1x Software Manual

Release 6.12/1.0

Embention Sistemas Inteligentes, S.A.

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Contents

Scope of Changes

- Version 1.0
  - Added:
    - Status Message variables new section.
  - Changed:
    - Status Message variables section renamed to Extended Status Message variables.
    - Sensor names modified to the sensor indices in the descriptions of BIT Variables and Real Variables (RVar) - 32 Bits sections.
  - Improved:
    - Clarification of the communication and data transmission between the GCS and the Air unit in the Communication - Air-GCS connection section.

Software Applications

Veronte Link

Veronte Link establishes communication between a computer and any Veronte product by creating a VCP bridge.
It allows multiple control stations and autopilots to be interconnected, operating simultaneously.
Veronte Link also includes a post-flight viewer to reproduce all recorded data from previous flights and generate plots and reports.

For more information, visit the Veronte Link user manual.

1x PDI Builder

1x PDI Builder is the main configuration tool to adapt a **Veronte Autopilot 1x** to a specific vehicle, including user-defined communication protocols.
1x PDI Builder includes:

- **Telemetry**: Real-time onboard UAV metrics, such as sensors, actuators, and control states.
- **Configuration**: Edit vehicle settings, such as servo trim, interface/port management, and modes.
- **Automations**: Actions that are automatically executed when a set of configured conditions is met.
- **Block Programs**: **Veronte Autopilot 1x** can be programmed with a user-friendly programming language.

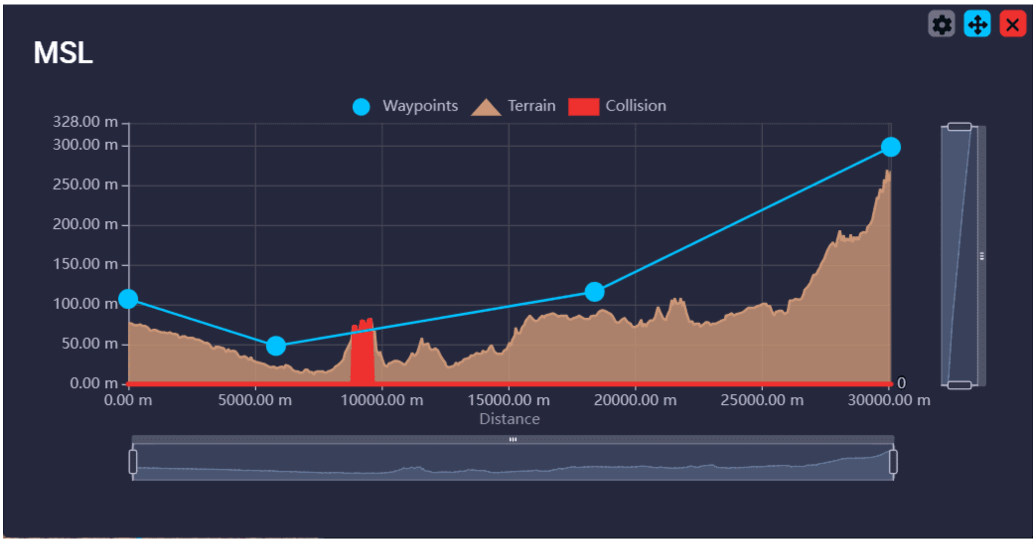
For more information, visit the 1x PDI Builder user manual.

Veronte Ops

Veronte Ops is the application used to operate and monitor the vehicle during missions.

To know more, read the Veronte Ops user manual.

Veronte Terrain Provider estimates and displays the terrain height and the aircraft height.
When working in conjunction with the Veronte Ops application, it helps to avoid collisions.



Heights example from Veronte Ops widget

For more information about **Veronte Terrain Provider**, read the Veronte Terrain Provider - Additional apps section of the **Veronte Ops** user manual.

Veronte HIL

Veronte HIL (Hardware In the Loop) is a simulation package for autopilot integration, development, and operator training.
This software allows extensive operation of the flight system in a simulated environment before executing real flight operations.
Its role is to perform HIL simulations with the real autopilot hardware, allowing the use of simulation applications like **X-Plane, Microsoft Flight Simulator,** or **Simulink**.

For more information, visit the Veronte HIL user manual.

Veronte Updater

Veronte Updater updates all Embention products.

For more information, visit the Veronte Updater user manual.

1x PDI Calibration

1x PDI Calibration sets up calibration parameters for 1x autopilots.
It allows the user to calibrate sensors, servos, and configure the radio module.

For more information, visit the 1x PDI Calibration user manual.

Veronte FDR

Veronte FDR manages autopilot files, allowing users to download registers generated by the autopilot and convert them to CSV files.
Three types of registers can be downloaded: **Onboard log, Fast log,** and **User log**.

For more information, visit the Veronte FDR user manual.

Veronte VSA

Veronte VSA works using a flight simulator to represent worldwide geographical scenarios: lands, seas, mountains, cities, airports, airfields, heliports...
Additionally, an internet connection is not necessary, allowing operation from any location without delays in scenario loading.

Veronte VSA displays a 3D view of the piloted aircraft and can be used as a **3D PFD (Primary Flight Display)** when using the first-person camera view. This system allows custom aircraft models to be displayed in the virtual environment. The **Planemaker** tool is available for creating custom models, enabling operators to visualize aircraft models in the interface.

For more information, visit the Veronte VSA user manual.

1x PDI Tuning

1x PDI Tuning allows managing the **control laws** of the **Autopilot 1x** during operation.
Users can adjust each **P (Proportional), I (Integral),** and **D (Derivative)** gain and select the **PID type** (Standard or Parallel).

For more information, visit the 1x PDI Tuning user manual.

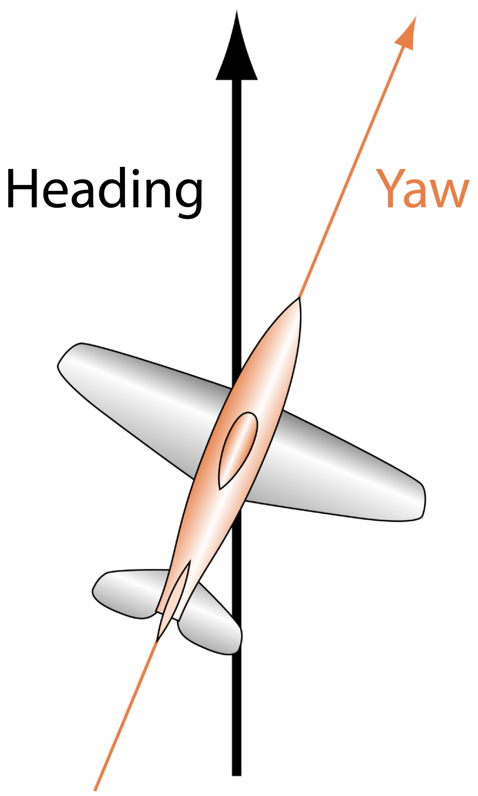
Nomenclature

This section defines the nomenclature convention employed by the software applications.

Reference Directions

- **Yaw** is the direction where the aircraft is pointing. It does not depend on the movement, as **Yaw** is aligned with the longitudinal axis of the aircraft.
- **Heading** is the movement direction projected to the ground. **Heading** does not depend on wind or **Yaw** direction; it only depends on the ground and the aircraft's movement.

> **Important**
>
> Both **Yaw** and **Heading** angles are measured concerning the **True North**, not the **Magnetic North**.



Direction names

Axes

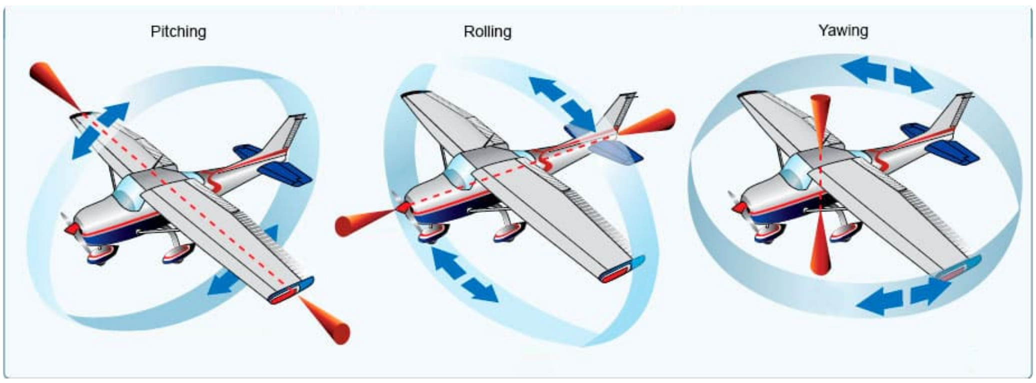
All signs are defined according to the **international aeronautical axes convention**:
Any deflection that generates **positive rotational forces** relative to the aircraft's aerodynamic center is considered **positive**, except for the **"y" axis (elevator)**, where downward movement is considered **negative**.

For example, when the elevator moves down, it generates a positive pitch, so the elevator is considered **positive** in the lower position.

Main Actuator Rules:

Actuator	Positive	Negative
Elevator	Down	Up
Rudder	Right	Left
Right Aileron	Up	Down
Left Aileron	Down	Up
Tail Rotor	Right	Left

Additionally, rotation names are summarized in the figure below:



Rotation names

Core architecture

Veronte Autopilot 1x is equipped with a Dual-Core Microcontroller. Both cores, hereinafter called **Core 1 (C1)** and **Core 2 (C2)**, work together to perform information processing operations efficienty and to coordinate the activities of other system components.

It is crucial to understand the performance of C1 and C2 in order to properly handle Autopilot 1x tasks.

- **Core 1**: It presents the following operation threads.
  - **High**: 1kHz guaranteed. Hardware interrupt in charge of certain critical or high-priority tasks which must be executed with a constant and predictable frequency.

    > ⓘ **Note**
    >
    > There is a permitted frequency fluctuation of 1%.

  - **Low**: Not guaranteed rate. In charge of non-priority tasks which tolerate non-guaranteed time consistency.
- **Core 2**: Execution rate of 400 Hz (configurable from 1x PDI Builder application).

Task distribution

Tasks distribution between processors:

Core 1		Core 2
High	Low	

Core 1		Core 2
• Sensors reading • FTS Management • I/O management (data from peripherals to internal pre-processing queues)	• Telemetry and logs management • Communication management • Files management • Additional helper tasks • SD writing	• Guidance, Navigation and Control (GNC) • Mission updating • Automations management • RAM writing

A proper comprehension of how cores manage different tasks, considering the priorities and execution rates previously explained, may be valuable to avoid delays in data processing and achieving a balanced functioning of the Veronte system.

Aspects to be considered:

- **C1 and C2 information interchange**: Cores share information through the **Cross-Core queue**, hence overfilling this queue may result in late processing of data.
- **Tasks distribution between C1 threads**: If acquisition tasks take too much processing time, C1 low task may not be executed as expected.
- **C1 High interruptions**: C1 high may interrupt C1 low task execution. In this case, C1 low will continue its execution at the same point once high priority tasks are fullfilled.

Monitoring variables

Distributing resources is decisive for the proper functioning of the system. For that reason, core-related values are monitored.

> ⓘ **Note**
>
> For further information regarding these variables, please consult their IDs in the Lists of Variables section of the present manual.

C1 is monitored by the following variables:

Core 1	
High	**Low**
	• C1 Low Frequency (BIT 400) • IO Max Time (RVar 2054) • CIO Average Time (RVar 2055) • CIO Running Frequency (RVar 2057)

Core 1	
• Acquisition Step Missed (BIT 402) • CIO Hi Overload warning (BIT 403) • Acquisition Task Timestep (RVar 2047) • Acquisition Task Maximum Timestep (RVar 2048) • Acquisition Task Average CPU Ratio (RVar 2050) • Acquisition Task Maximum CPU Ratio (RVar 2051) • Acquisition Task Average Time (RVar 2052) • Acquisition Task Maximum Time (RVar 2053) • Identifier of max duration step in acquisition (UVar 399)	

C2 is monitored by the following variables:

Core 2
• GNC fail (BIT 401) • GNC Realtime Error (BIT 404) • GNC Task Average CPU Ratio (RVar 2094) • GNC Task Maximum CPU Ratio (RVar 2095) • GNC Task Average Time (RVar 2096) • GNC Task Maximum Time (RVar 2097) • GNC Task Maximum Timestep (RVar 2098) • Max Duration of Step in GNC (RVar 2099) • GNC Timestep (RVar 2903) • Counter for C2 system BIT (UVar 20)

Cross-Core queue is monitored by the following variables:

Cross-Core Queue
• Cross Core Message Queue CPU Ratio (RVar 2049) • Cross-Core Message Queue Usage (RVar 2056)

Data Transmission

Veronte Autopilot 1x uses the Veronte Communicatin Protocol (VCP) for its communication with other **Veronte devices** or **Veronte applications**, such as **Veronte Ops**.

Communication originates from any COM Manager port and is sent/received through any interface connected to it (e.g. USB ↔ Commgr port 0).

Autopilot 1x will send:

- 1 VCP packet per **vector telemetry**.
- 1 VCP packet of **complementary vector telemetry**; only in case a widget whose variables have not been previoulsy added to the telemetry configuration is added in Veronte Ops.

  > **Note**
  >
  > Complementary vector telemetry always runs at a frequency of 10 Hz (not configurable) and variables are sent uncompressed.

- 1 VCP packet of **health status**.
- 1 VCP packet to update the **route** traced in **Veronte Ops**.

> **Important**
>
> A VCP message contains **11 bytes** of addresses (source and destination), CRC, header, etc., and **up to 255 bytes** of **data for telemetry vectors**.
>
> The maximum packet size supported by **VCP** is **266 bytes**. For more information on the VCP packet, read the Message structure section of the **VCP** user manual.
>
> Thus, it is up to the user to determine, based on its configuration, the amount of data in bytes to be sent from connected devices such as Radios, SatComs, etc., making sure that the bandwith of the device is enough.

Tip

Functional tests such as monitoring the value of the variables related to the interface used are recomended.

For example, if a radio connected to the RS232 is used for communication to the Ground Control Station (GCS), it is highly advised to monitor the variables:

- Rvar 48 - SCI-D Rx Rate (RS232)
- Rvar 49 - SCI-D Tx Rate (RS232)

Lists of interest

This section contains all the lists with information of interest for the user.

Activation System Error bits

The **System Error** variable is indicated by bit number 7. This bit checks whether the system is running properly. If one of certain malfunctions occur, the **System Error** will be set as 0 and the FTS will be activated. Otherwise, if everything is OK, it will remain as 1.

The **System Error** is triggered and set as 0 if one of the following unwanted events happens:

- **CIO low** has a frequency lower than 10 Hz. This error is indicated with a 0 in bit 400.
- **CIO high** has a frequency lower than 990 Hz. This error is indicated with a 0 in bit 402.
- **GNC** is 'dead'. This event is indicated with a 0 in bit 401.
- **GNC Realtime Error** because a GNC Step has been missed. This event is indicated with a 0 in bit 404.
- **System power up BIT error**. The initial value of this bit depends on the values of the bits listed below and represents their state at power-up. This error is indicated with a 0 in bit 12 if any of the following errors happens:
    - **RAM allocation** is in error state due to trying to use more memory than available. This error is indicated with a 0 in bit 8.
    - **PDI files** have a wrong configuration. This is indicated by a 0 in bit 9.
    - **Main Power supply A** is in error state. This error is indicated with a 0 in bit 117 if any of the following errors happens:
        - **Input supply voltage** is not between 6.5 and 36 V. This voltage is measured by RVar 400.
        - **Voltage received by Veronte through 5V port** is not between 4.75 and 5.25 V. This voltage is measured by RVar 402.
        - **Voltage received by Veronte through 3.6V port** is not between 3.42 and 3.78V. This voltage is measured by RVar 404.

- **File system manager** is in error state. This event is indicated with a 0 in bit 6.
- **Core 1** has a memory overflow allocated for local variables. This error is indicated with a 0 in bit 16.
- **Core 2** has a memory overflow allocated for local variables. This error is indicated with a 0 in bit 17.
- Any user bit configured as **safety bit** is 0. User bits are 1200 to 1499.

Status Message variables

The variables contained in the Veronte Autopilot 1x status message are the following.

ID	Name
0	Actuator Mode
1	Phase Identifier
6	Yaw
7	Pitch
8	Roll
100	Position Not Fixed
201	Current Section
204	Current Patchset ID (needed for guidance display)
300	Relative Timestamp
505	North Ground Velocity
506	East Ground Velocity

ID	Name
507	Down Ground Velocity
-	Guidance calculation identifier (needed for guidance display). It can be one of these variables depending on the guidance used: • **ID** 80: Detour calculation identifier • **ID** 81: Approach calculation identifier • **ID** 82: Climb calculation identifier • **ID** 83: Cruise calculation identifier • **ID** 84: Rendezvous calculation identifier • **ID** 85: Taxi calculation identifier • **ID** 86: VTOL calculation identifier

Extended Status Message variables

Information about the Veronte Autopilot 1x extended status message is contained in the following set of bit variables.

> ⓘ **Note**
>
> The **Extended Status Message** is only sent if one of the bits changes its value.

ID	Name
5	Power error
6	

ID	Name
	File System Error
8	Memory allocation
9	PDI Error
12	System Power up BIT Error
14	FTS-1 Feedback (>=V4.5)
15	FTS-2 Feedback (>=V4.5)
16	Stack C1 usage FAIL
17	Stack C2 usage FAIL
49	CPU temperature above 398.15K
50	Sensors Error
51	Sensor-Main IMU

ID	Name
52	Sensor-Secondary IMU
53	Sensor-Internal Magnetometer (LIS3MDL)
54	Sensor-External magnetometer (HMR2300)
73	CAN-A ERROR
74	CAN-B ERROR
87	GNSS1 Module Error
88	GNSS2 Module Error
117	Main Power Error
118	SUC Power Error
400	C1 Low Frequency
401	GNC fail

ID	Name
402	Acquisition step missed
403	CIO Hi Overload warning

List of Addresses

Every Embention device communicate with other devices/tools using its address through VCP.

The following list contains all these addresses:

Address	Recognized as	Description
0	Dummy for pdi builders	Dummy for pdi builder
1	Cloud	**Veronte Cloud** address
2	Vlink	Address used by **Veronte Link** app to communicate with Veronte units
2-3	App + Address	Veronte applications addresses. **App 2** is the one used by default

Address	Recognized as	Description
		by Veronte applications, although App 3 is also available
255-511	App dynamic + Address	**Dynamic addresses** for Veronte applications
998	Broadcast	To **all devices** on a network
999	Address unknown	This address can be used for a device that **does not** have a **valid address** configured
1000-1777	1x v4.0 + Address	Specific address of an **Autopilot 1x** with **hardware version 4.0**
1778-3999	1x v4.5 + Address	Specific address of an **Autopilot 1x** with **hardware version 4.5**
4000-17999		Specific address of an **Autopilot**

Address	Recognized as	Description
	1x v4.8 + Address	**1x** with **hardware version 4.8**
18000-19899	1x BCS + Address	Specific address of a **BCS** unit
19900-19999	1x v4.7. For internal use only + Address	Specific address of an **Autopilot 1x** with **hardware version 4.7**
20000-21999	Smart Can Isolator + Address	Specific address of a **Smart Can Isolator** unit
30000-31999	MC01 + Address	Specific address of a **MC01** unit
32000-34999	MC24 motor controller + Address	Specific address of a **MC24** unit
35000-39999	MC110 motor controller + Address	Specific address of a **MC110** unit
40000-41999	CEX + Address	Specific address of a **CEX** with **hardware version 1.2**
42000-43999		

Address	Recognized as	Description
	MEX + Address	Specific address of a **MEX** unit
44000-49999	CEX2 + Address	Specific address of a **CEX** with **hardware version 2.0**
50000-51089	Arbiter v1.0 + Address	Specific address of an **Arbiter** with **hardware version 1.0**
51090-51999	Arbiter v1.2 + Address	Specific address of an **Arbiter** with **hardware version 1.2**
52000-59999	Arbiter v1.8 + Address	Specific address of an **Arbiter** with **hardware version 1.8**
60000-65535	Reserved + Address	Reserved addresses
65536-69631	Virtual v4.0 + Address	Specific address of a **Virtual Autopilot 1x** with **hardware version 4.0**
69632-73727	Virtual v4.5 + Address	Specific address of a **Virtual**

Address	Recognized as	Description
		Autopilot 1x with **hardware version 4.5**
73728-77823	Virtual v4.8 + Address	Specific address of a **Virtual Autopilot 1x** with **hardware version 4.8**

Lists of Variables

This section shows all the variables employed by **Veronte Autopilot 1x**. All of them can be read and sent through telemetry.

These variables are classified into two main groups:

- **System variables**: Non-writable by the user.
- **User variables**: Writable by the user, marked in the tables below as 📝.

> **Important**
>
> Variables labeled as "**Deprecated**" are no longer used by the system.
>
> In order to avoid system incompatibilities, deprecated variables are only written by the autopilot when migrating a configuration from a previous version in which the variable was not obsolete.
> When a configuration is built from scratch, these variables must be defined by the user to be used.
> Thus, users are responsible for their correct assignment.

BIT Variables

> ⚠ **Warning**
>
> Bit Variables displayed on **Veronte Ops** labels will be shown as Red/Green depending on their state.
> **Red** stands for `0` and **Green** for `1`, changing the name displayed accordingly to the BIT value.

ID	Name	Description
0	Always Fail	This signal is always fail - 0 for fail, 1 for OK
1	Always OK	This signal is CIO always OK - 0 for fail, 1 for OK
2	License Check Pending	License state - 0 for license check pending, 1 for license checked
3	System Not Ready to Start	System is ready to start operating - 0 for not ready, 1 for ready
4	No Writing Telemetry	Telemetry is properly sending/ receiving - 0 for no, 1 for yes
5	Power Error	Power supply state - It will be 0

ID	Name	Description
		if any of the following conditions happens: • **Bit 117** is zero (power for Veronte has a failure) • **Bit 118** is zero (power for SuC has a failure)
6	File System Error	System file manager - Dependent on **File system status (UVar 96)** • 0 for error: if File system status > 0 • 1 for running OK: if File system status == 0
7	System Error	This bit checks whether the system is running properly. 0 for

ID	Name	Description
		system error, 1 for system OK.
8	Memory allocation	RAM allocation - 0 for trying to use more than available memory, 1 for running
9	PDI Error	PDI files - Dependent on **PDI Error Source (UVar 50)** • 0 for wrong PDI configuration: if PDI Error Source > 0 • 1 for running OK: if PDI Error Source == 0
10	CIO Low or C2 Error (Deprecated)	CIO low or C2 failed. Bits 400 and 401 are recommended instead - 0 for CIO low or C2 failed, 1 for

ID	Name	Description
		CIO high and C2 OK **Warning** **Deprecated variable**
11	4X CAN failed	For more information, check **BIT Variables - 4x Software Manual**
12	System Power up BIT Error	Power up - 0 for error, 1 for OK
13	Reset and Write Disabled	Reset and non-operation PDI writes are allowed - 0 for disabled, 1 for enabled
14	FTS-1 Feedback (>=V4.5)	Flight Termination System 1, microcontroller state for hardware version 4.7 or higher - 0 for error, 1 for running OK
15		Flight Termination System 2,

ID	Name	Description
	FTS-2 Feedback (>=V4.5)	microcontroller state for hardware version 4.7 or higher - 0 for error, 1 for running OK
16	Stack C1 usage FAIL	0 for stack overflow of core 1, 1 for OK
17	Stack C2 usage FAIL	0 for stack overflow of core 2, 1 for OK
18	PDI disabled	PDI Mode - 0 for disabled, 1 for enabled
📝 20-46	4xV Bit variables	For more information, check **BIT Variables - 4x Software Manual**
47	4xV Watchdog Error	**Note** For version 4.7 or higher For more information, check **BIT Variables - 4x**

ID	Name	Description
		Software Manual
49	CPU temperature above 398.15K	CPU temperature warning - 0 for CPU temperature above 398.15K (125ºC), 1 for CPU temperature below 398.15K (125ºC)
50	Sensors Error	Sensors state - 0 for error, 1 for running OK Selected sensors are not working or, if external sensors have been selected, they are not connected
51	Sensor-Main IMU	Sensor IMU 0 - 0 for disabled, 1 for enabled
52	Sensor-Secondary IMU	Sensor IMU 1 - 0 for disabled, 1 for enabled
53	Sensor-Internal Magnetometer (LIS3MDL)	**Internal 0 Magnetometer** -

ID	Name	Description
		0 for disabled, 1 for enabled
54	Sensor-External Magnetometer (HMR2300)	**External HMR2300 magnetometer** - 0 for disabled, 1 for enabled
55	Sensor-External Magnetometer (LIS3MDL)	**External LIS3MDL magnetometer** - 0 for disabled, 1 for enabled
56	Sensor-Static pressure (HSC)	Static Pressure Sensor 0 - 0 for disabled, 1 for enabled
57	Sensor-Static pressure (MS56)	Static Pressure Sensor 1 - 0 for disabled, 1 for enabled
58	Sensor-Dynamic pressure (HSC)	Dynamic Pressure Sensor 0 - 0 for disabled, 1 for enabled
59	Sensor-External I2C devices	0 for disabled, 1 for enabled
60-64		

ID	Name	Description
	Sensor-External I2C device 0-4	External communication I2C from device 0 to 4
65	SCI-A Transmitting (LTE/EXT. UART)	Serial Communication Interface - LTE/ EXT. UART transmission
66	SCI-A Receiving (LTE/ EXT. UART)	Serial Communication Interface - LTE/ EXT. UART reception 0 for not receiving, 1 for receiving
67	SCI-B Transmitting (LOS)	Serial Communication Interface - LOS transmission
68	SCI-B Receiving (LOS)	Serial Communication Interface - LOS reception 0 for not receiving, 1 for receiving
69		Serial Communication

ID	Name	Description
	SCI-C Transmitting (RS485)	Interface - RS485 transmission
70	SCI-C Receiving (RS485)	Serial Communication Interface - RS485 reception 0 for not receiving, 1 for receiving
71	SCI-D Transmitting (RS232)	Serial Communication Interface - RS232 transmission
72	SCI-D Receiving (RS232)	Serial Communication Interface - RS232 reception 0 for not receiving, 1 for receiving
73	CAN-A ERROR	CAN A state - 0 for error, 1 for OK
74	CAN-B ERROR	CAN B state - 0 for error, 1 for OK
75	CAN-A Warning	CAN A state - 0 for warning, 1 for OK

ID	Name	Description
76	CAN-B Warning	CAN B state - 0 for warning, 1 for OK
77	Vectornav GPS not fixed	0 for not fixed, 1 for fix
78	Vectornav IMU error	0 for error, 1 for OK
79	Vectornav Mag/Press error	0 for error, 1 for OK
80	Vectornav GPS error	0 for error, 1 for OK
81	Vectornav Navigation Error	Navigation state - 0 for error, 1 for OK
82	Sensor-External Magnetometer (HSCDTD008A)	**External HSCDTD008A magnetometer** - 0 for error, 1 for OK
83	IMU 2 BMI088	Sensor IMU 2 - 0 for error, 1 for OK
84	Sensor-Static pressure 2 (DPS310)	Static Pressure Sensor 2 - 0 for error, 1 for OK
85		

ID	Name	Description
	Sensor-Internal Magnetometer (MMC5883MA)	**Internal 1 Magnetometer** - 0 for error, 1 for OK
86	Sensor-External Magnetometer (MMC5883MA)	**External MMC5883MA magnetometer** - 0 for error, 1 for OK
87	GNSS1 Module Error	GPS module 1 state - 0 for error, 1 for OK
88	GNSS2 Module Error	GPS module 2 state - 0 for error, 1 for OK
89	Sensor-External Magnetometer (RM3100)	**External RM3100 magnetometer** - 0 for error, 1 for OK
90	IMU3 ADIS16505-3 (MCBSP)	Sensor IMU 3 - 0 for error, 1 for OK
91	Sensor-Internal Magnetometer (RM3100)	**Internal 2 Magnetometer** - 0 for error, 1 for OK
92		

ID	Name	Description
	Magnetometer reserved	0 for error, 1 for OK
93	SCI Expander (v4.7+)	SCI Expander for hardware version 4.7 or higher - 0 for error, 1 for OK
96	SCI-A Error (LTE/EXT. UART)	SCI A (LTE/EXT. UART) state - 0 for error in this port (invalid format or configuration), 1 for OK
97	SCI-B Error (LOS)	SCI B (LOS) state - 0 for error in this port (invalid format or configuration), 1 for OK
98	SCI-C Error (RS485)	SCI C (RS485) state - 0 for error in this port (invalid format or configuration), 1 for OK
99	SCI-D Error (RS232)	SCI D (RS232) state - 0 for error in this port (invalid format or

ID	Name	Description
		configuration), 1 for OK
100	Position not fixed	GNSS data reception - 0 for not receiving, 1 for receiving (Position fixed)
101	No valid SRTM at UAV position	0 for not valid, 1 for valid
102-103	CAN A-B Receiving	CAN A to B communication - 0 for not receiving, 1 for receiving
104-105	Stick PPM 0-1 not detected	Stick PPM 0 to 1 - 0 for not detecting, 1 for detecting
106	Magnetic field out of bounds (Deprecated)	0 for magnetic field out of bounds, 1 for OK **Warning** **Deprecated variable**
107	INS navigation OFF	0 for INS navigation OFF, 1

ID	Name	Description
		for INS navigation ON
113	Iridium Ready	Iridium ready state - 0 for not ready, 1 for ready
114	No valid Geoid at UAV position	0 for no valid geoid at UAV position, 1 for valid geoid at UAV position
115	EKF: Condition Number Error	Extended Kalman Filter state - 0 for error, 1 for running
116	Radar Altimeter CAN-RX Error	Radar Altimeter State - 0 for error, 1 for running
117	Main Power Error	Main power supply A. It will be 0 (indicating error state) if any of the following errors happen:

ID	Name	Description
		• Input supply voltage is not between 6.5 and 36 V. This voltage is measured by **RVar 400**. • Voltage received by Veronte through 5V port is not between 4.75 and 5.25 V. This voltage is measured by **RVar 402**. • Voltage received by Veronte through 3.6V port is not between 3.42 and 3.78V. This voltage is measured by **RVar 404**.
118	SUC Power Error	Power supply for system on microchip. It will be 0 (indicating error state) if any

ID	Name	Description
		of the following errors happen: • Voltage received by Veronte through 3.3V port is out of range. This voltage is measured by **RVar 401**. • Voltage received by Veronte SUC is out of range. This voltage is measured by **RVar 403**.
119	Not hovering guidance	Hovering guidance state - 0 for hovering guidance disabled, 1 for enabled
120-123	Pulse 0-3 not detected	Pulse 0 to 3 detection - 0 for pulse not detected, 1 for detected

ID	Name	Description
📝 124-129	4xV Bit variables	For more information, check **BIT Variables - 4x Software Manual**
130	EFK Navigation Error	Extended Kalman Filter navigation state - 0 for error, 1 for running
131	No magnetic field data	Bit to indicate if there is magnetic field in the SD - 0 for No Magnetic field data, 1 for Magnetic field data OK
132	Route not finished	0 for Route not finished, 1 for Route finished OK
150	External VCP Navigation Error	External VCP state - 0 for error, 1 for OK
📝 160	External Var Navigation Error	External Navigation state - 0 for error, 1 for running
170		

ID	Name	Description
	Selected Accelerometer Error	Selected accelerometer - 0 for error, 1 if at least one of the selected accelerometers is OK
171	Selected Gyroscope Error	Selected gyroscope - 0 for error, 1 if at least one of the selected gyroscopes is OK
172	Bias Accelerometer Saturated	0 for bias saturated, 1 for OK
173	Bias Gyroscope Saturated	0 for bias saturated, 1 for OK
180	External attitude	Kind of attitude calculation - 0 for external, 1 for internal
182	FTS Activation (>=V4.5)	Flight Termination System activation, for version 4.5 or higher - 0 for not

ID	Name	Description
		activated, 1 for activated
183	4X Selected	Current 1x Autopilot is the one selected by the arbiter - 0 when this AP is not the selected AP, 1 when this AP is the selected one
188	BIT for static pressure sensors Error	0 for static pressure sensors error, 1 for OK
189	BIT for magnetometer sensors Error	0 for magnetometer sensors error, 1 for OK
190	Internest ultrasound position status Error	0 for internest ultrasound position error, 1 for OK
191	Internest ultrasound angle status Error	0 for internest ultrasound angle error, 1 for OK
200		0 for GNSS navigation OFF, 1

ID	Name	Description
	GNSS1 Navigation Down	for GNSS navigation ON
201	DGNSS1 Input Off	0 for GNSS compass or RTK not activated, 1 for one of them activated
202	DGNSS1 Navigation Off	0 for GNSS compass or RTK not activated, 1 for one of them activated
203	GNSS1 Survey In Off	GNSS compass survey or RTK OFF, 1 for one of them ON
204	No DGNSS1 Float Solution	0 for no DGNSS1 float solution nor RTK, 1 for DGNSS1 float solution or RTK
205	No DGNSS1 Fixed Solution	0 for no DGNSS1 fixed solution nor RTK, 1 for DGNSS1 fixed solution or RTK
206		0 for invalid navigation

ID	Name	Description
	DGNSS1 Relative Position Invalid	position, 1 for valid navigation position
207	DGNSS1 not Moving baseline mode	0 for not moving baseline mode, 1 for moving baseline mode
210	DMA peripheral for SPIA A Error	DMA peripheral for SPIA A - 0 for error, 1 for OK
211	DMA peripheral for MCBSP A Error	DMA peripheral for MCBSP A - 0 for error, 1 for OK
230-293	4xV Bit variables	For more information, check **BIT Variables - 4x Software Manual**
300	GNSS2 Navigation Down	0 for GNSS navigation OFF, 1 for GNSS navigation ON
301	DGNSS2 Input Off	0 for GNSS compass or RTK not activated, 1 for one of them activated

ID	Name	Description
302	DGNSS2 Navigation Off	0 for GNSS compass or RTK not activated, 1 for one of them activated
303	GNSS2 Survey In Off	GNSS compass survey or RTK OFF, 1 for one of them ON
304	No DGNSS2 Float Solution	0 for no DGNSS2 float solution nor RTK, 1 for DGNSS2 float solution or RTK
305	No DGNSS2 Fixed Solution	0 for no DGNSS2 fixed solution nor RTK, 1 for DGNSS2 fixed solution or RTK
306	DGNSS2 Relative Position Invalid	0 for invalid navigation position, 1 for valid navigation position
307	DGNSS2 not Moving baseline mode	0 for not moving baseline mode, 1 for moving baseline mode

ID	Name	Description
308	SCI-E Transmitting (LTE)	SCI-E Transmitting (LTE)
309	SCI-E Receiving (LTE)	SCI-E Receiving (LTE)
310	SCI-F Transmitting (LTE Aux.)	SCI-F Transmitting (LTE Aux.)
311	SCI-F Receiving (LTE Aux.)	SCI-F Receiving (LTE Aux.)
312	SCI E Error (LTE)	SCI-E (LTE) - 0 for error, 1 for OK
313	SCI F Error (LTE Aux.)	SCI-F (LTE Aux.) - 0 for error, 1 for OK
329	3.3V Power Source	0 for error, 1 for OK
330	Jetibox COMM Error	Jetibox is communicating properly - 0 for error, 1 for OK
370-371	Smart Can Isolator A-B Domain Error	0 for error, 1 for OK
400		

ID	Name	Description
	C1 Low Frequency	C1 Low Frequency - Dependent on **CIO Running Frequency (RVar 2057)** (C1 low frequency) • 0 for error → CIO Running Frequency < 10 Hz • 1 for OK → CIO Running Frequency > 10 Hz
401	GNC fail	0 for error ('dead'), 1 for ok ('alive') - Dependent on **Counter for C2 system (UVar 20)**
402	Acquisition step missed	

ID	Name	Description
		• 0 for Acquisition step missed → C1 hi frequency fluctuation is higher than permitted (1%). • 1 for Acquisition Task OK → C1 hi frequency fluctuation is under set limits (1%).
403	CIO Hi Overload warning	C1 hi Overload - Dependent on **Acquisition Task Maximum CPU Ratio (RVar 2051)**

ID	Name	Description
		• 0 for Acquisition Task overload → Acquisition Task Maximum CPU Ratio > 90% • 1 for Acquisition Task usage OK → Acquisition Task Maximum CPU Ratio ≤ 90% **Note** Non-recoverable variable
404	GNC Realtime Error	

ID	Name	Description
		• 0 if C2 frequency < configured frequency (tolerance of 6 microseconds) • 1 if C2 frequency = configured frequency (tolerance of 6 microseconds)
405	Reserved	0 for error, 1 for OK
480	MC01 Stepper direction output	0 for error, 1 for OK
481	MC01 Brushless driver fault	0 for error, 1 for OK
482	MC Hall Sensor error	0 for error, 1 for OK
483	MC Sin/Cos Sensor error	0 for error, 1 for OK
484	MC general health error	0 for health error, 1 for status OK

ID	Name	Description
485	MC Current sensing error	0 for error, 1 for OK
486	MC Phase U Current Calibration Error	ADC phase U not calibrated - 0 for not calibrated, 1 for calibration OK
487	MC Phase V Current Calibration Error	ADC phase V not calibrated - 0 for not calibrated, 1 for calibration OK
488	MC Phase W Current Calibration Error	ADC phase W not calibrated - 0 for not calibrated, 1 for calibration OK
489	MC Maximum Temperature Error	Maximum power module temperature exceeded - 0 for error (exceeded), 1 for OK
490	MC Phase Error	Power module driver phase error reported - 0 for error, 1 for OK
491	MC General Driver Error	Power module driver error reported - 0 for error, 1 for OK

ID	Name	Description
492	MC Over-current AC	Current AC side limit exceeded - 0 for error (exceeded), 1 for OK
493	MC Over-voltage advertisement	Over-voltage DC side limit advertisement exceeded - 0 for error (exceeded), 1 for OK
494	MC Over-voltage caution	Over-voltage DC side limit caution exceeded - 0 for error (exceeded), 1 for OK
495	MC Under-voltage latching	Critical under-voltage DC side limit violation - 0 for error, 1 for OK
496	MC Under-voltage non latching	Non critical under-voltage DC side limit violation - 0 for error, 1 for OK
497	MC RMS imbalance	Current AC side imbalance - 0 for error, 1 for OK
498		

ID	Name	Description
	MC Open DC fault	Open-circuit DC side fault - 0 for error, 1 for OK
499	MC Over-current DC	Current DC side limit exceeded - 0 for error (exceeded), 1 for OK
500	Ground effect compensation variance disabled	0 for disabled, 1 for enabled
501	Ground effect compensation measurement disabled	0 for disabled, 1 for enabled
502	No SRTM data	Bit to indicate if there is SRTM in the SD - 0 for No SRTM data, 1 for SRTM data OK
503	No geoid data	Bit to indicate if there is Geoid data in the SD - 0 for No geoid data, 1 for Geoid data OK
600		

ID	Name	Description
	Wind Estimation Off	0 for disabled, 1 for enabled
📝 700-731	Servo 0-31 Saturated	0 for saturated, 1 for OK
📝 800-815	PWM 0-15 GPIO Off	PWM GPIO 0-15 communication State - 0 for Off, 1 for On
📝 816-819	EQEP_A-I (GPIO 17-20) Off	Input/Output State - 0 for Off, 1 for On
820-822	RSSI LED 0-2 Off	Received Signal Strength Indicator led state - 0 for Off, 1 for On
📝 823	GPIO 5 (GPIO28) Off	GPIO 5 Status (Low/High) - 0 for Off, 1 for On
📝 824	GPIO 6 (GPIO61) Off	GPIO 6 Status (Low/High) - 0 for Off, 1 for On
📝 825	GPIO 7 (GPIO60) Off	GPIO 7 Status (Low/High) - 0 for Off, 1 for On
📝 826	GPIO 8 (GPIO59) Off	GPIO 8 Status (Low/High) - 0 for Off, 1 for On

ID	Name	Description
827	GPIO 9 (GPIO17) Off	GPIO 9 Status (Low/High) - 0 for Off, 1 for On
828	GPIO 10 (GPIO58) Off	GPIO 10 Status (Low/High) - 0 for Off, 1 for On
829	GPIO 11 (GPIO16) Off	GPIO 11 Status (Low/High) - 0 for Off, 1 for On
830	GPIO 12 (GPIO53) Off	GPIO 12 Status (Low/High) - 0 for Off, 1 for On
831	GPIO 13 (GPIO20) Off	GPIO 13 Status (Low/High) - 0 for Off, 1 for On
832	GPIO 14 (GPIO23) Off	GPIO 14 Status (Low/High) - 0 for Off, 1 for On
833	GPIO 15 (GPIO51) Off	GPIO 15 Status (Low/High) - 0 for Off, 1 for On
834	GPIO 16 (GPIO52) Off	GPIO 16 Status (Low/High) - 0 for Off, 1 for On
835	GPIO 17 (GPIO49) Off	

ID	Name	Description
		GPIO 17 Status (Low/High) - 0 for Off, 1 for On
📝 836	GPIO 18 (GPIO08) Off	GPIO 18 Status (Low/High) - 0 for Off, 1 for On
📝 837	GPIO 19 (GPIO11) Off	GPIO 19 Status (Low/High) - 0 for Off, 1 for On
📝 838	GPIO 20 (GPIO10) Off	GPIO 20 Status (Low/High) - 0 for Off, 1 for On
📝 839	GPIO 21 (GPIO09) Off	GPIO 21 Status (Low/High) - 0 for Off, 1 for On
📝 900-931	Virtual GPIO 00-31 off	Virtual GPIO 00-31 Status (Low/High) - 0 for Off, 1 for On
1000-1009	Simulation BIT 00-09 Error	0 for error, 1 for OK
1010-1113	Custom msg 0-103 Rx Error	Custom message timeout - 0 for error, 1 for OK
📝 1120-1121	Entrance EKF GNSS1-2 OFF	GNSS 1-2 information considered in EKF

ID	Name	Description
		Navigation - 0 for entrance EKF GNSS OFF, 1 for ON EKF GNSS OFF may be because **Position not fixed** → EKF deactivated → INSS activated
📝 1122	Entrance EKF GNSS3 EXT OFF	External GNSS information considered in EKF Navigation - 0 for entrance EKF GNSS EXT OFF, 1 for ON
📝 1123	Entrance EKF Internest OFF	Internest information considered in EKF Navigation - 0 for entrance EKF internest OFF, 1 for ON
📝 1124	Entrance EKF GPSCOMPASS OFF	GNSS Compass information considered in EKF Navigation - 0 for entrance EKF GPSCOMPASS OFF, 1 for ON

ID	Name	Description
📝 1125	Entrance EKF Magnetometer OFF	Magnetometer information considered in EKF Navigation - 0 for entrance EKF magnetometer OFF, 1 for ON
📝 1126	Entrance EKF Static press OFF	Static Pressure sensor information considered in EKF Navigation - 0 for entrance EKF static pressure OFF, 1 for ON
📝 1127	Entrance EKF Altimeter press OFF	Altimeter information considered in EKF Navigation - 0 for entrance EKF altimeter OFF, 1 for ON
📝 1128	Entrance EKF Radar-altimeter press OFF	Radar Altimeter information considered in EKF Navigation - 0 for entrance EKF radar-altimeter OFF, 1 for ON

ID	Name	Description
📝 1129	Entrance EKF DEM OFF	DEM information considered in EKF Navigation - 0 for entrance EKF DEM OFF, 1 for ON
📝 1174	External IMU 0 accelerometer error	External IMU 0 accelerometer - 0 for error, 1 for OK
📝 1175	External IMU 0 gyroscope error	External IMU 0 gyroscope - 0 for error, 1 for OK
📝 1176	External IMU 1 accelerometer error	External IMU 1 accelerometer - 0 for error, 1 for OK
📝 1177	External IMU 1 gyroscope error	External IMU 1 gyroscope - 0 for error, 1 for OK
📝 1178	External magnetometer 0 error	External magnetometer 0 - 0 for error, 1 for OK
📝 1179	External magnetometer 1 error	External magnetometer 1 - 0 for error, 1 for OK
📝 1180-1181	Sniffer msg 0-1 Rx Error	

ID	Name	Description
		Sniffer receiver message 0-1 - 0 for error, 1 for OK
1200-1499	User BIT 00-299 error	User bit 0 to 299 - 0 for error, 1 for OK
2200	BIT Dummy Error	Bit for configurable checks - 0 for error, 1 for OK

Real Variables (RVar) - 32 Bits

ID	Name	Units/ Values	Description
0	IAS (Indicated Airspeed)	m/s	Pitot-static measurement speed
1	TAS (True Airspeed)	m/s	Speed relative to the airmass in which the vehicle is moving (IAS measurement corrected with Standard Atmosphere data)
2	GS (Ground Speed)	m/s	Horizontal speed, relative to the ground

ID	Name	Units/ Values	Description
3	Heading	rad	Direction in which the vehicle velocity vector is pointing
4	Flight Path Angle	rad	Angle between velocity vector and local horizontal line
5	Bank	rad	Angle around the Longitudinal Euler axis
6	Yaw	rad	Angle around the Vertical Euler axis
7	Pitch	rad	Angle around the Transverse Euler axis
8	Roll	rad	Angle around the Longitudinal Euler axis
9	Route-Guidance Tangential deviation	m	Tangencial distance to the desired position (guidance)
10	Route-Guidance	m	Horizontal distance to the

ID	Name	Units/ Values	Description
	Horizontal deviation		desired position (guidance)
11	Route-Guidance Perpendicular deviation	m	Perpendicular distance to the desired position (guidance)
12	p (Angular Velocity - X Body Axis)	rad/s	Angular velocity around longitudinal axis
13	q (Angular Velocity - Y Body Axis)	rad/s	Angular velocity around lateral axis
14	r (Angular Velocity - Z Body Axis)	rad/s	Angular velocity around vertical axis
15	Forward Acceleration - X Body Axis	m/s^2	Acceleration in the X-axis
16	Right Acceleration - Y Body Axis	m/s^2	Acceleration in the Y-axis
17	Bottom Acceleration - Z Body Axis	m/s^2	Acceleration in the Z-axis
18	RPM	rad/s (RDS)	Revolutions per minute

ID	Name	Units/ Values	Description
			configurable for external sensor
19	Front Ground Velocity	m/s	GV vector X component
20	Lateral Ground Velocity	m/s	GV vector Y component
21	Velocity	m/s	Velocity vector module
22	Forward Load Factor - X Body Axis	customType	G-force in X body axis
23	Right Load Factor - Y Body Axis	customType	G-force in Y body axis
24	Bottom Load Factor - Z Body Axis	customType	G-force in Z body axis
25	Tangential Acceleration	m/s^2	Absolute acceleration for tangential direction
26	Estimated air density	kg/m^3	Estimated air density at current altitude
28	Co-Yaw	rad	

ID	Name	Units/ Values	Description
			Acrobatic Yaw with Body Z' axis pointing to X
29	Co-Pitch	rad	Acrobatic Pitch with Body X' axis pointing to -Z
30	Co-Roll	rad	Acrobatic Roll with Y' keeping same as Y
31	Angular Acceleration - X Body Axis	rad/s²	Acceleration around the longitudinal axis
32	Angular Acceleration - Y Body Axis	rad/s²	Acceleration around the lateral axis
33	Angular Acceleration - Z Body Axis	rad/s²	Acceleration around the vertical axis
34	Body to NED Quaternion qs	customType	First component of body to NED orientation quaternion
35	Body to NED Quaternion qi	customType	Second component of body to NED orientation quaternion

ID	Name	Units/ Values	Description
36	Body to NED Quaternion qj	customType	Third component of body to NED orientation quaternion
37	Body to NED Quaternion qk	customType	Fourth component of body to NED orientation quaternion
40	RSSI	percentage	Received Signal Strength Indicator **Warning** **Deprecated variable**
42	SCI-A Rx Rate (LTE/EXT. UART)	bytes/s	Reception rate (in bytes per second) of 4G (hwv < 4.7) or external UART (hwv >=4.7) communications
43	SCI-A Tx Rate (LTE/EXT. UART)	bytes/s	Transmission rate (in bytes per second) of 4G (hwv < 4.7) or external UART

ID	Name	Units/ Values	Description
			(hwv >=4.7) communications
44	SCI-B Rx Rate (LOS)	bytes/s	Radio link reception byte rate
45	SCI-B Tx Rate (LOS)	bytes/s	Radio link transmission byte rate
46	SCI-C Rx Rate (RS485)	bytes/s	RS485 communication reception byte rate
47	SCI-C Tx Rate (RS485)	bytes/s	RS485 communication transmission byte rate
48	SCI-D Rx Rate (RS232)	bytes/s	RS232 communication reception byte rate
49	SCI-D Tx Rate (RS232)	bytes/s	RS232 communication transmission byte rate
50	CAN-A Tx Rate	pkts/s	CAN-A transmission packet rate

ID	Name	Units/ Values	Description
51	CAN-B Tx Rate	pkts/s	CAN-B transmission packet rate
52	CAN-A Tx skip Rate	pkts/s	CAN-A messages delayed because no mailbox is available for sending
53	CAN-B Tx skip Rate	pkts/s	CAN-B messages delayed because no mailbox is available for sending
56	Yaw Rate	rad/s	Rate of change of the yaw angle
57	Pitch Rate	rad/s	Rate of change of the pitch angle
58	Roll Rate	rad/s	Rate of change of the roll angle
59-64	COM 0-5 Parse Error Rate	messages	Each COM discard packages with these frequencies. Messages might be discarded because the calculated and

ID	Name	Units/ Values	Description
			the received CRC are different
65	GNSS Absolute Time Of Week Milliseconds as Unit32	customType	Time of the week expressed with milliseconds
66	GNSS Hours in the Current Day	customType	Elapsed hours in the current day
67	GNSS Minutes in the Current Hour	customType	Elapsed minutes in the current hour
68	GNSS Seconds in the Current Minute	customType	Elapsed seconds in the current minute
80	Estimated gyro bias x	rad/s	Gyro bias estimated during IMU calibration
81	Estimated gyro bias y	rad/s	Gyro bias estimated during IMU calibration
82	Estimated gyro bias z	rad/s	Gyro bias estimated during IMU calibration
83		m/s^2	Accelerometer bias estimated

ID	Name	Units/ Values	Description
	Estimated accelerometer bias x		during IMU calibration
84	Estimated accelerometer bias y	m/s²	Accelerometer bias estimated during IMU calibration
85	Estimated accelerometer bias z	m/s²	Accelerometer bias estimated during IMU calibration
90	SCI-E Rx Rate (LTE)	bytes/s	Reception rate (in bytes per seconds) of the first channel (port0) of the SCI expander (hwv >=4.7)
91	SCI-E Tx Rate (LTE)	bytes/s	Transmission rate (in bytes per seconds) of the first channel (port0) of the SCI expander (hwv >=4.7)
92	SCI-F Rx Rate (LTE Aux.)	bytes/s	Reception rate (in bytes per seconds) of the second channel

ID	Name	Units/ Values	Description
			(port1) of the SCI expander (hwv >=4.7)
93	SCI-F Tx Rate (LTE Aux.)	bytes/s	Transmission rate (in bytes per seconds) of the second channel (port1) of the SCI expander (hwv >=4.7)
100	Desired IAS (Indicated Airspeed)	m/s	Commanded IAS from guidance
101	Desired TAS (True Airspeed)	m/s	Commanded TAS from guidance
102	Desired GS (Ground Speed)	m/s	Commanded GS from guidance
103	Desired Heading	rad	Commanded Heading from guidance
104	Desired Flight Path Angle	rad	Commanded Flight Path Angle from guidance
105	Desired Bank	rad	

ID	Name	Units/ Values	Description
			Commanded Bank from guidance
106	Desired Yaw	rad	Commanded Yaw from guidance
107	Desired Pitch	rad	Commanded Pitch from guidance
108	Desired Roll	rad	Commanded Roll from guidance
112	Desired p (Angular Velocity - X Body Axis)	rad/s	Commanded angular velocity around longitudinal axis
113	Desired q (Angular Velocity - Y Body Axis)	rad/s	Commanded angular velocity around lateral axis
114	Desired r (Angular Velocity - Z Body Axis)	rad/s	Commanded angular velocity around vertical axis
115	Desired Forward Acceleration - X Body Axis	m/s^2	Commanded Forward Acceleration from guidance
		m/s^2	

ID	Name	Units/ Values	Description
116	Desired Right Acceleration - Y Body Axis		Commanded Right Acceleration from guidance
117	Desired Bottom Acceleration - Z Body Axis	m/s²	Commanded Bottom Acceleration from guidance
118	Desired RPM	rad/s	Commanded RPM from guidance
119	Desired Front Ground Velocity	m/s	Commanded Front GV from guidance
120	Desired Lateral Ground Velocity	m/s	Commanded Lateral GV from guidance
121	Desired Velocity	m/s	Commanded Velocity from guidance
122	Desired Forward Load Factor - X Body Axis	customType	Commanded Forward Load Factor from guidance
123	Desired Right Load Factor - Y Body Axis	customType	Commanded Right Load Factor from guidance
		customType	

ID	Name	Units/ Values	Description
📝 124	Desired Bottom Load Factor - Z Body Axis		Commanded Bottom Load Factor from guidance
📝 125	Desired Tangential Acceleration	m/s²	Commanded Tangential Acceleration from guidance
📝 126	Energy Rate Error	customType	Rate of change of the Total System Energy
📝 127	Energy Distribution Error	customType	Distribution of system energy between kinetical and geopotential energy
📝 128	Desired Co-Yaw	rad	Commanded co-yaw from guidance
📝 129	Desired Co-Pitch	rad	Commanded co-pitch from guidance
📝 130	Desired Co-Roll	rad	Commanded co-roll from guidance
📝 140	Climbing Initial Heading	rad	Heading in climbing phase

ID	Name	Units/ Values	Description
			(start of the route)
📝 141	Approach Initial Heading	rad	Heading in approach phase (end of the route)
📝 142	Headwind Direction	rad	Wind direction estimation
📝 143	Tailwind Direction	rad	Angle of the vector that would correspond to the opposite of the Headwind vector
📝 144	Runway Direction	rad	Runway angle
📝 145	Elevation of current route	rad	Elevation of tangent to current route at its closest point to desired position
📝 146	Azimuth of current route	rad	Azimuth of tangent to current route at its closest point to desired position
📝 147	Distance to closest obstacle	m	Signed distance to closest obstacle

ID	Name	Units/ Values	Description
			(negative means inside)
📝 148	Distance of obstacle repulsion	m	Distance at which the obstacles have an effect in the guidance
📝 200	Desired North Ground Velocity	m/s	Commanded North (NED Coordinates system) GV from guidance
📝 201	Desired East Ground Velocity	m/s	Commanded East (NED Coordinates system) GV from guidance
📝 202	Desired Down Ground Velocity	m/s	Commanded Down (NED Coordinates system) GV from guidance
📝 203	Desired 2D MSL (Height Above Mean Sea Level)	m	Commanded MSL from guidance in 2D height mode
📝 204	Desired 2D AGL (Above	m	Commanded AGL from guidance in 2D height mode

ID	Name	Units/ Values	Description
	Ground Level) - Height		
205	Desired 2D WGS84 Elevation (Height Over The Ellipsoid)	m	Commanded WGS84 Elevation from guidance in 2D height mode
206	Desired Longitude	rad	Commanded Longitude from guidance
207	Desired Latitude	rad	Commanded Latitude from guidance
208	Desired WGS84 Elevation (Height Over The Ellipsoid)	m	Commanded WGS84 Elevation from guidance
209	Desired MSL (Height Above Mean Sea Level) - Altitude	m	Commanded MSL Altitude from guidance
210	Desired AGL (Above Ground Level) - Height	m	Commanded AGL Altitude from guidance

ID	Name	Units/ Values	Description
250	Guidance North Position Error	m	Difference from Desired and actual north position
251	Guidance East Position Error	m	Difference from Desired and actual east position
252	Guidance Down Position Error	m	Difference from Desired and actual down position
253	Guidance PID North Desired Velocity	m/s	Difference from Desired and actual PID north velocity
254	Guidance PID East Desired Velocity	m/s	Difference from Desired and actual PID east velocity
255	Guidance PID Down Desired Velocity	m/s	Difference from Desired and actual PID down velocity
256	Desired Velocity X Body Axis	m/s	Commanded velocity in X-axis from guidance

ID	Name	Units/ Values	Description
257	Desired Velocity Y Body Axis	m/s	Commanded velocity in Y-axis from guidance
258	Desired Velocity Z Body Axis	m/s	Commanded velocity in Z-axis from guidance
259	External Yaw	rad	Yaw from external navigation source
260	External Pitch	rad	Pitch from external navigation source
261	External Roll	rad	Roll from external navigation source
262	External Roll Rate	rad/s	Roll rate from external navigation source
263	External Pitch Rate	rad/s	Pitch rate from external navigation source
264	External Yaw Rate	rad/s	Yaw rate from external navigation source
265	External Velocity North	m/s	Velocity North from external navigation source

ID	Name	Units/ Values	Description
266	External Velocity East	m/s	Velocity East from external navigation source
267	External Velocity Down	m/s	Velocity Down from external navigation source
268	External Acceleration x Body Axis	m/s²	Acceleration x body axis from external navigation source
269	External Acceleration y Body Axis	m/s²	Acceleration y body axis from external navigation source
270	External Acceleration z Body Axis	m/s²	Acceleration z body axis from external navigation source
271	External GNSS Time of Week	s	GNSS Time of week from external navigation source
300	Relative Timestamp	s	Time spent since power-on of the system
301		byte	

ID	Name	Units/ Values	Description
	Used Memory Space		SD used memory space
302	Free Memory Space	byte	SD free memory space
303	Dynamic Pressure	Pa	Physical measurement from Pitot (dynamic pressure)
304	Static Pressure (Deprecated)	Pa	Physical measurement from Pitot (static preassure) **Warning** **Deprecated variable**
305	Internal Temperature	K	Physical measurement from internal sensors
306	External Temperature	K	Physical measurement from Veronte sensors
307	Accelerometer - X Body Axis	m/s²	

ID	Name	Units/ Values	Description
			Accelerometer measurement for X axis
308	Accelerometer - Y Body Axis	m/s²	Accelerometer measurement for Y axis
309	Accelerometer - Z Body Axis	m/s²	Accelerometer measurement for Z axis
310	Gyroscope - X Body Axis	rad/s	Gyroscope measurement for X axis
311	Gyroscope - Y Body Axis	rad/s	Gyroscope measurement for Y axis
312	Gyroscope - Z Body Axis	rad/s	Gyroscope measurement for Z axis
313	Magnetometer - X Body Axis	T	Magnetometer measurement for X axis **Warning** **Deprecated variable**
		T	

ID	Name	Units/ Values	Description
314	Magnetometer - Y Body Axis		Magnetometer measurement for Y axis **Warning** **Deprecated variable**
315	Magnetometer - Z Body Axis	T	Magnetometer measurement for Z axis **Warning** **Deprecated variable**
322	Internal LIS3MDL Magnetometer Raw X in SI	T	**Internal 0 Magnetometer** raw measurement for X axis
323	Internal LIS3MDL Magnetometer Raw Y in SI	T	**Internal 0 Magnetometer** raw measurement for Y axis
324	Internal LIS3MDL Magnetometer Raw Z in SI	T	**Internal 0 Magnetometer** raw measurement for Z axis
325		K	

ID	Name	Units/ Values	Description
	Internal LIS3MDL Magnetometer Temperature		**Internal 0 Magnetometer** temperature
326	External LIS3MDL Magnetometer Raw X in SI	T	**External LIS3MDL Magnetometer** raw measurement for X axis
327	External LIS3MDL Magnetometer Raw Y in SI	T	**External LIS3MDL Magnetometer** raw measurement for Y axis
328	External LIS3MDL magnetometer raw Z in SI	T	**External LIS3MDL Magnetometer** raw measurement for Z axis
329	External LIS3MDL magnetometer temperature	K	**External LIS3MDL Magnetometer** temperature
330	IMU 0 Raw Accelerometer X Measurement	m/s^2	**IMU 0** raw accelerometer x measurement

ID	Name	Units/ Values	Description
331	IMU 0 Raw Accelerometer Y Measurement	m/s²	**IMU 0** raw accelerometer y measurement
332	IMU 0 Raw Accelerometer Z Measurement	m/s²	**IMU 0** raw accelerometer z measurement
333	IMU 0 Raw Gyroscope X Measurement	rad/s	**IMU 0** raw gyroscope x measurement
334	IMU 0 Raw Gyroscope Y Measurement	rad/s	**IMU 0** raw gyroscope y measurement
335	IMU 0 Raw Gyroscope Z Measurement	rad/s	**IMU 0** raw gyroscope z measurement
336	IMU 0 temperature measurement	K	**IMU 0** temperature measurement
337	IMU 1 Raw Accelerometer X Measurement	m/s²	**IMU 1** raw accelerometer x measurement
338	IMU 1 Raw Accelerometer	m/s²	

ID	Name	Units/ Values	Description
	Y Measurement		**IMU 1** raw accelerometer y measurement
339	IMU 1 Raw Accelerometer Z Measurement	m/s²	**IMU 1** raw accelerometer z measurement
340	IMU 1 Raw Gyroscope X Measurement	rad/s	**IMU 1** raw gyroscope x measurement
341	IMU 1 Raw Gyroscope Y Measurement	rad/s	**IMU 1** raw gyroscope y measurement
342	IMU 1 Raw Gyroscope Z Measurement	rad/s	**IMU 1** raw gyroscope z measurement
343	IMU 1 temperature Measurement	K	**IMU 1** temperature measurement
344	Static Pressure Sensor (MS56) Raw Measurement	Pa	Static pressure sensor 1 raw measurement
345	Static Pressure Sensor (MS56) Temperature	K	Static pressure sensor 1 temperature

ID	Name	Units/ Values	Description
346	Dynamic Pressure Sensor Raw Measurement	Pa	Dynamic pressure sensor 1 raw measurement
347	Dynamic Pressure Sensor Temperature	K	Dynamic pressure sensor 1 temperature
348	Static Pressure Sensor (HSC) Raw Measurement	Pa	Static pressure sensor 0 raw measurement
349	Static Pressure Sensor (HSC) Temperature	K	Static pressure sensor 0 temperature
350	Vectornav Message Frequency	Hz	External navigation source VectorNav sends messages with this frequency
351	Vectornav Raw Acc X Measurement	m/s²	Raw accelerometer X measurement from external navigation source VectorNav
352		m/s²	

ID	Name	Units/ Values	Description
	Vectornav Raw Acc Y Measurement		Raw accelerometer Y measurement from external navigation source VectorNav
353	Vectornav Raw Acc Z Measurement	m/s²	Raw accelerometer Z measurement from external navigation source VectorNav
354	Vectornav Raw Gyr X Measurement	rad/s	Raw gyroscope X measurement from external navigation source VectorNav
355	Vectornav Raw Gyr Y Measurement	rad/s	Raw gyroscope Y measurement from external navigation source VectorNav
356	Vectornav Raw Gyr Z Measurement	rad/s	Raw gyroscope Z measurement from external navigation source VectorNav
357	External HSCDTD008A	T	**External HSCDTD008A**

ID	Name	Units/ Values	Description
	Magnetometer Raw X in SI		**Magnetometer** raw measurement for X axis
358	External HSCDTD008A Magnetometer Raw Y in SI	T	**External HSCDTD008A Magnetometer** raw measurement for Y axis
359	External HSCDTD008A Magnetometer Raw Z in SI	T	**External HSCDTD008A Magnetometer** raw measurement for Z axis
360	External HSCDTD008A Magnetometer Temperature	K	**External HSCDTD008A Magnetometer** temperature
361	IMU 2 Raw Accelerometer X Measurement	m/s^2	**IMU 2** raw accelerometer x measurement
362	IMU 2 Raw Accelerometer Y Measurement	m/s^2	**IMU 2** raw accelerometer y measurement
363	IMU 2 Raw Accelerometer	m/s^2	

ID	Name	Units/ Values	Description
	Z Measurement		**IMU 2** raw accelerometer z measurement
364	IMU 2 Raw Gyroscope X Measurement	rad/s	**IMU 2** raw gyroscope x measurement
365	IMU 2 Raw Gyroscope Y Measurement	rad/s	**IMU 2** raw gyroscope y measurement
366	IMU 2 Raw Gyroscope Z Measurement	rad/s	**IMU 2** raw gyroscope z measurement
367	IMU 2 Temperature Measurement	K	**IMU 2** temperature measurement
368	Static Pressure Sensor (DPS310) Raw Measurement	Pa	Static pressure sensor 2 raw measurement
369	Static Pressure Sensor (DPS310) Temperature	K	Static pressure sensor 2 temperature
370	Internal Magnetometer MMC5883MA Raw Measure	T	**Internal 1 Magnetometer** raw measurement

ID	Name	Units/ Values	Description
	X Converted to SI		for X axis converted to SI
371	Internal Magnetometer MMC5883MA Raw Measure Y Converted to SI	T	**Internal 1 Magnetometer** raw measurement for Y axis converted to SI
372	Internal Magnetometer MMC5883MA Raw Measure Z Converted to SI	T	**Internal 1 Magnetometer** raw measurement for Z axis converted to SI
373	Internal Magnetometer MMC5883MA Temperature	K	**Internal 1 Magnetometer** temperature
374	External Magnetometer MMC5883MA Raw Measure X Converted to SI	T	**External MMC5883MA Magnetometer** raw measurement for X axis converted to SI
375	External Magnetometer MMC5883MA Raw Measure	T	**External MMC5883MA Magnetometer** raw measurement

ID	Name	Units/ Values	Description
	Y Converted to SI		for Y axis converted to SI
376	External Magnetometer MMC5883MA Raw Measure Z Converted to SI	T	**External MMC5883MA Magnetometer** raw measurement for Z axis converted to SI
377	External Magnetometer MMC5883MA Temperature	K	**External MMC5883MA Magnetometer** temperature
378	External Magnetometer RM3100 Raw Measure X Converted to SI	T	**External RM3100 Magnetometer** raw measurement for X axis converted to SI
379	External Magnetometer RM3100 Raw Measure Y Converted to SI	T	**External RM3100 Magnetometer** raw measurement for Y axis converted to SI
380	External Magnetometer RM3100 Raw Measure Z	T	**External RM3100 Magnetometer** raw measurement

ID	Name	Units/ Values	Description
	Converted to SI		for Z axis converted to SI
382	External Magnetometer HMR2300 Raw Measure X Converted to SI	T	**External HMR2300 Magnetometer** raw measurement for X axis converted to SI
383	External Magnetometer HMR2300 Raw Measure Y Converted to SI	T	**External HMR2300 Magnetometer** raw measurement for Y axis converted to SI
384	External Magnetometer HMR2300 Raw Measure Z Converted to SI	T	**External HMR2300 Magnetometer** raw measurement for Z axis converted to SI
385	External Magnetometer HMR2300 Temperature	K	**External HMR2300 Magnetometer** temperature
386	IMU 3 Raw Accelerometer X Measurement	m/s^2	**IMU 3** raw accelerometer x measurement

ID	Name	Units/ Values	Description
387	IMU 3 Raw Accelerometer Y Measurement	m/s²	**IMU 3** raw accelerometer y measurement
388	IMU 3 Raw Accelerometer Z Measurement	m/s²	**IMU 3** raw accelerometer z measurement
389	IMU 3 Raw Gyroscope X Measurement	rad/s	**IMU 3** raw gyroscope x measurement
390	IMU 3 Raw Gyroscope Y Measurement	rad/s	**IMU 3** raw gyroscope y measurement
391	IMU 3 Raw Gyroscope Z Measurement	rad/s	**IMU 3** raw gyroscope z measurement
392	IMU 3 Temperature Measurement	K	**IMU 3** temperature measurement
393	Internal Magnetometer RM3100 Raw Measure X Converted to SI	T	**Internal 2 Magnetometer** raw measurement for X axis converted to SI

ID	Name	Units/ Values	Description
394	Internal Magnetometer RM3100 Raw Measure Y Converted to SI	T	**Internal 2 Magnetometer** raw measurement for Y axis converted to SI
395	Internal Magnetometer RM3100 Raw Measure Z Converted to SI	T	**Internal 2 Magnetometer** raw measurement for Z axis converted to SI
400	Power Input	V	Voltage received by Veronte
401	Power Comicro 3.3V	V	Voltage received by Veronte through 3.3V port
402	Power 5V	V	Voltage received by Veronte through 5V port
403	SUC Power Input	V	Voltage received by Veronte SUC
404	Power 3.6V	V	Voltage received by Veronte through 3.6V port
405		K	

ID	Name	Units/ Values	Description
	CPU Temperature		Internal computer temperature
406	External IMU 0 raw accelerometer x measurement	m/s²	Saves the measurements of this external sensor in raw form, as received from the custom messages
407	External IMU 0 raw accelerometer y measurement	m/s²	Saves the measurements of this external sensor in raw form, as received from the custom messages
408	External IMU 0 raw accelerometer z measurement	m/s²	Saves the measurements of this external sensor in raw form, as received from the custom messages
409	External IMU 0 raw gyroscope x measurement	m/s²	Saves the measurements of this external sensor in raw form, as received

ID	Name	Units/ Values	Description
			from the custom messages
410	External IMU 0 raw gyroscope y measurement	m/s²	Saves the measurements of this external sensor in raw form, as received from the custom messages
411	External IMU 0 raw gyroscope z measurement	m/s²	Saves the measurements of this external sensor in raw form, as received from the custom messages
412	External IMU 0 temperature measurement	K	Saves the temperatures of this external sensor in raw form, as received from custom messages
413	External IMU 1 raw accelerometer x measurement	m/s²	Saves the measurements of this external sensor in raw form, as received

ID	Name	Units/ Values	Description
			from the custom messages
414	External IMU 1 raw accelerometer y measurement	m/s²	Saves the measurements of this external sensor in raw form, as received from the custom messages
415	External IMU 1 raw accelerometer z measurement	m/s²	Saves the measurements of this external sensor in raw form, as received from the custom messages
416	External IMU 1 raw gyroscope x measurement	m/s²	Saves the measurements of this external sensor in raw form, as received from the custom messages
417	External IMU 1 raw gyroscope y measurement	m/s²	Saves the measurements of this external sensor in raw form, as received

ID	Name	Units/ Values	Description
			from the custom messages
418	External IMU 1 raw gyroscope z measurement	m/s²	Saves the measurements of this external sensor in raw form, as received from the custom messages
419	External IMU 1 temperature measurement	K	Saves the temperatures of this external sensor in raw form, as received from custom messages
420	External magnetometer 0 raw measurement X	m/s²	Saves the measurements of this external sensor in raw form, as received from the custom messages
421	External magnetometer 0 raw measurement Y	m/s²	Saves the measurements of this external sensor in raw form, as received

ID	Name	Units/ Values	Description
			from the custom messages
422	External magnetometer 0 raw measurement Z	m/s²	Saves the measurements of this external sensor in raw form, as received from the custom messages
423	External magnetometer 0 temperature	K	Saves the temperatures of this external sensor in raw form, as received from custom messages
424	External magnetometer 1 raw measurement X	m/s²	Saves the measurements of this external sensor in raw form, as received from the custom messages
425	External magnetometer 1 raw measurement Y	m/s²	Saves the measurements of this external sensor in raw form, as received

ID	Name	Units/ Values	Description
			from the custom messages
426	External magnetometer 1 raw measurement Z	m/s^2	Saves the measurements of this external sensor in raw form, as received from the custom messages
427	External magnetometer 1 temperature	K	Saves the temperatures of this external sensor in raw form, as received from custom messages
500	Longitude	rad	East-West geographic coordinate
501	Latitude	rad	North-South geographic coordinate
502	WGS84 Elevation (Height Over the Ellipsoid)	m	Elevation over WGS84 reference frame
503	MSL (Height Above Mean	m	

ID	Name	Units/ Values	Description
	Sea Level) - Altitude		Altitude over the Mean Sea Level
504	AGL (Above Ground Level) - Height	m	Height Above Ground Level - Dependent on external sensors or own models with considerable error
505	North Ground Velocity	m/s	Ground Velocity component in the North direction (NED Coordinates system)
506	East Ground Velocity	m/s	Ground Velocity component in the East direction (NED Coordinates system)
507	Down Ground Velocity	m/s	Ground Velocity component in the resultant axis from North-East (NED Coordinates system)
508	Sensor IAS (Indicated Air Speed)	m/s	Pitot-static measurement speed

ID	Name	Units/ Values	Description
509	Angle of Attack - AoA	rad	Angle between reference body line and flow direction vector
510	Sideslip	rad	Angle between the flow direction vector and the longitudinal axis of the vehicle
511	GNSS1 MSL	m	Mean sea level (MSL) measurement provided by GPS 1
512	GNSS1 AGL	m	Above ground level (AGL level) measurement provided by GPS 1
513	GNSS2 MSL	m	Mean sea level (MSL) measurement provided by GPS 2
514	GNSS2 AGL	m	Above ground level (AGL level) measurement

ID	Name	Units/ Values	Description
			provided by GPS 2
551	Sagetech MXS - Longitude decimal part	degree	Sagetech variable, used by block to parse variables for GPS Navigation Data Message **Warning** **Variable for internal use**
552	Sagetech MXS - Longitude fractional part	degree	Sagetech variable, used by block to parse variables for GPS Navigation Data Message **Warning** **Variable for internal use**
553	Sagetech MXS - Latitude decimal part	degree	Sagetech variable, used by block to parse variables for GPS Navigation Data Message

ID	Name	Units/ Values	Description
			Warning **Variable for internal use**
554	Sagetech MXS - Latitude fractional part	degree	Sagetech variable, used by block to parse variables for GPS Navigation Data Message **Warning** **Variable for internal use**
555	Sagetech MXS - Ground speed	m/s	Sagetech variable, used by block to parse variables for GPS Navigation Data Message **Warning** **Variable for internal use**
556	Sagetech MXS - Ground track	degree	Sagetech variable, used by block to parse variables for GPS Navigation Data

ID	Name	Units/ Values	Description
			Message **Warning** **Variable for internal use**
560	ADS-B Out / Squawk	-	ADS-B Squawk code, 4 digits that allow the operator to inform about its status
600-603	Temperature 0-3	K	Variables to be configured with external temperature sensors **Warning** **Deprecated variables**
610	North Position EKF Variance	m^2	North position Extended Kalman Filter variance
611	East Position EKF Variance	m^2	East position Extended Kalman Filter variance
612	Down Position EKF Variance	m^2	Position variance component in the

ID	Name	Units/ Values	Description
			resultant axis from North-East
613	North Velocity EKF Variance	m^2/s^2	North velocity Extended Kalman Filter variance
614	East Velocity EKF Variance	m^2/s^2	East velocity Extended Kalman Filter variance
615	Down Velocity EKF Variance	m^2/s^2	Velocity variance component in the resultant axis from North-East
650	Gimbal Command Yaw	customType	Yaw sent to the gimbal
651	Gimbal Command Pitch	customType	Pitch sent to the gimbal
652	Gimbal Stick Yaw	customType	Yaw received from the joystick controlling the gimbal
653	Gimbal Stick Pitch	customType	Pitch received from the joystick controlling the gimbal
		customType	

ID	Name	Units/ Values	Description
654	Gimbal Pitch Correction 0		Correction calculated by the gimbal for the pitch control 0
655	Gimbal Pitch Correction 1	customType	Correction calculated by the gimbal for the pitch control 1
656	Gimbal Old Joint 0	customType	Auxiliar variable 0 for Gimbal control configuration
657	Gimbal Old Joint 1	customType	Auxiliar variable 1 for Gimbal control configuration
658	Cos (Gimbal Yaw)	customType	Auxiliar variable 0 for Gimbal control configuration
659	Sin (Gimbal Yaw)	customType	Auxiliar variable 1 for Gimbal control configuration
660	Gimbal Yaw Radian	customType	Auxiliar variable for Gimbal control configuration
661	Veronte Gimbal Yaw Output	customType	Yaw value the gimbal is sending as output

ID	Name	Units/ Values	Description
662	Veronte Gimbal Pitch Output	customType	Pitch value the gimbal is sending as output
663	Gimbal Phi(z)	customType	Auxiliar variable phi for Gimbal control configuration
664	Gimbal Theta(y)	customType	Auxiliar variable theta for Gimbal control configuration
665	Gimbal Psi(x)	customType	Auxiliar variable psi for Gimbal control configuration
666	Veronte Gimbal Roll Output (Degrees)	customType	Roll value the gimbal is sending as output
700-705	RPM 0-5	rad/s	Angular speed associated to pulse captured 0-5
750	Selected Controller Time Step	s	PID selected time step

ID	Name	Units/ Values	Description
751	Selected Controller Derivative Filtered Error	customType	PID selected derivative filtered error
752	Selected Controller Proportional Action	customType	PID selected proportional action
753	Selected Controller Derivative Action	customType	PID selected derivative action
754	Selected Controller Integral Input	customType	PID selected integral input
755	Selected Controller Integral Action	customType	PID selected integral action
756	Selected Controller Anti-windup Input	customType	PID selected anti-windup input
757	Selected Controller Derivative Error	customType	PID selected derivative error

ID	Name	Units/ Values	Description
800-815	PWM 0-15	customType	Pulse Width Modulation signal 0 to 15
📝 900-915	Stick Input r0 - r15	customType	Raw stick measurement from r0 to r15
📝 950-981	Stick Input s0 - s31	customType	**Warning** **Deprecated variables**
📝 1000-1031	Stick Input y0 - y31	customType	Servo position commanded from stick y0 to y31
📝 1050-1069	Control Output u0-u19 Before Servo Saturation	customType	Commanded control output before saturation correction
1100-1104	Lidar 0-4 Distance	m	Variable configurable for Lidar distances 0 to 4
📝 1105-1109	External Range Sensor 0-4 Measure	m	Variable configurable for external range sensors
		m	Shortest distance to desired path

ID	Name	Units/ Values	Description
1200	Route-Guidance Distance		(perpendicular distance)
1201	Radar AGL (Above Ground Level) - Height	m	Radar altimeter measure
1202	Radar Speed Down	m/s	Radar speed
1203	External Rotation for Follow Route	rad	Relative vector rotation when using Follow Route
1204	Time to Impact with Obstacles	s	Time calculated with Distance to Obstacle and travel speed
1300-1309	Timer 0-9	s	Configurable timers for automations
1320-1321	ADC 3.3V Input 0-1	V	CEX ADC 3.3 V inputs 0 and 1
1322-1323	ADC 5.0V Input 0-1	V	CEX ADC 5.0 V inputs 0 and 1
1324-1325	ADC 12.0V Input 0-1	V	CEX ADC 12.0 V inputs 0 and 1

ID	Name	Units/ Values	Description
1326-1327	ADC 36.0V Input 0-1	V	CEX ADC 36.0 V inputs 0 and 1
1328-1329	ADC vIn 0-1	V	CEX External power supplies 0 and 1
1330	PCB Temperature	K	CEX PCB Temperature (from ADC input)
1331	ADC HW Version	V	Hardware version of CEX ADC
📝 1350-1369	4xV Real variables	-	For more information, check **Real Variables - 4x Software Manual**
1400	Velocity - X Body Axis	m/s	Velocity on X-axis
1401	Velocity - Y Body Axis	m/s	Velocity on Y-axis
1402	Velocity - Z Body Axis	m/s	Velocity on Z-axis
1403	Estimated Dynamic Pressure	Pa	Dynamic pressure sensor raw measurement

ID	Name	Units/ Values	Description
1404	Barometric Pressure at Sea Level (QNH)	Pa	Introduced value for QNH
1450-1453	Captured Pulse 0-3	customType	Input values from pulses
1484	External IMU 0 accelerometer reception frequency	Hz	Reception frequencies of measurements from External IMU 0 accelerometer
1485	External IMU 0 gyroscope reception frequency	Hz	Reception frequencies of measurements from External IMU 0 gyroscope
1486	External IMU 1 accelerometer reception frequency	Hz	Reception frequencies of measurements from External IMU 1 accelerometer
1487	External IMU 1 gyroscope reception frequency	Hz	Reception frequencies of measurements from External IMU 1 gyroscope
1488-1489		Hz	

ID	Name	Units/ Values	Description
	External magnetometer 0-1 reception frequency		Reception frequencies of measurements from External magnetometer 0-1
1490	Internest Raw X Distance	m	Raw measurements for X-axis internest distance
1491	Internest Raw Y Distance	m	Raw measurements for Y-axis internest distance
1492	Internest Raw Z Distance	m	Raw measurements for Z-axis internest distance
1493	Internest Raw Angle	rad	Raw measurements for internest angle
1494	Internest Raw XY standard Deviation	m	Raw measurements for XY axis internest standard deviation

ID	Name	Units/ Values	Description
1495	Internest Raw Z standard Deviation	m	Raw measurements for Z-axis internest standard deviation
1496	Internest Raw Angle standard Deviation	rad	Raw measurements for internest angle standard deviation
1497	Internest Position Update Frequency	Hz	Frequency to update internest position
1500	GNSS1 Absolute Time of Week	s	Data from GNSS1 module: Time of week
1501	GNSS1 ECEF Position X	m	Data from GNSS1 module: ECEF (Earth-Centered Earth-Fixed coordinate system) X position
1502	GNSS1 ECEF Position Y	m	Data from GNSS1 module: ECEF (Earth-Centered

ID	Name	Units/ Values	Description
			Earth-Fixed coordinate system) Y position
1503	GNSS1 ECEF Position Z	m	Data from GNSS1 module: ECEF (Earth-Centered Earth-Fixed coordinate system) Z position
1504	GNSS1 Longitude	rad	Data from GNSS1 module: Longitude
1505	GNSS1 Latitude	rad	Data from GNSS1 module: Latitude
1506	GNSS1 Height Above Ellipsoid (WGS84)	m	Data from GNSS1 module: Height Above Ellipsoid (WGS84)
1509	GNSS1 PDOP (Dilution of Precision of Position)	customType	Data from GNSS1 module: PDOP - Relation between user position error and satellite position error
1510		m	

ID	Name	Units/ Values	Description
	GNSS1 Accuracy		Data from GNSS1 module: Accuracy
1511	GNSS1 Horizontal Accuracy Estimate	m	Data from GNSS1 module: Horizontal accuracy
1512	GNSS1 Vertical Accuracy Estimate	m	Data from GNSS1 module: Vertical accuracy
1513	GNSS1 Velocity North	m/s	Data from GNSS1 module: Velocity in North direction (NED Coordinates system)
1514	GNSS1 Velocity East	m/s	Data from GNSS1 module: Velocity in East direction (NED Coordinates system)
1515	GNSS1 Velocity Down	m/s	Data from GNSS1 module: Velocity in Down direction (NED Coordinates system)
1516		m/s	

ID	Name	Units/ Values	Description
	GNSS1 Speed Accuracy Estimate		Data from GNSS1 module: Speed accuracy
1517	GNSS1 Related Base Longitude	rad	Data from GNSS1 module: RTK Base longitude
1518	GNSS1 Related Base Latitude	rad	Data from GNSS1 module: RTK Base latitude
1519	GNSS1 Related Base WGS84 Altitude	m	Data from GNSS1 module: RTK Base WGS84 altitude
1520	GNSS1 Related Base to Rover Azimuth	rad	Data from GNSS1 module: RTK Base-Rover vector azimuth (Spherical coordinates system)
1521	GNSS1 Related Base to Rover Elevation	rad	Data from GNSS1 module: RTK Base-Rover vector elevation (Spherical coordinates system)

ID	Name	Units/ Values	Description
1522	GNSS1 Related Base to Rover Distance	m	Data from GNSS1 module: RTK Base-Rover vector distance (Spherical coordinates system)
1523	GNSS1 Related Base to Rover Accuracy	m	Data from GNSS1 module: RTK Base-Rover vector accuracy
1524	GNSS1 Survey in Accuracy	m	Data from GNSS1 module: RTK Base accuracy when base knows it is fixed in a particular position
1525	GNSS1 Related Base to Rover North	m	Data from GNSS1 module: RTK Base-Rover vector North (NED Coordinate system)
1526	GNSS1 Related Base to Rover East	m	Data from GNSS1 module: RTK Base-Rover vector East (NED Coordinate system)

ID	Name	Units/ Values	Description
1527	GNSS1 Related Base to Rover Down	m	Data from GNSS1 module: RTK Base-Rover vector Down (NED Coordinate system)
1528	GNSS1 Position Frequency	Hz	Data from GNSS1 module: Position frequency
1529	GNSS1 Jamming Indicator	%	Jamming indicator from U-Blox device 1 for GNSS
1600	GNSS2 Absolute Time of Week	s	Data from GNSS2 module: Time of week
1601	GNSS2 ECEF Position X	m	Data from GNSS2 module: ECEF (Earth-Centered Earth-Fixed coordinate system) X position
1602	GNSS2 ECEF Position Y	m	Data from GNSS2 module: ECEF (Earth-Centered Earth-Fixed coordinate

ID	Name	Units/ Values	Description
			system) Y position
1603	GNSS2 ECEF Position Z	m	Data from GNSS2 module: ECEF (Earth-Centered Earth-Fixed coordinate system) Z position
1604	GNSS2 Longitude	rad	Data from GNSS2 module: Longitude
1605	GNSS2 Latitude	rad	Data from GNSS2 module: Latitude
1606	GNSS2 Height Above Ellipsoid (WGS84)	m	Data from GNSS2 module: Height Above Ellipsoid (WGS84)
1609	GNSS2 PDOP (Dilution of Precision of Position)	customType	Data from GNSS2 module: PDOP - Relation between user position error and satellite position error
1610	GNSS2 Accuracy	m	Data from GNSS2 module: Accuracy
1611		m	

ID	Name	Units/ Values	Description
	GNSS2 Horizontal Accuracy Estimate		Data from GNSS2 module: Horizontal accuracy
1612	GNSS2 Vertical Accuracy Estimate	m	Data from GNSS2 module: Vertical accuracy
1613	GNSS2 Velocity North	m/s	Data from GNSS2 module: Velocity in North direction (NED Coordinates system)
1614	GNSS2 Velocity East	m/s	Data from GNSS2 module: Velocity in East direction (NED Coordinates system)
1615	GNSS2 Velocity Down	m/s	Data from GNSS2 module: Velocity in Down direction (NED Coordinates system)
1616	GNSS2 Speed Accuracy Estimate	m/s	Data from GNSS2 module: Speed accuracy
1617		rad	

ID	Name	Units/ Values	Description
	GNSS2 Related Base Longitude		Data from GNSS2 module: RTK Base longitude
1618	GNSS2 Related Base Latitude	rad	Data from GNSS2 module: RTK Base latitude
1619	GNSS2 Related Base WGS84 Altitude	m	Data from GNSS2 module: RTK Base WGS84 Altitude
1620	GNSS2 Related Base to Rover Azimuth	rad	Data from GNSS2 module: RTK Base-Rover vector azimuth (Spherical Coordinates system)
1621	GNSS2 Related Base to Rover Elevation	rad	Data from GNSS2 module: RTK Base-Rover vector elevation (Spherical Coordinates system)
1622	GNSS2 Related Base to Rover Distance	m	Data from GNSS2 module: RTK Base-Rover vector distance (Spherical

ID	Name	Units/ Values	Description
			Coordinates system)
1623	GNSS2 Related Base to Rover Accuracy	m	Data from GNSS2 module: RTK Base-Rover vector accuracy
1624	GNSS2 Survey in Accuracy	m	Data from GNSS2 module: RTK Base accuracy when base knows it is fixed in a particular position
1625	GNSS2 Related Base to Rover North	m	Data from GNSS2 module: RTK Base-Rover vector North (NED Coordinate system)
1626	GNSS2 Related Base to Rover East	m	Data from GNSS2 module: RTK Base-Rover vector East (NED Coordinate system)
1627	GNSS2 Related Base to Rover Down	m	Data from GNSS2 module: RTK Base-Rover vector Down (NED

