# SCANFISH FLIGHT V1.4

## 3D AUTOMATIC CONTROL USERGUIDE

Last update: 19/04/2023
Version: 1.5

# Contents


**1 Introduction ..... 4**

1.1 Formatting conventions ..... 4

**2 Enabling the automatic 3D control ..... 4**

2.1 Setting up importers ..... 5

**3 Engaging and disengaging the autopilot ..... 5**

**4 AutoPilot view ..... 6**

4.1 Segment control ..... 9

4.1.1 Distance from target and Flap offset value ..... 10

4.1.2 Flip segments ..... 10

4.1.3 Max movement distance in meters ..... 11

4.1.4 Max flap value ..... 11

4.1.5 Core interpolation ..... 11

4.1.6 Number of segments ..... 11

4.1.7 Exponential limiter ..... 12

4.1.8 Linear slope constant ..... 13

4.1.9 Linear intercept constant ..... 13

4.1.10 Recalculate segments ..... 14

4.2 PID control – Adjusting the PID ..... 14

4.2.1 Proportional gain ..... 15

4.2.2 Integral gain ..... 15

4.2.3 Derivative gain ..... 15

4.3 Regulation adjuster ..... 15

4.3.1 Samples off target ..... 16

4.3.2 Last avg data sample ..... 16

4.3.3 Number of samples before update ..... 16

4.3.4 Samples threshold ..... 16

**5 AutoPilot modes ..... 16**

5.1 Disabled ..... 16

5.2 Segment ..... 16
5.3 Segment + PID ..... 17
5.4 Segment + PID + Adjuster ..... 17
5.5 Reactions to incoming data ..... 17
**6 AutoPilot options menu ..... 17**

# 1 Introduction

This document is a quick description of how to set up, enable and use the automatic 3D control system for ScanFish Flight version 1.4.

## 1.1 Formatting conventions

Items formatted in **bold** are properties, buttons, or other elements in the ScanFish Flight software, when setting up the ScanFish automatic 3D control.

# 2 Enabling the automatic 3D control

The 3D control system works by using NMEA XTE, Distance Off Line (DOL) data, to navigate the ScanFish to a desired location. In order to access the 3D system controls an importer must be set up first.

The Fish DOL importer is DOL data indicating how far the ScanFish is from reaching its target run line.

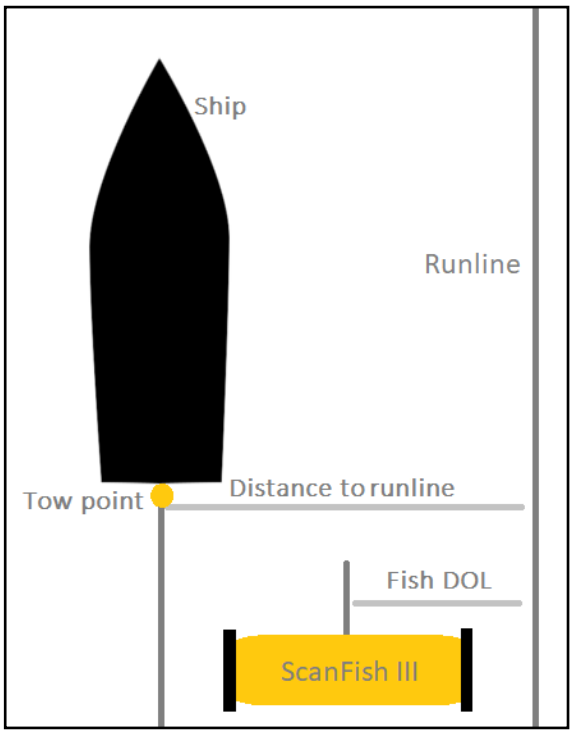


Figure 1 Overview of the DOL data needed

## 2.1 Setting up importers

Go to **Settings** and open the **Options** menu. Open the **Importers** submenu and select the **Fish DOL Importer** tab. Set the **Import driver** to NMEA and choose UDP connection and the port number on which the data should arrive.

