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Version control

Ver.	Date	Summary of changes
1.0	2021-10-04	Initial version
1.1	2021-10-28	Adapt maximum antenna gain for FCC compliance
1.2	2021-11-26	Add FLARM Hub 1.40 release notes
1.3	2022-01-26	Add FLATMUAOW conformity statements, 7.06/1.41 release notes
1.4	2022-02-10	Add publication dates to release notes. Add instructions on RF cable shortening.
1.5	2022-05-25	Add 7.07 release notes
1.6	2022-07-14	Add Hub 1.42 release notes
1.7	2022-09-01	Add 7.08 release notes
1.8	2022-10-11	Add Hub 1.43 release notes
1.9	2022-11-14	Add 7.09 release notes
1.10	2022-12-12	Add FLATMUACW conformity statements
1.11	2023-02-14	Add Hub 1.44 release notes and Ardupilot description
1.12	2023-05-12	Add 7.21 release notes
1.13	2023-08-18	Add Declarations of Conformity
1.14	2023-11-28	Add 7.22 and Hub 1.60, 1.61 release notes, description on Remote ID compliance
1.15	2024-02-06	Add Hub 1.62 release notes
1.16	2024-04-30	Add 7.24 release notes
1.17	2024-09-13	Add Hub 1.65 release notes. Update RemoteID and MAVLink interface description reflecting new interface.
1.18	2025-06-05	Add 7.40 release notes
1.19	2025-07-11	Add Hub 1.66 release notes. Add description to MAVlink heartbeat system status, Operator ID validation, improve clarity in MAVlink Parameter Protocol description, fix description of Remote ID serial ID, update LED description
1.20	2025-12-11	Add Hub 1.81 release notes. Adapt description of MAVlink configuration and flight detection.
1.21	2026-02-03	Add Hub 1.82 release notes

1.22	2026-02-06	Add 7.43 release notes, fix description of MAVLink OPEN_DRONE_ID_BASIC_ID messages.

Table of contents

1 Introduction

Atom UAV is a FLARM device developed specifically for UAVs. Leveraging the Atom platform, it is a miniature, feature-packed device that can be used standalone as an add-on or retrofit or integrated into other designs.

Highlights:

- Based on the FLARM Atom System-on-Chip platform
- Full, worldwide FLARM interoperability
- Cortex-M4F processing core
- Integrated Wi-Fi and Bluetooth module
- 72-channel u-blox GNSS engine
- Web app for configuration and diagnostics
- 1090MHz receiver for ADS-B and rebroadcast (TIS-B/ADS-R)
- Barometric sensor for pressure altitude
- Consolidated, unified traffic stream on JSON or MAVLink
- Direct broadcast remote ID, compliant with ASTM F3411-22 & F3588-22, EC 2019/945, EC 2020/1058, and JORF no. 0302 du 29 decembre 2019

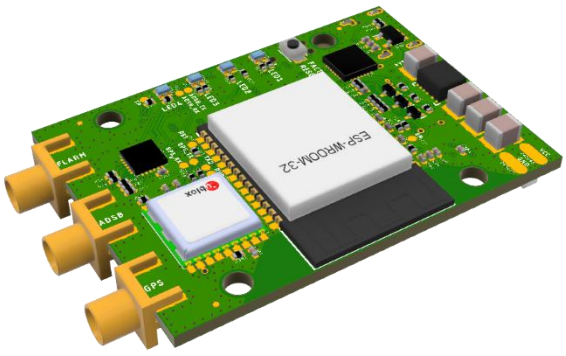
Atom UAV is available in two functionally equivalent variants:

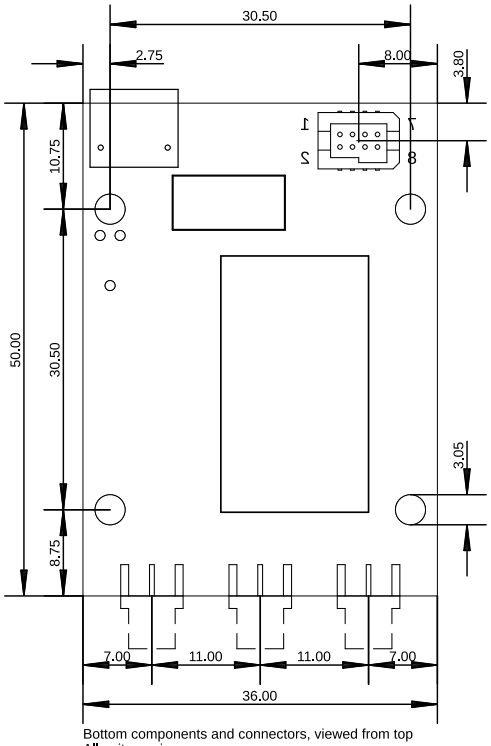
- **Atom UAV**: For standalone use, housed in a plastic enclosure, using a JST GH connector for power supply and data streaming, and an integrated Wi-Fi antenna. Ships with a complete set of antennas and cables.
- **Atom UAV OEM**: Board only, for embedded use with a board-to-board data connector and RF connectors for using dedicated antennas. Does not contain antennas or cables.

2 General Overview

2.1 Specifications

	Atom UAV	Atom UAV OEM
Dimensions	57x40x15 mm (54x40x15 mm w/o connectors)	57x36x10 mm (50x36x8 mm w/o connectors)
Mass	43 g	15 g
Mounting	N/A	4x3 mm holes, 30.5mm grid
Platform	FLARM Atom System-on-Chip	
Navigation	u-blox 8th generation multi-GNSS receiver	
Storage	32 MB NOR FLASH, microSD card slot	
Connectors	FLARM Radio: MCX	
	ADS-B Receiver: MCX	
	GNSS: MCX	
	N/A (internal antenna)	Wi-Fi: U.FL
	USB-C (power, virtual serial)	
	JST GH 6-pin	TFM-104-02-L-D 8-pin B2B
Protocols	JSON, MAVLink	
User Interface	4 LED status (bicolor)	
Power Supply	5-28 VDC (JST GH/TFM)	
	5 VDC (USB-C)	
Power Consumption	1.4 W typical	





Bottom components and connectors, viewed from top
All units are in mm

2.2 System Description

FLARM is the collision avoidance system and traffic awareness/electronic conspicuity technology used by General Aviation, light aircraft, and UAVs. It was designed to support self-separation for both VFR and IFR in applicable airspace classes. Aircraft with a FLARM system alert the pilots when on a collision course with another aircraft. Like TCAS/TAS, visual and aural warnings indicate that a collision is imminent, requiring the pilots to act. However, unlike TCAS, FLARM does not issue Resolution Advisories (RA), so pilots need to select the appropriate course of action themselves.

FLARM works by calculating and broadcasting its own predicted future 3D flight path to nearby aircraft, using a digital radio channel. At the same time, it receives the future flight path from surrounding aircraft.

