

PILOT HR



USER MANUAL

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1. FUNCTIONALITIES

1.1. Introduction

The **PROCESSOR HR** sits at the heart of a system which provides the autopilot, the navigation programme, the on-board PC, the skipper and the crew all the data they require. The data provided is optimised for accuracy, responsiveness and performance.

The PROCESSOR HR:

- Processes wind data (impact, apparent, true), Boat Speed and Speed over ground, accurate and responsive measurements of the boat's attitude.
- Measures, regardless of motion, the hull's behaviour as well as a rotating mast and mast distortion (geographical heading, angles, accelerations, rate of turn, magneto-metric vector)
- Gives an accurate dynamic calculation of true wind as a result of the compensation of measured data from the masthead sensor, the geometry between the mast and the hull and the use of correction tables.
- Improves the autopilot steering thanks to the enhancement of the sensors and data processing (measurements age, synchronisation, linearisation, offset / de-noising, high resolution)
- Saves all entries at high rate in the data-logs.

The **PILOT HR** is a software module integrated to the **PROCESSOR HR**. It manages a robust deterministic auto-steering process that is widely adjustable with 3 dimensions of movements.

The PILOT HR:

- It allows the data coming from the 3d Hull Sensor to be used with critical high quality information to calculate a Course To Steer at a higher rate.
- Sends a rudder angle command at high frequency to the Gyropilot2, which acts accordingly.

Basic configuration:

- Gyropilot2 with True Wind option
- HR wind vane or Carbowind
- Ultrasonic Speedometer
- Multigraphic Display
- PROCESSOR HR
- PILOT HR
- 3D Sensor

1.2. Main functionalities

Enhanced Performance:

- 3 dimensions of movement measurement.
- use of wind data compensated for the boat's movement.
- use of a responsive boat speed data

Several pilot modes, according to wind angles:

- True Heading
- True Wind Angle
- True Wind Angle for optimum VMG according to polar table
- Apparent Wind Angle

Significant reduction of **power consumption**:

- approximately twice less for the ram, compared to Gyropilot2
- replacement of a GyroTrack KVH (12 W) by a 3D Sensor (0.5 W) with processor (1 to 1.5 W)

Knowledge:

- the steering control is extremely adjustable (effect of heel angle, course in swell...)
- Data logs saved on the USB key include all data that can be used to improve settings and algorithms.

1.3. Control and command

The **PROCESSOR HR**:

- Collects all measurement data for the boat's movements, wind and speed (at a rate of 25Hz for the 3D HULL SENSOR).
- Processes the data, compensates for noise and corrects
- Uses a robust command algorithm to process and send command data at 25Hz.

The **PILOT HR**:

- Sends a command at 25Hz on the Toplevel bus for the Gyropilot2.

Therefore, the **Gyropilot2** plays only a simple role: actuator, rudder angle measurement, power consumption measurement.

2. USE OF THE PILOT HR



Steer the boat on a stable course (pay attention to the average rudder angle) for a few seconds before switching to **Auto mode**.



WARNINGS

The **PILOT HR** controls the Gyropilot2 as an actuator. Therefore, it is normal to read "steering mode" and a variable Course To Steer on the **Gyrographic** page.

"Ang.Opt.Polaire" mode specifically:

- To make sure the correct wind angle (close-hauled or reach) is selected, avoid switching to **Auto** with a True Wind Angle too close to 90°.
- For best results adjust the True Wind Angle close to the optimum value before switching to **Auto**

It is possible to adjust the polar optimum VMG angle up to $\pm 9^\circ$ with the keys **←** and **→**.

Tacking:

- When tacking or gybing with the **PILOT HR**, the boat turns in the direction shown by the button that has been pressed (nevertheless, avoid engaging an auto tack/gybe manoeuvre from a True Wind Angle too close to 90°).
- The tack/gybe speed and timing can be set (refer to the Tack Speed section below).
- In True Heading mode, the course to steer change value is 100°, whatever the wind angle.

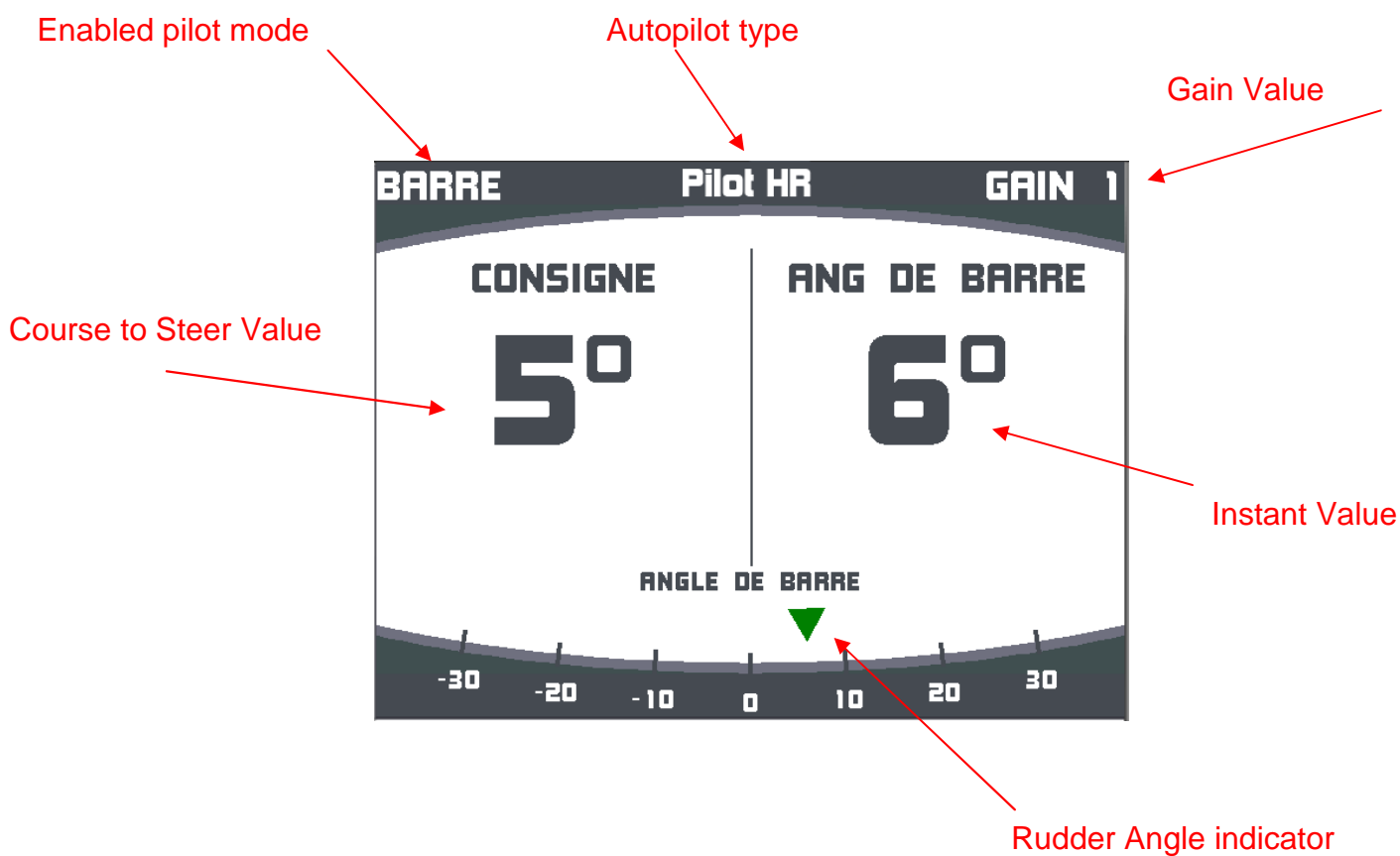
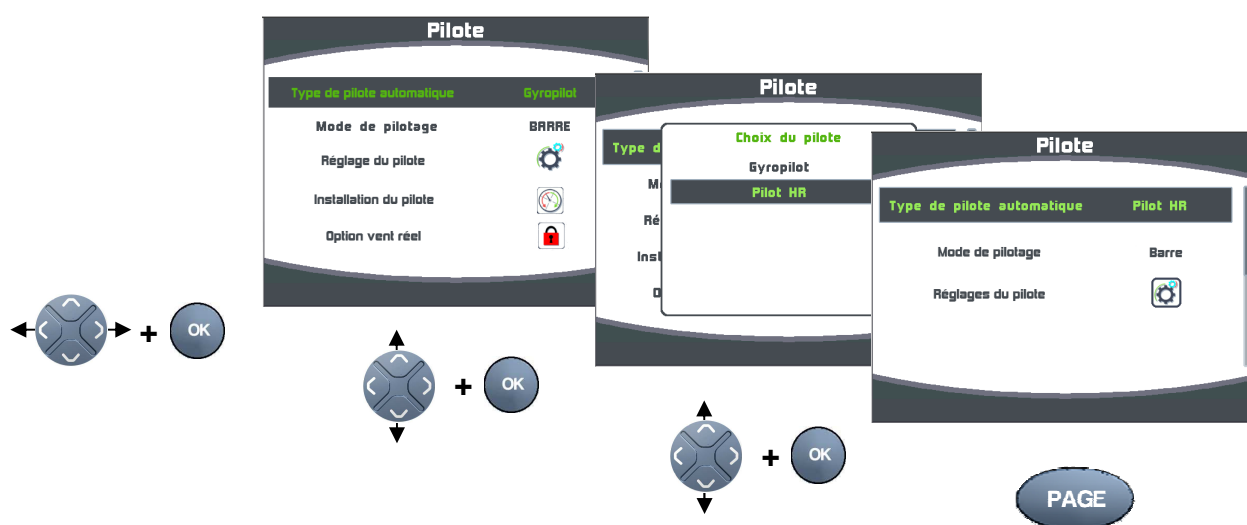
2.1. Use of the PILOT HR with a Multigraphic

