# 4x Software Manual

*Release 6.12*

**Embention**

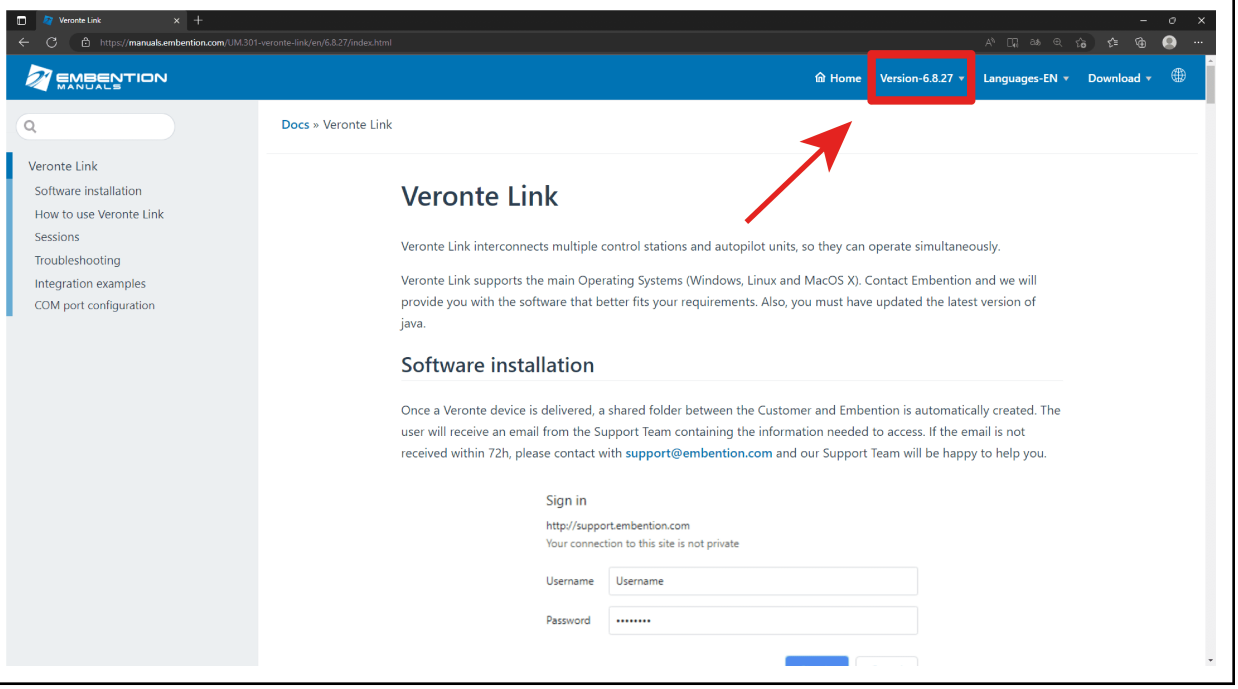
**2024-02-15**

# CONTENTS

In this manual the user can consult a brief description of all the applications created and designed to work together with the **Veronte Autopilot 4x**.

In addition, links are available to access the manuals for each application.

**Warning:** Select your version before reading any user manual for software. The following image shows where to select a version from any Embention user manual.



CHAPTER

ONE

# SOFTWARE APPLICATIONS

Due to the elements present in the **Autopilot 4x** system (Arbiters and Autopilots 1x), the software applications with which 4x works along are the ones listed below.

The following diagram summarizes the operation regarding these applications:

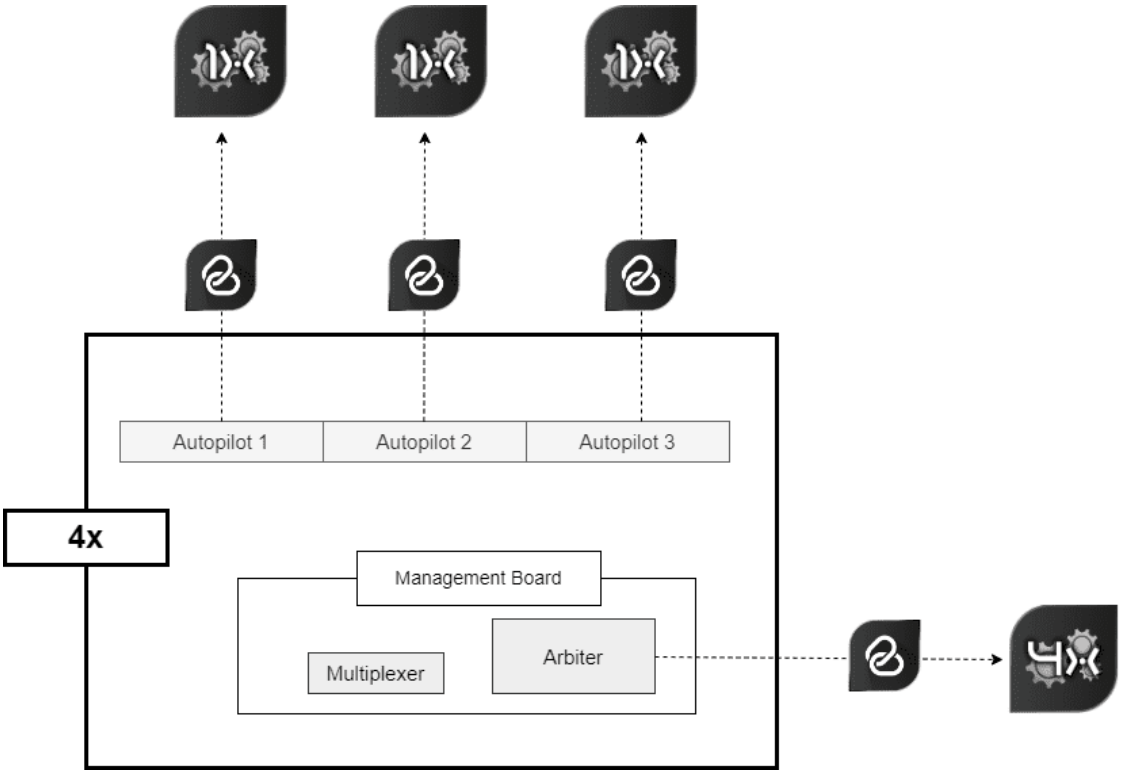



Fig. 1: **4x application diagram**

## 1.1 Veronte Link

Each inner **Autopilot 1x** and the **Arbiter** must be configured individually. First of all, a connection to a computer is required employing **Veronte Link**. All devices can be connected one by one or simultaneously, since **Veronte Link** is able to manage multiple connections.

For more information, read the user manual for Veronte Link.

## 1.2 1x Software Manual

To operate individually any **Veronte Autopilot 1x**, read the 1x Software Manual, since all software applications are applicable to **Autopilot 4x**.

## 1.3 1x PDI Builder

Each internal **Autopilot 1x** must be configured with **1x PDI Builder**, it allows to adapt the autopilot to a specific vehicle, including user-defined commnication 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 are accomplished.
- Block Programs: **Veronte Autopilot 1x** can be programmed with a friendly-user programming language.

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

## 1.4 4x PDI Builder

**4x PDI Builder** allows to configure the **Arbiter** communications, including CAN buses and input/output signals. It also configures the criterion to select the autopilot which controls the aircraft.

For more information, read the user manual for 4x PDI Builder.

CHAPTER

TWO

# LISTS OF VARIABLES

This section shows the variables employed by **Veronte Autopilot 4x**, both variables of the Arbiter and of Autopilots 1x.

A suitable configuration of the Autopilots 1x is key for ensuring proper communication and operation of the Autopilot 4x. Consider the structure of *Arbitration messages*, and consult the Lists of variables section of **1x Software Manual** for further information.

## 2.1 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. Othwerwise, if everything is OK, it will remain as 1.

> **Warning:** This bit works different for **Autopilot 1x** and **Arbiter**. This explanation is for **Arbiter**.

The **System Error** will be triggered and remain as 0 if one of the following unwanted events happens:

- An error occurred with **System power up** according to *bit 12*.
- RAM allocation is in error state due to try using more memory than available, this is indicated with a 0 on *bit 8*.
- CAN A bus is not working, hence *bit 73* is set as 0.
- CAN B bus is not working, hence *bit 74* is set as 0.
- One of the internal voltages is not in range, i.e. bit 5 of one of the Autopilots 1x is set as 0.
- There is not any autopilot alive.
- Low priority task frequency is not correct, i.e. *bit 400* is set as 0.
- Acquisition task frequency is not correct, i.e. *bit 402* is set as 0.

## 2.2 Bit Variables

**Important:** Variables marked with "*" are stored in **Autopilot 1x**. If communication is configured accordingly, they represent information transmitted from the **Arbiter**.

| ID | Name | Description |
|---|---|---|
| 6 | File System Error | System file manager - 0 for error, 1 for running |
| 7 | System Error | This bit checks whether the system is running properly. 0 for 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 - 0 for wrong PDI configuration, 1 for running OK |
| 10 | CIO Low or C2 Error<br><br>**Warning: Deprecated variable** | CIO low or C2 failed. Bits 400 and 401 are recommended instead |
| 11 | 4X CAN failed | Fail of CAN communication between 1x and Arbiter - 0 for fail, 1 for communication OK<br>This bit is initialized with 1. When it is set as 0, it cannot recover until 1x is restarted |
| 12 | System Power up BIT Error | Power up - 0 for error, 1 for OK |
| 16 | Stack C1 usage FAIL | 0 for stack overflow of core 1, 1 for OK |
| 20* | 4XV System | System Error bit (bit 7) from the Arbiter |
| 21* | 4XV System Power up BIT | Autopilot 4x power up - 0 for fail, 1 for running OK |
| 22* | 4XV PDI | PDI files for Autopilot 4x - 0 for wrong PDI configuration, 1 for OK |
| 23* | 4XV Memory allocation | RAM allocation - 0 for trying to use more than available memory, 1 for OK |
| 24* | 4XV CAN-A BUS OFF | Autopilot 4x CAN A bus - 0 for error, 1 for running OK |
| 25* | 4XV CAN-B BUS OFF | Autopilot 4x CAN B bus - 0 for error, 1 for running OK |
| 26* | 4XV C1 arbiter | Main Task of CP1 in Autopilot 4x - 0 for error, 1 for running OK |
| 27* | 4XV Acquisition arbiter | Autopilot 4x acquisition task in real time - 0 for error, 1 for OK |