ID	Name	Units/ Values	Description
			Coordinate system)
1628	GNSS2 Position Frequency	H	Data from GNSS2 module: Position frequency
1629	GNSS2 Jamming Indicator	%	Jamming indicator from U-Blox device 2 for GNSS
1700-1731	Actuator Output s0 - s31	customType	Configurable variable from actuator outputs to be transformed by the system
1800	Distance to Object of Interest 0	m	Spherical coordinate to object of interest 0: distance
1801	Azimuth to Object of Interest 0	rad	Spherical coordinate to object of interest 0: azimuth
1802	Elevation to Object of Interest 0	rad	Spherical coordinate to object of interest 0: elevation
1803		m	Spherical coordinate to

ID	Name	Units/ Values	Description
	Distance to Object of Interest 1		object of interest 1: distance
1804	Azimuth to Object of Interest 1	rad	Spherical coordinate to object of interest 1: azimuth
1805	Elevation to Object of Interest 1	rad	Spherical coordinate to object of interest 1: elevation
1806	Distance to Object of Interest 2	m	Spherical coordinate to object of interest 2: distance
1807	Azimuth to Object of Interest 2	rad	Spherical coordinate to object of interest 2: azimuth
1808	Elevation to Object of Interest 2	rad	Spherical coordinate to object of interest 2: elevation
1809	Distance to Object of Interest 3	m	Spherical coordinate to object of interest 3: distance

ID	Name	Units/ Values	Description
📝 1810	Azimuth to Object of Interest 3	rad	Spherical coordinate to object of interest 3: azimuth
📝 1811	Elevation to Object of Interest 3	rad	Spherical coordinate to object of interest 3: elevation
📝 1812	Distance to Object of Interest 4	m	Spherical coordinate to object of interest 4: distance
📝 1813	Azimuth to Object of Interest 4	rad	Spherical coordinate to object of interest 4: azimuth
📝 1814	Elevation to Object of Interest 4	rad	Spherical coordinate to object of interest 4: elevation
📝 1815	Distance to Object of Interest 5	m	Spherical coordinate to object of interest 5: distance
📝 1816	Azimuth to Object of Interest 5	rad	Spherical coordinate to

ID	Name	Units/ Values	Description
			object of interest 5: azimuth
1817	Elevation to Object of Interest 5	rad	Spherical coordinate to object of interest 5: elevation
1818	Distance to Object of Interest 6	m	Spherical coordinate to object of interest 6: distance
1819	Azimuth to Object of Interest 6	rad	Spherical coordinate to object of interest 6: azimuth
1820	Elevation to Object of Interest 6	rad	Spherical coordinate to object of interest 6: elevation
1821	Distance to Object of Interest 7	m	Spherical coordinate to object of interest 7: distance
1822	Azimuth to Object of Interest 7	rad	Spherical coordinate to object of interest 7: azimuth
		rad	

ID	Name	Units/ Values	Description
📝 1823	Elevation to Object of Interest 7		Spherical coordinate to object of interest 7: elevation
📝 1824	Distance to Object of Interest 8	m	Spherical coordinate to object of interest 8: distance
📝 1825	Azimuth to Object of Interest 8	rad	Spherical coordinate to object of interest 8: azimuth
📝 1826	Elevation to Object of Interest 8	rad	Spherical coordinate to object of interest 8: elevation
📝 1827	Distance to Object of Interest 9	m	Spherical coordinate to object of interest 9: distance
📝 1828	Azimuth to Object of Interest 9	rad	Spherical coordinate to object of interest 9: azimuth
📝 1829	Elevation to Object of Interest 9	rad	Spherical coordinate to

ID	Name	Units/ Values	Description
			object of interest 9: elevation
1830	Distance to Object of Interest 10	m	Spherical coordinate to object of interest 10: distance
1831	Azimuth to Object of Interest 10	rad	Spherical coordinate to object of interest 10: azimuth
1832	Elevation to Object of Interest 10	rad	Spherical coordinate to object of interest 10: elevation
1833	Distance to Object of Interest 11	m	Spherical coordinate to object of interest 11: distance
1834	Azimuth to Object of Interest 11	rad	Spherical coordinate to object of interest 11: azimuth
1835	Elevation to Object of Interest 11	rad	Spherical coordinate to object of interest 11: elevation
		m	

ID	Name	Units/ Values	Description
1836	Distance to Object of Interest 12		Spherical coordinate to object of interest 12: distance
1837	Azimuth to Object of Interest 12	rad	Spherical coordinate to object of interest 12: azimuth
1838	Elevation to Object of Interest 12	rad	Spherical coordinate to object of interest 12: elevation
1839	Distance to Object of Interest 13	m	Spherical coordinate to object of interest 13: distance
1840	Azimuth to Object of Interest 13	rad	Spherical coordinate to object of interest 13: azimuth
1841	Elevation to Object of Interest 13	rad	Spherical coordinate to object of interest 13: elevation
1842	Distance to Object of Interest 14	m	Spherical coordinate to

ID	Name	Units/ Values	Description
			object of interest 14: distance
📝 1843	Azimuth to Object of Interest 14	rad	Spherical coordinate to object of interest 14: azimuth
📝 1844	Elevation to Object of Interest 14	rad	Spherical coordinate to object of interest 14: elevation
📝 1845	Distance to Object of Interest 15	m	Spherical coordinate to object of interest 15: distance
📝 1846	Azimuth to Object of Interest 15	rad	Spherical coordinate to object of interest 15: azimuth
📝 1847	Elevation to Object of Interest 15	rad	Spherical coordinate to object of interest 15: elevation
📝 1848	Distance to Object of Interest 16	m	Spherical coordinate to object of interest 16: distance
		rad	

ID	Name	Units/ Values	Description
📝 1849	Azimuth to Object of Interest 16		Spherical coordinate to object of interest 16: azimuth
📝 1850	Elevation to Object of Interest 16	rad	Spherical coordinate to object of interest 16: elevation
📝 1851	Distance to Object of Interest 17	m	Spherical coordinate to object of interest 17: distance
📝 1852	Azimuth to Object of Interest 17	rad	Spherical coordinate to object of interest 17: azimuth
📝 1853	Elevation to Object of Interest 17	rad	Spherical coordinate to object of interest 17: elevation
📝 1854	Distance to Object of Interest 18	m	Spherical coordinate to object of interest 18: distance
📝 1855	Azimuth to Object of Interest 18	rad	Spherical coordinate to

ID	Name	Units/ Values	Description
			object of interest 18: azimuth
📝 1856	Elevation to Object of Interest 18	rad	Spherical coordinate to object of interest 18: elevation
📝 1857	Distance to Object of Interest 19	m	Spherical coordinate to object of interest 19: distance
📝 1858	Azimuth to Object of Interest 19	rad	Spherical coordinate to object of interest 19: azimuth
📝 1859	Elevation to Object of Interest 19	rad	Spherical coordinate to object of interest 19: elevation
📝 1860	Distance to Object of Interest 20	m	Spherical coordinate to object of interest 20: distance
📝 1861	Azimuth to Object of Interest 20	rad	Spherical coordinate to object of interest 20: azimuth
		rad	

ID	Name	Units/ Values	Description
1862	Elevation to Object of Interest 20		Spherical coordinate to object of interest 20: elevation
1863	Distance to Object of Interest 21	m	Spherical coordinate to object of interest 21: distance
1864	Azimuth to Object of Interest 21	rad	Spherical coordinate to object of interest 21: azimuth
1865	Elevation to Object of Interest 21	rad	Spherical coordinate to object of interest 21: elevation
1866	Distance to Object of Interest 22	m	Spherical coordinate to object of interest 22: distance
1867	Azimuth to Object of Interest 22	rad	Spherical coordinate to object of interest 22: azimuth
1868	Elevation to Object of Interest 22	rad	Spherical coordinate to

ID	Name	Units/ Values	Description
			object of interest 22: elevation
1869	Distance to Object of Interest 23	m	Spherical coordinate to object of interest 23: distance
1870	Azimuth to Object of Interest 23	rad	Spherical coordinate to object of interest 23: azimuth
1871	Elevation to Object of Interest 23	rad	Spherical coordinate to object of interest 23: elevation
1872	Distance to Object of Interest 24	m	Spherical coordinate to object of interest 24: distance
1873	Azimuth to Object of Interest 24	rad	Spherical coordinate to object of interest 24: azimuth
1874	Elevation to Object of Interest 24	rad	Spherical coordinate to object of interest 24: elevation
		m	

ID	Name	Units/ Values	Description
1875	Distance to Object of Interest 25		Spherical coordinate to object of interest 25: distance
1876	Azimuth to Object of Interest 25	rad	Spherical coordinate to object of interest 25: azimuth
1877	Elevation to Object of Interest 25	rad	Spherical coordinate to object of interest 25: elevation
1878	Distance to Object of Interest 26	m	Spherical coordinate to object of interest 26: distance
1879	Azimuth to Object of Interest 26	rad	Spherical coordinate to object of interest 26: azimuth
1880	Elevation to Object of Interest 26	rad	Spherical coordinate to object of interest 26: elevation
1881	Distance to Object of Interest 27	m	Spherical coordinate to

ID	Name	Units/ Values	Description
			object of interest 27: distance
1882	Azimuth to Object of Interest 27	rad	Spherical coordinate to object of interest 27: azimuth
1883	Elevation to Object of Interest 27	rad	Spherical coordinate to object of interest 27: elevation
1884	Distance to Object of Interest 28	m	Spherical coordinate to object of interest 28: distance
1885	Azimuth to Object of Interest 28	rad	Spherical coordinate to object of interest 28: azimuth
1886	Elevation to Object of Interest 28	rad	Spherical coordinate to object of interest 28: elevation
1887	Distance to Object of Interest 29	m	Spherical coordinate to object of interest 29: distance
		rad	

ID	Name	Units/ Values	Description
1888	Azimuth to Object of Interest 29		Spherical coordinate to object of interest 29: azimuth
1889	Elevation to Object of Interest 29	rad	Spherical coordinate to object of interest 29: elevation
1890	Distance to Object of Interest 30	m	Spherical coordinate to object of interest 30: distance
1891	Azimuth to Object of Interest 30	rad	Spherical coordinate to object of interest 30: azimuth
1892	Elevation to Object of Interest 30	rad	Spherical coordinate to object of interest 30: elevation
1893	Distance to Object of Interest 31	m	Spherical coordinate to object of interest 31: distance
1894	Azimuth to Object of Interest 31	rad	Spherical coordinate to

ID	Name	Units/ Values	Description
			object of interest 31: azimuth
📝 1895	Elevation to Object of Interest 31	rad	Spherical coordinate to object of interest 31: elevation
2000	RX Packet Error Rate (on board)	decimal	Value rating RX packets and expected RX packets, given as % error
2001	TX Packet Error Rate (on board)	decimal	Value rating TX packets and expected TX packets, given as % error
2002	Computed RX pkt/s Used for RX PER	messages	Packages per second received to the UAV configured in communication statistics
2003	Remote RX pkt/s Used for TX PER	messages	RX packages per second received and computed through communications

ID	Name	Units/ Values	Description
2004	Computed TX pkt/s Used for TX PER	messages	Packages per second transmitted to the UAV configured in communication statistics
2005	Remote TX pkt/s Used for RX PER	messages	TX packages per second received and computed through communications
2019	Stick RX Rate	Hz	Number of stick messages received per second
2020	Position Fix Time	s	Time spend with GNSS without losing fix
2040-2042	Tunnel Producer Receive Frequency 0-2	Hz	Tunnel producer 0-2 receives data at this frequency
2043-2045	Tunnel Consumer Send Frequency 0-2	Hz	Tunnel consumer 0-2 receives data at this frequency
2046		s	

ID	Name	Units/ Values	Description
	Max Duration of Step in CIO		Longest time duration from a step in CIO
2047	Acquisition Task Timestep	s	Average period to execute the acquisition thread
2048	Acquisition Task Maximum Timestep	s	Maximum period to execute the acquisition thread
2049	Cross Core Message Queue CPU Ratio	percentage	% of time of CPU that CIO waits for inter-core communications queue to be emptied
2050	Acquisition Task Average CPU Ratio	percentage	Average % of CPU time spent in the acquisition thread
2051	Acquisition Task Maximum CPU Ratio	percentage	Maximum % of CPU time spent in the acquisition thread
2052	Acquisition Task Average Time	s	Average time for acquisition thread
2053		s	

ID	Name	Units/ Values	Description
	Acquisition Task Maximum Time		Maximum time for acquisition thread
2054	CIO Max Time	s	Maximum time of CIO thread
2055	CIO Average Time	s	Average and Maximum time of CIO thread
2056	Cross-Core Message Queue Usage	%	Percentage of communication employed between both microprocessors
2057	CIO Running Frequency	Hz	C1 low running frequency (Veronte Autopilot 1x and MC) **Note** Only for MC
2058	CIO Min Running Frequency	Hz	Minimum assured frequency of low priority task **Note** Only for MC

ID	Name	Units/ Values	Description
2094	GNC Task Average CPU Ratio	percentage	Average % of CPU time of GNC task
2095	GNC Task Maximum CPU Ratio	percentage	Maximum % of CPU time of GNC task
2096	GNC Task Average Time	s	Average time spent on GNC task
2097	GNC Task Maximum Time	s	Maximum time spent on GNC task
2098	GNC Task Maximum Timestep	s	Maximum execution period for GNC task
2099	Max Duration of Step in GNC	s	Maximum duration of one step in GNC
2100	Gyroscope Based on Accelerometer - X Body Axis	rad/s	Gyroscope measurements obtained from accelerometer X-axis data
2101	Gyroscope Based on	rad/s	Gyroscope measurements obtained from

ID	Name	Units/ Values	Description
	Accelerometer - Y Body Axis		accelerometer Y-axis data
2102	Gyroscope Based on Accelerometer - Z Body Axis	rad/s	Gyroscope measurements obtained from accelerometer Z-axis data
2103	Acceleration North	m/s²	Acceleration in the North direction (NED Coordinates System)
2104	Acceleration East	m/s²	Acceleration in the East direction (NED Coordinates System)
2105	Acceleration Down	m/s²	Acceleration in the Down direction (NED Coordinates System)
2112	Estimated Dem	m	Altitude given by the estimated Digital Elevation Model
2200	Curve Length Covered	m	Total distance from current

ID	Name	Units/ Values	Description
			mission length covered
2201	Curve Length	m	Total distance from current mission length
2202	Curve Length Pending	m	Total distance from current mission length not covered yet
2203	Curve Parameter Covered	customType	Total length covered from current mission according to parameter selected
2204	Curve Parameter Range	customType	Total length from current mission according to parameter selected
2205	Curve Parameter Pending	customType	Total length from current mission to be covered according to parameter selected yet
2206		customType	

ID	Name	Units/ Values	Description
	Curve Horizontal Curvature		Horizontal curvature of the current curve
2250-2259	Reserved 0-9	customType	System reserved variables
📝 2300-2302	Joint 0-2 of Gimbal 0	rad	Variables for Gimbal 0 configuration - Angles sent to gimbal as Yaw (0), Pitch (1) and Roll (2)
📝 2303-2305	Joint 0-2 of Gimbal 1	rad	Variables for Gimbal 1 configuration - Angles sent to gimbal as Yaw (0), Pitch (1) and Roll (2)
📝2330	Control Loop Period	s	MC control loop period
📝2331	Control Loop Maximum Period	s	MC maximum control loop period
📝2332	Control Loop Duration	s	MC control loop average execution time

ID	Name	Units/ Values	Description
📝2333	MC Control Loop Maximum Duration	s	MC control loop maximum average execution time
📝2334	Control Loop CPU Usage Ratio	%	MC CPU usage ratio
📝2335	MC Control Loop Maximum CPU Usage Ratio	%	MC maximum CPU usage ratio
📝 2336-2338	MC U-V-W Phase Current	A	MC U-V-W phase current
📝2339	MC Electrical Angle	rad	MC electrical angle
📝2340	MC01 Mechanical Angle	rad	MC01 mechanical angle
📝2341	MC Mechanical Angular Speed	rad/s	MC mechanical angular speed
📝2342	MC01 Desired Mechanical Angle	rad	MC01 desired mechanical angle
📝2343		rad/s	

ID	Name	Units/ Values	Description
	MC01 Position Controller Output		MC01 position PDI output
2344	MC Desired Mechanical Angular Speed	rad/s	MC desired mechanical angular speed
2345	MC Desired Mechanical Angular Speed After Speed Limiter	rad/s	MC desired mechanical angular speed after speed limiter
2346	MC Speed Controller Output	A	MC speed controller output
2347-2348	MC Alpha-Beta Current	A	MC alpha and beta current after Clarke transformation
2349-2350	MC Actual Direct Current	A	MC actual direct current
2351	MC Desired Direct Current	A	MC desired direct current
2352	MC Desired Quadrature Current	A	MC desired quadrature current
2353		V	

ID	Name	Units/ Values	Description
	MC Direct Voltage From Controller Output		MC direct voltage from controller output
2354	MC Quadrature Voltage From Controller Output	V	MC quadrature voltage from controller output
2355-2356	MC Alpha - Beta Voltage From Current Controller Output	V	MC Alpha - Beta voltage from current controller output
2357-2358	MC01 Desired Clarke Alpha-Beta current	customType	MC01 desired Clarke currents
2359-2361	MC01 U-V-W Phase Space Vector Generator Output	customType	MC01 phase time constants
2362-2364	MC01 U-V-W Phase PWM Duty Cycle	percentage	MC01 U-V-W Phase PWM duty cycle
2365	MC01 Encoder Raw Angle	rad	

ID	Name	Units/ Values	Description
			MC01 encoder raw measured angle
📝2366	MC01 Stepper Output Frequency	Hz	MC01 stepper output frequency
📝2367	MC Mechanical Angle Error	rad	MC mechanical angle error
📝 2368-2370	MC U-V-W Phase BEMF	V	MC U-V-W phase electromechanical force
📝2371	MC Input Current DC side	A	MC input current DC side
📝2372	MC Input Normalized Command Speed	customType	MC input normalized command speed
📝 2373-2374	MC ADC in 0-1	V	System reserved variables
📝2375	MC Logic Board Temperature	K	MC logic board temperature
📝2376		K	MC IGBT filtered temperature

ID	Name	Units/ Values	Description
	MC Power Module Temperature		
2377	MC Motor Temperature	K	MC Motor temperature
2378	MC Input Voltage DC side	V	MC DC bus voltage
2379-2380	MC U-V Phase Hall current sensor	customType	System reserved variables
2381	MC Virtual and estimator angle difference	rad	MC Angle offset value from estimated and commanded angle to close control loop
2382	MC Low speed estimator angle	rad	MC Low speed observer estimated angle
2383	MC High speed estimator angle	rad	MC High speed observer estimated angle
2384	MC Low speed estimator speed	rad/s	MC Low speed observer

ID	Name	Units/ Values	Description
			estimated mechanical speed
2385	MC High speed estimator speed	rad/s	MC High speed observer estimated mechanical speed
📝 2400-2419	Control Output u0-19	customType	Control output 0 to 19 after servo saturation
📝 2500-2519	Stick Input u0-u19	customType	Intermediate values from stick used for arcade mode
📝 2600-2619	Stick Input d0-d19	customType	Intermediate values from stick used for arcade mode - delta values
2700-2739	Operation Guidance 00-39	customType	Configurable values used in different guidances - Position or values or vectors
2800	Wind Velocity North	m/s	Wind velocity vector pointing North direction

ID	Name	Units/ Values	Description
			(NED Coordinate system)
2801	Wind Velocity East	m/s	Wind velocity vector pointing East direction (NED Coordinate system)
2802	Wind Velocity Down	m/s	Wind velocity vector pointing Down direction (NED Coordinate system)
2803	Wind Velocity North Estimation Covariance	m/s	Wind velocity vector pointing North direction (NED Coordinate system) estimation covariance
2804	Cross North-East Wind Velocity Estimation Covariance	m/s	Wind velocity vector pointing cross North-East direction (NED Coordinate system) estimation covariance
2805	Wind Velocity Estimation	m/s	2-0 element from covariance matrix

ID	Name	Units/ Values	Description
	Uncertainty (Element 2-0)		in wind estimation
2806	Wind Velocity Estimation Uncertainty (Element 0-1)	m/s	0-1 element from covariance matrix in wind estimation
2807	Wind Velocity Estimation Uncertainty (Element 1-1)	m/s	1-1 element from covariance matrix in wind estimation
2808	Wind Velocity Estimation Uncertainty (Element 2-1)	m/s	2-1 element from covariance matrix in wind estimation
2809	Wind Velocity Estimation Uncertainty (Element 0-2)	m/s	0-2 element from covariance matrix in wind estimation
2810	Wind Velocity Estimation Uncertainty (Element 1-2)	m/s	1-2 element from covariance matrix in wind estimation
2811	Wind Velocity Estimation Uncertainty (Element 2-2)	m/s	2-2 element from covariance matrix in wind estimation
2812		degree	

ID	Name	Units/ Values	Description
	Wind Azimuth Angle		Wind estimated azimuth
2813	Wind Velocity in North-East plane	m/s	Horizontal wind velocity
2813	Wind Velocity in North-East plane	m/s	Horizontal wind velocity
2830-2893	Setup real 00-63	customType	Setup variable 00-63
2900	MSL Right from Actual QNH and Pressure Measurement	m	Mean Sea Level obtained from Actual QNH and current Pressure Measurement
2901	MSL for ISA and Pressure Measurement	m	Mean Sea Level calculated for ISO International Standard Atmosphere and Pressure Measurement
2902	Time Since Entering Current Phase	s	Time-lapse considered since entering the current phase
2903	GNC Timestep	s	

ID	Name	Units/ Values	Description
			Task execution period from GNC
2904	Total Flight Time	s	Time-lapse since the vehicle finished Standby **Warning** **Deprecated variable**
2905	Total Flight Distance	m	Distance covered by the vehicle in all mission length **Warning** **Deprecated variable**
2906	Reception Frequency of Simulated Navigation Data	Hz	Frequency at which the system receives Simulation Navigation Data
2907	Reception Frequency of External Navigation Data	Hz	Frequency at which the system receives External Navigation Data
2908-2927		s	

ID	Name	Units/ Values	Description
	Time in Phase 0-19		Time-lapse spent by the vehicle in phase 0 to 19
3000-3031	Simulation Variable 0-31	customType	Variables used for Simulation data
3100-3399	User Variable 00-299 (Real - 32 Bits)	customType	Free variables for the user to use
4100	Zero	customType	Constant value 0
4101	Rvar Disabled	customType	Disabled variable

Integer Variables (UVar) - 16 Bits

ID	Name	Description
0	Actuator Mode	Index pointing to the flight mode in use
1	Phase Identifier	Index pointing to the active phase
2	Internal ADC 0	Internal ADC pin **Warning** **Variable for internal use**
3-7	ADC 0-4	

ID	Name	Description
		Direct reading of ADC pins
8-18	Internal ADC 1-11	Internal ADC pin **Warning** **Variable for internal use**
19	Current envelope (deprecated)	Index pointing to the used envelope **Warning** **Deprecated variable**
20	Counter for C2 system	C2 counter to monitor if Core 2 is alive
21	Total memory for blocks allocation (low part)	Total words available for blocks (low part). It is stored in two parts because the size can be a number up to 32 bits, but the uvars are stored in variables of 16, so to get the true size the user would have to put

ID	Name	Description
		together both the low and the high part. **Note** 1 word = 2 bytes
22	Total memory for blocks allocation (high part)	Total words available for blocks (high part). It is stored in two parts because the size can be a number up to 32 bits, but the uvars are stored in variables of 16, so to get the true size the user would have to put together both the low and the high part. **Note** 1 word = 2 bytes
23	Memory used for blocks	Words used for blocks in allocator (low part).

ID	Name	Description
	allocation (low part)	It is stored in two parts because the size can be a number up to 32 bits, but the uvars are stored in variables of 16, so to get the true size the user would have to put together both the low and the high part. **Note** 1 word = 2 bytes
24	Memory used for blocks allocation (high part)	Words used for blocks in allocator (high part). It is stored in two parts because the size can be a number up to 32 bits, but the uvars are stored in variables of 16, so to get the true size the user would have to put together both the low and the high

ID	Name	Description
		part. **Note** 1 word = 2 bytes
25	SRTM source at UAV's position	Index for the SRTM source type: • 0: Processing • 1: Invalid • 2: 90-meter resolution in equator • 3: 30-meter resolution in equator
50	PDI error source	Index for PDI error source identification. For further information, consult the **List of PDI errors**
51	Operation error source	Index for operation error source identification
53	4XV Veronte ID	ID of this AP in a redundant (0-3) to compare with the

ID	Name	Description
		selected CAP. For more information, check **Integer Variables - 4x Software Manual**
54	4XV Veronte CAP	Current Autopilot 1x selected. For more information, check **Integer Variables - 4x Software Manual**
55-75	4xV Integer variables	For more information, check **Integer Variables - 4x Software Manual**
80	Detour calculation identifier	Counter of number of times a route change has been calculated
81	Approach calculation identifier	Counter of number of times Approach guidance has been calculated
82	Climb calculation identifier	Counter of number of times Climb

ID	Name	Description
		guidance has been calculated
83	Cruise calculation identifier	Counter of number of times Cruise guidance has been calculated
84	Rendezvous calculation identifier	Counter of number of times Rendezvous guidance has been calculated
85	Taxi calculation identifier	Counter of number of times Taxi guidance has been calculated
86	VTOL calculation identifier	Counter of number of times VTOL guidance has been calculated
90	Version Major	Major software version
91	Version Minor	Minor software version
92	Version Revision	Revision software version
95	UAV address	UAV address

ID	Name	Description
96	File system status	State error for DFS2 FS For further information, consult the **List of File system errors**
97	Number of registered partitions on DFS2 File System	Number of registered partitions on DFS2 File System
100	GNSS1 Number of Satellites Used in Solution	Number of satellites used in solution
101-102	GNSS1 rejected-accepted RTCM 1005	Number of RTCM rejected by wrong CRC - correctly received by Ublox 1005
103-104	GNSS1 rejected-accepted RTCM 1077	Number of RTCM rejected by wrong CRC - correctly received by Ublox 1077
105-106	GNSS1 rejected-accepted RTCM 1087	Number of RTCM rejected by wrong CRC - correctly

ID	Name	Description
		received by Ublox 1087
107-108	GNSS1 rejected-accepted RTCM 1127	Number of RTCM rejected by wrong CRC - correctly received by Ublox 1127
109-110	GNSS1 rejected-accepted RTCM 1230	Number of RTCM rejected by wrong CRC - correctly received by Ublox 1230
111-112	GNSS1 rejected-accepted RTCM 4072	Number of RTCM rejected by wrong CRC - correctly received by Ublox 4072
113	GNSS1 rejected RTCM unknown type	Number of RTCM unknown rejected by wrong CRC
114	GNSS1 week	GNSS1 week
115	GNSS1 Jamming Status	Output from GPS 1 jamming/ interference monitor:

ID	Name	Description
		• 0 = unknown or feature disabled • 1 = ok ⇒ no significant jamming • 2 = warning ⇒ interference visible but fix Ok • 3 = critical ⇒ interference visible and no fix
150	GNSS2 Number of Satellites Used in Solution	Number of Satellites Used in Solution
151-152	GNSS2 rejected-accepted RTCM 1005	Number of RTCM rejected by wrong CRC - correctly received by Ublox 1005
153-154	GNSS2 rejected-accepted RTCM 1077	Number of RTCM rejected by wrong CRC - correctly received by Ublox 1077
155-156	GNSS2 rejected-	Number of RTCM rejected by wrong

ID	Name	Description
	accepted RTCM 1087	CRC - correctly received by Ublox 1087
157-158	GNSS2 rejected-accepted RTCM 1127	Number of RTCM rejected by wrong CRC - correctly received by Ublox 1127
159-160	GNSS2 rejected-accepted RTCM 1230	Number of RTCM rejected by wrong CRC - correctly received by Ublox 1230
161-162	GNSS2 rejected-accepted RTCM 4072	Number of RTCM rejected by wrong CRC - correctly received by Ublox 4072
163	GNSS2 rejected RTCM unknown type	Number of RTCM unknown rejected by wrong CRC
164	GNSS2 week	GNSS2 week
165	GNSS2 Jamming Status	Output from GPS 2 jamming/ interference monitor:

ID	Name	Description
		• 0 = unknown or feature disabled • 1 = ok ⇒ no significant jamming • 2 = warning ⇒ interference visible but fix Ok • 3 = critical ⇒ interference visible and no fix
200	Radar Altimeter State	Index for the radar altimeter state
201	Current Section	ID of current patch being executed by the autopilot
202	Last Achieved Section	ID of last patch completed by the autopilot
203	Track Stage	Index of type of tracked route:

ID	Name	Description
		• 0: No route • 1: Route from mission • 2: Commanded route
204	Current patchset ID	Index showing the patchset: • 0: Approach • 1: Climb • 2: Route • 3: Taxi • 4: VTOL • 5: Rendezvous • 6: Detour
205	Amount of laps done	Number of laps completed on the route
310-311	Iridium sent-received	Number of packets successfully sent/ received
398	VectorNav Mode	Index showing external source VectorNav mode
399	Identifier of max duration step in acquisition	Identifier of maximum duration step in CIO

ID	Name	Description
		Warning **Variable for internal use**
400	Internest raw status	Internest raw status
401	Navigation source	Index pointing to the primary navigation source: • 1: Internal navigation • 2: Simulated navigation (IRX source) • 3: External navigation using VCP • 4: External navigation using dedicated variables • 5: External navigation from Vectornav VN-300
402	Raw position source identifier	GPS identifier selected as main

ID	Name	Description
📝 403	(Deprecated) Selected static pressure sensor	Static pressure sensor selection **Warning** **Deprecated variable**
404	Selected dynamic pressure sensor	Dynamic pressure sensor selection
405	Selected primary accelerometer (deprecated)	Primary accelerometer selection **Warning** **Deprecated variable**
406	Selected primary gyroscope (deprecated)	Primary gyroscope selection **Warning** **Deprecated variable**
📝 409	(Deprecated) Selected magnetometer	Magnetometer selection

ID	Name	Description
		Warning **Deprecated variable**
410	Selected stick priority table	Stick priority table selection
425	Identifier of max duration step in GNC	Step with maximum duration
426	Group of user bits selected for CBIT	Index pointing to the selected **list of safety bits**. This is the group of user bits selected to be computed with system CBIT.
449	Configured system errors that had triggered	Bitarray containing the errors that can trigger the System Error.
450	CAN-A Tx errors	CAN A communication errors in transmission
451	CAN-A Rx errors	CAN A communication errors in reception
452		

ID	Name	Description
	CAN-B Tx errors	CAN B communication errors in transmission
453	CAN-B Rx errors	CAN B communication errors in reception
454-459	CAN to Serial 0-5 frames dropped	Lost messages during CAN to Serial transformations
460-461	First-Last file Periodic log	First-Last file of the periodic log
462-463	First-Last file Event log	First-Last file of the event log
464-465	First-Last file Fast log	First-Last file of the fast log
480-485	COM0-5 packet discarded	Discarded packets at COM 0 to 5
490	Number of moving obstacles detected	Number of moving obstacles detected
491-492	Veronte static cfg CRC(no Operation) of	Veronte static cfg CRC (no Op.) of files

ID	Name	Description
	files (Higher-Lower 16 bits)	
493-494	Veronte static cfg CRC(no Operation) of memory (Higher-Lower 16 bits)	Veronte static cfg CRC (no Op.) of memory
495-496	Global configuration state (crc) of files-memory (Higher-Lower 16 bits)	Global configuration state (crc) of files and memory
497	Config manager status (flash / sd / maintenance mode)	Configuration manager status
498-499	Global configuration state (crc) of files-memory	Global configuration state (crc) of files and memory
550-557	Reserved 0-7	System reserved variables for Gimbal
600-615		

ID	Name	Description
	PPM channel 0-15 output	CEX PPM channel outputs
620	Jetibox max successfully parsed message	**Note** **CEX variable**
710	ADS-B OUT - Squawk Code	ADS-B Squawk code, 4 digits that allow the operator to inform about its status. This variable is closely related to the management of communications between transponders and Veronte Autopilot 1x.

ID	Name	Description
		Warning • **Deprecated variable** • If the user modifies this variable, it is not guaranteed that the transponder will continue to function correctly
711	ADS-B OUT - ICAO	ADS-B ICAO, 4 ASCII characters assigned by aircraft authority as an identifier. This variable is closely related to the management of communications between transponders and Veronte Autopilot 1x.

ID	Name	Description
		Warning • **Deprecated variable** • If the user modifies this variable, it is not guaranteed that the transponder will continue to function correctly
712	ADS-B OUT - Ident	Index indicating whether the identification is enabled or disabled. This is the identification of the UAV at the request of ATC. This variable is closely related to the management of communications between transponders and Veronte Autopilot 1x.

ID	Name	Description
		Warning • **Deprecated variable** • If the user modifies this variable, it is not guaranteed that the transponder will continue to function correctly
713	ADS-B OUT - Mode	Index of ADS-B mode: IN, OUT or BOTH. This variable is closely related to the management of communications between transponders and Veronte Autopilot 1x.

ID	Name	Description
		Warning • **Deprecated variable** • If the user modifies this variable, it is not guaranteed that the transponder will continue to function correctly
714-721	ADS-B OUT - Call sign 0-7	ADS-B Call sign, 9 ASCII characters used by the operator to be identified during communication. These variables are closely related to the management of communications between transponders and Veronte Autopilot 1x.

ID	Name	Description
		Warning • **Deprecated variables** • If the user modifies these variables, it is not guaranteed that the transponder will continue to function correctly
730	(Deprecated) Ping1090 - Sequence number	**Warning** **Deprecated variable**
741	(Deprecated) Sagetech MXS - Hemisphere data status	Sagetech variable, used by block to parse variables for GPS Navigation Data Message.

ID	Name	Description
		Warning • **Variable for internal use** (custom message for transponder) • If the user modifies this variable, it is not guaranteed that the transponder will continue to function correctly
742	(Deprecated) Sagetech MXS - Ground track	Sagetech variable, used by block to parse variables for GPS Navigation Data Message.

ID	Name	Description
		Warning • **Variable for internal use** (custom message for transponder) • If the user modifies this variable, it is not guaranteed that the transponder will continue to function correctly
743	(Deprecated) Sagetech MXS - Air speed	Sagetech variable, used by block to parse variables for GPS Navigation Data Message.

ID	Name	Description
		Warning • **Variable for internal use** (custom message for transponder) • If the user modifies this variable, it is not guaranteed that the transponder will continue to function correctly
750	ADS-B Out / ICAO High	ADS-B ICAO, 4 ASCII characters assigned by aircraft authority as an identifier. This variable is closely related to the management of communications between transponders and Veronte Autopilot 1x.

ID	Name	Description
		Warning • **Variable for internal use** (custom message for transponder) • If the user modifies this variable, it is not guaranteed that the transponder will continue to function correctly
751	ADS-B Out / ICAO Low	ADS-B ICAO, 4 ASCII characters assigned by aircraft authority as an identifier. This variable is closely related to the management of communications between transponders and Veronte Autopilot 1x.

ID	Name	Description
		Warning • **Variable for internal use** (custom message for transponder) • If the user modifies this variable, it is not guaranteed that the transponder will continue to function correctly
752	ADS-B Out / Emitter Type	Type/category of ADS-B emitter. This variable is closely related to the management of communications between transponders and Veronte Autopilot 1x.

ID	Name	Description
		Warning • **Variable for internal use** (custom message for transponder) • If the user modifies this variable, it is not guaranteed that the transponder will continue to function correctly
753-760	ADS-B Out / Call Sign 0-7	ADS-B Call sign, 9 ASCII characters used by operator to be identified during communication. This variable is closely related to the management of communications between transponders and Veronte Autopilot 1x.

ID	Name	Description
		Warning • **Variabled for internal use** (custom message for transponder) • If the user modifies these variables, it is not guaranteed that the transponder will continue to function correctly
761	ADS-B Out / Type	Model of ADS-B transponder. This variable is closely related to the management of communications between transponders and Veronte Autopilot 1x.

ID	Name	Description
		Warning • **Variable for internal use** (custom message for transponder) • If the user modifies this variable, it is not guaranteed that the transponder will continue to function correctly
762	ADS-B Out / Control	Index of ADS-B control: OFF, ADS-B IN, ADS-B OUT or BOTH (ADS-B IN and OUT). This variable is closely related to the management of communications between transponders and Veronte Autopilot 1x.

ID	Name	Description
		Warning • **Variable for internal use** (custom message for transponder) • If the user modifies this variable, it is not guaranteed that the transponder will continue to function correctly
763	ADS-B Out / Squawk	ADS-B Squawk code, 4 digits that allow the operator to inform about its status. This variable is closely related to the management of communications between transponders and Veronte Autopilot 1x.

ID	Name	Description
		Warning • **Variable for internal use** (custom message for transponder) • If the user modifies this variable, it is not guaranteed that the transponder will continue to function correctly
764	ADS-B Out / Ident	Index indicating whether the identification is enabled or disabled. This is the identification of the UAV at the request of ATC. This variable is closely related to the management of communications between transponders and

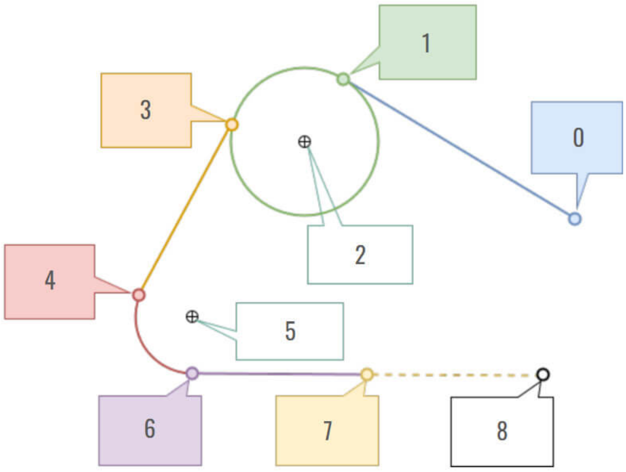
ID	Name	Description
		Veronte Autopilot 1x. **Warning** • **Variable for internal use** (custom message for transponder) • If the user modifies this variable, it is not guaranteed that the transponder will continue to function correctly
765	ADS-B Out / Custom	Variable for internal use for ADS-B Out. This variable is closely related to the management of communications between transponders and Veronte Autopilot 1x.

ID	Name	Description
		Warning • **Variable for internal use** (custom message for transponder) • If the user modifies this variable, it is not guaranteed that the transponder will continue to function correctly
800	MC Fault Id	Index of the MC error **Warning** **Deprecated variable**
801	MC Input Control Mode	Index of the MC control input mode:

ID	Name	Description
		• 1: PPM • 2: CAN • 3: both modes active (CAN priority)
802	MC Actual Control Machine State	State of motor controller: • 0: Motor stop and driver disabled • 1: Calibration of ADC reading • 2: Initial alignment procedure • 3: Open loop procedure • 4: Speed mode
📝 900-909	Simulation variable 00-09	Variables used for simulation data
📝 1000-1299	User Variable 00-299 (Unsigned Integer - 16 bits)	Free variables for user
2000	Uvar Disabled	Disabled variable
2001	Zero	

ID	Name	Description
		Variable with constant 0 value

Features Variables - 64 Bits



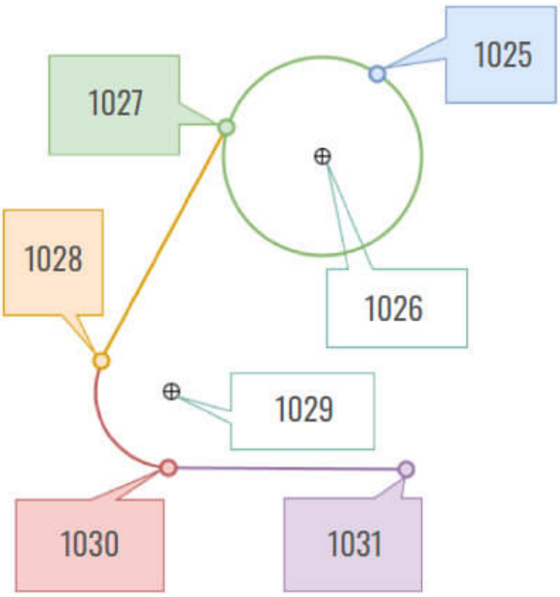
Landing route - Features variables

ID	Name	Form	Units	Description
0	Approach Initial Point	[lon, lat, height]	[rad, rad, m]	Landing Guidance Variable. Point **0** in **Landing capture**.
1	Approach Loiter Start	[lon, lat, height]	[rad, rad, m]	Landing Guidance Variable. Point **1** in **Landing capture**.
2				Landing Guidance

ID	Name	Form	Units	Description
	Approach Loiter Center	[lon, lat, height]	[rad, rad, m]	Variable. Point **2** in **Landing capture**.
3	Approach Loiter Finish	[lon, lat, height]	[rad, rad, m]	Landing Guidance Variable. Point **3** in **Landing capture**.
4	Approach Headturn Start	[lon, lat, height]	[rad, rad, m]	Landing Guidance Variable. Point **4** in **Landing capture**.
5	Approach Headturn Center	[lon, lat, height]	[rad, rad, m]	Landing Guidance Variable. Point **5** in **Landing capture**.
6	Approach Headturn Finish	[lon, lat, height]	[rad, rad, m]	Landing Guidance Variable. Point **6** in **Landing capture**.
7				Landing Guidance

ID	Name	Form	Units	Description
	Approach Touch Point	[lon, lat, height]	[rad, rad, m]	Variable. Point **7** in **Landing capture**.
8	Approach Runway End	[lon, lat, height]	[rad, rad, m]	Landing Guidance Variable. Point **8** in **Landing capture**.

> ⓘ **Note**
>
> For further information regarding Landing guidance, please refer to Landing - Guidance blocks of **Block Programs** section of the **1x PDI Builder** user manual.

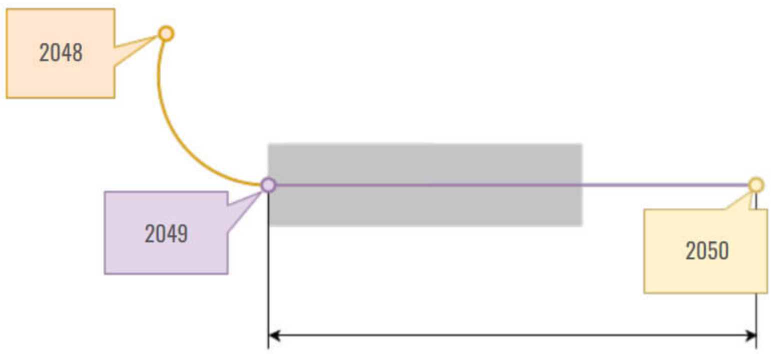


Climbing route - Features variables

ID	Name	Form	Units	Description
1025	Climb First Loiter Point	[lon, lat, height]	[rad, rad, m]	Climbing Guidance Variable. Point **1025** in **Climbing capture**.
1026	Climb Loiter Center	[lon, lat, height]	[rad, rad, m]	Climbing Guidance Variable. Point **1026** in **Climbing capture**.
1027	Climb Start Loiter	[lon, lat, height]	[rad, rad, m]	Climbing Guidance Variable. Point **1027** in **Climbing capture**.
1028	Climb Finish Headturn	[lon, lat, height]	[rad, rad, m]	Climbing Guidance Variable. Point **1028** in **Climbing capture**.
1029	Climb Headturn Center	[lon, lat, height]	[rad, rad, m]	Climbing Guidance Variable. Point **1029** in **Climbing capture**.

ID	Name	Form	Units	Description
1030	Climb Start Headturn	[lon, lat, height]	[rad, rad, m]	Climbing Guidance Variable. Point **1030** in **Climbing capture**.
1031	Climb Initial Point	[lon, lat, height]	[rad, rad, m]	Climbing Guidance Variable. Point **1031** in **Climbing capture**.

> ⓘ **Note**
>
> For further information regarding Climbing guidance, please refer to Climb - Guidance blocks of **Block Programs** section of the **1x PDI Builder** user manual.

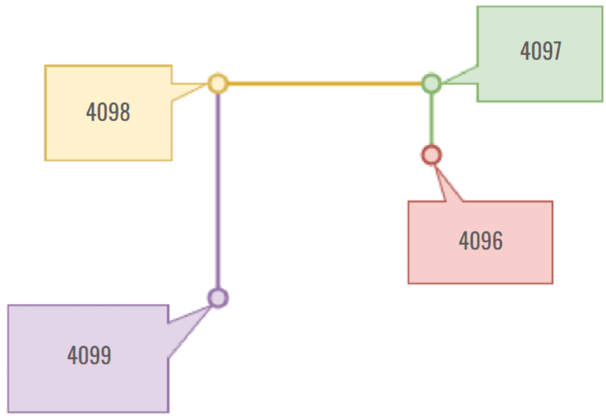


Taxi route - Features variables

ID	Name	Form	Units	Description
2048	Taxi Initial Point	[lon, lat, height]	[rad, rad, m]	Taxi Guidance Variable. Point **2048** in **Taxi capture**.
2049	Taxi Runway First Point	[lon, lat, height]	[rad, rad, m]	Taxi Guidance Variable. Point **2049** in **Taxi capture**.
2050	Taxi Runway Final Point	[lon, lat, height]	[rad, rad, m]	Taxi Guidance Variable. Point **2050** in **Taxi capture**.

Note

For further information regarding Taxi guidance, please refer to Taxi - Guidance blocks of **Block Programs** section of the **1x PDI Builder** user manual.



VTOL route - Features variables

ID	Name	Form	Units	Description
4096	Vtol 00	[lon, lat, height]	[rad, rad, m]	VTOL Initial point. Point **4096** in **VTOL route capture**.
4097	Vtol 01	[lon, lat, height]	[rad, rad, m]	VTOL Translate Start. Point **4097** in **VTOL route capture**.
4098	Vtol 02	[lon, lat, height]	[rad, rad, m]	VTOL Translate End. Point **4098** in **VTOL route capture**.
4099	Vtol 03	[lon, lat, height]	[rad, rad, m]	VTOL End point. Point **4099** in

ID	Name	Form	Units	Description
				VTOL route capture.

> ⓘ **Note**
>
> For further information regarding VTOL guidance, please refer to VTOL - Guidance blocks of **Block Programs** section of the **1x PDI Builder** user manual.

ID	Name	Form	Units	Description
3072 - 3075	Smooth 00 - 03	[lon, lat, height]	[rad, rad, m]	Smooth Feature Variable.
5120 - 5124	Detour 00 - 04	[lon, lat, height]	[rad, rad, m]	Detour Feature Variables.
6144	Runway Loiter	[lon, lat, height]	[rad, rad, m]	Runway Guidance Variable.
6145	Runway Touch Point	[lon, lat, height]	[rad, rad, m]	Runway Guidance Variable.
6146	Runway End Position	[lon, lat, height]	[rad, rad, m]	Runway Guidance Variable.

ID	Name	Form	Units	Description
7168 - 7169	Gimbal Pointing 00 - 01	[lon, lat, height]	[rad, rad, m]	Gimbal Pointing.
8192	UAV position	[lon, lat, height]	[rad, rad, m]	UAV position.
8193	Current phase	[lon, lat, height]	[rad, rad, m]	Current phase.
8194	Desired position	[lon, lat, height]	[rad, rad, m]	Desired position.
8195	Invalid ID attempted	[lon, lat, height]	[rad, rad, m]	Auxiliar feature - Not valid for users.
8196	Track position	[lon, lat, height]	[rad, rad, m]	Closer point in route to the current desired position.
8197	Operator position	[lon, lat, height]	[rad, rad, m]	Operator position.
8198	Start waypoint in current route	[lon, lat, height]	[rad, rad, m]	Start waypoint in current route.
8199				End waypoint in current route.

ID	Name	Form	Units	Description
	End waypoint in current route	[lon, lat, height]	[rad, rad, m]	
9216 - 9235	Phase 00 - 19	[lon, lat, height]	[rad, rad, m]	Phase.
10240 - 10247	Inflight Reference 00 - 07	[lon, lat, height]	[rad, rad, m]	Absolute or relative reference position useful during mission.
11264 - 11327	Obstacle Sensor 00 - 63	[lon, lat, height]	[rad, rad, m]	Obstacle Sensor.
12288	Rendezvous 00	[lon, lat, height]	[rad, rad, m]	Start point. For further information, please refer to **Rendezvous - Guidance blocks** of **Block Programs** section of the **1x PDI Builder** user manual.
12289	Rendezvous 01	[lon, lat, height]	[rad, rad, m]	Rendezvous relative point. For further information, please refer to **Rendezvous - Guidance blocks** of **Block Programs** section of the **1x PDI Builder** user manual.

ID	Name	Form	Units	Description
12290	Rendezvous 02	[lon, lat, height]	[rad, rad, m]	Docking relative point. For further information, please refer to **Rendezvous - Guidance blocks** of **Block Programs** section of the **1x PDI Builder** user manual.
13312 - 13327	Moving Obstacles 00 - 15	[lon, lat, height]	[rad, rad, m]	Moving Obstacle.
14336 - 14353	Fixed runway features 00 - 17	[lon, lat, height]	[rad, rad, m]	1x PDI Builder allows the configuration of up to **6 runways**. Each runway has 3 main points, **Initial point, End point**, and **Loiter Center**, which are repeated every three IDs. E.g. Initial point for Runway 0 is 14336, for Runway 1 is 14339, for Runway 2 is 14342, etc.
15360 - 15371	Fixed spot features 00 - 11	[lon, lat, height]	[rad, rad, m]	1x PDI Builder allows the configuration of up to **6 spots**. Each spot has 2 main

ID	Name	Form	Units	Description
				points, **Spot coordinates** and **Loiter Center**, which are repeated every two IDs. E.g. Spot coordinates for Spot 0 is 15360, for Spot 1 is 15362, for Spot 2 is **15364**, etc.
28672 - 28703	Moving Objects 00 - 31	[lon, lat, height]	[rad, rad, m]	Moving Objects.

Navigation Variables

The following variables of the **Autopilot 1x** take part in the **navigation** performance.

- **Bit Variables**

ID	Name
101	**No valid SRTM at UAV position**
114	**No valid Geoid at UAV position**

- **Real variables**:

ID	Name
0	**IAS (Indicated Airspeed)**
1	**TAS (True Airspeed)**
2	**GS (Ground Speed)**
3	**Heading**
4	**Flight Path Angle**
5	**Bank**
6	**Yaw**
7	**Pitch**
8	**Roll**

- **Integer variables**:

ID	Name
25	**SRTM source at UAV's position**

- **Feature variables**:

ID	Name
8192	**UAV position**

List of PDI Errors

The following table explains the list of possible errors from Veronte applications.

> **Note**
>
> The decimal value of the PDI Error Source (UVar 50) represents the PDI error ID listed in the following table.

Code	Nº	Explanation
pdi_ok	0	No errors detected
pdi_gpio	1	GPIOs function configuration
pdi_odt_pool_sz	2	Incorrect pool size in on-demand telemetry
pdi_telemetry_alloc	3	Could not allocate new telemetry vector
pdi_channelmgr	10	Channel manager configuration
pdi_sara	15	SARA sim type oor
pdi_vblk_sensrtm	16	Block for SRTM sensor
pdi_arcx	23	Arcade axis set of options
pdi_msg8_consumer_hi	24	Custom message consumer cannot be used in HI unless it is an external sensor
pdi_modes	27	Stick configuration modes
pdi_blkekfstp	41	Static pressure to EKF adapter block

Code	Nº	Explanation
pdi_gnss_blocks	45	GNSS constellations configuration (more than allowed)
pdi_cansuite_gpio	47	CAN suite gpio
pdi_vrng	48	Range sensors
pdi_fmset	50	Custom message set
pdi_pwm	54	PWM configuration
pdi_sniffer	63	Sniffer wires configuration
pdi_sniffer_read_only	64	Read-only variable selected in sniffer
pdi_fmsgc_read_only	65	Read-only variable selected in serial message consumer
pdi_canmsgc_read_only	66	Read-only variable selected in CAN message consumer
pdi_vref_read_only	67	Read-only vref variable
pdi_obstacle	68	Incorrect type of obstacle
pdi_obsense	69	Obstacle sensing mode or type oor
pdi_marks	71	Incorrect type of mark
pdi_fmsg_p	74	Custom message producers msg id oor
pdi_fmsg_c	75	

Code	Nº	Explanation
		Custom message consumers process parser oor
pdi_fmsgcan_c	76	CAN custom msg consumer msg id oor
pdi_telem	77	Telemetry configuration
pdi_sci	81	SCI config error
pdi_events	82	Invalid event
pdi_actions	83	Actmgr - List of actions
pdi_evact	84	Actmgr - List of related events and actions
pdi_cmd_not_allowed	85	Commands not allowed
pdi_wrapper	86	Wrapper range configuration incorrect
pdi_xpc_can_in	87	XPC for CAN messages input filters size ok
pdi_xpc_can_out	88	XPC for CAN messages output filters size ok
pdi_xpc_can_ser	89	XPC for CAN messages serialtocan size ok
pdi_xpc_can_gpio	90	XPC for CAN messages virtual gpios size ok
pdi_xpc_can_map	91	

Code	Nº	Explanation
		XPC for CAN messages and check their priority and connections
pdi_xpc_u8_map	92	XPC for u8 messages and check their priority and connections
pdi_internest	93	Internest version in range
pdi_internest1	94	Internest max_range_vbase in range
pdi_internest2	95	Internest max_range_vexplore in range
pdi_ecap	101	Capture
pdi_cappulse	116	ECAP pulse consumers
pdi_i2cdevs	117	I2C external devices
pdi_lossy_resize	120	Lossy resize error
pdi_rvector_resize	121	Rvector resize error
pdi_asciiparser	122	ASCII parser invalid configuration
pdi_telemetry_exceeded	123	Telemetry size exceeded
pdi_hi_3210_rx_tout	154	HI-3210 rx cannot be configured
pdi_hi_3210_tx_tout	155	HI-3210 tx cannot be configured
pdi_cmd_rdvzset	176	Rendezvous command base_yaw oor

Code	Nº	Explanation
pdi_cmd_taxiget	183	Taxi guidance block error. Could be invalid runway or invalid initial point
pdi_cmd_gtrack1	188	Invalid detour command
pdi_cmd_gtrack2	189	Invalid guidance block configuration
pdi_cmd_speed	192	Cruise speed command
pdi_cmd_gtrack	193	Invalid detour command
pdi_cmd_gtrkset	194	Track request command
pdi_cmd_stksrcr	208	Get stick raw channels from selected source
pdi_cmd_vtolset	212	VTOL request command
pdi_ini_nok	213	Cannot change to a phase different from INI with System BIT not OK and out of PDI mode
pdi_cmd_nav	215	Navigation command
pdi_cmd_gpio	218	GPIO command
pdi_cmd_phase	222	Commanded phase is out of range
pdi_cmd_gimbal	225	Gimbal commands
pdi_cmd_var	235	Variable set command
pdi_reset	239	Reset CPU IRX

Code	Nº	Explanation
pdi_acc2filt	257	Bosch IMU BMI088 (IMU2) Accelerometer filter
pdi_imu3_filter	258	ADIS16505 IMU filter not in range [0,6]
pdi_imu3_filter_bw	259	ADIS16505 IMU filter not compatible with Bandwidth limit
pdi_cansuite_in	288	CAN suite producer for Veronte
pdi_cansuite_out	289	CAN suite consumer for Veronte
pdi_cfg_can	290	CAN cfg
pdi_resize_can_cex	291	CEX CAN cfg
pdi_resize_can_commex	292	COMMEX CAN cfg
pdi_jeti_and_lift	293	Trying to configure jeti and lift (not enough memory)
pdi_srtm_calib	500	Tried to calibrate SRTM without valid SRTM data for current point
pdi_jid	501	Invalid feature
pdi_canid	502	Invalid CAN id
pdi_cfgid_mode0	503	Invalid Cfgid PDI (number of PDIs does not match)
pdi_cfgid_mode1	504	Invalid Cfgid PDI mode
pdi_cmd_mgr	505	

Code	Nº	Explanation
		Expected command size does not match
pdi_cmd_mgr1	506	Expected command size does not match
pdi_cancfg	507	Invalid CAN configuration
pdi_decimator	508	Invalid decimator
pdi_sci_cfg	509	Invalid SCI configuration
pdi_field1	510	Maximum ID of real variable exceeded
pdi_field2	511	Maximum ID of user variable exceeded
pdi_field3	512	Maximum ID of bit variable exceeded
pdi_field4	513	Maximum number of decimals for real variable exceeded
pdi_field5	514	Overflow for real variable detected
pdi_field6	515	Incorrect CRC field
pdi_field7	516	Field matcher number of bits outside range
pdi_field8	517	Field maximum skippable bits exceeded
pdi_field9	518	

Code	Nº	Explanation
		Maximum ID of real variable saved as string exceeded
pdi_field10	519	Field type out of range
pdi_flogic	520	Invalid event composition (Flogic)
pdi_flogic1	521	Invalid event composition (Flogic)
pdi_flogic2	522	Invalid event composition type
pdi_fref	523	Invalid type of position reference
pdi_irxtable	524	Invalid 3Dtable mode or vector is non-decreasing
pdi_limit	525	Invalid limit event type
pdi_lsm6ds3_cfg	526	Accelerometer/Gyroscope settings outside range
pdi_pdi_ver	527	Incompatible PDI version, try migrating offline and uploading a complete migrated configuration
pdi_rvarsensor	528	Id for Rvar out of range for Rvarsensor
pdi_stickrawtrans0	529	K value in stick outside range [-100, 100] or 0
pdi_stickrawtrans1	530	

Code	Nº	Explanation
		Maximum value read from stick for Configured range exceeded [4095]
pdi_stickrawtrans2	531	Maximum value read from stick for Raw stick trim exceeded [4095]
pdi_stickrawtrans3	532	Invalid transformation type for stick
pdi_stickcfg3	536	Invalid destination of stick device data
pdi_tllhcompressed	537	Longitude/Latitude outside range [-π,π]/[-0.5π,0.5π]
pdi_tunpatchset0	538	Patch selected as first has not been enabled
pdi_tunpatchset1	539	Patch selected as next has not been enabled
pdi_tunpatchset2	540	Patchtype point has not been enabled
pdi_tunpatchset3	541	Patchtype line has not been enabled
pdi_tunpatchset4	542	Patchtype orthodrome has not been enabled
pdi_tunpatchset5	543	Patchtype arc has not been enabled

Code	Nº	Explanation
pdi_tunpatchset6	544	Patchtype ellipse has not been enabled
pdi_tunpatchset8	546	No patchtype has been enabled
pdi_Ubxcfgnav5	547	Dynmodel out of range or incorrect UTC time
pdi_Ubxcfgnavx5	548	Maximum acceptable AssistNow Autonomous orbit error outside range [5, 1000]
pdi_Ubxcfgport	549	Port (for Ubx?) is neither SPI nor SCI
pdi_Ubxcfgrate	550	Invalid Ublox configuration rate
pdi_Ubxcfgsbas	551	Maximum number of SBAS prioritized tracking channels exceeded [3]
pdi_atunarray0	552	Invalid Tunarray index
pdi_atunarray1	553	Invalid Tunarray size
pdi_Ubxcfgtmode3	554	Error in receiver mode, neither enabled nor disabled
pdi_Uclk	555	Invalid chrono event
pdi_Uvarsensor	556	Id for Uvar out of range for Uvarsensor, or desired frequency too low (<1Hz)
pdi_Uclkmgr	557	

Code	Nº	Explanation
		Maximum number of event user chronos exceeded
pdi_varinit0	558	Maximum array size exceeded on initial values for user variables
pdi_varinit1	559	Initialized variable is unwritable
pdi_vref0	560	Maximum ID of Rvar variable exceeded in Vref
pdi_vref1	561	Maximum ID of Uvar variable exceeded in Vref
pdi_vref2	562	Maximum ID of Bvar variable exceeded in Vref
pdi_vref3	563	Invalid type of variable in Vref
pdi_xclkcfg0	564	Period time non-positive in event
pdi_xclkcfg1	565	Invalid period mode
pdi_xclkcfg2	566	Chrono position direction not correctly normalized
pdi_xclkcfg3	567	Invalid type of chrono
pdi_blk_batch	570	Maximum allowed block nesting depth exceeded [6] or incorrect number of inputs/outputs for block Patch
pdi_blk_ifelse	571	

Code	Nº	Explanation
		Error in the connections for block if/else
pdi_blk_switch	572	Error in the connections for block switch
pdi_blk_switch0	573	Invalid switch/ifelse/phase block configuration
pdi_blkmgr	574	Invalid block manager configuration
pdi_pinmux	576	Invalid switch/ifelse/phase block output configuration
pdi_blk_switchmap	577	Invalid mapping to cases in switch/phase block
pdi_accellimit	579	Envelope’s falling or rising edge is out of accepted limits
pdi_circle	583	Circle radius is less than or equal to 0
pdi_height	584	Height type is neither relative nor absolute
pdi_heightabs	585	Invalid absolute height type
pdi_rwy	586	Invalid runway preferred type
pdi_driver	588	Problem in Driver block configuration
pdi_mwk	592	Gyroscope measurement error

Code	Nº	Explanation
pdi_opinctrl	593	Invalid PID controller input type
pdi_pid	594	Invalid PID integral configuration (tau must be ≥ 0)
pdi_prediction	595	Error in the Model Prediction Control algorithm. Prediction Horizon out of range or zero diagonal matrix R
pdi_sysid	596	Error ID for given pdi check
pdi_tsched	597	Error ID for given pdi check
pdi_dwma	598	Error ID for given pdi check
pdi_iir	599	Error ID for given pdi check
pdi_butterworth	600	Error ID for given pdi check
pdi_usre2	601	Error incorrect user sensor variance
pdi_ubxcfgtp5	603	Ublox time pulse configuration
pdi_cfgmgr_load_secure	604	Error loading secure mode
pdi_cfgmgr_finit	605	Error PDI files
pdi_cfgmgr_timeout	606	Error, timeout while loading PDIs
pdi_invalidrotmat	607	Invalid rotation matrix (cannot be inverted)
pdi_apsel	608	

Code	Nº	Explanation
		Number of autopilots for redundancy less than 3
pdi_vblk_apsel	609	Invalid block AP selection configuration channel exceeds maximum number
pdi_vblk_arcade_bounce	610	Error in the connections for block Arcade Bounce
pdi_vblk_arcade_extend	611	Error in the connections for block Arcade Extend
pdi_vblk_btor	612	Error in the connections for bool to real block
pdi_vblk_bound	613	Error in the connections for block Bound
pdi_rldcfg0	614	Invalid dynamic pressure EKF entrance configuration
pdi_smoothvar	615	Smoother error
pdi_ubx_tout0	616	Could not receive ACKs from UBlox
pdi_ubx_tout1	617	Could not receive polling from Ublox
pdi_ubx_nack	618	A Ublox configuration message was rejected by a Ublox device (GNSS)
pdi_guid_pid	619	

Code	Nº	Explanation
		Invalid type of guidance controller
pdi_cmd_leg	620	Guidance uses an invalid runway or site
pdi_mixarray	622	Error in mixarray construction (possibly there is not enough RAM memory to store all the blocks)
pdi_xrtable	623	Invalid number of entries for XrTable
pdi_blk_varset	624	Block trying to write in an invalid variable, possibly the selected variable is not user writable
pdi_tuntrait	625	Error trying to resize an array out of its maximum size
pdi_asuite	626	Selected dynamic pressure sensor is not valid in this hardware version
pdi_xpcmap	627	Invalid producer/consumer in I/O connections
pdi_blk_arraysplit	628	Invalid block: array of less than 2 elements cannot be split
pdi_blk_array	629	Bundle block error, it must have more than one input and the input sizes must be one

Code	Nº	Explanation
pdi_vblk_varget	630	Invalid ID for block Read Real
pdi_vblk_vec_ops	631	Error in either Vector: Add, Subtract, Cross product, Matrix rotation or Matrix product
pdi_autotune	633	Invalid maximum duration of autotuning process or invalid number of stages for FFT
pdi_vblk_azeld1	634	Error in the connections for block azeld → xyz
pdi_vblk_azeld	635	Error in the connections for block xyz → azeld
pdi_vblk_dot	636	Error in the connections for block Dot Product
pdi_vblk_enctrl	637	Error in the connections for block Energy Control or invalid conversion factor from speed difference to desired acceleration
pdi_vblk_bnxb1	638	Error in the connections for block(s) AND/OR
pdi_vblk_r1xr1	639	Error in the connections for block x or invalid subfunction for the block
pdi_vblk_r2xr1	640	Error in the connections for block x+y or invalid subfunction for the block

Code	Nº	Explanation
pdi_vblk_rnxr1	641	Error in the connections for block(s) Multiply/Add Elements/ Norm or invalid subfunction for the block(s)
pdi_vblk_iir	642	Error in the connections for block IIR Filter or invalid parameters for the transfer function
pdi_vblk_kmultvec	643	Error in the connections for block Scale
pdi_vblk_manual	644	Error in the connections for block Manual or invalid stick control channel
pdi_vblk_minmax	645	Error in the connections for block(s) Min/Max
pdi_vblk_mix	646	Error in the connections for block MIX or invalid mix control channel
pdi_vblk_movern	647	Error in the connections for block MIX Move
pdi_vblk_not	648	Error in the connections for block NOT
pdi_vblk_phase	649	Default case does not exist for block Phase Switch
pdi_vblk_tsched	651	Error in the connections for block T-Sched PID

Code	Nº	Explanation
pdi_vblk_pid	652	Invalid configuration or connection of a PID block
pdi_vblk_poly	653	Error in the connections for block Polynomial
pdi_vblk_posset	654	Error in the connections for block Write Feature or Fid is not user writable
pdi_vblk_predictive	655	Error in the connections for block Predictive Control or number of elements for numerator/denominator unmatched to the expected input size
pdi_vblk_ramp	656	Error in the connections for block Ramp or rise time/settling time less than (or equal to) 0
pdi_vblk_matvec	657	Error in the connections for block Linear Transformation or matrix size unmatched to the expected input size
pdi_vblk_rtable3d	658	Error in the connections for block 3D Table Interpolation
pdi_vblk_rtob	659	Error in the connections for block Real to Bool
pdi_vblk_rtou	660	Error in the connections for block Real to Integer

Code	Nº	Explanation
pdi_vblk_runwrap	661	Error in the connections for block [-π,π] Unwrap
pdi_vblk_utor	662	Error in the connections for block Integer to Real
pdi_vblk_relthis	663	Error in the connections for block Relative Vector
pdi_cancfg1	664	Number of mailboxes dedicated to rx exceeds maximum [32] or the filter applied to mailbox subset exceeds maximum filter id
pdi_stickvar_cfg	665	Decimate time is higher than the minimum period or number of stick virtual inputs exceeds maximum configured for block Virtual stick
pdi_vblk_gimbal	666	Error in the connections for block Gimbal
pdi_vblk_hysteresis	667	Error in the connections for block Hysteresis
pdi_vblk_arctrim	668	Error in the connections for block Arc Trim or control vector unmatched to expected size
pdi_blockprog	669	Incomplete set of LSB bits or with bit holes for execution

Code	Nº	Explanation
		mask or slot is not within the mask
pdi_vblk_n2b	670	Error in the connections for block NED to Body/Body to NED
pdi_vblk_pwm	671	Error in the connections for block PWM or PWM id exceeds maximum
pdi_vblk_stick	672	Error in stick block, connections, dimensions of matrices or stick sources could be wrong
pdi_vblk_u2s	673	Error in actuator block, connections or dimensions of matrices could be wrong
pdi_vblk_interp	674	Error in vector interpolation block, connections or sizes could be wrong, also the points in the table must be sorted in increasing order of x
pdi_vblk_ratelim	678	Error in the connections for block Rate limiter
pdi_vblk_clock	679	Unable to reset the clock timer in block Clock
pdi_vblk_mult_varget	680	Unable to initialize output vector or invalid variable id in block Read Multiple Reals
pdi_vblk_mult_varset	681	

Code	Nº	Explanation
		Error in the connections for block Write Multiple Bits/Write Multiple Reals or input vector different from input variables or variable not user writable
pdi_vblk_pid_static	682	Unable to subscribe autotune in block PID
pdi_vblk_quatctrl	683	Set of configurable variables cannot be 0 or outside their range in block Quaternion Control
pdi_vblk_senstp	685	Error in pressure sensor block, could be that the selected pressure sensor in invalid in the current hardware or that the configured variance is negative or zero
pdi_vblk_sengnss	686	Error for block GNSS sensor
pdi_vblk_ekfpos	687	Error for block EKF position
pdi_vblk_ekfvel	688	Error for block EKF Velocity
pdi_vblk_ekfmis	689	Error for block EKF Misalignment
pdi_vblk_drnmis	690	Error for block EKF GNSS compass
pdi_vblk_senrel	691	Error for block Relative position (Sensors)

Code	Nº	Explanation
pdi_vblk_ekfdem	692	Error for block EKF Terrain Height
pdi_vblk_senmag	693	Error in magnetometer sensor block, the selected might be invalid in your current hardware or the configured variance is negative or zero
pdi_mdg_gain	694	Error for block Madgwick Gain Computer
pdi_vblk_senalt	696	Error for block Altimeter
pdi_vblk_ekfalt	697	Error for block EKF Altitude
pdi_vblk_ekfvdn	698	Error for block EKF Velocity Down
pdi_vblk_nav	699	Error for block Navigation
pdi_e2acc	700	Error for variance increment due to high acceleration
pdi_vblk_ekfsplit	701	Error for block EKF Split
pdi_vblk_fft	703	Error ID for block FFT
pdi_vblk_ecu	705	Error ID for block ECU control
pdi_vblk_fuzzy	706	Error ID for block Fuzzy Logic Controller
pdi_vblk_guidance	707	Input of guidance block could not be connected

Code	Nº	Explanation
pdi_vblk_sysid	709	Error ID for block System Identification
pdi_cex_pwm	710	Error ID for CEX pwm arbitration, src ID greater than pulses array
pdi_cex_esc_tm	711	Error ID for CEX ESC period
pdi_cex_mcu_tm	712	Error ID for CEX MCU period
pdi_vblk_climb	713	Incorrect climb block operation
pdi_vblk_leg	714	Incorrect leg block operation
pdi_flyto	715	Incorrect fly to command (non-existing patch)
pdi_vblk_approach	716	Incorrect approach block operation
pdi_vblk_yawing	717	Incorrect yawing block configuration
pdi_vblk_siggen	718	Incorrect signal generation configuration
pdi_vblk_pnav	719	Incorrect PNAV guidance configuration
pdi_vblk_genex	720	Incorrect GENEX guidance configuration
pdi_vblk_modpnav	721	Incorrect ModPNAV guidance configuration

Code	Nº	Explanation
pdi_blk_lib	722	Incorrect library
pdi_vblk_ewma	723	Incorrect EWMA block configuration
pdi_uarray_resize	724	Incorrect uarray resize
pdi_oprvar	725	Incorrect operation/setup rvar configuration
pdi_block_const	726	Error in block const
pdi_block_posget	727	Error in block posget
pdi_block_pnavbase	728	Error in block pnav base
pdi_block_arcade0	729	Error in block arcade
pdi_unescape	730	Error in escape itport
pdi_initial_alignment	731	The internal AHRS or EKF navigation estimation algorithm could not compute an initial orientation. Try commanding an initial yaw or adding an automation to do so
pdi_fft_block_disable	732	The FFT block is temporarily disabled in this version
pdi_vblk_acclim	733	Error in block acceleration limiter
pdi_ewma_avgvar	734	Error in EWMA average/variance time constants

Code	Nº	Explanation
pdi_sensor_fusion	735	Time constants for sensor fusion algorithm are incorrect
pdi_oprng	736	Error in operation range configuration
pdi_oprng_check	737	Error in operation range check
pdi_vgeoref	738	Error in vgeoref configuration
pdi_notch_filter	739	Incorrect notch filter parameters
pdi_notch_frequency	740	Incorrect notch filter frequency
pdi_geoid_version	741	Incorrect geoid version in SD
pdi_vblk_integrator	742	Error in the connections for block Integrator
pdi_vblk_derivative	743	Error in the connections for block Derivative
pdi_wrapper_ref	744	Incorrect envelope range (minimum must be less or equal than maximum)
pdi_sensor_fusion_sel	745	Selected gyroscopes or accelerometers are invalid in this hardware or the default sensor is not active
pdi_volume_id	746	Incorrect volume identifier
pdi_fload_missing	747	Missing file from file system
pdi_event_log	770	

Code	Nº	Explanation
		Maximum number of fields reached
pdi_onboard_log	771	Maximum number of fields reached
pdi_fast_log	772	Maximum number of fields reached
pdi_arbitration	10000	Error ID for Arbitration cfg
pdi_arbitration_can	10001	Error ID for Arbitration_can cfg
pdi_arbitration_can1	10002	Error ID for Arbitration_can cfg
pdi_arb_cfg0	10003	Error ID for Arb cfg preferred ap oor
pdi_arb_cfg1	10004	Error ID for Arb cfg method oor (out of range)
pdi_arb_cfg2	10005	Error ID for Arb cfg tmin oor
pdi_arb_cfg3	10006	Error ID for Arb cfg hysteresis oor
pdi_ap_nvars	10007	Error ID for Autopilot nvars oor
pdi_apcfg_nvars	10008	Error ID for Autopilot cfg nvars oor
pdi_jetibox	10009	Error ID for sci identifier of Jetibox cfg oor
pdi_jetibox_fmsgcmd	10010	Error ID for jetibox fmsg cmd oor

Code	Nº	Explanation
pdi_arb_init_time	10011	Error ID for Arbiter Power Init Time less than 0
pdi_arb_varcfg	10013	Incorrect arbiter variable configuration
pdi_hs_base_can_id	15000	High speed telemetry invalid Base CAN Id
pdi_hs_tm_nvars	15001	High speed telemetry number of variables too big
pdi_vmc_motor	20000	Motor cfg is not valid
pdi_vmc_control_mode	20001	Control mode is invalid
pdi_vmc_encoder_nbits	20002	Number of bits for encoder is invalid
pdi_mc_vmotor	20003	Virtual motor cfg invalid
pdi_mc_smo	20004	Slide Mode Observer cfg invalid
pdi_mc_control	20005	Control cfg invalid
pdi_mc_fault_detection	20006	Fault detection cfg invalid
pdi_mangle_rate	20007	Invalid filter time constant
pdi_low_pll	20008	Invalid cut-off frequency
pdi_ex_ussa76_cmd	20009	Invalid period to send external USSA76 calibration command
pdi_cfgmr_length	31999	Unexpected size of PDI or command

Code	Nº	Explanation
pdi_cfg_file	32000	Error on PDI or command (subtract 32000 to know the Id)
pdi_check_test	0xFFFF	Error ID for given PDI check.

List of File System Errors

Integer variable File system status (UVar 96) represents several **DFS2 FS-related error states**, as each of its 16 bits indicates a specific error condition.

BIT	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
STATUS		0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1

File system status

Below is a list of potential error conditions associated with each bit:

ID	Error description
0	Index sector is not correct (1 if not correct - 0 if correct)
1	Error initializing SD (1 if not correct - 0 if correct)
2	Nun& partition bigger than allowed (1 if bigger - 0 if not)
3	No more descriptor available (1 if not available - 0 if available)
4	The descriptor of a file was not correct (CRC failed) (1 if fail - 0 if not)
5	The new descriptor couldn't be created (1 if not created - 0 if created)

ID	Error description
6	Error updating the file size (1 if error updating - 0 if no error)
7	Error formatting because of system description size (1 if error formatting - 0 if not)
8	Error formatting driver not initialized (1 if error formatting - 0 if not)
9	Error formatting maximum partition number overpassed (1 if error formatting - 0 if not)
10	Error formatting not able to write index sector (1 if error formatting - 0 if not)
11	Error formatting partition not enabled (1 if error formatting - 0 if not)
12	Error writing the index for the log controller (1 if error formatting - 0 if not)
13	File was destroyed but was not closed or had pending requests (1 if not closed or pending requests - 0 if closed or had no pending requests)
14	Unable to read a sector (1 if unable - 0 if able)

Firmware Changelog

This section presents the changes between firmware versions of Veronte Autopilot 1x.

6.12.58

This section presents the changes between the previous firmware version of Veronte Autopilot 1x, **v.6.8.126**, and this firmware version, **v.6.12.58**.

Improved Flight Functionalities

- Geofencing with any shape
- New variable for distance to the closest obstacle
- Runway and spot positions are now accessible in PID blocks
- Count laps in a given closed patchset
- Signed patch curvature computation

Enhanced Blocks & Customization

- Extended support for external IMUs
- New numerical derivative block
- New integral derivative block
- New vector subtract block
- New vector cross-product block
- New Notch filter for IMUs
- Enhanced acceleration limit block
- Flight envelope moved to cruise guidance block
- Incremented serial over CAN and CAN Input/Output filters

Improved Altitude and Magnetic Field

- Enhanced magnetic field and geoid management onboard
- Geoid and estimated terrain height configuration separated
- Coarse and fine SRTM meshes deleted from PDI

Safety

- Position and velocity EKF adapters are now more robust
- Dedicated file for PDI error storage
- Support for formatting specific partitions on DFS2
- Configurable ranges for real operation variables
- Variable sharing for respect in 4x more robust

6.12.68

This section presents the changes between the previous firmware version of Veronte Autopilot 1x, **v.6.12.58**, and this firmware version, **v.6.12.68**.

Added

- BCS - System OK variable support

Improved

- GNSS Compass feature
- Extended response from System Status Manager
- Sniffer status bits management
- BCS - Optimised control and management of variables

6.12.92

This section presents the changes between the previous firmware version of Veronte Autopilot 1x, **v.6.12.68**, and this firmware version, **v.6.12.92**. For further details, please consult the Service Bulletin nº 0003.

Added

- Veronte SIL for Linux
- New PDI Error: **pdi_wrapper, ID 86**. It is triggered by the "wrapper class" (bounds a real number to the given limits) when the configured minimum limit is greater than the configured maximum limit

Improved

- The first order filter of the external commanded pressure USSA has been removed. The commanded pressure is now already filtered when the desired pressure is injected to the 1x air unit
- External command for atmospheric USSA calibration (from ground to air unit):
    - Now, it is calculated with the mean value of all active static pressure sensors for 5 seconds
    - In order to send the calculated command from the 1x ground unit, it is required to have position fixed and geoid data valid
- To decrease numerical errors in intertial navigation, velocity state in navigation is now double precision
- To avoid instabilities in the Extended Kalman Filter, the minimum variance of the relative position input block has been changed to 10e-4
- DEM calibration now computes an offset for the SRTM data so the estimated AGL equals the desired one for the current point of the UAV
- 8 bits checksum field on Custom Message feature is now applying a mask from the configured number of bits
- Order of application of acceleration and velocity limits in the envelope. Now the acceleration limits have more priority
- Optimisation in the readings of the Geoid, SRTM and magnetic field maps from the Internal Memory so that the number of readings from the Internal Memory is reduced
- Dynamic pressure measurement bounded to be equal or higher than 0 to prevent problems when computing its square root in the IAS computation
- Events are now only checked after the initialization of the sensors is finished. Also, the reading of the GPIO ports have been moved to be done before the execution of the blocks. Both changes prevent the execution of events using uninitialized states from the blocks computation or from the GPIOs
- In the transition from external navigation to internal, the position and velocity states are always kept in the transition. The EKF covariance matrix is initialized in the transition to its configured initial values

- Old static pressure user calibration set to zero, as it cannot be modified by an external tool
- CAN Custom Messages Producer initialization behavior
- GNSS compass: now GNSS position block considers as a rover any Ublox receiver that does not have enabled the RTCM messages 1005 or 4072
- GPIOs initialization in maintenance mode to avoid undesired behavior

6.12.112

This section presents the changes between the previous firmware version of Veronte Autopilot 1x, **v.6.12.92**, and this firmware version, **v.6.12.112**. For further details, please consult the Service Bulletin nº 0005 and Service Bulletin nº 0005 Rev.B.

Added

- PDI errors for maximum number of logs fields reached: pdi_event_log (ID 770), pdi_onboard_log (ID 771) and pdi_fast_log (ID 772).
- SIL example is provided with a new block to simulate VectorNAV navigation messages.

Improved

- Signal splitter behavior. If one of the consumers is not available, the available one will still consume the input signal.
- CPU temperature bit is now true when temperature is below maximum allowed temperature.
- Now the guidance is not restarted by default when changing the autopilot mode from "Manual" to "Auto", or when changing the selected autopilot in a 4x configuration.

> ⚠ **Warning**
>
> To keep the correct behavior, the block configuration should be set so that the guidance block is not executed when the autopilot is in "Manual" mode.
>
> This way, when the autopilot switches to "Auto" mode and the guidance block is executed again, the guidance will be restored as usual.

- RM3100 magnetometer is now being calibrated using the board temperature to interpolate the calibration parameters.
- ADS-B variables are not anymore user-writable.
- Position set and yaw set commands (IDs 201 and 202) are now only accepted if the UAV is in the initial phase.
- High priority thread CPU ratio performance to avoid a different behavior depending on the hardware version.
- DFS2 driver is now committing reliable values onto its BIT.
- Moving grid maps (used for geoid and magnetic field) are no longer reset due to negative increments of the grid position in the longitude direction.
- AGL calibration is now applied when there is no SRTM data available.
- Check for RX custom messages reception is now initialized as "False".
- Small increments in position close to the south pole are now computed properly.
- HIL sensor is now sending only IMU messages at high frequency to reduce CIO workload.
- RPM are now computed properly.
- 1xVeronte address is now also stored in case of a memory formatting error.
- Position and yaw commands are now rejected in PDI mode to avoid generating a System error.
- Serial over CAN can now work simultaneously on both CAN channels with Input/Output filters.
- CAN termination resistors are now set to HIGH by default on hardware versions higher than:
  - Veronte Autopilots: 1x - W/O DAA 4.8 → P006982 - B001037
  - Veronte Autopilots: 1x - Remote ID → P006142 - B001039

  - Veronte Autopilots: 1x - ADS-B → P006143 - B001040
  - Veronte Autopilot BCS 4.8 → P006417 - B001053
  - Veronte Autopilots: 4x - w/o DAA 1.8 → P006984 - B000905
  - Veronte Autopilots: 4x - Remote ID 1.8 → P006146 - B001055
  - Veronte Autopilots: 4x - ADS-B 1.8 → P006147 - B000335

6.12.116

This section presents the changes between the previous firmware version of Veronte Autopilot 1x, **v.6.12.112**, and this firmware version, **v.6.12.116**. For further details, please consult the Service Bulletin nº 0006.

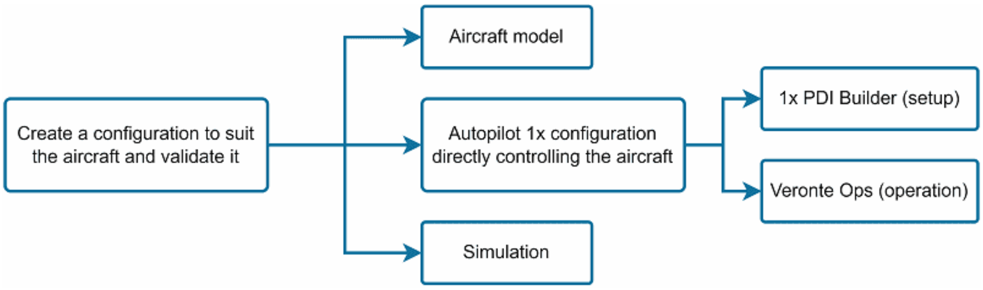
Changed

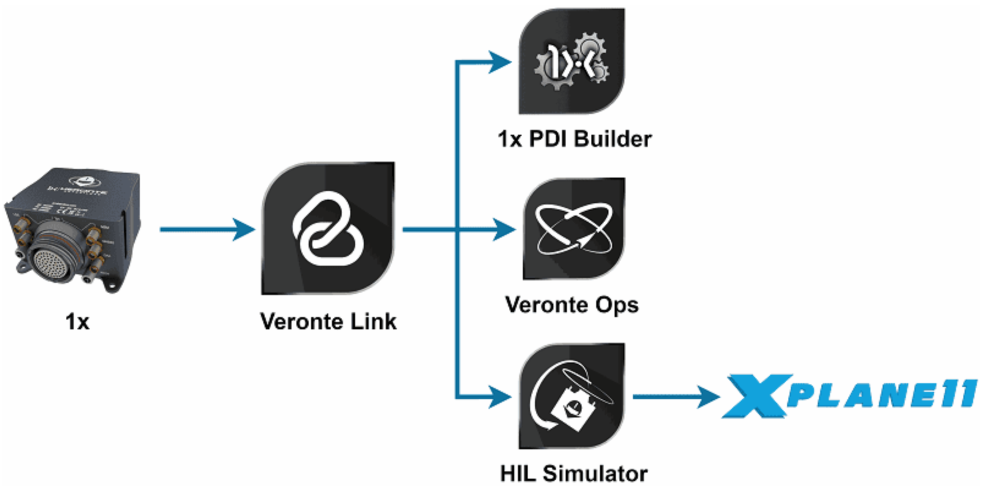
- Now the CAN bus terminal resistors are enabled by default in the AP0 of the 4xVeronte for HW versions higher than or equal to 4.8.

Step by step

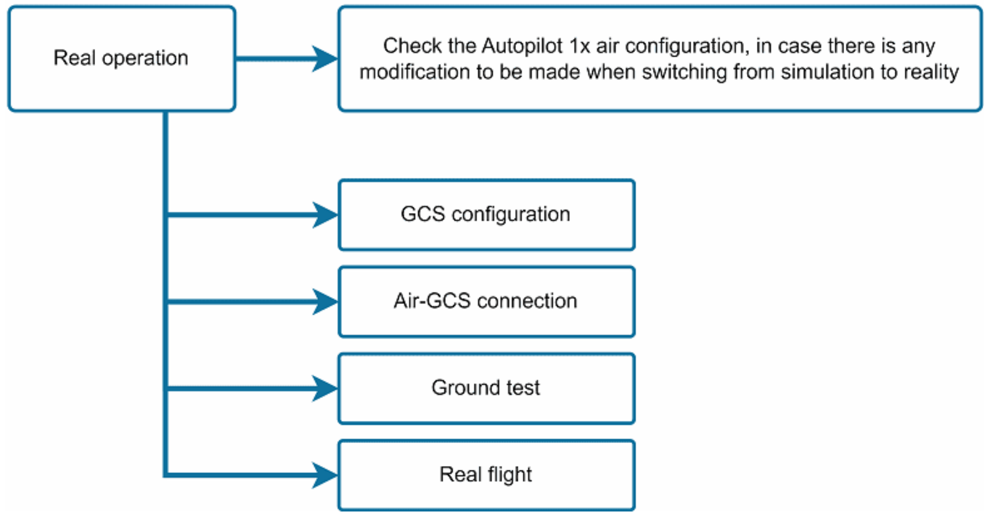
This section explains the main steps to be followed to create a new **PDI configuration** that adapts the Veronte Autopilot 1x performance to the aircraft and mission requirements. The process followed from the creation of a configuration until it is operated in flight with Veronte Autopilot 1x is divided into 2 phases:

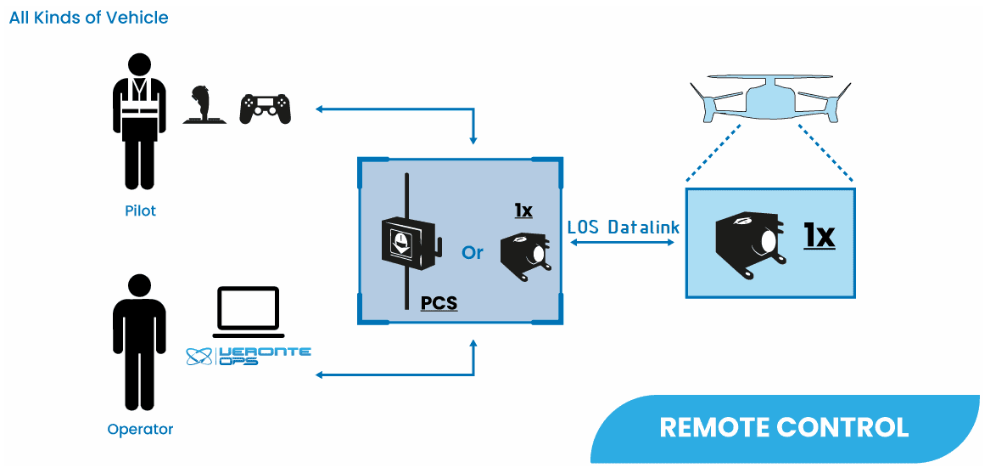
1. **Create a configuration** that suits the expected performance of the aircraft and validate it.