The autopilot **HR** requires the **PROCESSOR HR**.

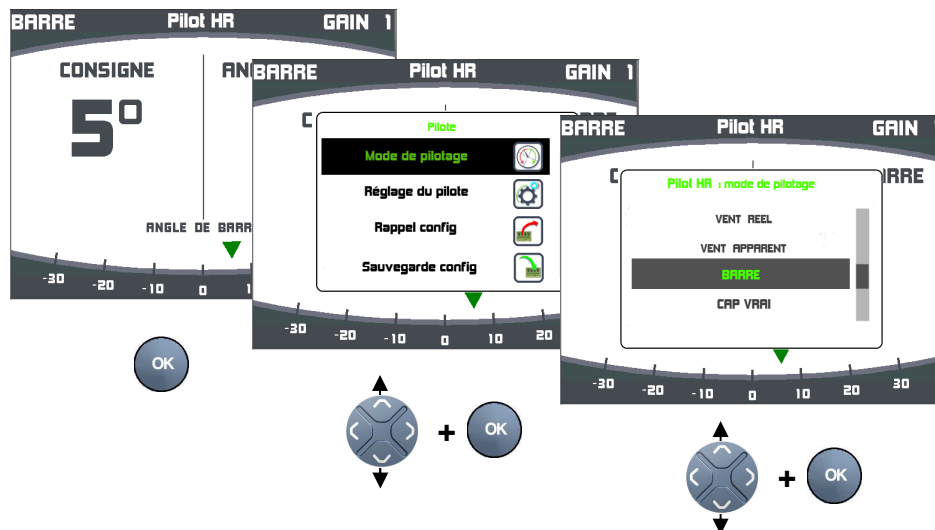
The default autopilot set on the **Multigraphic** is the **Gyropilot2**. You can choose to display either the **Gyropilot2** or the **PILOT HR**. The choice can be made at any time.

2.1.1. Selecting the HR Autopilot on the Multigraphic

Selecting the **HR** Autopilot is done from the icons in the "Pilot" menu.



2.1.2. Selecting the autopilot mode



Access the list of the five modes from the Pilot page. Press OK to confirm the selection of the mode.

5 autopilot modes are available:

- True Wind
- Apparent Wind
- Rudder
- True Heading
- Polar table

2.2. Description of the autopilot modes

2.2.1. True Heading mode

follows a True Heading.

Use:

- Sailing on a beam reach and the quickest route is a straight line (with steady wind).
- When the wind force is too low compared to the swell (too much "noise" in wind measurement)

2.2.2. True Wind Mode

Follows a True Wind Angle.

Use:

- With any wind angle

Note:

- The "hybridisation" period for Heading/True Wind can be set and has a great influence on the autopilot performance. Refer to **2.3.3**
- Thanks to the 3D inertial unit, a correction factor can be applied for the mast's movement effect on the aerial sensor. This suppresses around 80% of the noise in the wind data measurement.

2.2.3. Polar table mode

Follows an optimal wind angle to achieve a VMG calculated with the polar table data (target TWA).

Use:

- Beating or reaching with a variable wind speed

Note:

- This mode works as a "layer" on top of the True Wind Mode. A manual adjustment of the theoretical angle is possible (+/- 9° for a lower or high VMG than the target given by the polar table).
- The time allowed to reach the Course To Steer once the Auto mode is switched on can be set from the web page. Look for the value under "PolarReachSpeed".
- The Course To Steer, optimal VMG angle, must have been filtered for a good operation of that mode. (Filtering performance > 4).

2.2.4. Apparent Wind Mode

Follows an Apparent Wind Angle

Note:

- As for the True Wind Mode, a wind filter value has a great influence on the performance.

2.2.5. Rudder Mode

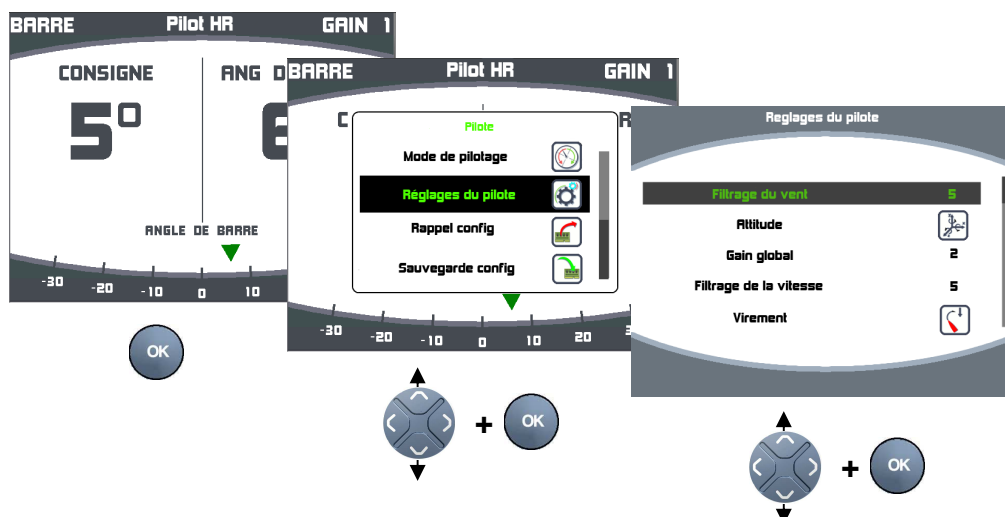
Operates like a rudder lock

Use:

- Check rudder angle and rudder ends.