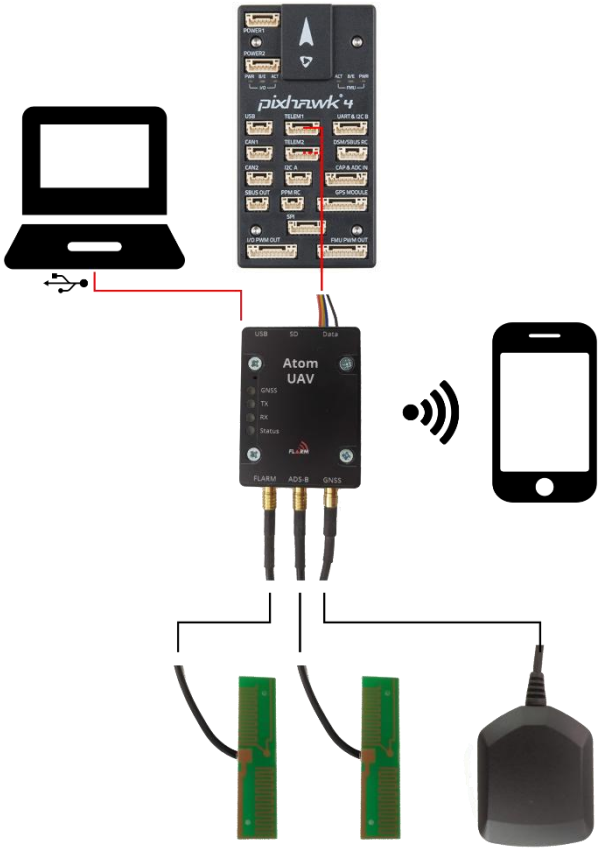
The system determines its position, altitude, and movement with a sensitive GNSS receiver. Based on those and other parameters, a precise projected flight path can be calculated. The flight path, together with additional information such as an identification number, is encoded before being broadcast over an encrypted radio channel twice per second. Flight models are available for most aircraft types, including piston-engine airplanes, jets, helicopters, gliders, hang gliders, paragliders, UAVs, etc.

FLARM was invented in 2004 following an increasing number of mid-air collisions. Research and accident investigations had shown that the see-and-avoid principle was insufficient to reliably detect approaching aircraft in time. It initially spread in the domain of non-powered aircraft but was soon followed by rapid expansion in powered airplanes and helicopters. Over 50,000 manned aircraft and many more UAVs already have a FLARM-system installed. In Europe, more than 50% of all General Aviation aircraft have FLARM (including nearly 100% of gliders). The technology has additionally spread to other parts of the world and is today also used most prominently in North and South America, Australia, New Zealand, South Africa, Israel, and some Asian countries.

Atom UAV is a FLARM device for installation in UAVs. It is based on the latest Atom SoC platform and features a web app called FLARM Hub. Atom UAV has been designed for worldwide use and connects to a range of flight computers. Configuration is simple through the web interface.

Atom UAV has a fully functional FLARM radio for receiving and transmitting traffic information, an ADS-B / Mode-S transponder receiver, and a modern GNSS receiver, as well as a Wi-Fi/Bluetooth radio for configuration and transmission/reception of Remote ID messages. This enables aircraft that are not yet equipped with FLARM to also be detected by Atom UAV.

As a transmitter, UAVs mounted with Atom UAV are visible by other FLARM-equipped devices and can be tracked by Remote ID receivers. As a receiver, it can receive and process FLARM, ADS-B and Remote ID signals from surrounding aircraft that are made available on the digital data interface on the JST or USB interface in various formats.



The diagram above shows a typical setup. Atom UAV is connected to a Pixhawk / PX4 flight controller, with a data interface and power supply. Optionally, power can be supplied through USB. Two FLARM/ADS-B antennas are connected to the FLARM and ADS-B RF connectors. A GNSS antenna is connected to the GNSS RF connector.

Internally, the device contains two microcontrollers. The Atom SoC runs the FLARM radio protocol. The periphery processor runs FLARM Hub and provides connectivity via Wi-Fi, USB and the JST/TFM connector. Both processors require individual firmware updates.

2.3 Abbreviations

Abbreviation	Meaning/Explanation
ADS-B	Automatic Dependent Surveillance — Broadcast
GNSS	Global Navigation Satellite System
GPS	Global Positioning System (NAVSTAR)
ISM	The ISM radio band (≈ 915 MHz)
RF	Radio Frequency/Radio
SoC	System-on-Chip
SRD860	The SRD860 radio band (≈ 868 MHz)
SSID	Service Set Identifier, (Wi-Fi network name)
SSR	Secondary Surveillance Radar
TAS	Traffic Advisory System
TCAS	Traffic alert and Collision Avoidance System
UAV	Unmanned Aerial Vehicle
UI	User Interface

3 Installation

3.1 Housing

Mount Atom UAV to a suitable mounting location. The orientation of the device is discretionary. The housing is not waterproof, and the ingression of solid particles and liquids must be avoided. Should the device get moist, it must be completely dried prior to further use. If the device becomes wet, it may be permanently damaged and rendered unusable. Should the device suddenly cool down, this may result in the formation of condensation.

3.2 Supplying Power

Atom UAV has two interfaces for power supply:

- USB connector with 5V (DC)
- JST/TFM connector 5-28V (DC)

The chosen cables must be of sufficient diameter to carry the power (1.4 W).

3.3 Antennas

The FLARM system uses a radio communication frequency in the SRD860 band (≈ 868 MHz) or in an ISM band (≈ 915 MHz) in different parts of the world. Atom UAV will automatically select the applicable frequency based on the GNSS position.

The following frequencies are used within the specified areas.

Area	Frequency
Europe	868.2 – 868.4 MHz
North America	902.2 – 927.8 MHz

The antennas should be selected for the frequency band applicable in the geographic area where the aircraft is being operated. Often, such antennas only cover one band and need to be selected carefully. However, the antennas shipped with the Atom UAV standalone variant (and listed as suggested accessories in Section 7) have wide band characteristics and cover the FLARM frequency bands of all regions, as well as the ADS-B band. Inappropriate antennas, especially antennas when placed at poor locations, can provide poor system performance.

Note: Atom UAV OEM ships without antennas. The integrator must carefully select appropriate antennas. Atom UAV will not automatically detect inappropriate or damaged antennas, including antennas for the wrong frequency band.

Note: Communication between FLARM devices employs an encrypted, patent-protected protocol. Any unlicensed use, copying, distribution, conversion, replication, access, interception, de-compiling, reverse engineering, or further transmission of knowledge so acquired relating to the system components or software/firmware, in whole or in part, is thus illegal.

3.3.1 RF Connectors

Atom UAV uses MCX connectors for all RF interfaces. The corresponding connector can be identified as GNSS, ADS-B and FLARM on the device housing (Atom UAV standalone variant) or on the PCB next to the connectors (Atom UAV OEM variant).

The Atom UAV OEM variant additionally has a U.FL connector for a Wi-Fi antenna.

3.3.2 Placement

For good performance of the FLARM system, the FLARM antenna must be placed at least 20 mm from larger pieces of conductive materials such as a metal surface. The FLARM antenna must be installed vertically (perpendicular to the horizontal plane).