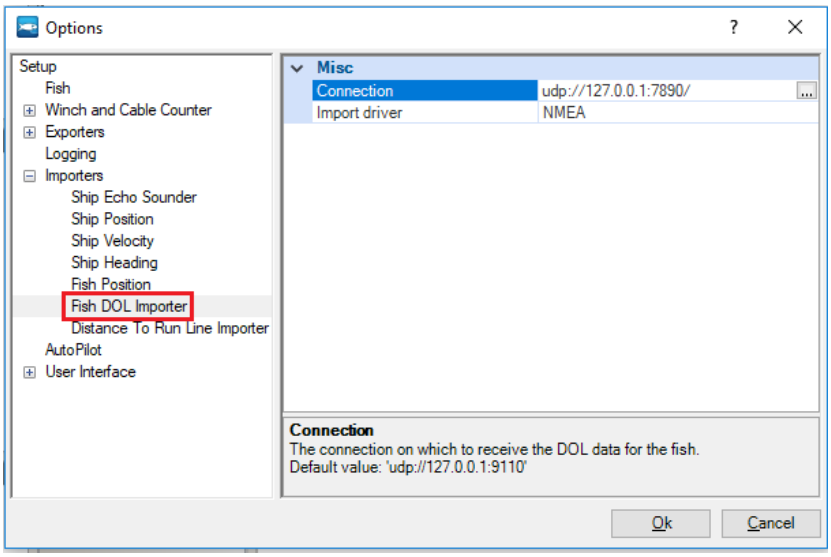


Figure 2 Setting up the Fish DOL Importer

# 3 Engaging and disengaging the autopilot

After having connected to the ScanFish and running a pre-flight check, make sure that data is received from the DOL importer. You can do this by looking at the **Alert** panel. If the **Fish DOL Importer** is green, as shown below, then data is being received. If no data has been received after six seconds the **Alert** panel will blink red.

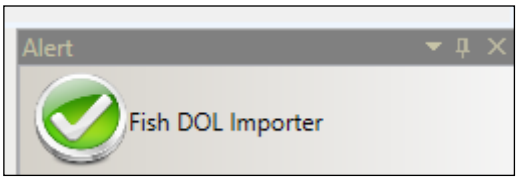


Figure 3 Alert panel showing autopilot data is being received

To activate the autopilot, click the **AutoPilot Mode** tab and select the **AutoPilot** mode from the drop-down menu. The different autopilot modes can be selected using the **AutoPilot Mode** drop-down menu.

If no DOL data is received the AutoPilot will not react and will no longer steer the ScanFish, regardless of which mode is chosen.

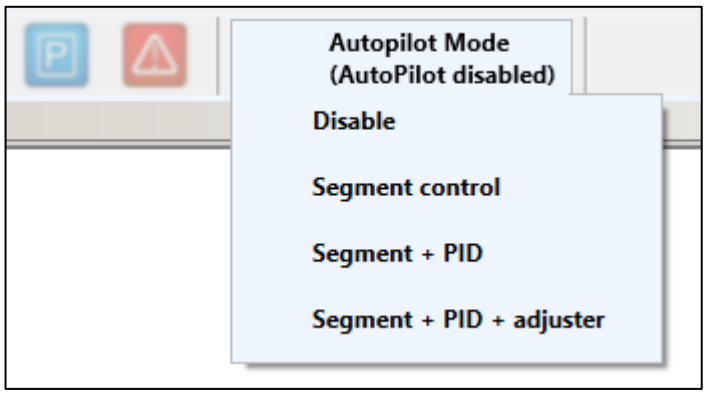


Figure 4 AutoPilot Mode selection

**Note:** Using the manual vertical flap handle will disengage the AutoPilot if the AutoPilot is already engaged.

# 4 AutoPilot view

To control and configure the autopilot a new autopilot view is available. To open the AutoPilot view go to **View** in the menu bar, select **Dockable Panels** in the drop-down menu and choose **AutoPilot** in the submenu.