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Table 1 – continued from previous page

| ID | Name | Description |
|---|---|---|
| 28* | 4XV Power A | State of power supply for Autopilot 4x - 0 for error, 1 for OK |
| 29* | 4XV not in maintenance mode | 1 for NOT in mantenance mode - 0 for maintenance mode |
| 30* | 4XV Alive 0 | Indicates whether Autopilot 1x number 0 is sending status messages or not - 0 for dead, 1 for alive |
| 31* | 4XV Alive 1 | Indicates whether Autopilot 1x number 1 is sending status messages or not - 0 for dead, 1 for alive |
| 32* | 4XV Alive 2 | Indicates whether Autopilot 1x number 2 is sending status messages or not - 0 for dead, 1 for alive |
| 33* | 4XV Alive 3 external | Indicates whether external Autopilot is sending status messages or not - 0 for dead, 1 for alive |
| 34* | 4XV Ready 0 | Inner Autopilot 1x number 0 state - 0 for not ready, 1 for ready |
| 35* | 4XV Ready 1 | Inner Autopilot 1x number 1 state - 0 for not ready, 1 for ready |
| 36* | 4XV Ready 2 | Inner Autopilot 1x number 2 state - 0 for not ready, 1 for ready |
| 37* | 4XV Ready 3 external | External Autopilot 1x state - 0 for not ready, 1 for ready |
| 38* | 4XV Arbitrating | Arbiter state - 0 for not ready, 1 for ready |
| 39* | 4XV File Open Error | System file manager state - 0 for error, 1 for running OK |
| 40* | 4XV PDI version not compatible | PDI files state - 0 for not compatible with current version, 1 for compatible |
| 41* | 4XV Stack usage FAIL | 0 for memory overflow allocated for local variables, 1 for OK |
| 42* | 4XV PWM1 GPIO Off | GPIO/PWM 1 Value to read - 0 for OFF, 1 for ON |
| 43* | 4XV PWM2 GPIO Off | GPIO/PWM 2 Value to read - 0 for OFF, 1 for ON |
| 44* | 4XV PWM3 GPIO Off | GPIO/PWM 3 Value to read - 0 for OFF, 1 for ON |
| 45* | 4XV PWM4 GPIO Off | GPIO/PWM 4 Value to read - 0 for OFF, 1 for ON |
| 46* | 4XV PWM5 GPIO Off | GPIO/PWM 5 Value to read - 0 for OFF, 1 for ON |
| 47 | 4XV Watchdog Error | *For version 4.7 or higher* - 0 for watchdog signal is not read correctly, 1 for OK |
| 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 |

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Table 1 – continued from previous page

| ID | Name | Description |
|---|---|---|
| 75 | CAN-A Warning | CAN A state - 0 for warning, 1 for OK |
| 76 | CAN-B Warning | CAN B state - 0 for warning, 1 for OK |
| 117 | Main Power Error | Main power supply A. It will be 0 fot indicating error state |
| 124 | 4XV Vcc for Arbiter CPU Error | Power state of CPU Arbiter (Based on *RVar 1360*) - 0 for error, 1 for OK |
| 125 | 4XV Vcc-A Error | State of redundant power supply A (Based on *RVar 1361*) - 0 for error, 1 for OK |
| 126 | 4XV Vcc-B Error | State of redundant power supply B (Based on *RVar 1362*)- 0 for error, 1 for OK |
| 127 | 4XV Vcc-1 Error | Power supply for inner Autopilot 1x number 1 (Based on *RVar 1363*) - 0 for error, 1 for OK |
| 128 | 4XV Vcc-2 Error | Power supply for inner Autopilot 1x number 2 (Based on *RVar 1364*) - 0 for error, 1 for OK |
| 129 | 4XV Vcc-3 Error | Power supply for inner Autopilot 1x number 3 (Based on *RVar 1365*) - 0 for error, 1 for OK |
| 183 | 4X Selected | 4x Veronte Autopilot selected - 0 when this AP is not the selected AP, 1 when this AP is the selected one |
| 230-293 | 4XV Custom msg 0-63 Rx Error | Custom message of Arbiter - 0 for timeout, 1 for OK |
| 400 | C1 Low Frequency | Low priority tasks frequency<br>• 0 for error → Running frequency < 10 Hz<br>• 1 for OK → Running frequency > 10 Hz |
| 402 | Acquisition step missed | • 0 for Acquisition step missed → C1 hi frequency fluctuation is higher than permited (1%)<br>• 1 for Acquisition step OK → C1 hi frequency fluctuation is under set limits (1%) |
| 800-805 | PWM 0-5 GPIO Off | PWM GPIO 0-5 communication Sate - 0 for Off, 1 for On |
| 1200-1209 | User BIT Error 00-09 | User bit 0 to 9 - 0 for error, 1 for OK |

## 2.3 Real Variables (RVar) - 32 Bits

**Important:** Variables marked with "*" are stored in **Autopilot 1x**. If communication is configured accordingly, they represent information transmitted from the **Arbiter**.