If the aircraft body contains large amounts of conductive materials such as carbon fiber, the antenna must be placed outside the vehicle body. If the selected antenna location does not give clear line of sight in all horizontal directions, two Atom UAV devices can be mounted to increase the coverage, using the radio diversity functionality described later in this document.

For good performance of the GNSS receiver, the GNSS antenna must be placed such that signals from the sky are not obstructed. The antenna should be mounted on a sufficiently large ground plane, either as part of the host PCB or on a separate metal plane that adds more than 20 mm of ground around the antenna.

Due to the larger transmit power of the ADS-B system, the placement is less crucial. However, the antenna should also be installed vertically and be placed at a sufficient distance from conductors.

Note: Atom UAV also receives and decodes Mode-S signals, which do not contain position information. Instead, the distance is estimated from the received signal strength. The radiation pattern of the ADS-B antenna installed on the aircraft should be omnidirectional to give accurate range information. Due to limitations in the MAVLink protocol, Mode-S targets are not available on this interface.

The Wi-Fi system has two functional modes. The first mode is the FLARM Hub web application for configuration. In that case, the antenna selection and placement are not crucial, since the device needs to only cover short ranges.

The second mode is for Remote ID. In that case, for the Atom UAV OEM variant, an antenna with sufficient gain must be selected as described in Section 8. The antenna must be installed vertically and placed in a location that allows for omnidirectional radiation characteristics, i.e., without conductors in the vicinity.

When using Remote ID with the Atom UAV standalone variant, the internal Wi-Fi antenna is used to transmit Wi-Fi packets. In that case it is recommended to place the device vertically such that the omnidirectional plane of the internal antenna is aligned with the horizontal plane.

For more general information on the placement of FLARM antennas, please see document FTD-041.

3.3.3 RF Cable Shortening

In some instances, the cables of the antennas shipped with Atom UAV are too long. This is particularly the case on small vehicles. In that case, it is recommended to shorten the cables. For good performance of the system, new RF connectors must be mounted. This can be done by cutting the cables (RG174) to the required length and crimping new connectors. Good experience has been gained with the following set of low-cost crimping tools and connectors:

- Amphenol RF 47-10150 Crimp Tool
- Amphenol RF 919-386P-51S Connector MXC Plug

Make sure to properly solder the center pin. With some experience, a new connector can be crimped in under a minute.

3.4 Data Interfaces

The Atom UAV standalone variant is mounted with a JST GH connector to facilitate connections to popular flight controllers. Atom UAV OEM variant is mounted with a TFM connector for ease of integration as a component into larger systems. The basic functionality is the same with both variants.

3.4.1 JST GH Connector

The Atom UAV standalone variant is equipped with a GH connector from JST[1]. It exposes a 3.3 V UART interface and may be used to supply power. The pin assignment is shown in the table below.

Table: JST-GH Pinout

Pin	Function	Function Alt
1	Vin 5–28 V	
2	TXD UART (Out)	
3	RXD UART (In)	
4	CANbus TX (Out)	GPIO
5	CANbus RX (In)	GPIO
6	GND	

When connecting to a Pixhawk or similar flight controller, the RX and TX lines must be crossed, i.e., TX of the flight controller must be connected to RX of the Atom UAV, etc.

The JST GH receptacle is surface-mounted to the board; thus, the mechanical stability is limited. Do not put force on the solder connections!

3.4.2 TFM Connector

The Atom UAV OEM variant is equipped with a TFM-104-02 board-to-board connector. The corresponding connector for the main board is the equivalent SFM connector. The table below shows the pin assignment.

Table: TFM-104-02-L-D Pinout

Pin	Function	Function Alt
1	Vin 5–28 V	
2	TXD UART (Out)	
3	DO NOT CONNECT	
4	RXD UART (In)	
5	DO NOT CONNECT	
6	CANbus TX (Out)	GPIO

[1] https://jst.de/product-family/show/89/gh

7	GND	
8	CANbus RX (In)	GPIO

3.4.3 USB Connector

The unit may be powered through the USB connector. This is mechanically less robust and thus not recommended in flight in any type of aircraft. For validation of the functionality, however, it provides a simple method for power and data connectivity.

The Atom UAV uses a CP2102 USB chip. The Virtual COM Port (VCP) drivers[2] must be installed on the host computer to use this feature. In Windows, use the "Device Manager"[3] to see what COM-port is used.

3.5 Status LEDs

On the Atom UAV standalone variant, the status LED functionality is described on the device housing. On the Atom UAV OEM variant, the LEDs are numbered from LED1 to LED4 on the PCB. The functionality of the LEDs is as follows:

- LED1: GNSS reception
- LED2: FLARM/Remote ID radio transmitting
- LED3: FLARM radio receiving
- LED4: Status

Each LED can be either **GREEN**, **AMBER**, **RED**, or **OFF**. The different states have the following meaning, depending on whether the device is in bootloader mode or if the application has booted, indicated by the four multicolor LEDs:

[2] Download from: https://www.silabs.com/developers/usb-to-uart-bridge-vcp-drivers
[3] In Windows, press the "Windows" key and X together, then M

	GNSS	Transmit	Receive	Status
Initialization				
Non-fatal error				
Fatal error				
Nominal state, no GPS fix				
Nominal state, 3D GPS fix, transmitting FLARM, Remote ID disabled				
Nominal state, 3D GPS fix, transmitting FLARM, Remote ID configured incorrectly				
Nominal state, 3D GPS fix, transmitting both FLARM and correct Remote ID				
Nominal state, 3D GPS fix, transmitting and receiving at least one aircraft				

The LED lights are also visualized in FLARM Hub on the Status page.

4 Configuration and Maintenance

Atom UAV can be configured via the HUB web interface. It runs its own Wi-Fi access point to which e.g., a mobile phone or laptop computer can connect. The SSID of the Wi-Fi is set to the (complete) Device ID as printed on the label, e.g., FLATMUAVW-000042 when the serial number is 42. The default password is "password". Please make sure to change when configuring the device.

Note: On the Atom UAV OEM variant, the Wi-Fi module comes with a U.FL connector instead of a PCB antenna. An antenna must be connected for proper operation. If not, the range might be insufficient for a reliable connection to operate the Web Interface.

Once connected to the Wi-Fi, open the address http://10.10.10.10 in a browser of the device that is connected to the Atom UAV. The web interface should now load. On the Status page, the connectivity, system information and GNSS fix are shown.

4.1 Configuration

The different configuration pages can be used to configure FLARM, the Wi-Fi and Bluetooth interfaces, and FLARM Hub. In the sections below, important aspects and additional information are given to each of the configuration items.