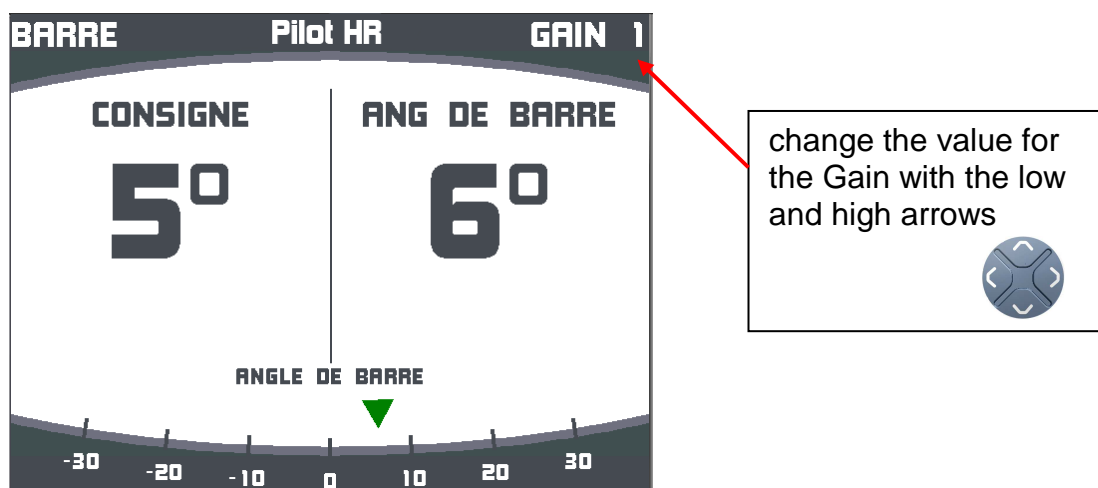
2.3. Settings for the PILOT HR

2.3.1. Multigraphic Menu

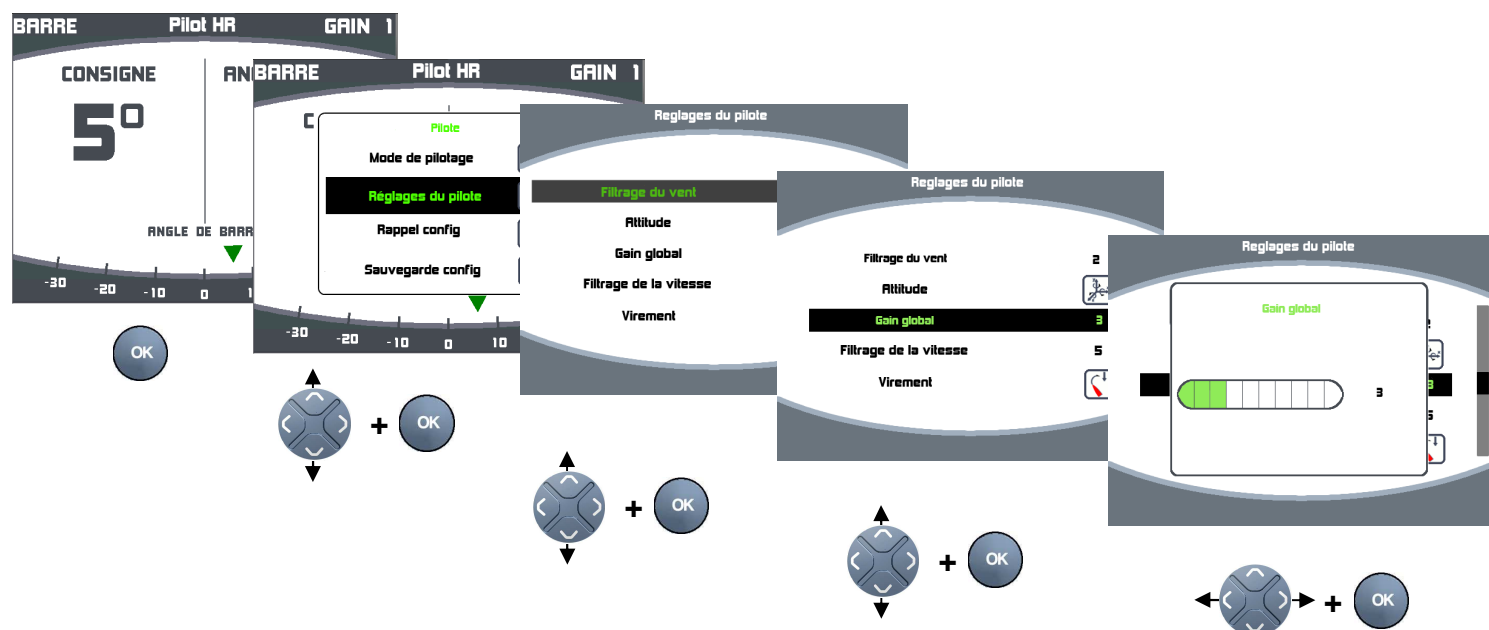


2.3.2. Gain settings

From autopilot page and acting on the high and low keys on the cursor pad:



From the autopilot settings menu:



The Gain applies to the yaw PID (proportional–integral–derivative) controller:

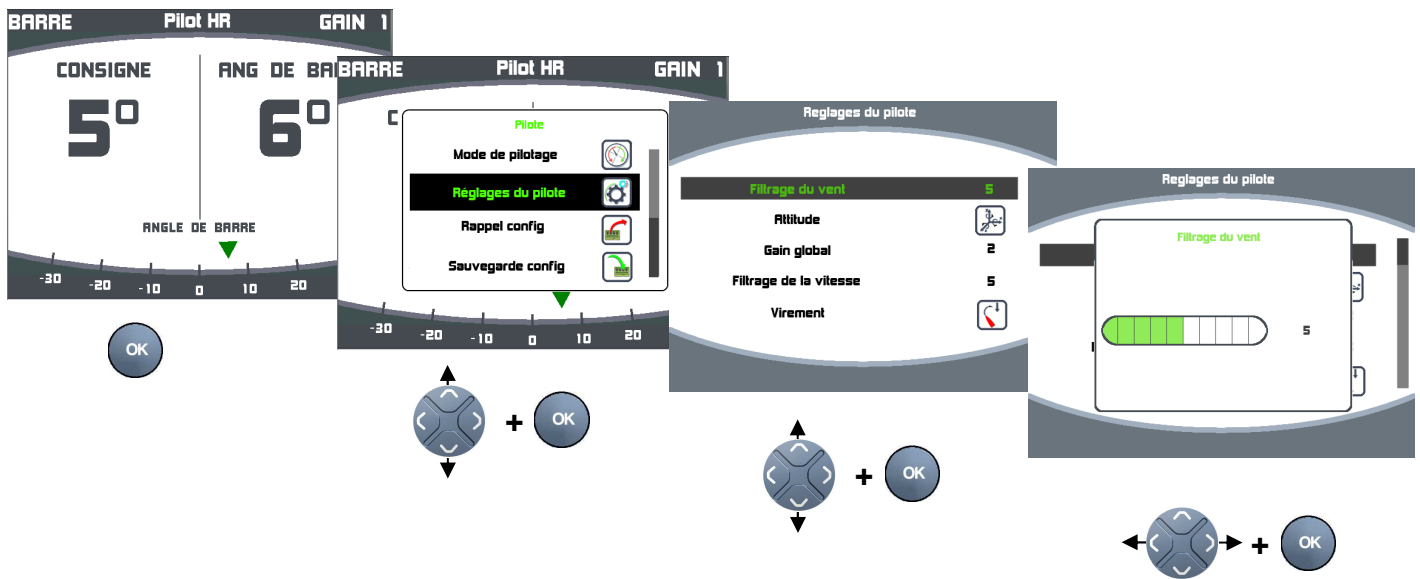
It adjusts the control variable that commands the rudder action for an error at a given yaw and given speed, therefore optimising the time required to correct the Course To Steer error.

This gain value change of one unit has the same effect as changing the three yaw PID components by one unit each.

The typical values are:

- 3 for light wind and calm sea
- 5 as average
- 7 for rough conditions (heavy waves, under spinnaker...)

2.3.3. Setting the Wind parameter



Under Wind mode (apparent, true, target true), a filter called "hybridisation" allows integrating:

- on short term: the internal current Course To Steer (for a straight route).
- on long term: an optimal calculated Course To Steer to get a nil value for the Wind CTS error.

The wind filter is a very important parameter and it greatly affects the autopilot behaviour. It is as important to set as the gain value.

Wind filter

Period for the wind hybridisation filter shut-off

0: instantaneously follow any true or apparent wind variation without considering the heading value coming from the 3D Sensor.

Use: never, only for test purposes.

The steering command is affected by a lot of noise.

4 to 6: Compromise between going straight and following the wind and boat speed variations.

Use: beating and reaching.

The steering command is affected by a little noise.

7 to 9: The wind data is used in the calculation of the Course To Steer for the long term. The boat tends to sail straight, despite the instantaneous wind and boat speed variations.

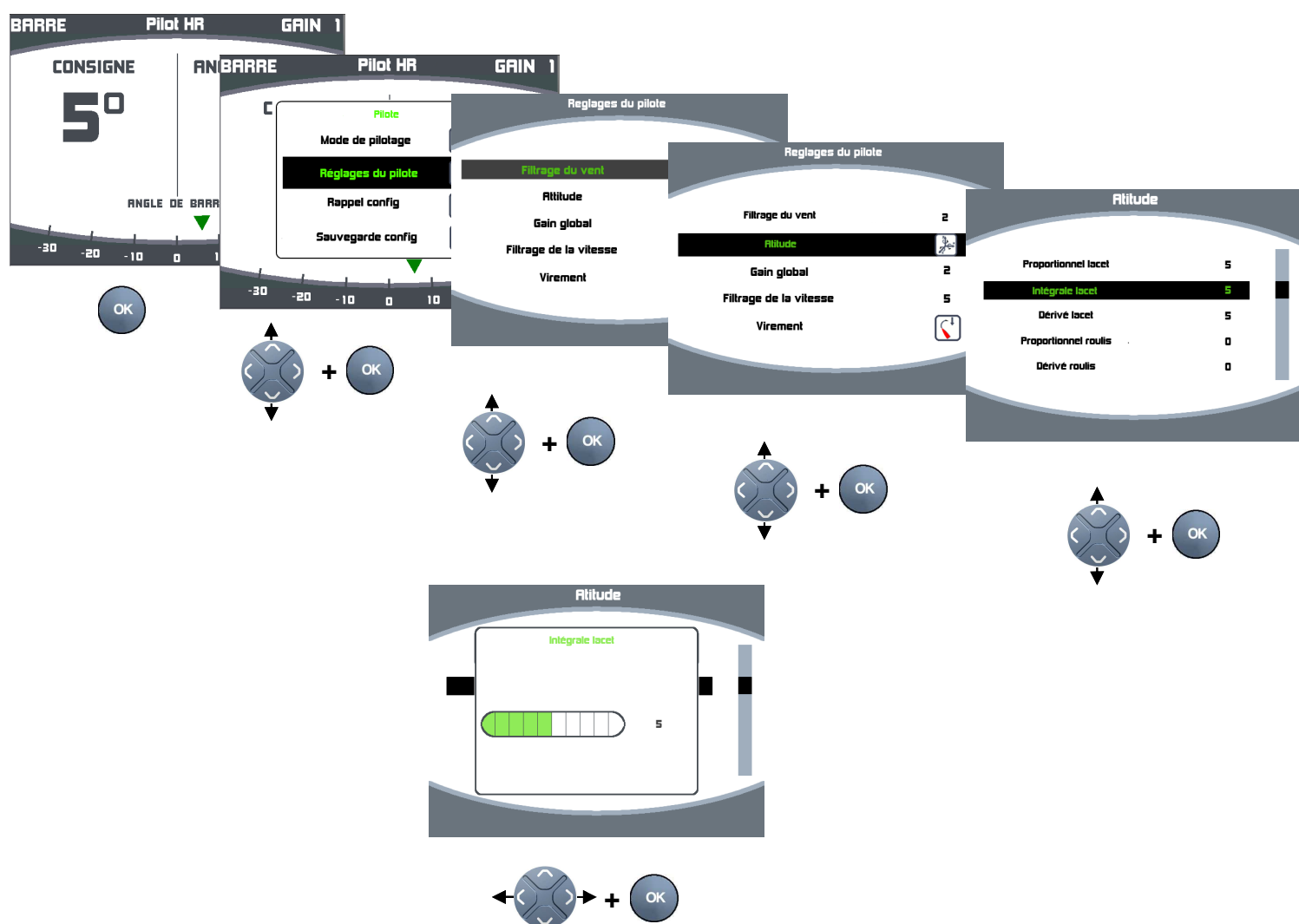
Use: reaching (where the quickest route is the straight line), with light wind and large swell.

The Course To Steer is no more affected by noise than when in Heading mode.

Setting	Wind-Heading shut-off period
0	0
1	0.4
2	1.6
3	3.2
4	6.4
5	<i>12.8</i>
6	25
7	51
8	102
9	204

Bold Italic: Default value

2.3.4. Yaw settings



Definition:

Yaw is the horizontal movement of the boat around a vertical axis.

Proportional / Yaw:

Adds an offset to the rudder angle proportionally to the heading error.
This implies a direct and instant action on the rudder.

Integral / Yaw:

Adds an offset to the rudder proportionally to the heading error multiplied by the time laps.

This is how the autopilot can implement a neutral position of the rudder, allowing the boat to sail straight and which, at some wind angles, might not be the mid-position.