| ID | Name | Units/Values | Description |
|---|---|---|---|
| 50 | CAN-A Tx Rate | pkts/s | CAN-A transmission packet rate |
| 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 |
| 300 | Relative Timestamp | s | CAN-A messages delayed because no mailbox is available for sending |
| 1350-1356 | 4XV ADC0-6 Converted Value | V | 4XV ADC0-6 Converted Values |
| 1357-1358 | 4XV Internal ADC7-8 Converted Value | V | 4XV Internal ADC7-8 Converted Values |
| 1359 | 4XV Internal ADC 9 Converted Value | V | 4XV Internal Arbiter identifier (A or B) |
| 1360 | 4XV Vcc for arbiter | V | Vcc for arbiter |
| 1361 | 4XV Vcc-A 3.3V | | Vcc-A 3.3V |
| 1362 | 4XV Vcc-B 3.3V | | Vcc-B 3.3V |
| 1363 | 4XV Vcc-0 | | Vcc-0 |
| 1364 | 4XV Vcc-1 | | Vcc-1 |
| 1365 | 4XV Vcc-2 | | Vcc-2 |
| 1366* | 4XV Autopilot 0 Score | customType | Score of Autopilot 1x number 0 |
| 1367* | 4XV Autopilot 1 Score | customType | Score of Autopilot 1x number 1 |
| 1368* | 4XV Autopilot 2 Score | customType | Score of Autopilot 1x number 2 |
| 1369* | 4XV Autopilot External Score | Decimal | Score of external Autopilot 1x |

## 2.4 Integer Variables (UVar) - 16 Bits

**Important:** Variables marked with "*" are stored in **Autopilot 1x**. If communication is configured accordingly, they represent information transmitted from the **Arbiter**.

| ID | Name | Description |
|---|---|---|
| 2 | Internal ADC 0 | Internal ADC pin<br>**Note:** Variable for internal use |
| 3-7 | ADC 0-4 | Direct reading of ADC pins |
| 8-17 | Internal ADC 1-10 | Internal ADC pins<br>**Note:** Variables for internal use |
| 53 | 4XV Veronte ID | ID of the Autopilot 1x for the redundant configuration (0 - 3) |
| 54 | 4XV Veronte CAP | Current Autopilot 1x selected - If the Autopilot has version 4.7 or higher, it is obtained from MUX readings, otherwise it is copied from RVar 55 (in this table) |
| 55* | 4XV Veronte selected | Autopilot 1x selected |
| 56* | 4XV Config manager status | Configuration manager state (flash, sd or safe) |
| 57* | 4XV File system status | State error for DFS2 file system |
| 58* | 4XV CAN-Serial 0 frames dropped | Lost messages during transformations CAN to Serial 0 |
| 59* | 4XV CAN-Serial 1 frames dropped | Lost messages during transformations CAN to Serial 1 |
| 90 | Version Major | Major software version |
| 91 | Version Minor | Minor software version |
| 92 | Version Revision | Revision software version |
| 95 | UAV address | UAV address |
| 450 | CAN-A Tx errors | CAN A communication errors in transmission |
| 451 | CAN-A Rx errors | CAN A communication errors in reception |
| 452 | CAN-B Tx errors | CAN B communication errors in transmission |
| 453 | CAN-B Rx errors | CAN B communication errors in reception |
| 454-455 | CAN to Serial 0-1 frames dropped | Lost messages during CAN to Serial transformations |
| 495 | Global configuration state (crc) of files (Higher 16 bits) | Global configuration state (crc) of files |
| 496 | Global configuration state (crc) of memory (Higher 16 bits) | Global configuration state (crc) of memory |
| 498 | Global configuration state (crc) of files | Global configuration state (crc) of files |
| 499 | Global configuration state (crc) of memory | Global configuration state (crc) of memory |

## 2.5 List of PDI errors

This section shows the errors that can be displayed by **Veronte Autopilot 4x**. The rest of errors can be read in the List of PDI errors section of **1x Software Manual**.

| Code | Nº | Explanation |
|---|---|---|
| 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 out of range |
| pdi_arb_cfg1 | 10004 | Error ID for Arb cfg method out of range |
| pdi_arb_cfg2 | 10005 | Error ID for Arb cfg tmin out of range |
| pdi_arb_cfg3 | 10006 | Error ID for Arb cfg hysteresis out of range |
| pdi_arb_init_time | 10011 | Error ID for Arbiter Power Init Time less than 0 |
| pdi_arb_varcfg | 10013 | Incorrect arbiter variable configuration |

CHAPTER

THREE

# CAN BUS PROTOCOL

CAN message structure is defined by two main parts: **cmd** and **data**.

1. **cmd (8 bits - 1 byte)**: First byte refers to the **Message Type**.

   Messages Type are defined as follows:

| Type | Value | Description |
|---|---|---|
| t_arbitration | 0 | Arbitration message |
| t_version | 1 | Version request / response |
| t_pwm_0_3_set | 2 | PWMs 0 to 3 |
| t_pwm_4_7_set | 3 | PWMs 4 to 7 |
| | 4 | Reserved |
| t_esc_tm | 5 | Scorpion Tribunus ESC telemetry data |
| t_esc_tm2 | 6 | Jeti ESC telemetry data |
| t_bec_tm1 | 7 | Jeti BEC telemetry data 1 |
| t_bec_tm2 | 8 | Jeti BEC telemetry data 2 |
| t_temp_tm | 9 | Jeti Temperature sensor telemetry data |
| t_mcu_cmd | 10 | Lift MCU battery command |
| t_pwm_8_11_set | 11 | PWMs 8 to 11 |
| t_pwm_12_15_set | 12 | PWMs 12 to 15 |
| t_pwm_16_19_set | 13 | PWMs 16 to 19 |
| | 14 | Reserved |
| | 15 | Reserved |
| t_cmd_maint | 16 | Command to go to Maintenance Mode |
| t_stick_sel | 17 | Command for Stick selection |
| t_mcu_tm1 | 18 | Lift MCU telemetry data 1 |
| t_mcu_tm2 | 19 | Lift MCU telemetry data 2 |