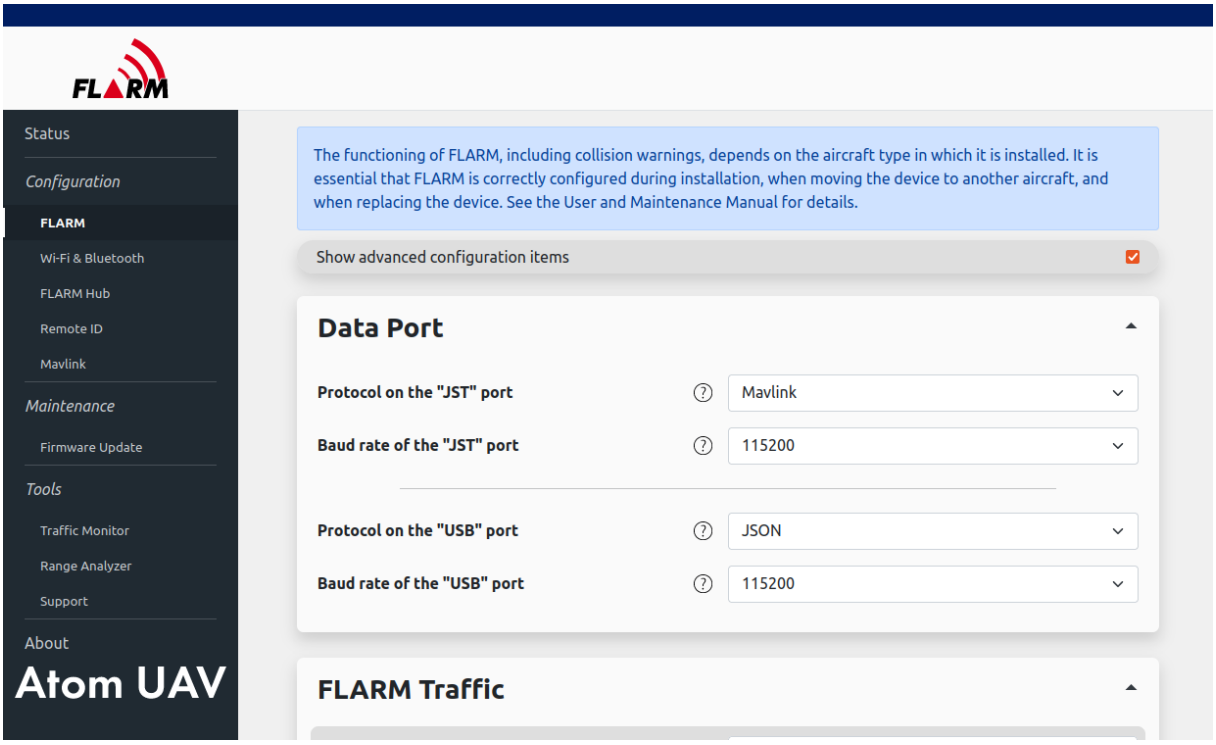
4.1.1 FLARM

Explanations for each field are available as a tooltip by hovering over or clicking on the question mark next to each field.

When a configuration item is changed (selecting a dropdown item, radio button, or moving focus away from a text field), the configuration is automatically applied to FLARM. No additional step is necessary to apply the value. A successful change of the configuration item is indicated as a green border around, and a green checkmark inside, the field. An incorrect value is indicated as a red border around the field with a red exclamation mark inside.

4.1.1.1 Port Configuration

The protocol and baud rate can be configured independently for the JST and USB ports. There is a choice between JSON and MAVLink for the JST port, and JSON for the USB port. If desired, output on either one or both ports can be deactivated.



Please note that the default on the JST port is MAVLink, and output on the USB port is deactivated.

For more information on the host settings for the MAVLink interface, please refer to Section 5.1. For more information on the JSON interface, please see Section 5.2.

4.1.1.2 Radio Diversity

Atom UAV supports radio diversity by using two devices concurrently. This facilitates achieving sufficient radio coverage in larger airframes with RF shadowing, e.g., due to large carbon fiber bodies or battery assemblies. In such a setup, both devices will emit the same ID (and thus be seen as one aircraft by other receivers) while ignoring signals transmitted by each other.

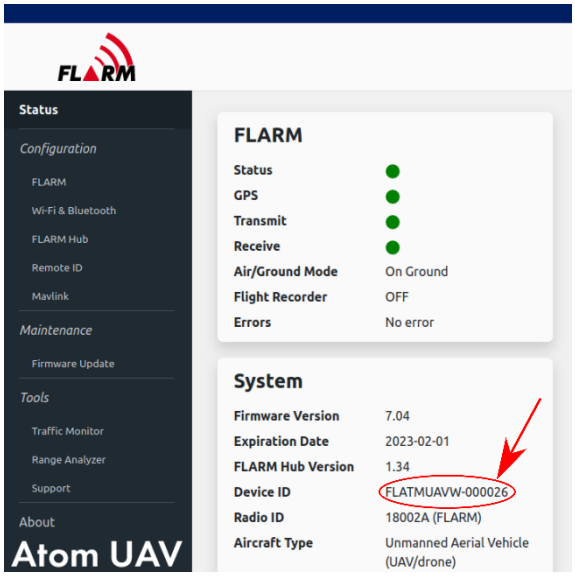
Diversity can be configured on the web interface under “Configuration”, “FLARM”, “Radio Diversity”. It requires defining a primary and a secondary device, where the secondary is explicitly linked to the primary through a reference (part of the serial number).

In normal operation, i.e., a device that is not as part of a primary/secondary setup, choose the “No diversity” option. This is the default setting.

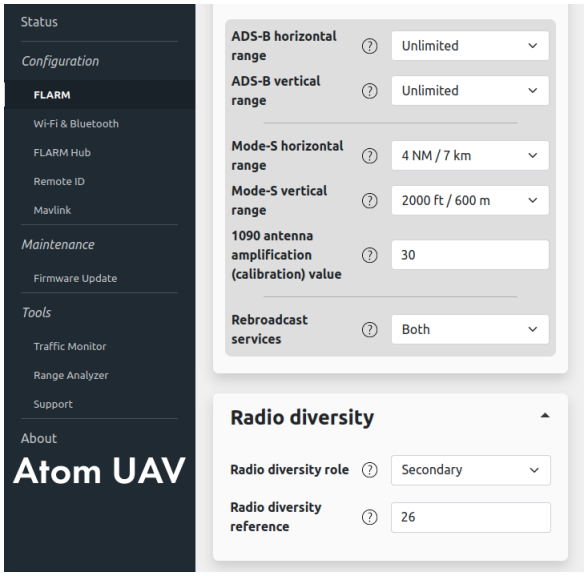
To use radio diversity, configure both the primary and secondary. Inappropriate or incomplete configuration may lead to loss of function or multiple targets being transmitted from the same vehicle.

The secondary device requires the reference to the primary device. This reference is the serial number of the primary device, as can be found on the sticker on the device or in the web interface, on the "Status" page, under "System", "Device ID", e.g., 26 for the primary with the Device ID FLATMUAVW-000026.

Note: Only devices of the same type can be used in a diversity setup. Specifically, the OEM variant cannot be mixed with the standalone variant.



Identification of serial number in primary device



Setting radio diversity role in secondary device

4.1.2 Wi-Fi & Bluetooth

Wi-Fi and Bluetooth settings and network names can optionally be changed, e.g., to make it easier to identify a particular device. The default password ("password") must be changed during initial configuration.