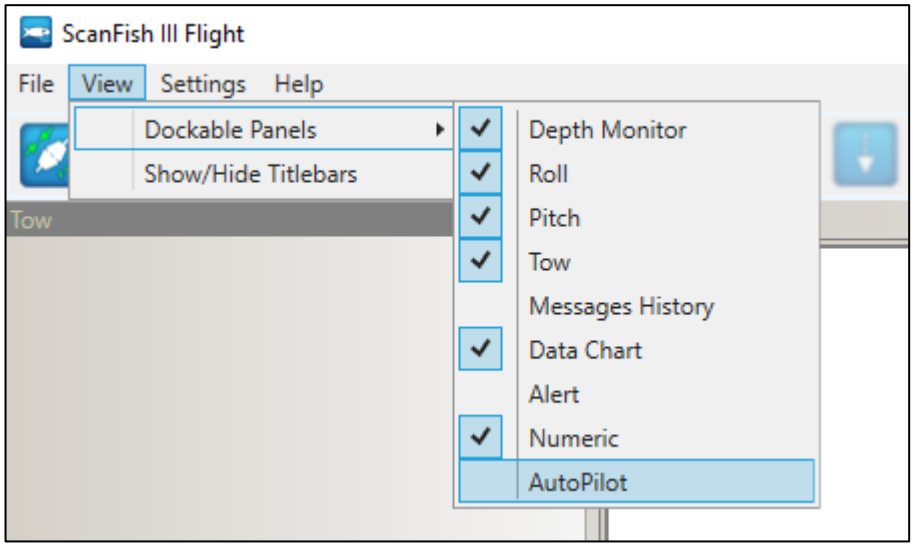


Figure 5 Opening the AutoPilot view

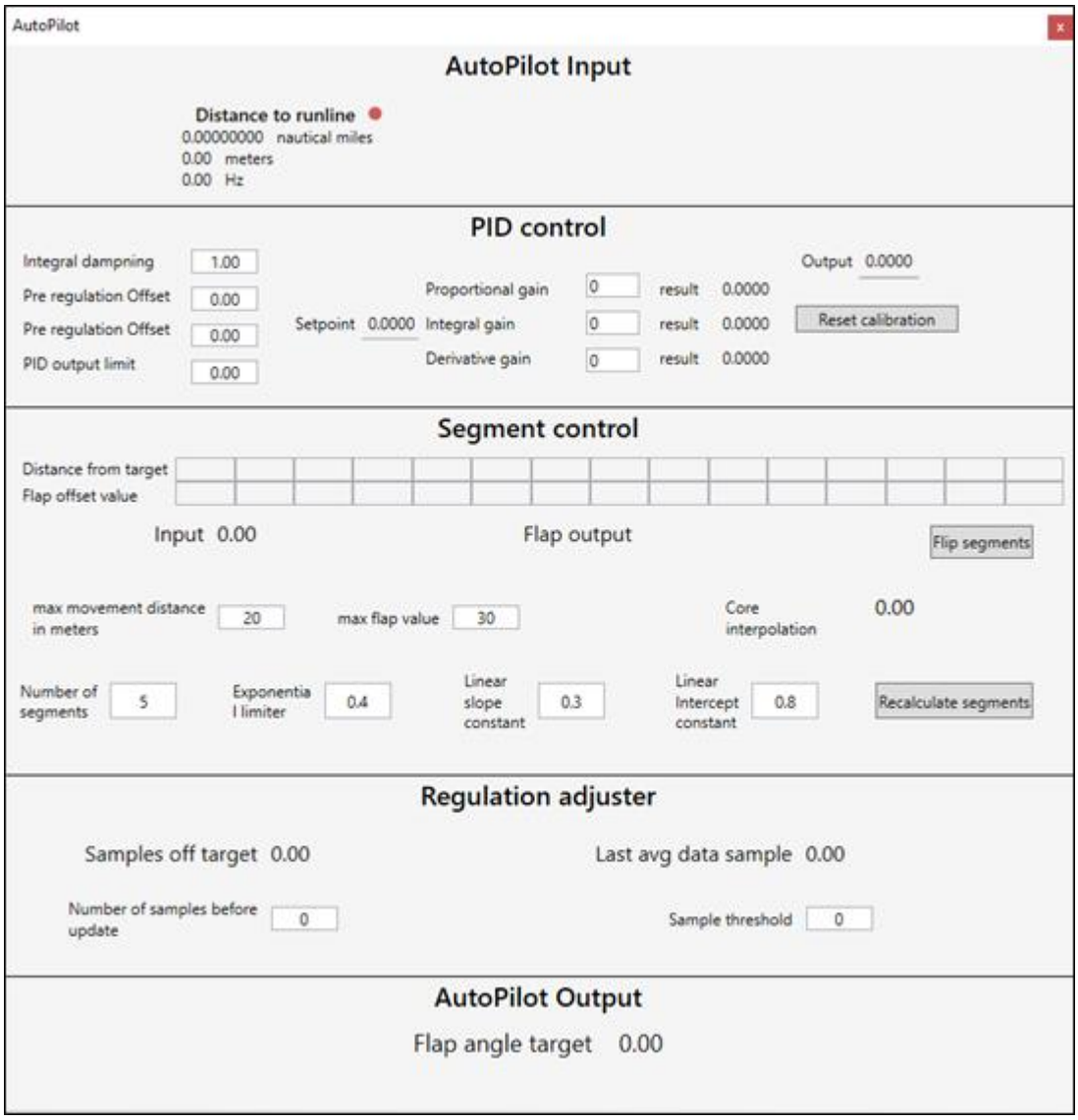


Figure 6 The AutoPilot view

- **AutoPilot Input**
  Found at the top of the **AutoPilot** view, indicates the incoming DOL values and at what frequency they are coming in at.
- **PID control**
  Where the settings for the PID can be regulated. It is also possible to monitor how the PID behaves with the current settings. When changing the PID settings, click the **Reset calibration** button to reset the PID with the new settings.
- **Segment control**
  It is the basis for all of the AutoPilot modes. This control is the core of how the AutoPilot behaves.

- **Regulation adjuster**
  Tries to automatically correct the values in the segment control by counting the number of samples by which the ScanFish is outside the set threshold. After a certain number of these samples, it adjusts the **Segment Control**.
- **AutoPilot output**
  Located at the bottom of the view, it is the flap angle sent to the ScanFish. This is the summary result of the AutoPilot calculation.

The flow of data through the AutoPilot is as follows: The input is sent to each of the two controls and the adjuster. The Segment output is then added with the PID output if the PID is activated by the user. After summing the output of the active controllers, the resulting flap angle is sent to the ScanFish.