**Note:** All these *Message Type* are defined as a “Matcher” in the CAN custom messages configuration. For example, for PWMs 0-3, the *Message Type* will be configured as follows:

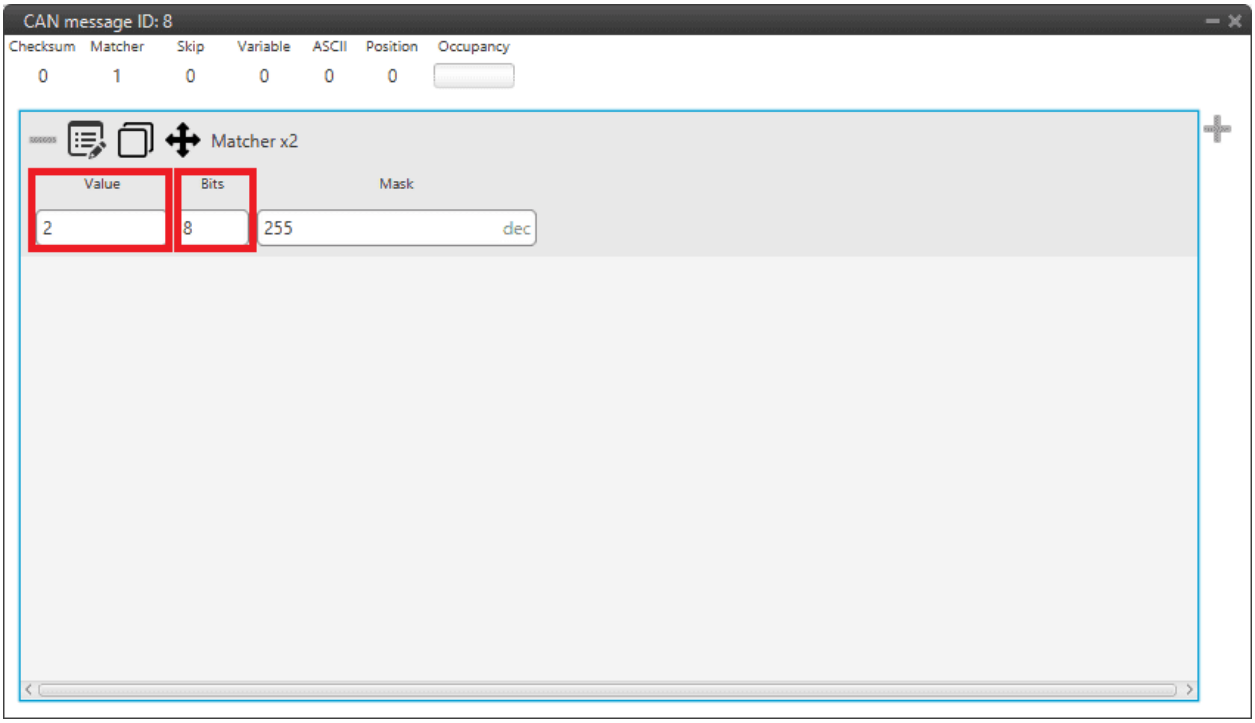


Fig. 1: **Message Type example**

- **Value**: **2**. This is because it is the value for the message for PWMs 0 to 3 (it is **indifferent to the PWM number**).
- **Bits**: **8**. This is because the *Message Type* is an 8-bit message.

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2. **data (up to 56 bits - 8 bytes)**: The following bytes refer to the **Message data**.

The following examples include complete messages, so each beginning corresponds to *Message Type*.

## 3.1 Arbitration messages

### 3.1.1 Status Message

**Status message** summarizes the status of all autopilots. This message is a **producer** in the **4x PDI Builder** configuration, since it is created from the CAN messages of all three or four autopilots.

| Byte | Position | Value | Description |
|---|---|---|---|
| 0 | 0 - 7 | 0x00 | Header |
| 1 | 0 - 7 | 0xFF | Status message Header |
| 2 | 0 - 6 | 0 - 3 | Selected AP (0 = AP1, 1 = AP2, 2 = AP3, 3 = External AP) |
| | 7 | 0 - 1 | Arbitration OFF/ON |
| 3 | 0 | 0 - 1 | AP1 Alive |
| | 1 | 0 - 1 | AP2 Alive |
| | 2 | 0 - 1 | AP3 Alive |
| | 3 | 0 - 1 | External AP Alive |
| | 4 | 0 - 1 | AP1 Ready |
| | 5 | 0 - 1 | AP2 Ready |
| | 6 | 0 - 1 | AP3 Ready |
| | 7 | 0 - 1 | External AP Ready |
| 4 | 0 | 0 - 1 | CBIT. System error. Will fail if any of the below items fail. |
| | 1 | 0 - 1 | PBIT. System Boot Ok. |
| | 2 | 0 - 1 | PDI Ok. Will fail if there is an error in configuration files. |
| | 3 | 0 - 1 | Memory Allocation OK |
| | 4 | 0 - 1 | CAN A Ok |
| | 5 | 0 - 1 | CAN B Ok |
| | 6 | 0 - 1 | CIO Low Task Ok |
| | 7 | 0 - 1 | CIO High Task Ok |
| 5 | 0 | 0 - 1 | Power OK. All power indicators are OK. |
| | 1 | 0 - 1 | A Bus Voltage Ok |
| | 2 | 0 - 1 | B Bus Voltage Ok |
| | 3 | 0 - 1 | Arbiter Voltage Ok |
| | 4 | 0 - 1 | AP1 Voltage Ok |
| | 5 | 0 - 1 | AP2 Voltage Ok |
| | 6 | 0 - 1 | AP3 Voltage Ok |
| | 7 | 0 - 1 | Arbiter Mode. 1 = Normal, 0 = Maintenance |