Wireless connectivity (Wi-Fi and Bluetooth) can be disabled under configurable conditions (in-flight, with valid GPS, or after specific elapsed time since power-on).

4.1.3 Configuration Lock

To prevent unauthorized people from modifying the configuration, the configuration can be locked by a password. Set a password that is different from the Wi-Fi password. Users will still be able to access FLARM Hub but will not be able to change the locked configuration items.

4.1.4 Remote ID

Atom UAV allows to transmit in accordance with ASTM F3411-19 and F3411-22/DIN EN 4709-002, EC 2019/945, EC 2020/1058, and JORF no. 0302 du 29 decembre 2019. The device emits all information through the Wi-Fi Beacon Frame, NAN, and French Remote ID standards.

The standards allow for multiple types of identifiers. The identifier can be either based on the Atom UAV serial number (e.g., when used as an "Add-On"), a CAA registration ID which is validated by the device, or an UTM-assigned UUID.

Remote ID can be configured through the Atom UAV's web interface, which can be accessed by either connecting to the Atom UAV's WiFi Access Point and visiting http://10.10.10.10 or through the FLARM App available in Google Play and the App Store. Remote ID can also be configured over MAVLink.

Atom UAV has two modes of operation:

- **Self mode**, where the contents of the Remote ID packets are generated by the Atom UAV.
- **MAVLink Open Drone ID TX/RX component**, where the contents of the Remote ID packets are generated by the autopilot.

Messages are transmitted immediately after bootup, even if no position is available. The messages are emitted at 2 Hz using the configured Wi-Fi message format.

Remote ID messages are received only when the transmit function is activated as well. Only WiFi NAN messages are received and are translated to MAVLink ADSB_VEHICLE messages.

Note: When the device is used as a Standard Remote ID device, the serial number must be provided over the MAVlink Open Drone ID (OPEN_DRONE_ID_SELF_ID) message.

4.1.4.1 Self mode

By default, Atom UAV and Atom OEM will generate and transmit Remote ID packets containing an ANSI CTA-2063-A serial number based on the device's serial number. For ANSI CTA-2063-A compliance, the serial number begins with FLARM's manufacturer code 1710 and a length encoded as a digit or letter. Furthermore, letter Is in the are replaced with digit 1s, letter Os are replaced with digit 0s, and non-letter/digit characters are removed. For example:

Device serial number	Transmitted serial number
FLATMUAVW-004771	1710FFLATMUAVW004771

FLATMUAOW-006358	1710FFLATMUA0W006358

Depending on the country of operation, you may also need to configure an operator identifier (EU and US)

Other configuration items follow the ASTM and DIN standards, some of which are optional, depending on the region. Atom UAV implements the full stack of messages and gives users the option to set all values according to regulations.

Note: Please refer to the local civil aviation authority or legislation to ensure the requirements are fulfilled.

Note: Atom UAV requires the user to set the correct and valid entries in each configuration field.

Note: To prevent tampering with the Remote ID during flight the WiFi Access Point password can be set to a secret value, or the WiFi can be turned off.

The take-off location is determined as the first available fix. It is therefore recommended to only power up the Atom UAV at the takeoff location.

4.1.4.2 MAVLink Open Drone ID TX/RX component

Atom UAV can be configured to act as a MAVLink Open Drone ID TX/RX component. To enable this in in the web interface, navigate to the Remote ID page, choose "Show advanced configuration items", and set "Source of remote id data" to MAVLink. The MAVLink messages are described in the MAVLink Interface section (5.1).

4.1.4.3 Configuration advice

To use Atom UAV as a F3411-22-compliant Broadcast Module, i.e. as an Add-On module, set the following configuration:

- Set Remote ID/Enable remote id to "Enabled".
- Set Remote ID country to either EU or US.
- Set Remote ID/Identifier type to "Serial Number".
- Set Remote ID/format to either NAN or Beacon.

To use Atom UAV as a F3411-22 Standard Remote ID device, i.e. as a part of the UAV, connect it to the drone's autopilot with the JST connector and set the following configuration:

- Set FLARM/Data Port/Protocol on the "JST" port to "MAVLink".
- Set Remote ID/Enable remote id to "Enabled".

- Set Remote ID/Identifier type to your identifier type, either a CAA registration ID, a UTM assigned UUID, or a Session ID.
- Set Remote ID/format to either NAN or Beacon.
- Set MAVLink/GNSS source to MAVLink.

For maximum Remote ID range, Atom UAV should be attached to the airframe with a clear view of the ground and away from large metal components. Atom UAV OEM requires an external WiFi antenna which will further increase Remote ID range. Please see Section 8 for recommended accessories.

4.1.4.4 Operator ID Validation

The Hub Web interface is in compliance with EN 4709-002 regarding the Operator ID (or Operator Registration Number):

The value to be entered in the text box is of the form

`FIN87astrdge12k8-xyz`

Where `FIN87astrdge12k8` is the UAS operator registration number (including the checksum as the last alphanumeric character). A private part `xyz` is used to validate the Operator ID but is not stored.

To clear the Operator ID, an empty field is also accepted.

4.1.5 MAVLink

On FLARM Hub, a separate configuration page is available for all functions related to the MAVLink integration. Atom UAV supports using an external GNSS solution provided through the MAVLink interface. For more details on the setup and requirements on the host, please refer to Section 5.1.

The ports status block on the configuration page shows which port has been configured through MAVLink, and if Atom UAV receives a heartbeat message ("Connected" is true). For reference, the System and Component IDs are shown. Furthermore, a packet counter allows to quickly diagnose the MAVLink data link.

For the configuration of a systematic offset between the GNSS source (e.g., PX4) and the Atom UAV, a configuration item is available. The procedure is described in Section 5.1.2.2. The "Timepulse offset valid" flag shows if both Atom UAV and host (e.g., PX4) have a valid fix and time reference, and the "Measured timepulse offset" shows the difference in the time pulse in milliseconds.

The Atom UAV can be configured and monitored through the MAVLink interface. Configuration variables can be read and set using MAVLink's Parameter Protocol

(for integer values) and Extended Parameter Protocol (for string values). For more information, see sections 5.1.2 and 5.1.3.

4.1.6 Flight State Detection

The UAV's flight state is included as a flag in both Remote ID and FLARM transmissions. Certain functions, such as maintenance, are only permitted when the device is in the ground state. For FLARM, other aircraft only generate collision warnings if the Atom UAV reports itself as flying.

By default, the Atom UAV switches to flight state if any of the following conditions are met:

- GPS horizontal position changes by more than 10 m,
- GPS altitude increases by more than 15 m or decreases by more than 30 m, or
- barometric altitude changes by more than 5.5m within the last 60 seconds.

Without a valid GPS fix, Atom UAV remains in ground state.

To allow the system to establish a stable reference ("initial position"), this reference is continuously updated for at least 10 seconds, up to a maximum of 60 seconds after the first GPS fix—or until a significant barometric altitude change is detected, whichever occurs first.