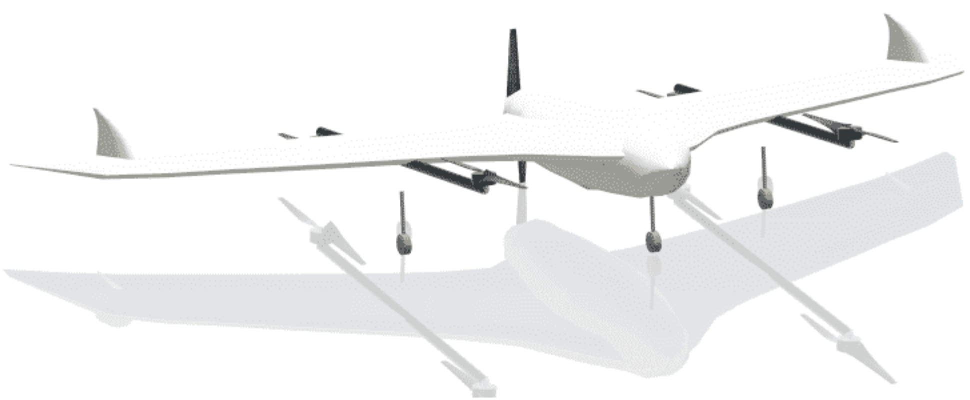


2. **Real operation**





VTOL



Follow the steps described in each one of the following sections to be able to:

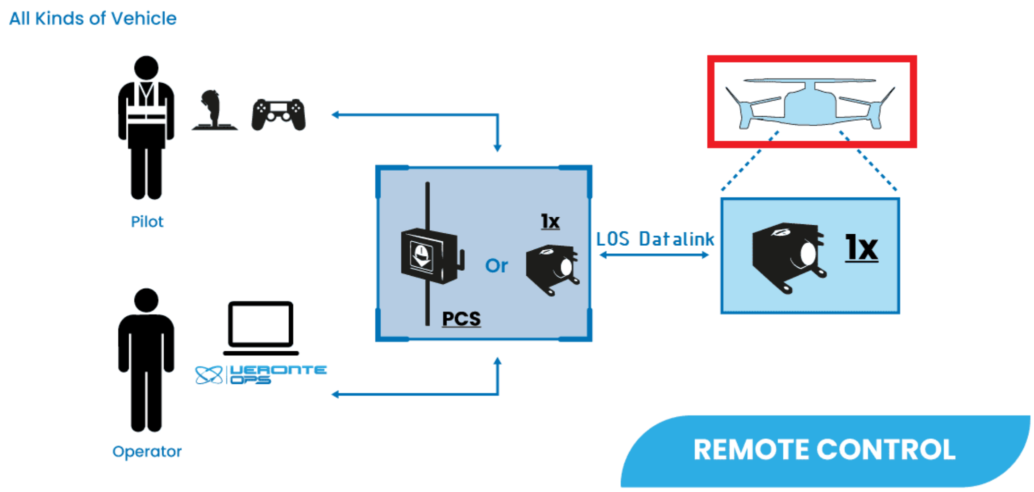
- Adapt a basic Veronte Autopilot 1x configuration to a VTOL aircraft ⇒ 1x Air configuration.

- Perform HIL simulations to validate the aircraft model and configuration ⇒ Simulation.
- Create the Ground Control Station (GCS) configuration that will be part of the standard operation layout ⇒ 1x GCS configuration.
- Establish the communication/connection between both parts of the standard operation layout, the GCS and Autopilot 1x in the VTOL ⇒ Air-GCS connection.
- Ground test to check that all system and electronics work and behave correctly before flight.
- Real operation.

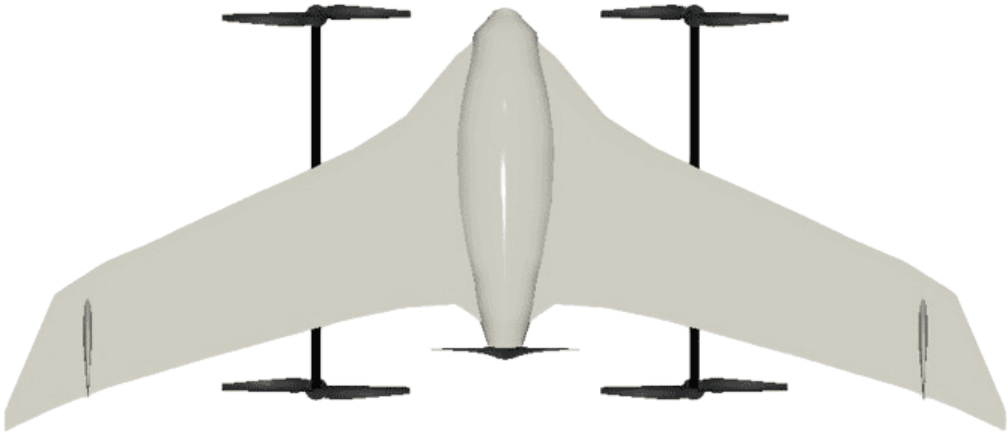
However, first it is necessary to define some aspects of the aircraft model to be taken into account when adjusting the configuration to the expected performance of the aircraft.

Aircraft specifications

This section defines the main geometrical and operational specifications of the Embention VTOL aircraft.

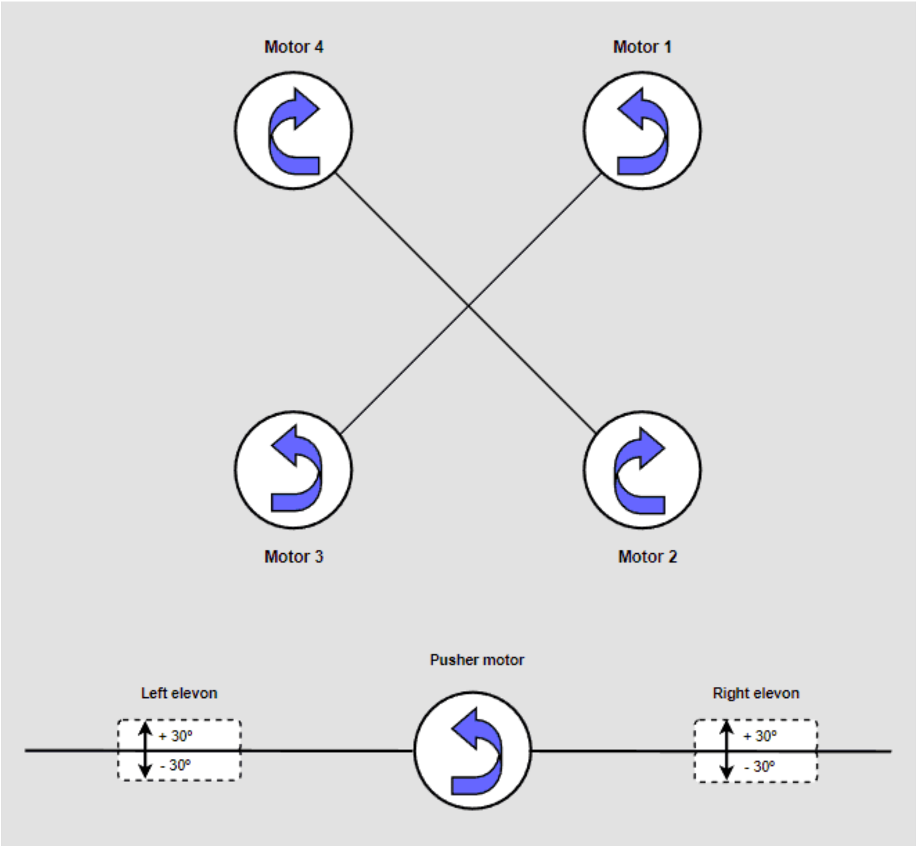


Embention VTOL Aircraft



- **Name**: Embention VTOL aircraft
- **Aircraft type**: VTOL
    - The VTOL is composed of **4 vertical propellers** for quadcopter configuration and **1 pusher motor** for Fixed-Wing (FW) configuration.
    - The frame is a **flying wing** composed of **two elevators and two vertical fins without rudder**.

Explanation



Rotation

Geometric Specifications

Parameter	Value
Weight	4.2 Kg
Longitudinal CG location	0.38 m
Vertical CG location	0.0 m
Max. Deflection Right Elevator	±30º
Max. Deflection Left Elevator	±30º

Airfoil

Component	Specification
Wing	MH60
Vertical fins	NACA 0009

Engine Specifications

Parameter	Value
Number of propellers	5
Rotation propeller 1	CCW
Rotation propeller 2	CW
Rotation propeller 3	CCW
Rotation propeller 4	CW
Rotation propeller 5	CW
Propeller 1-4 (vertical) diameter	15x5.5

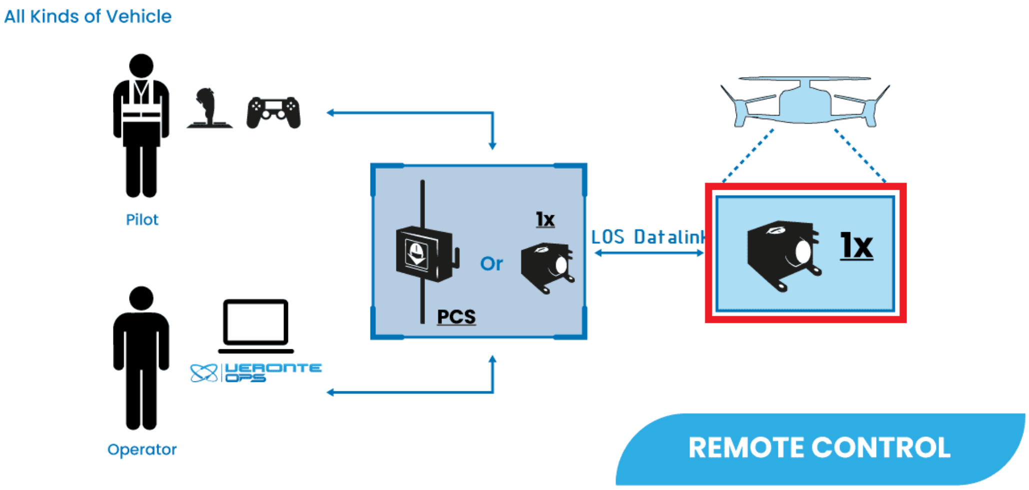
Parameter	Value
Propeller 5 (pusher) diameter	12x6e

Operational Specifications

Parameter	Value
Stall speed (no flaps)	15 m/s
Cruise speed	25 m/s
Maximum speed	30 m/s

1x Air configuration

This section defines the Autopilot 1x configuration that will control the aircraft, i.e., that will be inside the VTOL.



This is divided into 2 parts:

- 1x PDI Builder configuration: The creation of the 1x configuration in the **1x PDI Builder** app.
- Operation: The definition of the operation and mission of the aircraft in **Veronte Ops**.

1x PDI Builder configuration

1x PDI Builder

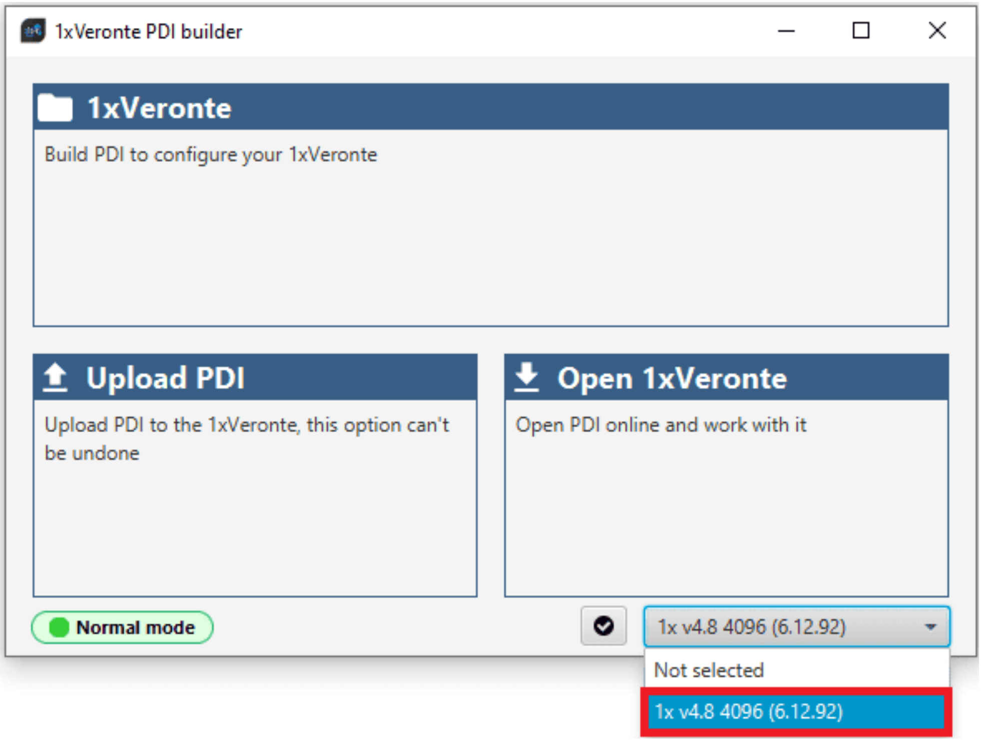
1x PDI Builder is the main configuration tool to adapt a Veronte Autopilot 1x to a specific vehicle, including user-defined communication protocols. 1x PDI Builder allows the user to change the configuration inside the autopilot, create new configurations or work on a configuration offline.

> **Note**
>
> For more information about the installation and use of 1x PDI Builder, visit the 1x PDI Builder user manual.

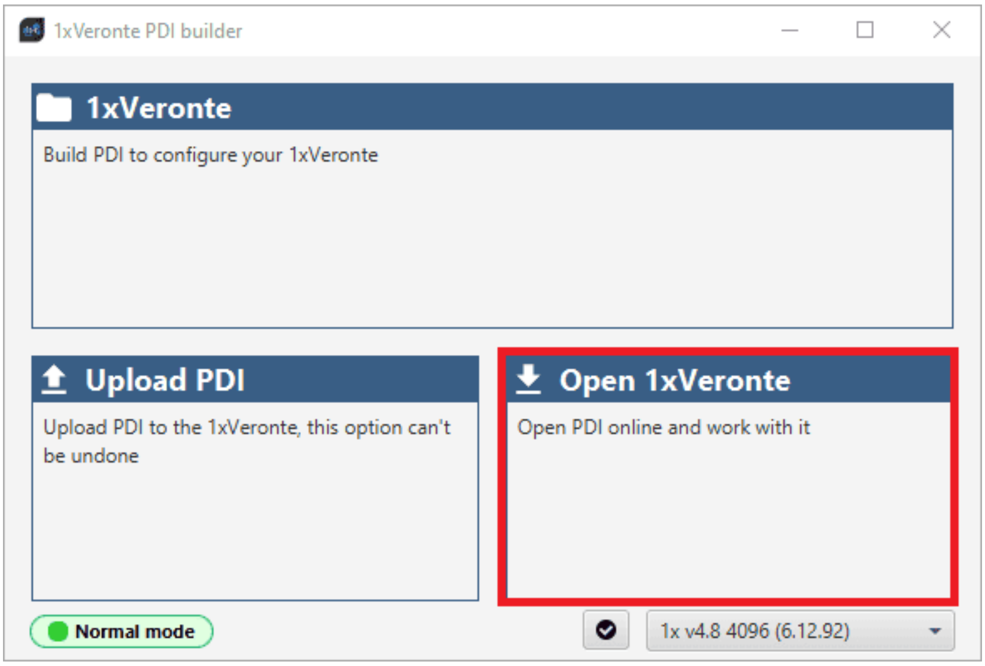
Once the application is installed, the user has two options to configure the autopilot. On the one hand, the user can download one of the templates provided by Embention that best suits his platform, on the other hand, the user can configure the Autopilot 1x from scratch.

> **Tip**
>
> It is highly recommended to follow the first option, which is explained throughout this step-by-step.

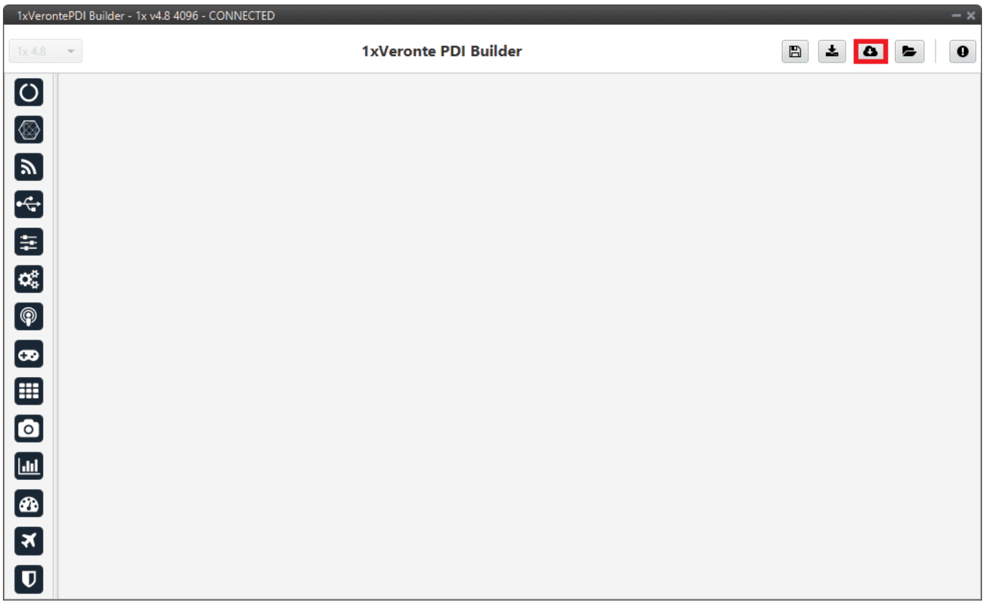
1. Open the 1x PDI Builder application and select the connected Autopilot 1x:



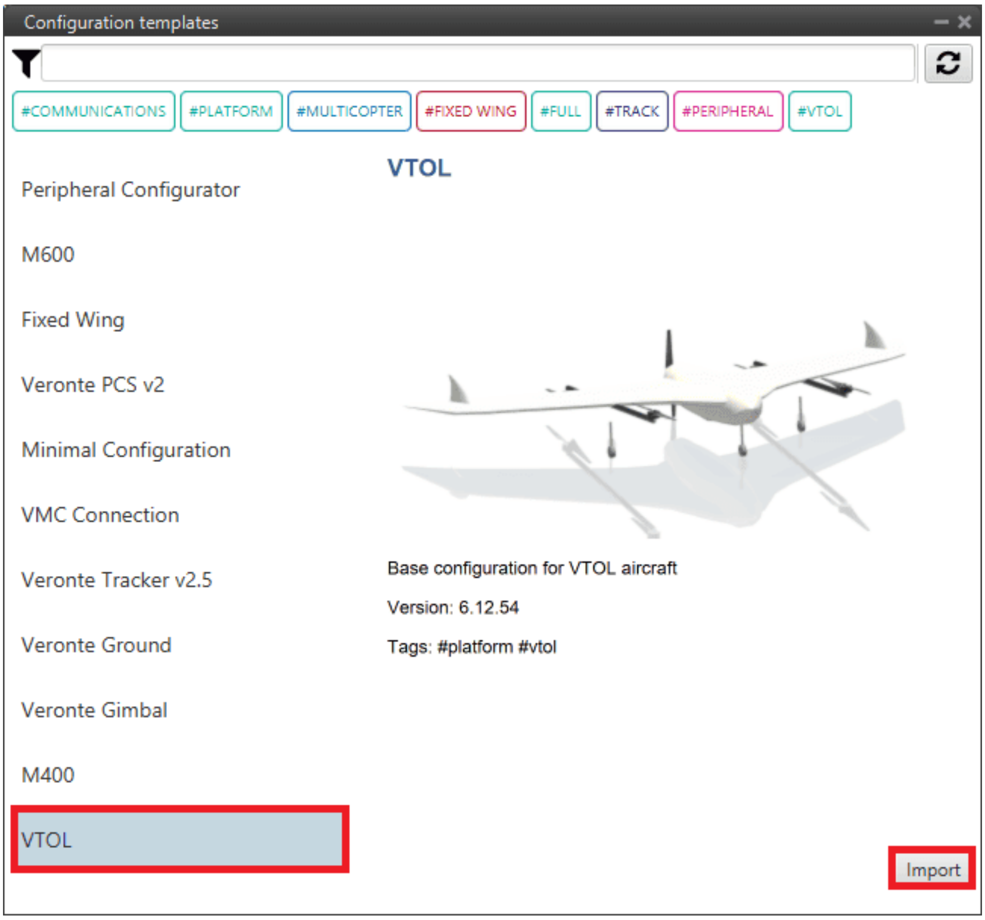
2. Select the **Open 1xVeronte** option to directly edit the configuration loaded in the 1x:



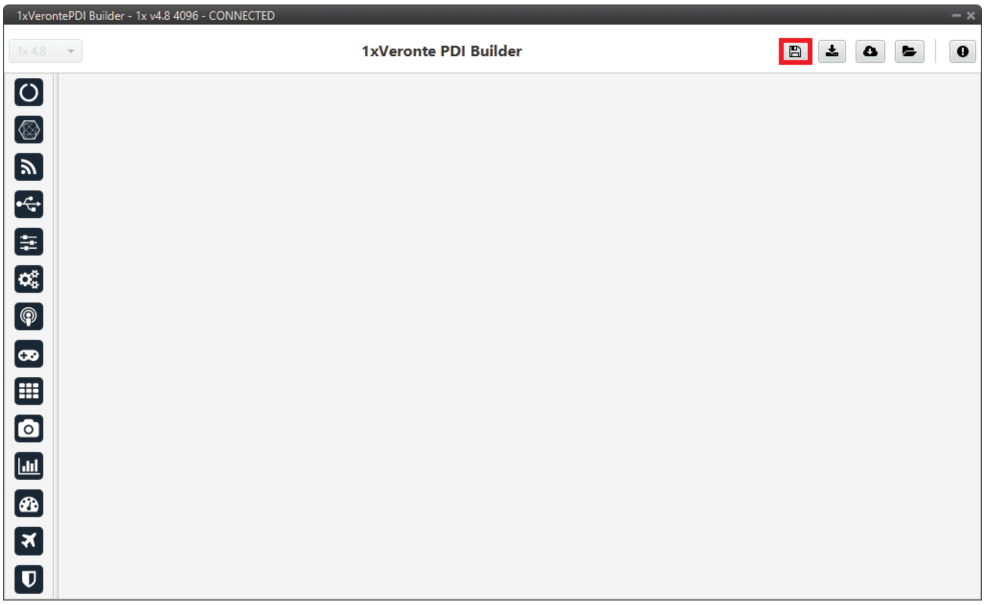
3. Click the **Import PDI from repo** button in the menu bar:



4. Select the **VTOL** template and import it:



5. Finally, click the **Save and close** button to save the downloaded template to the connected Autopilot 1x:



> **Note**
>
> In order to save the configuration, Veronte Autopilot 1x must enter in maintenance mode. Then, after saving any changes, Autopilot 1x will RESET and 1x PDI Builder software will consequently close. For more information, visit the Configuration section of the **1x PDI Builder** user manual.

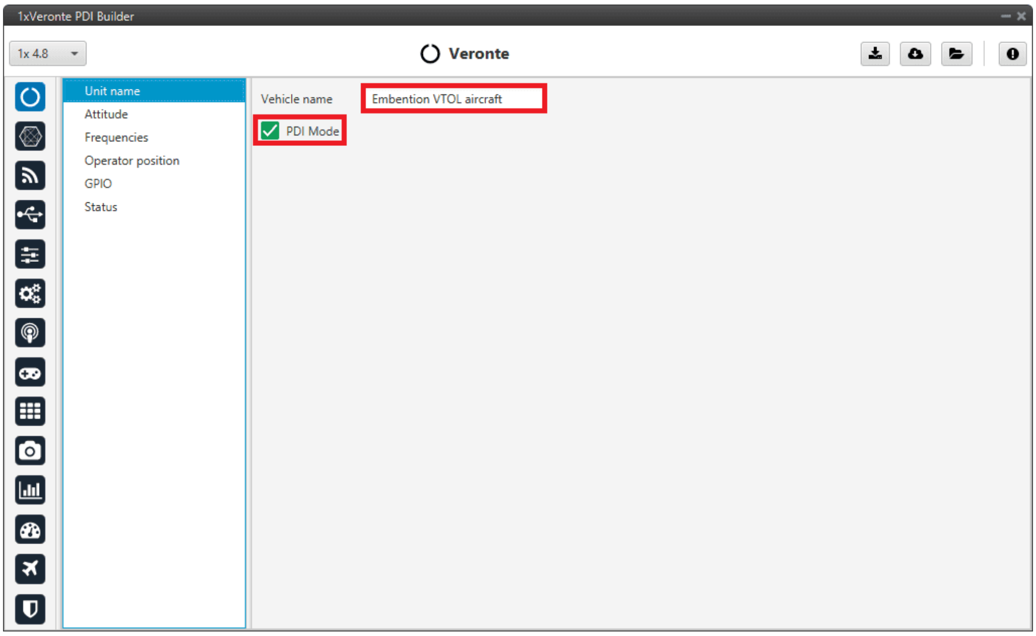
For a basic configuration of the Autopilot 1x, the following parameters must be configured:

- Name & attitude
- Actuators & SU Matrix
- Modes & Phases
- Block Programs
- Automations
- Sensors
- HIL configuration
- Checklist

Name & Attitude

Unit name

To start a configuration, it is necessary to define a name for the configuration and it is recommended to be in **PDI mode** while performing the configuration and simulations.



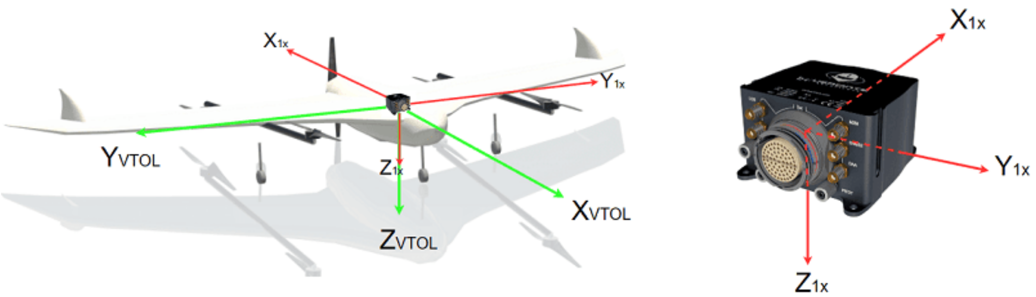
Unit name & PDI mode

> **Danger**
>
> PDI mode is intended for development purposes since it allows flight phase changes with system, sensor and PDI errors.
>
> It is highly recommended to limit its use to simulation and ground testing of peripherals during the development phase.
>
> Therefore, as it is not advisable to operate in PDI mode, please disable it once the configuration is finished and intended to be used in flight.

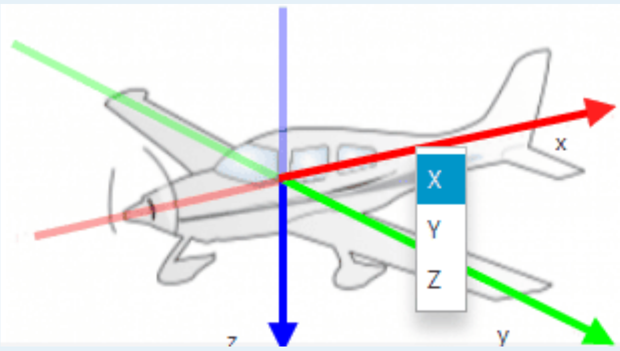
For more information, visit the Unit name - Veronte section of the **1x PDI Builder** user manual.

Attitude

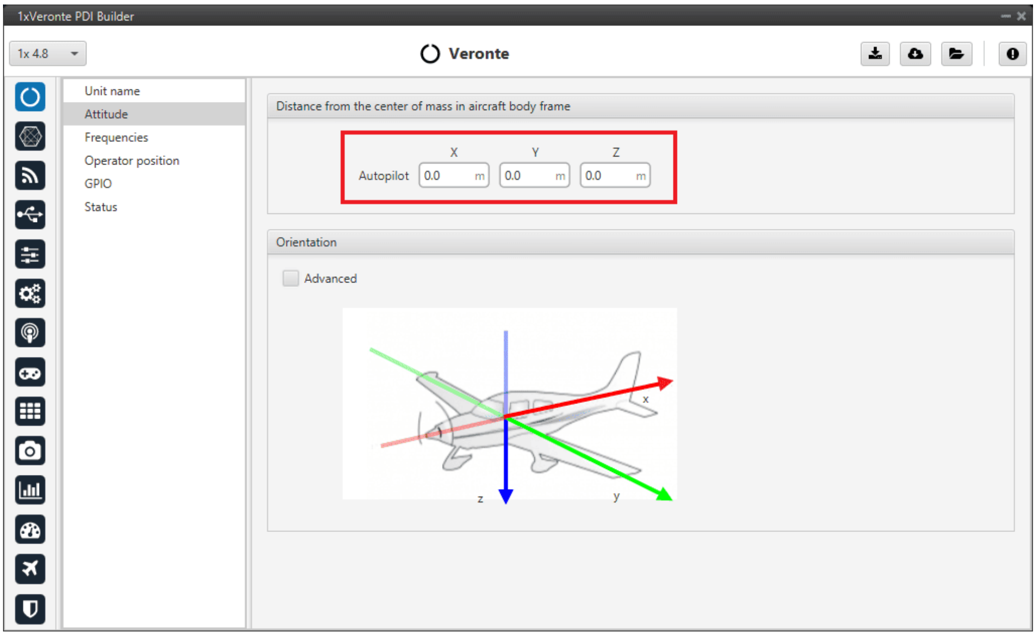
The autopilot orientation corresponds to a rotation of 180º around the Z-axis on the aircraft axes.



Orientation

> ⓘ **Note**
>
> Since it is a simple orientation to define, we can do it directly from the aircraft schematic.
>
> 
>
>
> **Change orientation**

Regarding the center of gravity, Autopilot 1x is located at the center of gravity, so the distance to it is zero.



Embention VTOL aircraft Attitude

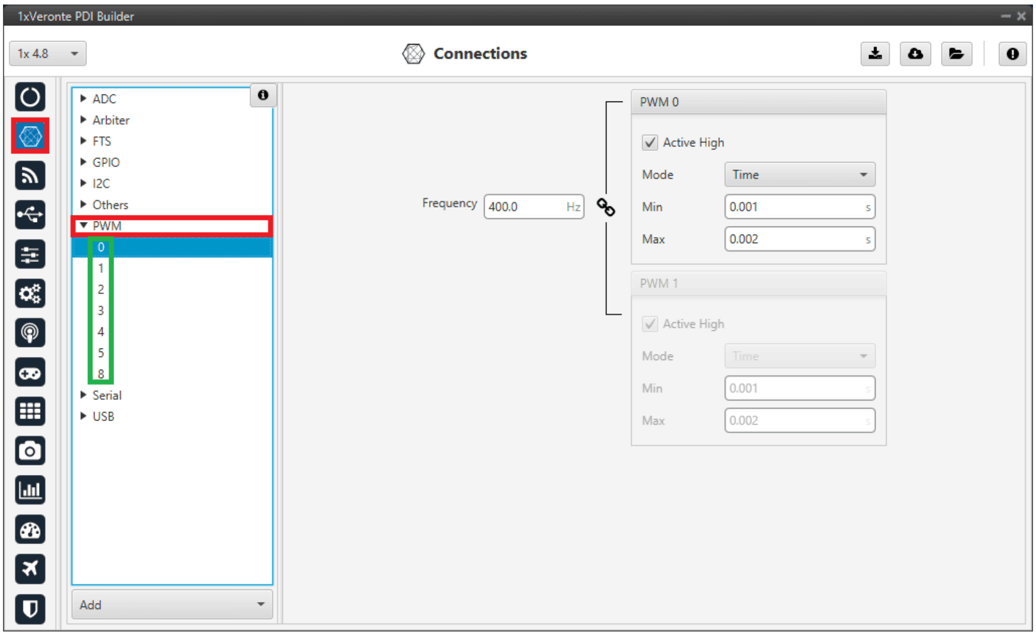
For more information, visit the Attitude - Veronte section of the **1x PDI Builder** user manual.

Actuators & SU Matrix

GPIO to PWM connection

Servos and ESC use PWM signals for control. Therefore, since all PWM/GPIO pins are configured as GPIO output by default, it is necessary to change them to PWM output (as many pins as servos/actuators).

> **Note**
>
> For the Embention VTOL aircraft 7 PWM output pins have been configured. Each of these pins will control the movement of each of the 7 servo/actuators available on the platform.



PWM connections

For detailed information on how to set up a **GPIO connection to a PWM connection**, visit the PWM - Connections section of the **1x PDI Builder** user manual.

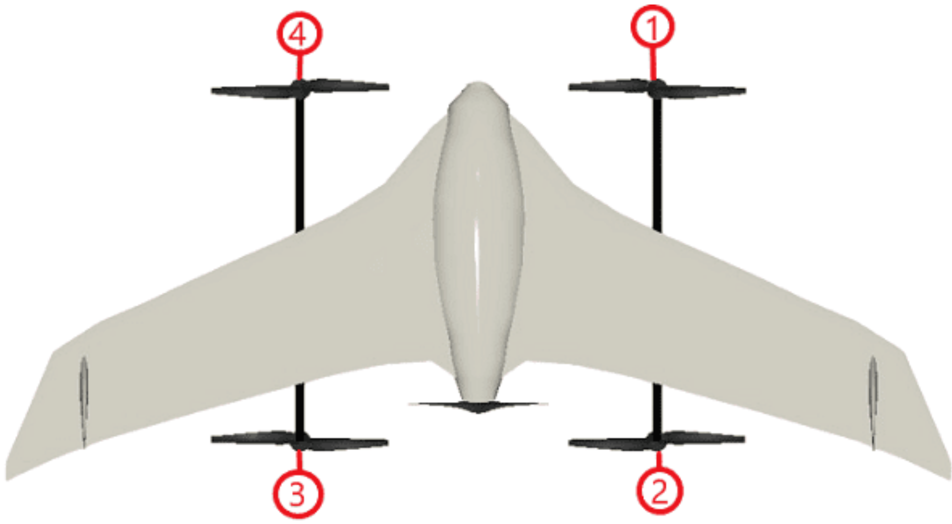
Actuators

The following table shows the correspondence between the actuators of the Embention VTOL aircraft and the servos:

Servo	Servo 0 (S0)	Servo 1 (S1)	Servo 2 (S2)	Servo 3 (S3)	Servo 4 (S4)	Servo 5 (S5)	Servo 6 (S6)
Actuator	Motor 1	Motor 2	Motor 3	Motor 4	Pusher motor	Right elevator	Left elevator

Motor Numbering

In general, the numbering will be defined by the customer. In this case, the motors are numbered **clockwise**, with number 1 being the motor located to the right of the front of the vehicle.



Motor numbering

To define the actuators position, users must first establish a criterion, in the Embention VTOL aircraft it is as follows:

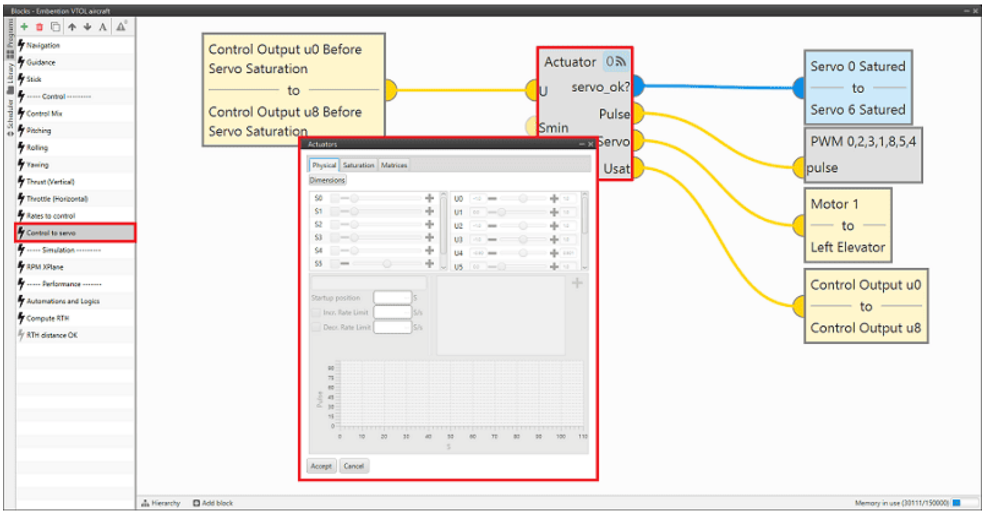
- **Motors**: It is set in the range **0 to 1**.
  - At minimum position (0% RPM) → **0**
  - At maximum position (100% RPM) → **1**
- **Linear actuators**: Defined by angle, from -30º to +30º.

> ⓘ **Note**
>
> The range of deflection does not have to be symmetrical, although in this case it is.

Next, the position of the actuators must be defined with the Actuator block of the **1x PDI Builder** app. The steps below summarize the configuration to be performed by the user for this block:

1. Go to **Block Programs menu** → click on "**Launch Editor**".

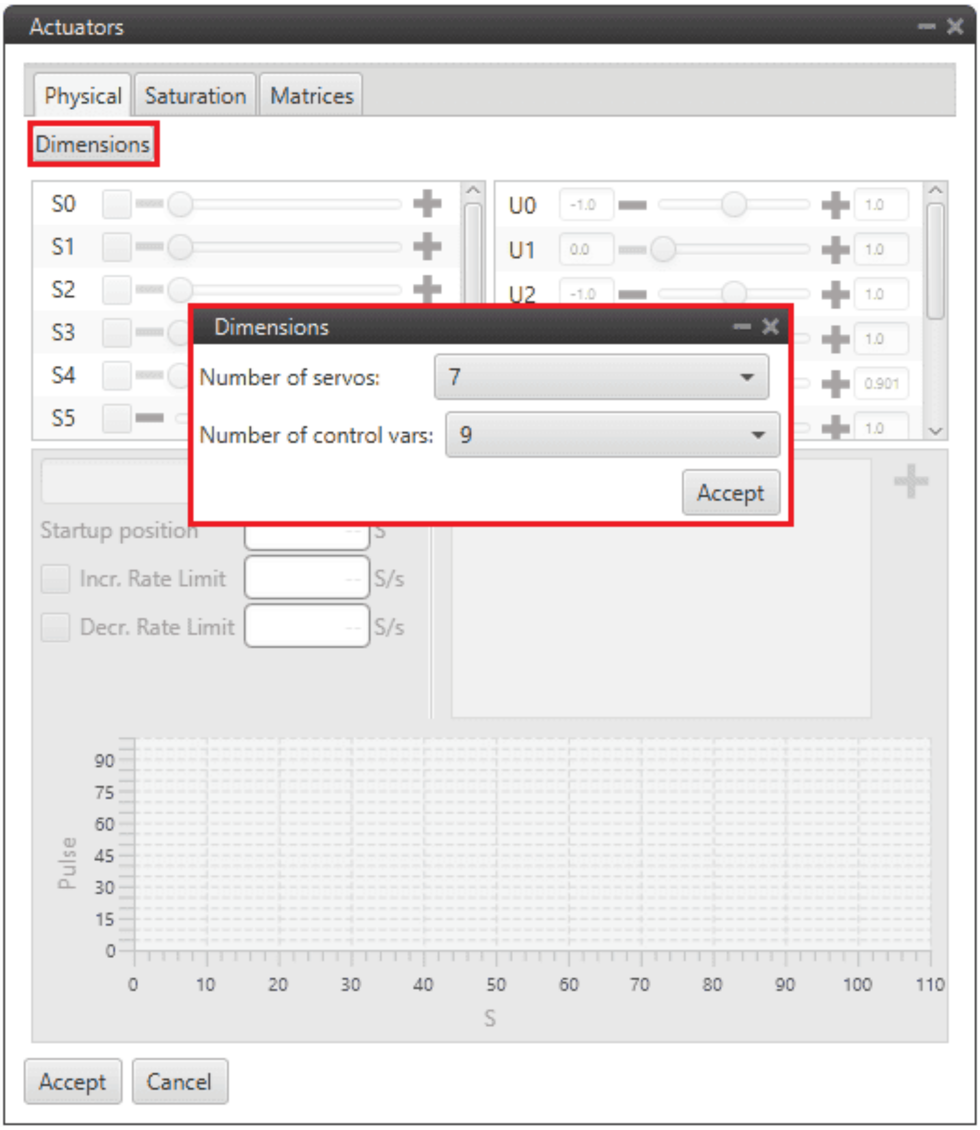
2. Go to "**Control to servo**" program → double-click on the **Actuator block** to start configuring it.



Control to servo

3. Define the dimension of the matrix formed by the servos and the control outputs to be configured.

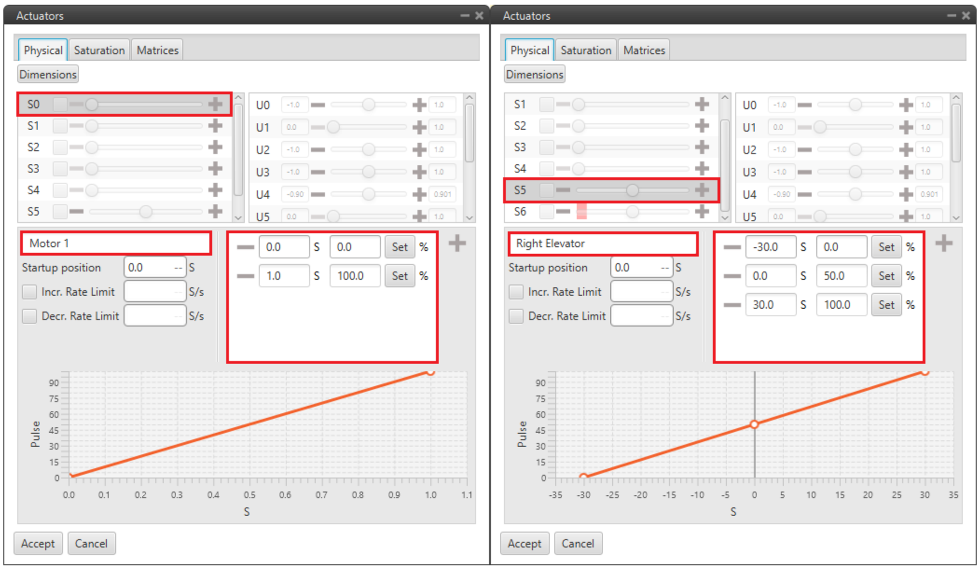
   For the Embention VTOL aircraft, a 7x9 matrix has to be defined, since there are 7 servos on the platform and 9 control outputs are required.



Dimensions

> **Note**
>
> Once the control outputs have been defined, the configuration of the block programs can begin. These configurations determine the Autopilot's behavior in the automations that allow it to control the aircraft.

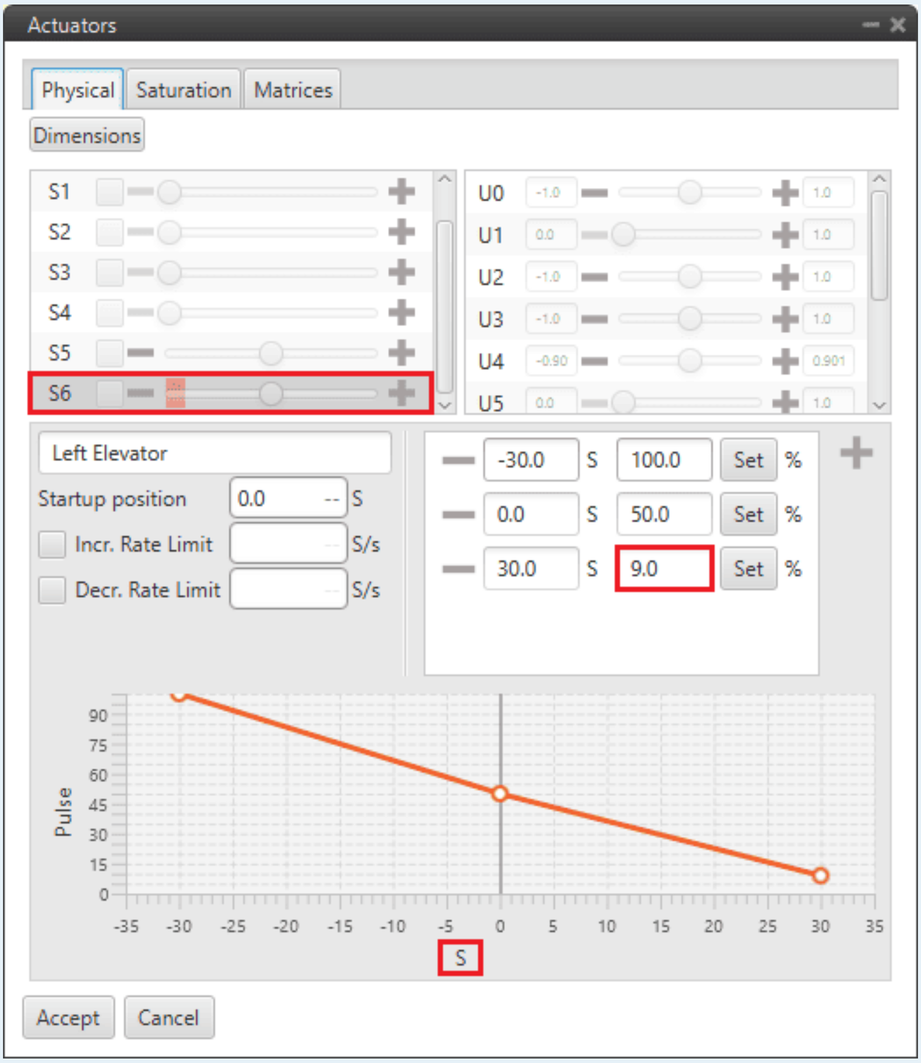
4. For each servo, define the servo position of the servo that responds to the PWM connection pulse, i.e., we try to find the PWM pulse for which the servo position is the desired one.



Motor 1 / Right Elevator actuator definition

Note

The servo position does not have to be symmetrical. In the case of Embention VTOL Aircraft, we have the example of the servo corresponding to the Left Elevator (S6).



Left Elevator actuator definition

For this S6, the PWM pulse should allow to achieve a deflection of ± 30º. For the +30º deflection, it is achieved with 9% of the PWM pulse, unlike the Right Elevator (S5) which was obtained with 100%.

Important

The variable **S** in the graph is a position that can represent any variable desired by the user (**rad**, **º**, **RPM**).

> **Important**
>
> A complete explanation of the use of the **Actuator block** in the **Control to servo program** can be found at Control to servo - Block Programs section of this manual.

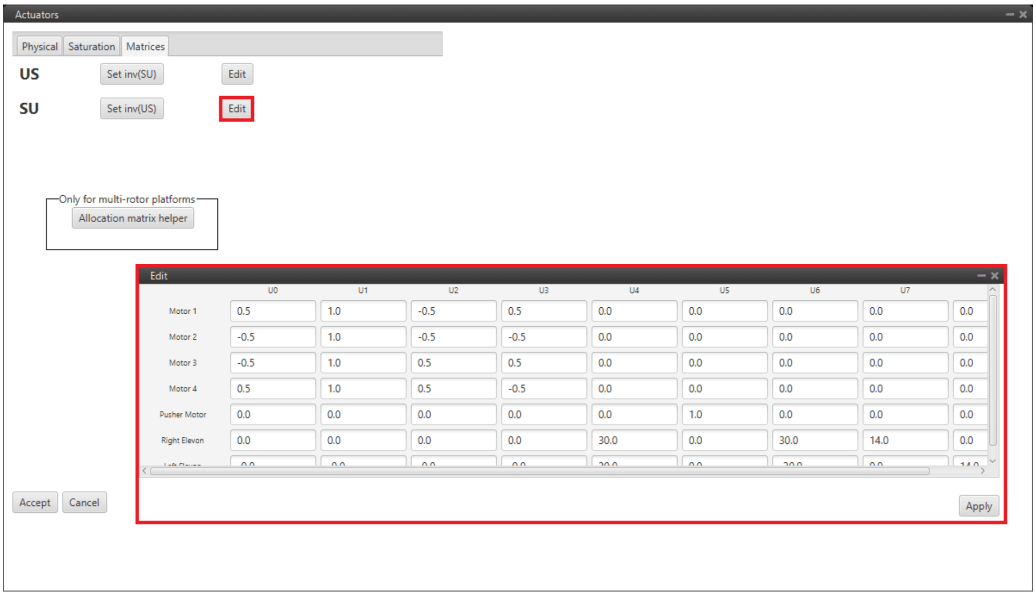
SU Matrix

SU matrix contains the relationship between each actuator (S) and its control output (U). Although it is also possible to define the US matrix (inverse of the SU matrix), the SU matrix is usually defined because the visualization of the movement is more intuitive this way.

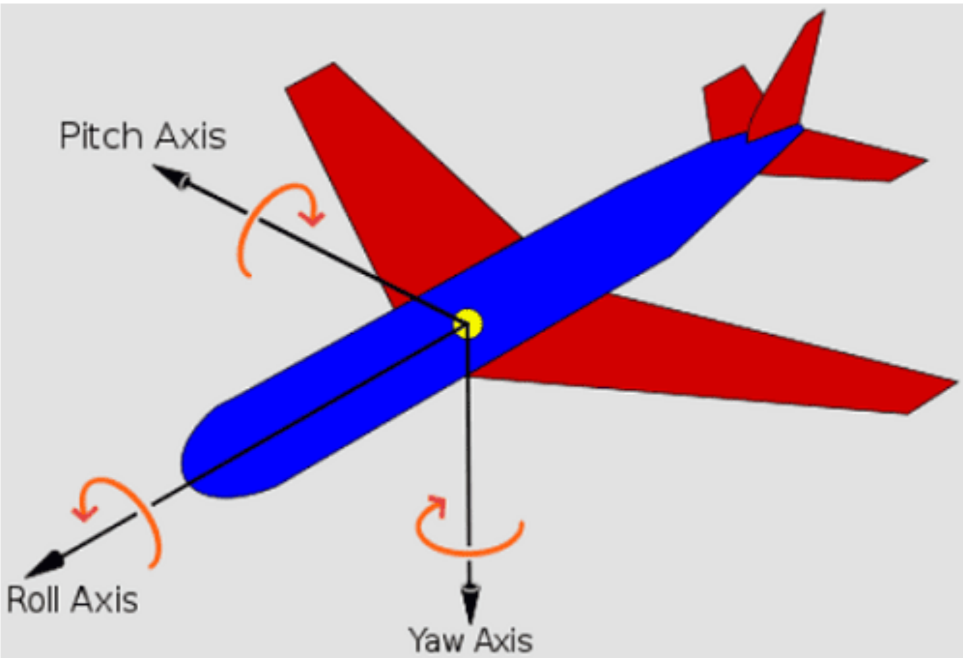
In the SU matrix of the Embention VTOL aircraft, each of the 9 defined control outputs represents an aircraft control action, as can be seen in the following table.

Control output	u0	u1	u2	u3	u4	u5	u6	u
Action	Pitch (Quad)	Thrust (Vertical)	Roll (Quad)	Yaw (Quad)	Pitch (Plane)	Throttle (Horizontal)	Roll (Plane)	Adv Ya (Ri

These actions can be performed thanks to the variation of the position of the 7 platform servos already mentioned.

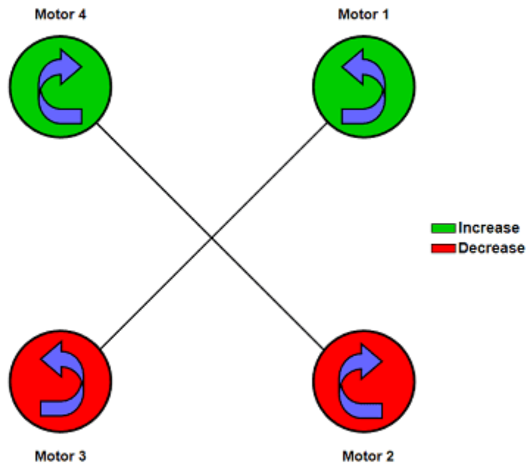


SU Matrix

> ### Sign Convention
>
> - Positive angle means deflection upward or to the right.
> - Negative angle means deflection downward or to the left.
>
> 
>

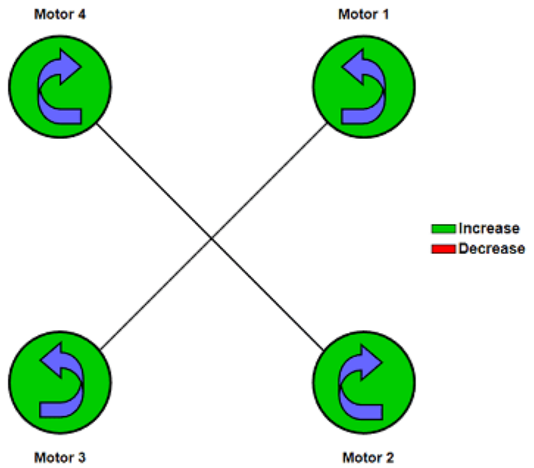
u0 -- Pitch (Q)

Servos	u0
Motor 1	0.5
Motor 2	-0.5
Motor 3	-0.5
Motor 4	0.5
Pusher motor	0.0
Right elevator	0.0
Left elevator	0.0



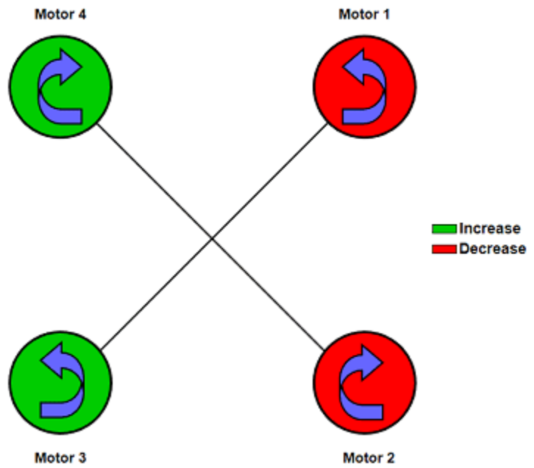
u1 -- Thrust (vertical)

Servos	u1
Motor 1	0.5
Motor 2	0.5
Motor 3	0.5
Motor 4	0.5
Pusher motor	0.0
Right elevator	0.0
Left elevator	0.0



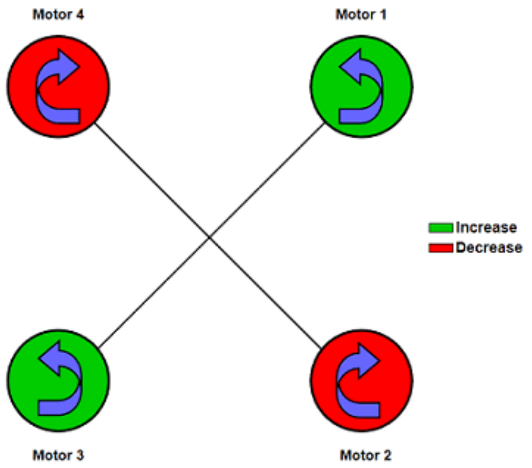
u2 -- Roll (Q)

Servos	u2
Motor 1	-0.5
Motor 2	-0.5
Motor 3	0.5
Motor 4	0.5
Pusher motor	0.0
Right elevator	0.0
Left elevator	0.0



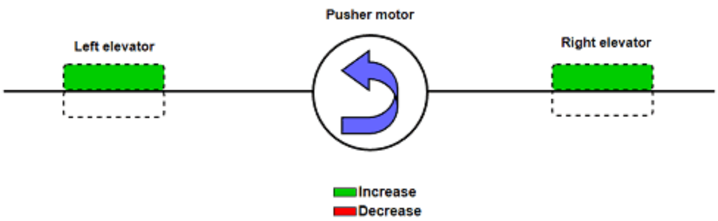
u3 -- Yaw (Q)

Servos	u3
Motor 1	0.5
Motor 2	-0.5
Motor 3	0.5
Motor 4	-0.5
Pusher motor	0.0
Right elevator	0.0
Left elevator	0.0



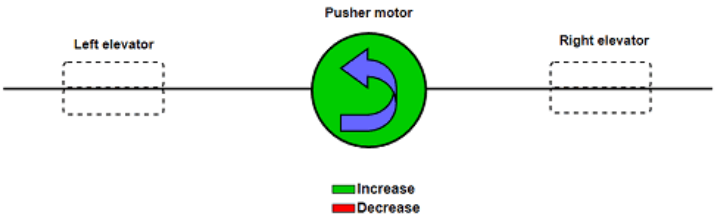
u4 -- Pitch (P)

Servos	u4
Motor 1	0.0
Motor 2	0.0
Motor 3	0.0
Motor 4	0.0
Pusher motor	0.0
Right elevator	30.0
Left elevator	30.0



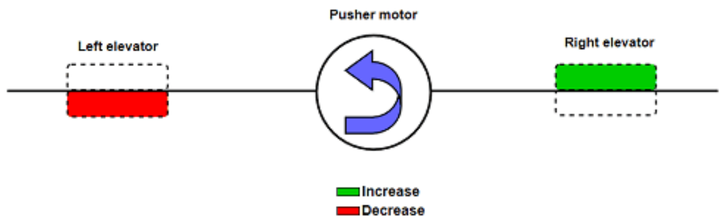
u5 -- Throttle (horizontal)

Servos	u5
Motor 1	0.0
Motor 2	0.0
Motor 3	0.0
Motor 4	0.0
Pusher motor	1.0
Right elevator	0.0
Left elevator	0.0



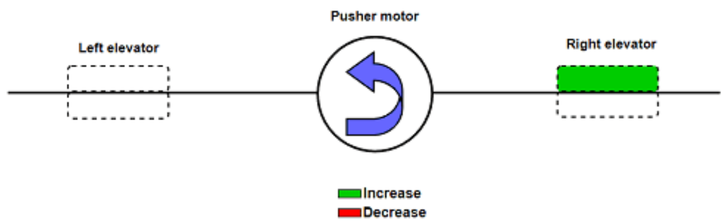
u6 -- Roll (P)

Servos	u6
Motor 1	0.0
Motor 2	0.0
Motor 3	0.0
Motor 4	0.0
Pusher motor	0.0
Right elevator	30.0
Left elevator	-30.0



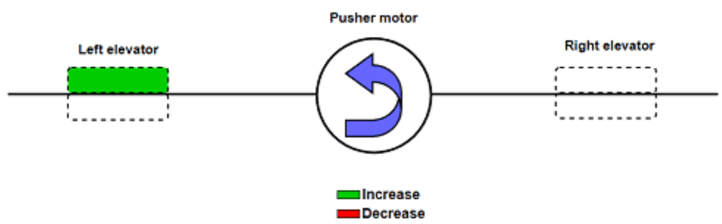
u7 -- Adverse Yaw (Right)

Servos	u7
Motor 1	0.0
Motor 2	0.0
Motor 3	0.0
Motor 4	0.0
Pusher motor	0.0
Right elevator	14.0
Left elevator	0.0



u8 -- Adverse Yaw (Left)

Servos	u8
Motor 1	0.0
Motor 2	0.0
Motor 3	0.0
Motor 4	0.0
Pusher motor	0.0
Right elevator	0.0
Left elevator	14.0



For more information, visit the Actuator - Servos blocks of the **Block Programs** section of the **1x PDI Builder** user manual.

> **Important**
>
> A complete explanation of the use of the **Actuator block** in the **Control to servo program** can be found at Control to servo - Block Programs section of this manual.

Modes & Phases

Modes definition

The flight modes determine who is in charge of controlling each one of the aircrafts control channels. Each of the channels represents a control output, defined by the customer in the Block Programs configuration. In the Embention VTOL aircraft these channels are linked in order to each control output of the SU matrix.

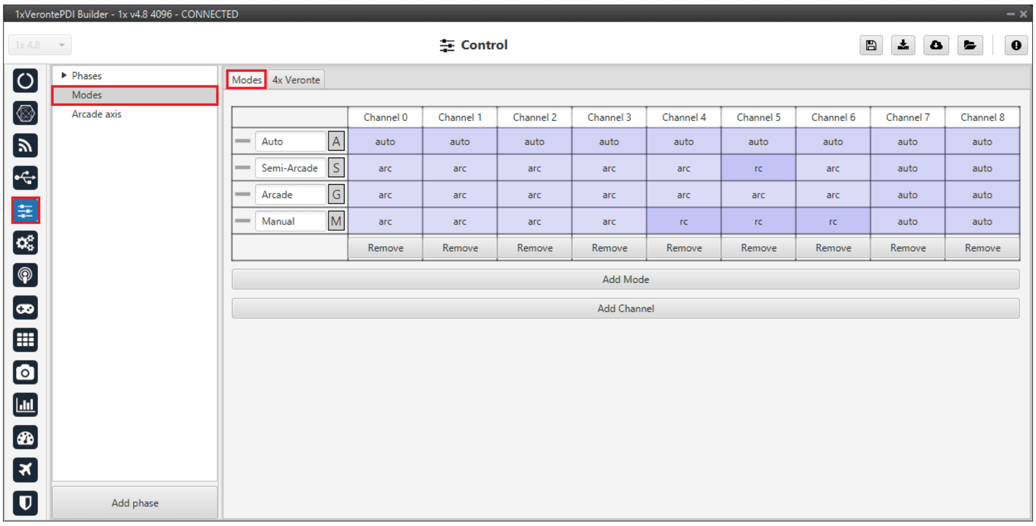
Channel	0	1	2	3	4	5	6	7	8
Control output	u0	u1	u2	u3	u4	u5	u6	u7	u8
Action	Pitch (Q)	Throttle (Q)	Roll (Q)	Yaw (Q)	Pitch (P)	Thrust (P)	Roll (P)	Adverse Yaw Right (P)	Adverse Yaw Left (P)

There are four different **control modes** and it is possible to combine them to create custom flight modes. The options available are:

- **auto**: Automatic mode.
- **rc**: Radio Control mode, i.e. manual mode.
- **arc**: Arcade mode, this could be considered as a mix between automatic and manual.
- **mix**: In this mode, it is possible to select in which step of the controller the pilot command will enter.

For more information on these control modes, visit the Modes - Control section of the **1x PDI Builder** user manual.

For each of the channels of the 4 **flight modes** defined, a control mode must be assigned to it.



Modes definition

> ⓘ **Note**
>
> The controls to perform the control action Adverse Yaw, correspond to channels 7 and 8 and are performed in **Auto** mode.
>
> This is because these actions are complementary to the Roll movement, so being a correction, they must be performed automatically by the autopilot **for all flight modes**.

- **Auto flight mode** `A`
  In this mode, all control outputs (channels) defining the aircraft performances are automatically controlled by the autopilot (auto mode).
- **Semi-Arcade flight mode** `S`
  In this mode, the Pitch, Thrust, Roll and Yaw controls are controlled in **arc mode**. That is, the input information is sent from the pilot's stick to the autopilot, and it is the autopilot that takes over the performance. The Throttle action is controlled directly by the pilot stick in **rc mode**.
- **Arcade flight mode** `G`

In this flight mode, the aircraft performances are controlled in **arc mode**. So, when the pilot commands a desired pitch, roll, IAS, heading and so on, and it will be the control system that will be in charge of making the platform follow those commands.

- **Manual flight mode** `M`

  The manual flight mode mixes **rc** control mode with **arc**:

  - For the quadcopter control, **arc mode** must be defined since the pilot's stick cannot act on the motors.
  - For the fixed wing control, **rc mode** can be set so that the pilot's stick acts directly on the elevators and throttle.

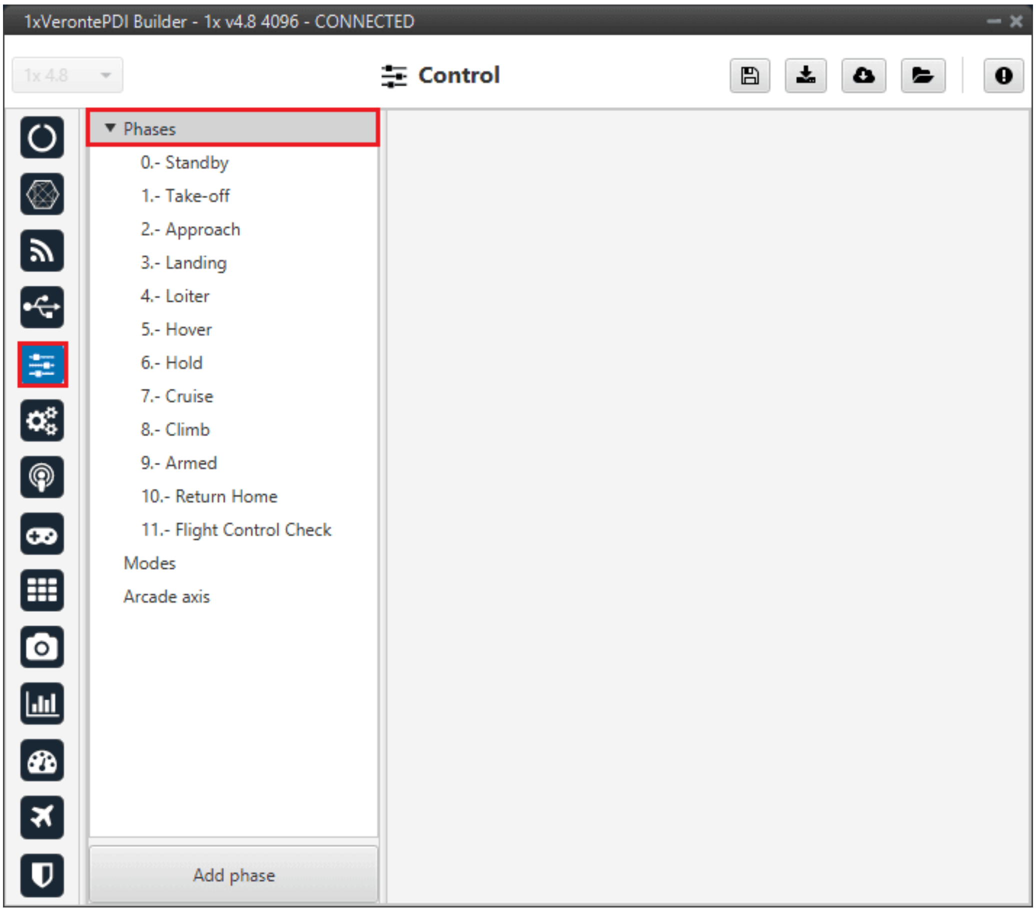
Phases definition

The flight phases that will control the aircraft in the different stages of the operation must be created (defined not configured).

For the operation of the Embention VTOL aircraft 12 flight phases have been defined:

0. **Standby**: All actuators are deactivated.
1. **Take-off**: Aircraft vertical take-off.
2. **Approach**: Execute approach maneuver to the runway defined for VTOL.
3. **Landing**: Aircraft vertical landing.
4. **Loiter**: Loiter at current position and altitude.
5. **Hover**: Maintain current 3D position.
6. **Hold**: Stabilize attitude and vertical speed.
7. **Cruise**: Follow defined mission.
8. **Climb**: Ascend to the loiter from the runway.
9. **Armed**: Vertical propellers run-up.
10. **Return Home**: Go to one of the pre-defined landing points and hover.
11. **Flight Control Check**: Manual check of elevators and horizontal motor.

> ⓘ **Note**
>
> In addition to these phases, when Veronte Autopilot 1x boots up it is by default in the "**Initial**" phase.



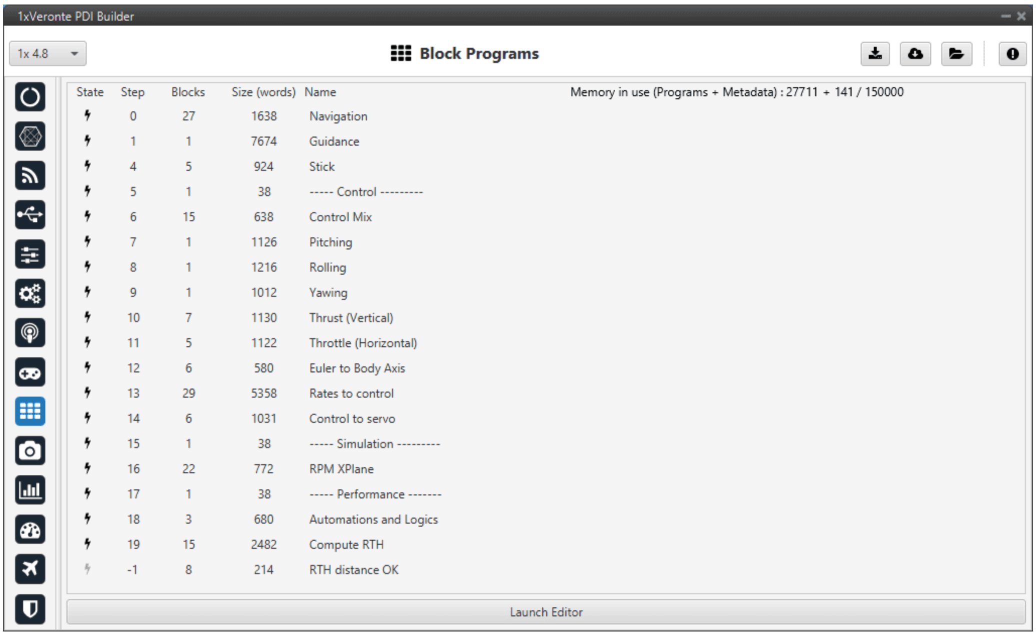
Phases definition

> ⓘ **Note**
>
> The configuration of the flight phases (guidance and control commands) is done in the Block Programs menu.

For more information, refer to the Phases - Control section of the **1x PDI Builder** user manual.

Block Programs

In this section the user can configure and develop the different programs for aircraft control, guidance, navigation, etc.



Block Programs menu

The following programs have been developed for the configuration of the Embention VTOl aircraft:

> **Note**
>
> The program name is defined by the user, so they do not have to match these.

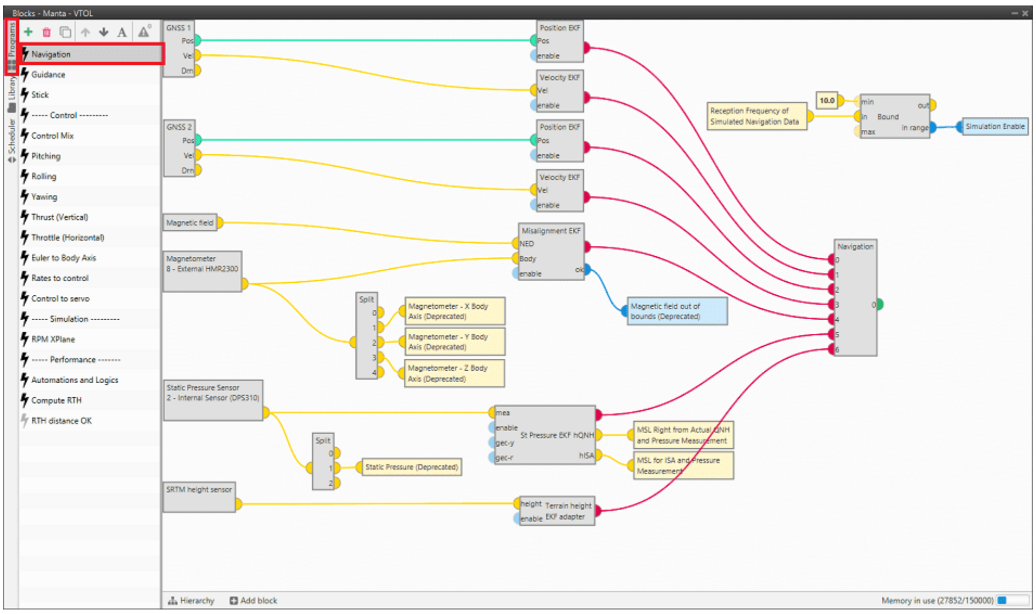
- Navigation: Control laws that allow navigation through the use of both **internal and external sensors**.
- Guidance: Control laws that allow obtaining a precise **guidance** to perform the **desired mission**.
- Stick: Block program to transform pilot stick actions into **input values** to Autopilot 1x.
- Control Mix: Block program that establishes the optimal **flight configuration** as a function of the IAS value.
- Pitching: Control laws for performing perform **Pitch** in both multicopter and fixed-wing (FW) flight configurations.
- Rolling: Control laws for performing **Roll** in both multicopter and fixed-wing (FW) flight configurations.
- Yawing: Control laws for performing **Yaw** in both multicopter and fixed-wing (FW) flight configurations.

- Thrust (Vertical): Control laws for performing **Thrust** in multicopter flight configurations.
- Throttle (Horizontal): Control laws for performing **Thrust** in fixed-wing (FW) flight configurations.
- Euler to Body Axis: Program that transforms a reference system from **Euler Axis** to **Body Axis**.
- Rates to control: Control laws that transform the desired guidance variables into **output controls**.
- Control to servo: Control laws that transform output controls into **servo actions**.
- RPM XPlane: Program that allows to transform the aircraft real performance in a **simulated environment**.
- Compute RTH: Program to allow the aircraft to choose from several points which is the best one to be used as **RTH point** for the RTH phase.
- RTH distance OK: Program to check if a particular point is suitable to start the **RTH phase**.

For more information, visit the Block Programs section of the **1x PDI Builder** user manual.

Navigation

The following program is defined to configure all sensors that will be used to determine the navigation of the Autopilot 1x.



Navigation - Program

Follow the steps below for a basic configuration of the sensors that enable 1x navigation.

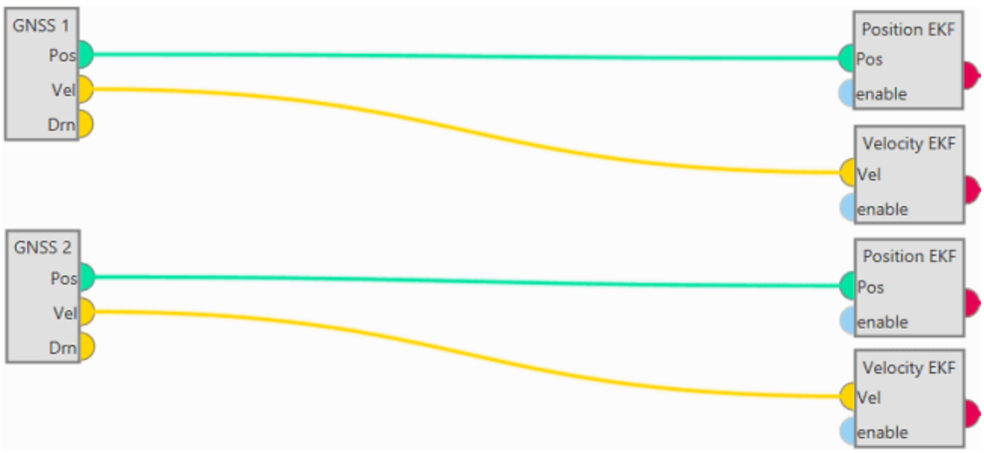
> **Important**
>
> Each sensor used in the autopilot navigation must be connected to its corresponding **EKF adapter** in order to be read correctly by the Navigation block algorithm.

GNSS Sensors

> **Important**
>
> The GNSS sensor block must be connected to two different EKF adapters for its two outputs, Position EKF block and Velocity EKF block.

For more information on this block, visit the GNSS sensor - Sensors blocks section of the **1x PDI Builder** user manual.

- GNSS blocks



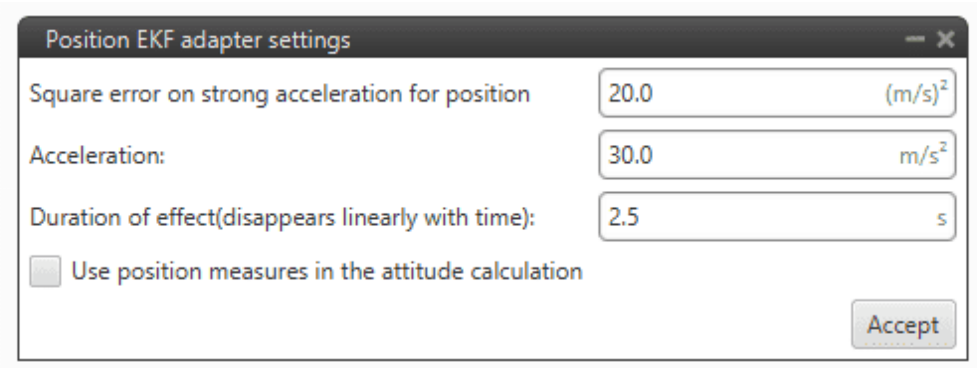
- GNSS
  - Meas Rate: 0.25 s
  - PPP: Disabled
- Survey In: Disabled
- SPI Port - Mask in
  - ublox: Enabled
  - nmea: Disabled

        - rtcm: Disabled
        - rtcm3: Enabled
    - SPI Port - Mask out
        - ublox: Enabled
        - nmea: Disabled
        - rtcm3: Disabled

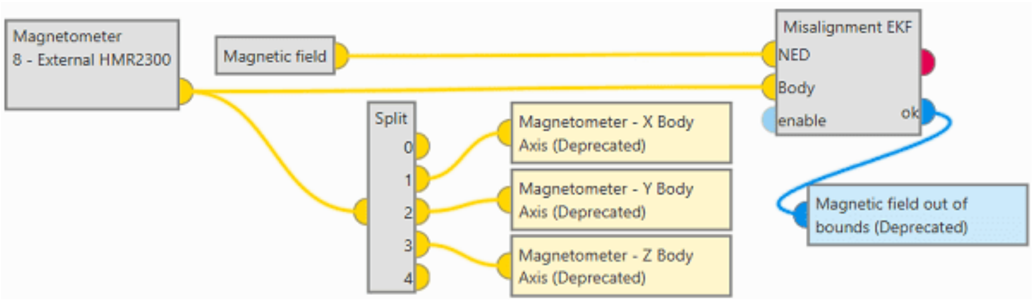
- Position/Velocity EKF Adapters

> **Note**
>
> The EKF adapters used for the GNSS sensor block, Position EKF block and Velocity EKF block, have the same configuration parameters, so only one of them is shown, the other being similar.

    - Square error on strong acceleration for position = $20.0; (m/s)^2$
    - Acceleration = $30.0; m/s^2$
    - Duration of effect (disappears lineary with time) = $2.5; s$
    - Use position measures in the attitude calculation: *Disabled*



Magnetometer Sensor

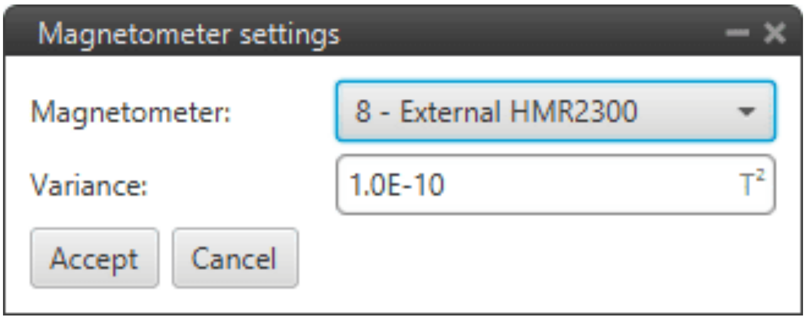


For more information, visit the Magnetometer - Sensors blocks section of the **1x PDI Builder** user manual.

The basic configuration of these blocks is shown below:

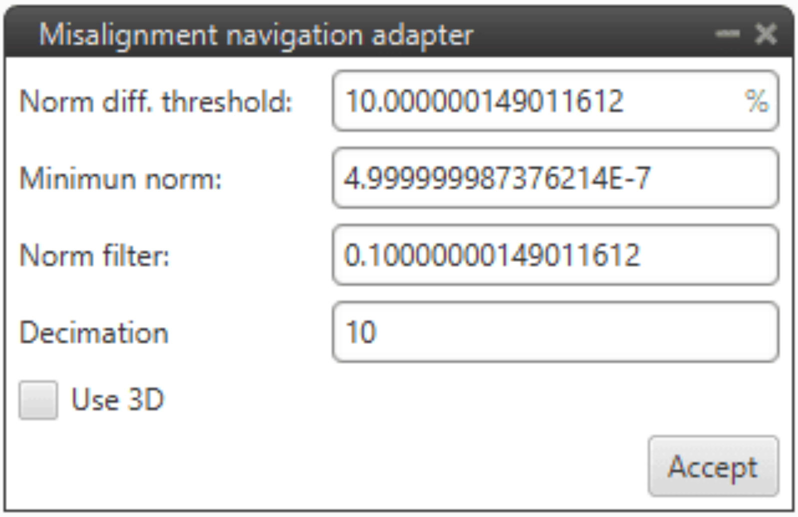
- Magnetic field block

  This block has no configuration. For a detailed explanation about it, refer to the Magnetic Field - Sensors blocks section of the **1x PDI Builder** user manual,

- Magnetometer block
  - 

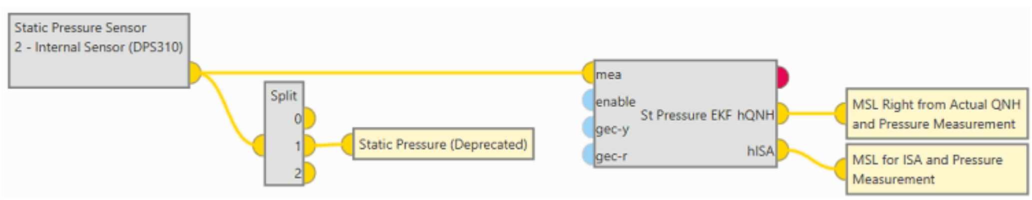
    Magnetometer: External HMR2300
  - Variance: 1.0E-10 T^2

- Misalignment EKF Adapter

  - 

    Norm diff. threshold: 10 %
  - Minimun norm: 5E-7
  - Norm filter: 0.1
  - Decimation: 10
  - Use 3D: Disabled

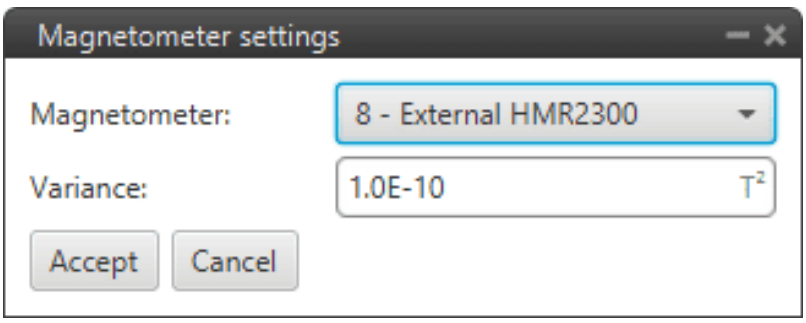
Static Pressure Sensor



For more information, visit the Static Pressure - Sensors blocks section of the **1x PDI Builder** user manual.

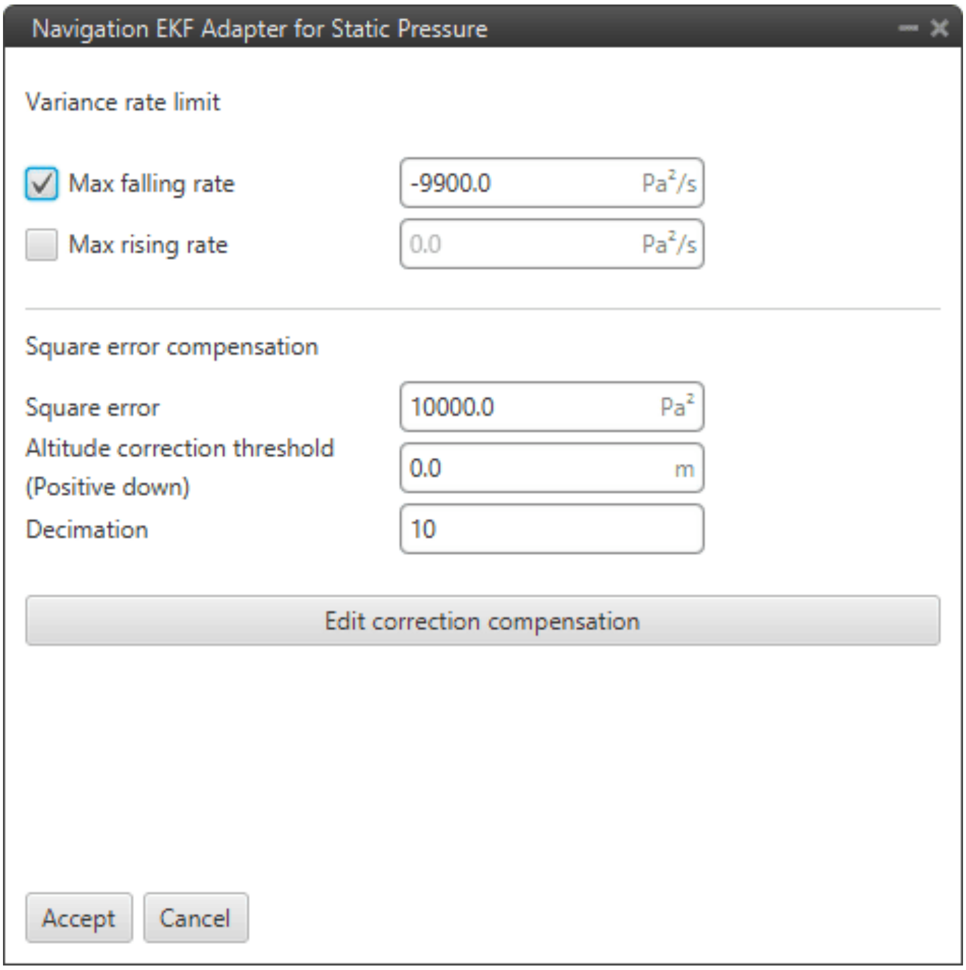
The basic configuration of these blocks is shown below:

- Static Pressure block



  - Static pressure sensor: Internal Sensor (DPS310)
  - Variance: 1000.0 Pa²

- Static Pressure EKF Adapter



  - Max falling rate: Enabled, ⇒ -9900.0 Pa²/s
  - Max rising rate: Disabled
  - Square error: 10000.0 Pa²
  - Altitude correction threshold: 0.0 m
  - Decimation: 10
  - Edit correction compensation:

Points entered:

-5.0 ; -1.5

-4.0 ; -0.5

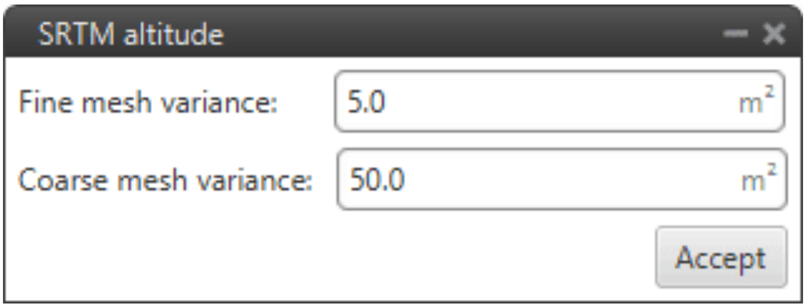
-0.5 ; -0.5

1.0 ; 1.0

SRTM height Sensor

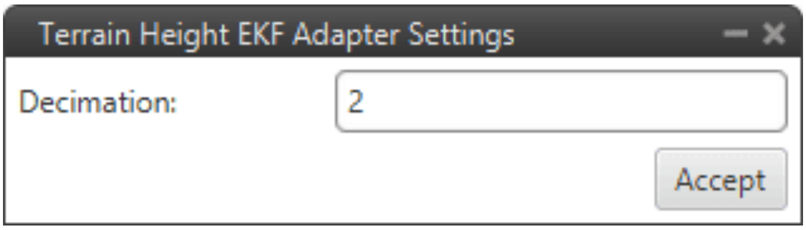
For more information, visit the SRTM height - Sensors block section of the **1x PDI Builder** user manual.