### 3.1.2 Score Message

**Score message** contains the final score of an specific autopilot. This message is a **producer** in the **4x PDI Builder** configuration, so it is created from the CAN messages of all three or four autopilots.

| Byte | Position | Value | Description |
|---|---|---|---|
| 0 | 0 - 7 | 0x00 | Header |
| 1 | 0 - 7 | 0 - 3 | Autopilot ID (0 = AP1, 1 = AP2, 2 = AP3, 3 = External AP) |
| 2 - 5 | 0 - 31 | 0 - 0xFFFFFFFF | Autopilot Arbitration Score |

### 3.1.3 Ready Message

**Ready message** is sent from **Autopilot 1x** to **Arbiter**. It tells whether an **Autopilot 1x** is ready to fly or not. It is as **consumer** in the **4x PDI Builder** configuration, so it is stored in memory.

| Byte | Position | Value | Description |
|---|---|---|---|
| 0 | 0 - 7 | 0x00 | Header |
| 1 | 0 - 7 | 0xFF | Ready Message Header |
| 2 | 0 (1 bit) | 0 - 1 | Ready/Not Ready |

### 3.1.4 Arbitration Message

**Arbitration message** tells the arbitration value of a specific variable. It is as **consumer** in the **4x PDI Builder** configuration, since it is stored in memory.

| Byte | Position | Value | Description |
|---|---|---|---|
| 0 | 0 - 7 | 0x00 | Header |
| 1 | 0 - 7 | 0 - 31 | Arbitration Variable Number |
| 2 - 5 | 0 - 31 | 0 - 0xFFFFFFFF | Arbitration Variable Value |

CHAPTER

FOUR

# STATUS MANAGEMENT

## 4.1 Arbiter boot

When the **Arbiter** is booted, it enters an **Iddle** state, trying to verify the status of the system.

While **Iddle**, the **Status Message** is not sent.

If all checks success, the **Arbiter** will enter **Normal mode**.

If, after 30 seconds, system errors are still present, **Arbiter** will enter **Maintenance mode**.

## 4.2 Status message

Once in **Normal mode**, the **Arbiter** will start sending the **Status** and **Scores** telemetry messages.

The frequency of these messages is configurable. They can also be disabled.

The status message contains information such as:

- Arbitration ON/OFF
- Selected autopilot
- System BITs
- etc.

While in **Maintenance Mode**, the **Arbiter** will send the **Status** message, even if it is disabled, but will not send the **Scores** messages.

## 4.3 Ready status

After the **Arbiter** enters **Normal mode**, it will wait until a Ready Message from each autopilot is received. Only then the Arbitration will start.