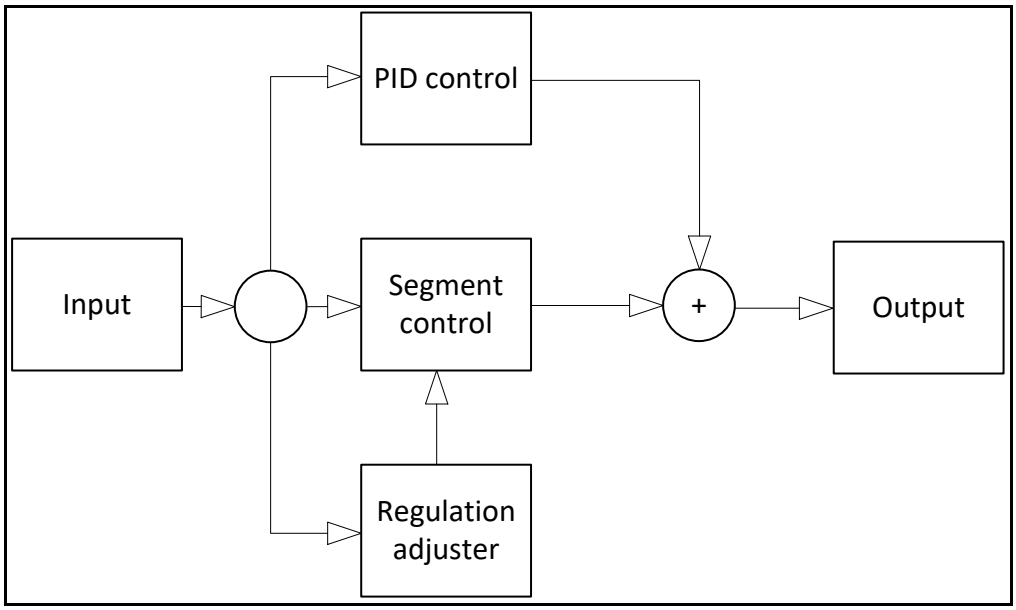


Figure 7 Data flow of the AutoPilot

## 4.1 Segment control

In the middle of the **AutoPilot** view is the **Segment control**.

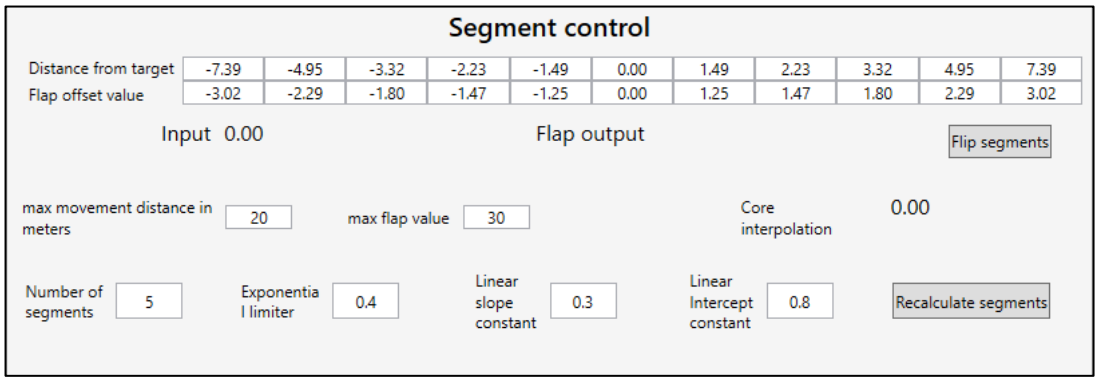


Figure 8 Segment control settings

A segment is defined as the distance between two points of the axis on which the ScanFish can move sideways. Each segment has a flap angle associated with it so that, if the ScanFish is located on a segment, its vertical flaps are set to the angle associated with the segment.

Figure 9 ScanFish sideway axis split up into segments

As an example, if the ScanFish is located between the points -1.0 and -2.0 the vertical flaps of the ScanFish are set to *-1.0*. So as the ScanFish gets further away from the runline the flap angle increases in order to push the ScanFish back towards the runline. If the ScanFish passes a distance of 2 metres to the port side (-2.0) the flap angle is set to maximum -2.0 degrees.