The basic configuration of these blocks is shown below:

- SRTM height block
  - 

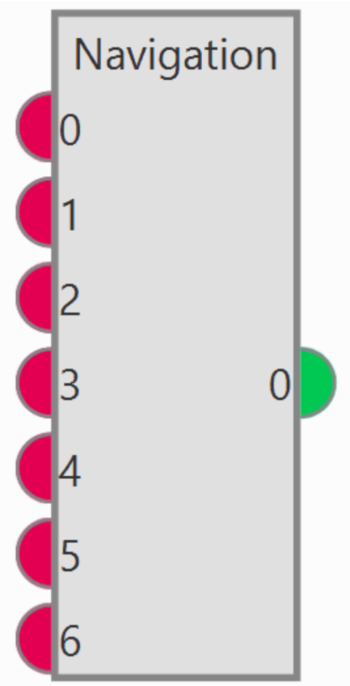
    Fine mesh variance: 5.0 m²
  - Coarse mesh variance: 50.0 m²

- Terrain height EKF Adapter

- 

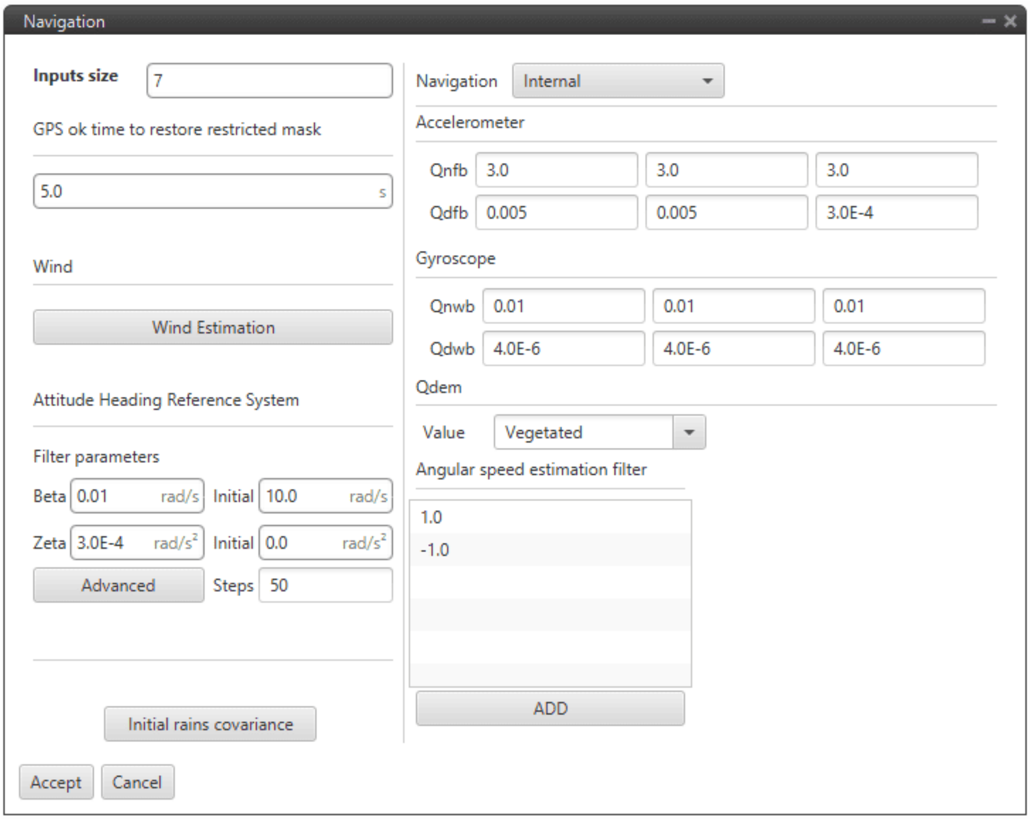
  Decimation: 2

Navigation Block



For more information, visit the Navigation - Navigation blocks section of the **1x PDI Builder** user manual.

The basic configuration of this block is shown below:



- Inputs size: **7**

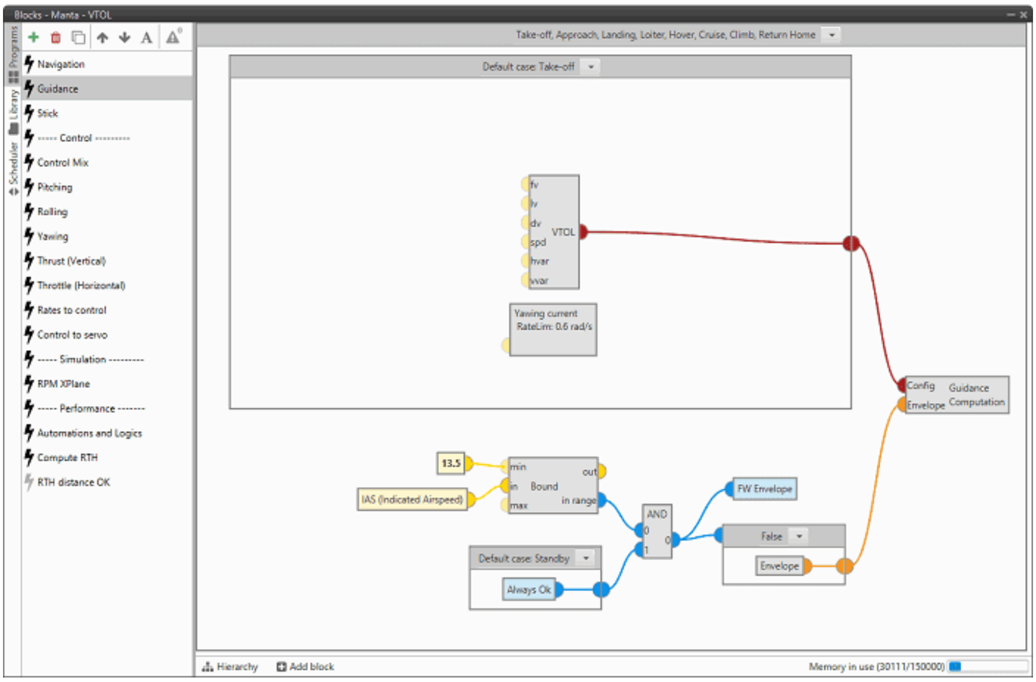
> **Important**
>
> Navigation block is configured to have as many inputs as EKF adapters are used in the sensors. These adapters are the ones that transmit the measurements to the Navigation block.

- GPS ok time to restore restricted mask: **5.0**
- Filter parameters
  - Beta: $0.01\ rad/s$; Initial: $10.0\ rad/s$
  - Zeta: $3.0E-4\ rad/s^2$; Initial: $0.0\ rad/s^2$
- Navigation: *Internal*
- Accelerometer
  - Qnfb: 3.0 ; 3.0 ; 3.0
  - Qdfb: 0.005 ; 0.005 ; $3.0E-4$
- Gyroscope
  - Qnwb: 0.01 ; 0.01 ; 0.01
  - Qdwb: $4.0E-6$; $4.0E-6$; $4.0E-6$

- Qdem
  - Value: *Vegetated*

Guidance

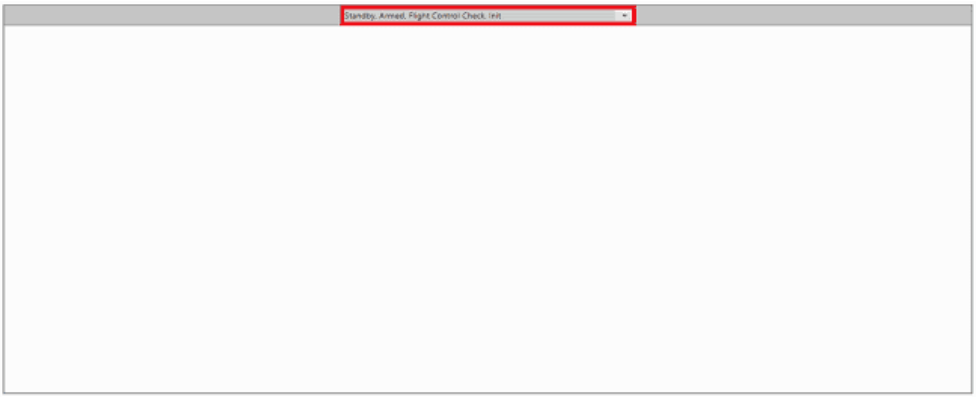
The guidance program defines the **control laws** in each of the flight phases.



Guidance - Program

- **Standby, Armed, Flight Control Check, Init**

  In these flight phases, guidance control is not necessary since the aircraft is not flying.

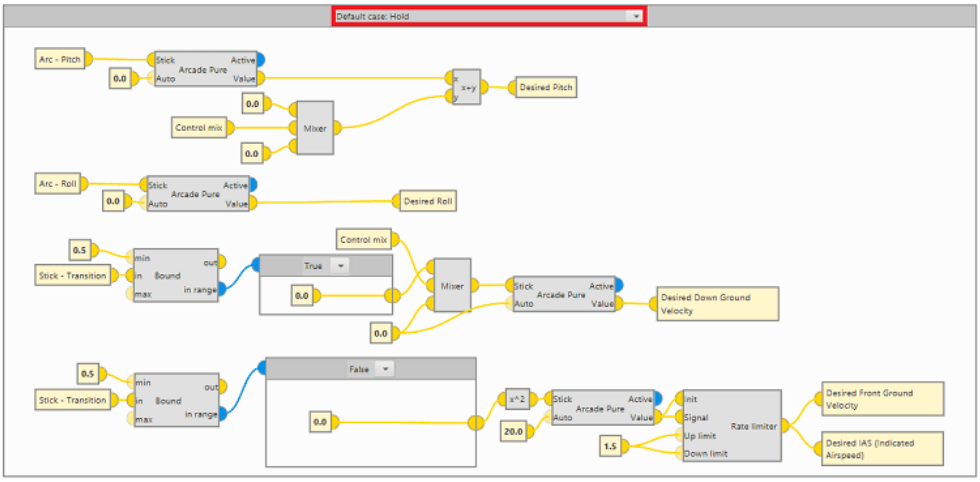


Guidance - Standby, Armed, Flight Control Check and Init phases

- **Hold**

The Hold flight phase stabilizes the attitude and vertical speed of the aircraft.

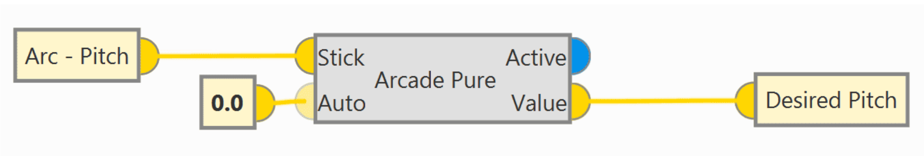
> **Important**
>
> The values in Auto mode of the control variables are null, being the Stick commands the ones that modify these variables.



Guidance - Hold phase

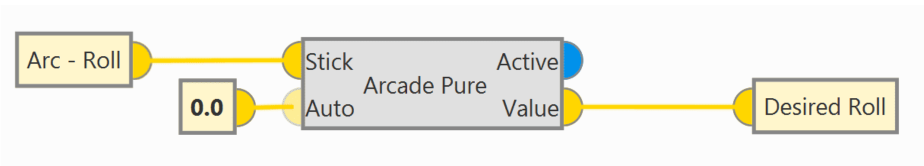
- The **Desired Pitch** value is obtained from the Arcade Pure block.

  The Stick input reads the value of the Arc-Pitch variable, which will directly define the **Desired Pitch** when the aircraft is in Arcade mode.

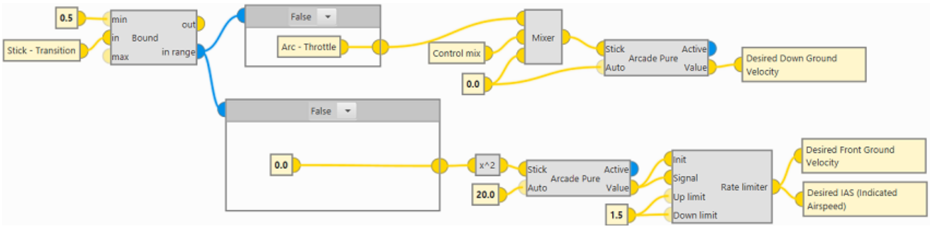
- The **Desired Roll** value is obtained from the Arcade Pure block.

  The Stick input reads the value of the Arc-Roll variable, which will directly define the **Desired Roll** when the aircraft is in Arcade mode.

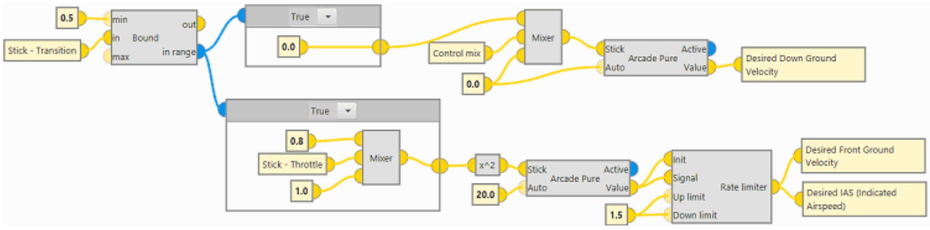
  

- If the value of the **Stick-Transition** variable is **less than 0.5** (aircraft flying in **quadcopter configuration**):
  - The **Desired Down Ground Velocity** value is obtained from the Arcade Pure block, where the Stick input directly reads the value of the Arc-Throttle variable.

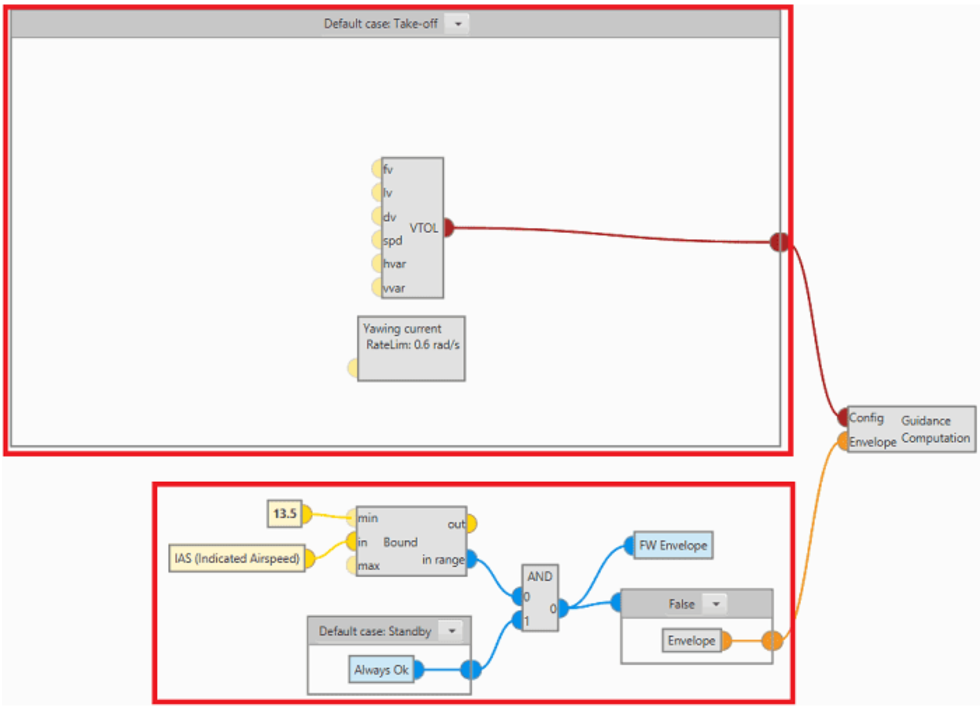
    - The **Desired Front Ground Velocity** and **Desired IAS** values are obtained from the Arcade Pure block in Auto mode with a value of **20.0**.



  - If the value of the **Stick-Transition** variable is **greater than 0.5** the aircraft transitions to **FW configuration** and the control variable becomes **Desired Front Ground Velocity**:
    - The **Desired Down Ground Velocity** value is null.
    - The **Desired Front Ground Velocity** and **Desired IAS** values are obtained from the Arcade Pure block, in which the Stick input has a value dependent on the Stick-Throttle variable.



- **Take-off, Approach, Landing, Loiter, Hover, Cruise, Climb, Return Home**
  In the following phases the guidance control is mainly configured with the Guidance Computation block, which is set with two inputs: **Config** and **Envelope**. The latter being common for this group of phases.



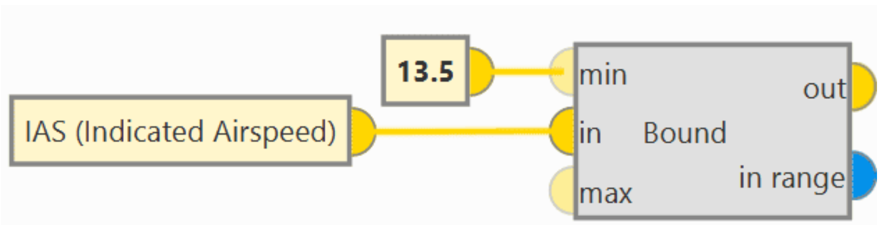
Guidance - Take-off, Approach, Landing, Loiter, Hover, Cruise, Climb and Return Home phases

- **Envelope input**

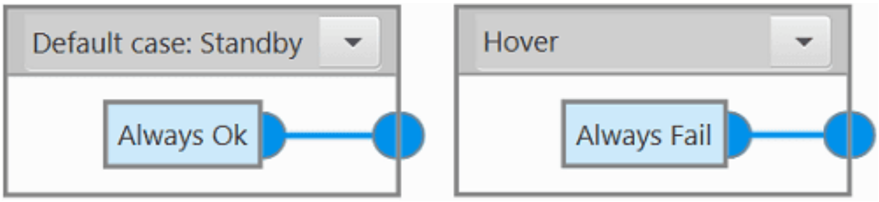
  The Envelope input must always be connected to the Envelope block. This block defines the limits that must not be exceeded during operation, so these limits will depend on the flight configuration (Multi or FW).

  To establish which flight configuration the aircraft is in, the following logic is defined:

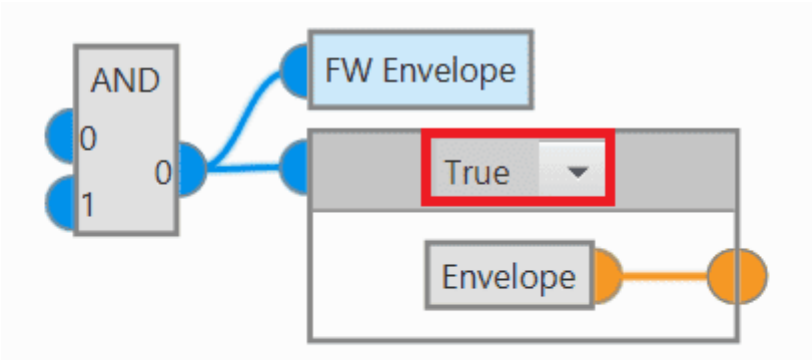
  1. The Bound block returns the bit in range **true** if IAS is greater than **13.5 m/s**.

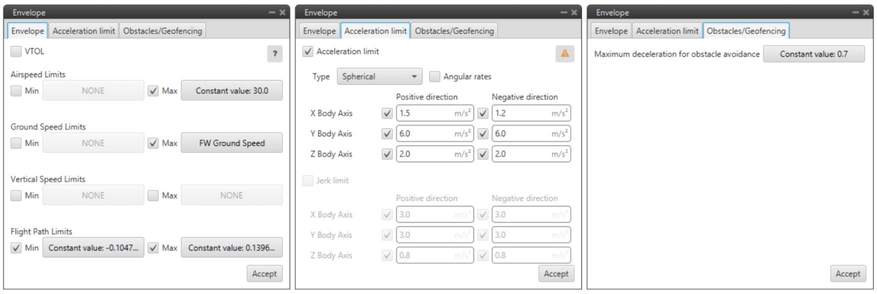
     

  2. Always Ok bit in flight phase Standby or Always Fail bit in flight phase Hover.



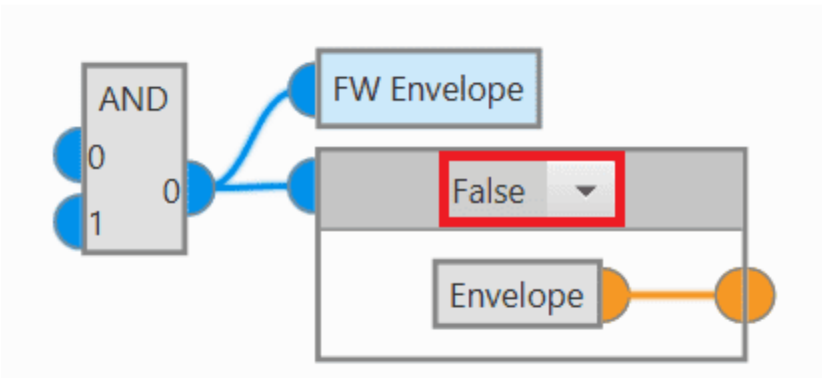
3. If both **bits** (1 and 2) are **true**, the FW Envelope bit is **true** and the Envelope block is defined for the **FW configuration**.

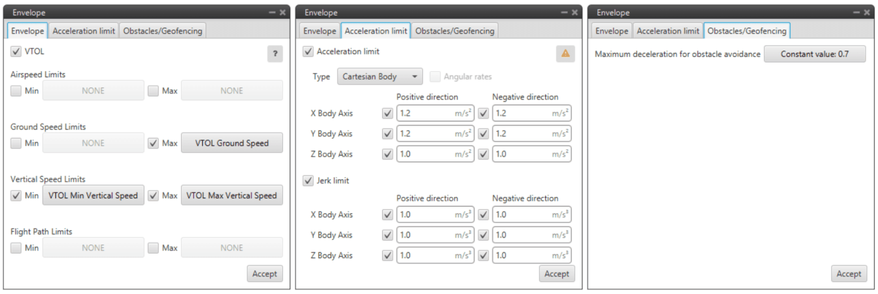




Envelope block - FW configuration

4. If it is **not** satisfied that both **bits** (1 and 2) are **true**, the FW Envelope bit is **false** and the Envelope block is set for the **quadcopter configuration**.





Envelope block - Quadcopter configuration

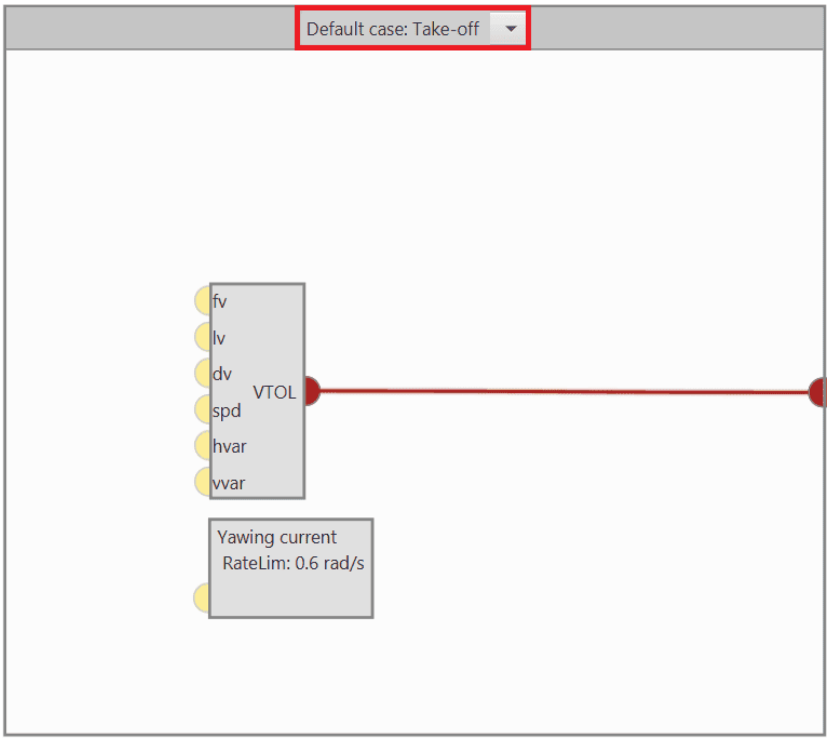
- **Config input**

  The Config input must always be connected to a Guidance block, which will vary depending on the flight phase.

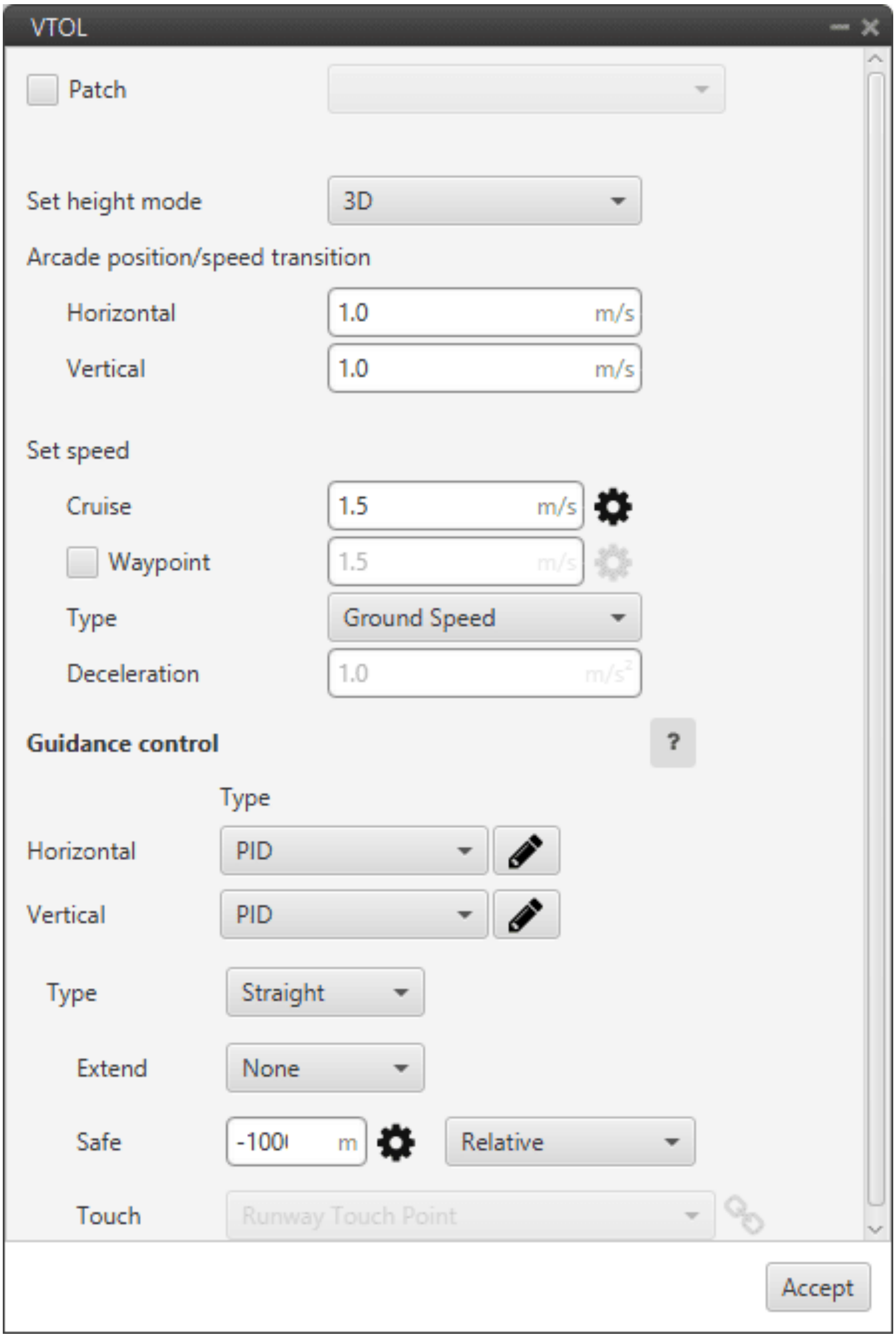
  - **Take-off**

    The guidance configuration in this phase consists of the VTOL block, which is linked to the Config input, and the Yawing current block.

    - **VTOL** guidance is used in multicopters for the **take-off** and landing operations.



A basic configuration of this block is shown below:



- Patch: Disabled
- Set height mode: 3D
- Arcade position/speed transition

  Horizontal: 1.0 m/s

Vertical: 1.0 m/s

- Set speed

  Cruise: 1.5 m/s

  Waypoint: Disabled

  Type: Ground Speed

  Deceleration: 1.0 m/s²

- Guidance control

  Horizontal: PID

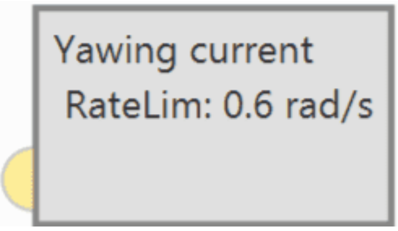
  Vertical: PID

  Type: Straight

  Extend: None

  Safe: -1000.0 m ⇒ Relative

- With the Yawing current block it is intended that the aircraft **maintains the yaw angle it has when entering the phase**, i.e. Desired Yaw = Current Yaw.

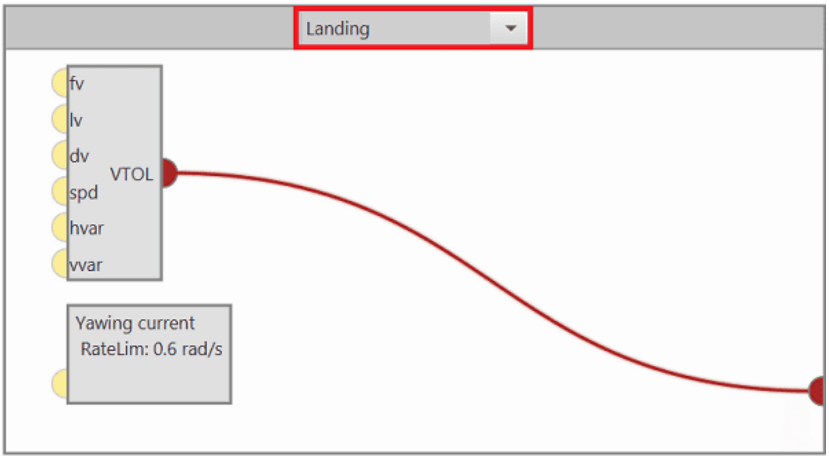


In addition, a **limit rate value** of $0.6\ rad/s$ has been defined to control the speed at which the aircraft yaws in the guidance of this phase.

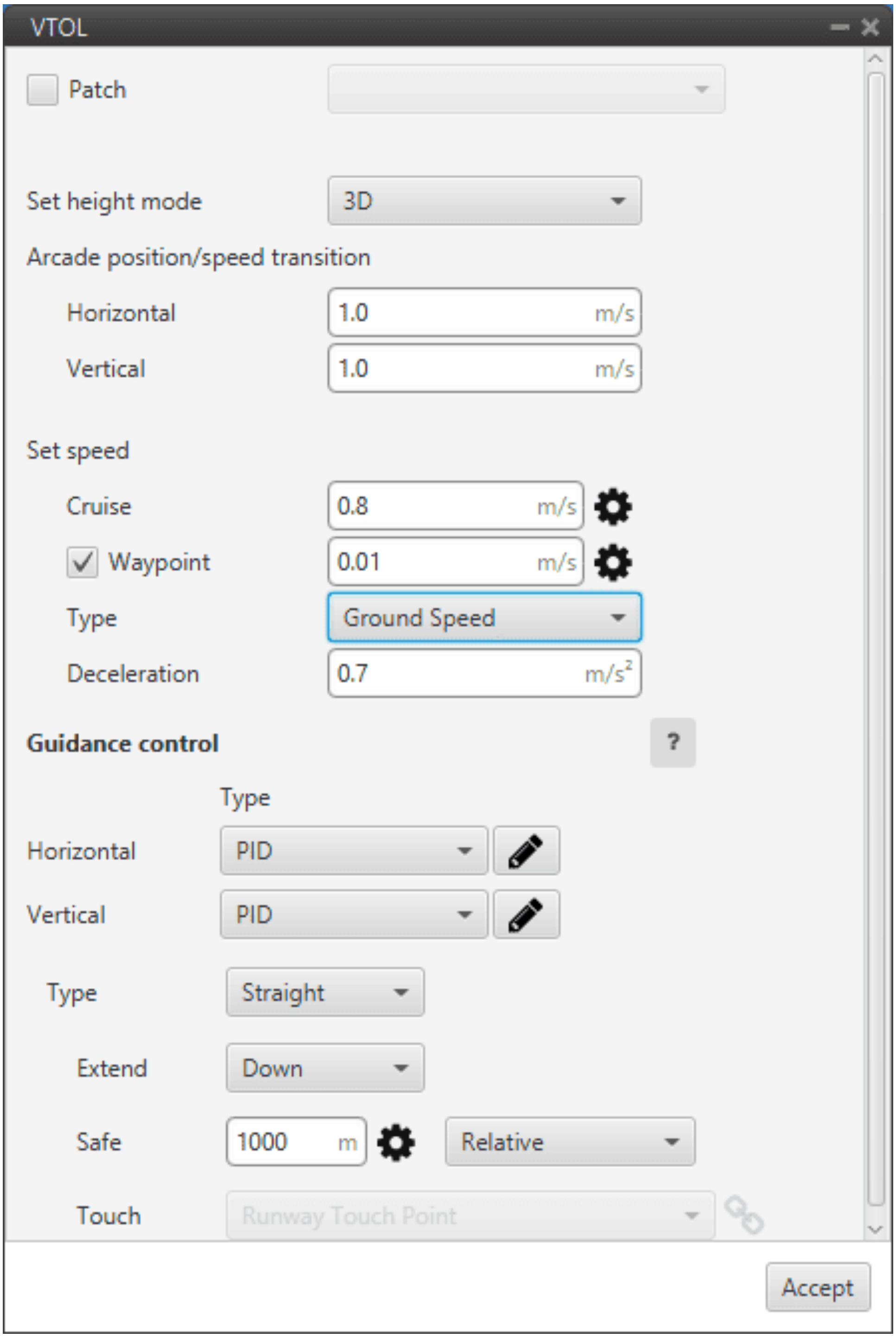
- **Landing**

  The guidance configuration in this phase consists of the VTOL block, which is linked to the Config input, and the Yawing current block.

  - **VTOL** guidance is used in multicopters for the take-off and **landing** operations.

    A basic configuration of this block is shown below:



- Patch: Disabled
- Set height mode: 3D
- Arcade position/speed transition

  Horizontal: 1.0 m/s

Vertical: 1.0 m/s

- Set speed

  Cruise: 0.8 m/s

  Waypoint: 0.01 m/s

  Type: Ground Speed

  Deceleration: 0.7 m/s²

- Guidance control

  Horizontal: PID

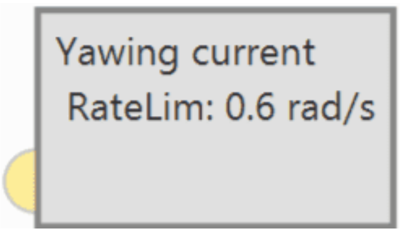
  Vertical: PID

  Type: Straight

  Extend: Down

  Safe: -1000.0 m ⇒ Relative

- With the Yawing current block it is intended that the aircraft **maintains the yaw angle it has when entering the phase**, i.e. Desired Yaw = Current Yaw.

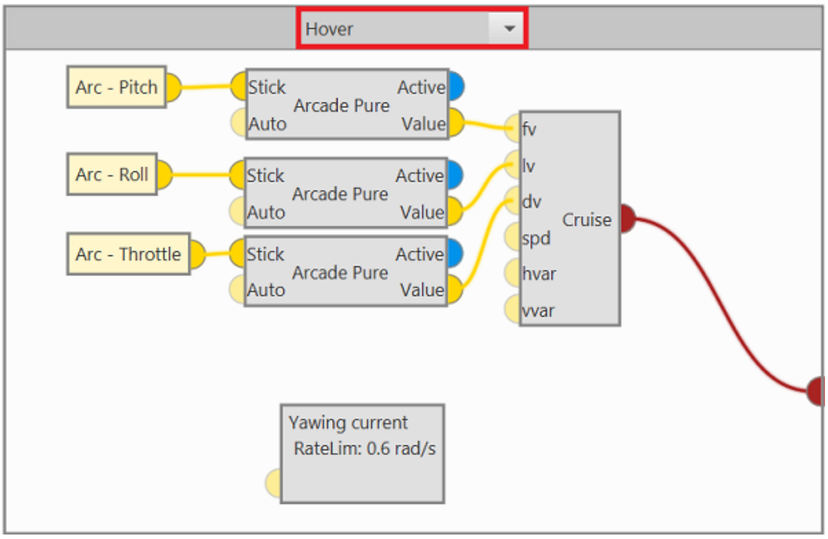
  

  In addition, a **limit rate value** of $0.6\ rad/s$ has been defined to control the speed at which the aircraft yaws in the guidance of this phase.

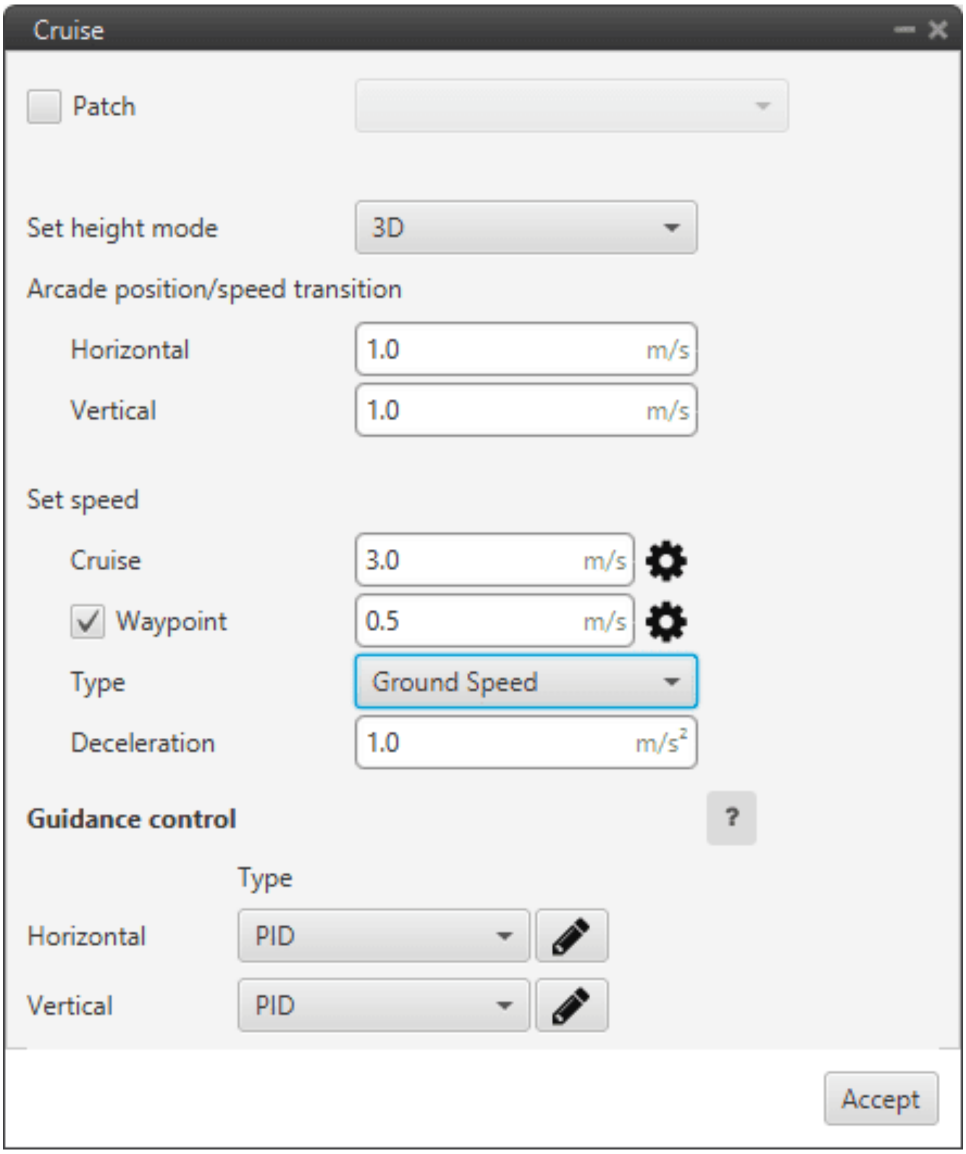
- **Hover**

  The guidance configuration in this phase consists of the Cruise block, which is linked to the Config input, and the Yawing current block.

  - **Cruise** guidance is used to make the aircraft follow a position-based route created by the user.

    A basic configuration of this block is shown below:



- Patch: Disabled
- Set height mode: 3D
- Arcade position/speed transition

  Horizontal: 1.0 m/s

  Vertical: 1.0 m/s
- Set speed

  Cruise: 3 m/s

  Waypoint: 0.5 m/s

Type: Ground Speed

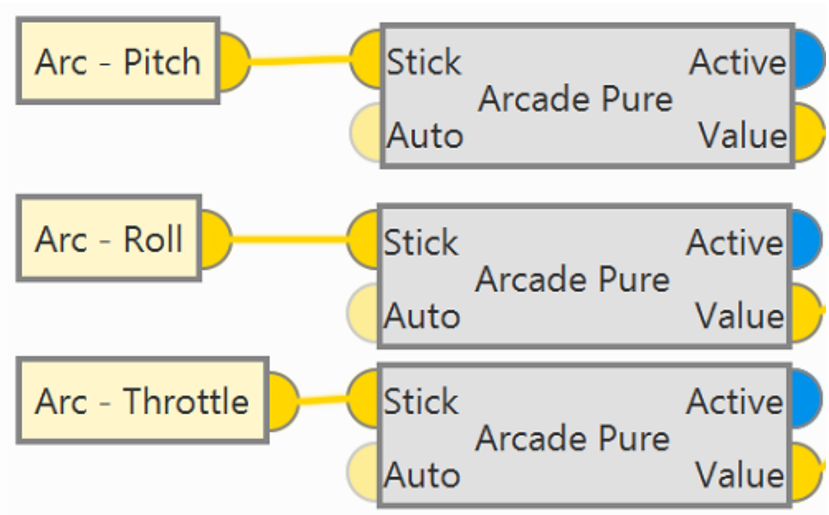
Deceleration: 1.0 m/s²

- Guidance control

  Horizontal: PID

  Vertical: PID

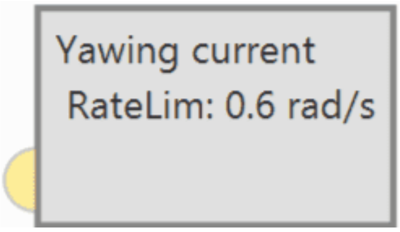
Moreover, the output of each of the **Arcade Pure** blocks are used as inputs for this guidance block. These output values match the value of the Stick input when the aircraft is controlled in **Arcade mode**.



- Arcade Pure (Arc-Pitch) ⇒ **fv**: The **Pitch** value commanded by the **stick** will be the **first** component of the desired 'hover here' arcade velocity in the horizontal plane.
- Arcade Pure (Arc-Roll) ⇒ **lv**: The **Roll** value commanded by the **stick** will be the **second** component of the desired 'hover here' arcade velocity in the horizontal plane.
- Arcade Pure (Arc-Throttle) ⇒ **dv**: The **Throttle** value commanded by the **stick** will be the **down** (vertical) component of the desired 'hover here' arcade velocity.

For more information, visit the Guidance blocks common configuration - Guidance blocks section of the **1x PDI Builder** user manual.

- With the Yawing current block it is intended that the aircraft **maintains the yaw angle it has when entering the phase**, i.e. Desired Yaw = Current Yaw.

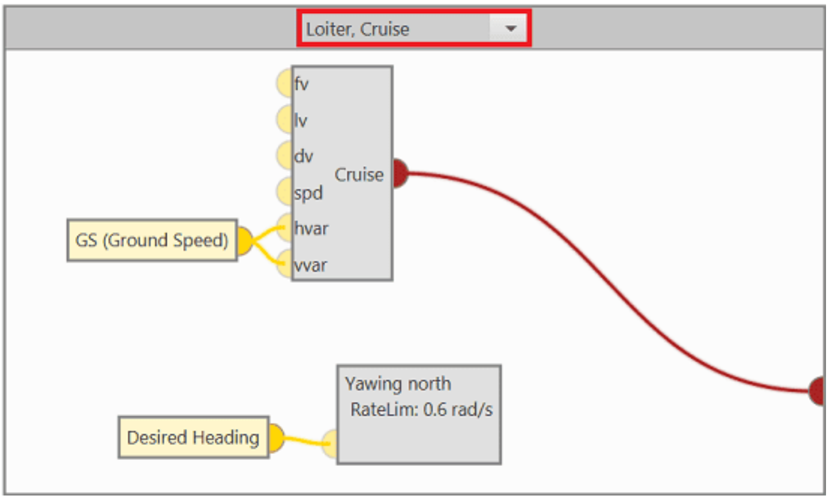
  

  In addition, a **limit rate value** of $0.6\ rad/s$ has been defined to control the speed at which the aircraft yaws in the guidance of this phase.

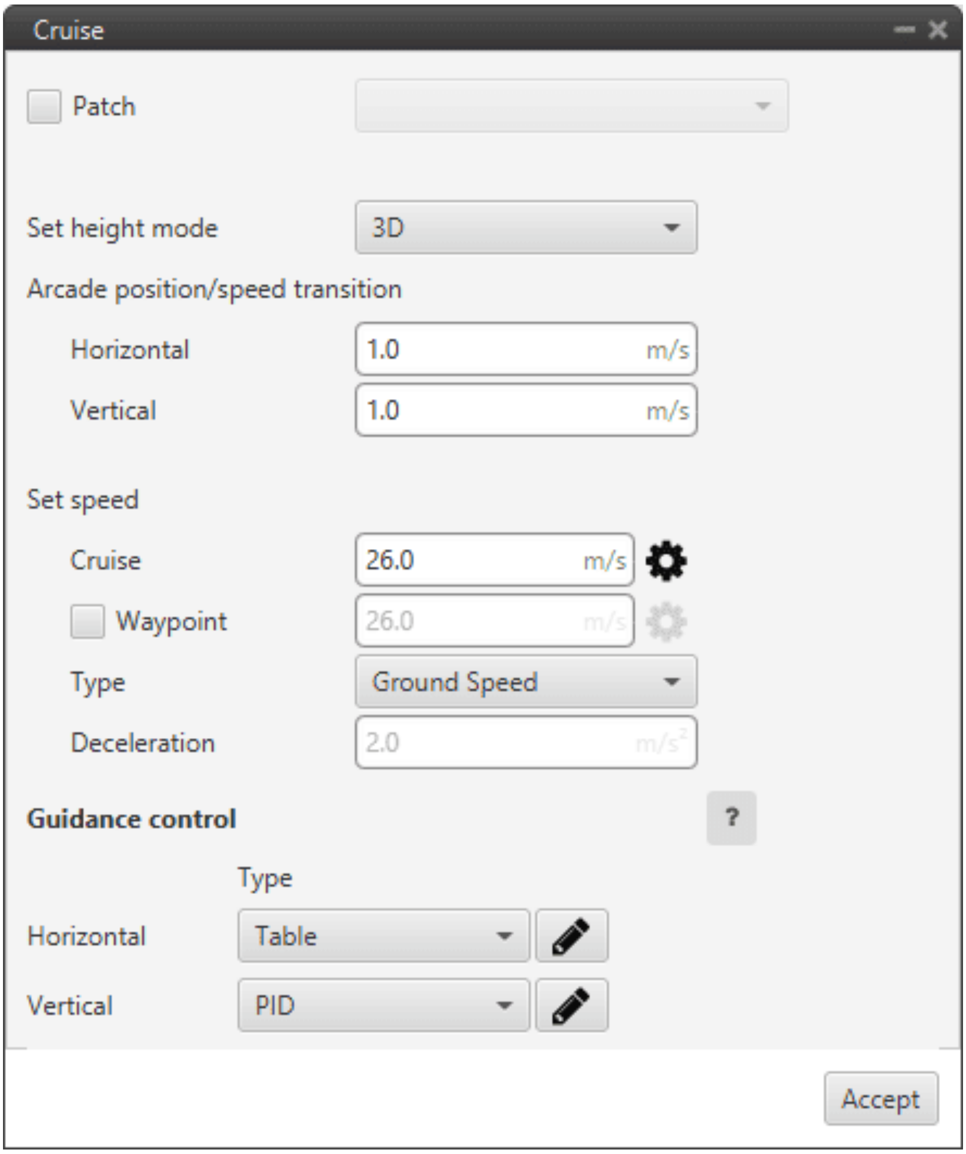
- **Loiter** and **Cruise**

  The guidance configuration for theses phases is composed of the Cruise block, which is linked to the Config input, and the Yawing north block.

  - **Cruise** guidance is used to make the aircraft follow a position-based route created by the user.

    A basic configuration of this block is shown below:

- 

  Patch: Disabled

- Set height mode: 3D

- Arcade position/speed transition

  Horizontal: 1.0 m/s

  Vertical: 1.0 m/s

- Set speed

  Cruise: 26 m/s

  Waypoint: Disabled

  Type: Ground Speed

  Deceleration: 2.0 m/s²

- Guidance control

  Horizontal: PID

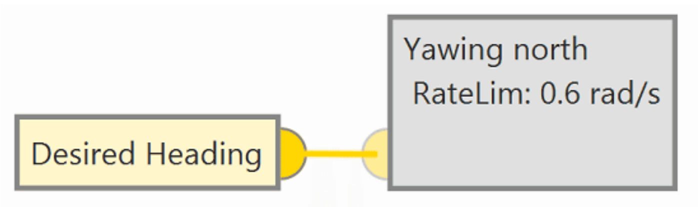
  Vertical: PID

In addition, the GS (Ground Speed) variable is linked to 2 inputs of this guidance block:

- GS (Ground Speed) ⇒ **hvar**: **Horizontal** scale variable used for the T-Sched PID.
- GS (Ground Speed) ⇒ **vvar**: **Vertical** scale variable used for the T-Sched PID.

For more information, visit the Guidance blocks common configuration - Guidance blocks section of the **1x PDI Builder** user manual.

- With the Yawing north block it is desired that the aircraft maintains the yaw to the north (angle 0º). However, if there is any variable connected to the input of the block, this is taken as an offset with respect to the reference, that being 0º, the aircraft will point directly to the angle indicated as offset.



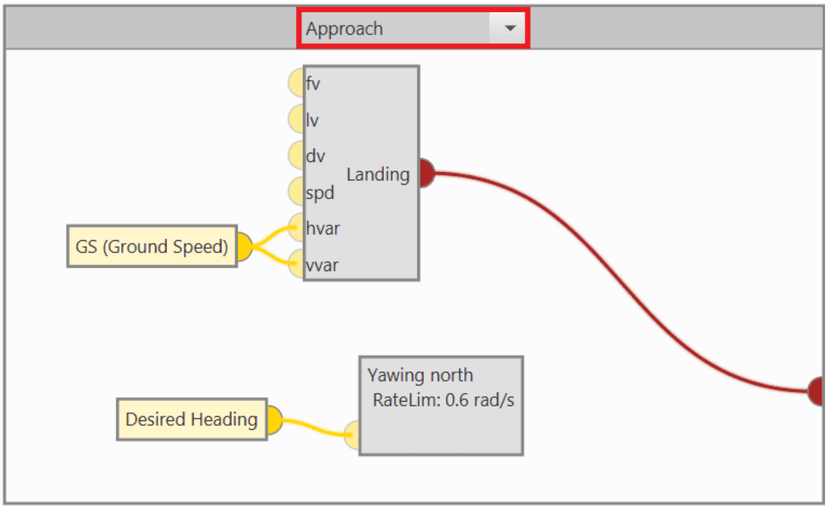
In this case, the variable Desired Heading is connected to the input, so Desired Yaw = Desired Heading.

In addition, a **limit rate value** of $0.6\ rad/s$ has been defined for controlling the speed at which the aircraft yaws in the guidance of this phase.

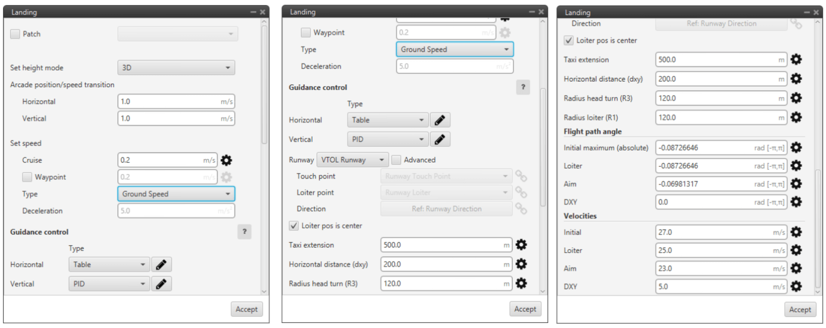
- **Approach**

  The guidance configuration in this phase consists of the Landing block, which is linked to the Config input, and the Yawing north block.

  - **Landing** guidance is used to generate the flying path the aircraft will follow when landing on a certain runway.



A basic configuration of this block is shown below:

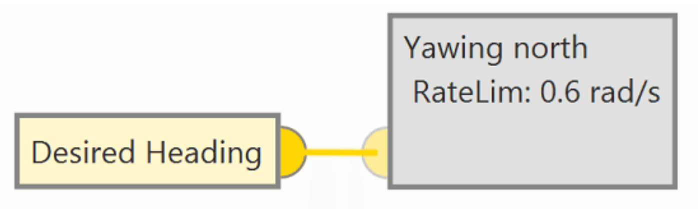


In addition, the GS (Ground Speed) variable is linked to 2 inputs of this guidance block:

- GS (Ground Speed) ⇒ **hvar**: **Horizontal** scale variable used for the T-Sched PID.
- GS (Ground Speed) ⇒ **vvar**: **Vertical** scale variable used for the T-Sched PID.

For more information, visit the Guidance blocks common configuration - Guidance blocks section of the **1x PDI Builder** user manual.

- With the Yawing north block it is desired that the aircraft maintains the yaw to the north (angle 0º). However, if there is any variable connected to the input of the block, this is taken as an offset with respect to the reference, that being 0º, the aircraft will point directly to the angle indicated as offset.

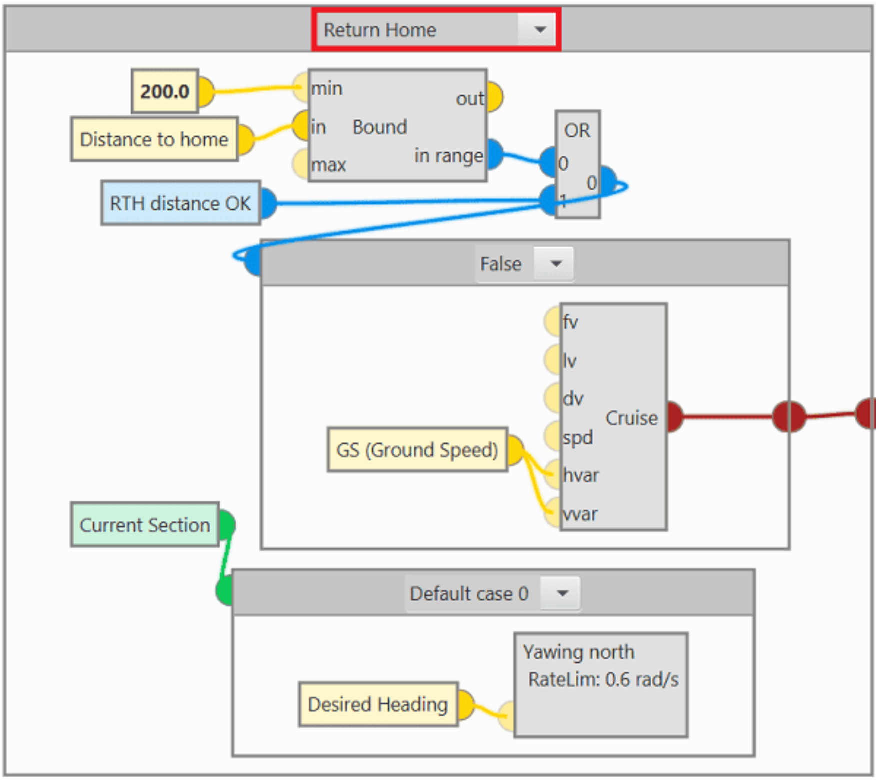


In this case, the variable Desired Heading is connected to the input, so Desired Yaw = Desired Heading.

In addition, a **limit rate value** of $0.6 \ rad/s$ has been defined for controlling the speed at which the aircraft yaws in the guidance of this phase.

- **Return Home**

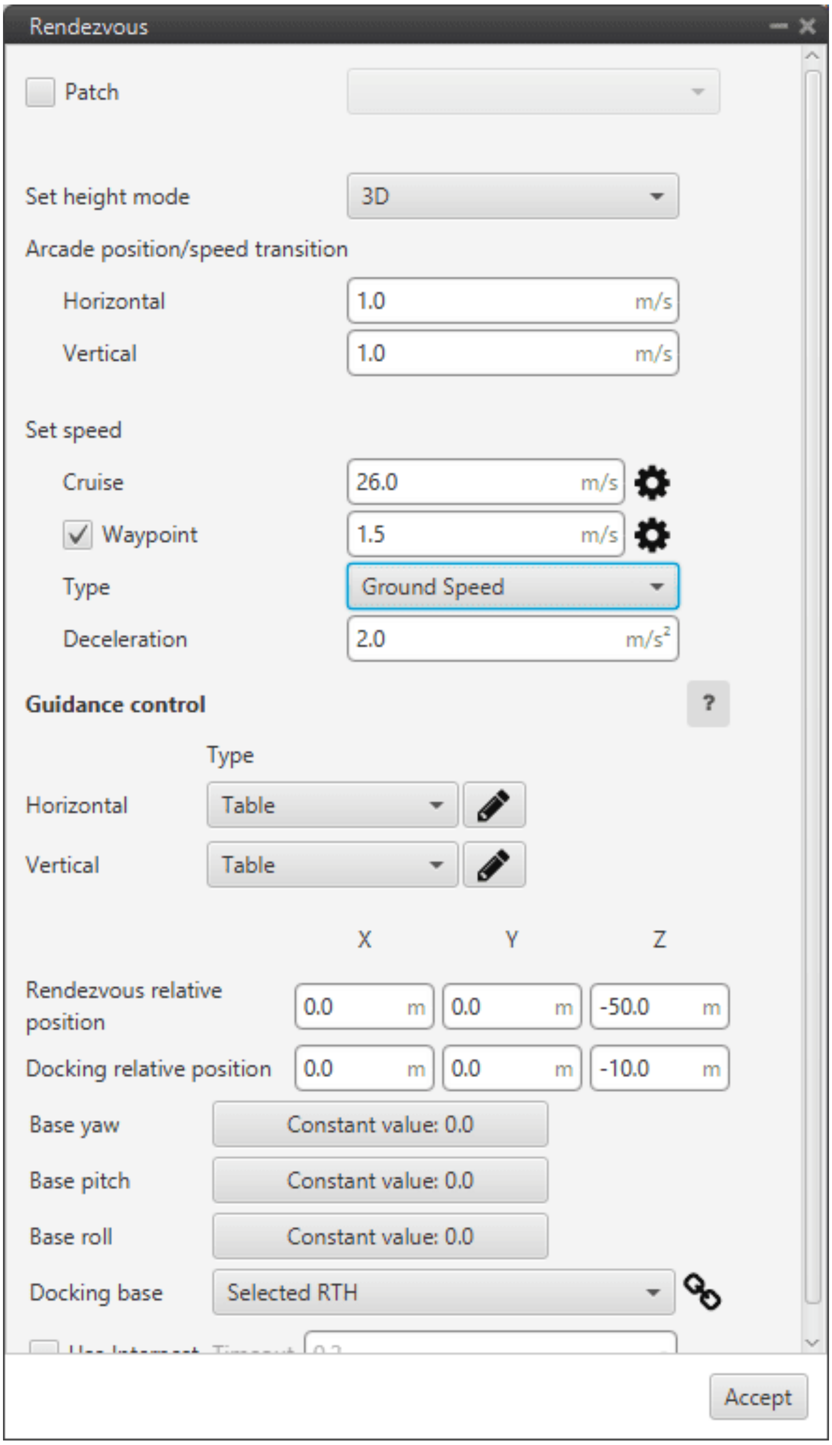
  On the one hand, the configuration of the guidance in this phase which will be linked to the Config input, depends on the definition of the **Home** point.



- If the Home point is **defined**, the Rendezvous block defines the guidance configuration for this phase.

> **Explanation**
>
> For the Home point to be defined, one of the two input bits of the **OR** block must be **true**.

Rendezvous guidance is used to follow a route to the runway. A basic configuration of this block is shown below:



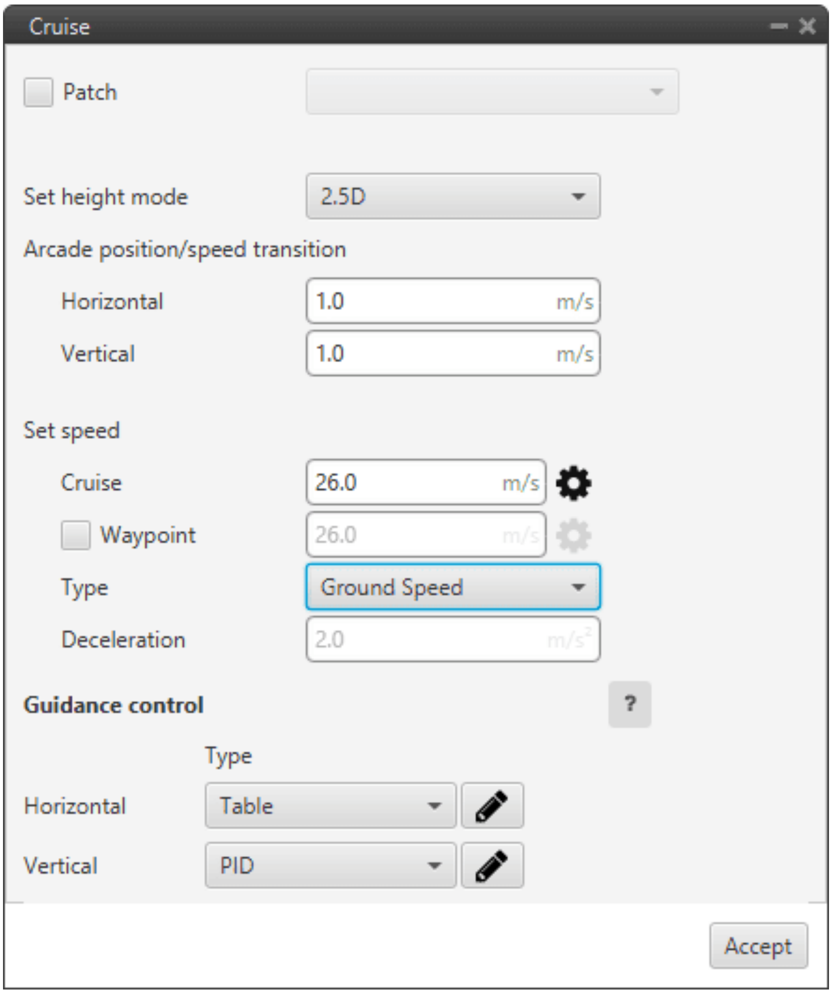
In addition, the GS (Ground Speed) variable is linked to 2 inputs of this guidance block:

- GS (Ground Speed) ⇒ **hvar**: **Horizontal** scale variable used for the T-Sched PID.
- GS (Ground Speed) ⇒ **vvar**: **Vertical** scale variable used for the T-Sched PID.

For more information, visit the Guidance blocks common configuration - Guidance blocks section of the **1x PDI Builder** user manual.

- If the Home point is **not defined**, the Cruise block defines the guidance configuration for this phase.

Cruise guidance is used to follow a route until the Home point is defined. A basic configuration of this block is shown below:



In addition, the GS (Ground Speed) variable is linked to 2 inputs of this guidance block:

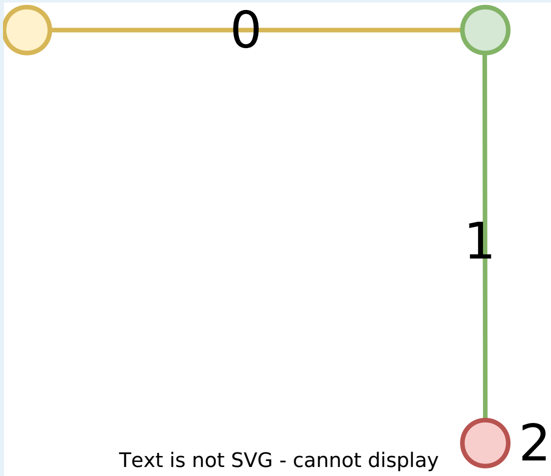
- GS (Ground Speed) ⇒ **hvar**: **Horizontal** scale variable used for the T-Sched PID.
- GS (Ground Speed) ⇒ **vvar**: **Vertical** scale variable used for the T-Sched PID.

For more information, visit the Guidance blocks common configuration - Guidance blocks section of the **1x PDI Builder** user manual.

On the other hand, the value of the **Current Section** variable defines the aircraft reference for **Yaw**, i.e. it defines which yawing guidance block will be employed.

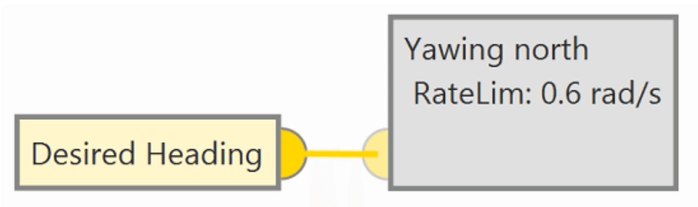
Note

Rendezvous guidance is divided into 3 sections (0, 1 and 2) where the aircraft behavior changes.



Sections of the rendezvous guidance

- In **case 0**, the Yawing north block is used.

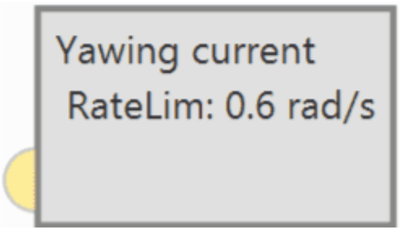


With this block it is desired that the aircraft maintains the yaw to the north (angle 0º).

However, if there is any variable connected to the input of the block, this is taken as an offset with respect to the reference, that being 0º, the aircraft will point directly to the angle indicated as offset.

In this case, the variable Desired Heading is connected to the input, so Desired Yaw = Desired Heading.
In addition, a **limit rate value** of $0.6\ rad/s$ has been defined for controlling the speed at which the aircraft yaws in the guidance of this phase.

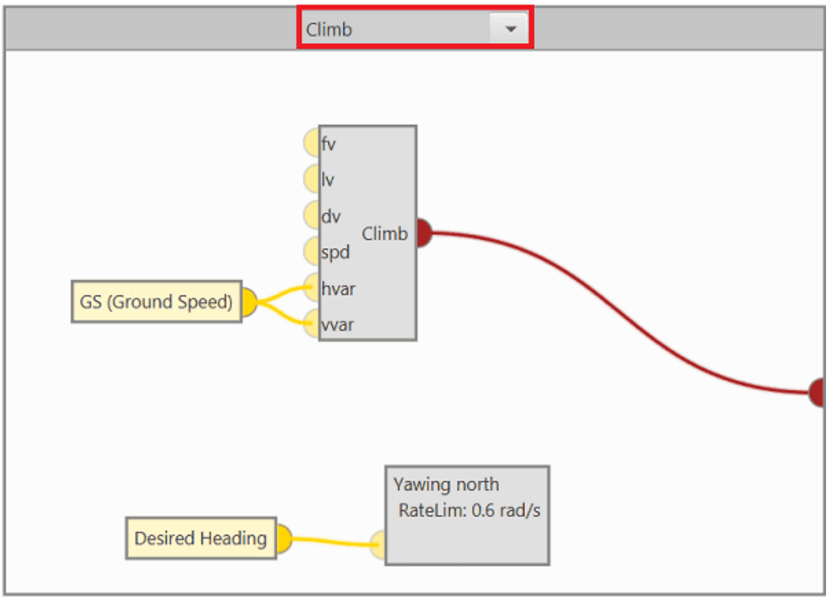
- In **cases 1 and 2**, the Yawing current block is used:



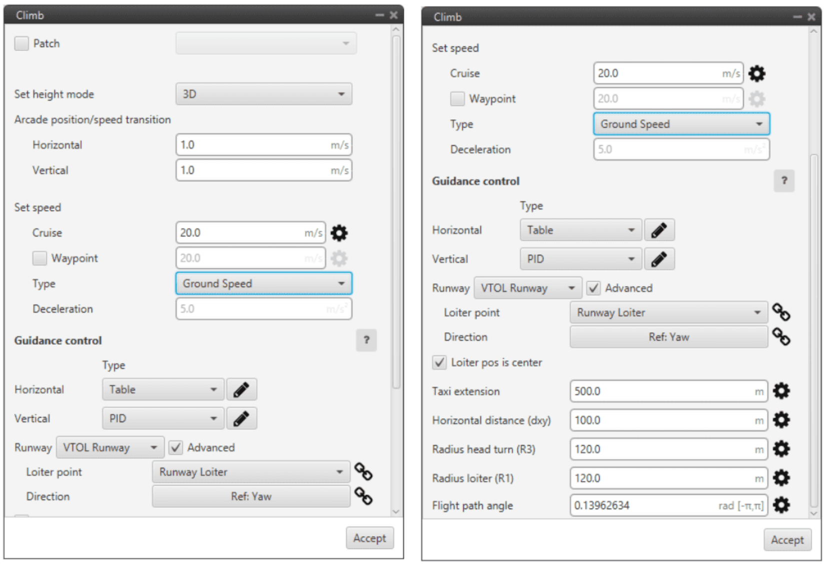
With the Yawing current block it is intended that the aircraft **maintains the yaw angle it has when entering the phase**, i.e. Desired Yaw = Current Yaw.

In addition, a **limit rate value** of $0.6\ rad/s$ has been defined to control the speed at which the aircraft yaws in the guidance of this phase.

- **Climb**
The guidance configuration in this phase consists of the Climb block, which is linked to the Config input, and the Yawing north block.
  - **Climb** guidance is used to make the aircraft climb from the start of the phase to another altitude.



A basic configuration of this block is shown below:

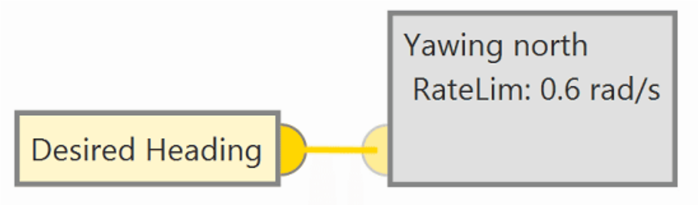


In addition, the GS (Ground Speed) variable is linked to 2 inputs of this guidance block:

- GS (Ground Speed) ⇒ **hvar**: **Horizontal** scale variable used for the T-Sched PID.
- GS (Ground Speed) ⇒ **vvar**: **Vertical** scale variable used for the T-Sched PID.

For more information, visit the Guidance blocks common configuration - Guidance blocks section of the **1x PDI Builder** user manual.

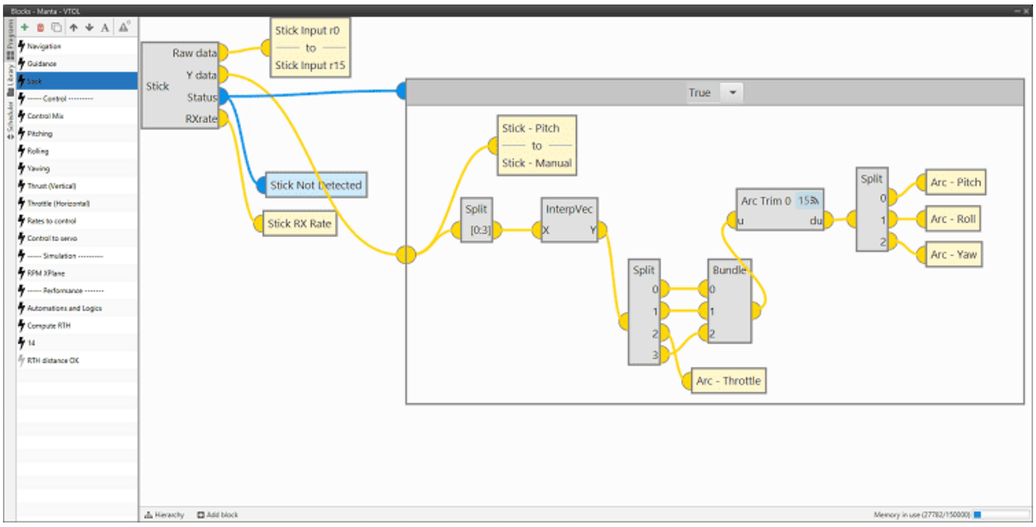
- With the Yawing north block it is desired that the aircraft maintains the yaw to the north (angle 0º). However, if there is any variable connected to the input of the block, this is taken as an offset with respect to the reference, that being 0º, the aircraft will point directly to the angle indicated as offset.



In this case, the variable Desired Heading is connected to the input, so Desired Yaw = Desired Heading.

In addition, a **limit rate value** of $0.6\ rad/s$ has been defined for controlling the speed at which the aircraft yaws in the guidance of this phase.

Stick



Stick - Program

Users can observe 2 parts in this program:

- **Stick block**

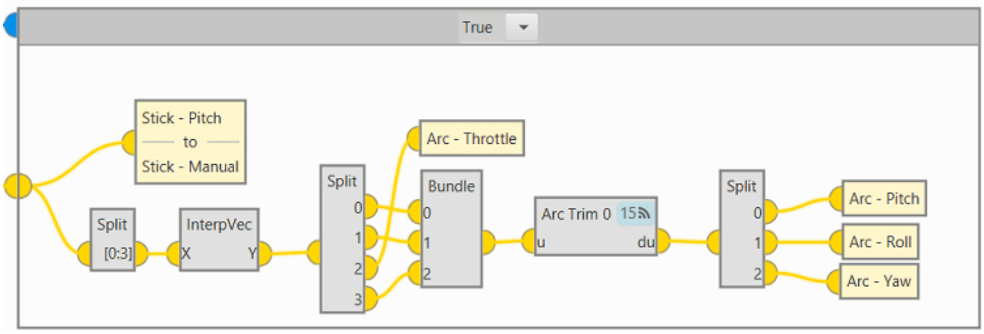
Stick block is a stick reader, with it the user can configure the stick parameters for manual and arcade modes.

- The configuration of this block while performing **simulation** is detailed in the Stick - Simulation section of this manual.
- In the section Stick - Air-GCS Connection of this manual, the user can find more information on configuring the **Stick** block for **real operation**.

- **If-Else Switch block**

  This block is defined to write the control variables that are commanded by the stick:

  - **Arc - Pitch**
  - **Arc - Roll**
  - **Arc - Yaw**
  - **Arc - Throttle**

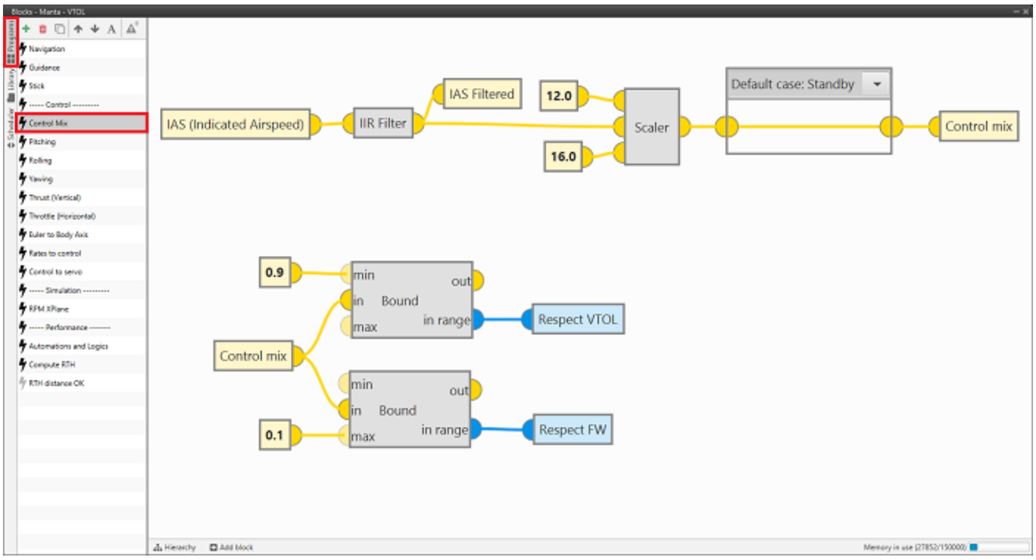


The behavior of this block depends on the value of the output Status of the Stick block. When this output is **True**, the output Y data of the Stick block is linked to this block as an entry and the transformation of the values of this output follows the following logic:

1. The Split block is used to transform the input vector to form one with the first four variables of the input vector.
2. This vector is interpolated with the InterpVec block.
3. With the Split and Bundle blocks, this vector is transformed into a three-component vector.
4. Finally, the vector is passed through the Arc Trim block and the variables are named by separating them with the Split block.

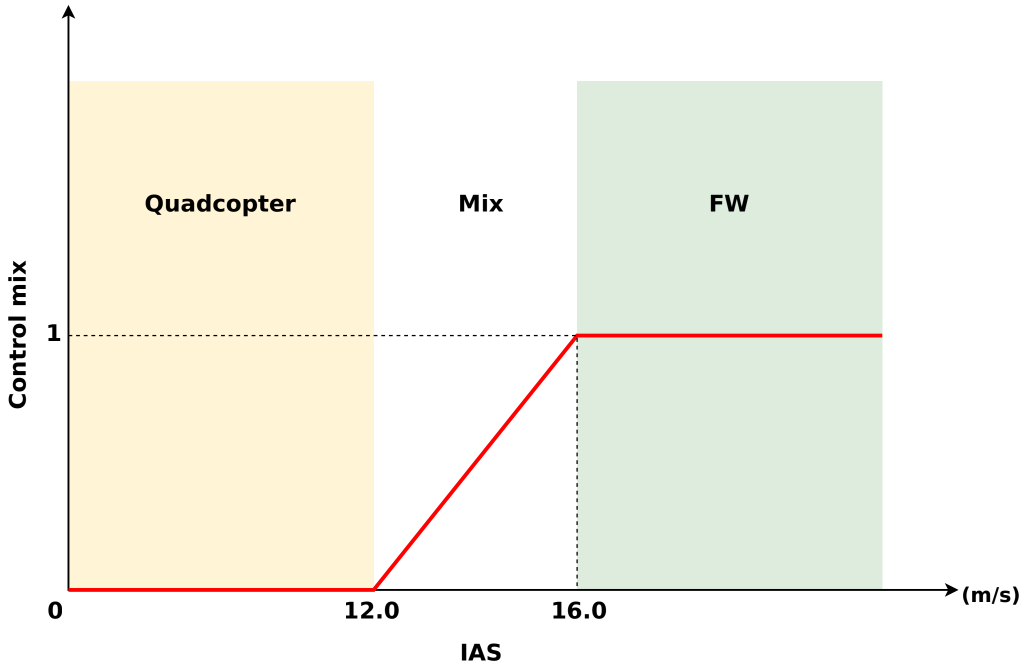
Control Mix

Control Mix - Program is based on the value of the IAS (Indicated Airspeep) to determine the **flight configuration** of the platform (**Multi or FW**). The program executes several calculations to determine the Control mix variable, which has a value from 0 to 1, and indicates the speed at which the platform should switch its flight configuration to FW.



Control Mix - Program

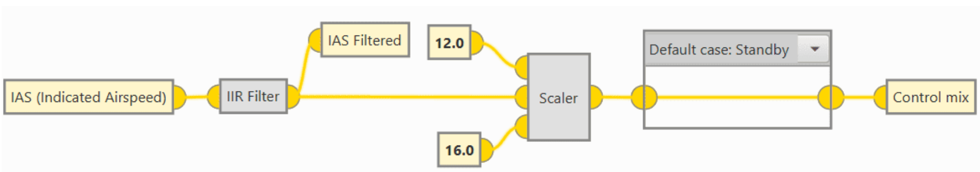
Analytically, the following diagram shows the operation of the program, which provides a value to the Control mix variable depending on the value of the IAS.



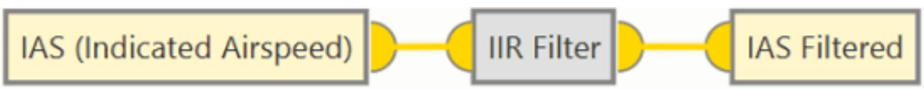
- **Control mix = 0** ⇒ indicates that the platform should adopt a quadcopter configuration.
- **0 < Control mix < 1** ⇒ indicates that the platform will operate in multicopter mode and in FW mode equally.
- **Control mix = 1** ⇒ indicates that the platform should adopt a FW configuration.

The operation of the program can be divided into two stages. A first stage in which, depending on the IAS, a value is assigned to the Control mix variable and a second stage in which, depending on the value of the Control mix variable, the flight configuration is determined.

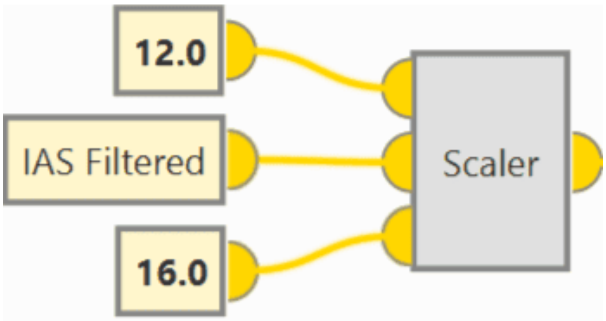
1. **Value of the variable**



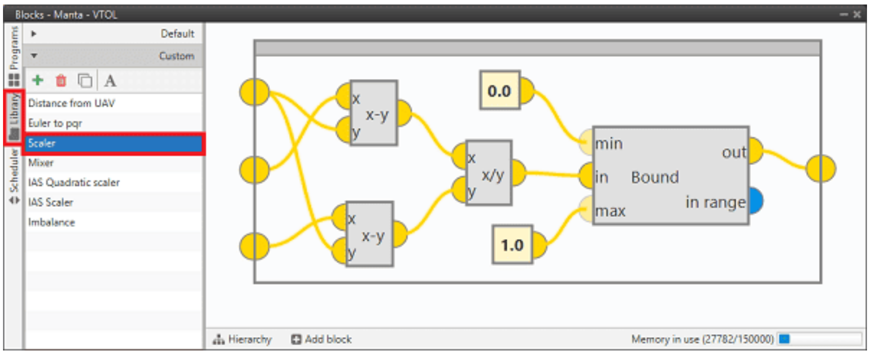
   - To evaluate the IAS variable in a controlled way, the IIR Filter block is applied to it, which returns the IAS Filtered variable.



   - The IAS Filtered variable is evaluated in the **Scaler** block. This block returns a value between 0 and 1, with respect to two limit values.

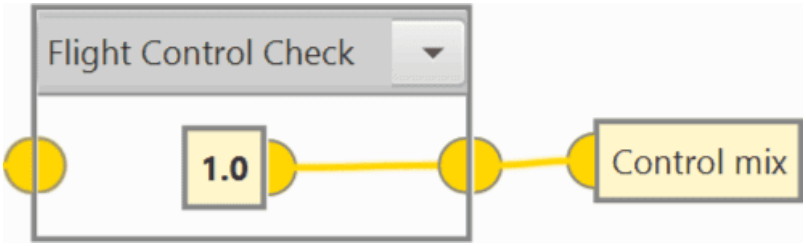


The **Scaler** block is a **custom** block located in the **Library**.

> **Scaler Block - Explanation**
>
> **Scaler** block rates the input value with respect to the range defined by the limit values (12 to 16).
>
> 
>
>
> **Scaler - Program**
>
> Bound block returns a maximum value **1** and a minimum value **0**.

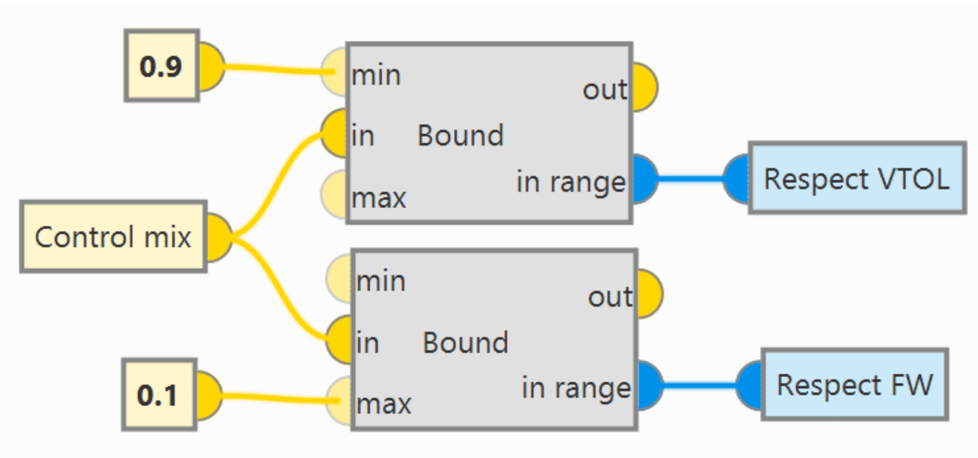
- Depending on the flight phase, **Flight Control Check** or **Standby**, the Control mix variable is assigned.
  - **Standby**: In this flight phase the Control mix variable is the output value of the **Scaler** block.

  - **Flight Control Check**: In this flight phase, the Control mix variable has value **1.0** since it is necessary for the aircraft to act in FW configuration.



2. **Flight configuration**

   This part of the program is used to keep stable the PID controllers that allow the control of the aircraft. This control is performed with the value of the Control mix variable.