If the Atom UAV is connected via MAVLink, the system status field in the MAVLink heartbeat overrides the internal detection logic. The status is mapped to the flight state as follows:

System Status (MAV_STATE)	Flight State
MAV_STATE_UNINIT	Ground
MAV_STATE_BOOT	Ground
MAV_STATE_CALIBRATING	Ground
MAV_STATE_STANDBY	Ground
MAV_STATE_ACTIVE	Flight
MAV_STATE_CRITICAL	Flight
MAV_STATE_EMERGENCY	Flight (Emergency)
MAV_STATE_POWEROFF	Ground
MAV_STATE_FLIGHT_TERMINATION	Flight (Emergency)

If the flight state is Flight (Emergency), this emergency status is also transmitted via RemoteID.

4.2 Firmware Updates

The Atom UAV is equipped with two microcontrollers and thus needs two firmware files to operate. The Atom chip firmware running the FLARM protocol has an expiration date and needs to be updated annually.

The update process is as follows. On the navigation bar of the page, go to "Maintenance", "Firmware Update". To update the Atom with a new Atom Firmware, a `.fw` file is needed. To update FLARM Hub, a `.bin` file is needed.

4.3 Traffic Monitor

The traffic monitor displays traffic received by Atom UAV, using symbology like TCAS. It does not issue collision warnings. Targets for all received types of signals are shown.

The traffic monitor can be used e.g., to troubleshoot connectivity and configuration issues. It should not be used for collision avoidance purposes. When on the ground, aircraft with elevated privacy settings (Stealth or No Track mode enabled, Random ID selected) will not be shown.

When using the traffic monitor, note the zoom level and vertical axis reference (North Up or Track Up).

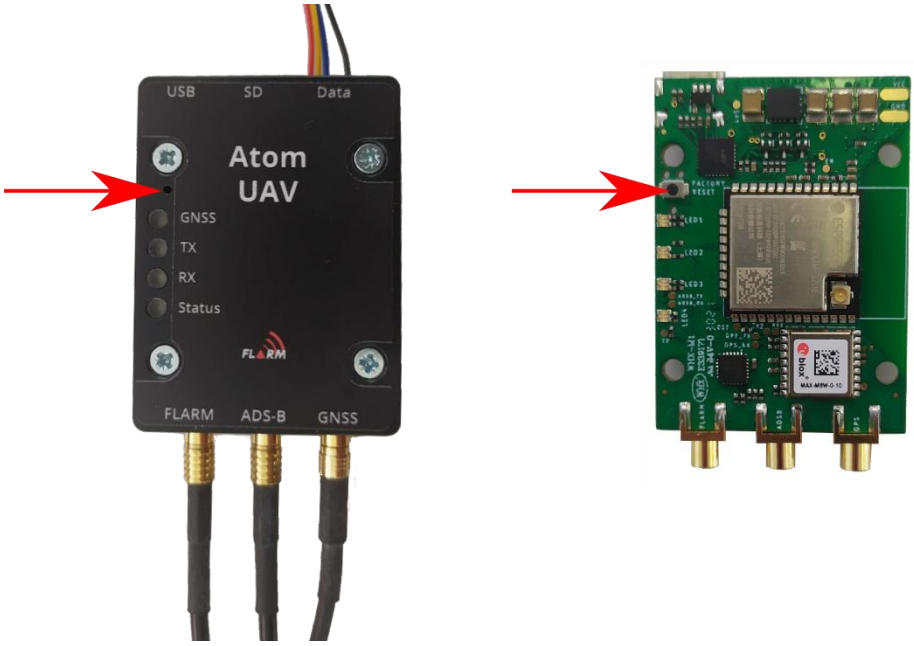
4.4 Support Package Download

FLARM Hub can create a zip file containing configuration and debug data. The button to create the zip file can be found on the Tools / Support page. The zip file is saved on the connected computer or mobile device.

Note: The package creation and download take approximately 10 minutes to complete, during which the device will be inoperable.

4.5 Factory Reset

A factory reset can be triggered by holding the button pressed while powering up the device (hold for at least 1s).



The following items are reverted to factory default settings:

- FLARM configuration
- FLARM Hub configuration
- Wi-Fi SSID and password
- Bluetooth name

The firmware versions (Atom and Hub) do not change.

5 Interfaces

The Atom UAV can provide traffic information on both the USB connector and JST/TFM connector and provides different protocols. Furthermore, MAVLink can be used to provide the navigation solution to Atom UAV, e.g., if a high-quality navigation source is already present on the vehicle.

5.1 MAVLink Interface

MAVLink[4] is a protocol used by many popular flight control systems for drones, e.g., PX4, ArduPilot and more. MAVLink connectivity is available on the JST GH/TFM UART connector, if enabled in the HUB firmware. The HEARTBEAT and ADSB_VEHICLE messages are published to output traffic information. The baud rate is set to 115200 (8N1).

The HEARTBEAT message contains a system status flag, which is set to MAV_STATE_STANDBY while the system is initializing and acquiring a GNSS position. Once the system is fully operational and is transmitting FLARM messages, the system status is set to MAV_STATE_ACTIVE.

The system ID is adapted from the MAVLink master (usually the autopilot).

5.1.1 Integration with PX4 and ArduPilot

Wire up the JST/TFM MAVLink connector to the TELEM1 (or TELEM2) port on the Pixhawk controller (RX and TX lines need to be crossed, a cable is provided in the Atom UAV standalone variant).

The status of the MAVLink connection is shown on the Atom UAV web interface in the “MAVLink” page.

Atom UAV will emit ADSB_VEHICLE messages for each received target from either FLARM, ADS-B or Remote ID.

The interface functionality has been verified on the Pixhawk 4 hardware with the PX4 (1.14.0) and ArduPilot (ArduCopter 4.3.3) firmware.

5.1.1.1 PX4 settings

For PX4, configure the following parameters with a Ground control software like QGroundControl (via Parameters-> MAVLink and Parameters-> Serial):

- MAV_1_CONFIG: TELEM 1 (or TELEM 2)
- MAV_1_FORWARD: 1

[4] https://mavlink.io/en/

- MAV_1_MODE: Custom
- SER_TEL1_BAUD (or SER_TEL2_BAUD): 115200 8N1

With "MAV_1_FORWARD: 1", Atom UAVs HEARTBEAT and ADSB_VEHICLE messages will be forwarded to the Ground Control Station and can be seen in its MAVLink Inspector with the component id 160.

The MAV mode "MAV_1_MODE: Custom" disables any predefined set of messages to be sent by the flight controller to the Atom UAV, except HEARTBEAT, which is always sent. Atom UAV will subscribe automatically to SYSTEM_TIME and GPS_RAW_INT messages.

On PX4, some settings may appear only after a reboot after enabling another MAVLink instance. Make sure to reboot the flight controller to apply the settings.