This parameter allows a long term Course To Steer, but can induce a slow undulation around the CTS if it is set too high.

Derivative / Yaw:

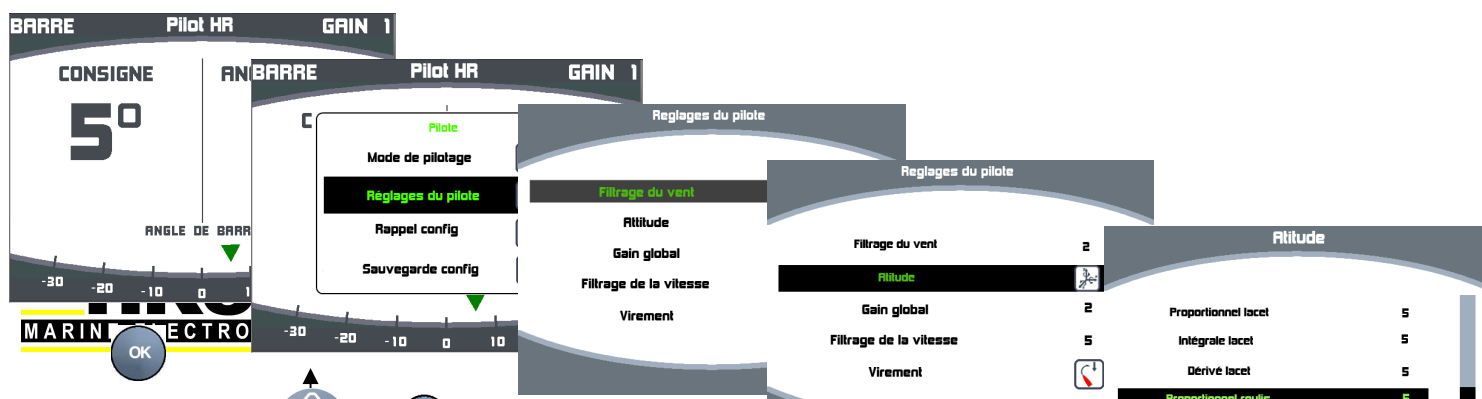
Adds an offset to the rudder proportionally to the yaw rate.

The action of this parameter is anticipating the yaw rotation angle. It gives a correction to the rudder as soon as possible and thus, keeping the boat as much on a straight course as possible. Also, when there are great Course To Steer changes, like tacking, it brings the rudder back in mid-position to anticipate the over steering.

Settings Table:

Settings	Proportional / Yaw	Integral / Yaw	Derivative / Yaw
0	0%	0%	0%
1	41%	41%	41%
2	51%	51%	51%
3	64%	64%	64%
4	80%	80%	80%
5	100%	100%	100%
6	125%	125%	125%
7	156%	156%	156%
8	195%	195%	195%
9	244%	244%	244%

2.3.5. Roll settings



Definition:

Roll motion is a boat's rotation movement around its longitudinal axis.

The angle defined by the horizontal reference is therefore the heel angle.

The roll rate is the angle and speed of that rotation, here called "Derivative Roll"

Proportional / Roll

Adds an offset to the rudder angle proportionally to the heel angle.

This parameter induces an instant rudder action when the boat's heel angle changes (wind gust, uncontrolled luffing...). It allows rebalancing the boat instantaneously when there is a variation of the hull's wet surface area (waves motion, gusts of wind...).

The KpRoll factor can be set in the constants configuration file. It must be positive if the boat tends to luff.

Its estimation is simple: i.e. the tiller is pulled to 4° on the windward side for a 20° heel angle: $KpRoll = 4/20$. Enter "KpRoll=0.2", then restart and set "Proportional Roll" to 5.

**CAUTION:**

A brutal change of Proportional Roll creates a sudden shift of the rudder. The Yaw process will take some time to regain balance. Therefore, it would be preferable to temporarily switch on "Stop" when this factor meets changes that are too strong.

Derivative / Roll

Adds an offset to the rudder proportionally to the roll rate (°/s).

This parameter is anticipating the heel angle. It allows a rudder correction as soon as possible when the conditions change and to keep a heel angle as constant as possible.

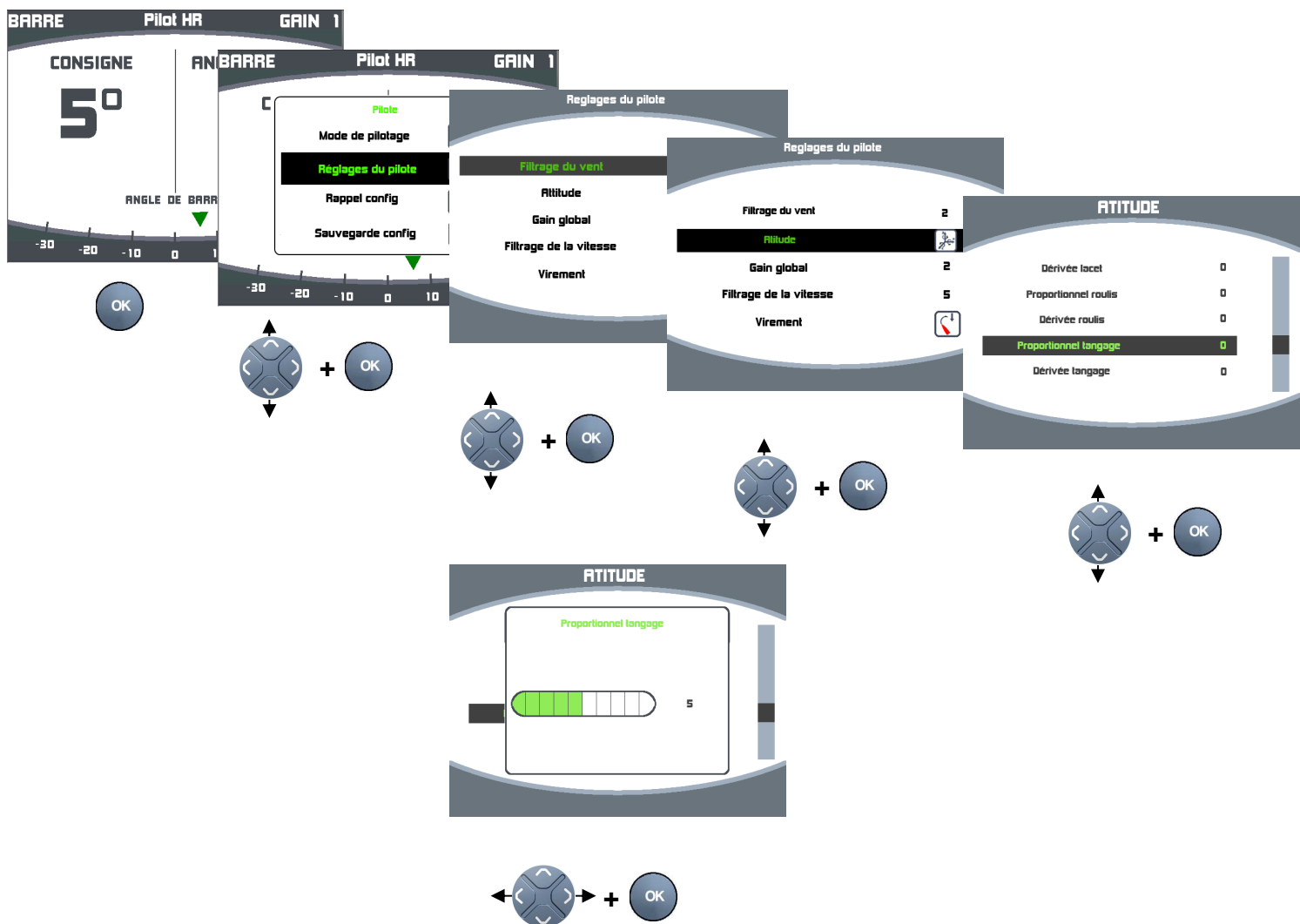
When the boat's heel angle is in a synchronous manner with the swell, this factor is a fourth of a wave phase ahead.