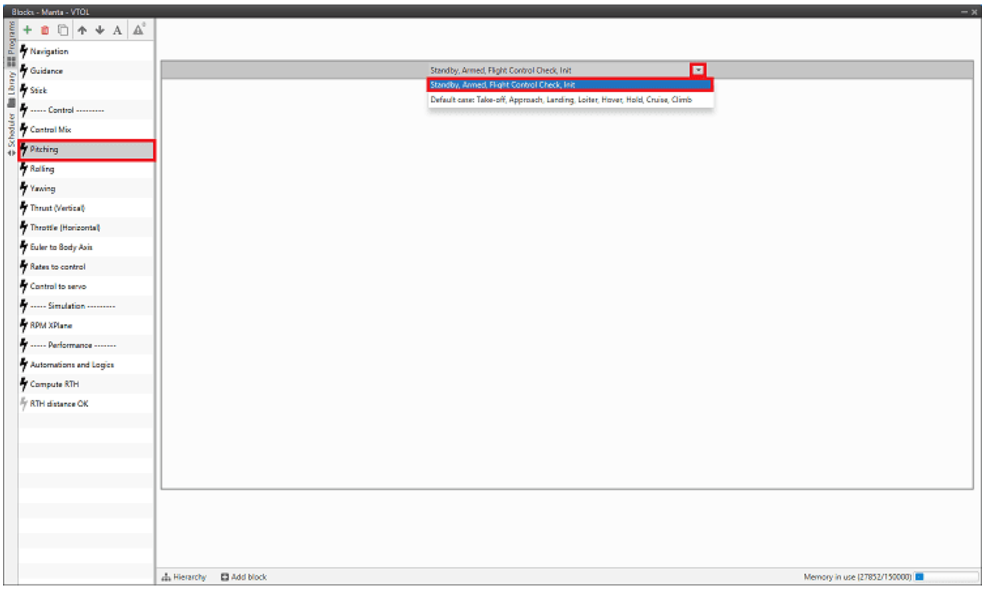
   - If **Control mix > 0.9**, Respect VTOL bit is true and the PID quadcopter controller is stabilized.
   - If **Control mix < 0.1**, Respect FW bit is true and the PID FW controller is stabilized.

Pitching

The following program is used to define the behavior and control of the aircraft to perform **Pitch**. The design of the program is made according to the flight phase, dividing the program into three groups of phases where the design of the control laws are similar.

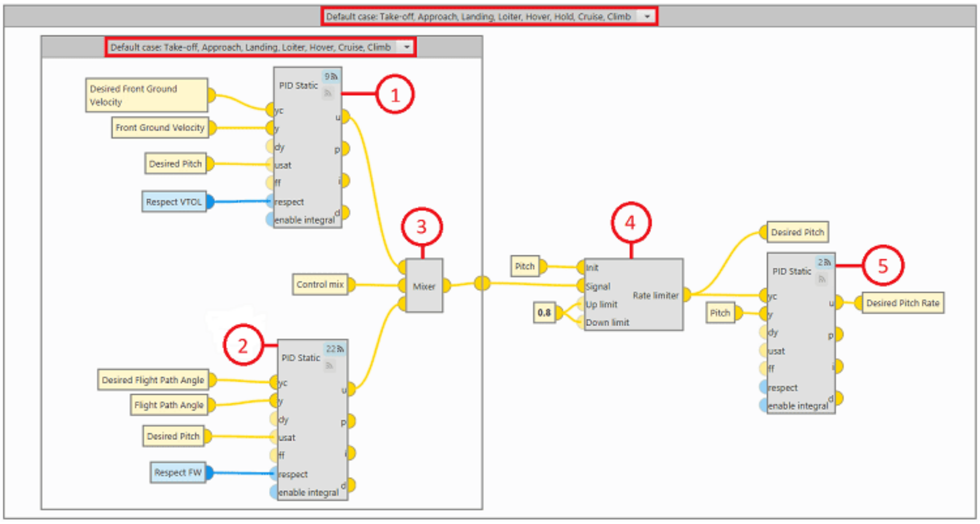
- **Standby, Armed, Flight Control Check, Init**

  In these flight phases, the aircraft does not require any design laws for pitch control since it is not flying.



- **Take-off, Approach, Landing, Loiter, Hover, Cruise, Climb**

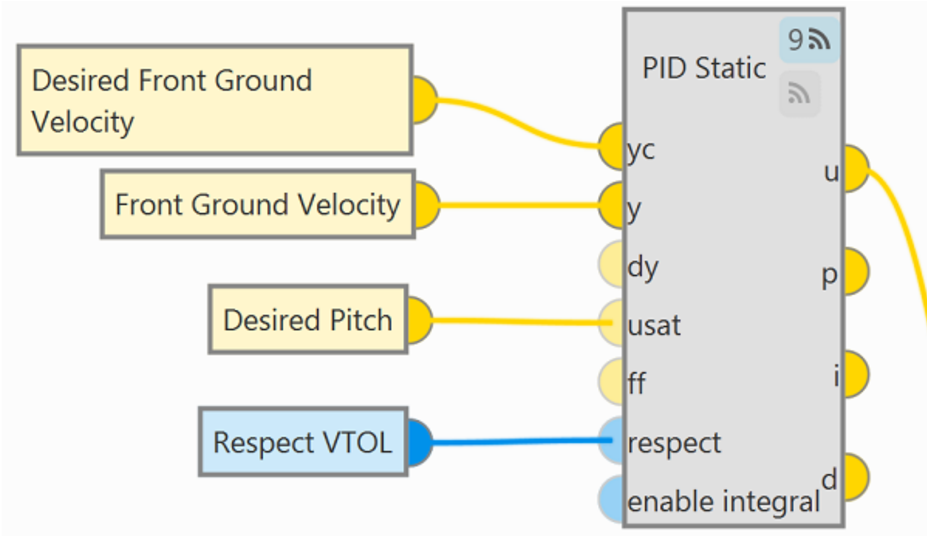
  Pitch control will depend on the Control mix variable, since the aircraft flight configuration is essential in controlling the aircraft.



The program is basically controlled by 3 PID controllers, which provide the speed ratio as a function of the input variable and the desired variable.

1. The PID controller is defined for **quadcopter** flight configuration.

   In the **quadcopter** configuration, Pitch is performed to be able to control the **Front Ground Velocity**, so this velocity will be the input variable in the PID controller.

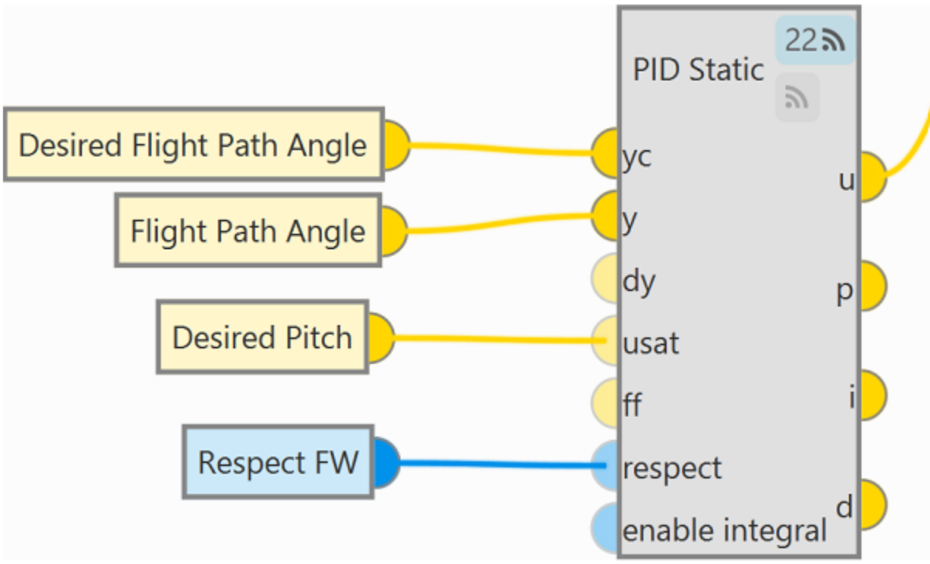


Important

When the **Respect VTOL** bit (set in the Control Mix program) is true, the **u** output of the PID block is equal to the **usat** input. That is, when the bit is true, the output of the PID block will be the output variable of the Rate limiter block, Desired Pitch.

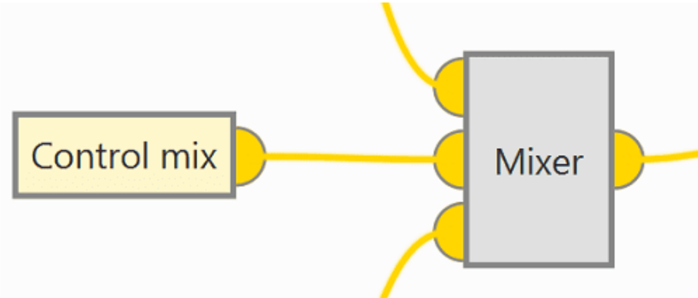
2. The PID controller is defined for the **FW** flight configuration.

   In **FW** configuration, Pitch is performed to control the **Flight Path Angle**, so this variable will be the input variable in the PID controller.

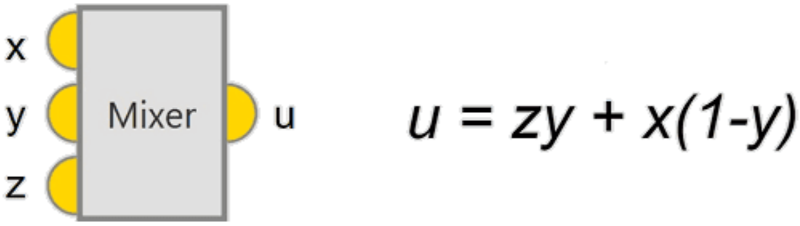


> **Important**
>
> When the **Respect FW** bit (set in the Control Mix program) is true, the **u** output of the PID block is equal to the **usat** input. That is, when the bit is true, the output of the PID block will be the output variable of the Rate limiter block, Desired Pitch.

3. **Mixer** block provides the output signals of the above PID controllers depending on the Control mix variable.

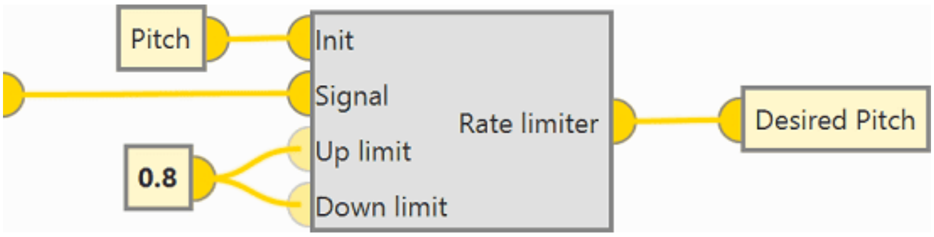


Mixer block is a **custom** program located in the **Library**.

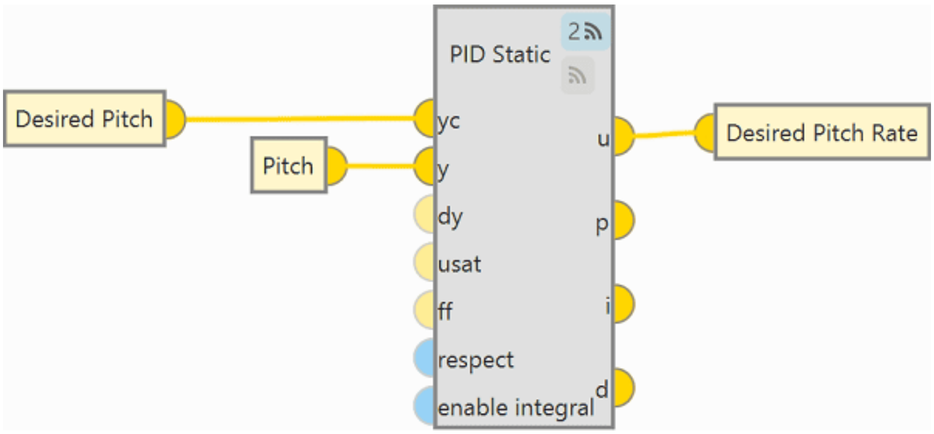
> **Mixer Block - Explanation**
>
> **Mixer** block implements the following relationship between input variables and output variables.
>
> 
>
>
> For more information on custom blocks, visit the Library blocks - Block Programs section of the **1x PDI Builder** user manual.

4. The Rate limiter block is defined to adjust the input signal to a **controlled gain**.

   This block limits the rate of change of the variable by limiting the rate of rise and fall of the variable. The purpose is to achieve a controlled rate of change that allows safe operation of the aircraft.

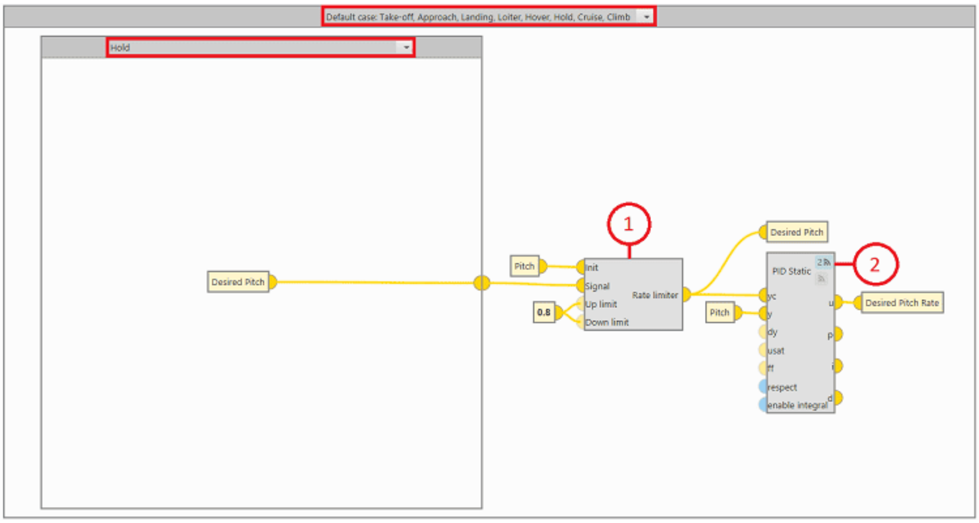


5. A PID controller is defined giving the **Desired Pitch Rate**.



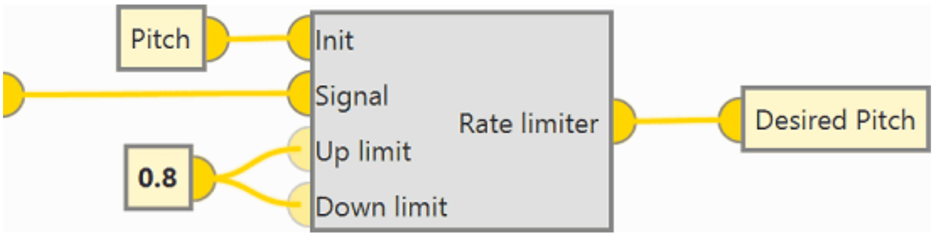
- **Hold**

  In this flight phase, the output of the PID controller is the **Desired Pitch Rate**. Since this flight phase is intended to keep the aircraft **attitude constant**, no PID controller is defined to provide a rate of change.



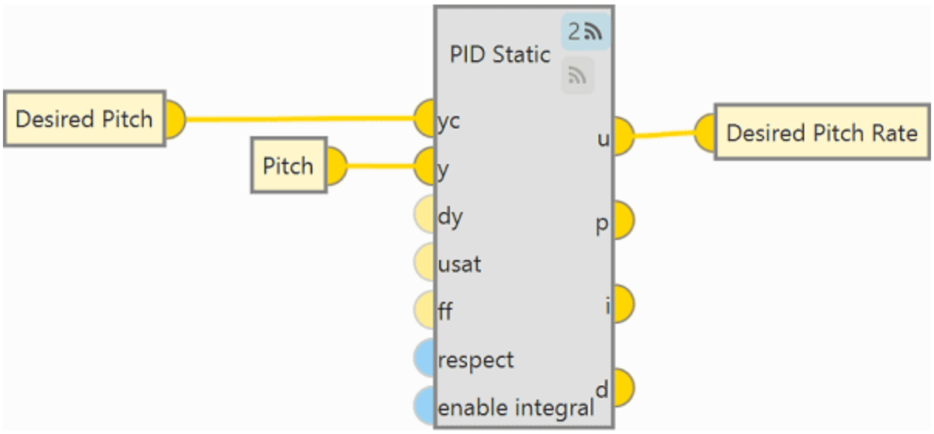
1. The Rate limiter block is defined to adjust the input signal to a controlled gain.

   This block limits the rate of change of the variable by limiting the rate of rise and fall of the variable. The objective is to achieve a controlled rate of change that allows safe operation of the aircraft.



The Signal input variable of the Rate limiter block, Desired Pitch, is generated by the Guidance program. In the Hold flight phase it is intended to stabilize the aircraft attitude, that is why the Desired Pitch control is independent of the flight configuration.

2. A PID controller is defined giving the **Desired Pitch Rate** variable.

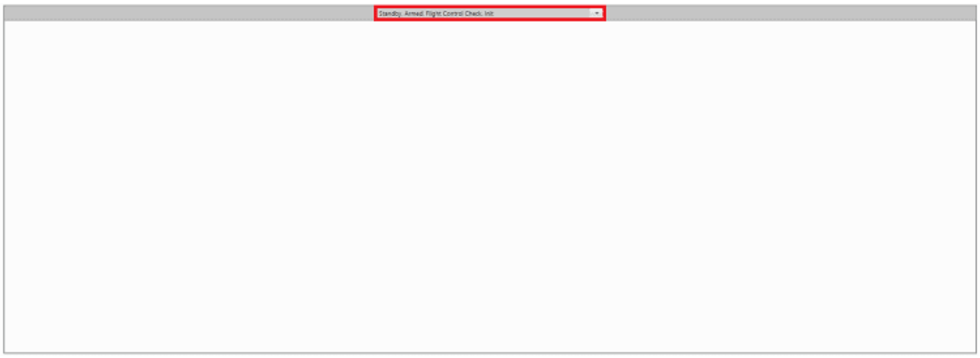


Rolling

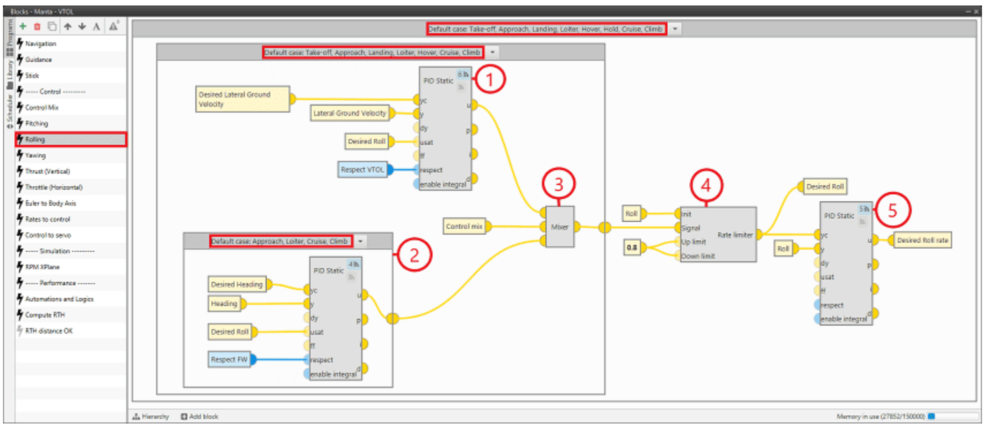
The following program is used to define the behavior and control of the aircraft to perform **Roll**. The logic of the program design is similar to the one used in the program to control the Pitch, it is done according to the flight phase in which the aircraft is, dividing the program into four groups of phases where the design of the control laws are similar.

> **Important**
>
> The effect on the aircraft when rolling depends on the flight configuration in which it is flying.
>
> If rolling is performed flying in **quadcopter configuration**, the effect on the aircraft is the variation of the **Lateral Ground Velocity** and if rolling is performed flying in **FW configuration** the effect on the aircraft is the variation of the **Heading**.

- **Standby, Armed, Flight Control Check, Init**
  In these flight phases, the aircraft does not require any design laws for roll control since it is not flying and is therefore at rest with respect to the ground.



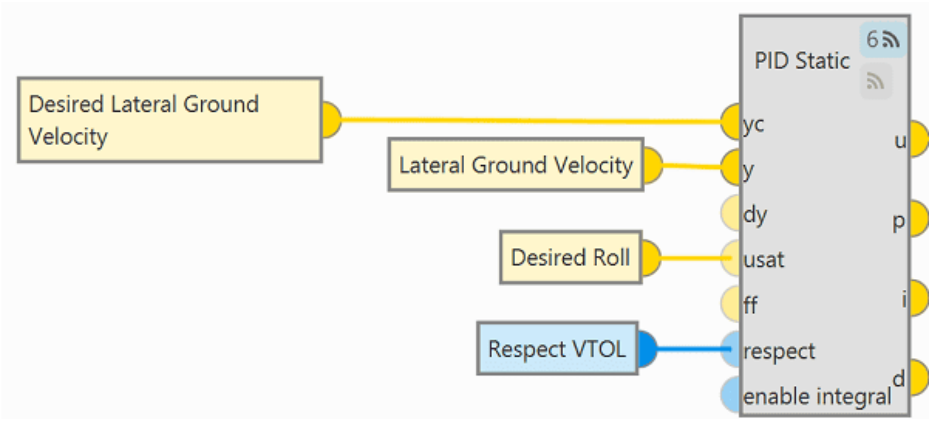
- **Approach, Loiter, Cruise, Climb**



The program is basically controlled by 3 PID controllers, which provide the speed ratio as a function of the input variable and the desired variable.

1. PID controller for **quadcopter** flight configuration.

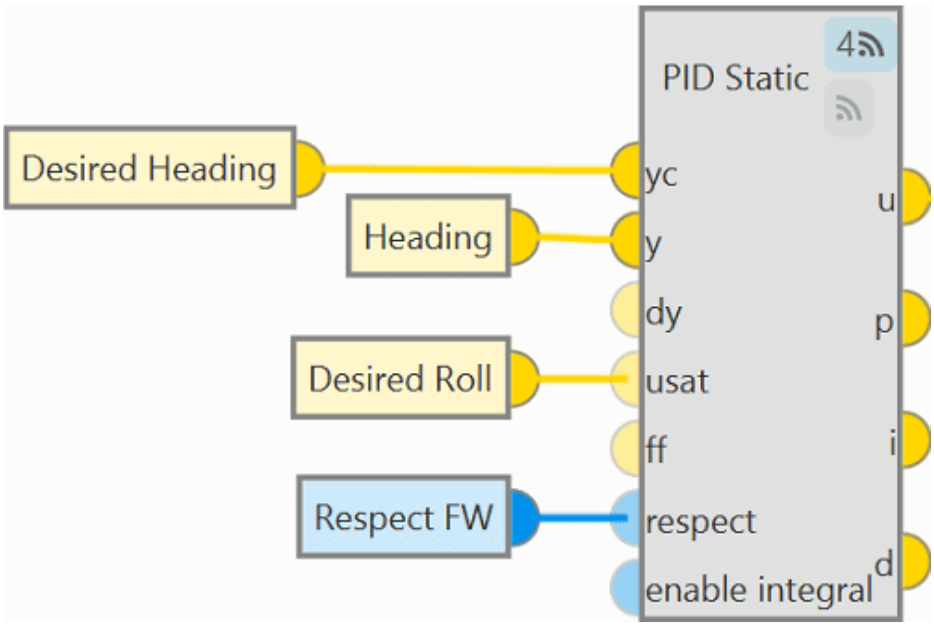
In **quadcopter** configuration, Roll is performed to be able to control the **Lateral Ground Velocity**, so this velocity will be the input variable in the PID controller.



> **Important**
>
> When the **Respect VTOL** bit (set in the Control Mix program) is true, the **u** output of the PID block is equal to the **usat** input. That is, when the bit is true, the output of the PID block will be the output variable of the Rate limiter block, Desired Roll.

2. PID controller for **FW** flight configuration.

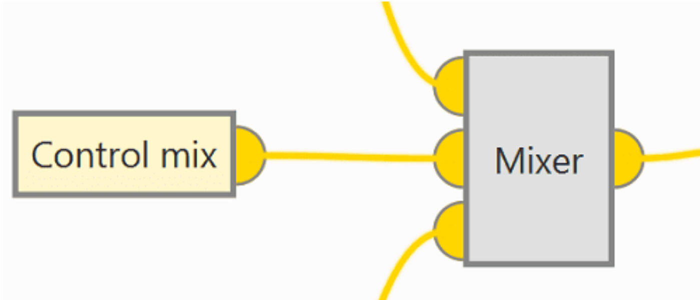
   In **FW** configuration, Roll is performed to control the **Heading**, so this variable will be the input variable in the PID controller.



Important

When the **Respect FW** bit (set in the Control Mix program) is true, the **u** output of the PID block is equal to the **usat** input. That is, when the bit is true, the output of the PID block will be the output variable of the Rate limiter block, Desired Roll.

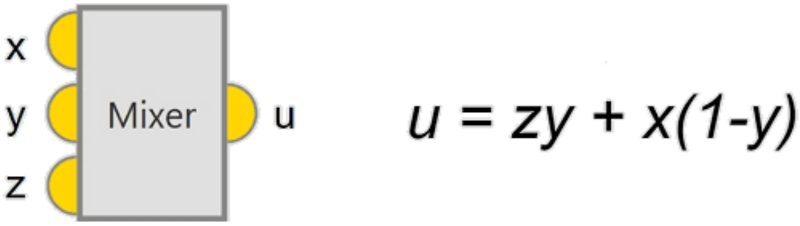
3. **Mixer** block provides the output signals of the above PID controllers depending on the Control mix variable.



Mixer block is a **custom** program located in the **Library**.

Mixer Block - Explanation

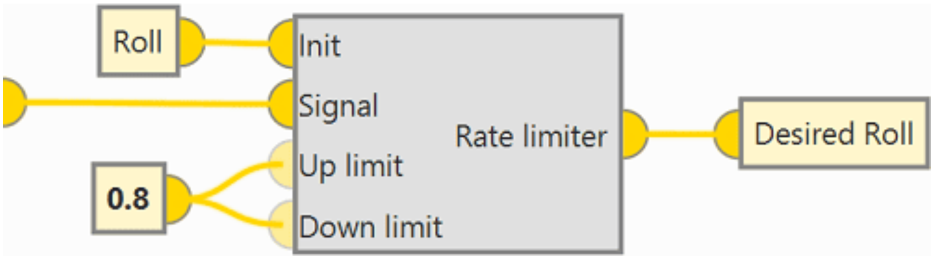
Mixer block implements the following relationship between input variables and output variables.



For more information on custom blocks, visit the Library blocks - Block Programs section of the **1x PDI Builder** user manual.

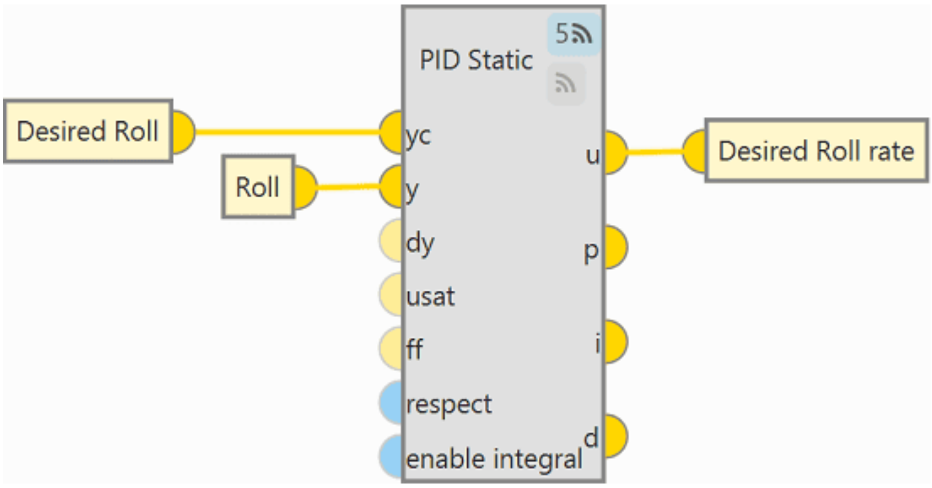
4. Rate limiter block is defined to adjust the input signal to a **controlled gain**.

It limits the rate of change of the variable controlled by the PID by limiting the rate of rise and fall of the variable. The purpose is to achieve a controlled rate of change that allows safe operation of the aircraft.

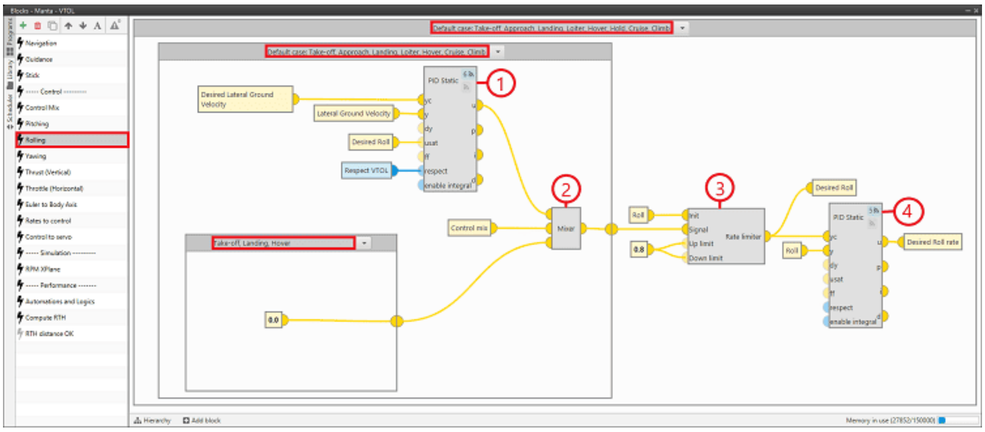


5. PID controller giving the **Desired Roll rate**.

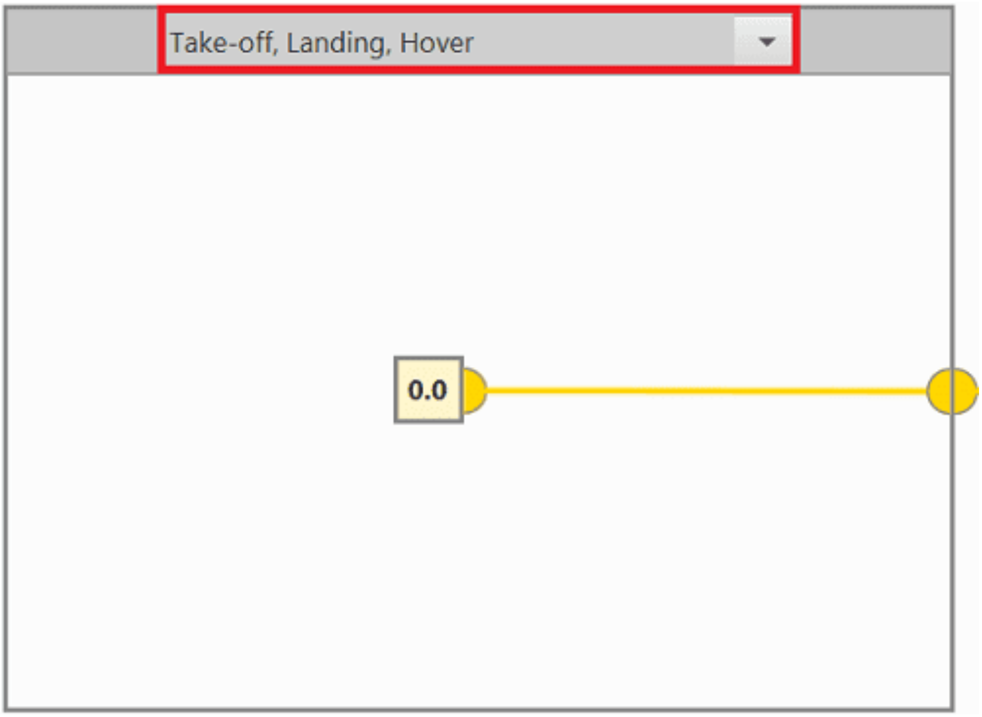
   This controller will provide the rate of change of the **Roll** variable.



- **Take-off, Landing, Hover**

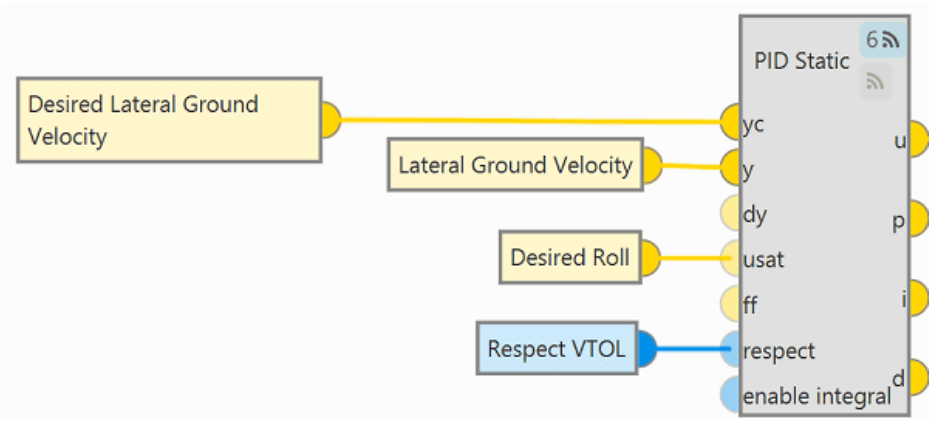


In these flight phases the **FW** flight configuration is not taken into account, since **these flight phases must be performed in quadcopter configuration**. For this reason, **no** PID controller is defined to control the **Heading**.



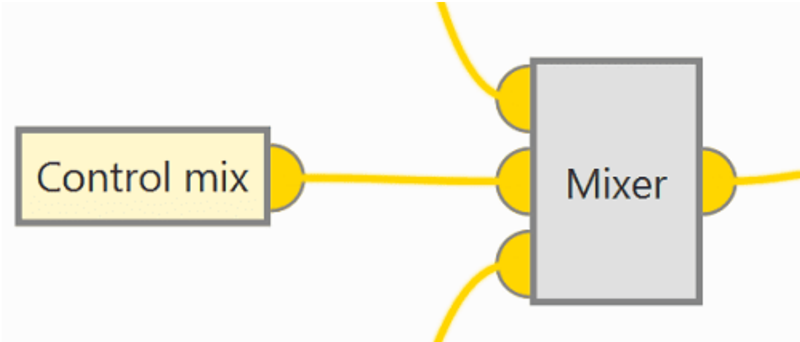
1. PID controller for **quadcopter** flight configuration.

   This controller will provide the rate of change of the Lateral Ground Velocity variable.



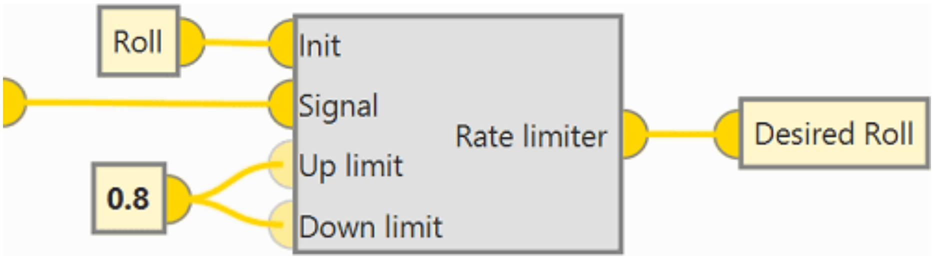
> **Important**
>
> When the **Respect VTOL** bit (set in the Control Mix program) is true, the **u** output of the PID block is equal to the **usat** input. That is, when the bit is true, the output of the PID block will be the output variable of the Rate limiter block, Desired Roll.

2. **Mixer** block provides the output signal of the above PID controller depending on the Control mix variable.



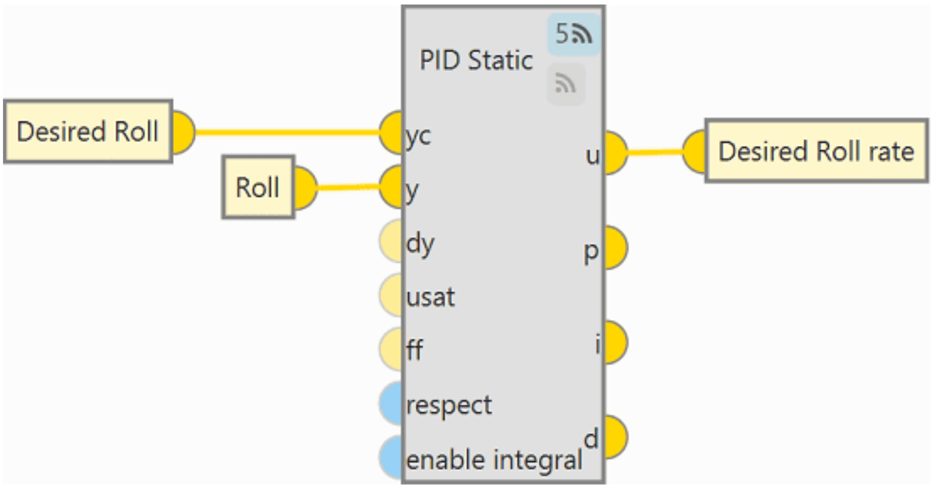
3. Rate limiter block is defined to adjust the input signal to a **controlled gain**.

   It limits the rate of change of the variable controlled by the PID by limiting the rate of rise and fall of the variable. The purpose is to achieve a controlled rate of change that allows safe operation of the aircraft.

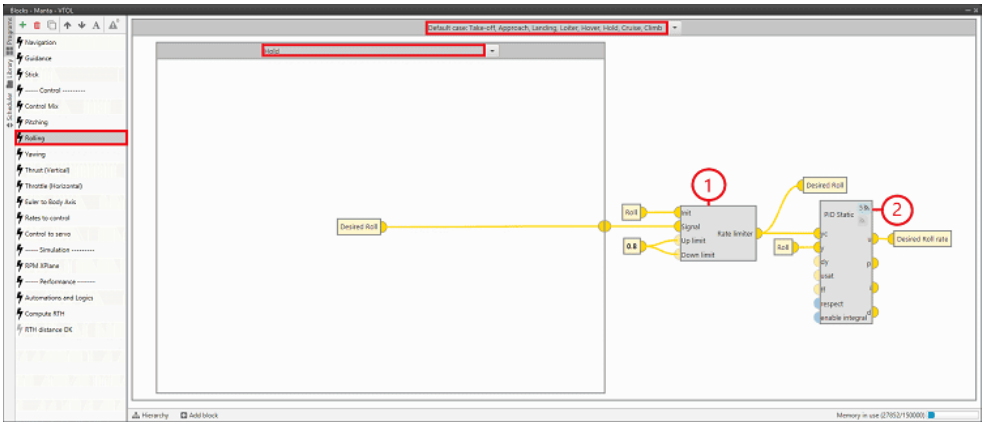


4. PID controller giving the control variable **Desired Roll rate**.

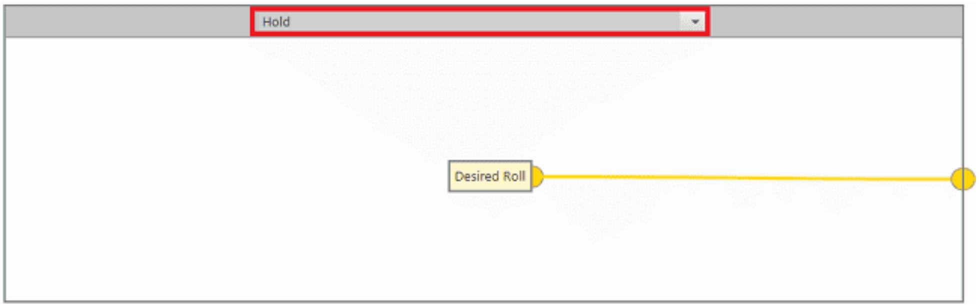
   This controller will provide the rate of change of the **Roll** variable.



- **Hold**



In this flight phase it is **not necessary** to define the **Roll control**, since it is intended to keep a **constant attitude** of the aircraft, so the value of the **Desired Roll** variable will come directly from the Guidance program.



1. Rate limiter block is defined to adjust the input signal to a **controlled gain**.
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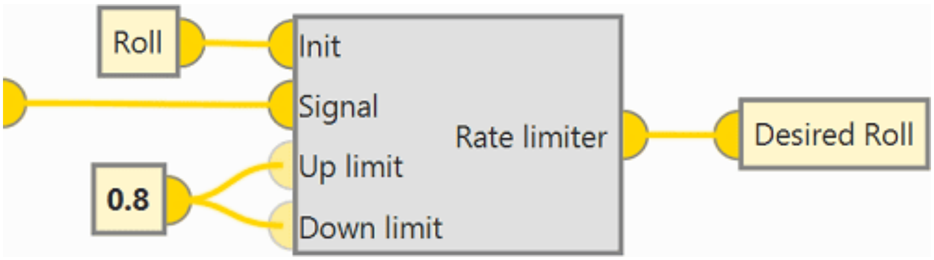
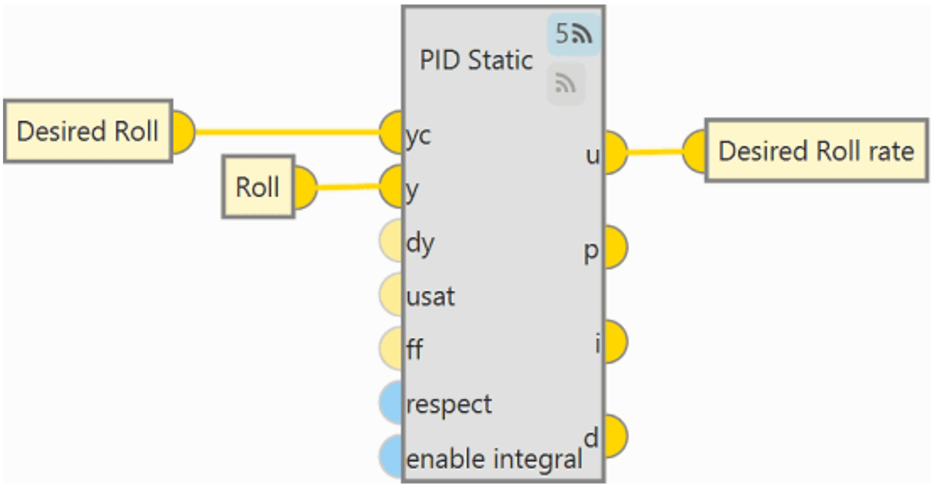
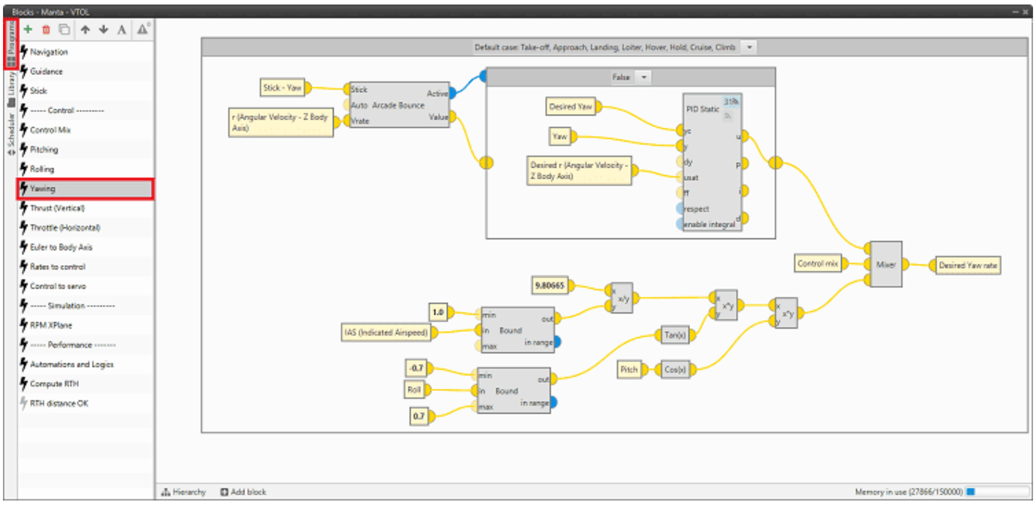


2. PID controller giving the control variable **Desired Roll rate**.
   This controller will provide the rate of change of the **Roll** variable.



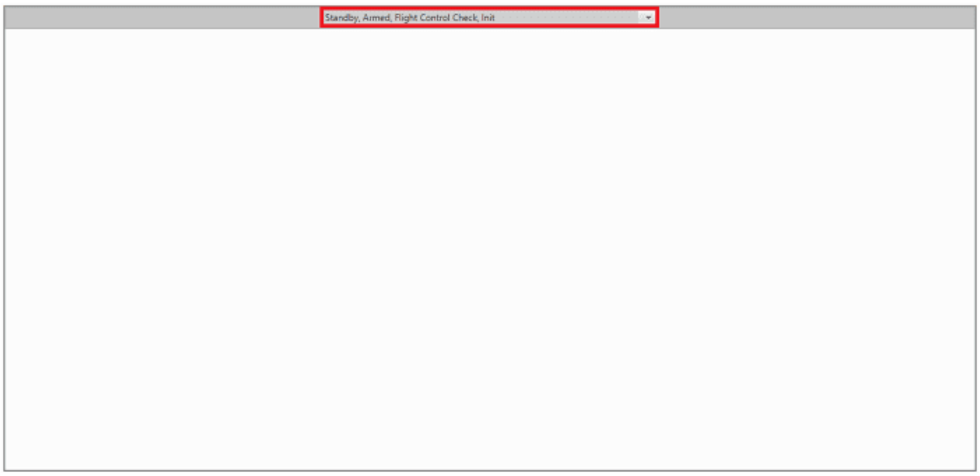
Yawing

As with the Pitching and Rolling programs, the program to control the **Yaw** is performed depending on the phase of flight in which it is flying.



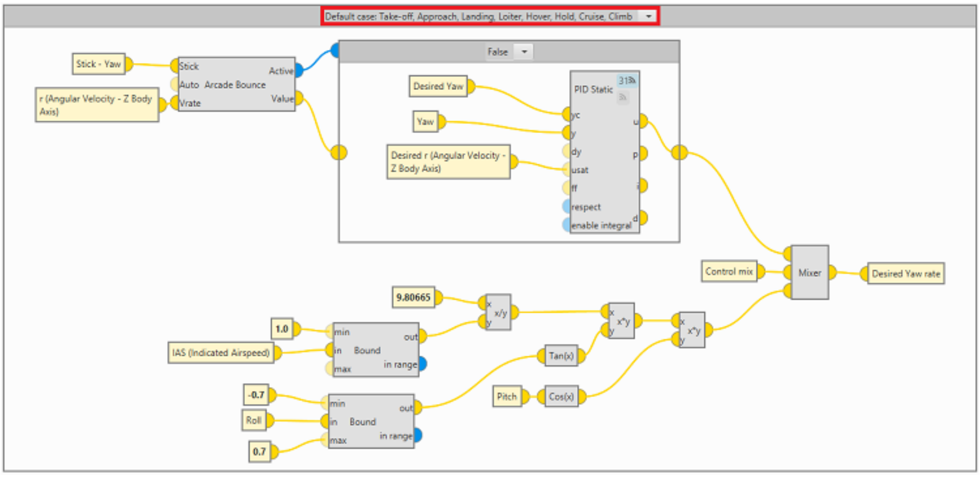
- **Standby, Armed, Flight Control Check, Init**

  For these flight phases no definition of the yaw control program is required as they are phases where the aircraft is not flying.



- **Take-off, Approach, Landing, Loiter, Hover, Hold, Cruise, Climb**

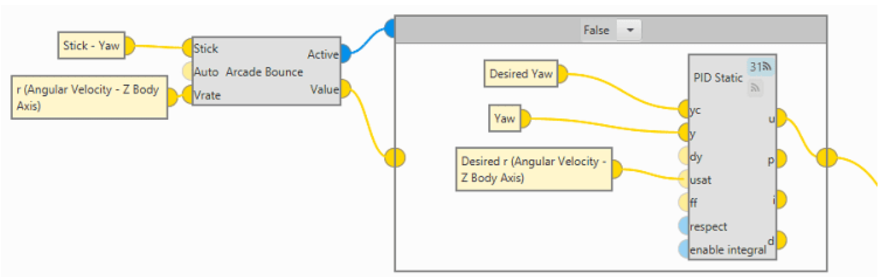
  In these flight phases, **Yaw** control is performed depending on the aircraft flight configuration, quadcopter or FW. For this reason, it is necessary to define two control paths, one to control the Yaw when the aircraft flies at **low speeds (Multi)** and another one when the aircraft flies at **high speeds** and, therefore transitions to the **Fixed Wing** (FW) flight configuration.



  The program logic has been divided into three sections/parts. Two of them to define the aircraft control according to the flight configuration and, once these controls are defined, in the third section of this program, the output signals of both are provided to the Control mix variable by means of the **Mixer** block.

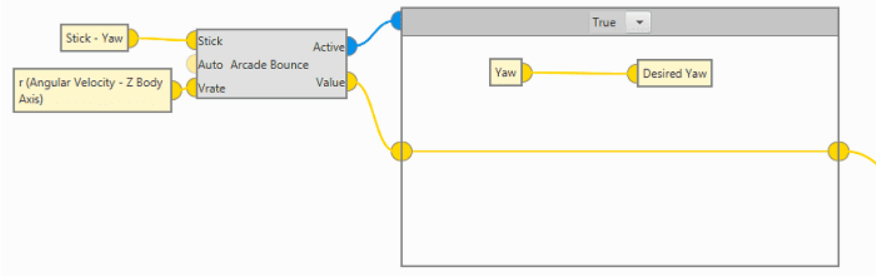
  1. **Quadcopter control**
     - **False**

       In this case, Autopilot 1x is controlled in **Auto** mode, so the Arcade Bounce block will return a **false** bit. Therefore, **Yaw** control is performed with a PID controller.



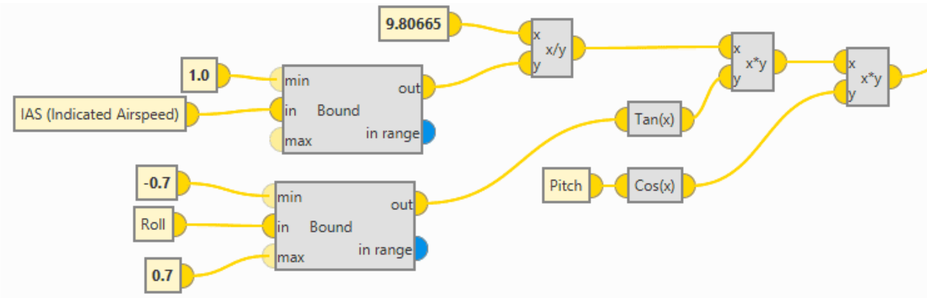
     - **True**

In this case, Autopilot 1x takes into account the Stick input in the Arcade Bounde block and returns a **true** bit. Therefore, the value of the **Desired Yaw rate** is the one commanded by the stick entry.



2. **FW control**

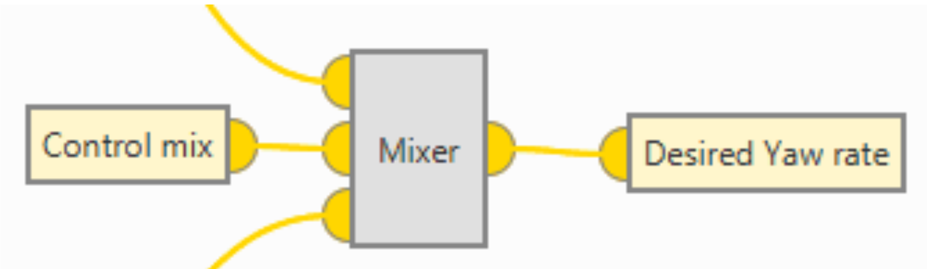
   In FW configuration, the turns do not depend only on the yaw as in quadcopter configuration, but also on the roll and pitch to perform a coordinated turn, hereafter called "Coordinate Turn". The following algorithm represents this **Coordinate Turn** performed by the aircraft:



   Bound block limits the **IAS** and **Roll** values. The minimum value for the **IAS** is $1.0\ m/s$, and the value for the **Roll** angle should be between $[-0.7,\ 0.7]\ rad$.

3. **Mix control**

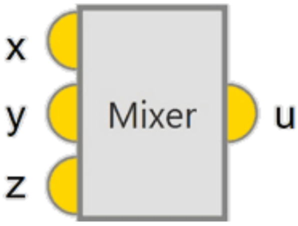
   Mixer block has as inputs the output signals of the previous controls and the Control mix variable. In this way, the block selects which configuration controls the aircraft, providing the **Desired Yaw rate** value.



   Mixer block is a **custom** program located in the **Library**.

Mixer Block - Explanation

Mixer block implements the following relationship between input variables and output variables.



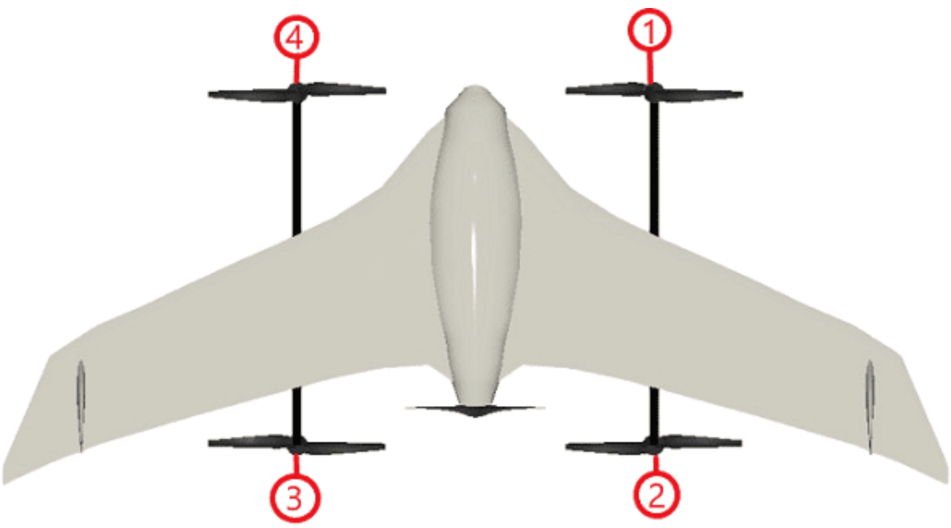
$$u = zy + x(1-y)$$

For more information on custom blocks, visit the Library blocks - Block Programs section of the **1x PDI Builder** user manual.

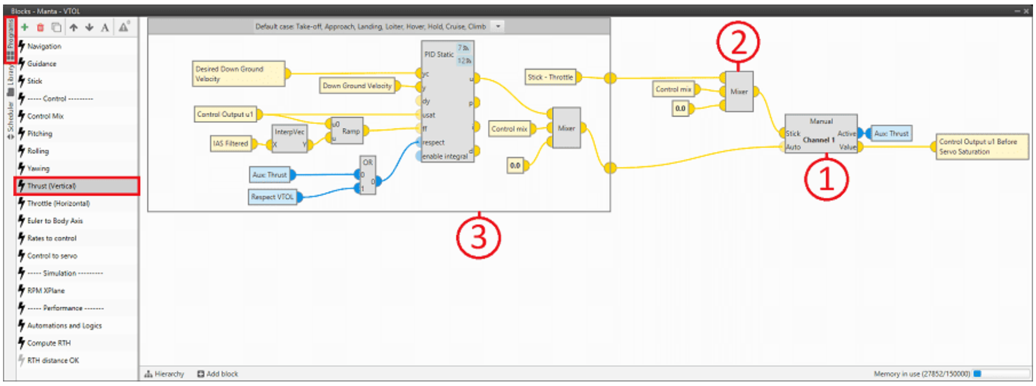
Thrust (Vertical)

Explanation

Thrust program is defined to control the **vertical thrust** of the aircraft. For this purpose, the motors involved are the vertical ones, which allow the aircraft to fly in **quadcopter** configuration.

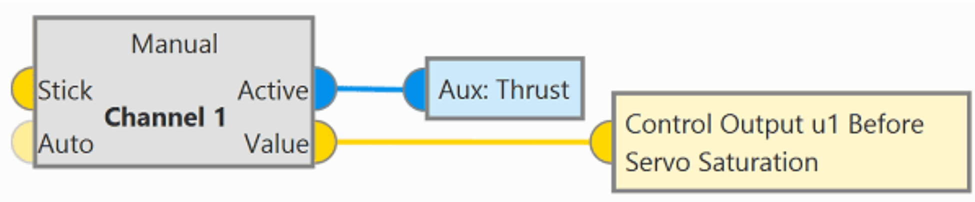


Thrust actuation is performed with the use of **Channel 1**. This channel is controlled with the Manual block, which is configured to process thrust control depending on the control mode. This block switches between two input signals according to the current mode of the configured channel.



Thrust (Vertical) - Program

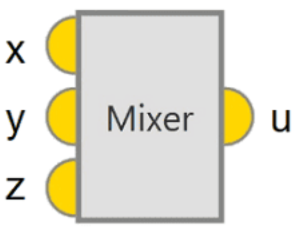
1. The **Manual** block receives two input signals, Stick and Auto and provides two output signals, Value, which depends on the flight mode, and Active.



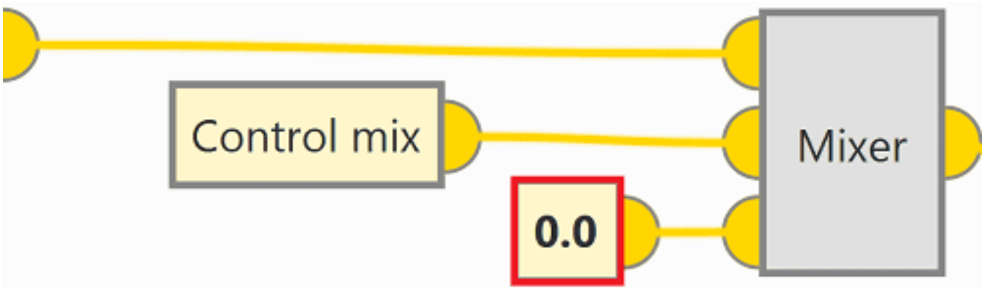
The Value output of this block must be linked to the Control Output u1 Before Servo Saturation variable, since this variable controls the actuation of the Thrust defined in the Actuator block.

Moreover, the Aux: Thrust bit is **true** when the Autopilot 1x is **not controlled by the stick**.

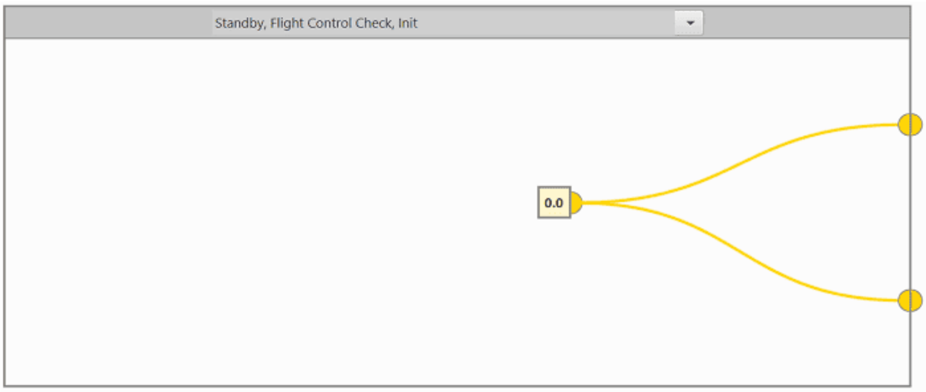
2. The **Mixer** block provides the value for the Stick input to the **Manual** block as a function of the Control mix variable. This is a **custom** block located in the **Library**.

> **Mixer Block - Explanation**
>
> **Mixer** block implements the following relationship between input variables and output variables:
>
> 
>
>
> $$u = zy + x(1-y)$$
>
> For more information on custom blocks, visit the Library blocks - Block Programs section of the **1x PDI Builder** user manual.

As the Control mix variable indicates the control rate of the aircraft in FW flight configuration, only the part proportional to the rate controlled in quadcopter configuration is maintained.

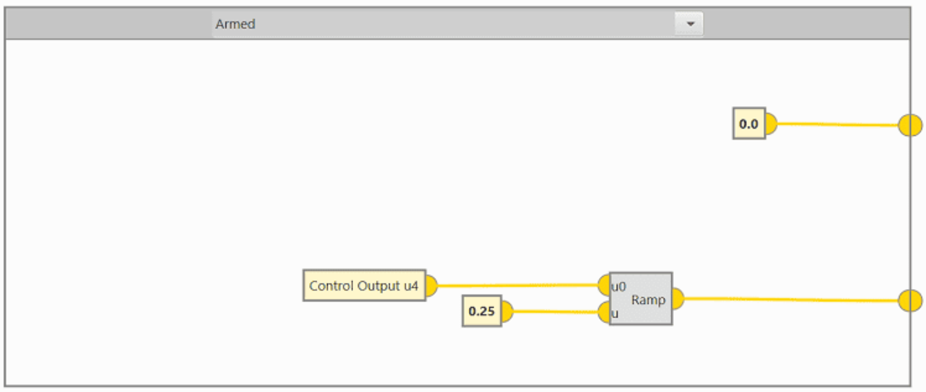


3. The input variable Auto to the **Manual** block and the input variable to the **Mixer** block, which corresponds to the **quadcopter** configuration, depends on the flight phase:
   - **Standby, Flight Control Check, Init**
     Since no Thrust action is required in these flight phases, the values for the Stick and Auto inputs are set to **0.0**. Therefore, the output value of the Manual block is null. This is because the Control Output u1 Before Servo Saturation variable must be null regardless of the flight control mode.

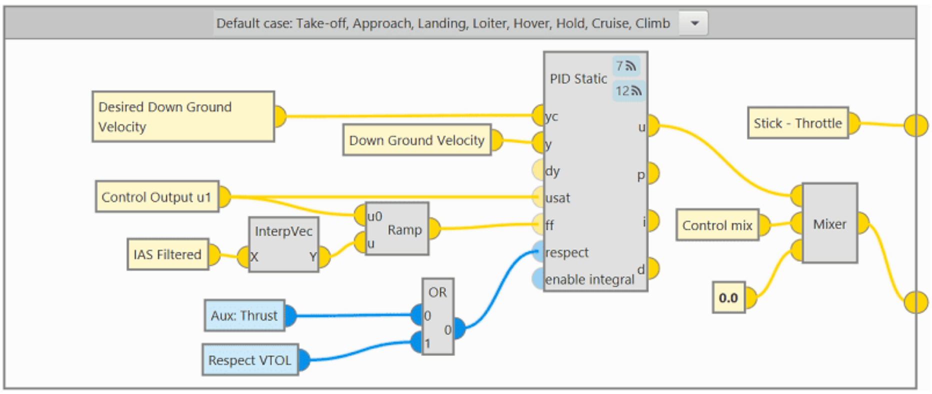
   - **Armed**
     In the Armed flight phase, the Autopilot 1x automatically activates the aircraft's four motors up to **25%** of their **maximum RPM**.

     > **Note**
     > This RPM value is not sufficient to lift the aircraft, it only activates the motors.



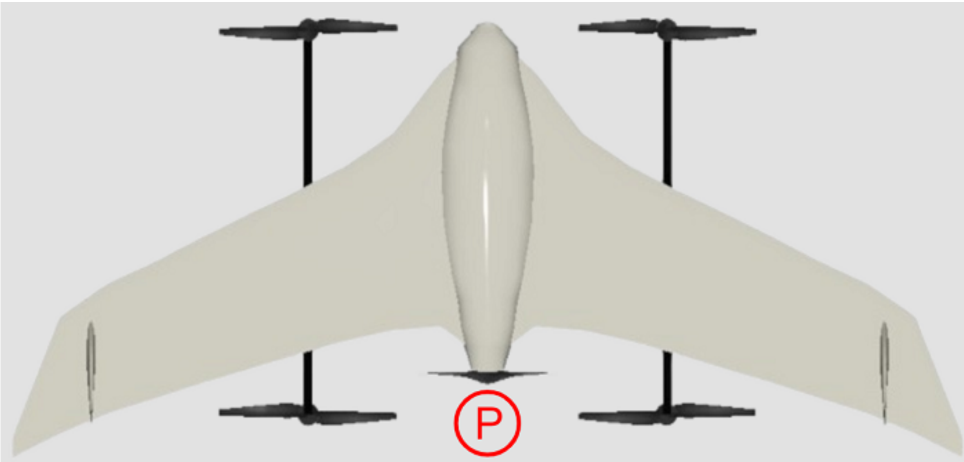
- **Stick input**: This value remains zero since in this flight phase the **aircraft** is **only controlled in auto mode**.
- **Auto input**: Corresponds to the output of the Ramp block.
  This block is used to activate the motors at 25% of their maximum RPM, as it allows to control the rate of change of the Control Output u4 variable.

◦ **Take-off, Approach, Landing, Loiter, Hover, Hold, Cruise, Climb**

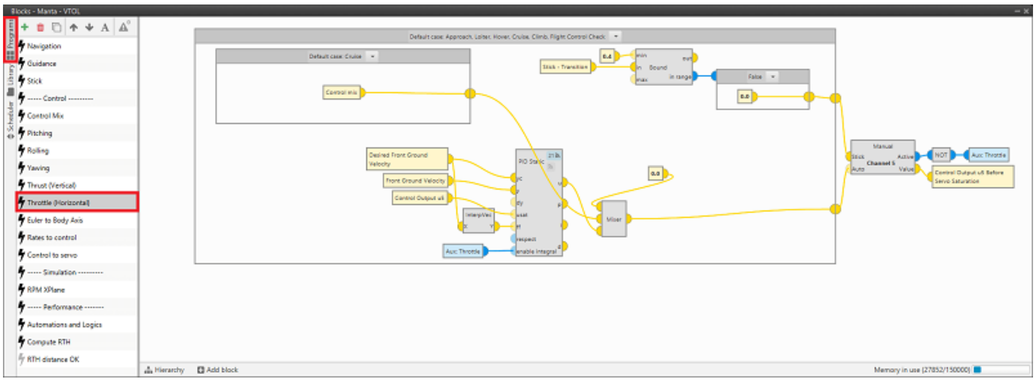


- **Stick input**: This value is defined as the part of the **Stick-Throttle** variable that is controlled by the quadcopter.
- **Auto input**: The Auto input is written by the **Mixer** block. This block receives 3 input signals, 2 of them correspond to the Thrust control in **quadcopter (1)** and **FW (2)** flight configurations, and the value of the third input is the variable Control mix written by the Control Mix program.
  1. The control signal in the **quadcopter flight configuration** is defined with a PID controller.
  2. The control signal in the **FW flight configuration** is **zero** since no Thrust control is performed in this flight configuration.

Throttle (Horizontal)

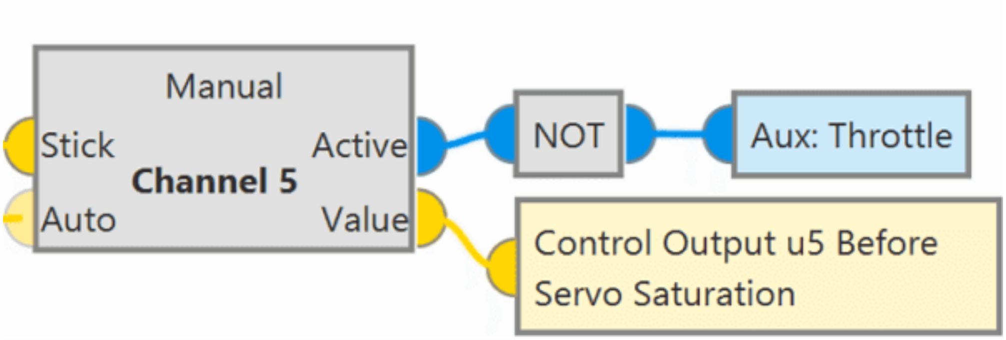
> **Explanation**
>
> Throttle program is defined to control the **horizontal thrust** of the aircraft. For this purpose, pusher motor is involved, which allow the aircraft to fly in **FW** configuration.
>
> 
>

Throttle actuation is performed with the use of **Channel 5**. This channel is controlled with the Manual block, which is configured to process throttle control depending on the control mode. This block switches between two input signals according to the current mode of the configured channel.



Throttle (Horizontal) - Program

The **Manual** block receives two input signals, Stick and Auto and provides two output signals, Value, which depends on the flight mode, and Active.



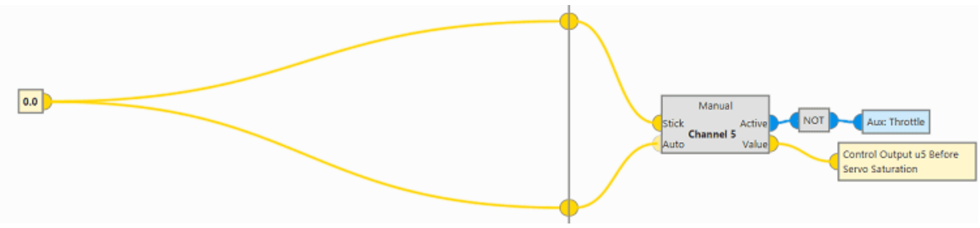
The Value output of this block must be linked to the Control Output u5 Before Servo Saturation variable, since this variable controls the actuation of the Throttle defined in the Actuator block.

Moreover, the Aux: Throttle bit is **true** when the Autopilot 1x is **not controlled by the stick**.

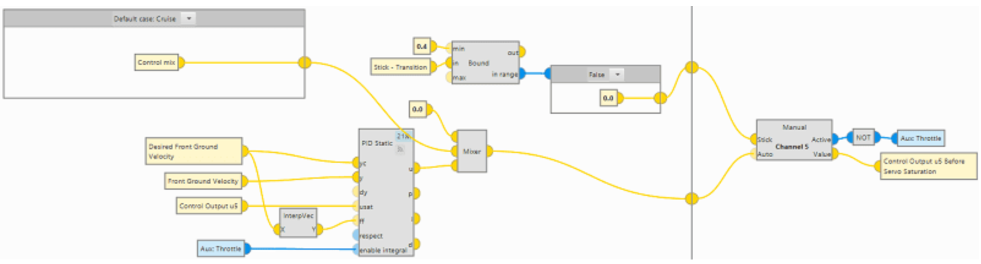
The input variables, Stick and Auto, are different depending on the flight phase:

- **Standby, Take-off, Landing, Init**

  Since no Throttle action is required in these flight phases, the values for the Stick and Auto inputs are set to **0.0**. Therefore, the output value of the Manual block is null.

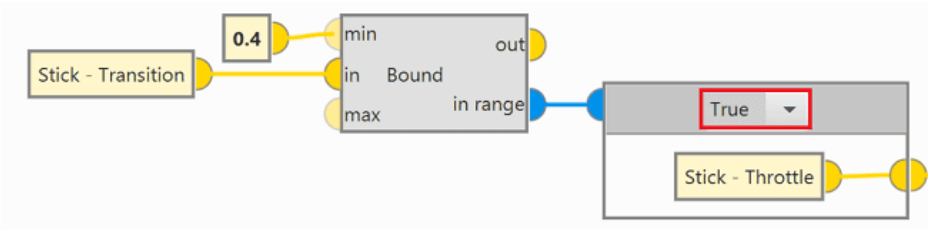
  

- **Approach, Loiter, Hover, Cruise, Climb, Flight Control Check**

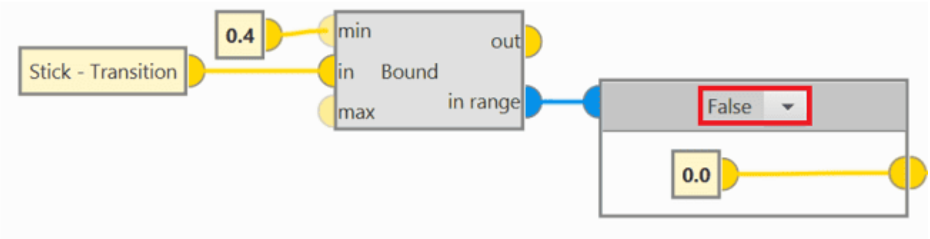
  

  - **Stick input**

    If the Stick-Transition variable has a value **greater than 0.4** ⇒ in range bit will be **true** and the Stick input of the **Manual** block will be written by the Stick-Throttle variable.



Otherwise, if this variable has a value **less than 0.4** ⇒ in range bit will be **false** and the Stick input will have a value of **0.0**.

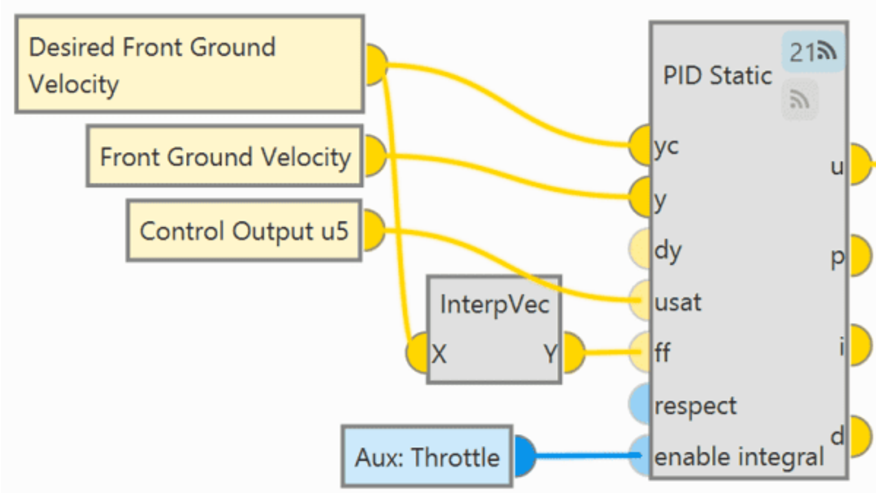


> ⓘ **Note**
>
> The Stick-Transition variable represents the position of the Stick command that defines the aircraft control mode. This command has two values: **1** for control of the aircraft using the **stick pilot**, and **0** for control of the aircraft in **Auto** mode, i.e., with Autopilot 1x.

- **Auto input**

  The Auto input is written by the **Mixer** block. This blocks receives 3 input signals, 2 of them correspond to the Throttle control signals in **quadcopter (1)** and **FW (2)** flight configurations, and the value of the third signal **(3)** will be different depending on the flight phase.

  1. The control signal in the **quadcopter flight configuration** is **zero** since no Throttle control is performed in this flight configuration.
  2. The control signal in the **FW flight configuration** is defined with a PID controller.

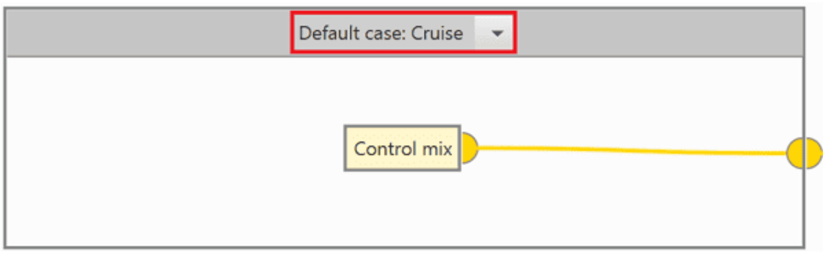


3. The input variable to the **Mixer** block is different in the Cruise and Hold flight phases:

   - **Cruise**

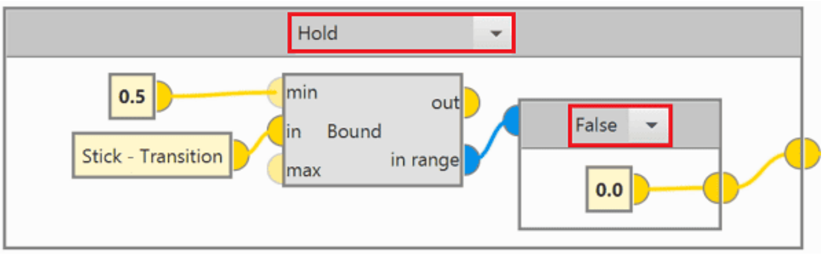
     In this flight phase, the input to the **Mixer** block is simply the variable Control mix written by the Control Mix program.

     > **Important**
     >
     > This also applies to all other flight phases that are not explicitly defined, as this is the "Default case".

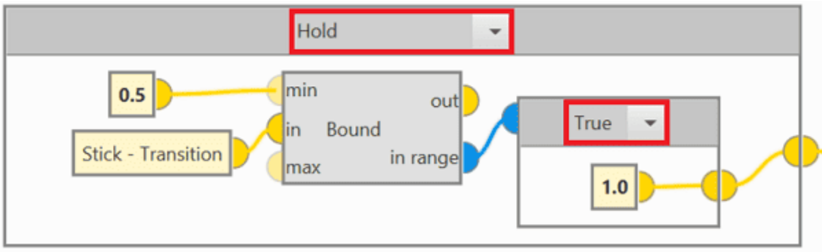
     

   - **Hold**

     In this flight phase, if the Stick-Transition variable has a value **less than 0.5** ⇒ Input for Mixer block = **0.0**.

     Otherwise, if the Stick-Transition variable has a value **greater than 0.5** ⇒ Input for Mixer block = **1.0**.

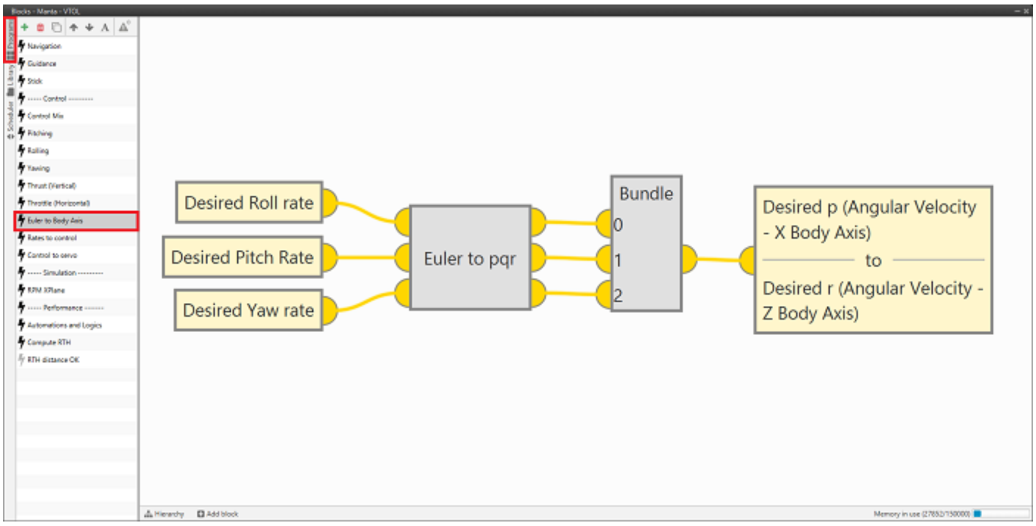


> **Note**
>
> This control logic represents the limits of the Control mix variable, being **0** quadcopter configuration and **1** FW configuration.

Euler to Body Axis

The following program defines the transformation between **Euler** axis and **Body** axis.

The control variables Desired Roll rate, Desired Pitch rate and Desired Yaw rate are expressed in Euler axis, so to transform these variables into control outputs, it is necessary to transform them to the aircraft axis (Body axis).

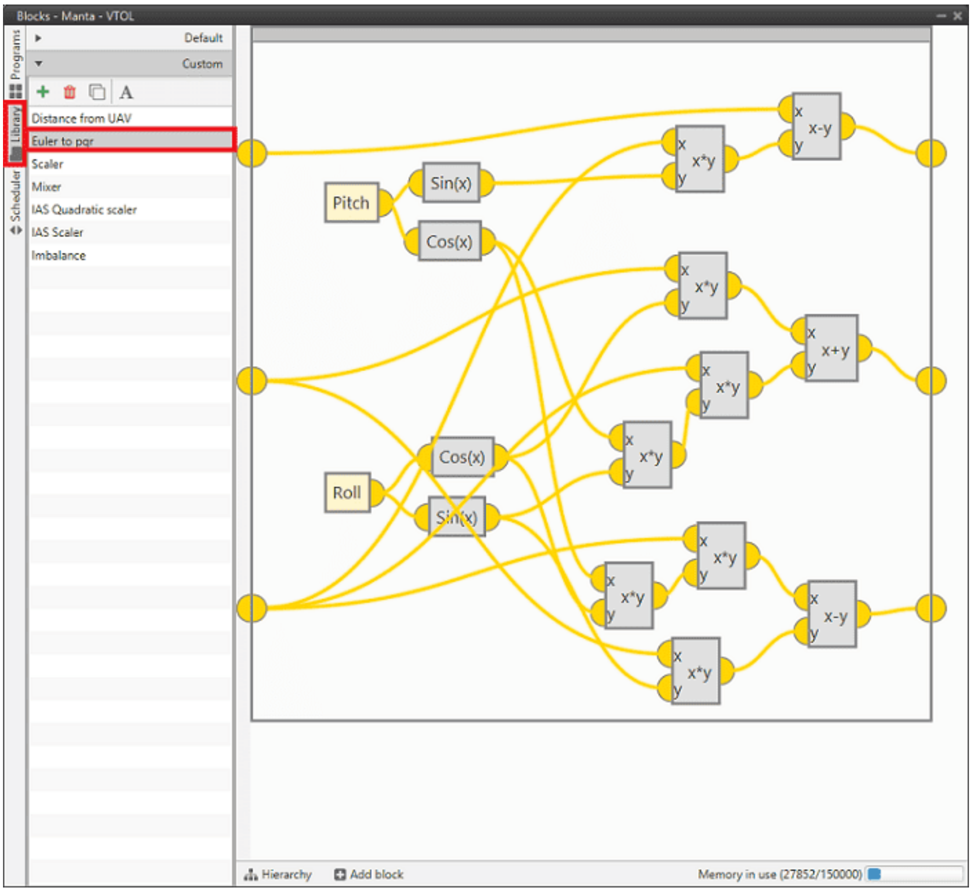


Euler to Body Axis - Program

For this purpose, a **custom block**, **Euler to pqr** block, has been created in the **Library blocks**. In this block, the mathematical relationships necessary to achieve this transformation have been defined.

Euler To Pqr Block - Explanation

The algorithm of this block and the mathematical relationships it implements are shown below:



Euler to pqr block

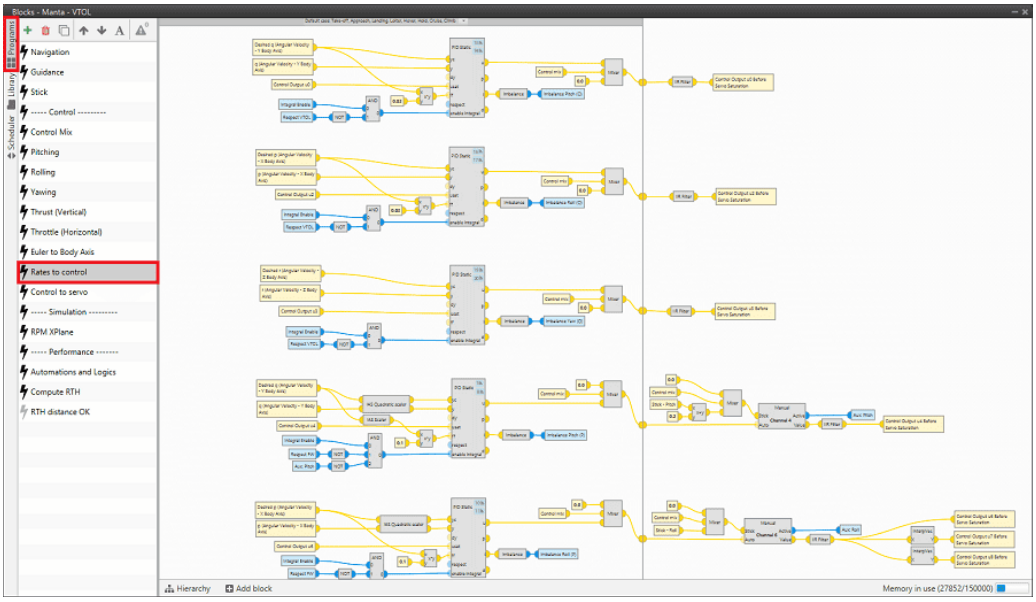
The transformation between axes that is performed is as follows:

$$\begin{bmatrix} P \\ Q \\ R \end{bmatrix} = \begin{bmatrix} 1 & 0 & -\sin(\theta) \\ 0 & \cos(\phi) & \sin(\phi)\cos(\theta) \\ 0 & -\sin(\phi) & \cos(\phi)\cos(\theta) \end{bmatrix} \begin{bmatrix} \dot{\phi} \\ \dot{\theta} \\ \dot{\psi} \end{bmatrix}$$

For more information on custom blocks, visit the Library blocks - Block Programs section of the **1x PDI Builder** user manual.

Rates to control

The following program is defined to control the value of the **control outputs** to perform the desired action defined by the Guidance and Navigation program variables.



Rates to control - Program

For the definition of this program, it is first necessary to create the following **custom blocks** in the **Library blocks**. For more information on custom blocks, visit the Library blocks - Block Programs section of the **1x PDI Builder** user manual.

Ias Scaler Block - Explanation

IAS Scaler allows to **scale linearly** an input variable with the indicated airspeed.

This block implements the following formula:

$$u = \frac{v_i}{\max(v,\ v_i)} \cdot x$$

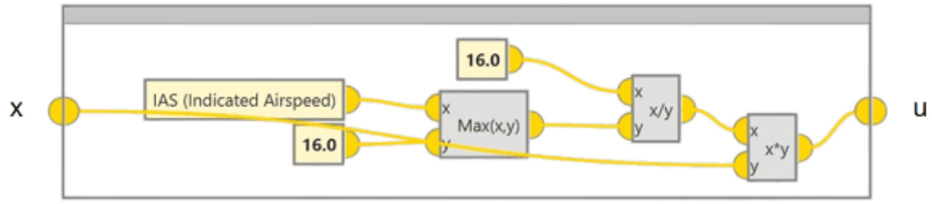
Where,

- u : output
- v_i : nominal speed, in this case 16 m/s
- v : actual measured speed, in this case Indicated Airspeed (IAS)
- x : input

Therefore, it would be:

$$u = \frac{16}{\max(IAS,\ 16)} \cdot x$$

Note that this formula has a lower saturation value of 16 m/s, so the **scaling** in this case is done for **speeds higher than the nominal**.



Ias Quadratic Scaler Block - Explanation

IAS Quadratic Scaler allows **quadratic scaling** two input variables with the indicated airspeed.

This block implements the following formulas:

$$u_1 = \left(\frac{v_i}{\max(v,\ v_i)}\right)^2 \cdot x_1$$

$$u_2 = \left(\frac{v_i}{\max(v,\ v_i)}\right)^2 \cdot x_2$$

Where,

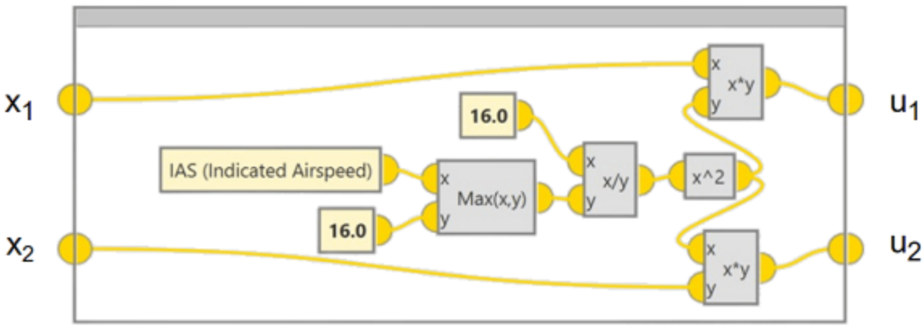
- u_1 : output variable 1
- u_2 : output variable 2
- v_i : nominal speed, in this case 16 m/s
- v : actual measured speed, in this case Indicated Airspeed (IAS)
- x_1 : input variable 1
- x_2 : input variable 2

Therefore, it would be:

$$u_1 = \left(\frac{16}{\max(IAS,\ 16)}\right)^2 \cdot x_1$$

$$u_2 = \left(\frac{16}{\max(IAS,\ 16)}\right)^2 \cdot x_2$$

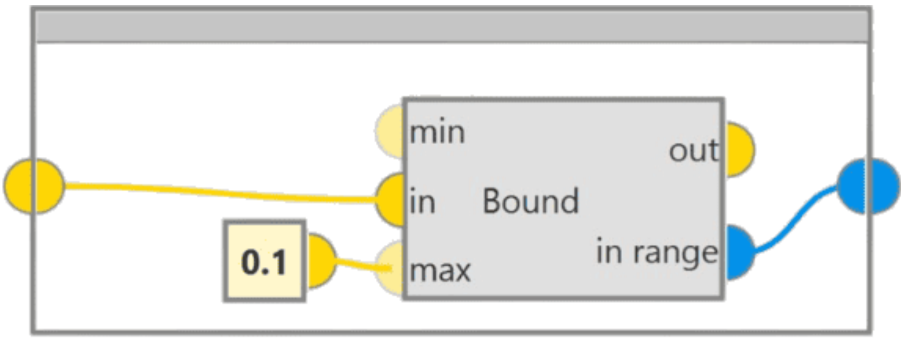
Note that this formula has a lower saturation value of 16 m/s, so the **scaling** in this case is done for **speeds higher than the nominal**.