5.1.1.2 ArduPilot settings

For ArduPilot, configure these values (via Parameters-> SERIAL):

- SERIAL1_BAUD (or SERIAL2_BAUD): 115200
- SERIAL1_PROTOCOL (or SERIAL2_PROTOCOL): MAVLink2

Only HEARTBEAT messages are sent to Atom UAV by default. Atom UAV will subscribe automatically to SYSTEM_TIME and GPS_RAW_INT messages.

At the time of writing this document, ArduPilot does not forward ADSB_VEHICLE messages from Atom UAV to the Ground Control Station.

Make sure to reboot the flight controller afterwards to apply the settings.

5.1.2 External Navigation Source

Instead of using the integrated GNSS module for positioning, Atom UAV can use the navigation solution from a flight controller such as a Pixhawk 4. This can be selected through configuration.

Note: The FLARM radio protocol relies on accurate (milliseconds) timing. Inaccurate timing will gradually lead to a loss of connectivity with other FLARM systems. Configurations using the external navigation source must be thoroughly validated against a stock Atom UAV, or any other reference unit.

5.1.2.1 Setup

When MAVLink is selected as a GNSS source (see Section 4.1.5), Atom UAV consumes the GPS_RAW_INT and SYSTEM_TIME messages and issues the TIMESYNC message for time synchronization. Because the FLARM RF protocol is

time-sensitive, the MAVLink time base needs to be accurate. To reduce jitter, a MAVLink mode such as Custom should be used that emits as few as possible messages. It is crucial that the system time of the flight controller system is sufficiently accurate and aligned with the GPS time. If the time drifts more than ~10 ms, the receive/transmit timing of the FLARM system might go into a state where it is not visible to other vehicles and does not receive traffic information from surrounding aircraft.

5.1.2.2 Timepulse offset

A static time offset is configurable to compensate for systematic latency. To configure the timepulse offset, a GNSS antenna must be connected to the Atom UAV and a position fix must be acquired on both Atom UAV and the flight controller. When a position and time fix is available from both Atom UAV and the flight controller, Atom UAV automatically and continuously measures the time offset. This shown and continuously updated in the web interface in the "MAVLink" page (see Section 4.1.5).

Once a consistent time pulse offset is observed, this must be set in the MAVLink configuration page.

The measured offset is also available over the MAVLink Parameter Protocol, see Section 5.1.4.3.

Note: Versions of ArduPilot (≤4.1.0) and PX4-Autopilot (≤1.15.0) at the time of writing of this document have a limitation that the system time only re-synchronizes to the GNSS time when the drift is larger than 5s. This is not sufficient for long-time operation of the Atom UAV. The drift has been measured at ~0.5 ms/min. For short missions in the order of 20 min this is not an issue. For longer missions it is suggested to improve the time synchronization of the flight controller or use a dedicated GPS antenna.

5.1.3 Compatible Ground Control Software

The surrounding traffic can be displayed on the ground control software. In the figure below, an example is shown for QGroundControl v4.1.1. The red arrow indicates the own vehicle position, and the blue arrow shows the target and trajectory of a target received through Atom UAV:

Other ground control software may offer support, too.

5.1.4 Configuration

The Atom UAV can be configured via MAVLink using MAVLink's Parameter Protocol and Extended Parameter Protocol. Numerical parameters are set with the Parameter Protocol, and string parameters with the Extended Parameter Protocol

There are three categories of parameters: FLARM parameters for the FLARM core functionality, Hub parameters the Remote-ID and interface settings, and time synchronization status.

5.1.4.1 FLARM Parameters

For a detailed description, please refer to FTD-014 FLARM Configuration Specification. MAVLink Parameter IDs are limited to 16 characters, so in some cases the MAVLink Parameter ID is an abbreviation of the FLARM configuration item.

The following FLARM parameters are supported using the Parameter Protocol:

MAVLink Parameter ID	Type	FLARM configuration item if different
ADSBRANGE	MAVLINK_TYPE_INT32_T	
ADSBVRANGE	MAVLINK_TYPE_INT32_T	
RANGE	MAVLINK_TYPE_INT32_T	
RDIODVRSTYREF	MAVLINK_TYPE_INT32_T	RADIODIVERSITYREFERENCE
RDIODVRSTYROLE	MAVLINK_TYPE_INT32_T	RADIODIVERSITYROLE
REBCASTSERVICES	MAVLINK_TYPE_INT32_T	REBROADCASTSERVICES
VRANGE	MAVLINK_TYPE_INT32_T	

The following FLARM parameters are supported using the Extended Parameter Protocol:

MAVLink Parameter ID	Type	Notes
BUILD	MAVLINK_PARAM_EXT_TYPE_CUSTOM	Read only
DEVICEID	MAVLINK_PARAM_EXT_TYPE_CUSTOM	Read only
SER	MAVLINK_PARAM_EXT_TYPE_CUSTOM	Read only
SWEXP	MAVLINK_PARAM_EXT_TYPE_CUSTOM	Read only
SWVER	MAVLINK_PARAM_EXT_TYPE_CUSTOM	Read only

5.1.4.2 Hub Parameters

The following Hub parameters are supported using the Parameter Protocol:

MAVLINK Parameter ID	Type	Minimum	Default	Maximum	Units
GNSS_SOURCE	INT32_T	0 (internal)	0 (internal)	1 (external)	
LED_BRIGHTNESS	INT32_T	0	100	100	%
RID_ENABLED	INT32_T	0 (disabled)	1 (NAN)	3 (French Beacon)	
RID_COUNTRY	INT32_T	0 (none)	0 (none)	2 (US)	
RID_FORMAT	INT32_T	0 (NAN)	0 (NAN)	2 (FR)	
RID_SOURCE	INT32_T	0 (self)	0 (self)	1 (MAVLink)	
TP_OFFSET	INT32_T	0	90	1000	ms
UART1_BAUD	INT32_T	0	115200	10000000	baud
UART1_PROTOCOL	INT32_T	0 (none)	1 (MAVLink)	2 (JSON)	
UART2_BAUD	INT32_T	0	115200	230400	baud
UART2_PROTOCOL	INT32_T	0 (none)	0 (none)	2 (JSON)	
WIRELESS	INT32_T	0	253 (always on)	255	minutes

Please note that in the table above, MAVLINK_TYPE_INT32_T is shortened to INT32_T.

GNSS_SOURCE sets the source of GNSS navigation data. Valid values are:

Value	GNSS source (GNSS_SOURCE)
0	Internal
1	External

For more information, see section 5.1.2.

LED_BRIGHTNESS sets the brightness of the four indicator LEDs during operation as a percentage of maximum brightness (values between 0 and 100). The LEDs are always set to maximum brightness during startup and when an error is detected.

RID_ENABLED sets whether Remote ID is enabled. Valid values are:

Value	Remote ID state (RID_ENABLED)
0	Disabled
1	Enabled

RID_COUNTRY sets the country for configuration validation:

Value	Country (RID_COUNTRY)

0	No validation
1	ASD-STAN EN 4709-002 (Europe)
2	ASTM F3411-22 (USA)

RID_FORMAT sets the format of the Remote ID packets:

Value	Format (RID_FORMAT)
0	NAN
1	Beacon Frames
2	French Beacon Frames

RID_SOURCE sets the source to compose the Remote ID data, see Section 4.1.4 for more details:

Value	Source (RID_SOURCE)
0	Self
1	Open Drone ID MAVlink messages

TP_OFFSET sets the timepulse offset in milliseconds when GNSS_SOURCE is 1. For more information, see section 5.1.2.2.