Settings	Proportional / Roll (°rudder/°error)	Derivative / Roll (°/s)
<i>0</i>	<i>0% of KpRoll</i>	<i>0% of KdRoll</i>
1	41% of KpRoll	41% of KdRoll
2	51% of KpRoll	51% of KdRoll
3	64% of KpRoll	64% of KdRoll
4	80% of KpRoll	80% of KdRoll
5	100% of KpRoll	100% of KdRoll
6	125% of KpRoll	125% of KdRoll
7	156% of KpRoll	156% of KdRoll
8	195% of KpRoll	195% of KdRoll
9	244% of KpRoll	244% of KdRoll

Bold Italic: Default value

KpRoll, KdRoll are hidden by default in the constants configuration file, but they remain settable. Their default value is 0.2.

2.3.6. Pitch settings



Definition:

Pitch is the up/down rotation of the boat its lateral axis.

The trim indicates the position or the balanced state of boat in respect to the horizontal plan.

The trim angle is the longitudinal tilt of the boat, also called Pitch angle.

Proportional / Pitch

Adds an offset to the rudder angle proportionally to the pitch angle.

This parameter induces an instant rudder action when the boat's pitch angle changes in the waves.

Derivative / Pitch

Adds an offset to the rudder proportionally to the pitch rate (°/s).

This parameter is anticipating the trim angle. It allows a rudder correction as soon as possible when the conditions change and to keep a trim angle as constant as possible.

When the boat's pitch angle is in a synchronous manner with the swell, this factor is a

fourth of a wave phase ahead.

Note:

The possible use of pitch in the rudder control has been coded to evaluate the gain on safety or performance.

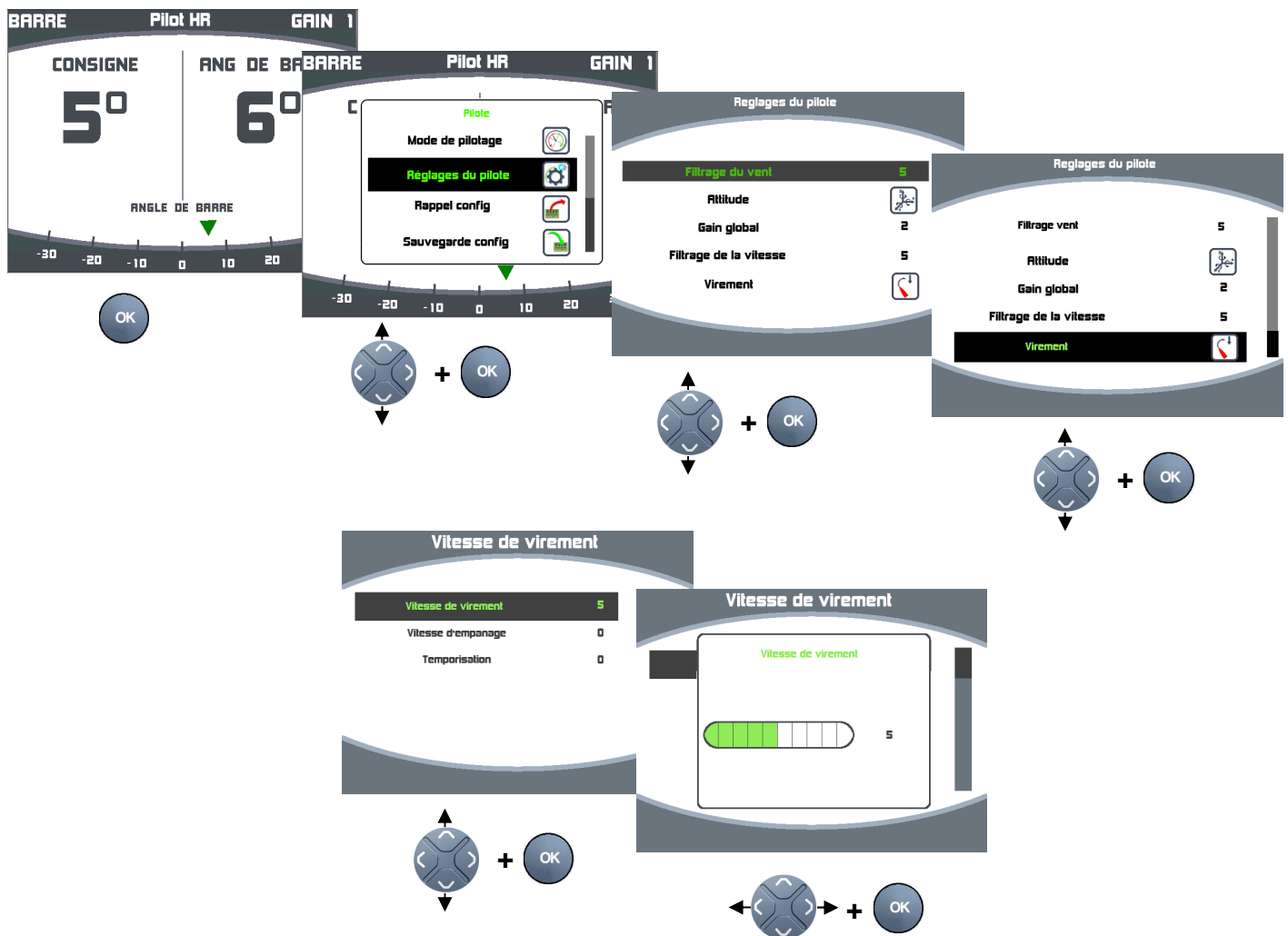
It can be used to act briefly on the rudder when the boat rides a wave or in a surfing situation, to choose a track shifting on purpose (provided you disable the Derivative / Yaw which is a conflicting factor).

Settings	Proportional / Pitch (°rudder/°error)	Derivative / Pitch (°/s)
0	<i>0% of KpPitch</i>	<i>0% of KdPitch</i>
1	41% of KpPitch	41% of KdPitch
2	51% of KpPitch	51% of KdPitch
3	64% of KpPitch	64% of KdPitch
4	80% of KpPitch	80% of KdPitch
5	100% of KpPitch	100% of KdPitch
6	125% of KpPitch	125% of KdPitch
7	156% of KpPitch	156% of KdPitch
8	195% of KpPitch	195% of KdPitch
9	244% of KpPitch	244% of KdPitch

Bold Italic: Default value

KpPitch, KdPitch are hidden by default in the constants configuration file, but they remain settable. Their default value is 0.2.

2.3.7. Setting the tack speed



Tack Speed:

Determines the yaw rate when tacking.

