the impression of flying in the wrong direction (too much into the wind).

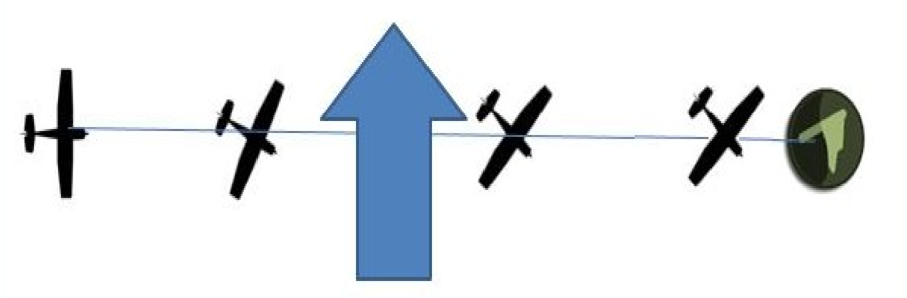


Figure 20 *Flight in strong winds according to GPS (CMG)*

Choosing GPS or barometer altimeter

Autopilot allows you to select the type of altimeter, which is used to maintain altitude in AUTO mode.

Barometric altimeter is recommended for most flights. It provides high precision of determining the altitude, but it is sensitive to changes in atmospheric pressure. Due to changing weather the altitude indicated by the altimeter can change within a few meters in comparison to the initial value during the flight.

GPS altimeter is insensitive to weather conditions and provides a small percentage error at high altitudes. However, it provides a significant absolute error of indications and its reading can change unexpectedly and jump up or down even more than 20m. It should be taken in account while selecting flight altitude in AUTO mode.

PC application configuration

Autopilot can be configured and updated via the USB port using **FPV manager** software, running on a computer that is running Windows XP, Vista, Win7 and Win8, in both 32 and 64 bit versions.

Configuration application (executable file FPV_manager.EXE) requires the. NET Framework software version 3.5, which is shipped with the newer versions of Windows and does not require any additional installation. Older versions of Windows XP, however, may not have it. Then it must be downloaded from the Microsoft and installed on your system:

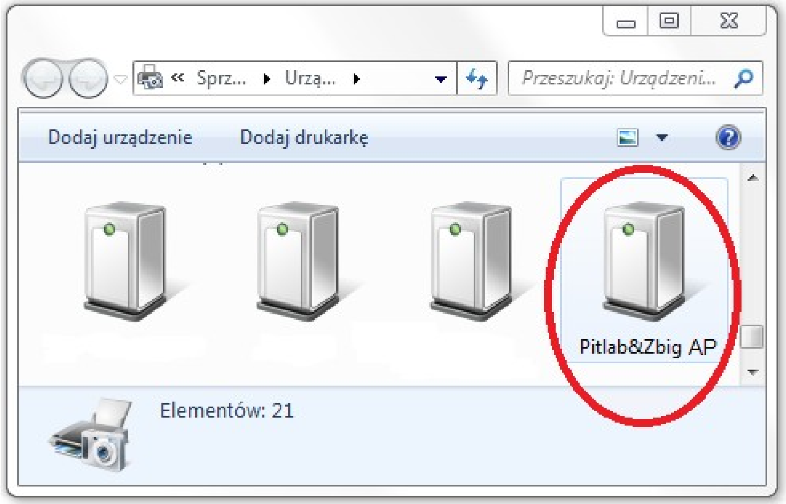
http://www.microsoft.com/downloads/pl-pl/details.aspx?FamilyID=333325fd-ae52-4e35-b531-508d977d32a6

The latest version of the configuration software can always be found on the manufacturer's website:

http://www.pitlab.com/dedalus-autopilot/download.html

The configuration application is ready for use immediately after saving it to local or removable drive and does not require installation on Windows. The application can be run from anywhere, even from removable media such USB flash drive or directly from a network location, on any Windows computer.

The application communicates with the controller pad via USB and standard mini-USB cable. Windows automatically recognizes the connected device, without the need to install additional drivers. The device is seen in Windows as **Pitlab & Zbig AP**. Once the FPV manager application is started, go to the Autopilot tab. If the device is connected to your computer, it will be the automatically identified. The **Firmware** subpage displays basic information about the device.



Software Update

Manufacturer makes updated Autopilot software and firmware available on its website. It includes functional enhancements and bug fixes. To update the software, the file with the new firmware version (with **.de** extension) should be copied to the local disk. After that, click **Upload Firmware** button and select the new firmware file. The update process takes from a few to several seconds, and the progress is indicated by a progress bar in an application.

RC Setup

Configuration and the correct connection of the receiver verification can be made in the FPV_manager application, **Autopilot->Radio PPM.**

In the **PPM Input** panel current signal levels from each receiver channel or decoded PPM (CPPM or SBus) signals are presented.

In the **PPM Output** panel are the current output signals of autopilot servos and motor controller values are presented.

In the **PPM Input mode and mapping** panel you can find settings for communication with RC receiver through parallel connection (parallel inputs), or one of the two Serial PPM (CPPM or SBus) inputs connected to input 1. Here we make the appropriate channel assignments of the CPPM signal to the autopilot function, and additional PPM Aux2 to AUX5 outputs.

Calibrations

Autopilot is factory calibrated and ready to operate, and you will not need to calibrate the device on your own.

However, there can be special circumstances in which it will be necessary to re-calibrate the system if there are problems with its proper operation. Problems may arise as a result of strong mechanical or thermal shocks, or natural aging of electronic components. This FPV_manager application allows you to perform additional Autopilot calibration (in order to shorten the maintenance of the device), but before using any calibration function you should contact the manufacturer to determine the nature and cause of the problem, and obtain instructions on how to calibrate it properly.

Check list before the flight

Set the autopilot in AUTO mode and tilt the model left and right check if ailerons counteract the tilting in correct direction.

Check on screen if GNSS receiver started to track satellites and the displayed status is **Ready to Fly.** The LED on the GPS receiver should also blink when there is no lock and become solid green when the satellites are acquired.

You should also verify reported distance from a base. It should be not bigger then 10m. In case is bigger please store new base position using menu command **Store->Store base.**

If something is still not known

We have endeavored to describe all aspects of the configuration and use of the autopilot. If, despite that, some things are not clear, please ask. Together with a group of experienced users we are available online on RC Groups. Traditionally, at this point in the section "UAV - Unmanned Aerial Vehicles" we discuss our products, share our experiences and talk about the new functionality of devices, as well as inform about new releases of software and firmware.

Service and warranty

We strive to make our equipment reliable. This is reflected in the free warranty repair of all our equipment for 2 years from time of purchase. We also provide after sales service.

If something is not working or was crashed please contact to us and send the unit to our office at the following address:

PitLab Piotr Laskowski
ul. Jana Olbrachta 58a/163
01-111 Warszawa
Poland

NOTE: When sending the hardware to service please remember to include sheet of paper with return address and detailed description of the problem.

Declaration of Conformity

The Dedalus autopilot is conformed with essential requirements in the range:

- Protection of health and the safety of the user
  art. 3.1 directive 1999/8/WE, EN 60950-1:2004
- Electromagnetic compatibility (EMC)
  art. 3.1b directive 1999/5/WE, EN 301 489-1 V1.6.1