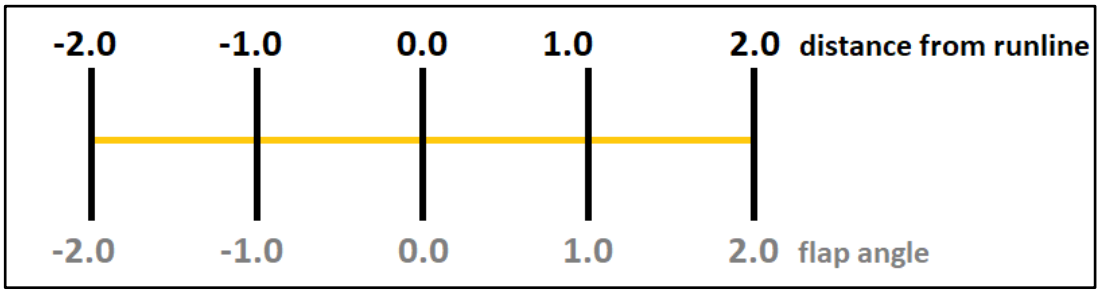


Figure 10 Example of segment distances paired with flap angles

### 4.1.1 Distance from target and Flap offset value

An overview of the segments is shown in the **Segment control** as pairs of the distance thresholds (**Distance from target**) and resulting flap angles (**Flap offset value**).

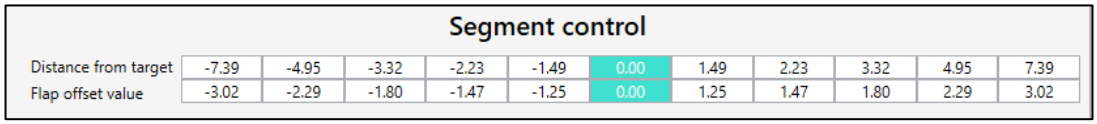


Figure 11 Indication of the segment the ScanFish is within the threshold of the runline

As the ScanFish moves back and forth, the runline segment control updates the active segment indicating what threshold the ScanFish has passed and what flap angle is set as a result of the current distance from the runline. The values of each individual segment can manually be edited.

**Note**: The runline **Distance from target** cannot be edited, however the **Flap offset angle** can be.

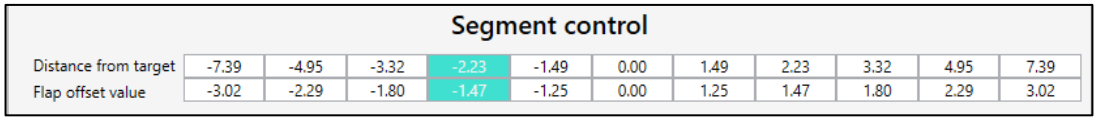


Figure 12 Indication of the segment the ScanFish is within the threshold of the second segment to the port side of the runline

### 4.1.2 Flip segments

If ScanFish moves further away from the runline when the **Segment control** is activated, it might be necessary to flip the flap angles sent to the ScanFish. Click the **Flip segments** button to do so.

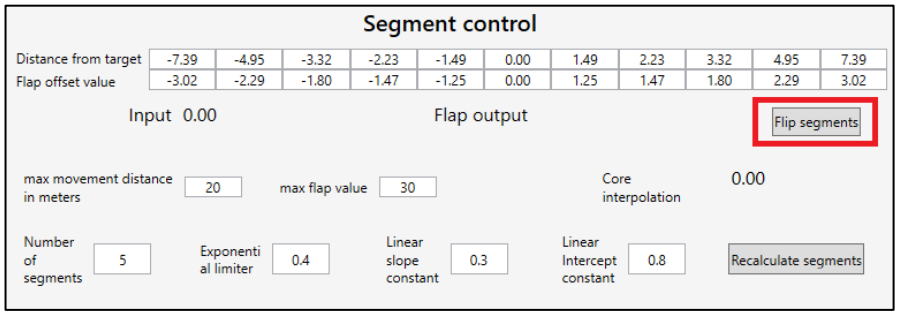


Figure 13 Flip segments button location

### 4.1.3 Max movement distance in meters

This value determines the maximum change in the DOL values that is accepted as a valid change. This is a safeguard against the ScanFish performing excessive movements in reaction to unexpectedly large changes in DOL.

### 4.1.4 Max flap value

This sets the maximum value the segment generator is allowed to use. It is possible to manually set a larger flap angle. **Note**: There is a limit of how large a value can be set, as it is restricted by the angle the 3D flaps can move.

### 4.1.5 Core interpolation

This is a legacy indicator and is not in use. It has been removed in the latest version of ScanFish Flight.

### 4.1.6 Number of segments

This value sets the number of segments added to each side of the runline. The default value is set to **five**. Increasing this value enables a finer grade of control for the AutoPilot.

### 4.1.7 Exponential limiter

When calculating the default values for the segment distances, an exponential function is used. This value controls how large the generated distances become. An example of how the segment distance increases with a set limit of 0.25 can be seen below.