Imbalance Block - Explanation

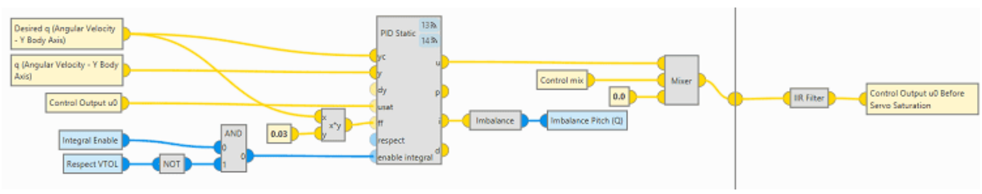
This **Imbalance** block is used to determine whether a variable remains constant over time. This is achieve by checking that the rate of change of the evaluated variable is as close as possible to **0.0**.

To do this, the input variable is evaluated with the Bound block where the output in range is set to **true** if the value of the variable is **less than 0.1**.



Once the custom blocks have been created, in this program the different control outputs are defined for each of the control actions in quadcopter or FW configuration:

- **Pitch quadcopter - u0**

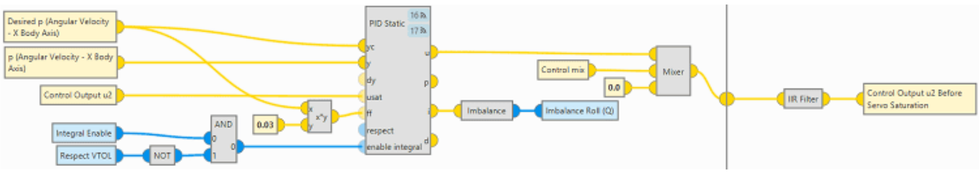


  - PID controller allows to calculate the output response to reach the Desired q (Angular Velocity - Y Body Axis) variable.

  - **Mixer** block provides the output signal from the PID controller to the **quadcopter** flight configuration rate.
  - IIR Filter block adapts the signal with a low pass filter. In this way, the aircraft is able to perform a controlled actuation.

> ⓘ **Note**
>
> This control logic allows Autopilot 1x to compare the variable **q (Angular Velocity - Y Body Axis)**, obtained in the **Navigation** program, and the **Desired q (Angular Velocity - Y Body Axis)** variable, obtained in the **Guidance** program, and determine the response that the aircraft must have to reach the desired variable.
>
> To achieve this desired value, the **Control Output u0** variable is determined, which defines the position of the actuators/servos for **pitching** in **quadcopter** flight configuration.

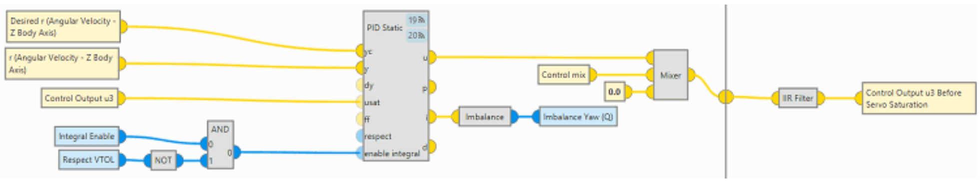
- **Roll quadcopter - u2**



  - PID controller allows to calculate the output response to reach the Desired p (Angular Velocity - X Body Axis) variable.
  - **Mixer** block provides the output signal from the PID controller to the **quadcopter** flight configuration rate.
  - IIR Filter block adapts the signal with a low pass filter. In this way, the aircraft is able to perform a controlled actuation.

> ⓘ **Note**
>
> This control logic allows Autopilot 1x to compare the variable **p (Angular Velocity - X Body Axis)**, obtained in the **Navigation** program, and the **Desired p (Angular Velocity - X Body Axis)** variable, obtained in the **Guidance** program, and determine the response that the aircraft must have to reach the desired variable.
>
> To achieve this desired value, the **Control Output u2** variable is determined, which defines the position of the actuators/servos for **rolling** in **quadcopter** flight configuration.

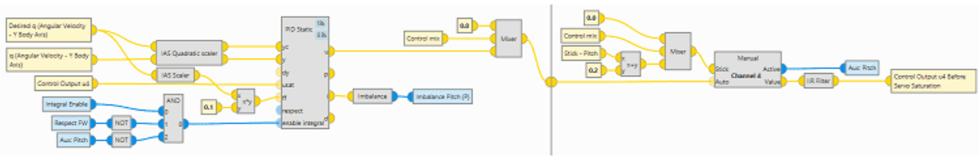
- **Yaw quadcopter - u3**



  - PID controller allows to calculate the output response to reach the Desired r (Angular Velocity - Z Body Axis) variable.
  - **Mixer** block provides the output signal from the PID controller to the **quadcopter** flight configuration rate.
  - IIR Filter block adapts the signal with a low pass filter. In this way, the aircraft is able to perform a controlled actuation.

> ⓘ **Note**
>
> This control logic allows Autopilot 1x to compare the variable **r (Angular Velocity - Z Body Axis)**, obtained in the **Navigation** program, and the **Desired r (Angular Velocity - Z Body Axis)** variable, obtained in the **Guidance** program, and determine the response that the aircraft must have to reach the desired variable.
>
> To achieve this desired value, the **Control Output u3** variable is determined, which defines the position of the actuators/servos for **yawing** in **quadcopter** flight configuration.

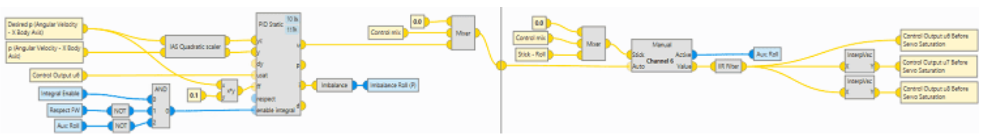
- **Pitch FW - u4**



  - **IAS Quadratic scaler** block
  - **IAS Scaler** block
  - PID controller providing the desired change variable to **Pitch** in **FW** flight configuration.
  - **Mixer** block provides the output signal from the PID controller to the **FW** flight configuration rate.
  - Manual block changes the output value depending on the control mode.
  - IIR Filter block adapts the signal with a low pass filter. In this way, the aircraft is able to perform a controlled actuation.
  - InterpVec block applies the configured table interpolation on each of the components of the input vector.

> **Note**
>
> This control logic allows Autopilot 1x to compare the variable **q (Angular Velocity - Y Body Axis)**, obtained in the **Navigation** program, and the **Desired q (Angular Velocity - Y Body Axis)** variable, obtained in the **Guidance** program, and determine the response that the aircraft must have to reach the desired variable.
>
> To achieve this desired value, the **Control Output u4** variable is determined, which defines the position of the actuators/servos for **pitching** in **FW** flight configuration.

- **Roll FW - u6**



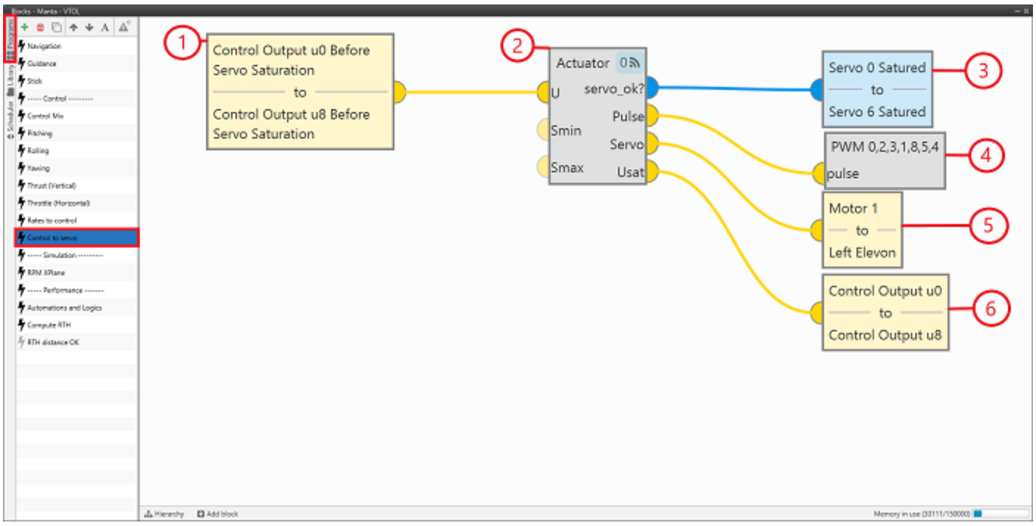
  - **IAS Quadratic scaler block**
  - PID controller providing the desired change variable to **Roll** in **FW** flight configuration.

- **Mixer** block provides the output signal from the PID controller to the **FW** flight configuration rate.
- Manual block changes the output value depending on the control mode.
- IIR Filter block adapts the signal with a low pass filter. In this way, the aircraft is able to perform a controlled actuation.
- InterpVec block applies the configured table interpolation on each of the components of the input vector.

> **Note**
>
> This control logic allows Autopilot 1x to compare the variable **p (Angular Velocity - X Body Axis)**, obtained in the **Navigation** program, and the **Desired p (Angular Velocity - X Body Axis)** variable, obtained in the **Guidance** program, and determine the response that the aircraft must have to reach the desired variable.
>
> To achieve this desired value, the **Control Output u6** variable is determined, which defines the position of the actuators/servos for **rolling** in **FW** flight configuration.

Control to servo

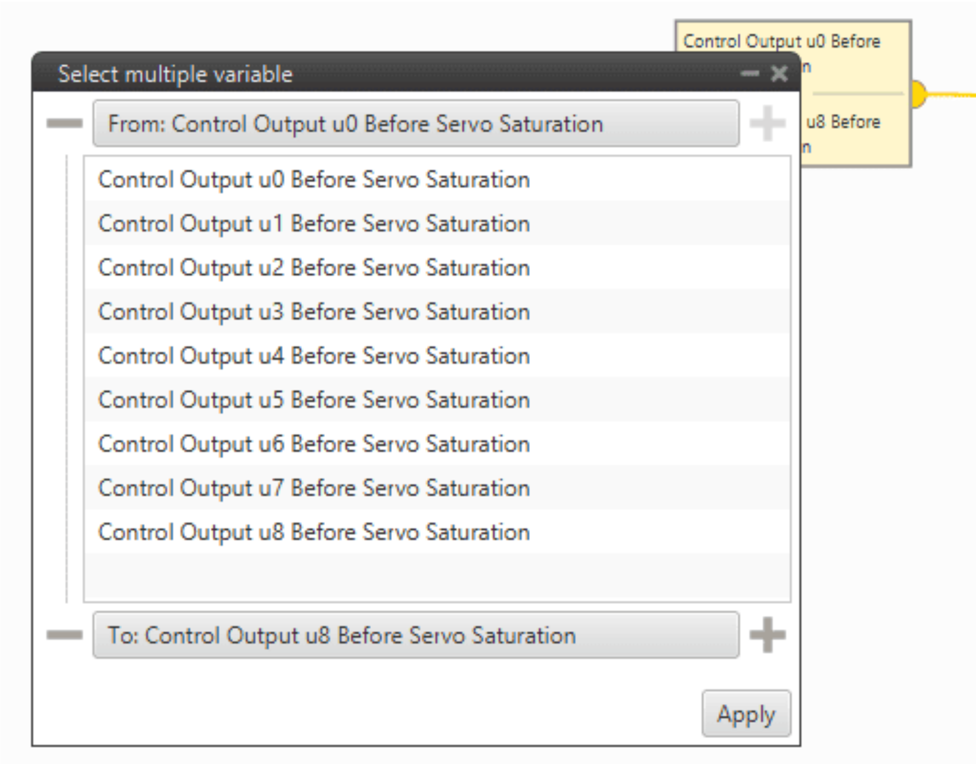
The following program allows the user to configure the transformation between the action and the servo value. To do this, the **Actuator** block and the different inputs and outputs must be configured.



Control to servo - Program

In this program it is necessary to define and configure the following blocks:

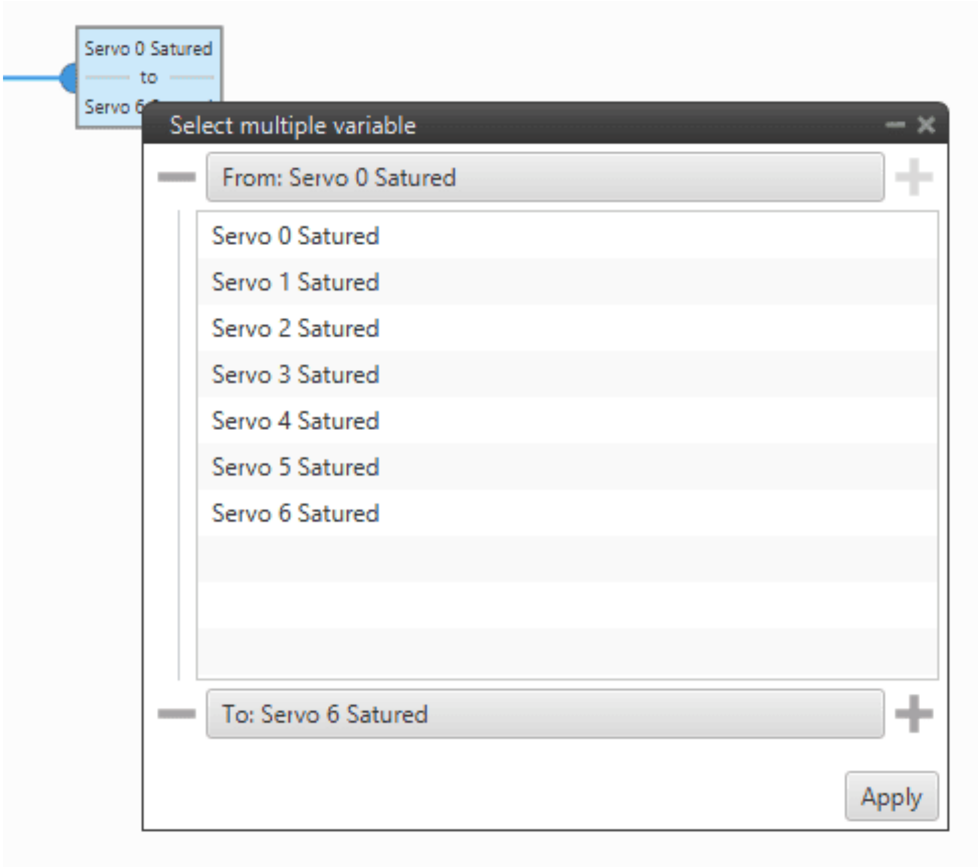
1. A Read multiple Reals block with the variables that define the actions commanded by the control programs.



2. Actuator block that transforms input variables into servo values.

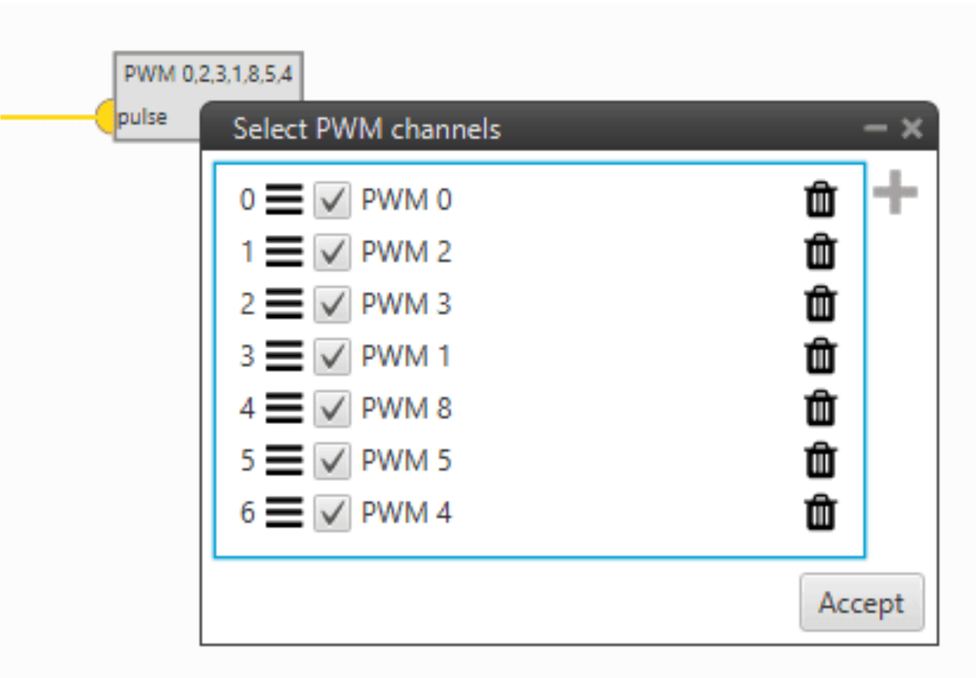
> **Important**
>
> The configuration of the **Actuator** block is defined in the Actuators - Actuators & SU Matrix section of this manual.

3. A Write multiple Bits block with the servo bits that had to be trimmed to prevent saturation.

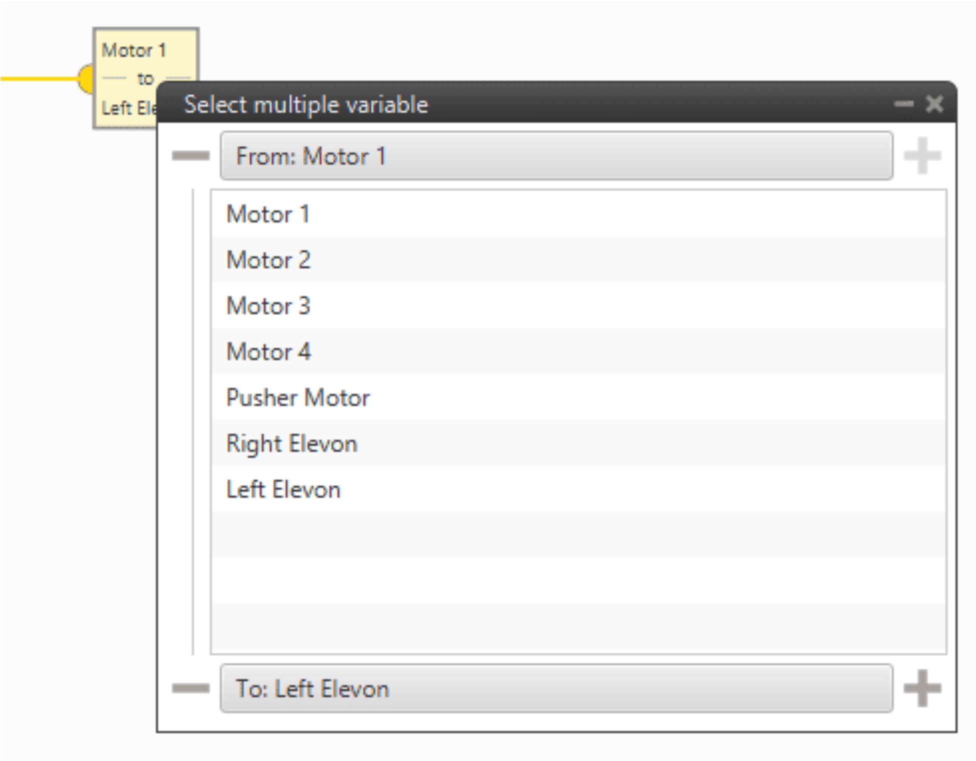


4. A PWM block to indicate the PWM variables to which the PWM pulse should be transmitted for each servo.

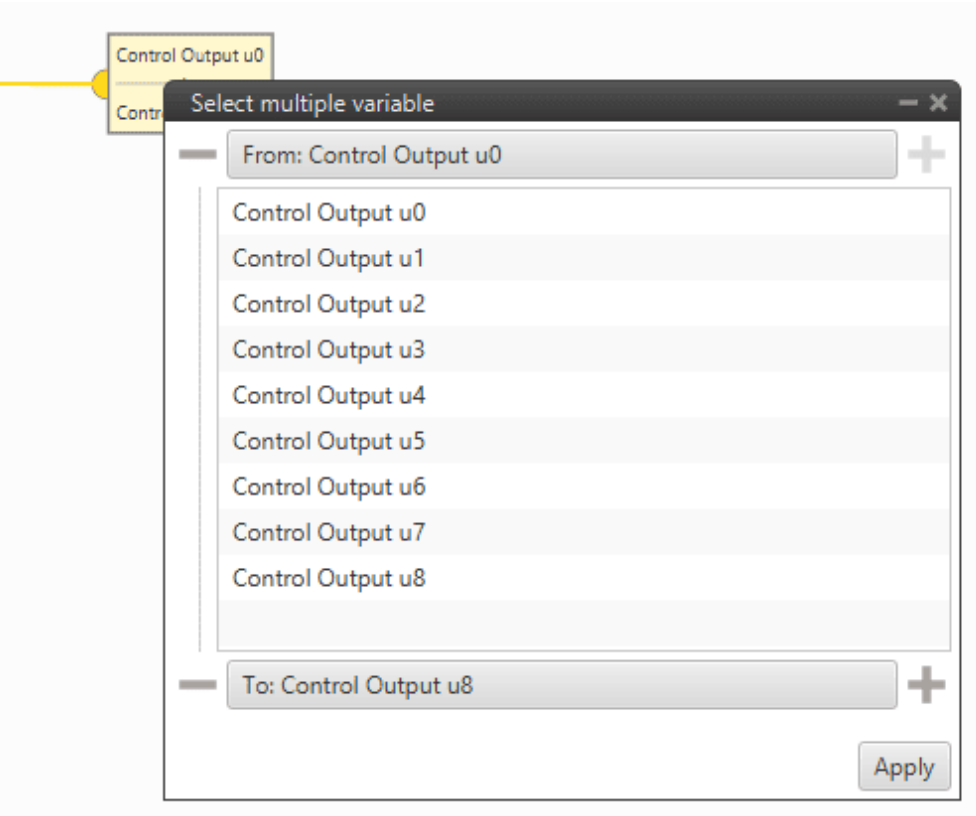
> **Note**
>
> The pins to which the servos are connected must match those previously changed from GPIO to PWM.



5. A Write multiple Reals block that writes the servo value that generates the actuator motion to the servo variables.



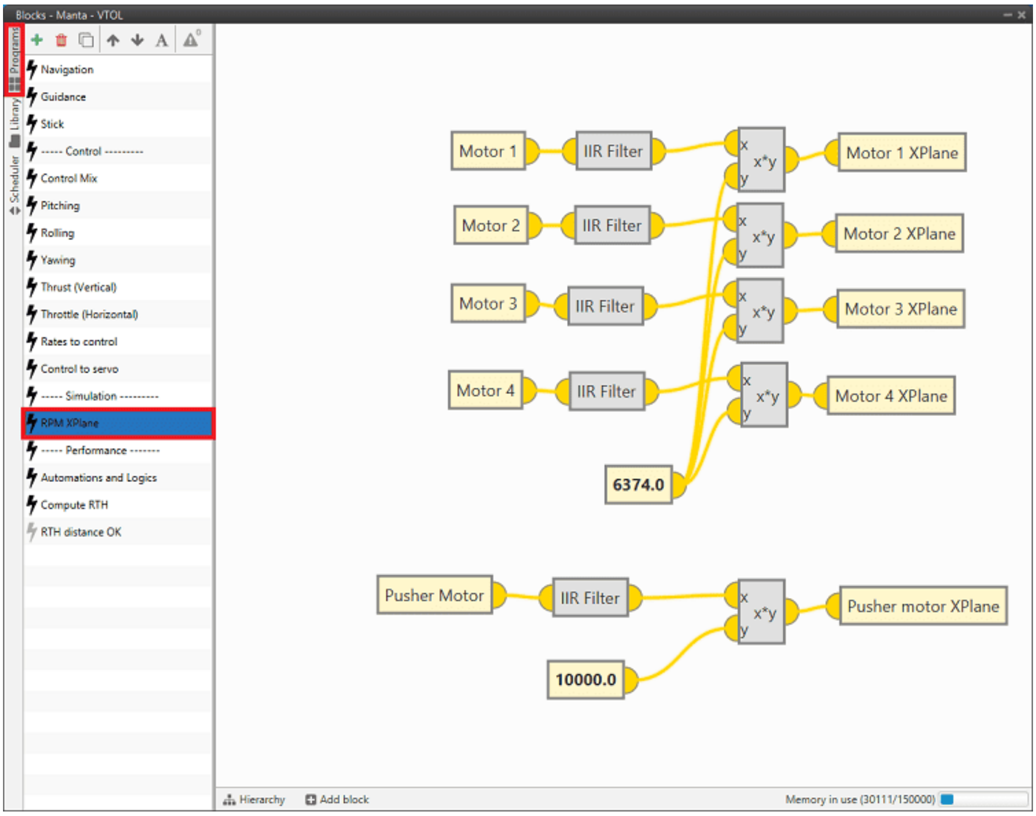
6. A Write multiple Reals block with the variables for Control actions after servo saturation.



RPM XPlane

The following program is defined to adapt the performance of the aircraft in real flight to a simulation environment with X-Plane11 software.

This allows to use the same 1x air configuration without having to make 2 different ones for the "phase" of creating and validating the configuration and the real operation.



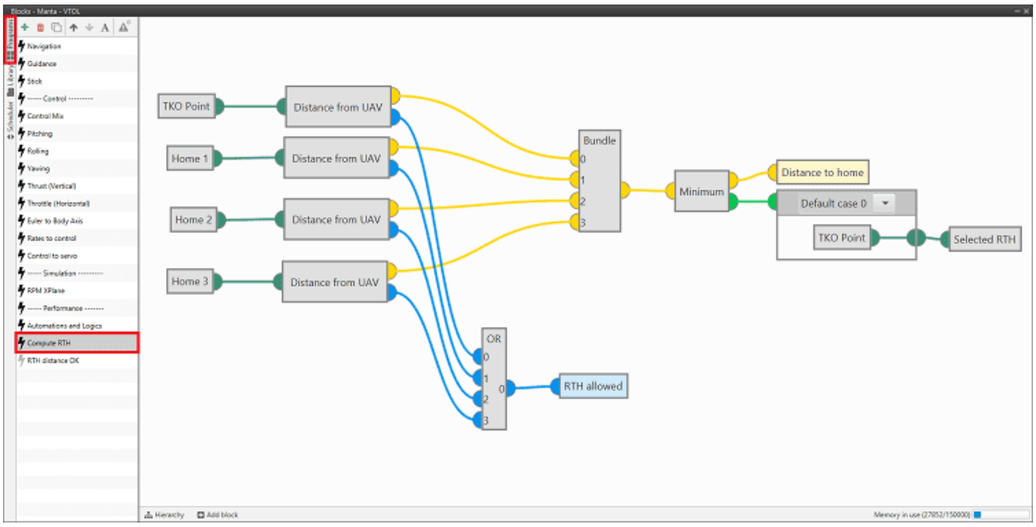
RPM XPlane - Program

For this purpose, the IIR Filter block is used. This block is a low pass filter that allows the motor RPM of the motor to be raised in a controlled way.

Motor X variables have a value from **0 to 1** and are multiplied by the **maximum RPM** of the motor. The result of this multiplication will be the value used in the simulation.

Compute RTH

The following program is defined to set which **Home point** the Autopilot 1x will use when the Return to Home (RTH) phase is executed.



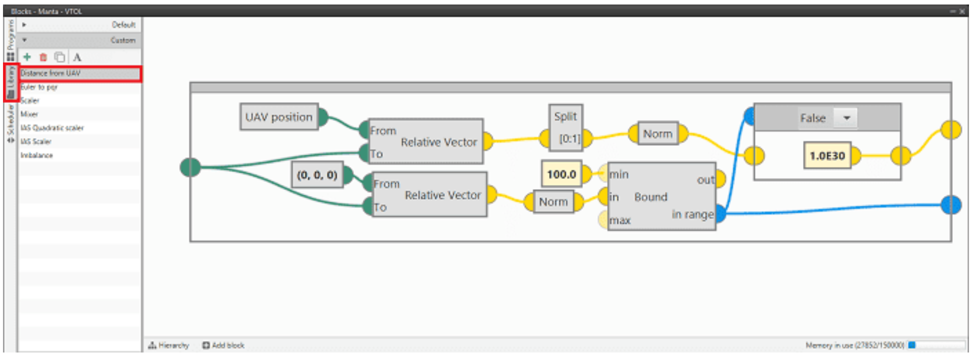
Compute RTH - Program

The program is defined as follows:

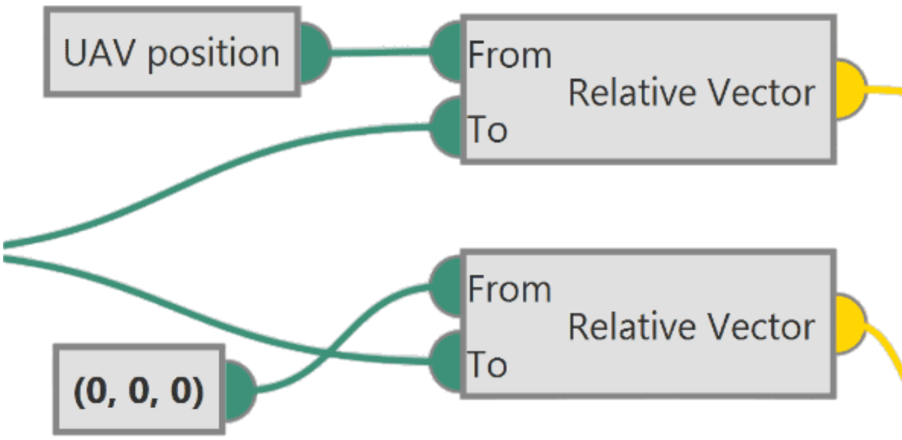
The distance between the UAV and each of the predefined points (TKO Point, Home 1, Home 2, Home 3) is calculated using the **Distance from UAV** block. This is a **custom** block created in the **Library blocks**.

Distance From Uav Block - Explanation

This block follows the following structure:

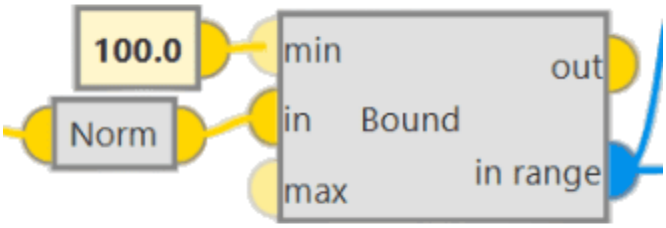


The distance **from the UAV position to the predefined point** and the distance **from the NED origin to the predefined point** are calculated. These distances are calculated using the **Relative Vector** block, which returns a relative vector in NED frame from the two input positions. For more information on this block, visit the Positions blocks - Block Programs section of the **1x PDI Builder** user manual.



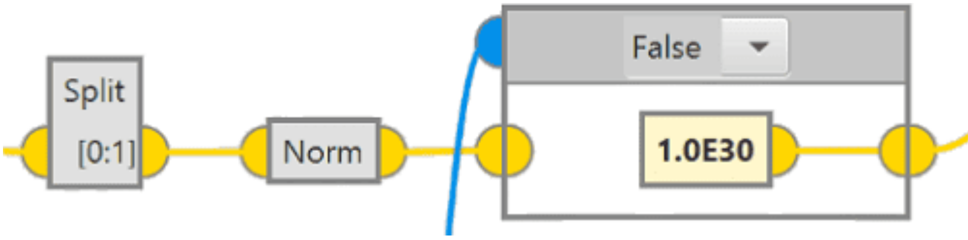
Distance from (0, 0, 0) to Home

- Once this distance has been calculated, the Relative Vector block returns a vector of three components (North, East, Down).
- Then, the Norm block returns the norm of this vector and the Bound block evaluates if this value is within the defined limits (**100 m minimum**). The reason for defining this minimum is because if no Home point has been predefined, Autopilot 1x will take as point the origin **(0, 0, 0)**. Thus, to avoid guidance errors when flying around the origin, this minimum distance is defined.



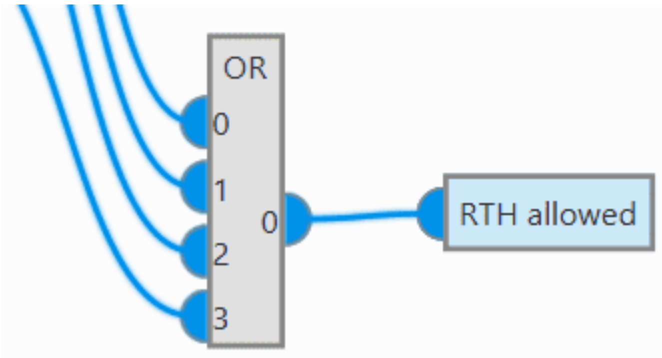
Distance from UAV position to Home

- Once this distance has been calculated, the Relative Vector block returns a vector of three components (North, East, Down).
- The first 2 components of this vector should be used in the program to determine the distance between the two points. To do this, the Split block is used to create a vector with the first two variables and then, the Norm block returns the norm of this vector.
- This value will only be taken as valid if the **distance to the origin** is **greater than 100 m**, so the Bound block will return the bit as **true**. Otherwise, if the bit is **false**, i.e., the distance is **less than 100 m**, a distance large enough for this point to be discarded as a valid point is defined.

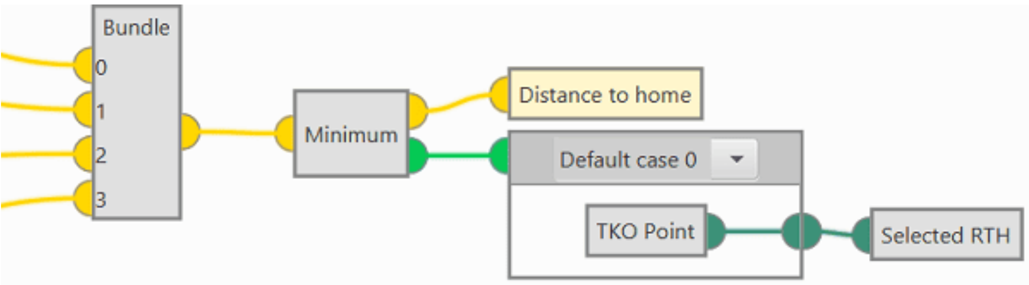


For more information on custom blocks, visit the Library blocks - Block Programs section of the **1x PDI Builder** user manual.

After evaluating the distance between the defined points and the UAV, the bit RTH allowed will be **true** if one or more of them can be taken as a **valid point**. In case **no valid point** is found, this bit will be **false** and it will **not** be possible to transition to the **RTH phase**.

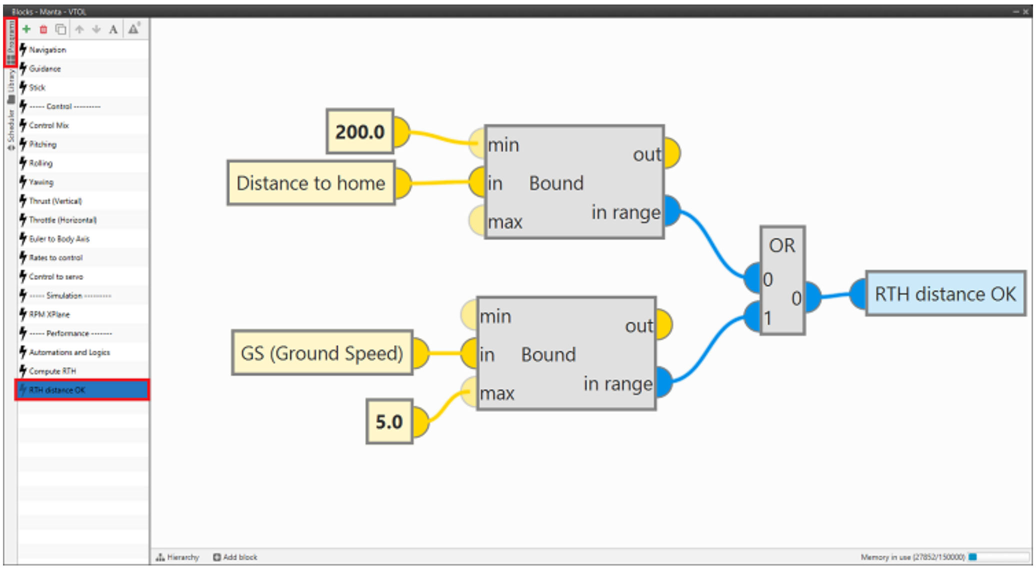


Finally, among all the valid Home points, the one to which the UAV has less distance is chosen and selected as the point to use in the RTH phase.



RTH distance OK

The following program is defined to determine whether the **Home point** to be used in the **RTH phase** selected in the previous program, Compute RTH, is valid or not.

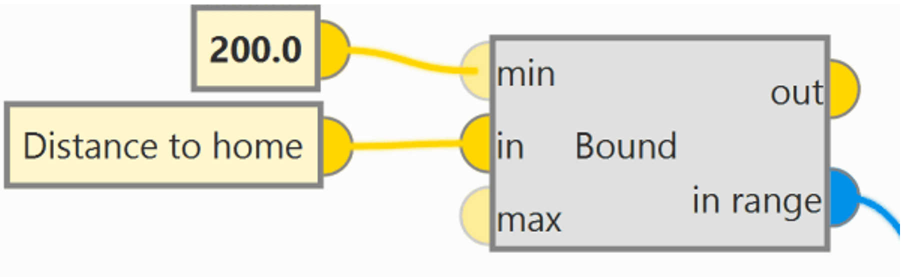


RTH distance OK - Program

For this purpose, the program defines two conditions that determine the validity of the **Home point** selected:

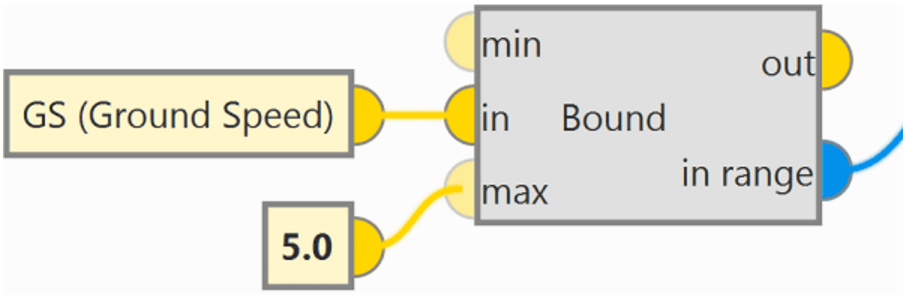
- **Distance to home**

  A **minimum distance** of **200 meters** is set at which the **Home point** has to be from the **UAV**. If the value of the Distance to home variable is within the defined range, the Bound block returns a **true** bit.



- **GS (Ground Speed)**

  A **maximum GS** of **5.0 m/s** is defined. If this speed is within the defined range, the Bound block returns a **true** bit.

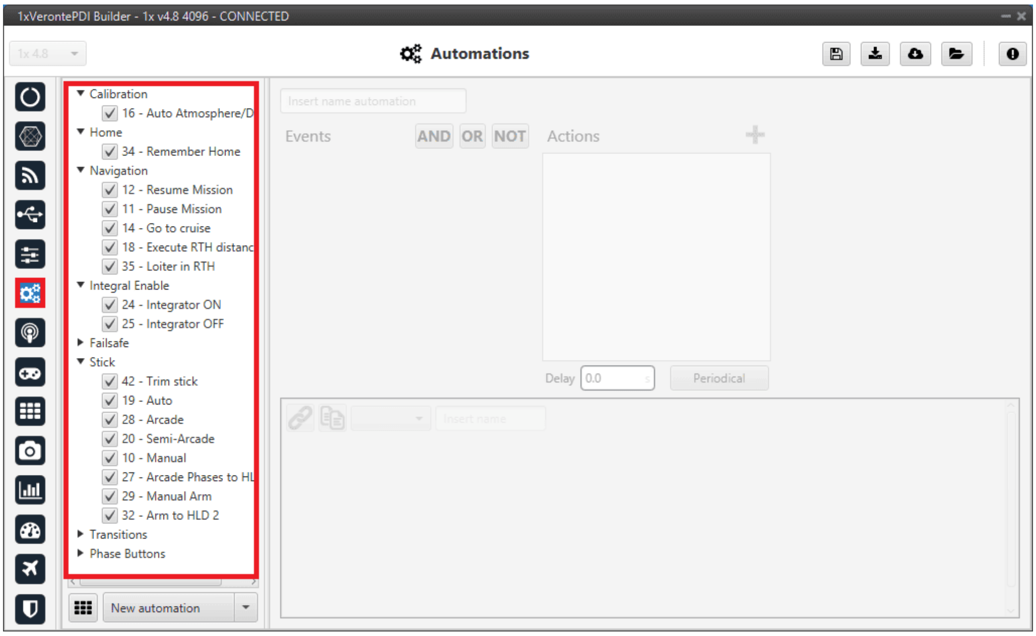


If **one** of these two conditions is met, the **Home point** is taken as **valid** and Autopilot 1x will guide to this point. Otherwise, if neither of the two conditions is met, the Loiter in RTH automation will cause the aircraft to perfom a **Loiter** until one of those two conditions is met.

These conditions allow the aircraft to perform a **controlled transition**, having enough distance and time to perform it safely.

Automations

Automations are actions that are carried out when a combination of events happens, i.e., when the events are accomplished the action is done. For more information on automations, visit the Automations section of the **1x PDI Builder** user manual.

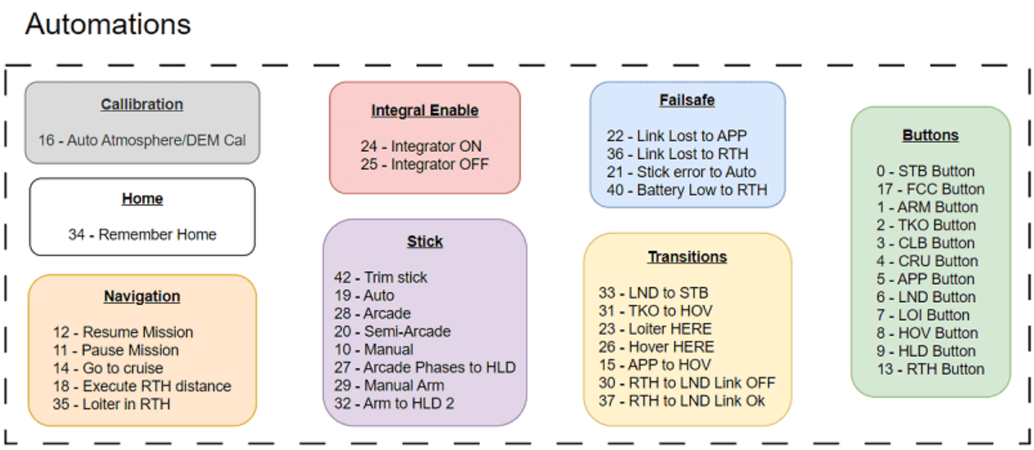


VTOL Automations

The different events, actions and automations that have been created for the operation of the Embention VTOL aircraft are shown below.

> ⚠ **Warning**
>
> The user can create as many automations as desired up to a maximum of **500 events**, **120 actions** and **100 automations**.

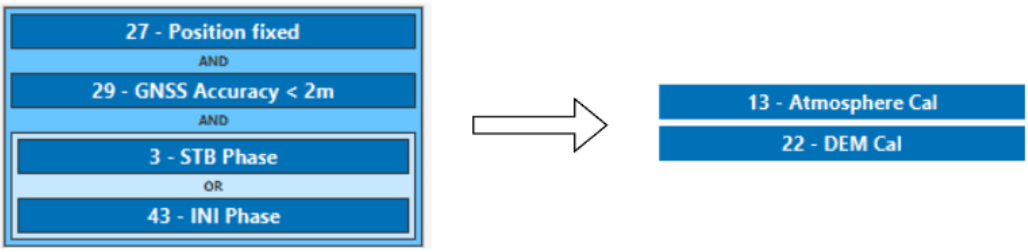
The automations have been divided into groups depending on the functionality for which they have been created:



Calibration

16 - Auto Atmosphere/DEM Cal

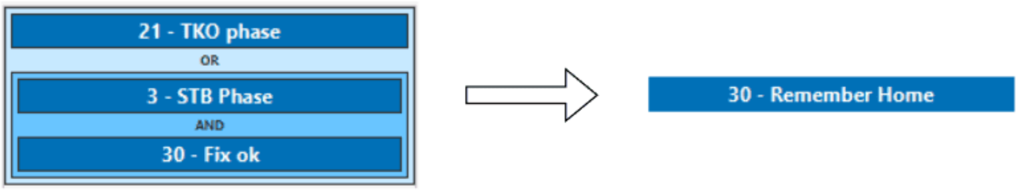
This automation establishes the events that must be triggered for the autopilot to perform an atmospheric calibration. For this, the autopilot position must be fixed, with a GNSS accuracy of less than 2 meters, and be in the STB or INI phase.



Home

34 - Remember Home

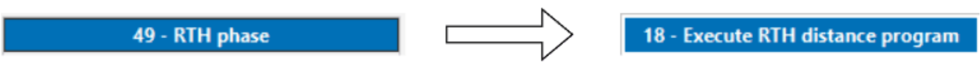
This automation remembers the take-off point. In the RTH phase, the autopilot guides the aircraft to the nearest Home point, so if no other point has been established in the mission, the autopilot will automatically establish a path to guide the aircraft back to the take-off point.



Navigation

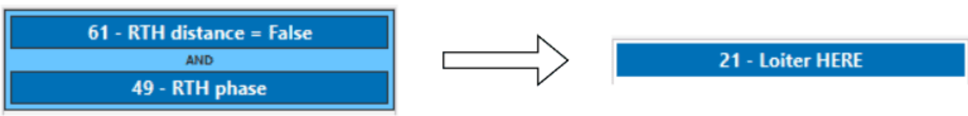
- **18 - Execute RTH distance**

  When the autopilot is in RTH phase, it executes the program RTH distance ok which calculates the distance to the nearest Home point.

- **35 - Loiter in RTH**

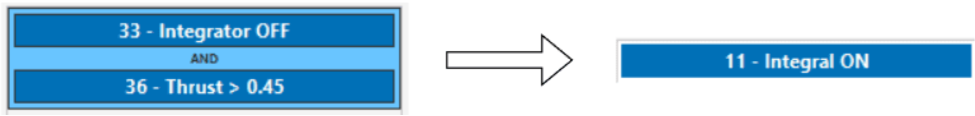
  This automation allows the aircraft to perform a Loiter when it is in RTH phase and does not meet the conditions to take the RTH point as correct.

Integral Enable

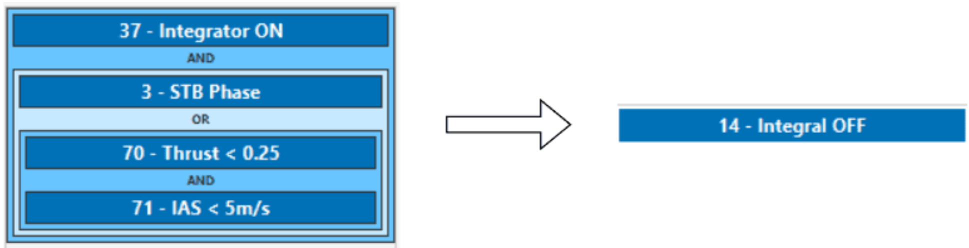
The following automations set the value of the **Integral Enable** bit, which is used as the value for the enable integral input of the **PID controllers** used in Rates to control program.

- **24 - Integrator ON**



  When **Integral ON** is triggered, a value of **1** is stored in the Integral Enable bit, turning **true**. Therefore, the enable integral input of the PDI controller is true, which means that the PDI works as usual.

- **25 - Integrator OFF**



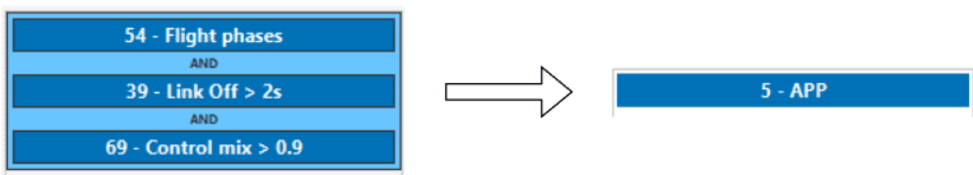
  When **Integral OFF** is triggered, a value of **0** is stored in the Integral Enable bit, turning **false**. Therefore, the enable integral input of the PDI controller is false, which implies that the integral term is exponentially discharged.

Failsafe

The following automatioms are defined to ensure the performance of the aircraft by activating predetermined actions in case of **failure**. For example, in case of stick error, stick connection error or in case of low battery.

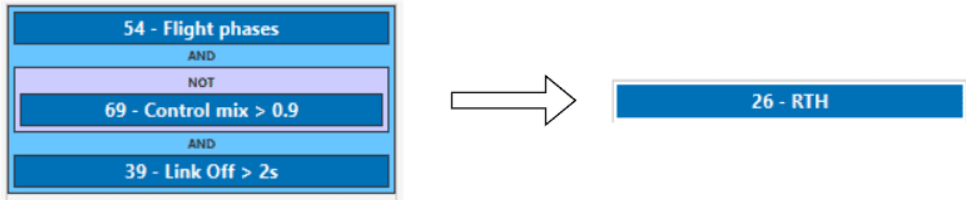
- **22 - Link Lost to APP**

  When the aircraft is in one of the flight phases (Loiter, Hover, Hold, Cruise, Climb, Approach, Return Home or Take-off), with a control mix value **greater than 0.9** and loses radio connection for 2 seconds, it automatically switches to the Approach (APP) phase.



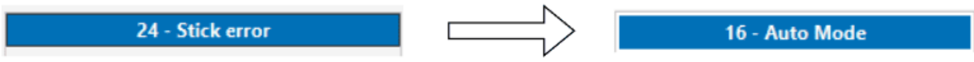
- **36 - Link Lost to RTH**

  When the aircraft is in one of the flight phases (Loiter, Hover, Hold, Cruise, Climb, Approach, Return Home or Take-off), with a control mix value **less than 0.9** and loses radio connection for 2 seconds, it automatically switches to the RTH phase.



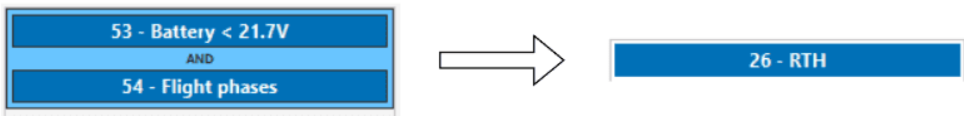
- **21 - Stick error to Auto**

  The autopilot switches to auto mode when Stick error bit is false.



- **40 - Battery Low to RTH**

  When the battery drops below a certain value, in this case 21.7 V, and the aircraft is in one of the flight phases (Loiter, Hover, Hold, Cruise, Climb, Approach, Return Home or Take-off), the autopilot will automatically guide the aircraft to RTH phase.

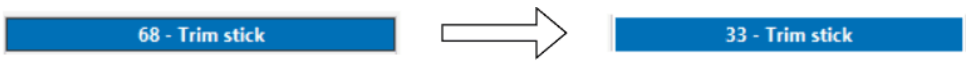


Stick

The following automations change the flight mode depending on the stick position, for this the Stick-mode and Stick-Manual variables are used.

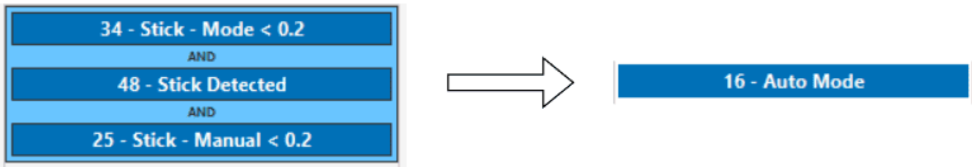
> ⓘ **Note**
>
> - Stick-mode: 3 positions (0; 0.5; 1)
> - Stick-manual: 2 positions (0; 1)

- **42 - Trim stick**



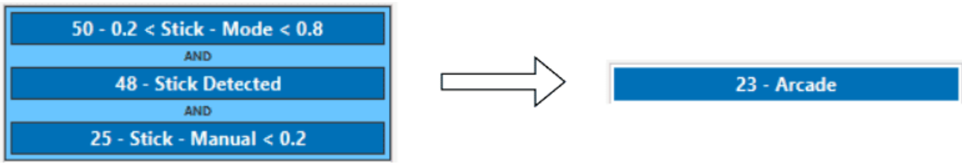
- **19 - Auto**

The autopilot switches to Auto mode when the Stick-mode variable has a value of **0** and the Stick-manual variable has a value of **0**.



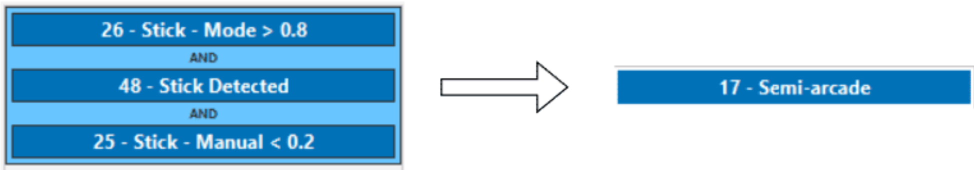
- **28 - Arcade**

  The autopilot switches to Arcade mode when the Stick-mode variable has a value of **0.5** and the Stick-manual variable has a value of **0**.



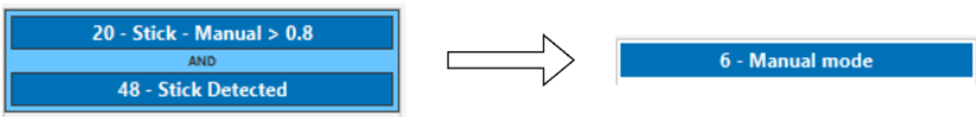
- **20 - Semi-Arcade**

  The autopilot switches to Semi-Arcade mode when the Stick-mode variable has a value of **1** and the Stick-manual variable has a value of **0**.



- **10 - Manual**

  The autopilot switches to Manual mode when the Stick-manual variable has a value of **1**.



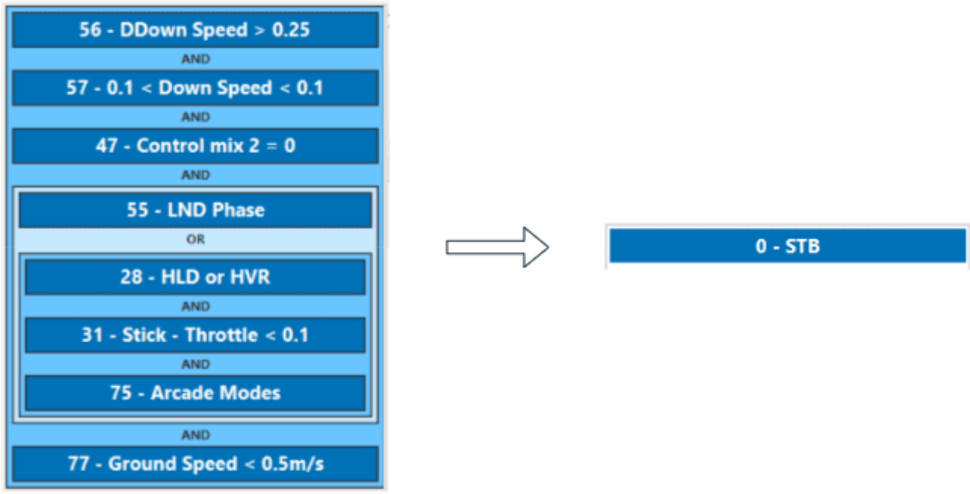
Transitions

- **33 - LND to STB**

  This automation is complex due to the number of events that must be triggered for the aircraft to automatically transition from the Landing phase to the Standby phase:

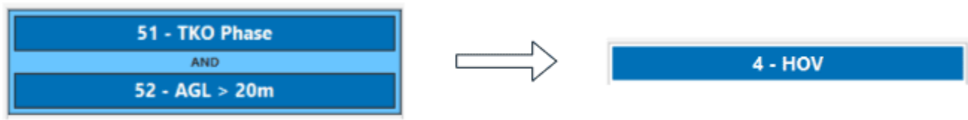
  - The aircraft must be on the ground, which means that the **Down Speed is zero** (event 57) as well as have a speed with respect to the ground that allows it to stop safely (event 77).
  - While in Landing phase, the **Desired Down Speed** (DDown Speed) must have a value **greater than 0** (event 56).

  - The aircraft must be in **quadcopter flight configuration** (event 47).
  - The aircraft must be in the Landing phase or in the Hold or Hover phases, in arcade mode and with a value of 0 in the Stick-throttle command.



- **31 - TKO to HOV**

  The following automation indicates the height above ground level at which the aircraft passes from Take-off to the Hover phase.



- **23 - Loiter HERE**

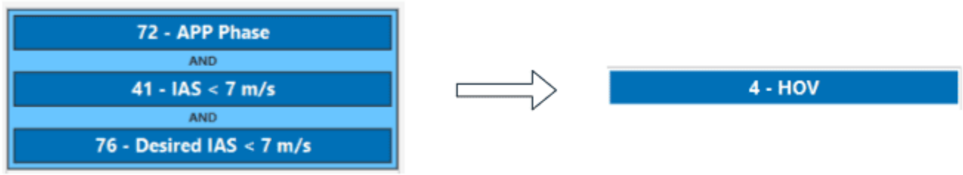
  With this automation, the aircraft performs a Loiter around the point where it transitions to the Loiter phase.

- **26 - Hover HERE**

  The aircraft performs the Hover actuation at the point where it transitions to the Hover phase.

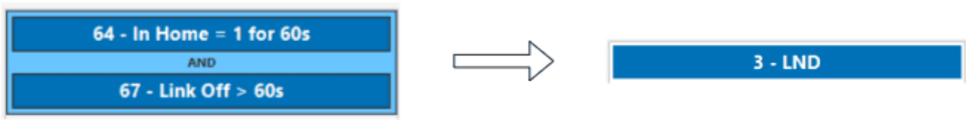
- **15 - APP to HOV**

  In the Approach phase, if the airspeed is less than 7 m/s, the aircraft will move to the Hover phase at that point. This automation is used to perform a Hover over the defined Home point.



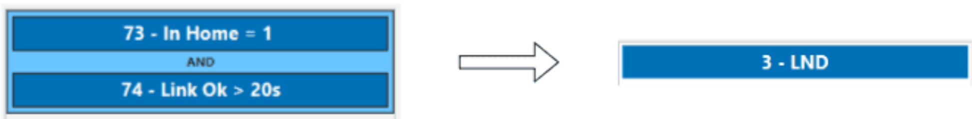
- **30 - RTH to LND Link Off**

  If Hover is performed at the defined Home point and the connection is lost for 1 minute, Autopilot 1x transitions to the Landing phase.



- **37 - RTH to LND Link Ok**

  When the aircraft performs a Hover over the Home point for more than 20 seconds without losing connection, it automatically transitions to the Landing phase.



Phase Buttons

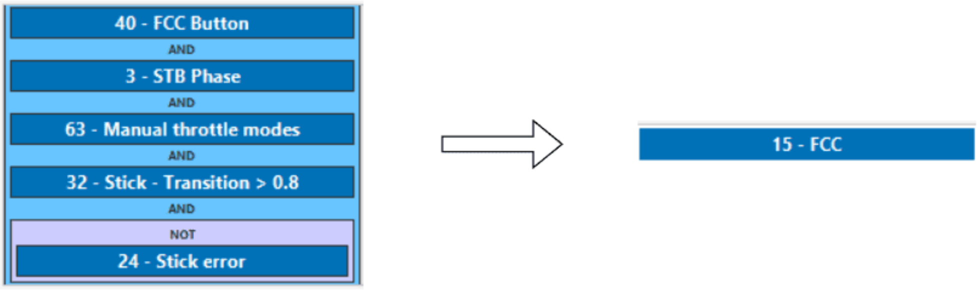
The following automations are defined for entering and transitioning between flight phases in Veronte Ops. These actions are triggered by buttons that will appear in the **Veronte Panel**.

For some of these automations it will only be necessary to "slide" the button to trigger the flight phase change action, however, for others it will be necessary that some additional event is fulfilled to trigger the phase change.

> ⓘ **Note**
>
> For more information on the possible flight phases, visit Phases definition - Modes & Phases section of this manual.

- **17 - FCC Button**.

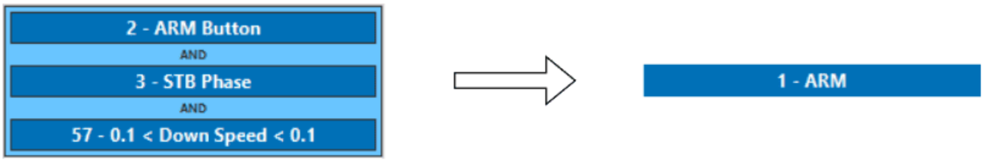
  To start the Flight Control Check (FCC) phase, in addition to pressing the FCC Button, Autopilot 1x must be in STB phase and the stick pilot must command the 1x.



This flight phase is only performed in FW flight configuration, so the Stick - Transition variable that defines the configuration in which the aircraft flies must be greater than 0.8. This is because this variable is 0 when the configuration is quadcopter and 1 when the configuration is FW.

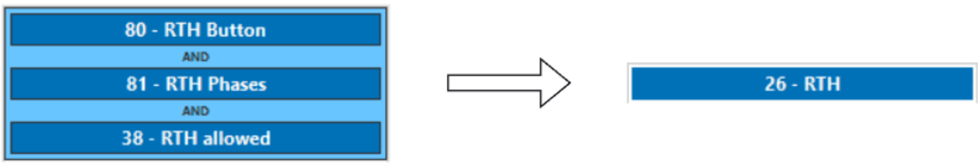
- **1 - ARM Button**.

  To switch to Armed (ARM) phase, the ARM Button must be pressed, the autopilot must be in STB phase and the Down speed must be around 0.



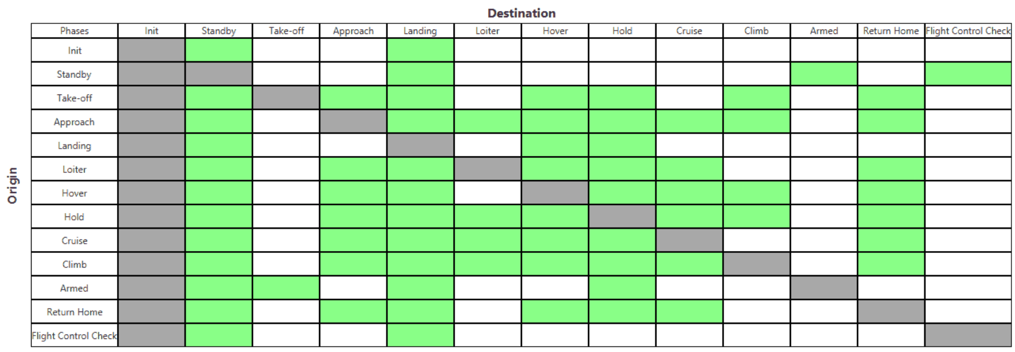
- **13 - RTH Button**.

  To switch to RTH phase, the RTH Button must be pressed, RTH allowed bit must be true (when the autopilot can guide the platform to a defined Home point) and the autopilot must be in one of the flight phases that allows it to switch to RTH (HOV, APP, LOI, CRUISE, HLD).



Transitions table

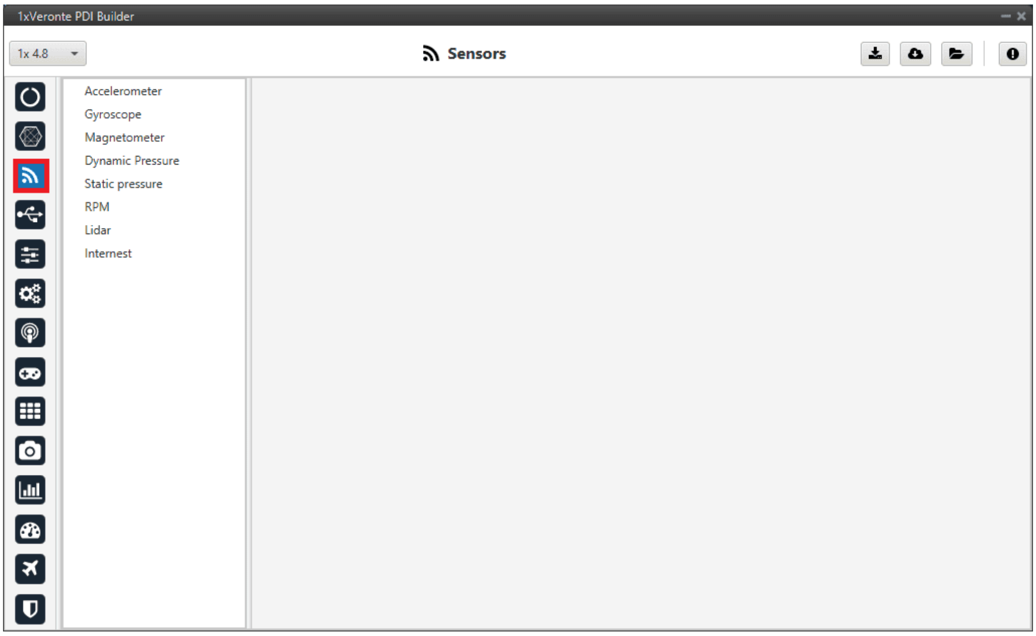
The following table shows the different possibilities for a transition between two flight phases.



Transitions Table

Sensors

The configuration of the different sensors used for autopilot navigation is explained below.



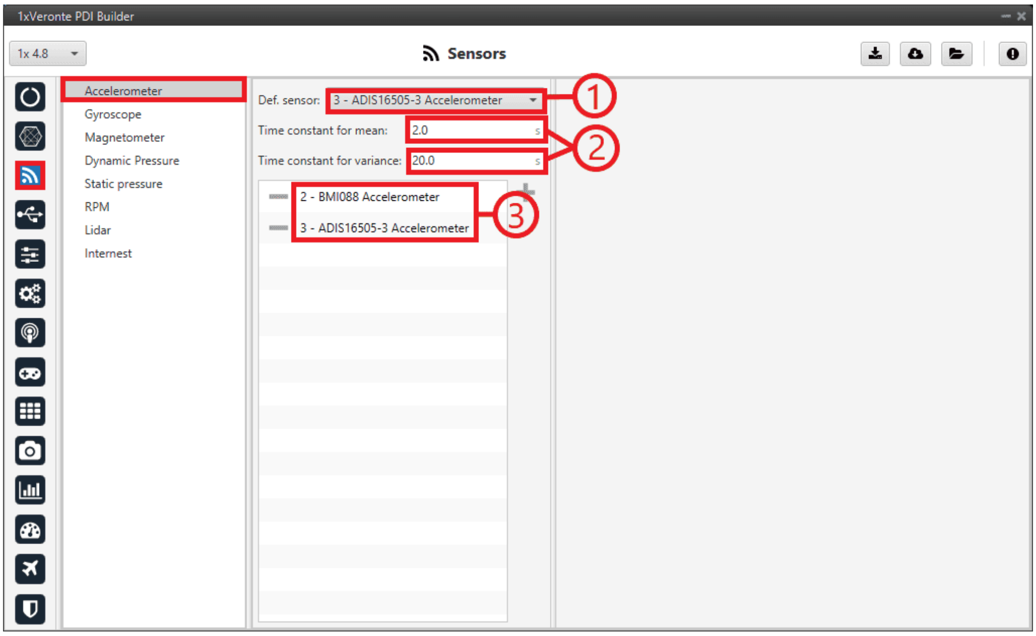
Sensors Panel

Veronte Autopilot 1x incorporates 3 Inertial Measurement Units (IMUs) that allow the 1x system to measure different variables and that are the main source of navigation data.

Accelerometer

> **Note**
>
> For a detailed explanation of the available accelerometer sensors, please visit the Accelerometer - Sensors section of the **1x PDI Builder** user manual.

The accelerometer from the IMU can be configured as explained in the panels shown below.

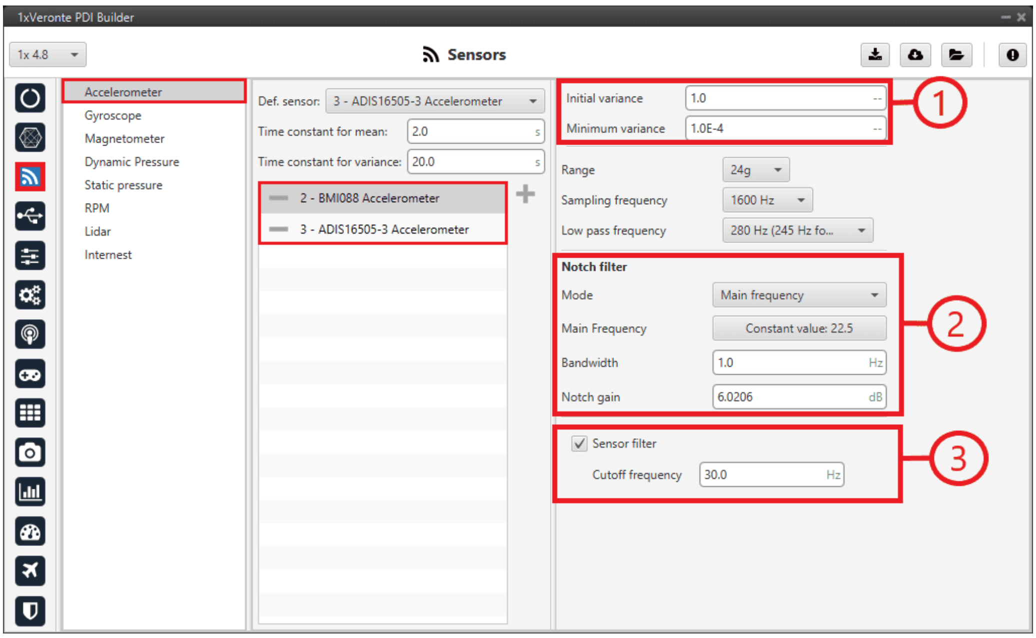


Accelerometer Panel

> **Important**
>
> It is recommended to select multiple of these sensors for the navigation algorithm, so that Veronte Autopilot 1x performs a combination of all the measurements of the selected accelerometers.
>
> This combination consists of calculating the means and variances of each of these accelerometers in a given time (Time constant for mean and Time constant for variance) to obtain a weighted mean with the inverse of the variance. The lower the variance, the greater the weight of that sensor in the mean.

1. The ADIS16505-3 Accelerometer sensor has been chosen as the **default sensor**. If all other sensors fail, the measurement value will be that of the default sensor.
2. A time of 2 seconds has been defined for the **Time constant for mean**, and 20 seconds for the **Time constant for variance**.
3. The **BMI088** and **ADIS16505-3** accelerometers sensors have been selected and their configuration is described below.

Common configuration of BMI088 Accelerometer and ADIS16505-3 Accelerometer



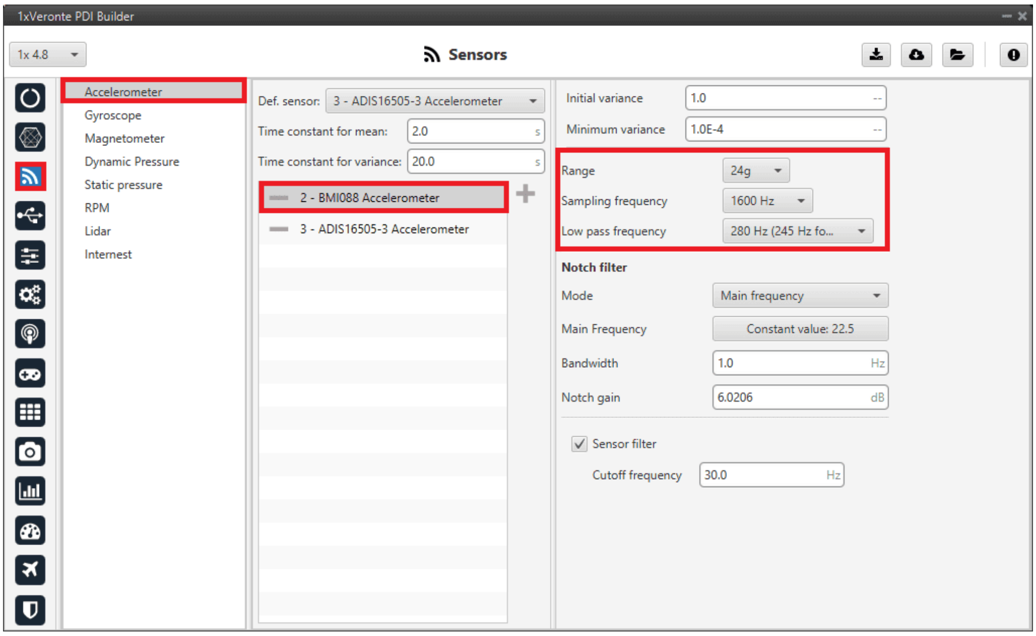
Common configuration

1. **Initial variance = 1.0**

   Minimum variance = 1.0E-4
2. **Notch filter**: It is a filter that dampens signals only at a specific frequency.
   - **Mode**: Main frequency
   - **Main Frequency**: 22.5
   - **Bandwidth**: 1.0 Hz
   - **Notch gain**: 6.0206 dB
3. **Sensor filter**: Enabled.
   - **Cutoff frequency**: 30.0 Hz

BMI088 Accelerometer

This panel displays the possible parameters that can be configured for the internal BMI088 Accelerometer.



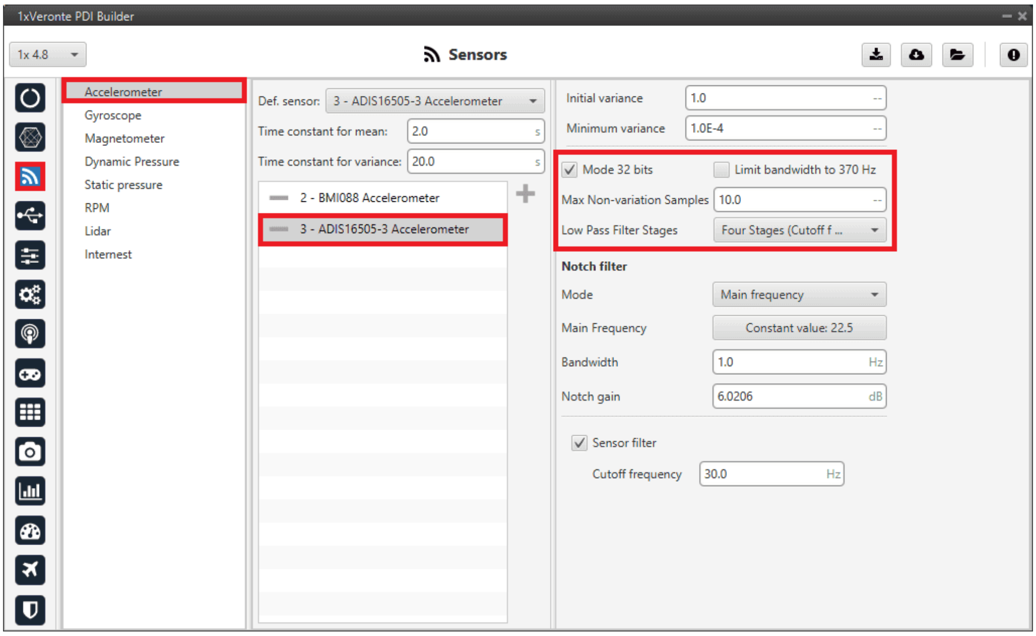
BMI088 Accelerometer Panel

- **Range**: We select a high range of forces that the accelerometer can measure. The lowest accuracy is accepted so that the system does not saturate.
- **Sampling frequency**: That is the frequency at which the measurements are read out. We recommend the highest (**1600Hz**).

- **Low pass frequency**: The cutoff frequency is set to **280Hz (245 Hz for the Z axis)**.

ADIS16505-3 Accelerometer

This panel displays the possible parameters that can be configured for the internal ADIS16505-3 Accelerometer.



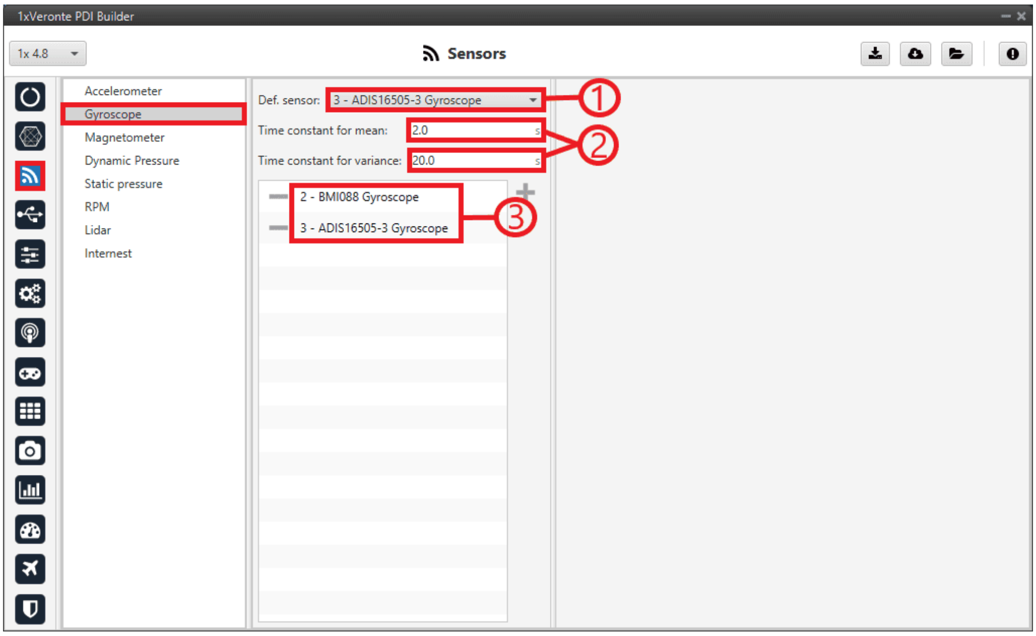
ADIS16505-3 Accelerometer Panel

- **Mode 32 bits**: Following the recommendation, we **enable** it.
- **Limit bandwith to 370Hz**: Following the recommendation, we **disable** it.
- **Max Non-variation Samples**: This is configured manually.
- **Low Pass Filter Stages**: Following the recommendation, **4 stages (Cutoff f=40Hz)** are configured.

Gyroscope

> ⓘ **Note**
>
> For a detailed explanation of the available gyroscope sensors, please visit the Gyroscope - Sensors section of the **1x PDI Builder** user manual.

The gyroscope from the IMU can be configured as explained in the panels shown below.

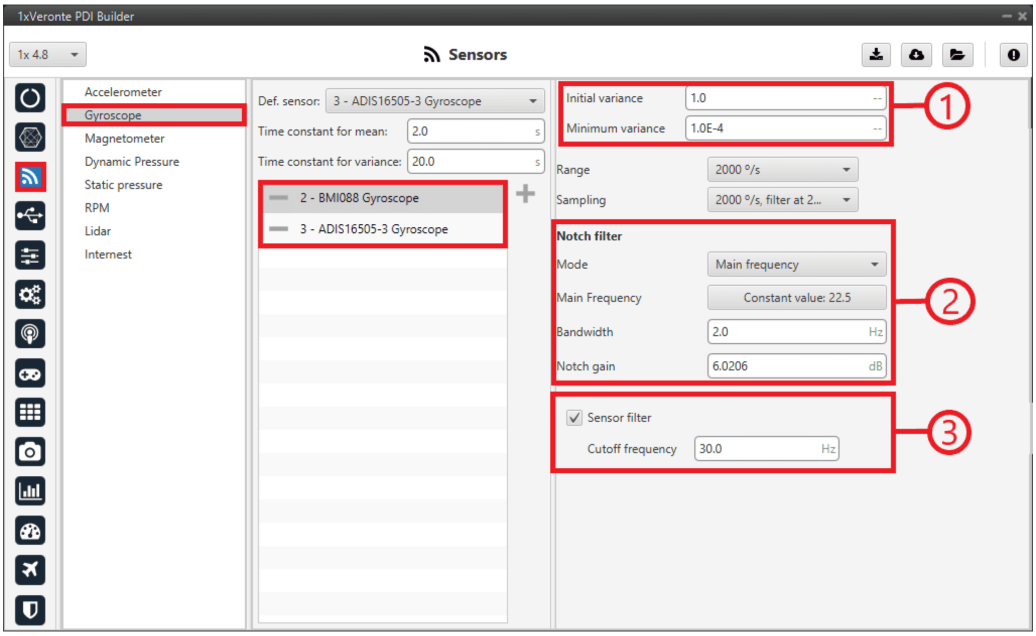


Gyroscope Panel

> **Important**
>
> It is recommended to select multiple of these sensors for the navigation algorithm, so that Veronte Autopilot 1x performs a combination of all the measurements of the selected gyroscopes.
>
> This combination consists of calculating the means and variances of each of these gyroscopes in a given time (Time constant for mean and Time constant for variance) to obtain a weighted mean with the inverse of the variance. The lower the variance, the greater the weight of that sensor in the mean.

1. The ADIS16505-3 Gyroscope sensor has been chosen as the **default sensor**. If all other sensors fail, the measurement value will be that of the default sensor.
2. A time of 2 seconds has been defined for the **Time constant for mean**, and 20 seconds for the **Time constant for variance**.
3. The **BMI088** and **ADIS16505-3** gyroscopes sensors have been selected and their configuration is described below.

Common configuration of BMI088 Gyroscope and ADIS16505-3 Gyroscope



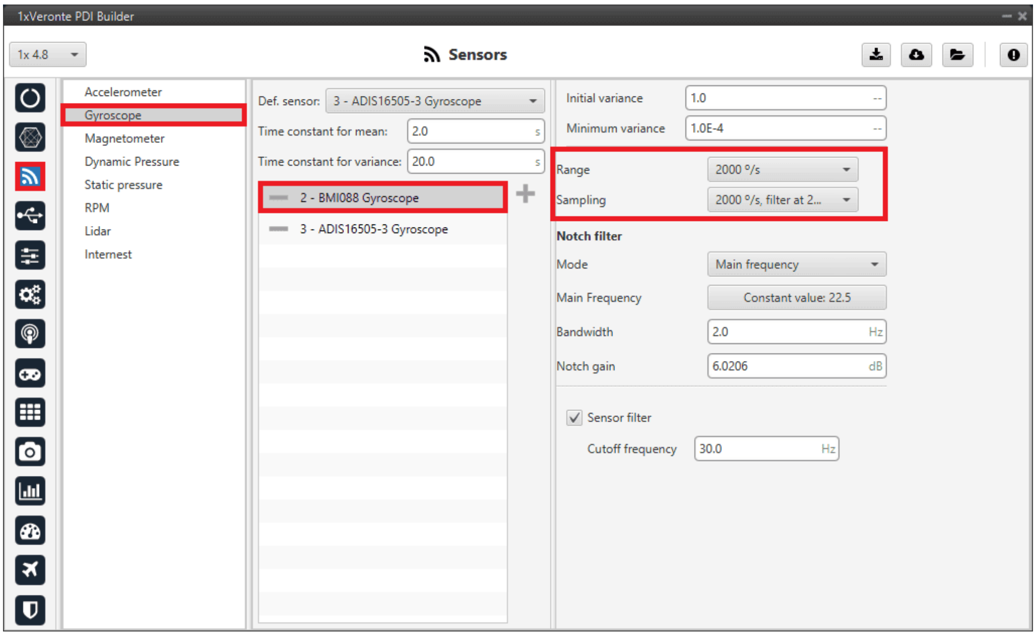
Common configuration

1. **Initial variance = 1.0**

   Minimum variance = 1.0E-4
2. **Notch filter**: It is a filter that dampens signals only at a specific frequency.
   - **Mode**: Main frequency
   - **Main Frequency**: 22.5
   - **Bandwidth**: 1.0 Hz
   - **Notch gain**: 6.0206 dB
3. **Sensor filter**: Enabled.
   - **Cutoff frequency**: 30.0 Hz

BMI088 Gyroscope

This panel displays the possible parameters that can be configured for the internal BMI088 Gyroscope.

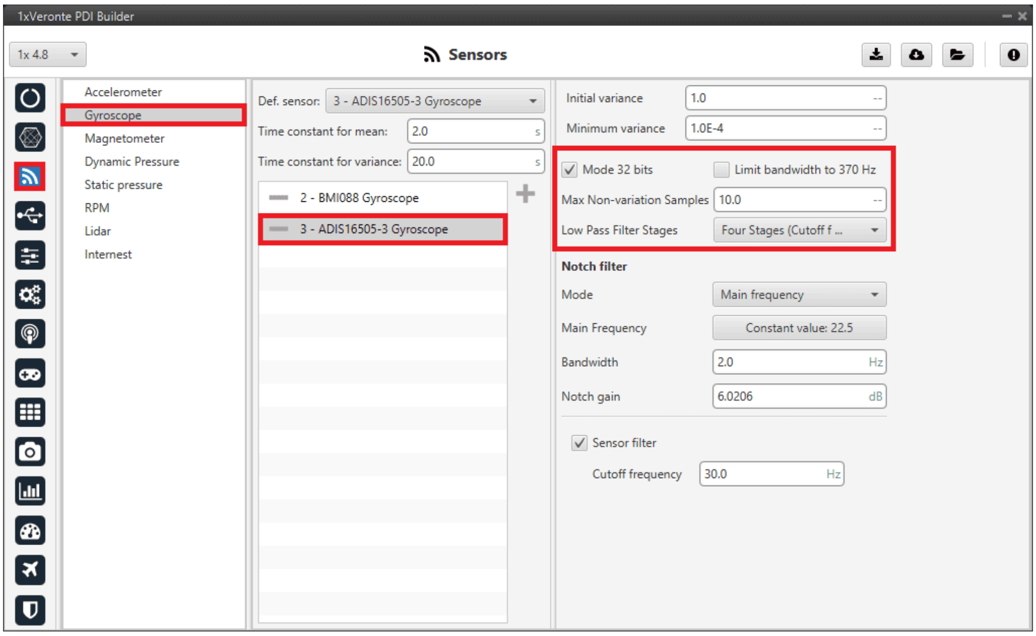


BMI088 Gyroscope Panel

- **Range**: We select a high performance range, **2000°s.**. The lower accuracy is accepted so that the system does not saturate.
- **Sampling**: The angular velocity is set to **2000°s filter at 230 Hz**.

ADIS16505-3 Gyroscope

This panel displays the possible parameters that can be configured for the internal ADIS16505-3 Gyroscope.