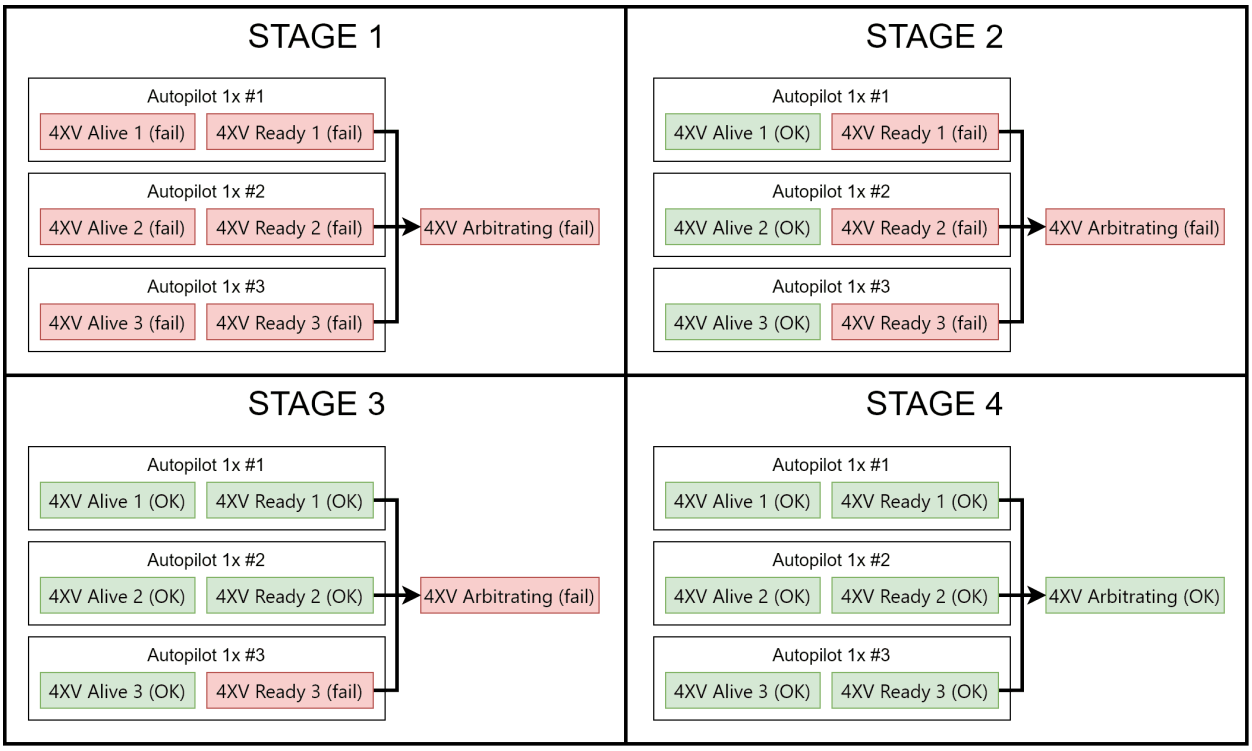


Fig. 1: **Example of normal arbitration start**

If the Arbiter is in maintenance mode, the arbitration will not start. Even if the **Ready messages** are received.

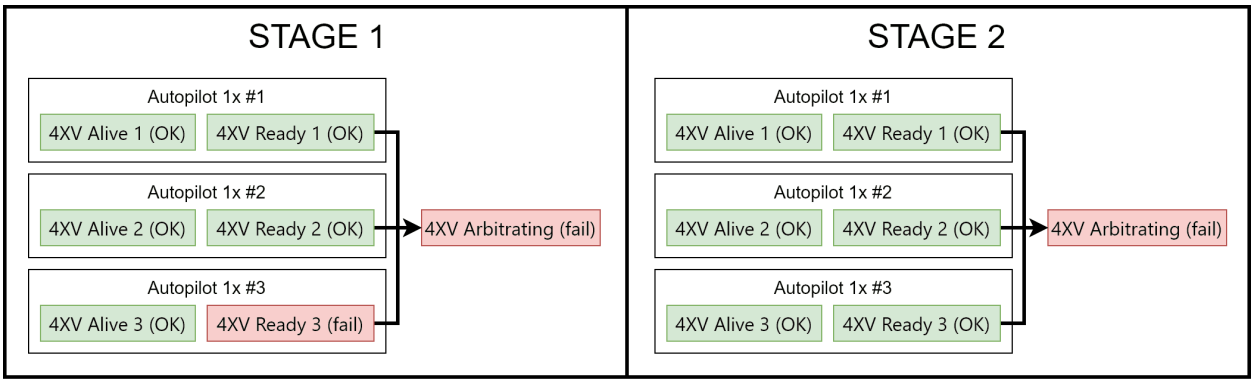


Fig. 2: **Example of failed arbitration start**

## 4.4 Alive status

Once arbitration starts, all autopilots are declared as alive by default, but it is possible that they are declared as **Dead** if a critical error is found.