By default, set on 5, the tack speed is 20°/s.

Can be adjusted from the web page "TackingSpeed".

Gybe Speed:

Determines the yaw rate when gybing.

By default, set on 5, the gybe speed is 10°/s.

Can be adjusted from the web page "GibingSpeed »".

Boom shift damping:

Sets a pause when gybing downwind to help the boom crossover.

The default value is nil. It is expressed in seconds.

Can be adjusted from the web page "SecPerBoomTp »".

Angle offset when the boom crosses over:

A specific offset for running situations applies for the pause.

This offset can be set in the constants configuration file under the "GibingBoomOff" field.

When a positive value is set, the pause applies once the boat is on the new tack.

The default value is nil (the pause occurs when the boat is exactly downwind).

2.3.8. Settings in the web page

Enter all the values correctly in the web page for optimised operation of the PILOT HR.

HardRudderLimit :

Mechanical rudder end when the rudder is configured. Smallest value. Example: If the starboard rudder end is 27° and the port rudder end is 25°, enter 25°.

VitesseCoque :

The autopilot behaves differently when the boat is planning or not. The hull speed commonly matches the target boat speed when sailing upwind with a 15 knots wind speed. (8knots for a Class40)

AsservSpeed :

Default value is 3. Should you wish to increase the rudder action when the boat is planning, you need to decrease that value to 2 or 1.

Surf Max Val :

Amplitude in degrees given to the autopilot to steer over the CTS in order to ease when surfing and then luff to catch speed back after surfing.

2.4. Activation of the PILOT HR licence

Since Version 3.7, the PILOT HR must be activated with a software key linked to the serial number of the Gyropilot2. This key must be entered in the Web page, under the installation configuration section, [PilotHR] field.

3. SUPER MODES

This section describes the principle and behaviour of the two "Super Modes". Super Modes are layers added on top of the standard modes such as "Compass, AWA, TWA".

3.1. SuperMode Gust

The gust mode has been designed only with a safety aim: giving to the autopilot an escape strategy in case of a gust. It is not meant to optimise the boat's track and speed.

The gust mode is available as an extra layer on top of the following modes: -
True Heading

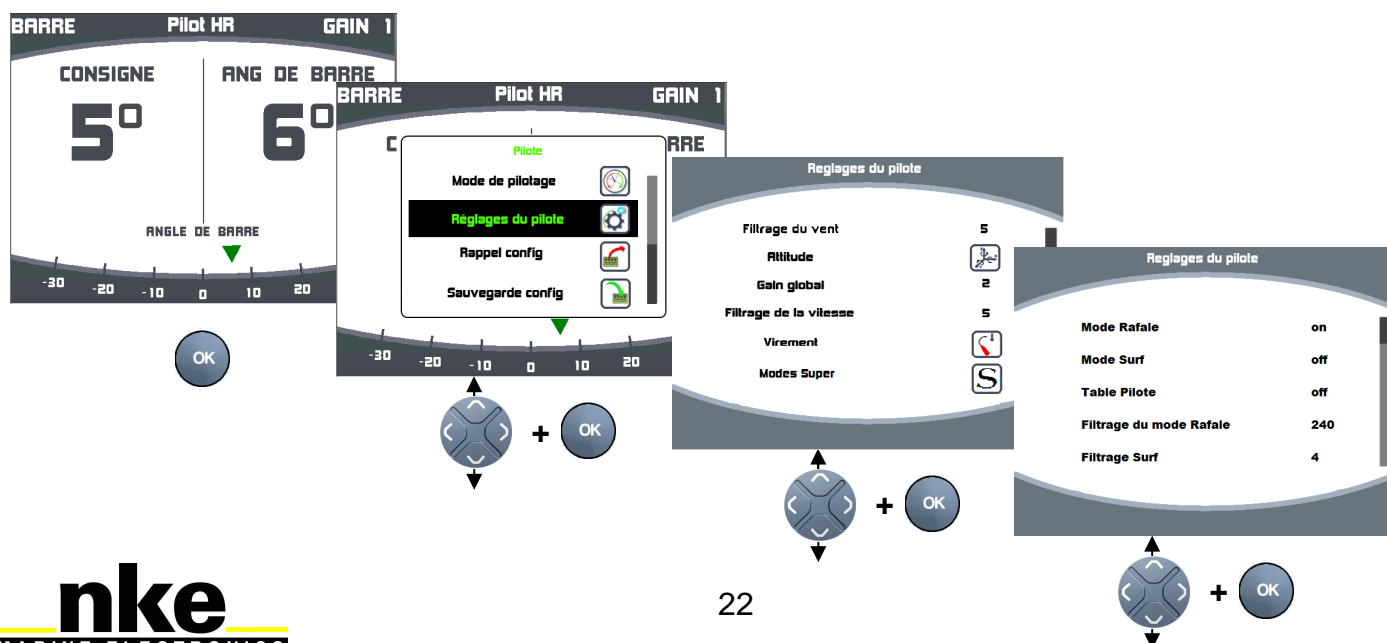
- Apparent Wind
- True Wind

3.1.1. Enabling the gust mode in the PROCESSOR HR

In order to enable the gust mode, the parameter "ModeRafale" must be accessible in the processor Web page under "Configuration of the installation" at "Y". The processor must be restarted once a parameter has been modified.

3.1.2. Enabling/disabling with a Multigraphic.

Once the gust mode has been enabled in the Web page of the processor, the function becomes available in the Multigraphic. Go into the pilot settings menu from the PILOT HR page, then go to the Super Modes menu and choose "on" for the gust mode.



3.1.3. Operation

Gust mode Table:

TWA	TWS Delta	Offset	Tempo N-1	Tempo new Consigne
30	2	0	0'20"	5"
	4	0	0'20"	4'30"
	6	0	0'20"	4'00
	8	0	0'30"	3'30"
	10	0	0'30"	1'30"
	12	0	0'30"	1'00"
50	2	-1	0'20"	5"
	4	-2	0'20"	4'30"
	6	-4	0'20"	4'00
	8	-5	0'30"	3'30"
	10	-7	0'30"	1'30"
	12	-8	0'30"	1'00"
80	2	-2	0'20"	5"
	4	-4	0'20"	4'30"
	6	-7	0'20"	4'00
	8	-10	0'30"	3'30"
	10	-13	0'30"	1'30"
	12	-16	0'30"	1'00"
110	2	0	0'20"	5"
	4	0	0'20"	4'30"
	6	0	0'20"	4'00
	8	0	0'30"	3'30"
	10	0	0'30"	1'30"
	12	0	0'30"	1'00"
160	2	2	0'20"	5"
	4	4	0'20"	4'30"
	6	6	0'20"	4'00
	8	8	0'30"	3'30"
	10	10	0'30"	1'30"
	12	12	0'30"	1'00"
180	2	0	0'20"	5"
	4	0	0'20"	4'30"
	6	0	0'20"	4'00
	8	0	0'30"	3'30"
	10	0	0'30"	1'30"
	12	0	0'30"	1'00"

Sectors:

The table features 6 sectors, each with 6 actions. Having 6 sectors allows the setting of various strategies, according to True Wind Angle.

Example: sail upwind when beating, sail downwind when reaching and do nothing when beam reaching.

When you enter values for these sectors, the True Wind Angle value must be identical for each 6 actions in the involved sector.