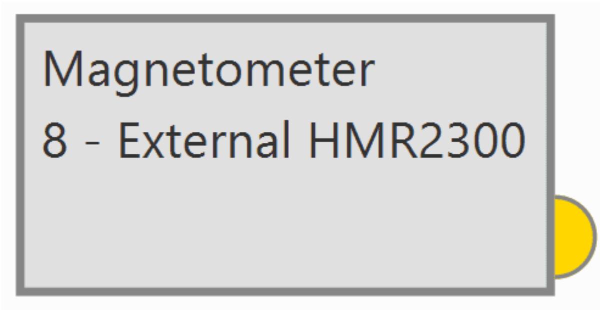
ADIS16505-3 Gyroscope Panel

- **Mode 32 bits**: Following the recommendation, we **enable** it.

- **Limit bandwith to 370Hz**: Following the recommendation, we **disable** it.
- **Max Non-variation Samples**: This is configured manually.
- **Low Pass Filter Stages**: Following the recommendation, **4 stages (Cutoff f=40Hz)** are configured.

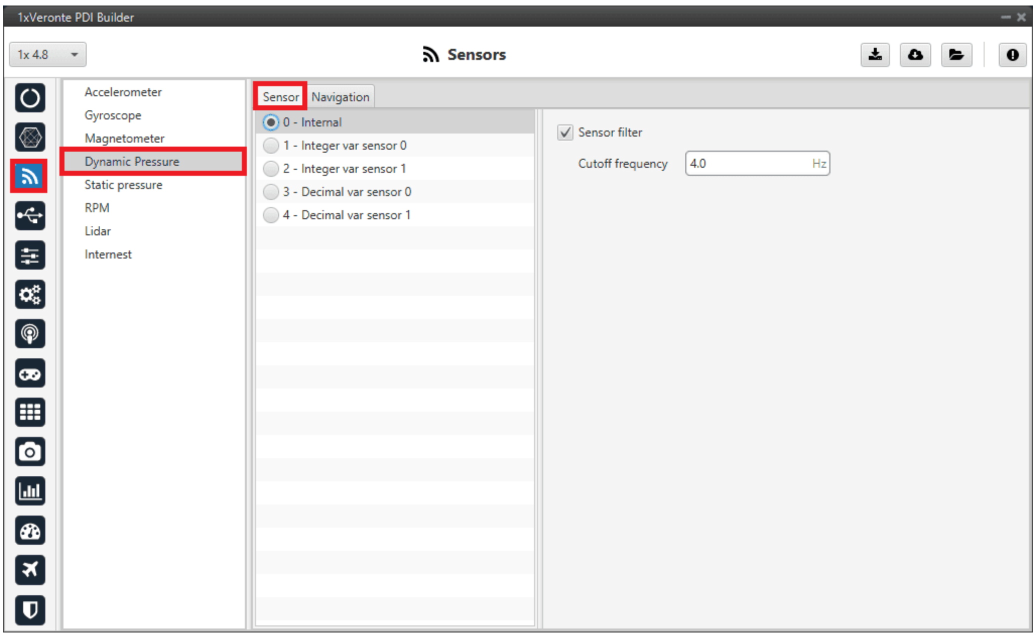
Magnetometer

It is not necessary to configure the magnetometer in this section. It is selected directly in the Navigation program - Block programs.



Dynamic Pressure

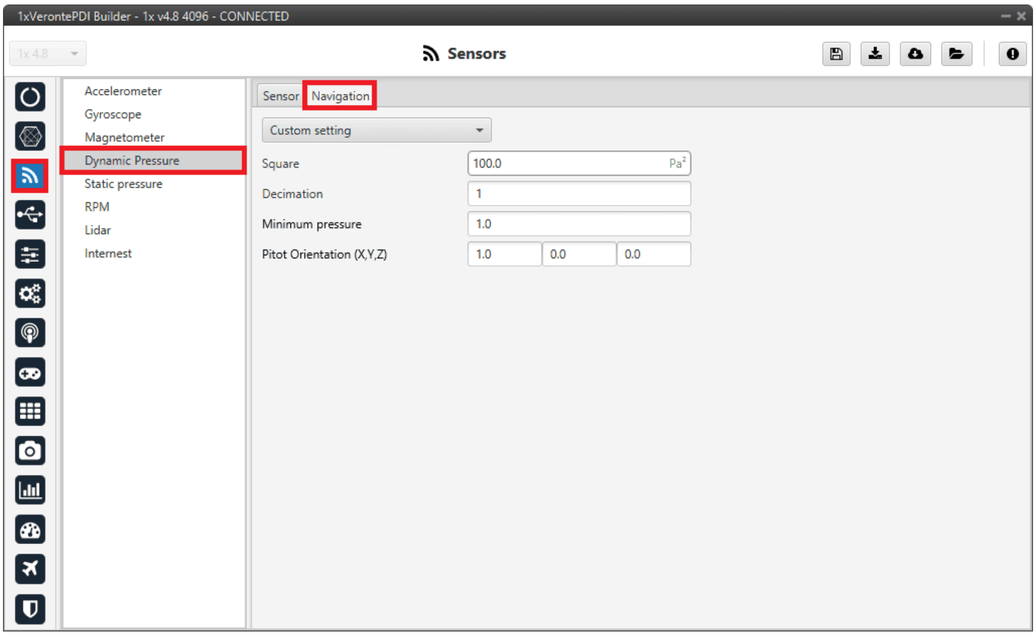
The Internal channel has been selected. In this case the Autopilot 1x uses a value provided by the internal sensor.



Sensor panel - Dynamic Pressure

A **cutoff frequency** of **1.0 Hz** has been defined in the **Sensor** panel for the low pass filter. It is necessary to **enable** the **sensor filter** to be able to define the cutoff frequency.

The image below shows a basic configuration of the **Navigation** panel.

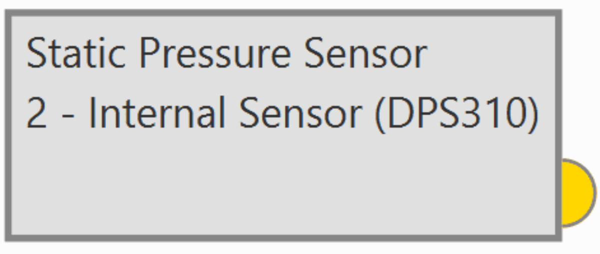


Navigation panel - Dynamic Pressure

> ⓘ **Note**
>
> For a detailed explanation of the available dynamic pressure sensors, please visit the Dynamic Pressure - Sensors section of the **1x PDI Builder** user manual.

Static Pressure

It is not necessary to configure the Static Pressure sensor in this section. It is selected directly in the Navigation program - Block programs.



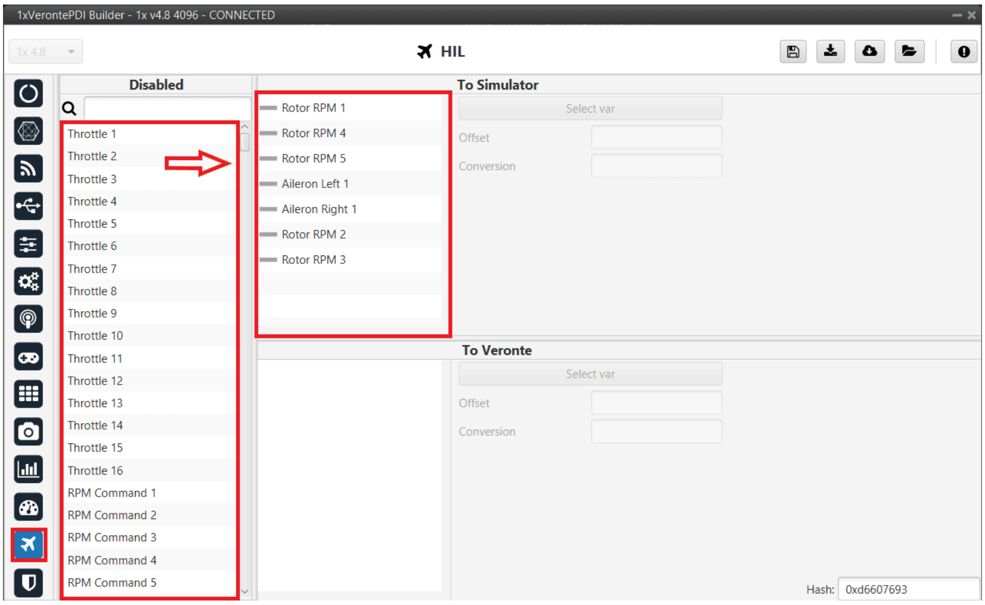
HIL Configuration

HIL Simulator is the Veronte application that allows Veronte Autopilot 1x to communicate with a simulator acting as a "bridge" between both. Therefore, users must configure this menu to simulate the performance of the Embention

VTOL aircraft 1x in the selected simulator, in this case X-Plane11 has been chosen. For more information, please visit HIL Simulator user manual.

To configure the simulation variables follow the steps below:

1. Find the **simulator variables** that have been configured in the aircraft model.
   Once found, drag and drop each of them into the **To Simulator** panel. In this panel users can see all the variables selected to be sent to the simulator.
   For Embention VTOL Aircraft select the following variables:
   - Rotor RPM 1
   - Rotor RPM 2
   - Rotor RPM 3
   - Rotor RPM 4
   - Rotor RPM 5
   - Aileron Right 1
   - Aileron Left 1

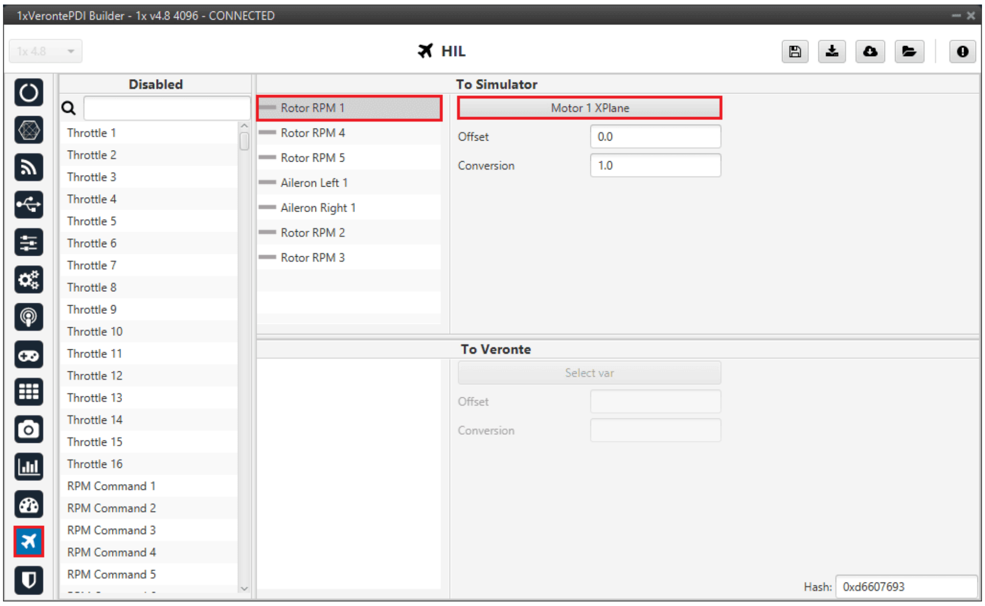
   Simulator variables

2. Associate each actuator variable (Control Output) of Autopilot 1x that matches that of the simulator.

ⓘ **Note**

The variables that have been assigned in the Control to servo program to each actuator are the ones to be linked to the simulator internal variables.

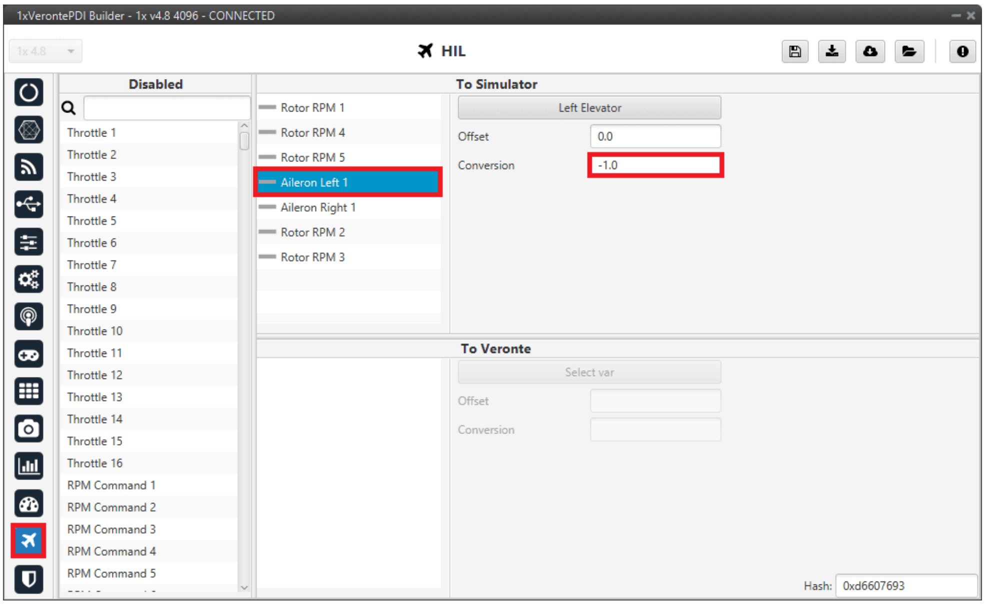
- Rotor RPM 1 ⇒ Motor 1 XPlane
- Rotor RPM 2 ⇒ Motor 2 XPlane
- Rotor RPM 3 ⇒ Motor 3 XPlane
- Rotor RPM 4 ⇒ Motor 4 XPlane
- Rotor RPM 5 ⇒ Pusher motor Xplane
- Aileron Right 1 ⇒ Right Elevator
- Aileron Left 1 ⇒ Left Elevator



Autopilot 1x variables

3. Set the **Offset** and **Conversion** variables if necessary.

   To adjust the aircraft performance to the simulation, a **conversion** factor of **- 1.0** has been defined for both **elevators**. This factor allows the simulation to match the actual aircraft conditions.



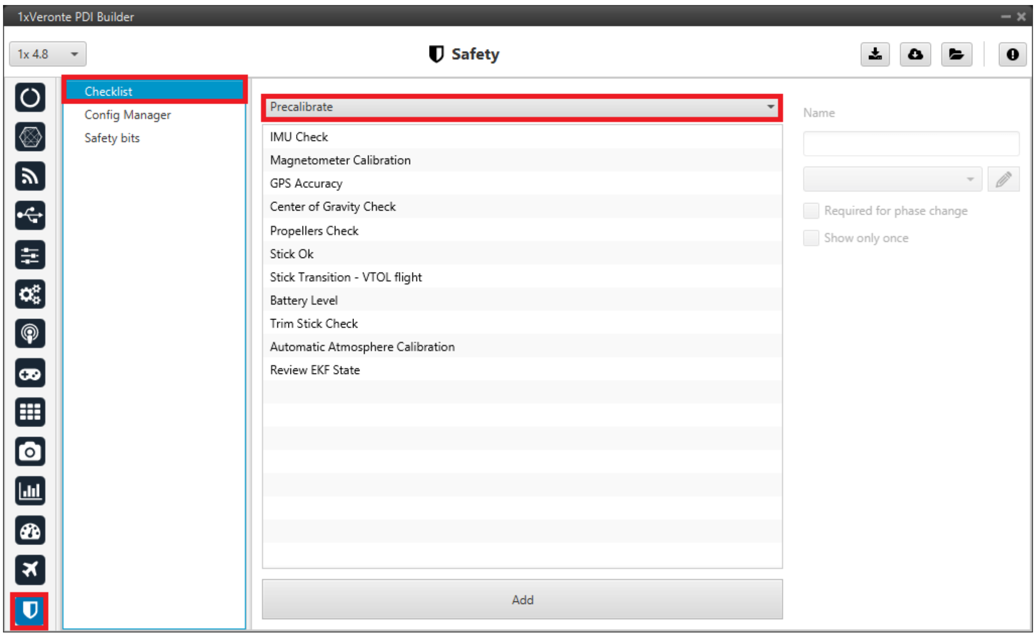
Conversion - Right elevator

For more information on this menu, visit the HIL section of the **1x PDI Builder** user manual.

Checklist

This feature is used to ensure that certain requirements have been accomplished, for example, prior to a phase change or to avoid a possible malfunction.

The checklist configured here will appear in **Veronte Ops** in the **Checklist** widget. For more information on this, visit Veronte Ops manual.



Checklist panel

In this configuration, a basic Checklist has been defined. In it, 2 different types of checks are configured, checks for operator information only (None) and checks automatically performed by Veronte Autopilot 1x (In Range check).

In the **Precalibrate** phase, the following checks are established:

- IMU Check ⇛ None
- Magnetometer Calibration ⇛ None
- GPS Accuracy ⇛ None
- Center of Gravity Check ⇛ None
- Propellers Check ⇛ None
- Stick Ok ⇛ **In Range Check**
  - Check performed automatically if the Stick Not Detected variable is in the range [0.9 - 1.1].
- Stick Transition - VTOL flight ⇛ **In Range Check**
  - Check performed automatically if the Stick - Transition variable is in the range [0.0 - 0.4].
- Battery Level ⇛ **In Range Check**
  - Check performed automatically if the Power Input variable is in the range [23.8 - 26.0].
- Trim Stick Check ⇛ None
- Automatic Atmosphere Calibration ⇛ None
- Reviw EKF State ⇛ None

For more information on the Checklist options, visit the Safety - Configuration section of the **1x PDI Builder** user manual.

Operation

This section will explain how to design a basic operation in **Veronte Ops**, as well as the different automations and events that can be combined to allow Autopilot 1x to guide the aircraft according to the desired laws.

Veronte Ops is an application for vehicle **operation and monitoring** during missions. For more information, visit the Veronte Ops user manual.

To familiarize the user with the basic functioning of this tool, 3 operations will be explained as examples. Previously, the following steps must be followed to start designing an operation:

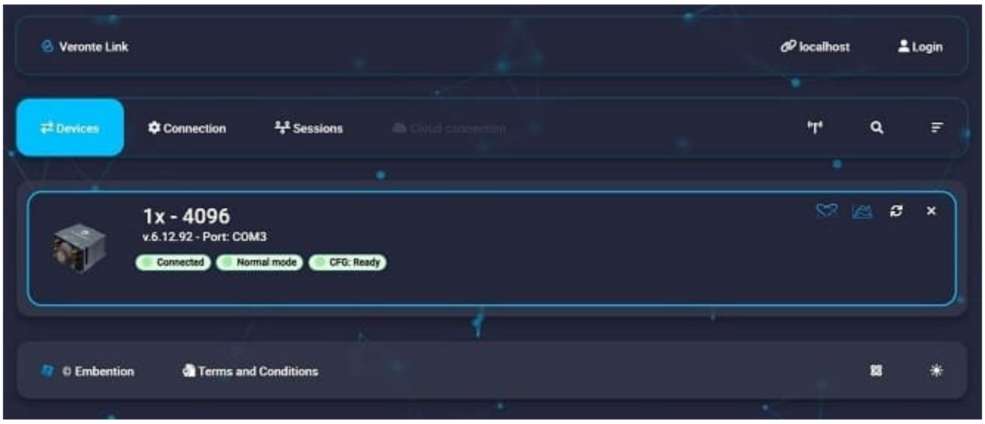
1. Download, install and open **Veronte Ops**.

   There are 2 ways to work with this application: as a website app or by installing it throught an executable.

   > **Hint**
   >
   > It is recommend to use the **executable** version if working **offline**.

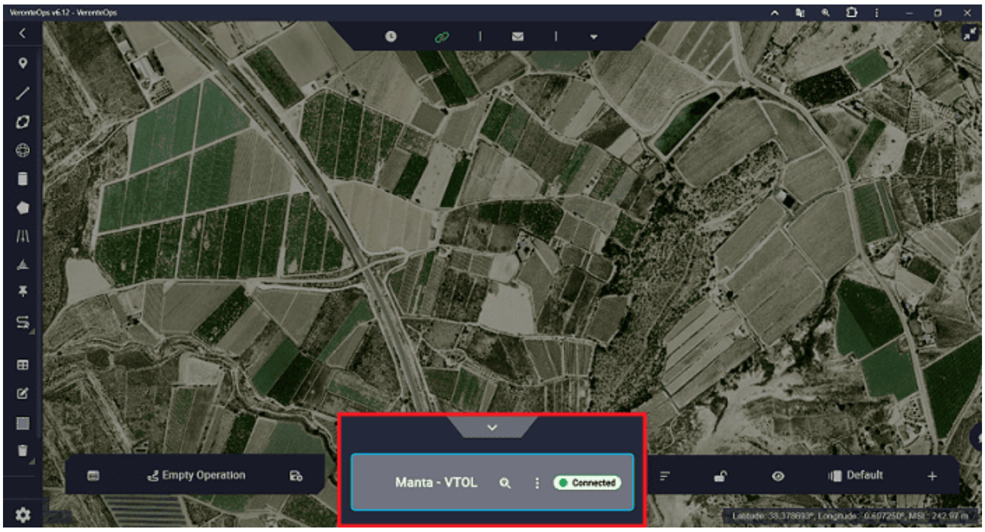
   For more information, visit the Download and Installation - Quick Start section of the **Veronte Ops** user manual.
2. Connect Autopilot 1x to the PC (usually via USB) for design operation.

   For more information on this connection, visit the Basic connection for operation - Quick Start of the **1x Hardware Manual**.
3. In order to work with the autopilot with Veronte applications, it is first necessary to configure **Veronte Link** to recognize it. If users need more details on how do this, visit the Serial connection - Integration examples section of the **Veronte Link** user manual.

   Operation - Veronte Link

4. Once the autopilot is recognized in **Veronte Link**, it will appear in Veronte Ops to be selected:



Operation - Platform selected

For more information, visit the Platform - Panels section of the **Veronte Ops** user manual.

5. Finally, navigate on the map to the location where the mission is to be created.

Followed these steps, the following three operations are defined:

- Operation 1. This is a simple operation, in which the aircraft performs a mission consisting of a closed loop passing through all flight phases.
- Operation 2. In this operation, the different options offered by the **areas tools** (Sphere, Cylinder, Prism) will be used. These can be linked to an automation or defined as **obstacles**.
- Operation 3. This operation combines the use of the **marks** option and automations to create an operation composed of two missions.

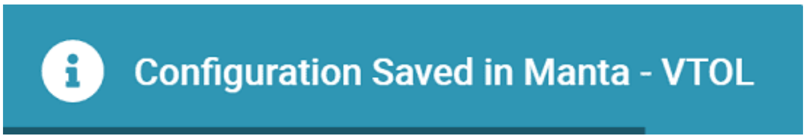
Once the operation is configured, it is necessary to **save and upload** it to Autopilot 1x. To do that, users must use the following options available in the **Operation Panel**:

Operation panel actions

1.  **Save Operation**: Click on it to apply any change if necessary.
2.  **Upload to**: Click on it to update the loaded operation in Autopilot 1x with the new **saved changes**.

> **Note**
>
> This option will only be available if the changes made have been previously saved, i.e. the **Save Operation** option must have been used.

The following message indicates that the operation configuration has been uploaded successfully.



Configuration Saved

For more information, visit the Operation actions - Operation section of the **Veronte Ops** user manual.

Finally, to start flying, it is useful to create a **Workspace** to control the mission. The Workspace section of this manual presents the main elements advised for setting up a workspace.

For more information, visit the Workspace - Panels section of the **Veronte Ops** user manual.

Operation 1

This operation will be defined as a closed route in figure of `8`. It is a simple and basic mission that will serve as an example to learn how to use the Veronte Ops application.

Mission

Once the desired location for the mission has been selected, there are two ways to create an `8` figure route:

- Generate route option.
- Segments option.

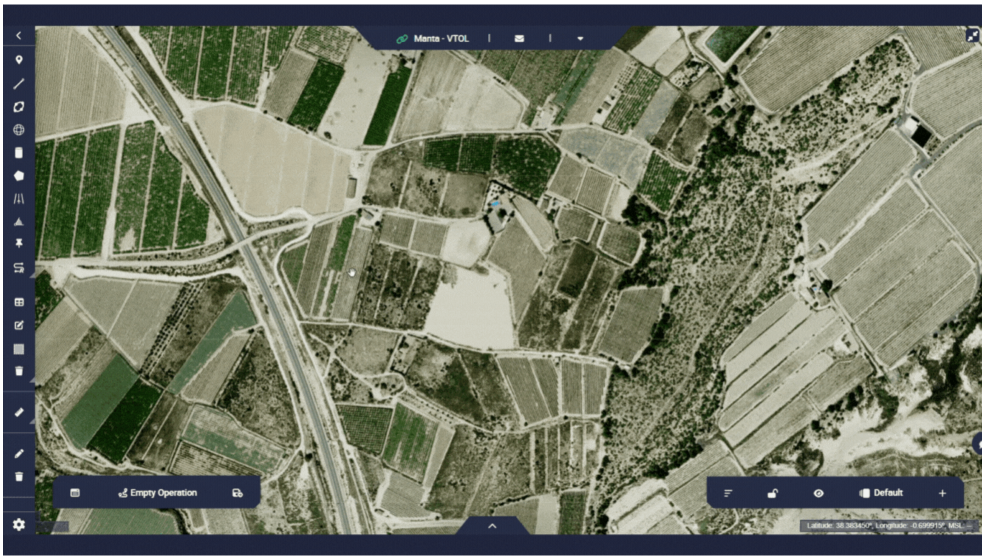
Generate route

This option allows to create missions with predefined routes: **Spiral**, **Photogrammetry** and **Figure**.

Follow the steps below to define the mission using the Generate route option:

1. Go to Mission Toolbar → Generate route → **Create figure**.

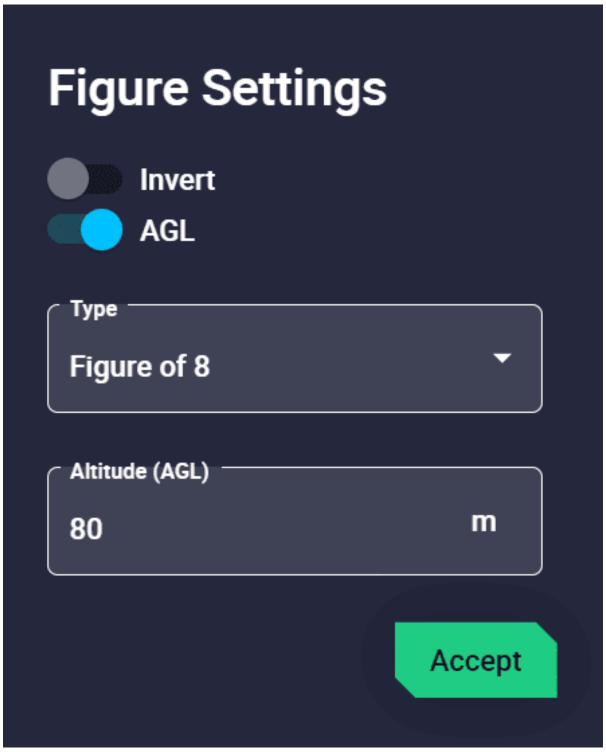
   Click and drag to create the figure in the desired location.



Operation 1 - Create Figure

2. Configure the **Figure Settings**.

   For more information on the parameters to be configured, visit the Generate route - Operation section of the **Veronte Ops** user manual.



Operation 1 - Figure Settings

3. Use the Edit Mission option in the Mission Toolbar if the user wants to edit the location of a waypoint or the curvature of the route.

Operation 1 - Edit Mission

Segments

This option allows the user to define the location and altitude of each waypoint, thus defining the mission in more detail.

Follow the steps below to define the mission using Segments.

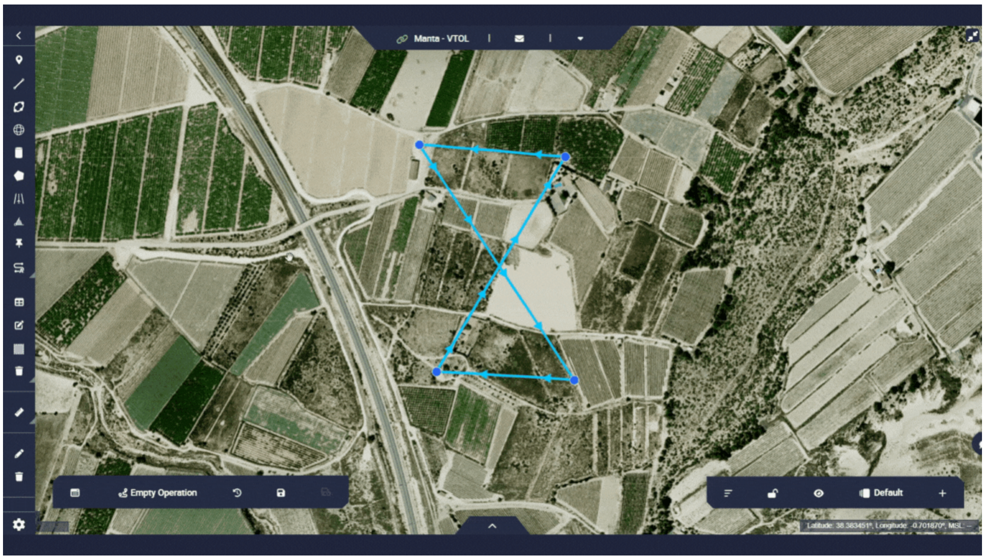
1. Go to Mission Toolbar → **Segment**.

   Set as many segments as wished. These segments, separated by waypoints, will draw the mission.

   > **Hint**
   >
   > Set the segments following the desired direction of the route.

Operation 1 - Segment

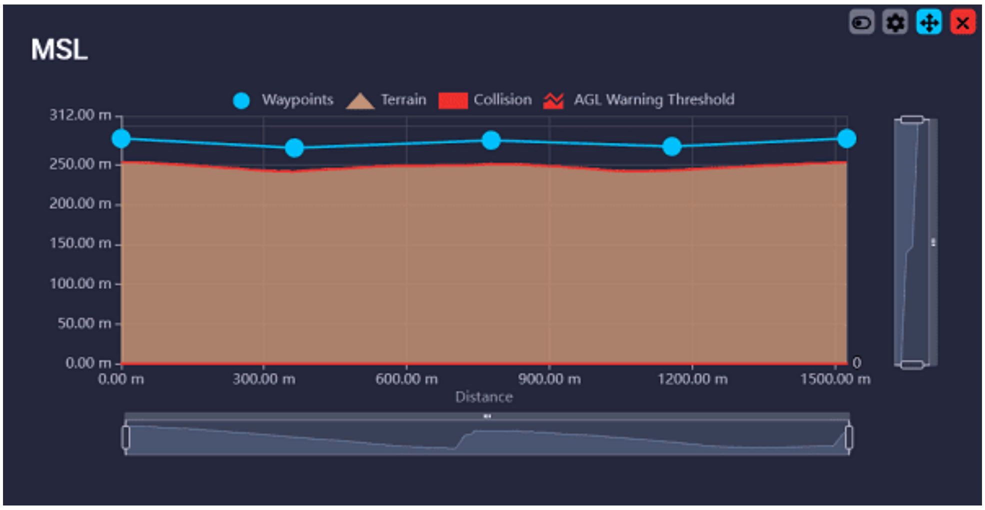
2. Use the Edit Mission option in the Mission Toolbar if the user wants to edit the location of a waypoint and the curvature of the route.



Operation 1 - Edit Mission

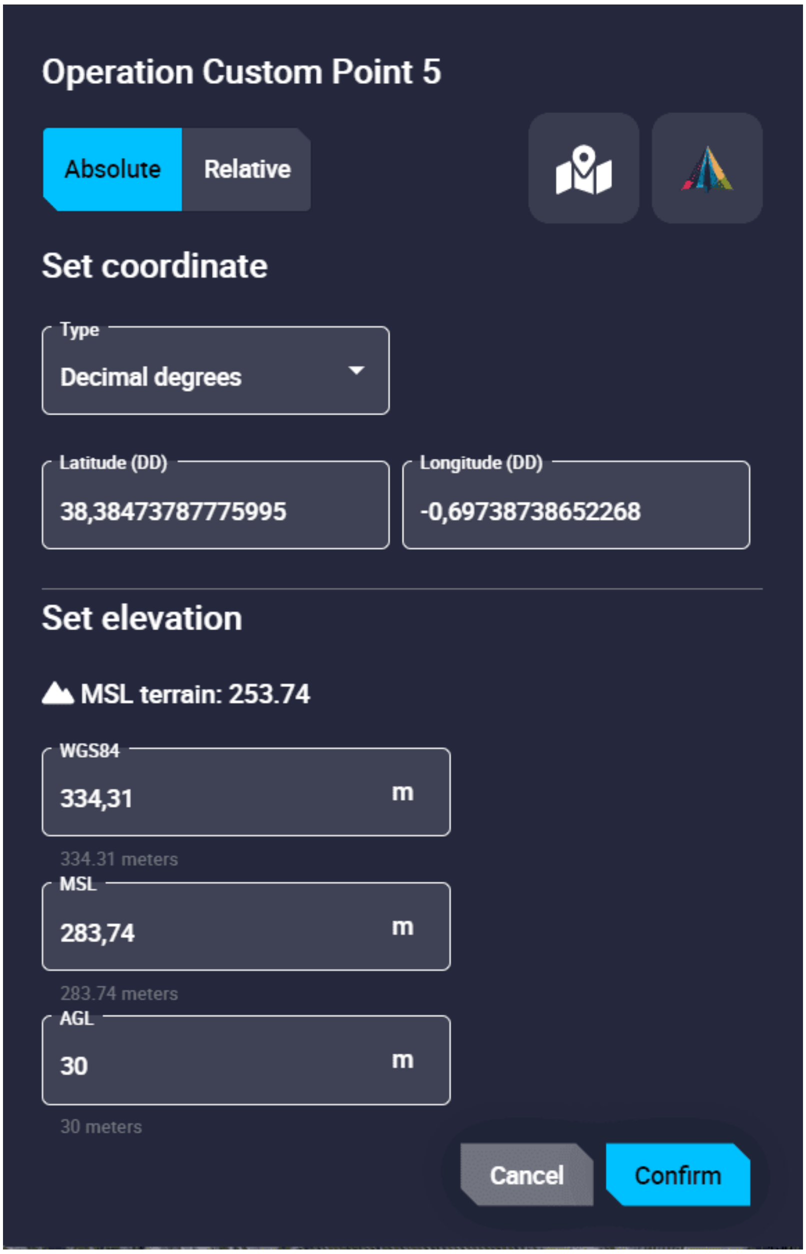
3. Check the altitude of the route waypoints with respect to the ground, **to make sure that the route is feasible**, i.e. does not interfere with the terrain.

   To do this, right-click on any waypoint of the route → **Open elevations**.



Operation 1 - Elevations panel

4. Configure the settings for each waypoint to define its altitude and location. To do this, right-click on a waypoint → **Waypoints Settings**.



Operation 1 - Waypoints Settings

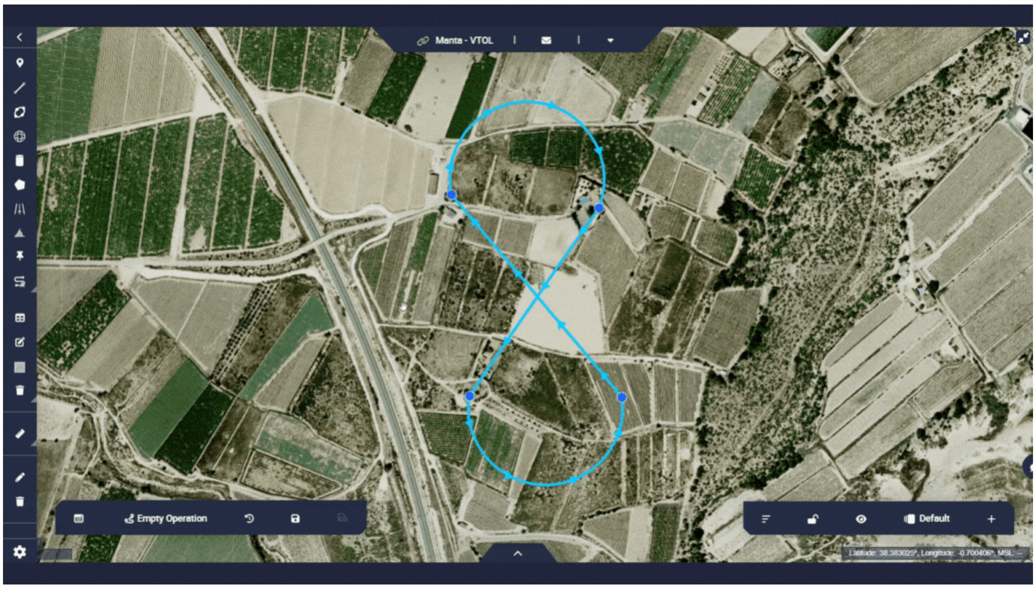
> For more information on the parameters to be configured, visit the Waypoint - Operation section of the **Veronte Ops** user manual.

Start Route

The user must define a waypoint as the start of the route. This will be the point where the aircraft will start the Cruise phase.

> **Important**
>
> If this point is not defined, **Veronte Ops** will not allow the operation to be saved.

To define a waypoint as the start of the route, right click on the desired waypoint to be the start of the route → Select the **Set Start Route** option:



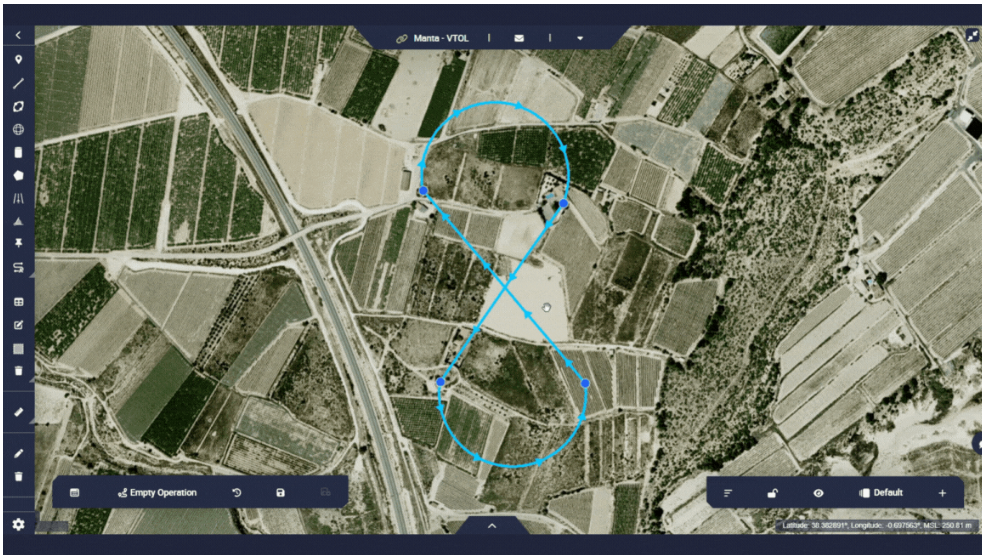
Operation 1 - Start Route

Runway

For the operation of the Embention VTOL aircraft it is necessary to define a runway since in the Approach phase a route will be generated to guide the aircraft to fly to it.

Follow the steps below to define a runway:

1. Go to Mission Toolbar → **Set a Runway**.
2. Click on the map to define the start point of the runway → Click on a second point to define the end of the runway.
3. Use the Edit Mission option to locate the Loiter point where the user wants it to be.
   This will be the point around which the Loiter will take place.



Operation 1 - Runway

4. Go to Operation Panel → Customize → **Runway**.

   Link the runway defined in the **1x PDI Builder** configuration with the just created runway.

Operation 1 - Set runway

> ⓘ **Note**
>
> Adjust the runway parameters so that the aircraft performs the desired operation.
>
> For more information on the parameters to be configured, visit the Runway - Operation section of the **Veronte Ops** user manual.

Home Point

The Home point will be the point used to execute the **Compute RTH** program of the **1x PDI Builder** configuration. This will be the point to which the Autopilot 1x will guide the aircraft in the Return to Home phase.

Follow the steps below to define a waypoint as Home point:

1. Go to Mission Toolbar → **Waypoint**.
2. Click on the map to set a waypoint.

> **Note**
>
> The user also has the option to use an existing waypoint.

3. Go to Operation Panel → Customize → **Custom Points**.

   Link the Home point defined in the **1x PDI Builder** configuration with the desired waypoint.

Operation 1 - Home Point

> **Note**
>
> If the user does not define this point, Autopilot 1x will guide the aircraft to the **take-off point** in the Return Home phase.

Operation 2

This operation implements some of the main functionalities of the **areas** option. Generally, these areas are used as **events** that trigger an action, or as **obstacles** that the guidance program will avoid flying over.

As an example, two areas will be added to the Operation 1 mission:

- Area 1 → Within this area the aircraft will switch directly to the **Return to Home** phase.
- Area 2 → Area defined as **obstacle**, the autopilot system will prevent the aircraft from entering this area.

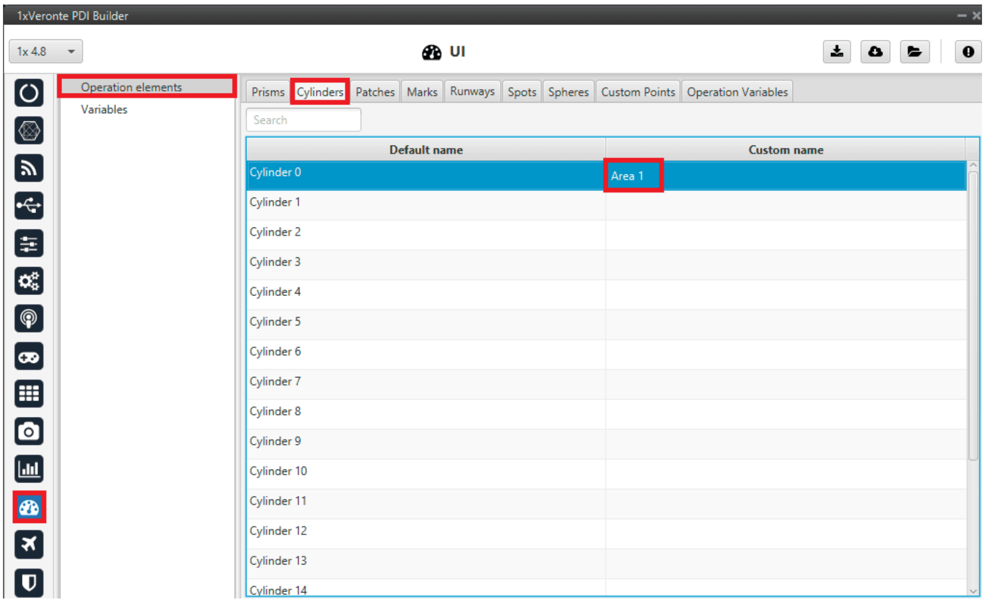
> **Important**
>
> To configure the **areas with events and actions** in **Veronte Ops**, it is necessary to first define them in the Operation elements panel of the **UI menu** of the **1x PDI Builder** app.

> **Note**
>
> In this case, the areas used will be cylinders, although they can also be prisms or spheres following the same steps.

Area 1

1. In the 1x PDI Builder app → go to UI menu → Operation elements panel → **Cylinders tab**.

   Define the area by setting a **custom name**:

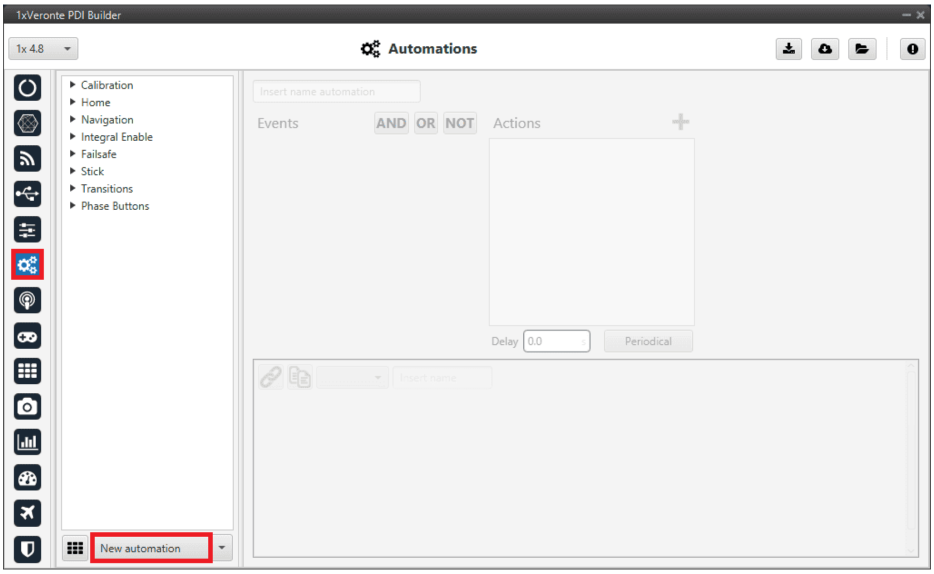


Operation 2 - UI menu

2. In the 1x PDI Builder app → go to **Automations menu**.

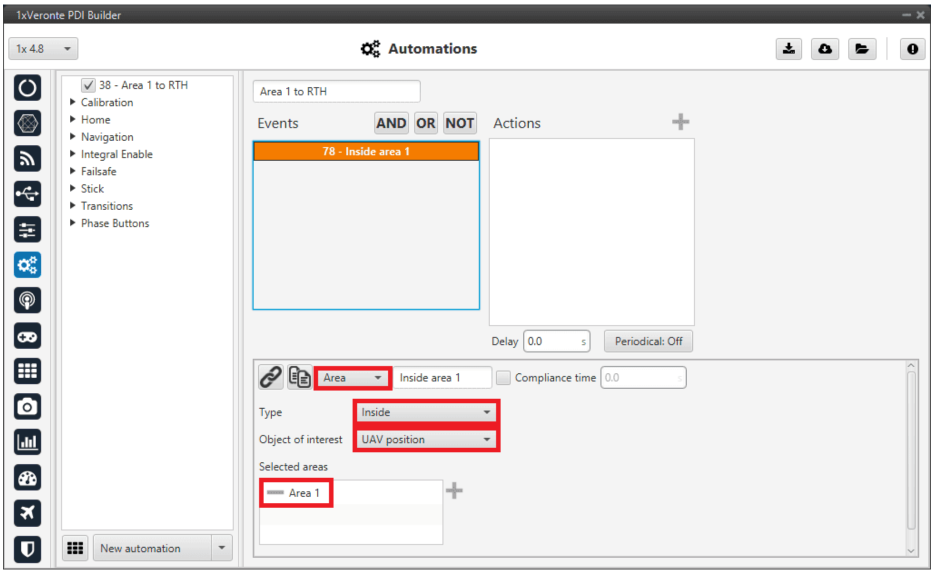
   An automation will be created for the autopilot to pass to the Return to Home phase when it is inside Area 1:

   - Create a **new automation**.



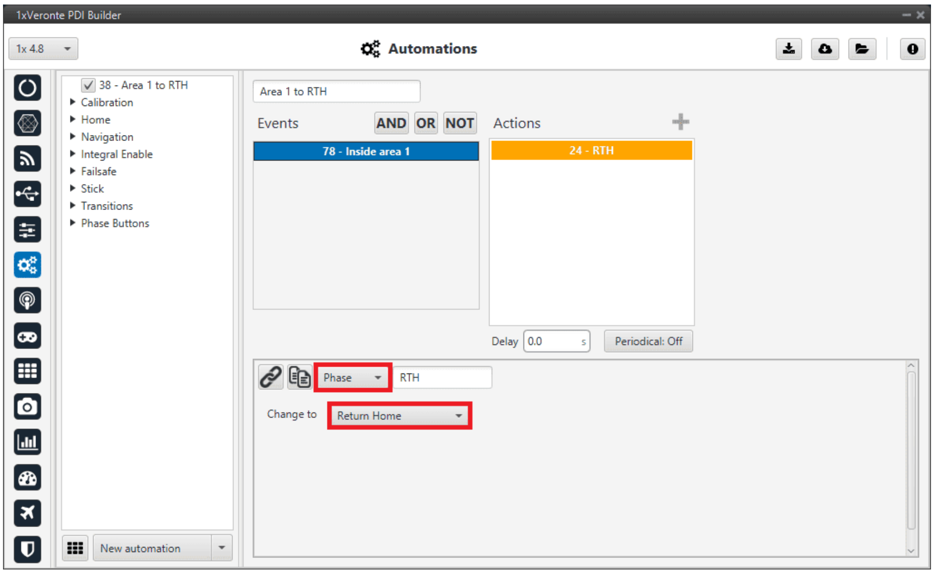
Operation 2 - New Automation

   - To configure the desired event, select the **Area** as the event type and choose the **Inside** type, since the event is that the **aircraft is inside area 1**.



Operation 2 - Event

- Define an **action** of type **Phase**. In this case, the action is to change to Return Home phase.



Operation 2 - Action

For more information, visit the Automations - Configuration section of the **1x PDI Builder** user manual.

3. Save the configuration so that the changes made will appear in **Veronte Ops**.
4. Create the area in **Veronte Ops** (in the mission created for Operation 1). For this:

   In Veronte Ops → go to Mission Toolbar → **Set a Cylinder**.

   Click and drag to set a cylinder to the desired position.

5. Use the Edit Mission option of the Mission Toolbar if the user wishes to edit the exact location and radius of the cylinder.

Operation 2 - Cylinder

6. Configure the cylinder by setting its height and radius.

   For more information on the parameters to be configured, visit the Cylinder - Operation section of the **Veronte Ops** user manual.

7. Go to Operation Panel → Customize → Areas → **Cylinders**.

   Link the area defined in the **1x PDI Builder** configuration to the just created cylinder.

Operation 2 - Set cylinder

Area 2

1. Create the area in **Veronte Ops** (in the mission created for Operation 1). For this:

In Veronte Ops → go to Mission Toolbar → **Set a Cylinder**.

Click and drag to set a cylinder to the desired position.

2. Use the Edit Mission option of the Mission Toolbar if the user wishes to edit the exact location and radius of the cylinder.
3. Right click on the configured cylinder → Select **Set Obstacle** option.

Operation 2 - Obstacle

4. Configure the cylinder by setting its height and radius.

   For more information on the parameters to be configured, visit the Cylinder - Operation section of the **Veronte Ops** user manual.

> **Note**
>
> It is also possible to create an automation associated to an obstacle. To do so, once the area has been defined as an obstacle, follow the steps explained in Area 1 to create the automation.

Operation 3

This operation implements some of the functionalities offered by the combination of the **Automations** with the **Mark** option of the Mission Toolbar.

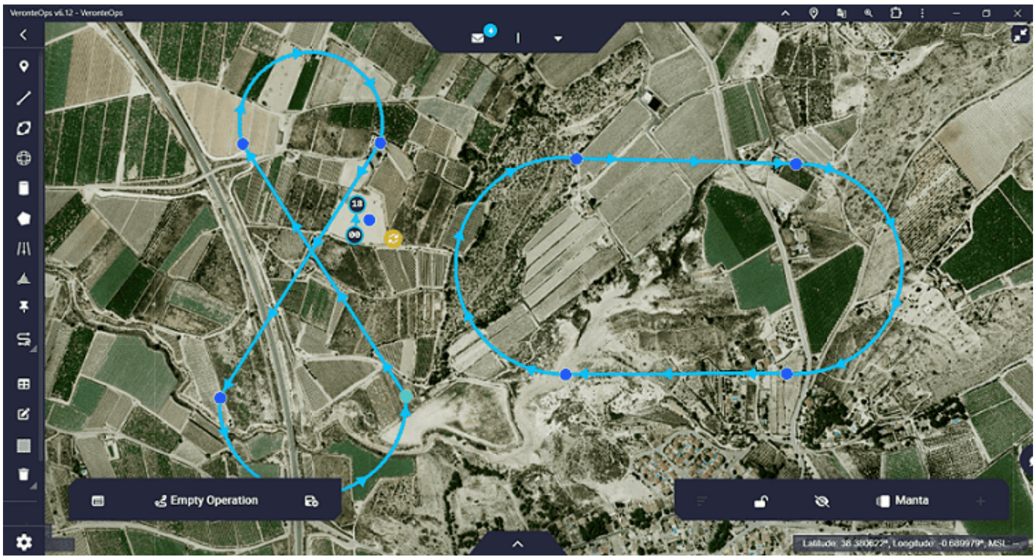
To explain this tool, an operation composed of two missions with closed circuits is created.

In the first mission, which is the same as the one created for Operation 1, the **Mark A** is defined. Then, when the aircraft achieves this mark an automation will send the aircraft to move to the second mission. In this second mission, the **Mark B** will be defined from which the aircraft will start the **Approach** phase.

Missions

As mentioned above, two closed circuits are defined:

- The first circuit with the figure of `8`.
- The second circuit, at the same altitude as the first one, with the figure of `Racetrack`.



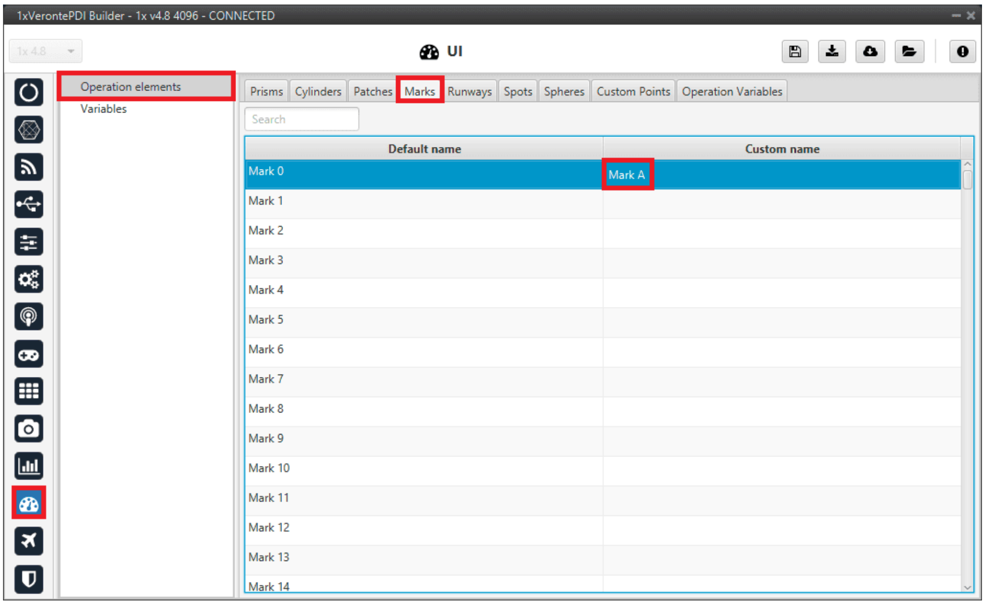
Operation 3 - Missions

Mark A

The operation starts with the route of the first mission, therefore, a point of this circuit is defined as the Start Route. At one point on this route the **Mark A** is defined.

Follow the steps below to define the mark and the automation associated with it:

1. First it is required to define the mark in the **1x PDI Builder** configuration.
   In the 1x PDI Builder app → go to UI menu → Operation elements panel → **Marks tab**.
   Define the mark by setting a **custom name**.

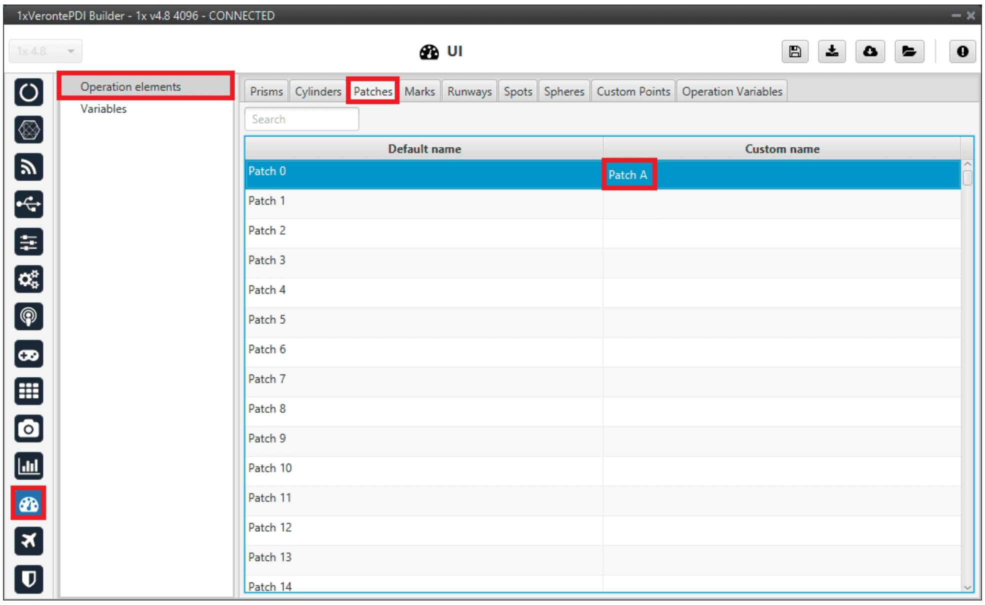


Operation 3 - Mark A definition

2. It is also necessary to define the **patch** where the autopilot will guide the aircraft when it reaches **Mark A**.

   In the 1x PDI Builder app → go to UI menu → Operation elements panel → **Patches tab**.

   Define the patch by setting a **custom name**.



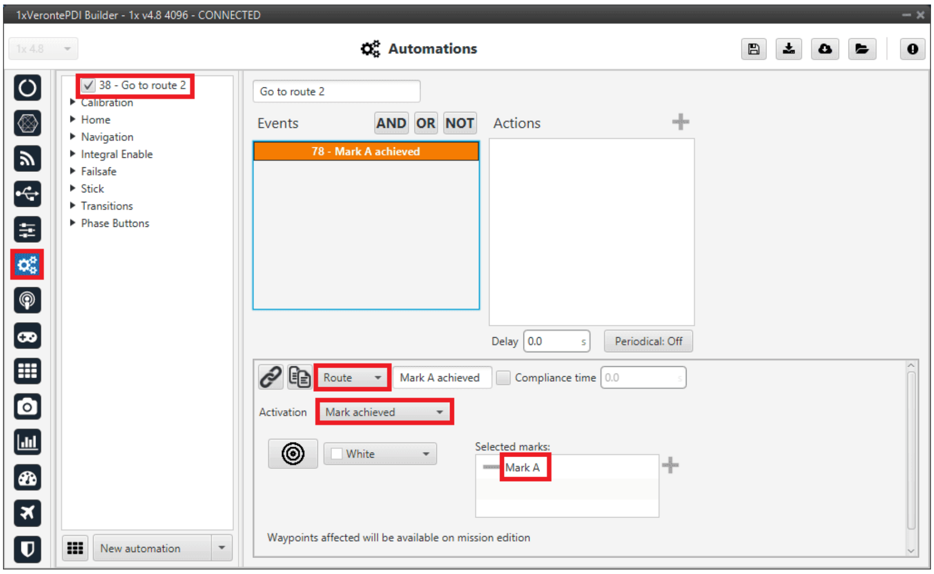
Operation 3 - Patch A definition

3. In the 1x PDI Builder app → go to Automations menu → **New automation**.

An automation will be created so that, once this mark is achieved, the aircraft **will go to** the desired point:

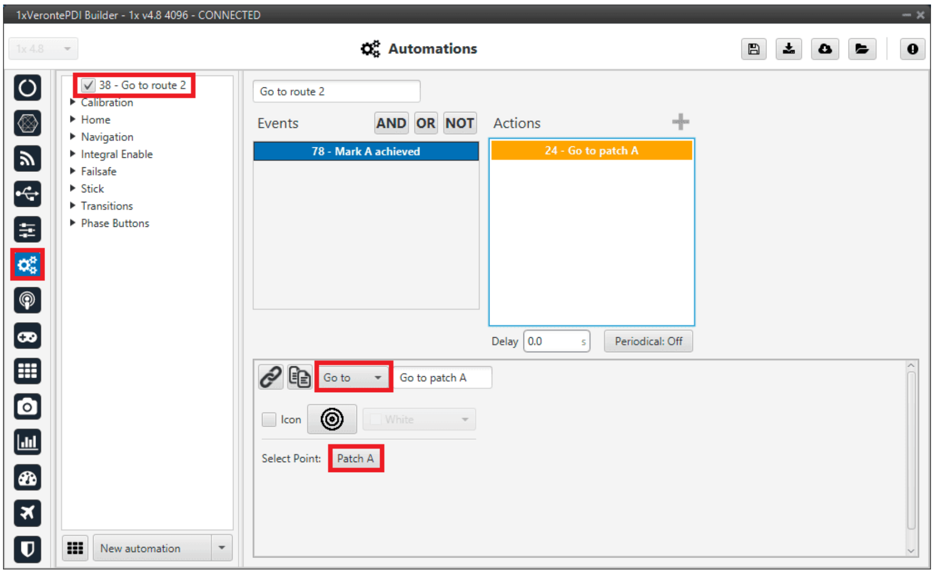
- To configure this event, select the **Route** type and choose the **mark achieved** option.

  For more information, visit the Route - Events section of the **1x PDI Builder** user manual.



Operation 3 - Mark A event

- To define the action triggered by the event, set up a **Go to** action. This action guides the aircraft to the selected **patch**. For more information, visit the Go to - Actions section of the **1x PDI Builder** user manual.



Operation 3 - Mark A action

4. Save the configuration so that the changes made will appear in **Veronte Ops**.

5. Create the mark in **Veronte Ops**. For this:

   In Veronte Ops → go to Mission Toolbar → **Mark**.

   Click on the desired patch to place a mark on the route.

   Then, with the Edit Mission option of the Mission Toolbar, users can more precisely place the mark.

Operation 3 - Mark A creation

6. Go to Operation Panel → Customize → **Marks**.

   Link the mark defined in the **1x PDI Builder** configuration with the just created mark.

Operation 3 - Set Mark A

7. Go to Operation Panel → Customize → **Patches**.

Link the patch defined in the **1x PDI Builder** configuration to the desired patch where the autopilot will guide the aircraft. In this case, a patch from the second mission.

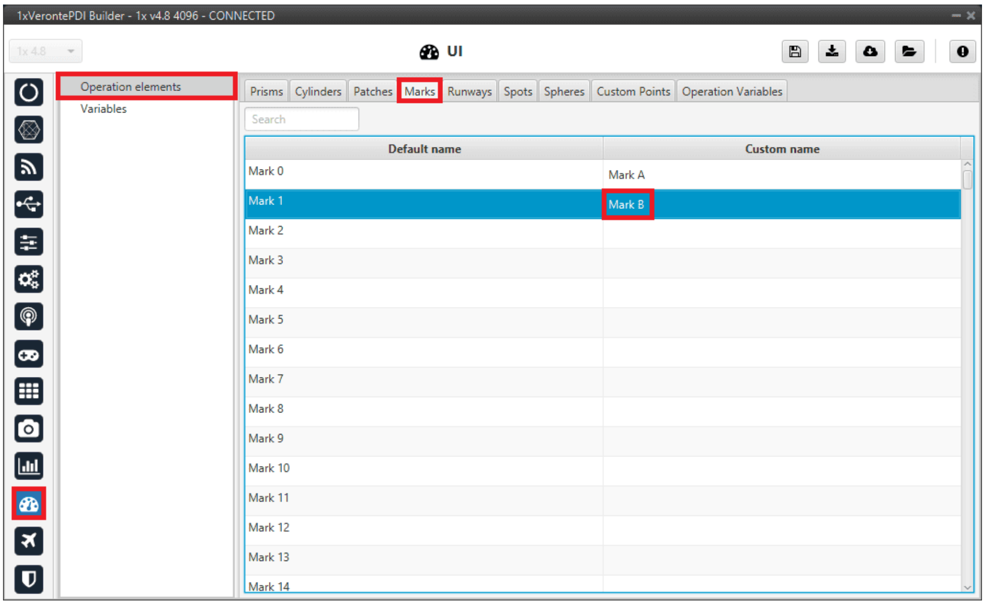
Operation 3 - Set Patch A

Mark B

Follow the steps below to define the **Mark B**:

1. In the 1x PDI Builder app → go to UI menu → Operation elements panel → **Marks tab**.

   Define the mark by setting a **custom name**.

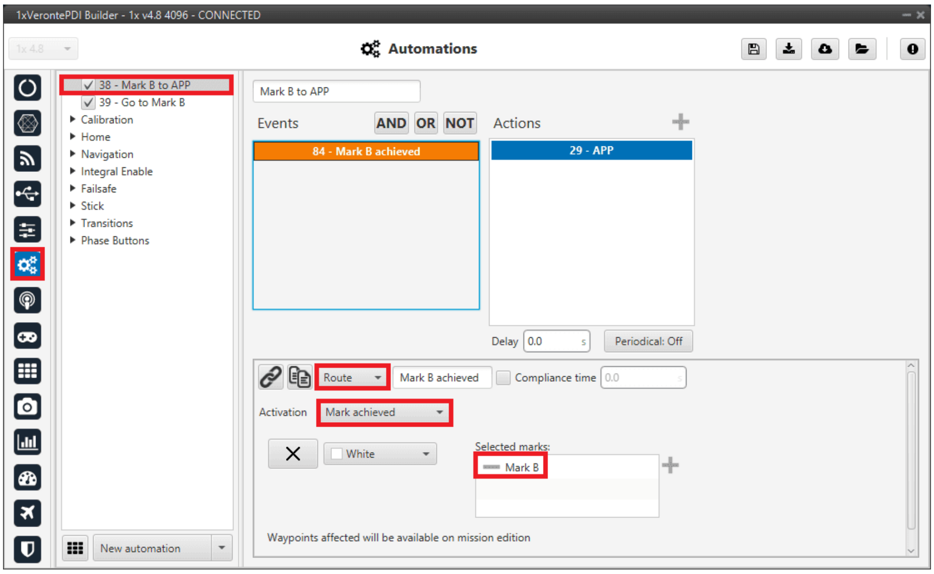
   Operation 3 - Mark B definition

2. In the 1x PDI Builder app → go to Automations menu → **New automation**.

An automation will be created so that, once this mark is achieved, the aircraft begins its **approach** phase.

- To configure this event, select the **Route** type and choose the **mark achieved** option.

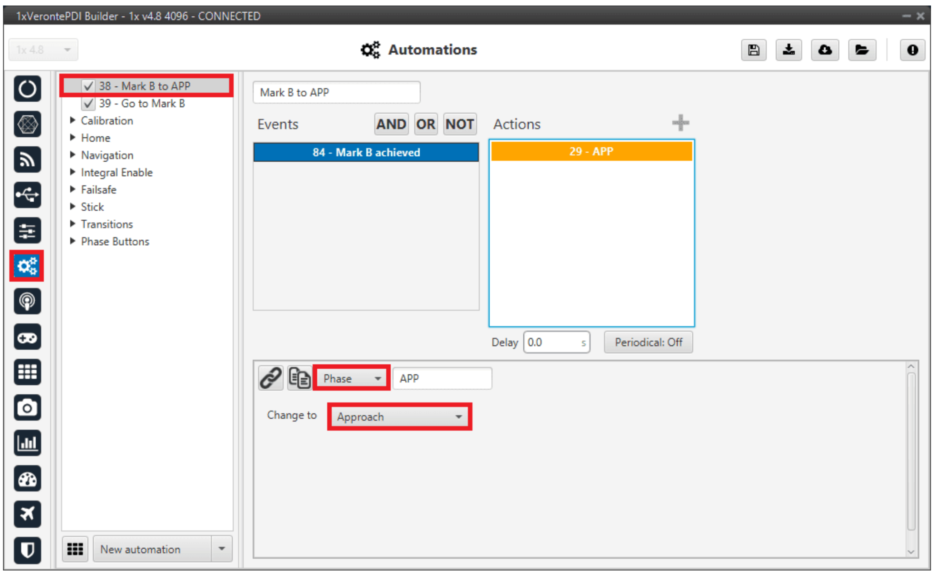
  For more information, visit the Route - Events section of the **1x PDI Builder** user manual.



Operation 3 - Mark B event

- To define the action triggered by the event, configure a **Phase** action and select the phase to change, in this case to the Approach phase.

  For more information, visit the Phase - Actions section of the **1x PDI Builder** user manual.



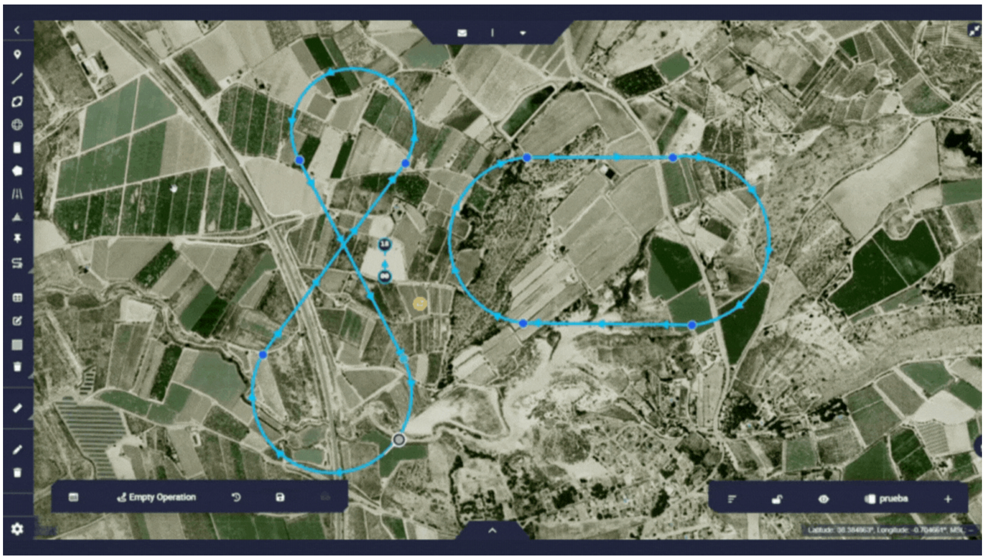
Operation 3 - Mark B action

3. Save the configuration so that the changes made will appear in **Veronte Ops**.
4. Create the mark in **Veronte Ops**. For this:

   In Veronte Ops → go to Mission Toolbar → **Mark**.

   Click on the desired patch to place a mark on the route.

   Then, with the Edit Mission option of the Mission Toolbar, users can more precisely place the mark.

   Operation 3 - Mark B creation

5. Go to Operation Panel → Customize → **Marks**.

   Link the mark defined in the **1x PDI Builder** configuration with the just created mark.

   Operation 3 - Set Mark B

Workspace

The creation of a customized workspace allows the user to display the desired information to monitor the operation.

Workspace example

For more information, visit the Workspace - Panels section of the **Veronte Ops** user manual.

This section explains the **main** settings and **widgets** that are recommended be incorporated in the workspace to perform a **basic** flight.

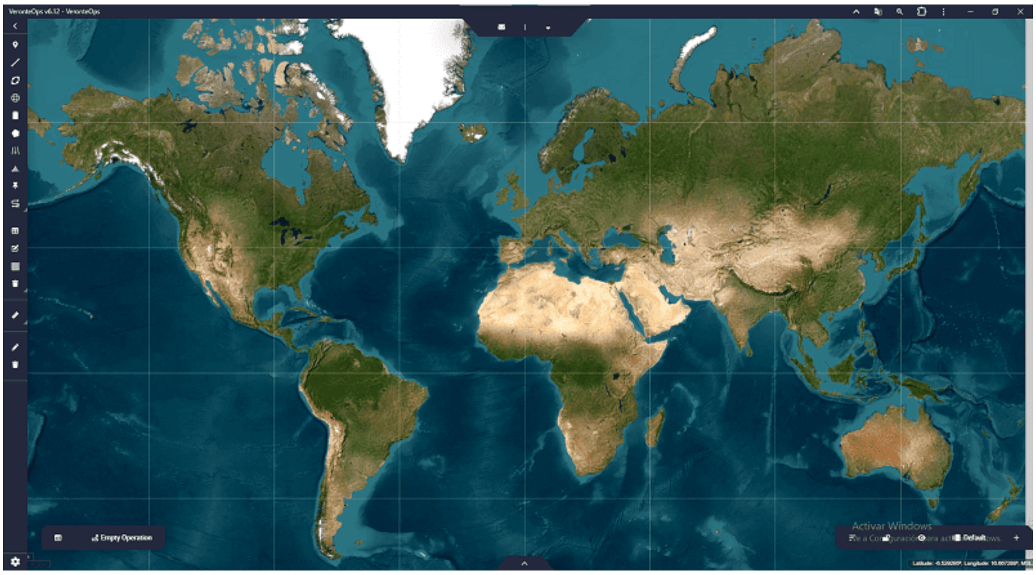
> **Note**
>
> This workspace is designed specifically for the operation being performed, so not all the widgets explained below are necessarily useful for all operations.

> **Important**
>
> The widgets explained are not mandatory, each user should configure the workspace by adding the widgets that provide the best information about the operation.

Map

Veronte Ops offers the possibility to choose the map on which users want to operate. Users can choose from the maps provided by Veronte Ops or upload their own map.

In this operation, the **ESRI Satellite** map has been employed.



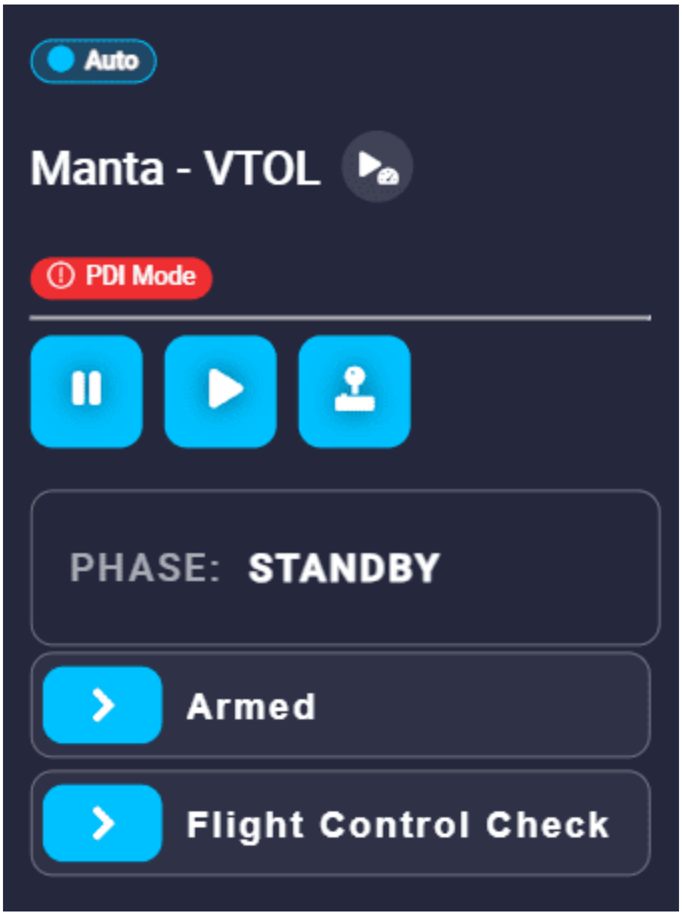
Workspace - Map

For more information, visit the Map option - Workspace section of the **Veronte Ops** user manual.

Main

Widgets from the "Main" category that have been used are presented below. For more information on these widgets, visit the Main - Widgets section of the **Veronte Ops** user manual.

- Veronte Panel. This pannel is the basic operator tool. It includes all basic commands (phase and action buttons) and information needed during a standard mission. These commands can be triggered with a single click, by sliding and/or automatically.



Workspace - Veronte Panel

> **Important**
>
> **PDI Mode**: This only appers if PDI Mode is configured in the **1x PDI Builder** app.

- Checklist. This panel is used to make sure that some requirements have been met. This represents the checklist explained in Checklist - 1x PDI Builder configuration section.

Workspace - Checklist

> **Important**
>
> It must be previously defined in the Checklist panel of the **Safety menu** of the **1x PDI Builder** app.

Displays

These widgets allow the user to display in real time the value of a variable.

For more information, visit the Displays - Widgets section of the **Veronte Ops** user manual.

- Label. With labels the user can display the value of an **Integer variable**, **Real variable** or **Bit variable**. For a basic flight, the following labels are recommended:

Variable	Label	Type
GNSS1 Accuracy		Real variable
GNSS2 Accuracy		Real variable

Variable	Label	Type
AGL		Real variable
MSL		Real variable
Position Fix		Bit variable
System Error		Bit variable
Sensors Error		Bit variable
Stick not detected		Bit variable

It may also be interesting to display other variables in the labels:

- Stick-Pitch, Stick-Roll, Stick-Throttle, etc.
- Arc-Pitch, Arc-Roll, Arc-Throttle, Arc-Yaw
- Pitching (Q), Pitching (P), Rolling (Q), Rolling (P), etc
- Down Ground Velocity
- Static Pressure
- PDI error
- Power input

Charts

For more information, visit the Charts - Widgets section of the **Veronte Ops** user manual.

- Chart. Charts widgets allow the user to represent any variable of the system with respect to time. Thus, the user can visualize the evolution of that variable over time.

Workspace - Charts

For a **basic** flight, the following variables are recommended for charts:

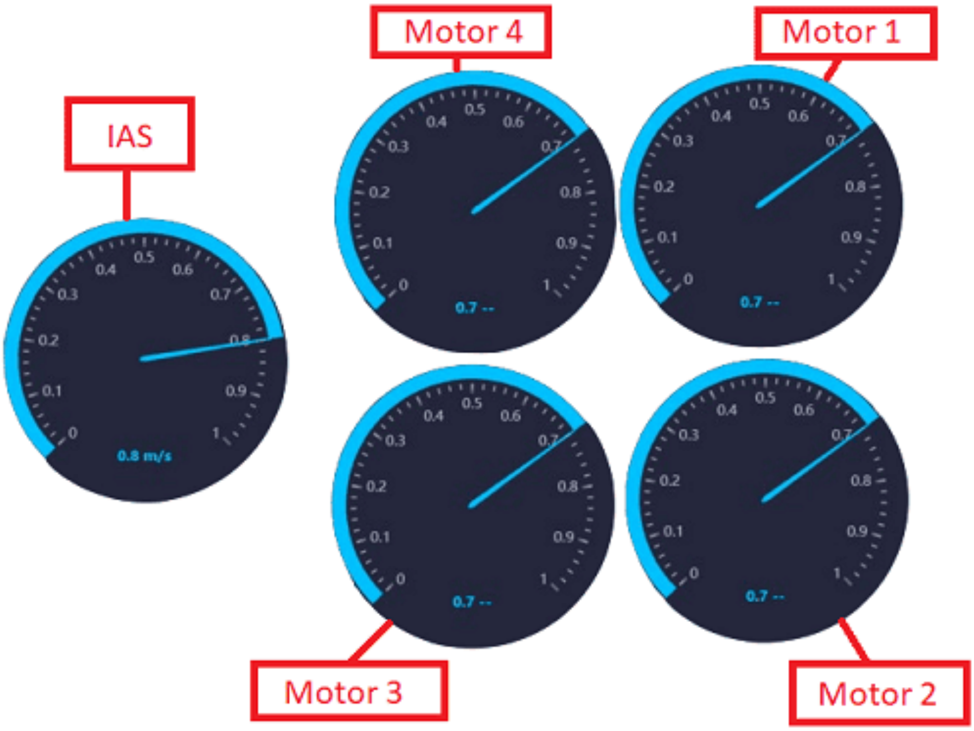
Variable 1	Variable 2
Desired Roll	Roll
Desired Pitch	Pitch
Desired Yaw	Yaw
Desired Ground Speed (GS)	Ground Speed (GS)
Desired Front GV	Front GV
Desired Down GV	Down GV
Desired Lateral GV	Lateral GV
Desired Heading	Heading
Desired IAS	IAS
Desired FPA	Flight Path Angle (FPA)

It may also be interesting to plot the following variables:

- Control mix
- Roll rate, Pitch rate, Yaw rate
- P, Q, R (Angular Velocity)

- Gauge. Gauge widget is a data visualisation tool that can be used to show the progress of data or display data in ranges in a precise and compact area.

  This widget can also be useful to represent variables such as **IAS** or **Motor RPM**:



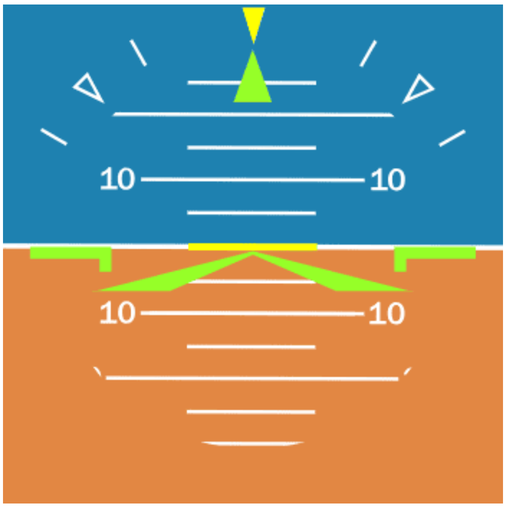
Workspace - Gauge

Flight instruments

Workspace - Flight instruments

For more information, visit the Flight instruments - Widgets section of the **Veronte Ops** user manual.

- Attitude. The attitude widget, commonly known as Primary Flight Display (PFD) or 'artificial horizon', represents graphically the attitude of the aircraft (**roll** and **pitch**).

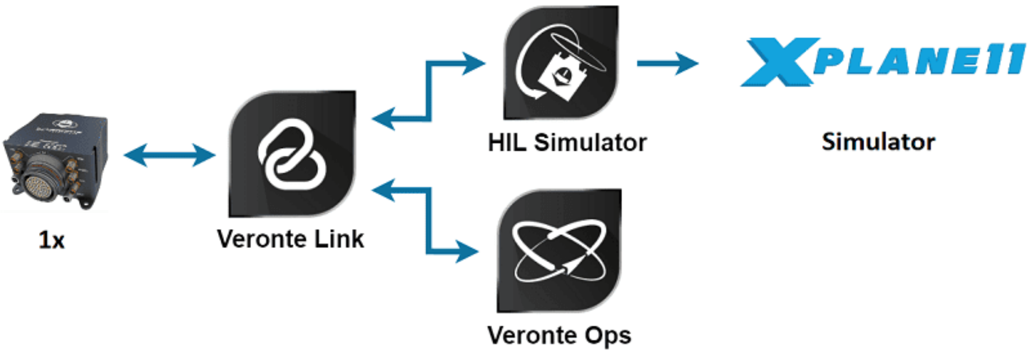
  Workspace - Attitude

- Heading. The heading widget, commonly known as **compass**, usually shows the platform's yaw relative to the magnetic north.

Workspace - Heading

Simulation

This section explains the steps to follow to simulate in **X-Plane 11** the operations defined in the Operation section.



The simulation will be performed using the HIL Simulator tool.

> **Important**
>
> To configure X-Plane correctly, follow the steps of X-Plane 11 section of the **HIL Simulator** user manual.

Once **X-Plane 11** has been correctly configured and the simulation has been started, in the following sections the user will be able to find the simulation of the operations:

- Operation 1
- Operation 2
- Operation 3

It also explains the Stick configuration to be performed in order to integrate and simulate the missions using a **stick**.

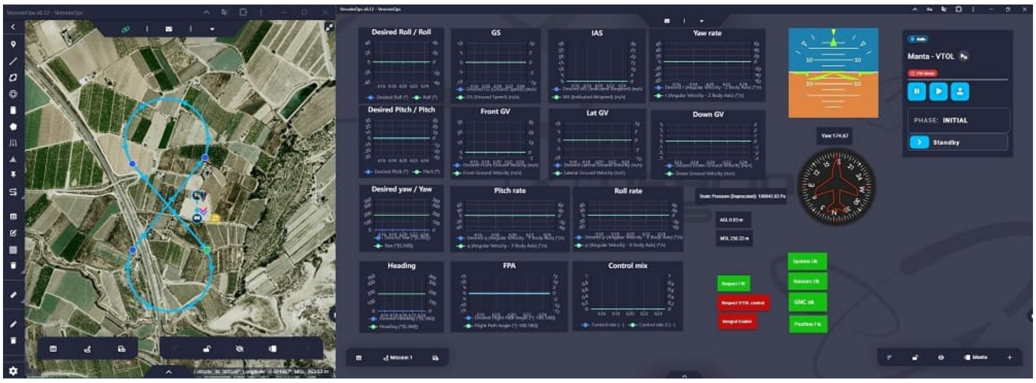
Operation 1

In this operation, the aircraft performs a mission consisting of a runway for the approach phase in Fixed-Wing (FW) flight configuration and a closed loop passing through all flight phases.

The performance of the aircraft in each of these phases and the transitions between phases that are triggered, are explained below.

Initial and Standby

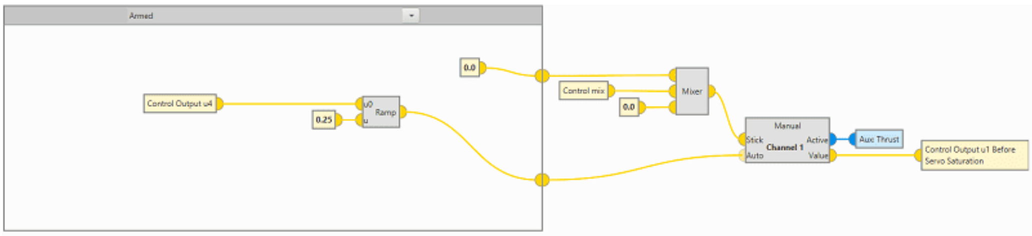
In these flight phases all actuators are disabled. The guidance program does not send any commands to the actuators, so the charts do not show any data.



Operation 1 - Initial flight phase

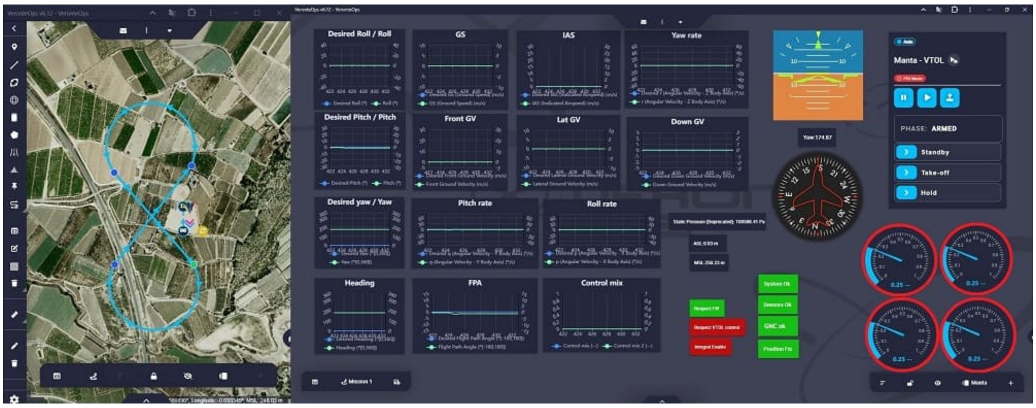
Armed

In this flight phase, the four motors providing the thrust increase the RPM to **25%**. This increase, as explained, has been defined in the block programs.



Operation 1 - Armed in Block Programs

This activation of the motors can be easily visualized with the gauges added to the workspace.