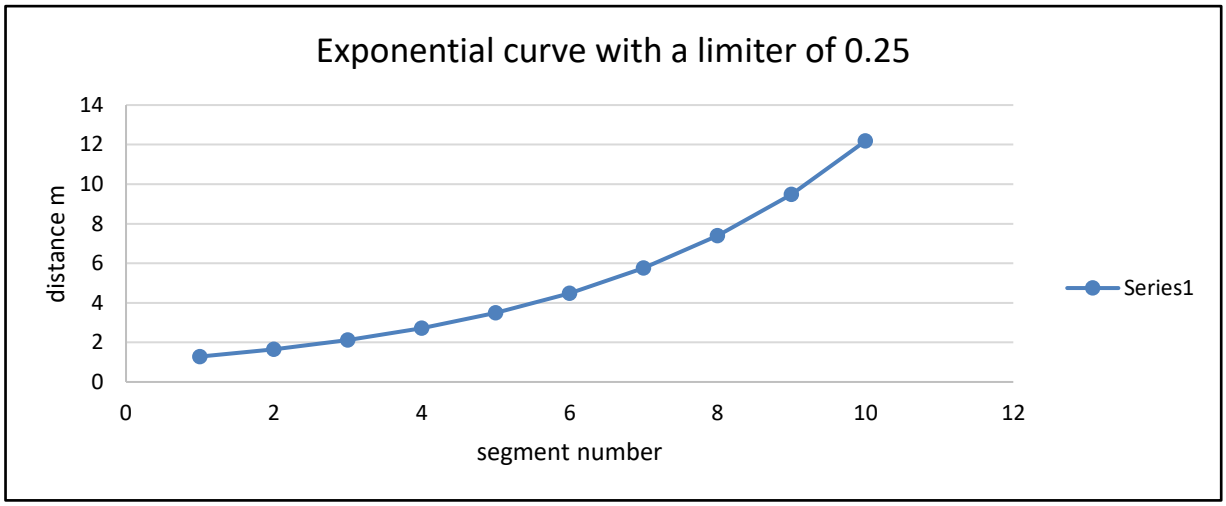


Figure 14 Segment values on the starboard side

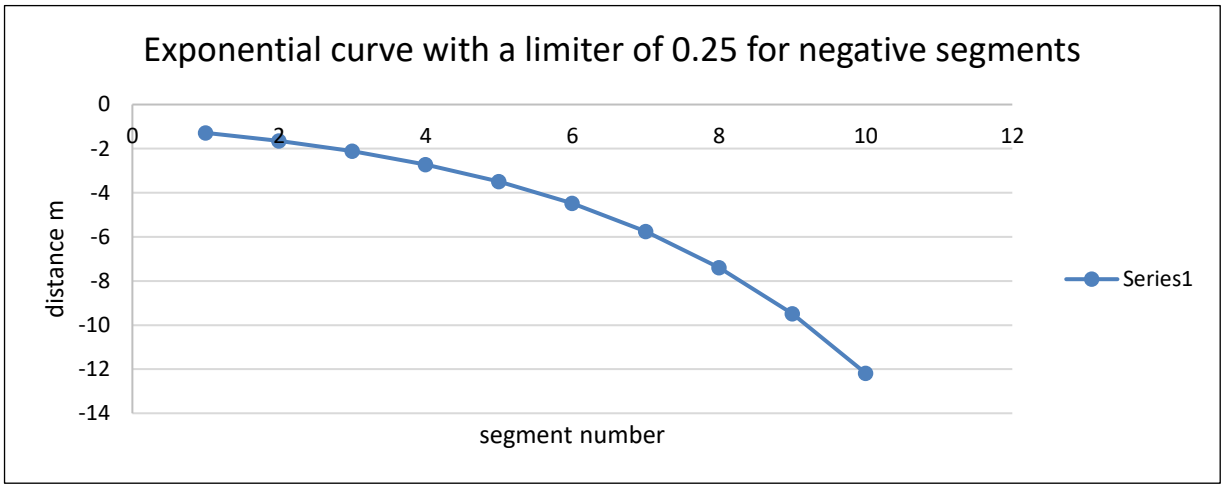


Figure 15 Segment values on the port side

### 4.1.8 Linear slope constant

When calculating the default values for the segment flap angles a linear function is used. This value controls how large the angle becomes. The function for calculating the angles is shown in the formula below:

$$Flap\ angle\ = LinearSlopeConstant\ \times\ SegmentNumber + LinearInterceptConstant$$

The linear slope constant determines how fast the angle increases for each segment. An example can be seen below with a slope constant of 0.3 and an intercept constant of 0.8.