A sector is active when the True Wind Angle value is between the value of the previous sector and the value of the current sector. Which means that the TWA field figures the lowest value for that sector.

Example: With the previous table, when sailing with a 150° True Wind Angle, the potential actions are featured in the sector Nr 5.

Actions:

Fields descriptions:

- TWA: Lowest value for that sector.
- TWS Delta: TWS I.
- Offset: Offset added to the autopilot CTS.
- Tempo N-1: In seconds. If time elapsed, go to the lower CTS.
- Tempo new CTS: In seconds. If time elapsed, the current CTS is considered.

TWS features an average. It is a running average, in seconds and given by the "Gust Mode Filter", accessible from the Multigraphic in autopilot settings menu. This value must be > 60. When the current TWS value is greater than the reference TWS, it means gust. To enable an action, the gust must be greater than the TWS Delta value. If the case occurs, the related offset applies and the timers are activated.

Example: We sail with a 150° True Wind Angle and we pressed Auto, the wind was blowing 15 knots. This sets the reference. The wind slows down or remains stable -> no action.

The wind picks up. Following our table, a first action is enabled for a 2 knots gust. This means that once the wind speed is over 17 knots, a 2° offset will be applied and the boat sails 2° downwind.

The wind blows stronger to reach 20 knots. That means a 5 knot gust (20-15). 5 knots being greater than 4, it reaches the second action setting. The second action is enabled and the boat will sail 4° downwind.

Time-out functions:

For each activation, time-out functions are reset. To go back to an action, the wind must have gone back down to the previous level and the time featured in Tempo N-1 has elapsed.

Therefore, when the gust is blowing only 5 seconds, but the field Tempo N-1 shows 20 seconds, the boat will not come back to the previous CTS once the wind slows back down (5 seconds), but after 20 seconds. This allows the autopilot to take time to change the Course To Steer.

Tempo new CTS: is useful if the gust lasts. When the gust stays on and the action remains active while the New CTS time elapsed, the current CTS becomes the reference one (CTS + offset from the Super Mode).

User actions:

When a user action is made and the Super gust mode is already working, the reference for the user action is "original autopilot CTS + SuperMode Gust's offset".

Example: We sail with a 150° True Wind Angle with a 5 knot gust and the Super Mode offset is 4°. The original autopilot CTS is True Heading 90°, adding the 4° offset of the SuperMode Gust, the autopilot steers now to $90+4=94^\circ$ True. Now, if the user presses +1 on the autopilot command, the new CTS will not be $90+1=91^\circ$, but $90+4+1=95^\circ$ True.

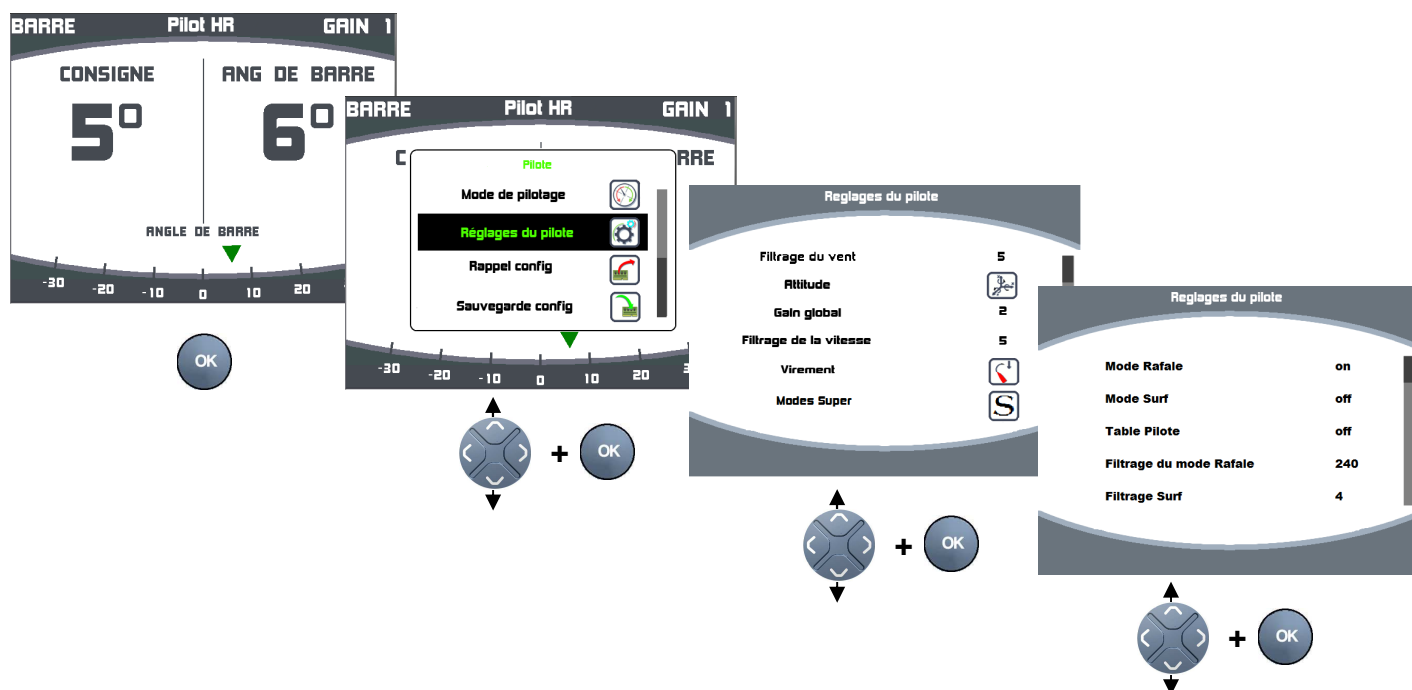
3.2. SuperMode Surf

3.2.1. Activation of the SuperMode Surf with the PROCESSOR HR

In order to enable the Surf mode, the parameter "ModeSurf" must be accessible in the processor Web page under "Configuration of the installation" at "Y". The processor must be restarted once a parameter has been modified.

3.2.2. Enabling/disabling with a Multigraphic.

Once the Surf mode has been enabled in the Web page of the processor, the function becomes available in the Multigraphic. Go into the pilot settings menu from the PILOT HR page, then go to the Super Modes menu and choose "on" for the Surf mode.



3.2.3. SuperMode Surf aim

The principle is the same as the Gust mode. An offset is added to the current CTS, temporarily or permanently.

Available autopilot modes:

In principle, the Surf super mode has been designed for the True Wind Mode and the Polar table mode.

Behaviour with the Surf super mode:

The Surf Super mode aims to reproduce what a skipper would do when the boat can surf. Sail down in the surf when the boat accelerates to keep boat speed and improve the VMG, then sail back towards the wind when the surf ends to pick up speed.

3.2.4. Gain for mode surf

The only accessible setting is the gain. Its average value is 5. The gain in Surf mode stands for "aggressiveness". When the value is over 5, the autopilot will sail straight downwind in the surf and rapidly sail back towards the wind to pick up speed. If you think that the autopilot steers too far downwind, you can reduce the value to 4 or 3.

3.3. Pilot page Display

The actions for Super Mode can be seen on the channel "Pilot Super". We recommend displaying on the pilot page of the Multigraphic.

3.4. Operating tips, guidance