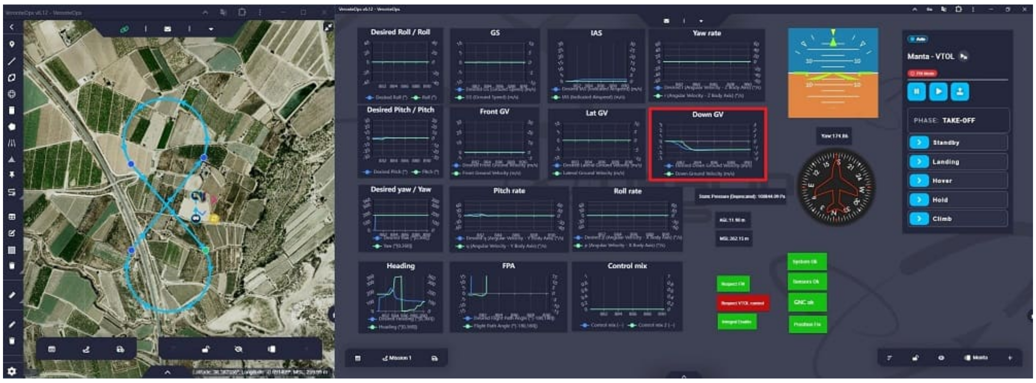


Operation 1 - Armed flight phase

Take-off

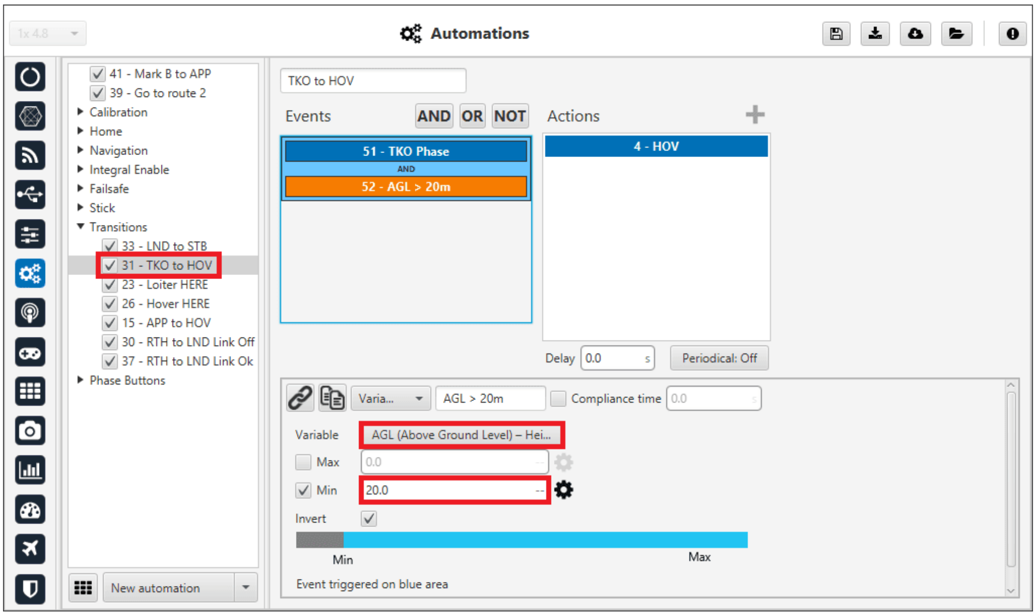
Since Take-off phase is performed with the aircraft in **quadcopter** flight configuration, the control variable is the Down Ground Velocity (DGV).

The aircraft performs a take-off at a DGV of **1.5 m/s**.



Operation 1 - Take-off flight phase

Once the aircraft reaches **20 meters** (AGL), Autopilot 1x transitions to the **Hover** flight phase. This automation has been explained in the Automations - 1x PDI Builder configuration section.



Operation 1 - TKO to HOV automation

Hover

In this flight phase, Veronte Autopilot 1x stabilizes the 3D position, so the aircraft attitude control variables (Desired Pitch, Desired Roll, Desired Yaw), Desired Down Ground Speed and Desired IAS variables are **null and constant**.

Operation 1 - Hover flight phase

Cruise

When the operator commands Autopilot 1x to swtich to the **Cruise** flight phase, a path to the mission point defined as **Start Route** is automatically generated.

To switch from Hover to Cruise, the aircraft changes the flight configuration from quadcopter to **FW**. This change can be represented by plotting the Control mix variable on a chart.

In this workspace, two labels have been added to show the behavior of the PID controllers for quadcopter and FW control:

In this flight phase, the control variables for **attitude** are: Desired Pitch, Desired Roll and Desired Yaw. And for **aircraft speed**: Front Ground Velocity and Lateral Ground Speed.

Operation 1 - Cruise flight phase

Veronte Ops allows users to visualize the aircraft trajectory during the mission. For more information, visit the Platform icon - Veronte Ops configuration of the **Veronte Ops** user manual.

Operation 1 - Trajectory in cruise flight phase

> ⓘ **Note**
>
> In this operation, the aircraft will remain in the Cruise phase until a phase change is commanded.

Loiter

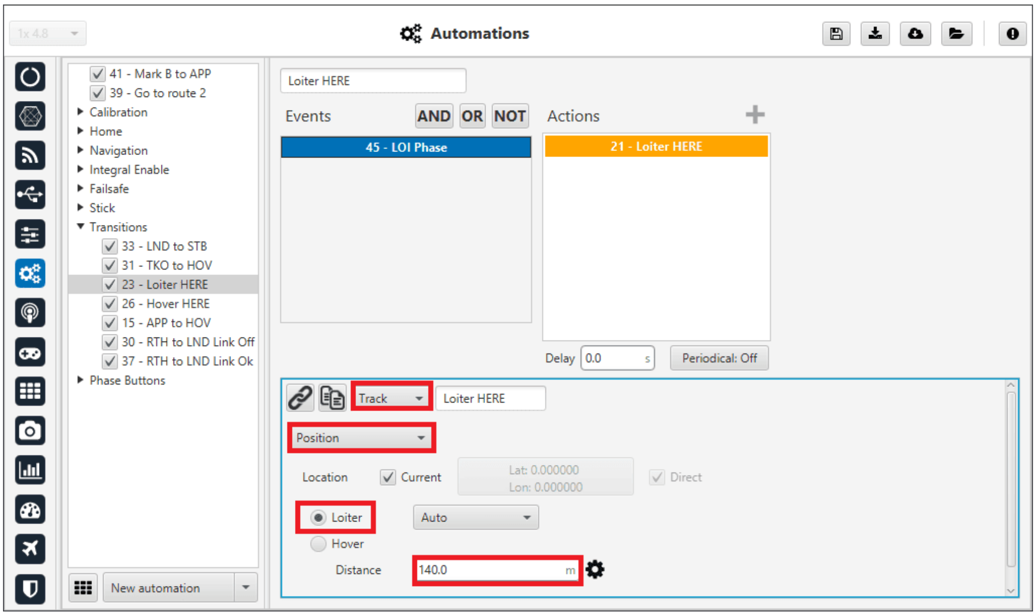
> ⓘ **Note**
>
> Loiter phase can only be entered manually by the user from its phase button on the Veronte Panel.

When the operator commands Autopilot 1x to switch to Loiter flight phase, a circular path is generated around a point, which is the current position where the aircraft is at that moment.

> ⓘ **Note**
>
> The aircraft follows this route until another phase change command is given.

Operation 1 - Loiter flight phase

The path configuration for Loiter is defined in the following automation:



Operation 1 - Loiter here automation

For more information, visit the Automations - 1x Air configuration section of this manual.

Hold

In this flight phase, the aircraft attitude and vertical velocity are stabilized. The control variables Desired Pitch, Desired Roll, Desired Yaw and Desired Down Ground Velocity are **null and constant**.

Operation 1 - Hold flight phase

Approach

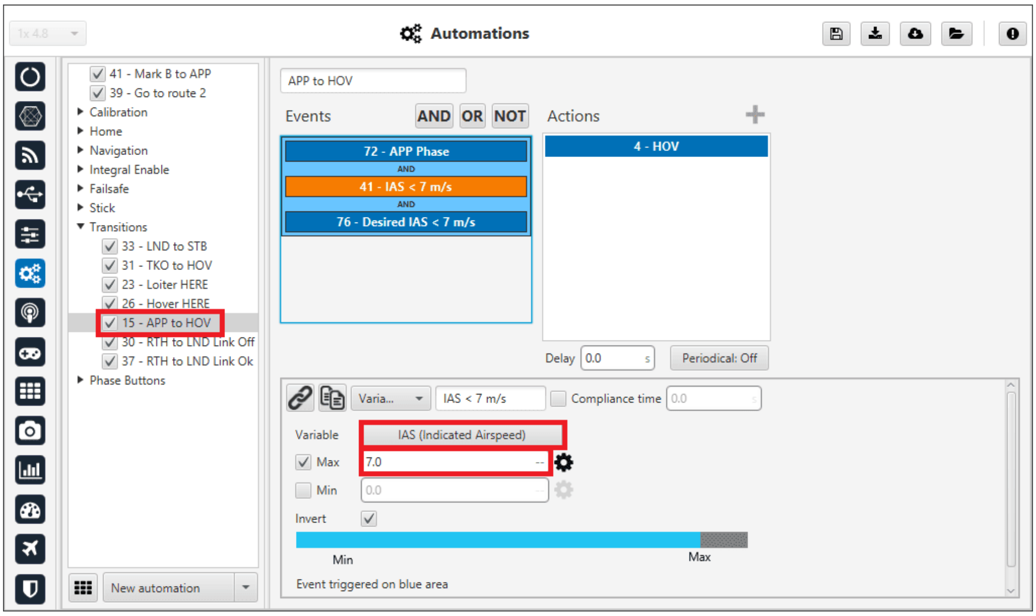
When the aircraft enters the Approach flight phase, the guidance program automatically generates a path to the runway. This path will have enough distance for the aircraft to lose altitude and perform the approach correctly.

Operation 1 - Approach flight phase

Approach phase ends on the runway, where the aircraft transitions to the **Hover** flight phase.

Operation 1 - Approach to Hover transition

The automation that enables the transition from the **Approach** phase to the **Hover** phase has been defined in the 1x PDI Builder configuration:

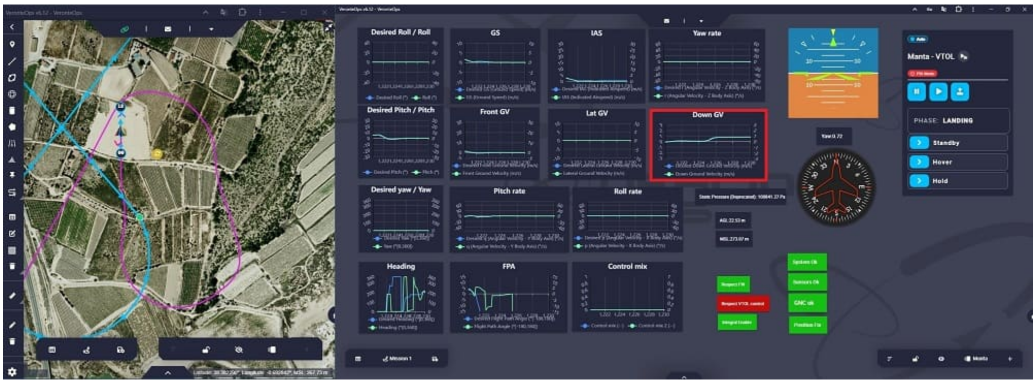


Operation 1 - APP to HOV automation

For more information, visit the Automations - 1x Air configuration section of this manual.

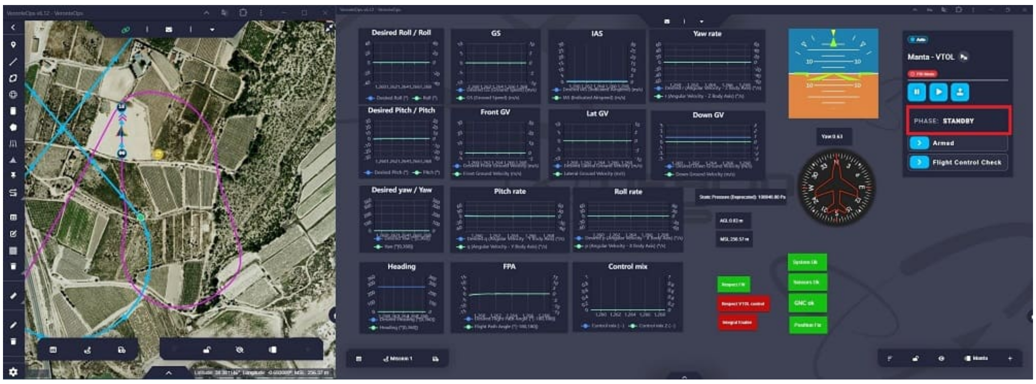
Landing

The control variable for the Landing phase is the Desired Down Ground Velocity:



Operation 1 - Landing flight phase

At the end of the Landing phase, the aircraft enters the **Standby** phase.



Operation 1 - Landing to Standby transition

The automation that allows the transition from the **Landing** phase to the **Standby** phase has been defined in the 1x PDI Builder configuration:

Operation 1 - LND to STB automation

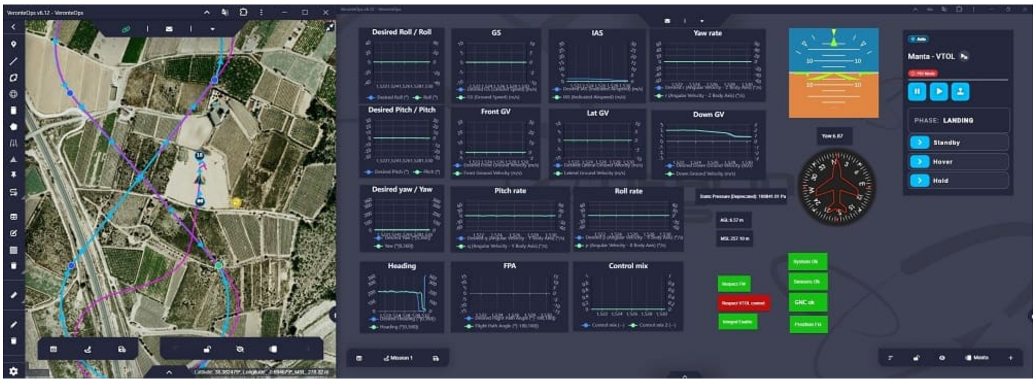
For more information, visit the Automations - 1x Air configuration section of this manual.

Return to Home

When the aircraft enters the Return to Home phase, the guidance program automatically generates a path to the point defined as **Home**.

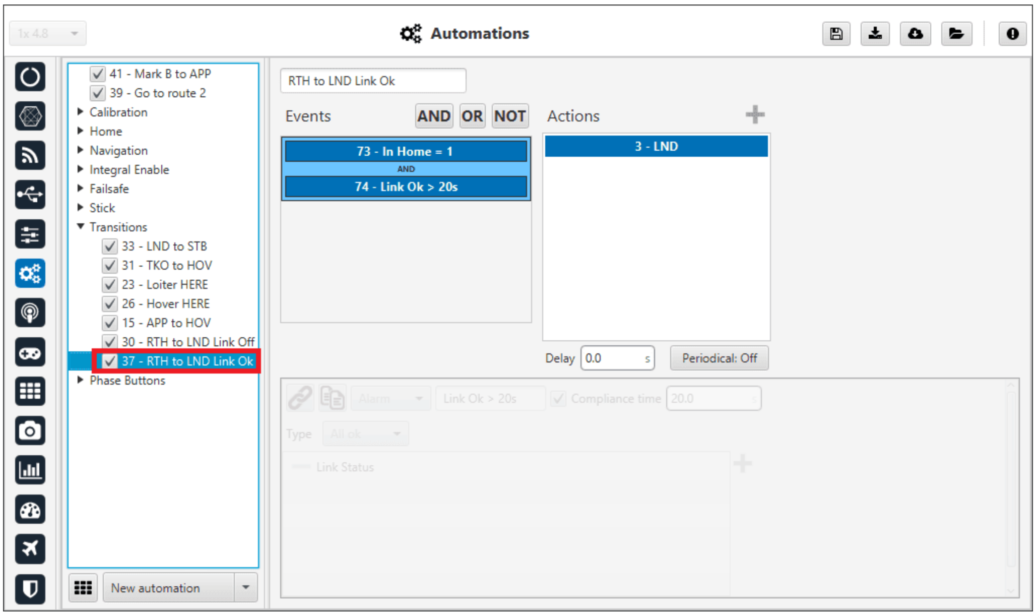
Operation 1 - Return to Home flight phase

This flight phase ends at the **Home** point, where the aircraft passes to the **Landing** flight phase.



Operation 1 - Return to Home to Landing transition

The automation that enables the transition from the **Return to Home** phase to the **Landing** phase has been defined in the 1x PDI Builder configuration:



Operation 1 - RTH to LND automation

For more information, visit the Automations - 1x Air configuration section of this manual.

Operation 2

Operation 2 is the same as Operation 1 but with the addition of two areas that trigger an action:

- **Area 1**: Change to Return to Home flight phase.
- **Area 2**: Obstacle.

The actions triggered in this operation will be performed while the aircraft is flying in the Cruise phase. This phase begins at the point defined as **Start**

Route, therefore, following the route orientation, the aircraft will pass firstly through area 2 and secondly through area 1.

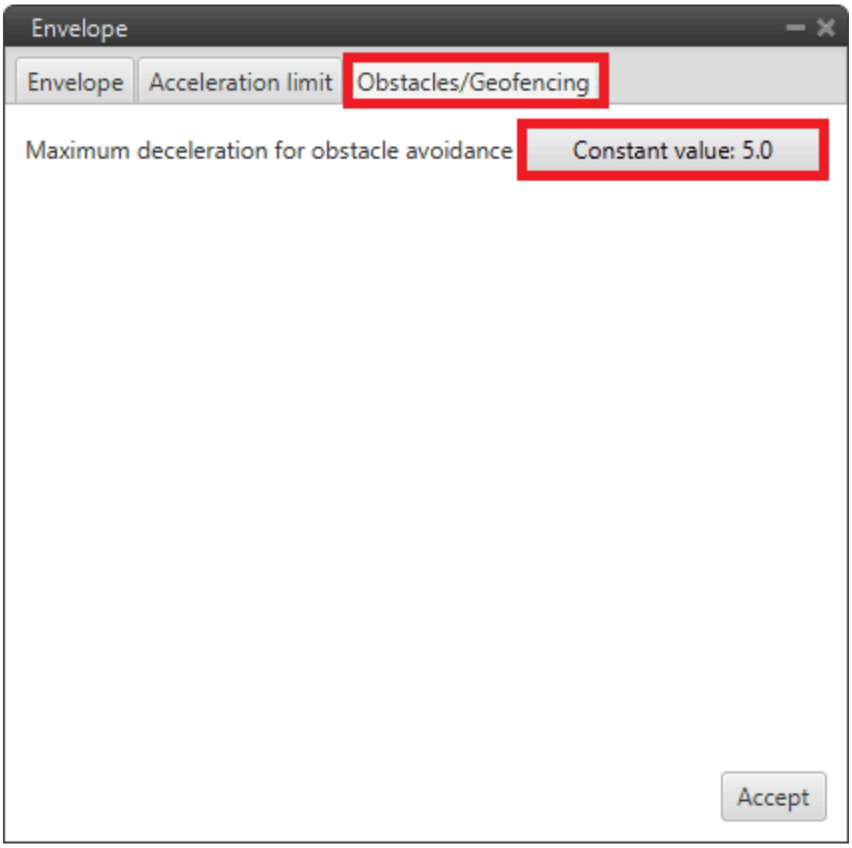
> ⓘ **Note**
>
> The transitions between phases and basic actions to perform the operation have already been explained in Operation 1, so only the parts specific to Operation 2 are detailed in this section.

Area 2

As area 2 has been defined as an **obstacle**, the guidance program will prevent the aircraft from flying **within** this area by creating an alternative trajectory:

Operation 2 - Obstacle avoidance trajectory

The Maximum deceleration for obstacle avoidance is defined in the Envelope block - Guidance program of the 1x PDI Builder configuration.



Operation 2 - Envelope block

Area 1

Area 1 is linked to a phase change automation that is activated when the aircraft flies **inside** it. **Autopilot 1x** will switch to the **Return Home** phase of flight.

Operation 2 - Area 1 to RTH

Operation 3

In this operation, two missions have been defined, each consisting of a closed loop and a mark:

- **Mark A**: Triggers the **Go To** action to Mission 2.

- **Mark B**: Triggers the action to change to the **Approach** flight phase.

> ⓘ **Note**
>
> The transitions between phases and basic actions to perform the operation have already been explained in Operation 1, so only the aspects specific to Operation 3 are detailed in this section.

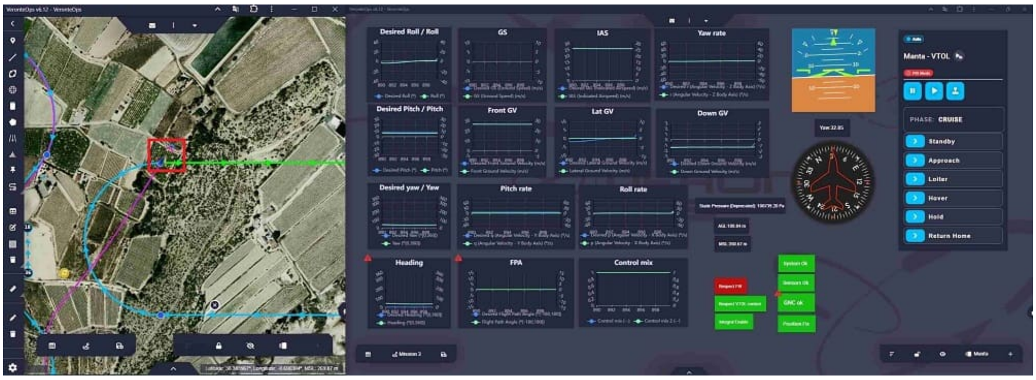
Mark A to Mission 2

The cruise phase begins at the point defined as the **Start Route**.

When the aircraft flies through the first mission and reaches **Mark A**, the action to **go to** the second mission is triggered. For this purpose, the guidance program generates a path between the current location of Autopilot 1x (i.e. the point where the mark is placed) and the selected **patch**:

Operation 3 - Mark A to Patch A

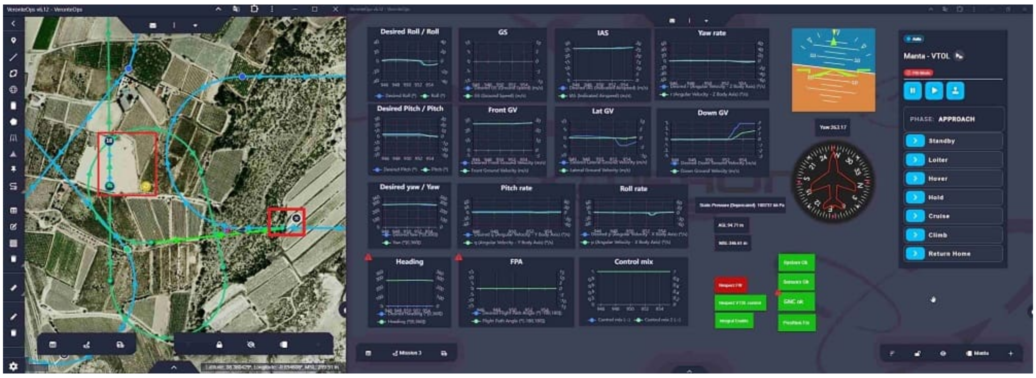
When the aircraft arrives at the selected patch, it will continue flying Mission 2.



Operation 3 - Mission 2

Mark B to Approach phase

When the aircraft reaches the **Mark B** in the second mission, a phase change to the **approach** phase is triggered. Consequently, the guidance program will automatically generate a route to the **runway**.

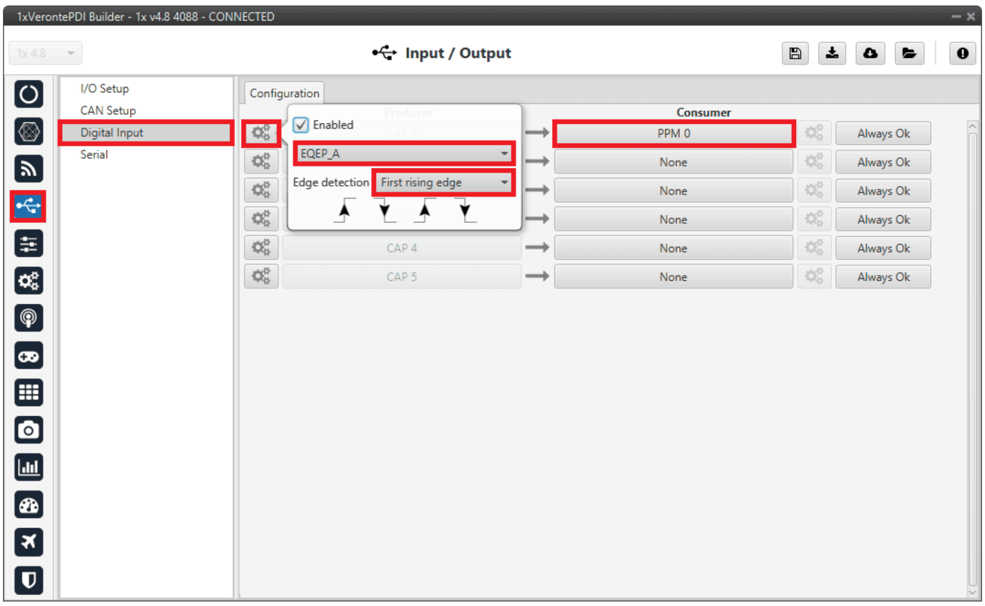


Operation 3 - Mark B to Approach phase

Stick

When performing HIL simulations, the user only uses one Autopilot 1x. Follow the steps below to configure the stick for this case:

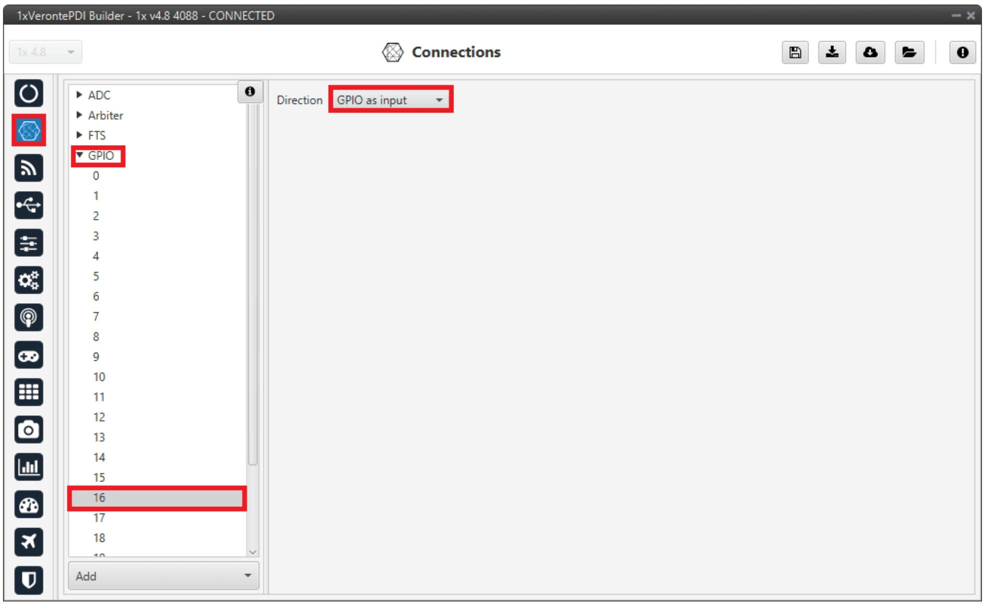
1. Go to Input/Output menu → **Digital Input panel**.
   - Producer: **CAP 0**
     - Enabled
     - Select the pin to which the transmitter is connected, in this case EQEP_A
     - Edge detection: First rising edge
   - Consumer: **PPM 0**



Simulation - Digital Input configuration

2. Go to Connections menu → **GPIO panel**.

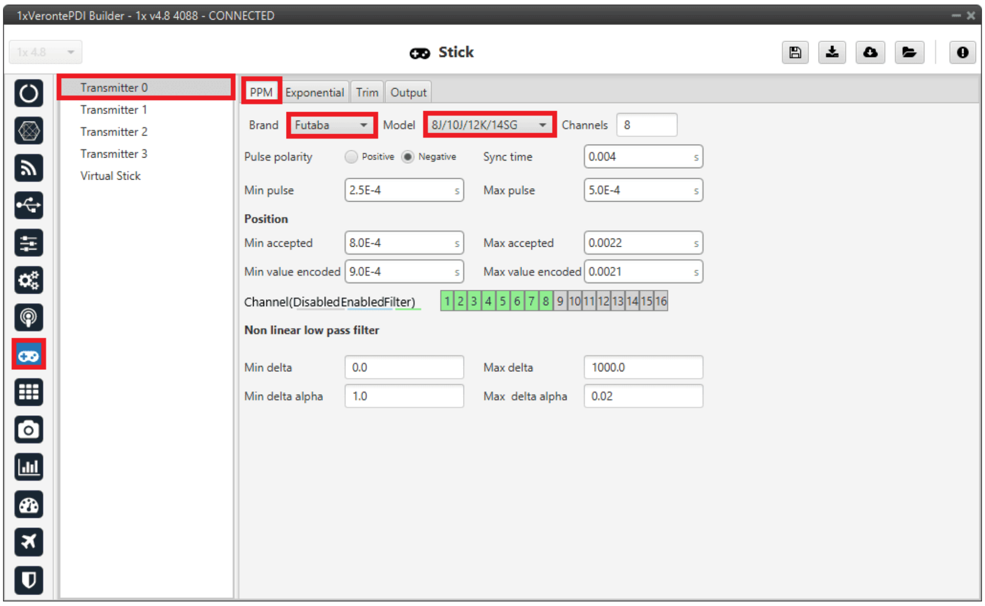
   Verify that the pin to which the transmitter is connected, in this case GPIO 16 (i.e., EQEP A), is set as **input**.



Simulation - GPIO configuration

3. Go to Stick menu → Transmitter 0 panel → **PPM tab**.

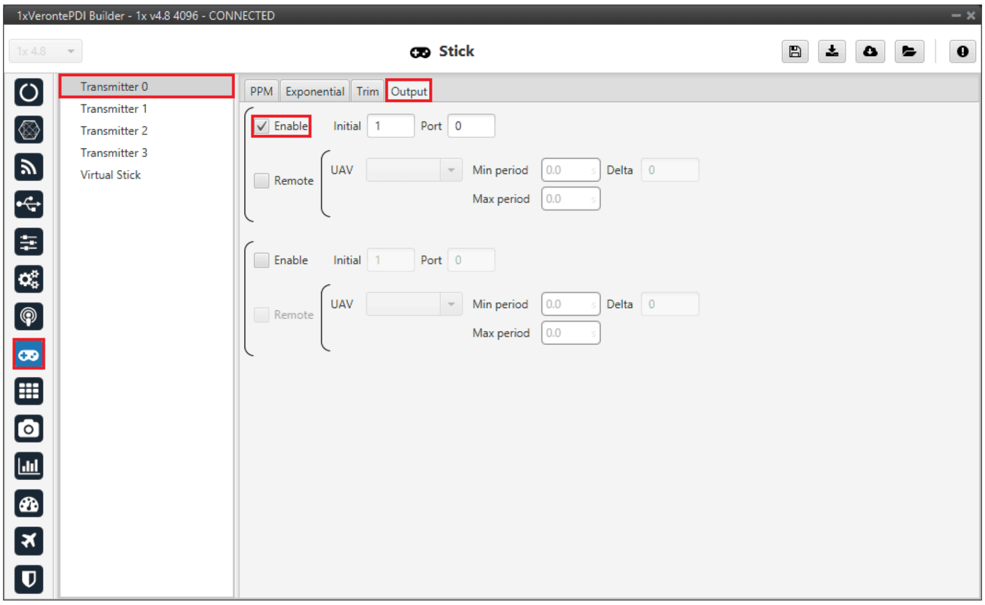
   Select the brand of transmitter that applies.



Simulation - PPM configuration

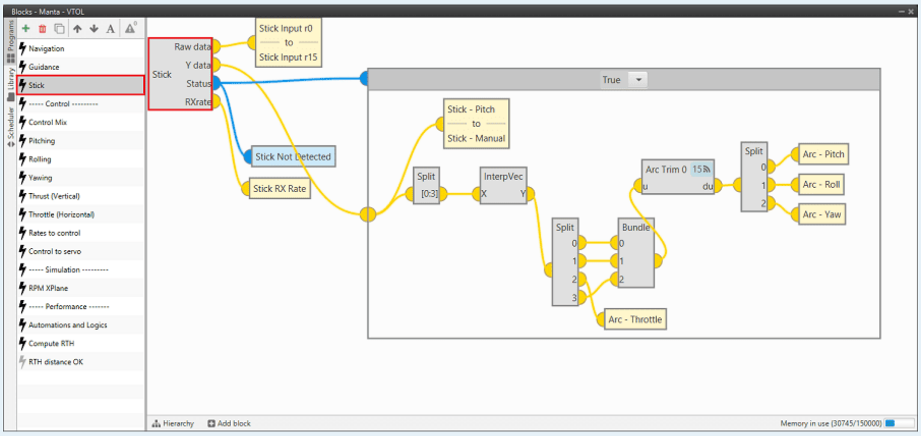
4. Go to Stick menu → Transmitter 0 panel → **Output tab**.

   Just click on **Enable**.

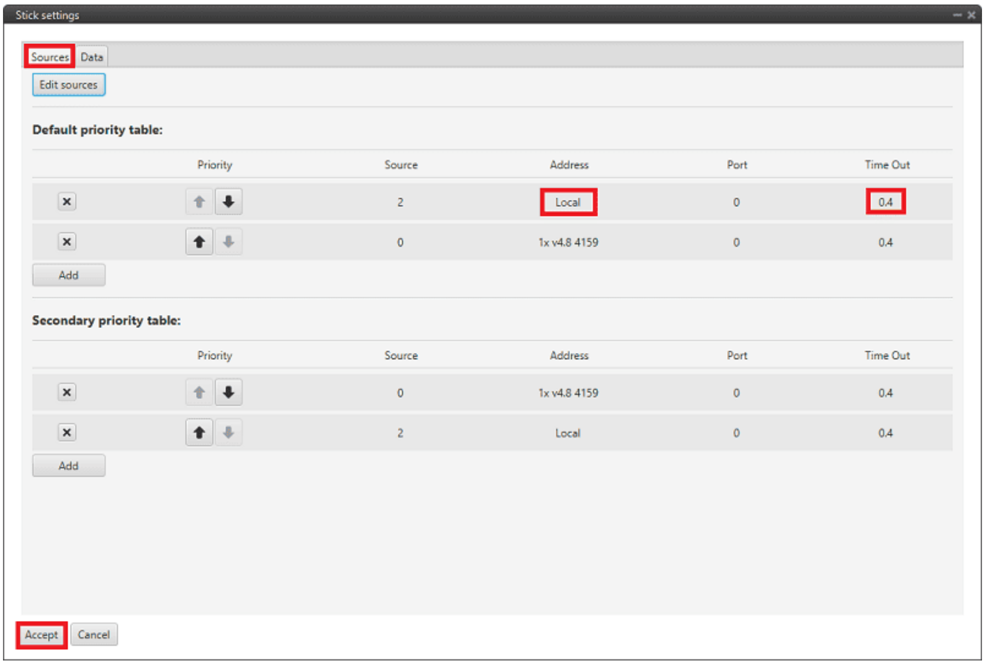


Simulation - Output configuration

5. Go to Block Programs menu → **Stick program** → Double click on the **Stick block** → **Edit sources**.

> ### ⓘ Note
>
> This is the Stick progam explained in the **1x Air configuration** section of this manual.
>
> 
>
>
> **Stick program**

Input the **Local address** to receive the stick information from that source and put it as the **highest priority** in the priority table. We recommend a Time Out of **0.4 s**.

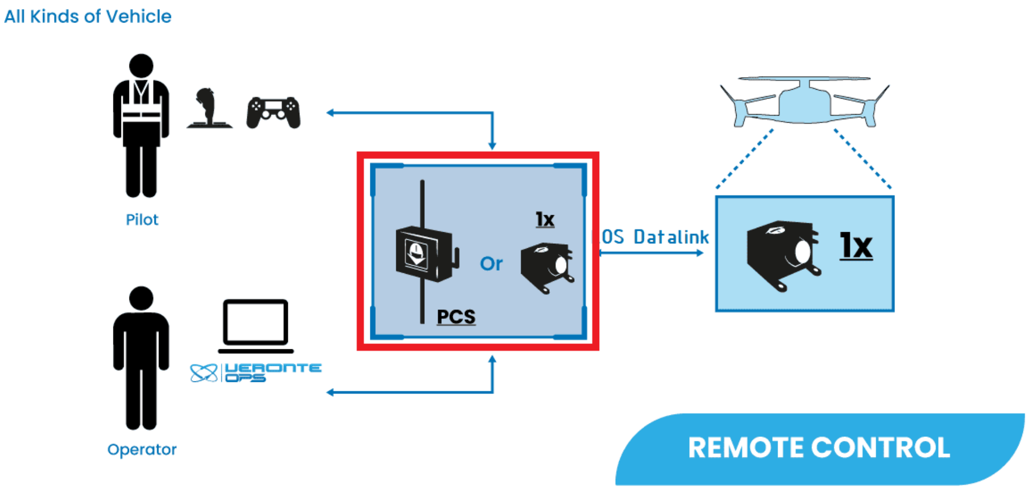


Simulation - Stick block configuration

1x GCS configuration

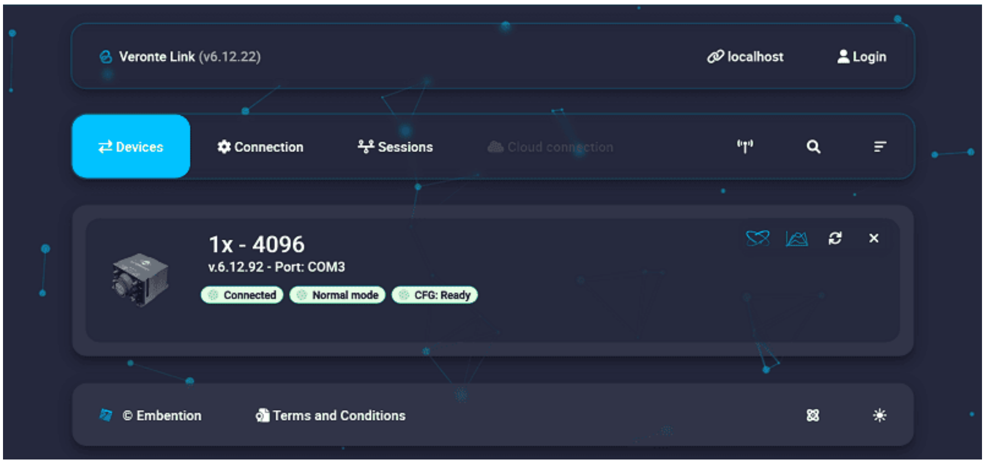
This section defines the GCS (Ground Control Station) configuration to be used to communicate with the Veronte Autopilot 1x on board the aircraft.

> ⓘ **Note**
>
> In this case, an Autopilot 1x is used as GCS.

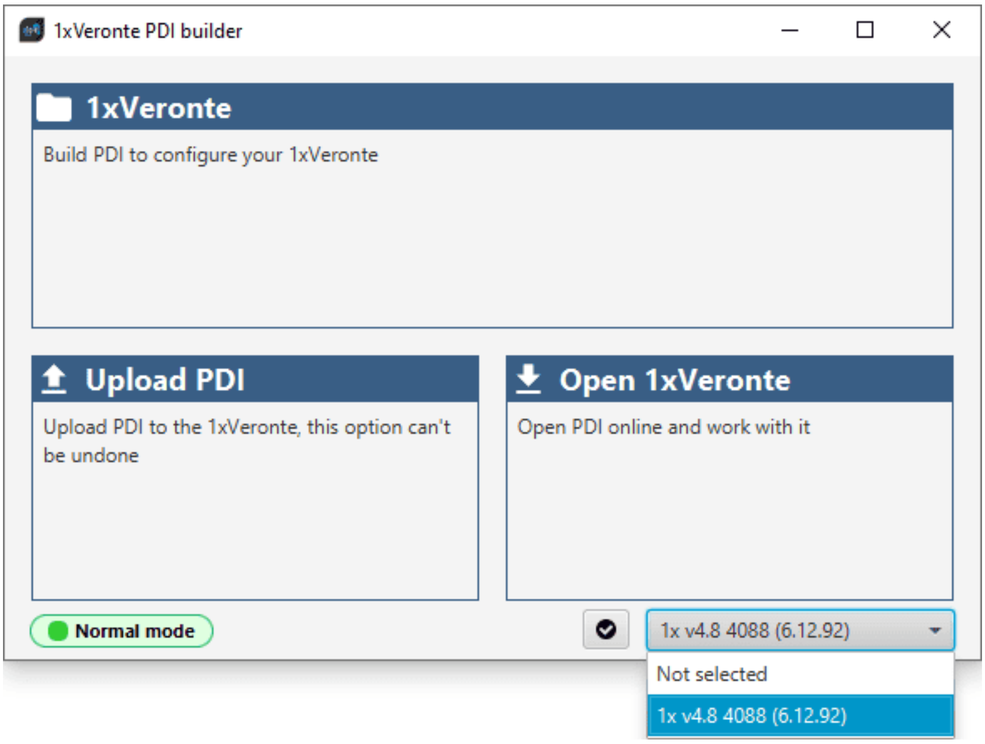


To configure the 1x Ground unit, the user must download the **Veronte Ground** template available in the **1x PDI Builder** software. To do so, follow the steps below:

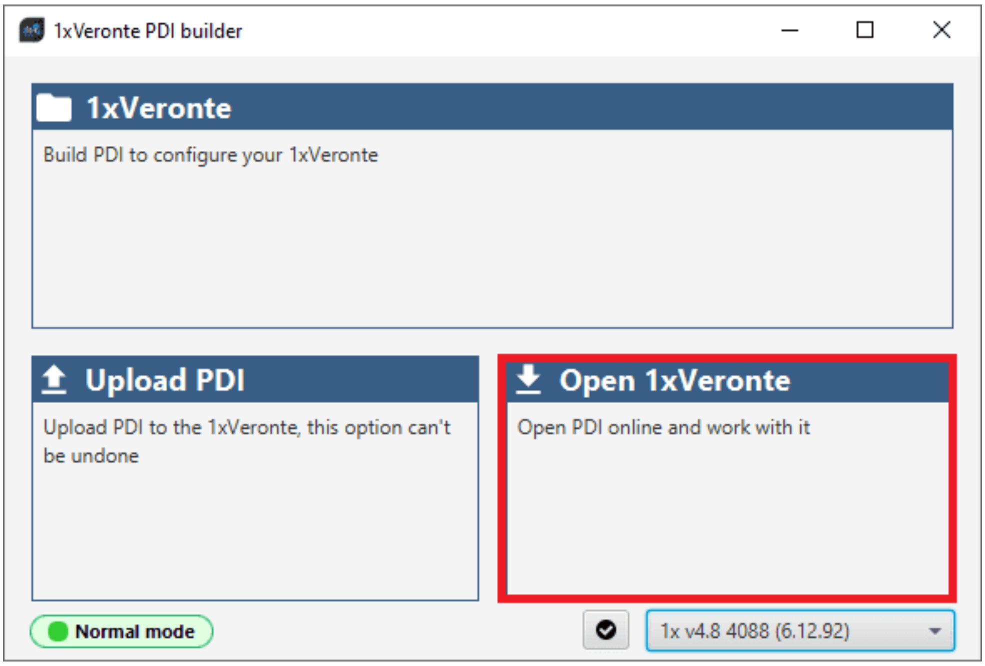
1. Connect the Autopilot 1x to be configured as Veronte Ground to the PC, in this case, the connection is made via **USB**. Users can refer to the Basic connection for operation - Quick Start section of the **1x Hardware Manual** for instructions on how to make this connection.
2. Check in **Veronte Link** that the Autopilot 1x is in **ready** status.



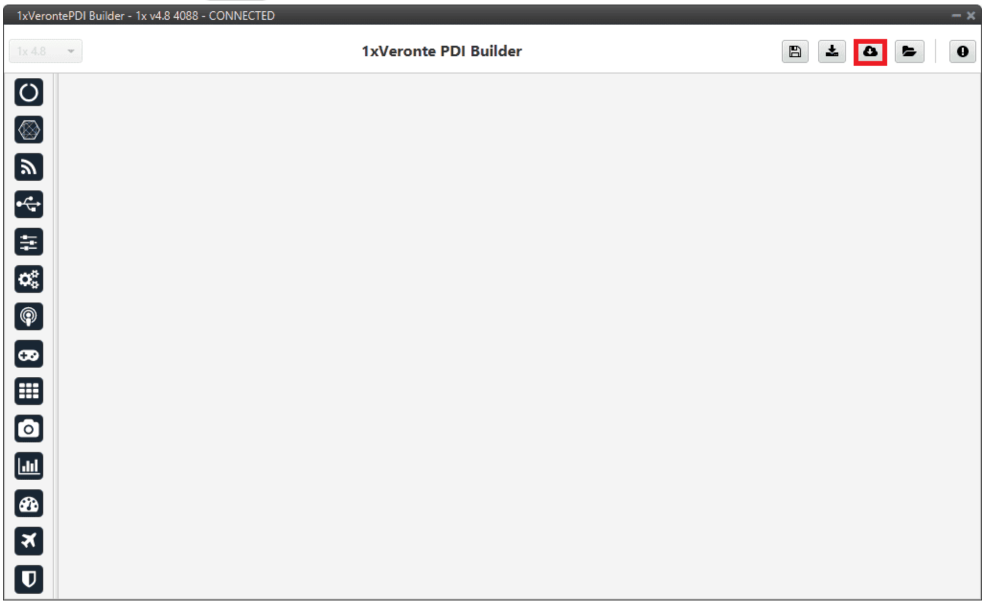
   For a detailed explanation of how to set up this connection, please refer to the Serial connection - Integration examples section of the **Veronte Link** user manual.
3. Open the **1x PDI Builder** app and select the Autopilot 1x:



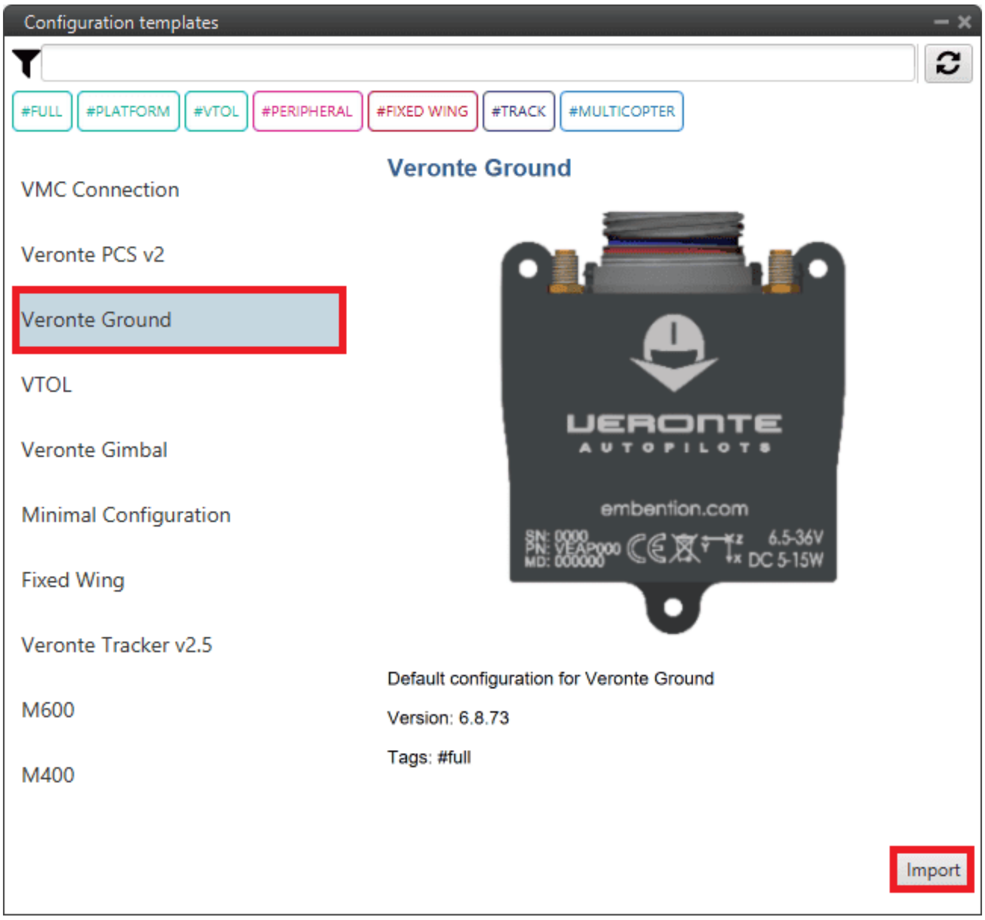
4. Select the **Open 1xVeronte** option to access the configuration of the connected unit:



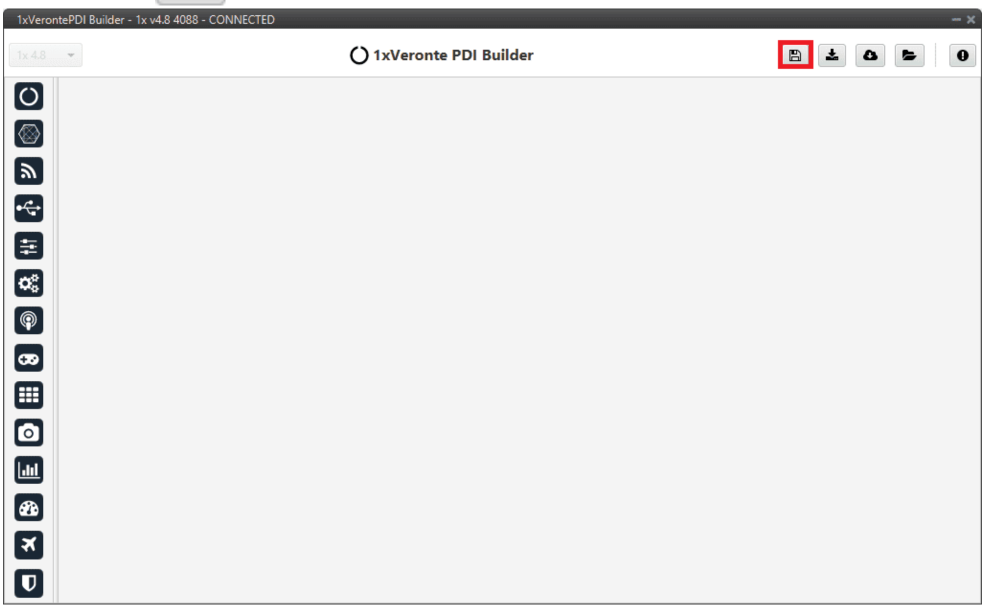
5. Click on the  button in the menu bar to access the Veronte **templates**:



6. Select the **Veronte Ground** template and click **import**:



7. Click the button to load the downloaded template into Autopilot 1x.

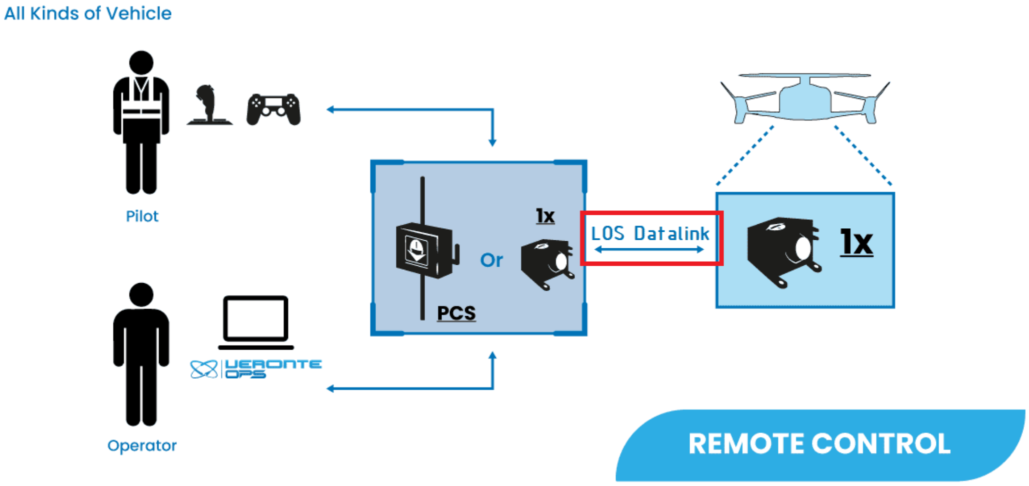


> **Important**
>
> In order to save the configuration, Veronte Autopilot 1x must enter in maintenance mode. Then, after saving any changes, Autopilot 1x will RESET and 1x PDI Builder software will consequently close. For more information on this, visit the Configuration section of the **1x PDI Builder** user manual.

Once the **Veronte Ground** template has been downloaded and uploaded into the Autopilot 1x, follow the steps in the next section, Air-GCS connection, to set up the connection between GCS and the on-board Autopilot 1x.

Air-GCS connection

This section defines how to configure the air-ground Autopilots 1x to communicate with each other and send the desired information.



- Communication. This section defines the different configurations that must be performed to ensure communication between Autopilots 1x.
- Stick. This section defines the configuration of the Autopilots 1x to receive the commands sent by the Stick.

Communication

This section explains the steps to follow to set up **radio communication** between Autopilots 1x. Follow the steps below:

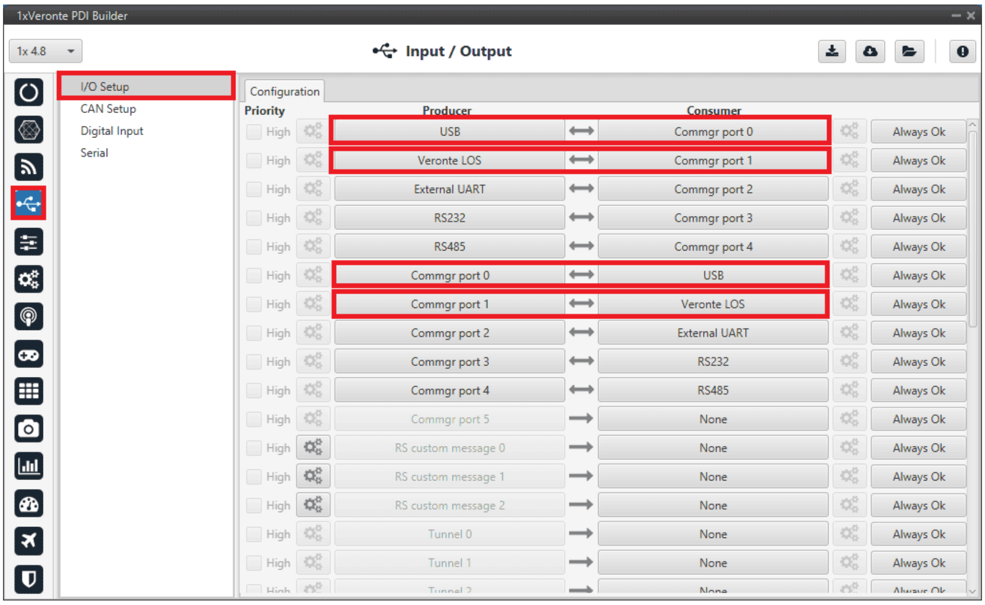
GND unit configuration

1. Go to Input/Output menu → **I/O Setup panel**.

   The following connections betweens **producers** and **consumers** must be configured here:

   - **USB** ↔ **Commgr port 0**.
   - **Veronte LOS** ↔ **Commgr port 1**.
   - **Commgr port 0** ↔ **USB**.
   - **Commgr port 1** ↔ **Veronte LOS**.

> ⓘ **Note**
>
> It is not necessary to use these particular COM Manager ports, however, the connections between these producer and consumer must be **bidirectional**.



Ground unit - Input/Output configuration

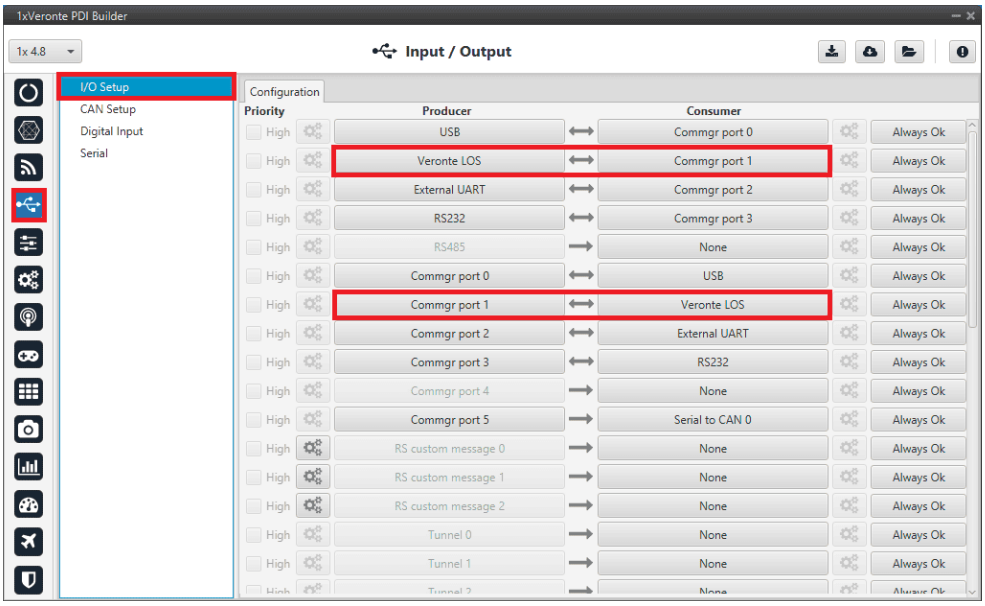
Air unit configuration

1. Go to Input/Output menu → **I/O Setup panel**.

   Configure the following connections between **producers** and **consumers**:

   - **Veronte LOS** ↔ **Commgr port 1**.
   - **Commgr port 1** ↔ **Veronte LOS**.

> **Note**
>
> It is not necessary to use these particular COM Manager ports, however, the connections between these producer and consumer must be **bidirectional**.



Air unit - Input/Output configuration

For more information, visit the Input/Output - Configuration section of the **1x PDI Builder** user manual.

GND-Air communication configuration

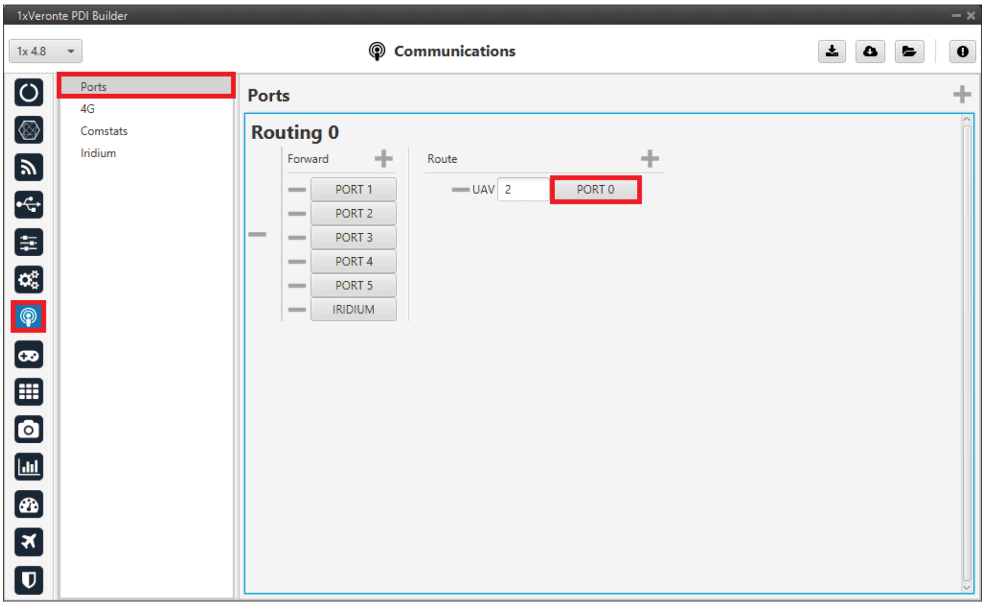
To establish a proper communication between the ground and air units, it is necessary to configure the **ports** menu of the **ground unit**.

1. Go to Communications menu → **Ports panel**.
2. In order to establish the connection between the PC and the 1x air unit thanks to the radio connection with the 1x ground, a routing of the communications must be made to the port to which the USB consumer is connected.

   Therefore, set a routing of **Address 2** (address by which Autopilots 1x ground and air units **communicates with all Veronte applications**) through **Commgr port 0**.

   This way, any messages that are received through a Commgr Port (i.e. through Veronte LOS) with **address 2**, will be re-routed through **Port 0**

(USB) and received by **Veronte Ops** software, including any messages generated by 1x ground unit itself.



Ground unit - Routing configuration

For more information, please refer to the Communication between Veronte Autopilots 1x - Integration examples section of the **1x PDI Builder** user manual.

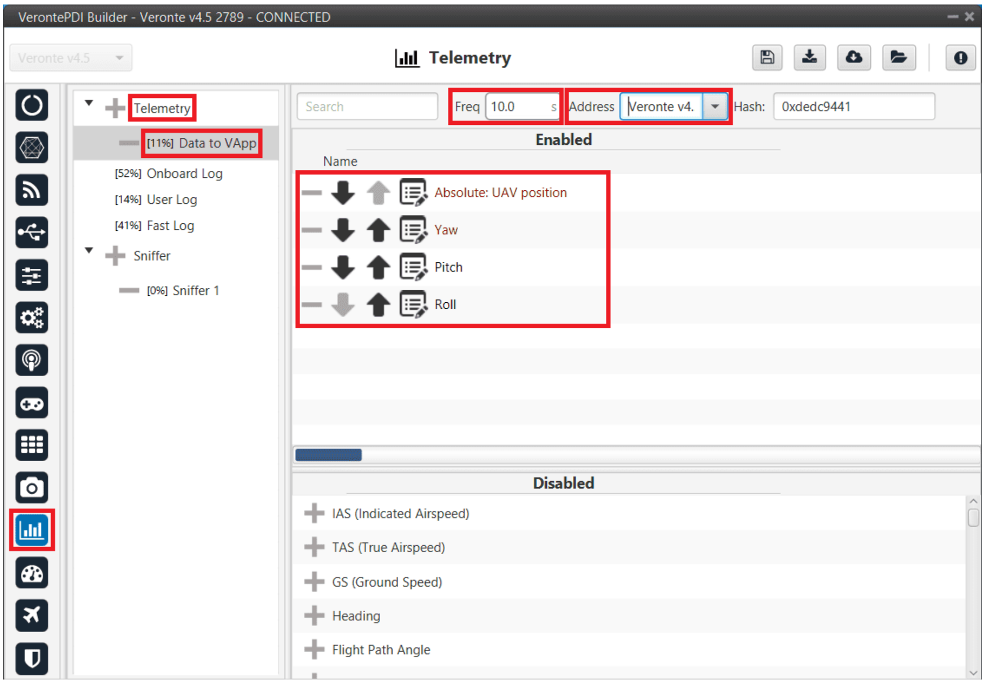
GND-Air data transmission configuration

To enable the data transmission between the ground and air units, the **telemetry** and **sniffer** menus must be configured, respectively.

A simple example of use between a ground unit and an air unit is shown below:

In the **1x ground unit**:

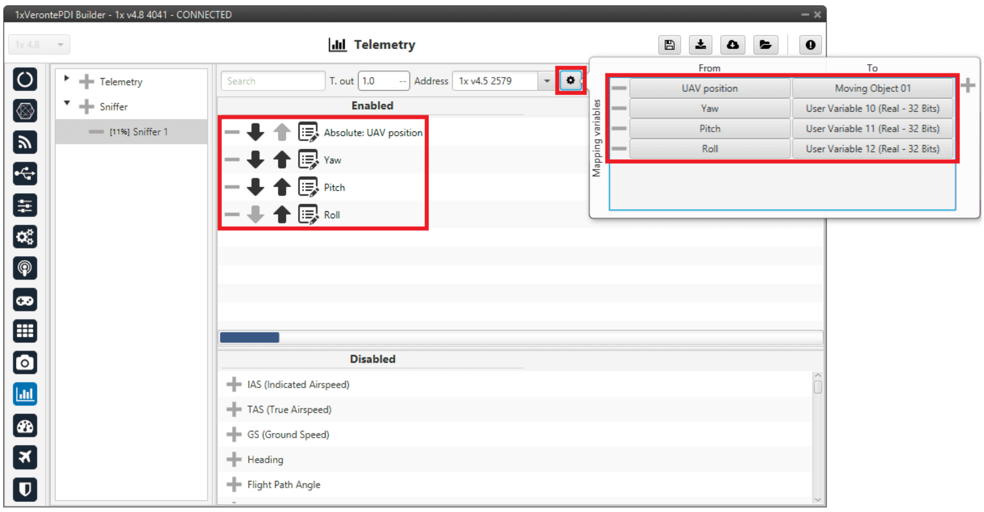
1. Go to Telemetry menu → Telemetry panel → **Data link to VApp tab** (for more information about this, see Data vectors - Telemetry section of **1x PDI Builder** user manual).
2. Add the variables: Absolute: UAV position, Yaw, Pitch and Roll.
3. Set a **Frequency**, it is recommended to set it to **10 Hz**.
4. On **Address**, point to the **1x air unit** (it is needed to have both units connected through the radio in order to be able to see them on the menu).



1x ground unit - Telemetry

For the **1x air** unit:

1. Go to Telemetry menu → **Sniffer panel** (for more information about this, see Sniffer - Telemetry section of **1x PDI Builder** user manual).
2. Add a new Sniffer.
3. Configure the same **variables** (keeping the **same order**) than in the ground unit.
4. On **Address**, point to the **1x ground unit**.
5. In the gear next to it, configure the 4 incoming variables as System Variables: assign UAV Position to **Moving Object** and the 3 variables from attitude to 3 different **User Variables** (keeping the **same order** as well).



1x air unit - Sniffer

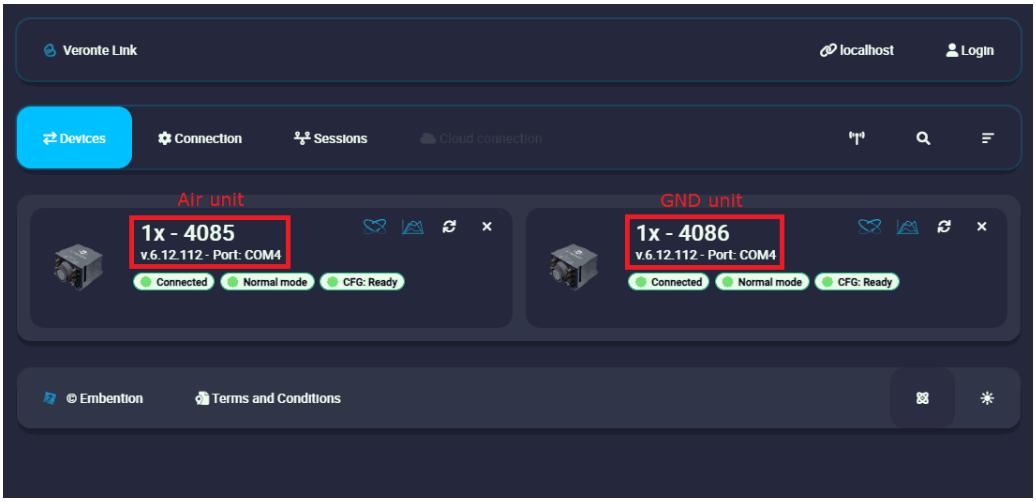
Radio pairing

In order to establish communication between the two units, it is necessary that the **radios** of both devices are **paired**. For this operation, there is an internal **Digi** radio in both Veronte Autopilots 1x.

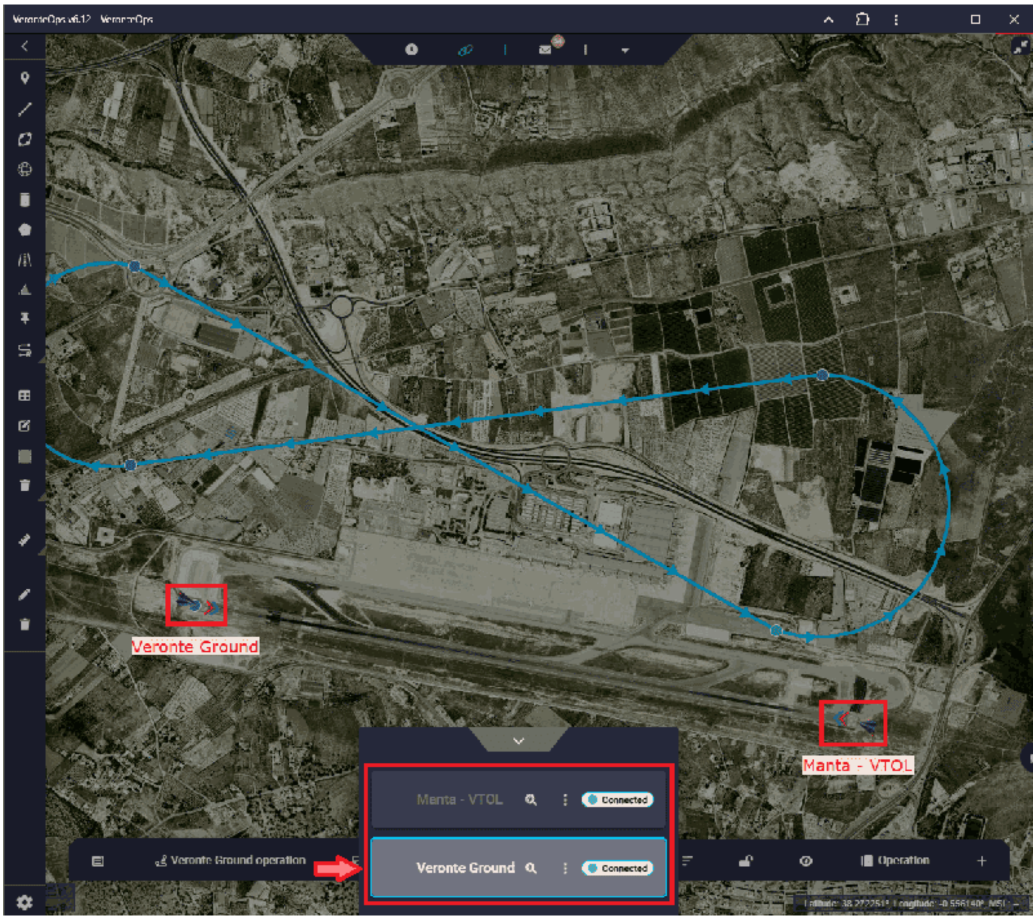
Follow the steps described in the Digi internal radio - Integration examples section of the **1x PDI Builder** user manual, for both units, GND and air.

If everything went well, the user will be able to see the air unit in both **Veronte Link** and **Veronte Ops** by **physically connecting only the ground unit**.

> ⓘ **Note**
>
> Autopilot 1x configured as the GND unit has address **4086** and the air unit has address **4085**.



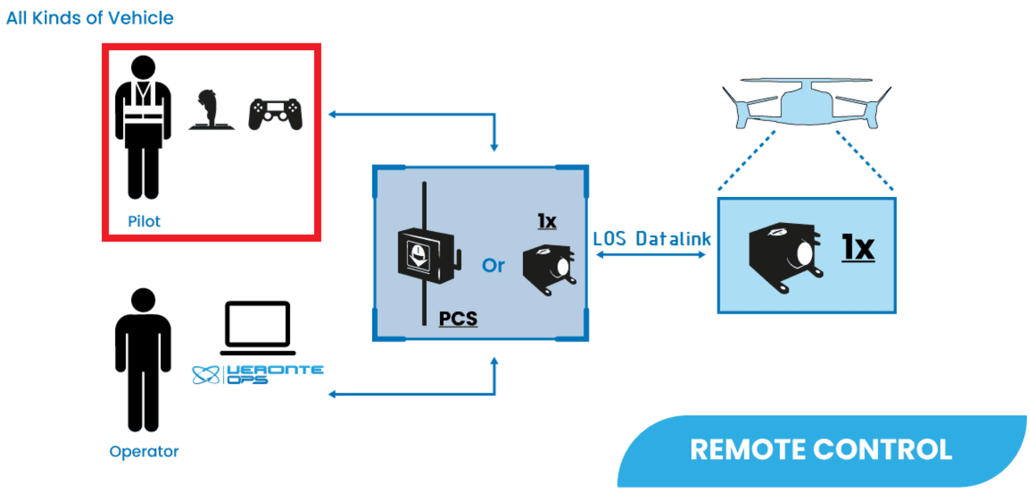
Radio pairing - Veronte Link



Radio pairing - Veronte Ops

Stick

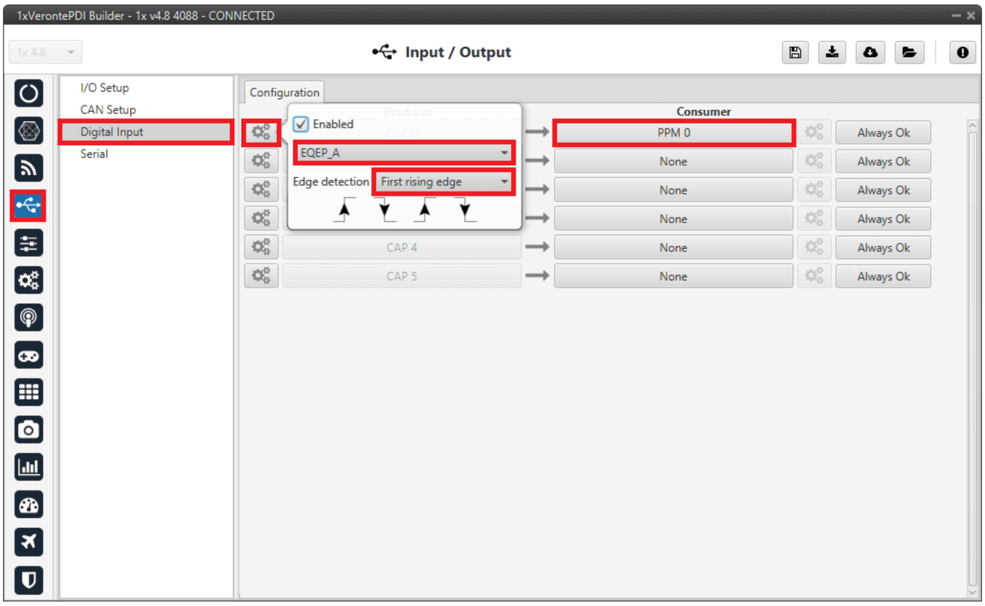
Veronte Standard Layout is the case where the 1x ground unit (or BCS/PCS) sends commands directly to the 1x air unit. So the stick is connected directly to the **1x ground unit**.



Follow the steps below to perform a correct stick configuration on both units.

Ground unit

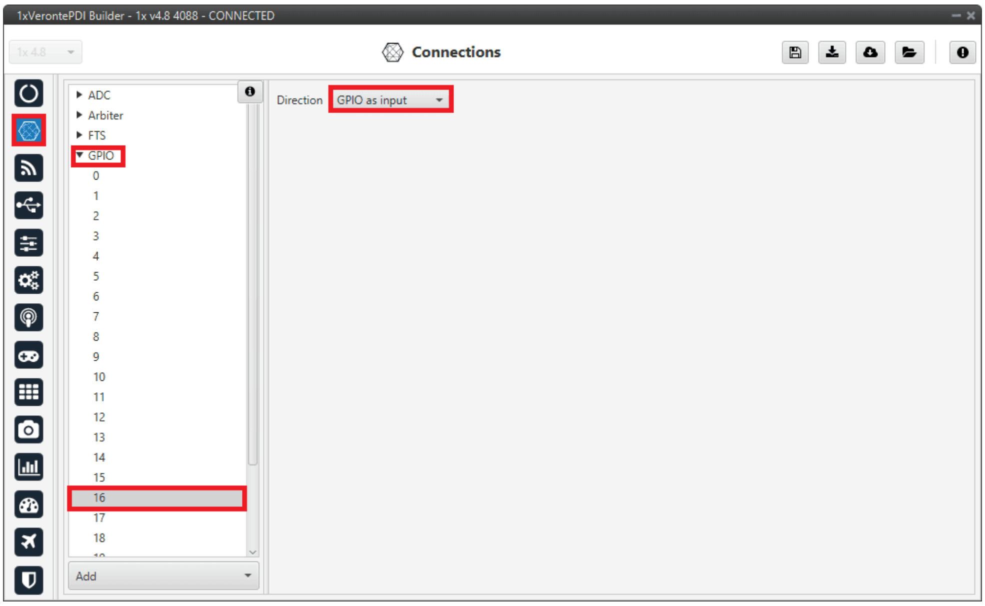
1. Go to Input/Output menu → **Digital Input panel**.
   - Producer: **CAP 0**
     - Enabled
     - Select the pin to which the transmitter is connected, in this case EQEP_A
     - Edge detection: First rising edge
   - Consumer: **PPM 0**



Ground unit - Digital Input configuration

2. Go to Connections menu → **GPIO panel**.

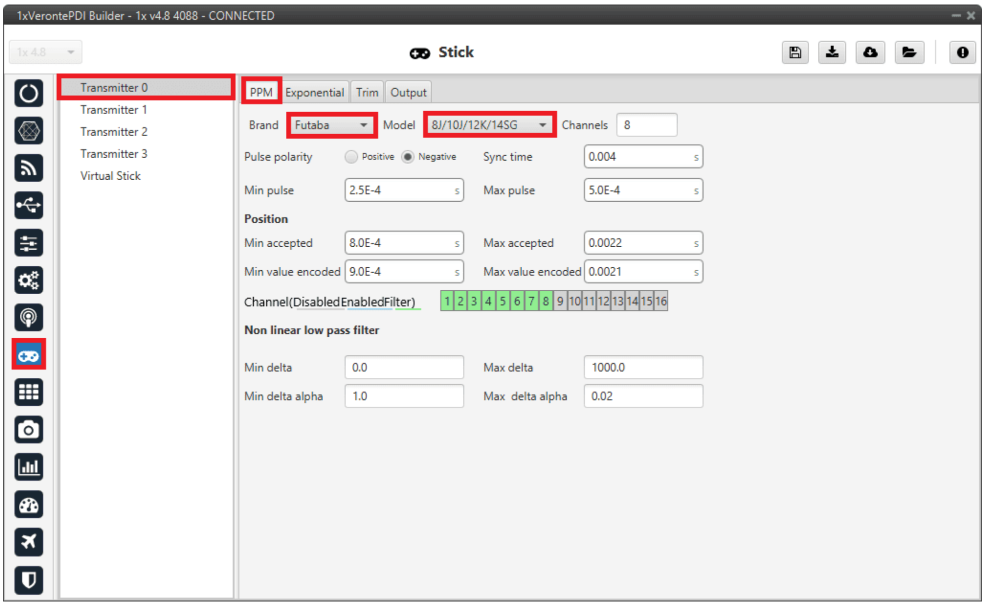
   Verify that the pin to which the transmitter is connected, in this case GPIO 16 (i.e., EQEP A), is set as **input**.



Ground unit - GPIO configuration

3. Go to Stick menu → Transmitter 0 panel → **PPM tab**.

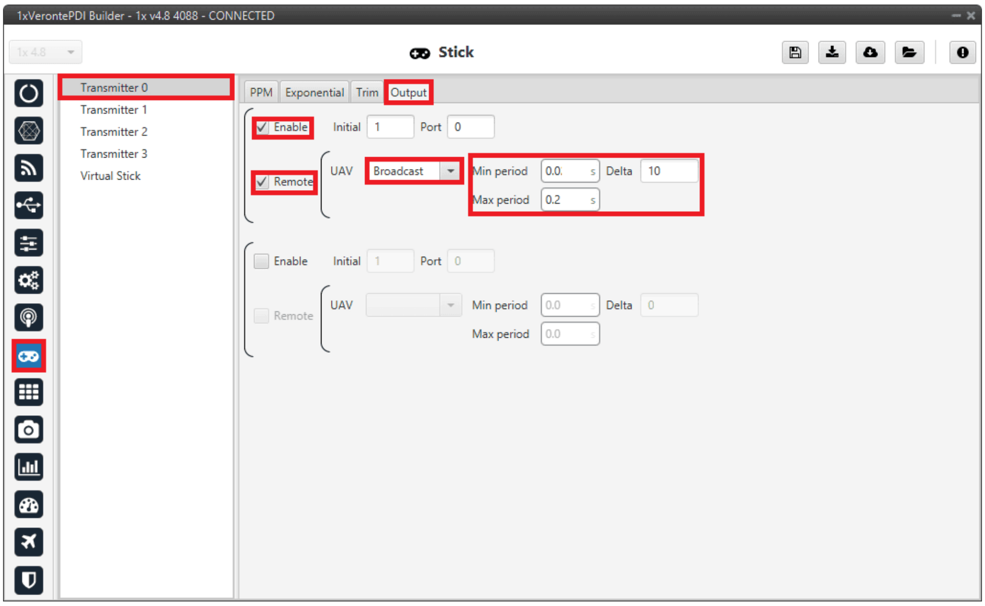
   Select the brand of transmitter that applies.



Ground unit - PPM configuration

4. Go to Stick menu → Transmitter 0 panel → **Output tab**.

   Click on **Enable** and on **Remote** to send the stick information to the air unit. The recommended values for the configurable parameters have been entered here, as detailed in the Output - Stick section of the **1x PDI Builder** user manual.



Ground unit - Output configuration

If all these settings are correct, users can check that **'Stick PPM 0 not detected'** variable of the **GND unit** is true.

Stick PPM 0 not detected variable - True

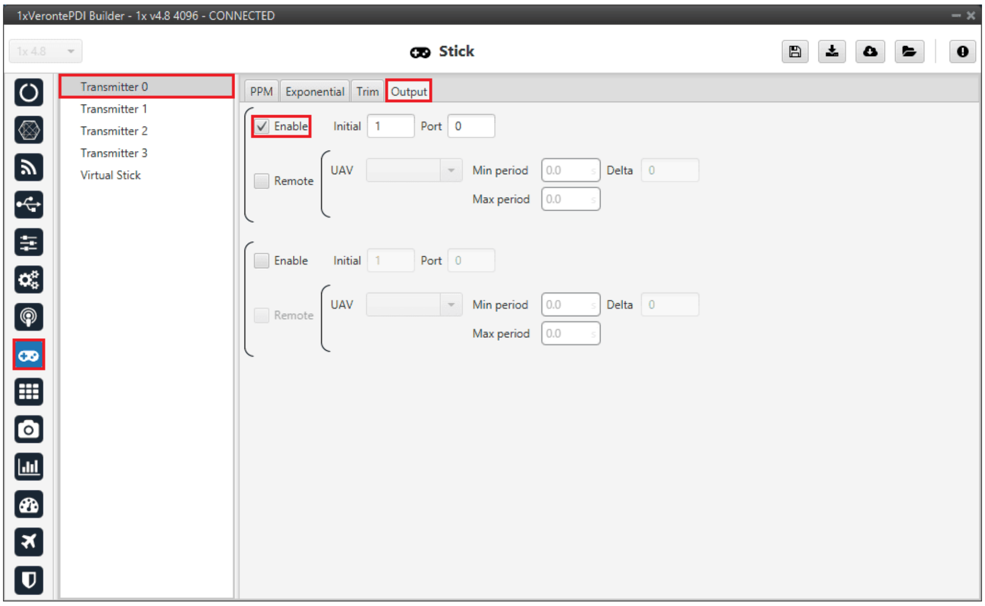
Air unit

1. Go to Stick menu → Transmitter 0 panel → **PPM tab**.

   Select the brand of transmitter that applies (make the same configuration as for the ground unit).

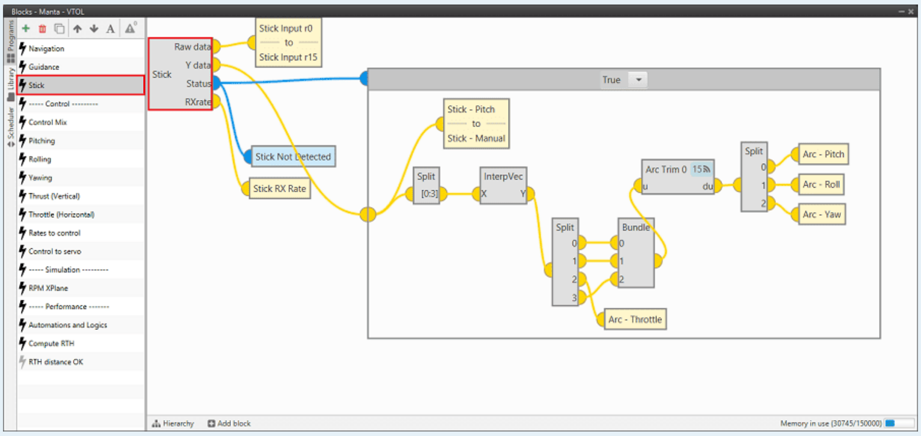
2. Go to Stick menu → Transmitter 0 panel → **Output tab**.

   Just click on **Enable**.

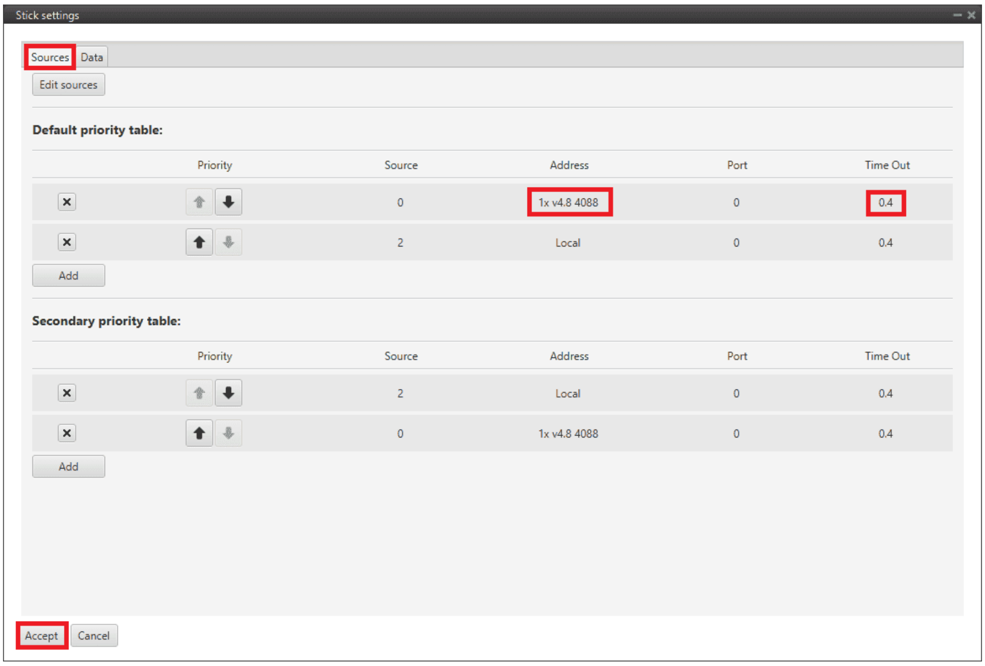
   

   Air unit - Output configuration

3. Go to Block Programs menu → **Stick program** → Double click on the **Stick block** → **Edit sources**.

> ⓘ **Note**
>
> This is the Stick progam explained in the **1x Air configuration** section of this manual.
>
> 
>
> **Stick program**

Input the **ground unit address** to receive the stick information from that source and put it as the **highest priority** in the priority table. We recommend a Time Out of **0.4 s**.



Air unit - Stick block configuration

Then, if all is correct, users can check that **'Stick not detected'** variable of the **AIR unit** is true.

Stick not detected variable - True

And that means that the communication between the GND and the AIR unit is correctly configured.