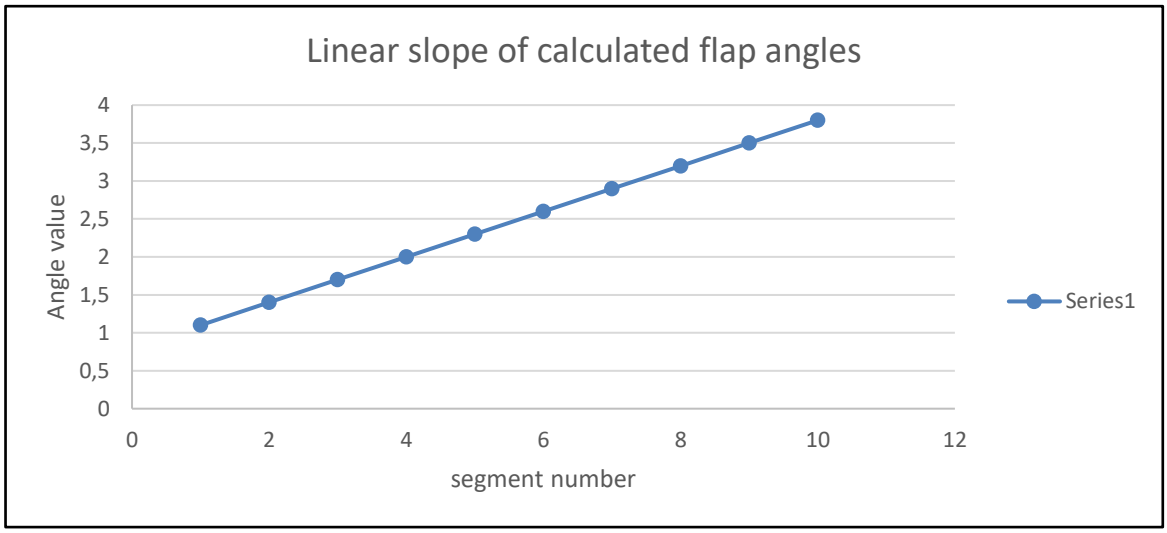


Figure 16 Flap angle development example

### 4.1.9 Linear intercept constant

The linear intercept constant determines where the linear function intersects the y-axis.

### 4.1.10 Recalculate segments

If a value is changed and a recalculation of the segments is needed, click the **Recalculate segments** button. A recalculation is needed when changing:

- The middle segment indicating the run line
- Max movement distance in meters
- Number of segments
- Exponential limiter
- Linear slope and intercepts constants

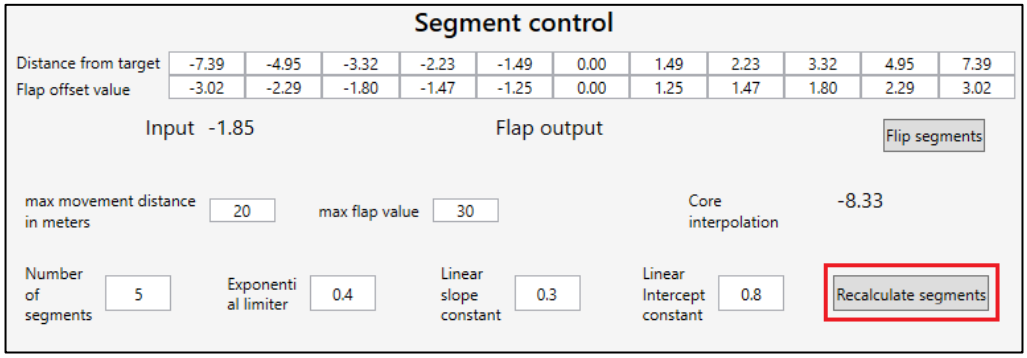


Figure 17 Location of the Recalculate segment button

## 4.2 PID control – Adjusting the PID

The **PID control** is a supplement to the Segment control. When the Segment control sets a static flap angle based on the ScanFish's distance to the runline, the PID control adds a dynamic flap movement centred on the static position set by the segment control.

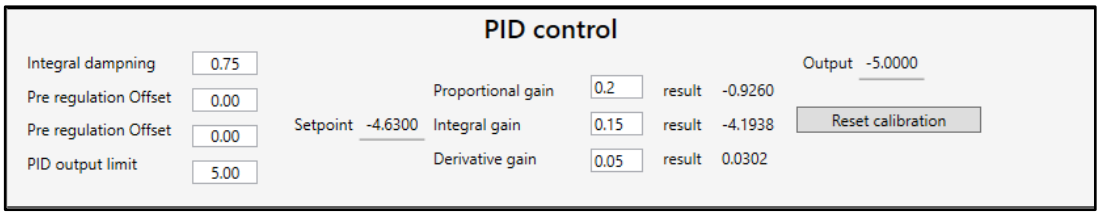


Figure 18 Overview of the PID control

The PID regulations can be fine-tuned using the **PID control** in the **AutoPilot** view.

Here you can adjust the **Proportional**, **Integral** and **Derivative gain** constants, as well as set the PID output limit and a damping mechanism for the integral gain.

**Integral damping** works as a percentage of how much of the integral gain to use in the regulation.

The output limit is used to set the maximum value the PID control can output.

### 4.2.1 Proportional gain

The proportional gain constant dictates how much the system should react to the latest incoming DOL data. The proportional gain constant produces an output value that is proportional to the current distance to the target value. The proportional response is adjusted by multiplying the error by this constant.