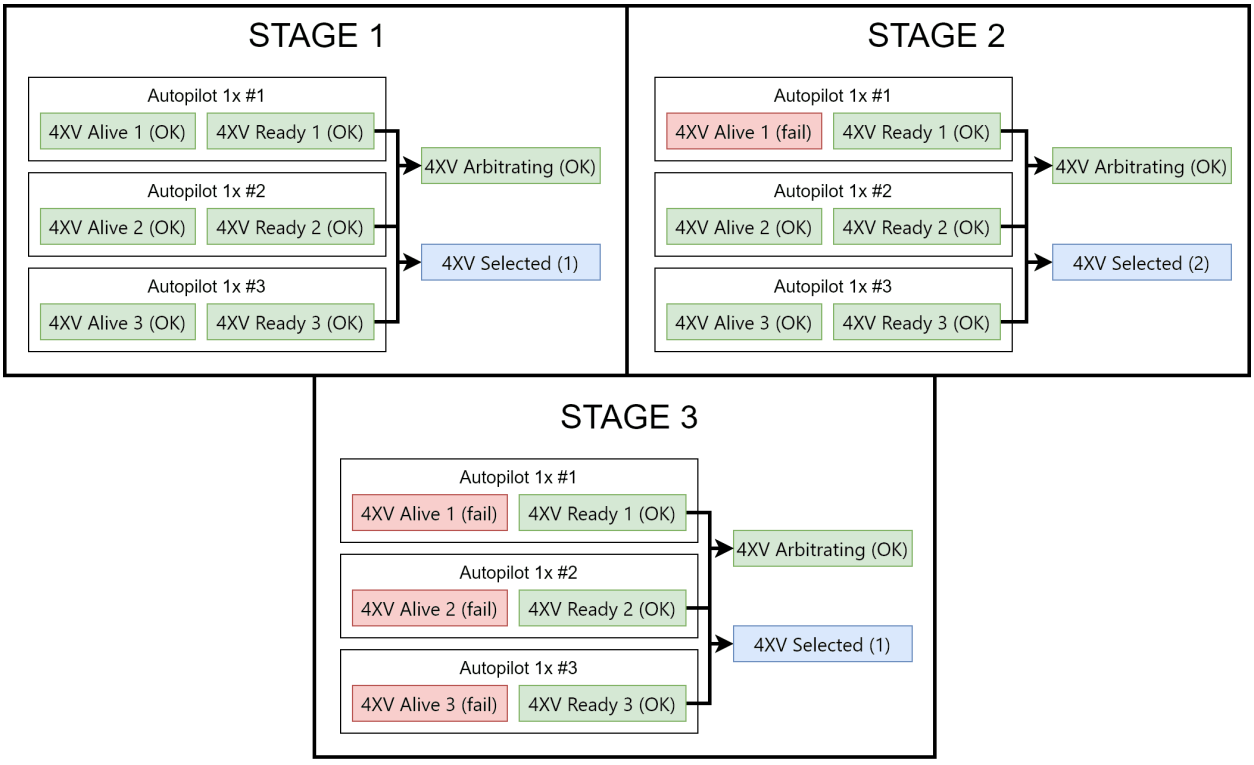


Fig. 3: **Example of APs being declared Dead**

The **Arbiter** will declare an autopilot dead if one of the following incidences is found:

- One of the arbitration messages (including the Ready message) is not received for 0.1 seconds.
- A **Not Ready** message is received.
- A **System Not OK** error is raised on any of the autopilots, activating the **FTS signal**.
- The **watchdog** signal for any autopilot is not ok.

**Warning:** Make sure to configure the sending of arbitration messages as **High priority**. Otherwise, the sending of messages could be shortly interrupted by a higher priority task and the autopilot will be declared **Dead**.

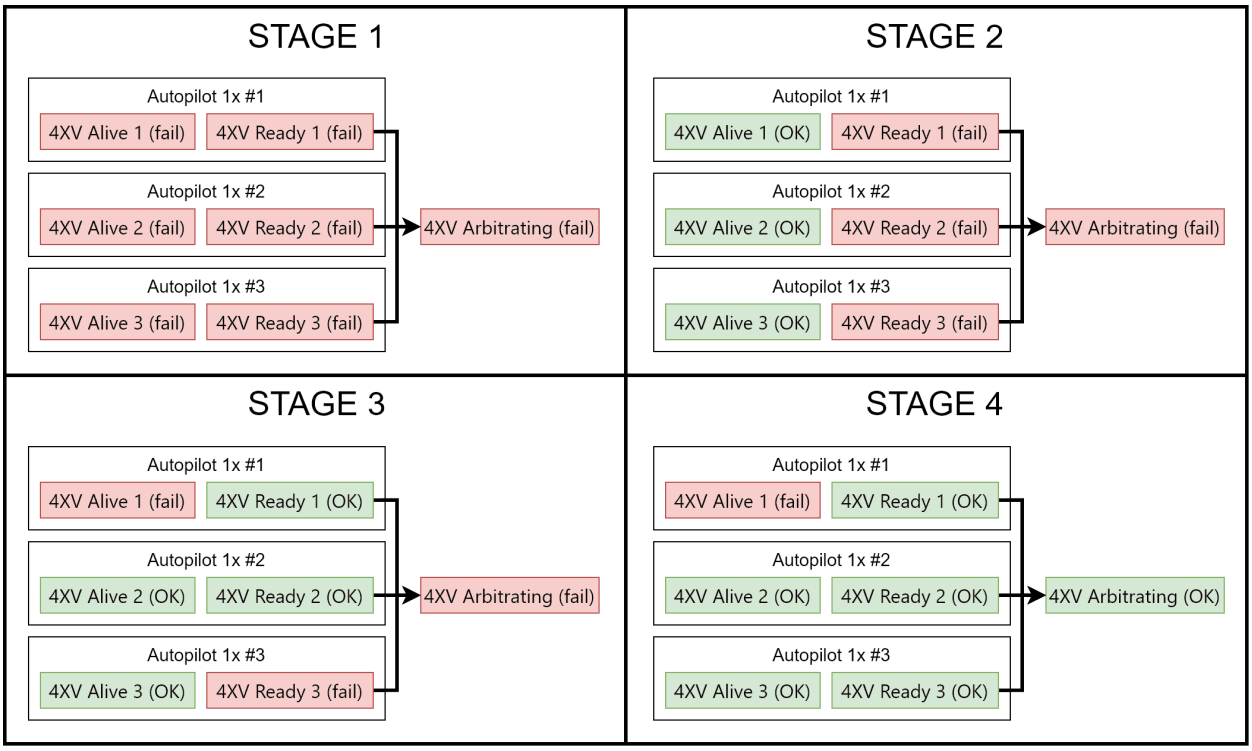


Fig. 4: **APs being declared Dead when arbitration starts due to missed messages**

A **Dead** autopilot can never be selected again as long as arbitration persists.

The **Dead** status is not reversible, it is necessary to reboot the whole system in order to recover a **Dead** autopilot.

If the number of **Alive** autopilots is 2 or less, relative arbitration variables are disabled (since at least 3 autopilots are needed).

If **only one** autopilot is **Alive**, it will be selected no matter the score.

If all autopilots are **Dead**, the **Preferred** autopilot will be selected.

## 4.5 Maintenance Mode

Maintenance mode is used for changing the **Arbiter** configuration.

Arbitration is disabled while in maintenance mode.

**Arbiter** will also enter maintenance Mode after a failed boot.

The reason of the failed boot can be checked in the **Status message**.