A proportional gain value of **1** will result in a 1:1 ratio of the distance from target in meters to the flap angle. Increasing the value to **2** will result in a 1:2 ratio, meaning if the distance from target is 2 meters the result sent to the ScanFish will be **4**.

Setting the proportional gain too high will result in a system that oscillates around the desired runline.

### 4.2.2 Integral gain

The contribution from the integral term is proportional to both the magnitude of the error and the duration of the error. The integral is the sum of the instantaneous error over time and gives the accumulated offset that should have been corrected previously. The accumulated error is multiplied by the integral gain constant and added to the output value.

It serves as a memory buffer for the past values sent to the flaps and helps accelerate the movement towards the desired position. Note that too high an integral gain can result in the system overshooting the runline as the accumulated error values are larger than the proportional value.

### 4.2.3 Derivative gain

The derivative error is used to predict the systems behaviour, helping the system settle on the correct runline and overall system stability.

## 4.3 Regulation adjuster

The **Regulation adjuster** tries to automatically correct the values in the segment control, by counting the number of samples by which the ScanFish is outside the set threshold. After a certain number of these samples, it adjusts the **Segment control**.

Figure 19 Regulation adjuster settings

#### 4.3.1 Samples off target

Determines the number of samples the ScanFish should be off from the runline before adjusting the segments table.

#### 4.3.2 Last avg data sample

Shows the average value of the sample distances outside the set threshold away from the runline from the last segment adjustment.

#### 4.3.3 Number of samples before update

Indicates how many samples over the threshold should be counted before adjusting the segment table.

#### 4.3.4 Samples threshold

Sets the threshold the samples should pass before being counted as off target.

# 5 AutoPilot modes

## 5.1 Disabled

In the **Disabled** mode, the flaps are locked in the zero position and will remain in this position until the flaps are moved manually or if another AutoPilot mode is chosen.

This is the default mode for the AutoPilot.

## 5.2 Segment

The **Segment** sets the flap angle based on the distance between the ScanFish and the target runline.

## 5.3 Segment + PID

The **Segment + PID** adds the PID result to the result of the **Segment** regulation before sending the value to the ScanFish.

## 5.4 Segment + PID + Adjuster

Works the same as the **Segment+ PID** regulation, but after a certain number of samples outside the threshold an adjustment to the segment table will be made.

## 5.5 Reactions to incoming data

The autopilot system runs on a pulse determined by the incoming data streams. Every action made by the autopilot is based upon the data pulse. If no data is received then the autopilot will not update, resulting in no change to the 3D flap angle values!

# 6 AutoPilot options menu

To open the **AutoPilot options menu**, click **Settings** and select **Options**. When the **Options menu** is open, select the **AutoPilot** tab.

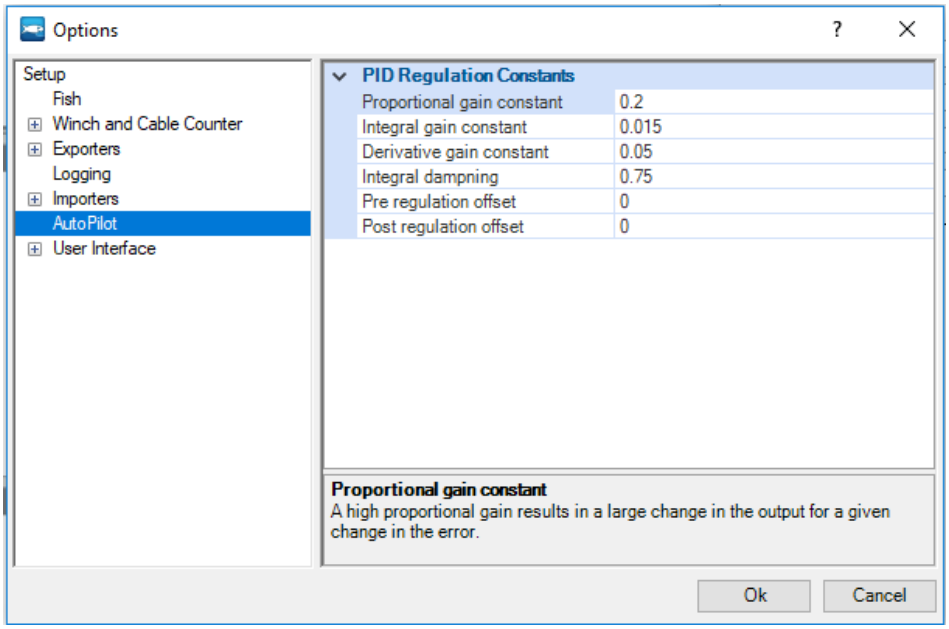


Figure 20 The AutoPilot options menu, where the default values of the PID regulation for the AutoPilot can be set.