UART1_BAUD and UART2 set the baud rates of the corresponding UART, where the JST interface is UART1 and the USB interface is UART2.

UART1_PROTOCOL and UART2_PROTOCOL set the protocol for the corresponding UART. For more information, see section 5.

WIRELESS sets the wireless connectivity. Valid values are:

Value	Effect
0	No connectivity
1-252	Switch off after 1-252 minutes
253	Always on
254	Cut on GPS fix
255	Switch off in flight

The following Hub parameters are supported using the Extended Parameter Protocol:

MAVLink Parameter ID	Type
RID_SSID	MAVLINK_PARAM_EXT_TYPE_CUSTOM
RID_OPERATOR_ID	MAVLINK_PARAM_EXT_TYPE_CUSTOM
WIFI_AP_KEY	MAVLINK_PARAM_EXT_TYPE_CUSTOM
WIFI_AP_SSID	MAVLINK_PARAM_EXT_TYPE_CUSTOM
HUBVER	MAVLINK_PARAM_EXT_TYPE_CUSTOM

RID_SSID sets the SSID when the Remote ID is configured to transmit WiFi Beacon Frames. WIFI_AP_{SSID,KEY} set the SSID and key for the WiFi Access Point.

RID_OPERATOR_ID is the Operator ID, which must be of form `FIN87astrdge12k8-xyz`. The whole string is validated and stored in form `FIN87astrdge12k8` when the validation passes.

HUBVER is a read-only parameter, providing the version of the Hub firmware, e.g. "1.81".

5.1.4.3 Time Synchronization Status

These read-only parameters related to the time synchronization status are supported using the Parameter Protocol:

MAVLink Parameter ID	Type	Description
M_TP_OFFSET	MAVLINK_TYPE_INT32_T	Measured time pulse offset in milliseconds between internal GNSS receiver and time pulse from flight controller.
M_TP_OFFSET_VALI	MAVLINK_TYPE_INT32_T	Flag to indicate that measured time pulse offset is valid (1 if true, 0 otherwise)
M_TP_UTC_MAVLINK	MAVLINK_TYPE_INT32_T	UTC time in seconds as received from the flight controller.
M_TP_UTC_INTERNL	MAVLINK_TYPE_INT32_T	UTC time in seconds of Atom UAV internal clock.
M_TP_TIMEOUT	MAVLINK_TYPE_UINT32_T	Uptime in microseconds when the time synchronization is considered timed out. Updates multiple times per second.
M_TP_INTERVL	MAVLINK_TYPE_UINT32_T	Measured round trip time between this and last time synchronization received from flight controller.

A condensed set of these parameters are also available in the Hub Web interface on the MAVlink page.

5.1.5 Remote ID Open Drone ID TX/RX mode

When the source of Remote ID data is configured to be MAVLink, Atom UAV acts as Open Drone ID TX/RX module. The contents of the Remote ID packets are taken directly from the contents of the MAVLink OPEN_DRONE_ID_* messages. This gives the operator full control over the contents of the packets.

Atom UAV transmits Open Drone ID packets at a rate of 2Hz. If no new OPEN_DRONE_ID_* message is received, then Atom UAV will retransmit packets with the contents of the last message. There is no timeout on the message content.

MAVLink messages are partially supported. Notable deviations from the Open Drone ID / MAVLink specification are:

- There are two slots for OPEN_DRONE_ID_BASIC_ID messages, and both are transmitted. Sending OPEN_DRONE_ID_BASIC_ID messages will alternatively overwrite the first and second slots. Typically, one is used for the serial number and the other is mission or operator specific.
- OPEN_DRONE_ID_AUTHENTICATION messages are ignored. Authentication is not supported.
- OPEN_DRONE_ID_MESSAGE_PACK messages are ignored. Message Packs are not supported.
- OPEN_DRONE_ID_ARM_STATUS messages are sent once per second. Atom UAV will report the status MAV_ODID_ARM_STATUS_GOOD_TO_ARM once it has a 3D GPS fix, Remote ID is enabled, and the configuration is good for the country of operation.

In summary:

Message	Notes
OPEN_DRONE_ID_AUTHENTICATION	Ignored
OPEN_DRONE_ID_BASIC_ID	Supported
OPEN_DRONE_ID_LOCATION	Supported
OPEN_DRONE_ID_SELF_ID	Supported
OPEN_DRONE_ID_SYSTEM	Supported
OPEN_DRONE_ID_OPERATOR_ID	Supported
OPEN_DRONE_ID_MESSAGE_PACK	Ignored
OPEN_DRONE_ID_ARM_STATUS	Supported
OPEN_DRONE_ID_SYSTEM_UPDATE	Supported

5.2 JSON Interface

A JSON message stream is available on the JST port or USB port. A detailed interface description can be found in document FTD-092.The protocol sends out unsolicited heartbeat and traffic information.

Example stream:

```
{“heartbeat”:{“protocol”:{“version”:1},”system”:{“id”:”FLAFUS10W-000051”}}}\r\n
```

{“navigation”:{“pos”:{“lat”:47.18686,”lon”:8.477258,”alt”:482,”baro”:352},”mov”:{“speed”:0.01,”gnd”:true},”time”:1622118506}}\r\n

{“traffic”:{“id”:{“flarm”:14622722},”src”:{“flarm”:{}},”type”:1,”pos”:{“lat”:47.1868486,”lon”:8.4772844,”alt”:488},”mov”:{“gnd”:true,”climb”:-0.1},”time”:1622118506}}\r\n

{“traffic”:{“id”:{“flarm”:14622761},”src”:{“flarm”:{}},”type”:1,”pos”:{“lat”:47.1867496,”lon”:8.4766621,”alt”:497},”mov”:{“gnd”:true,”climb”:-0.1},”time”:1622118506}}\r\n

6 Mandatory Firmware Update

To allow global and synchronized changes to the FLARM ecosystem, every FLARM device should be updated with the latest firmware version at least once per year (every 12 calendar months) as part of the annual maintenance.

Since firmware release 7.40, there is no more fixed expiration date. It is nevertheless recommended to regularly update the device.

To stay up to date with additional unscheduled updates and other important information, sign up to the newsletter from the FLARM website to ensure that important communication is not missed:

https://flarm.com/blog/

Alternatively, periodically check the firmware update page:

https://flarm.com/support/firmware-updates/

7 Packing List

There are two Atom UAV versions: standalone and OEM. The standalone variant is complete with a plastic enclosure and comes with all the antennas and cables required to use the product right away. The OEM variant is only shipped with a fully tested and certified board that can be integrated into a flight system.

7.1 Atom UAV

- Atom UAV device
- 2x FLARM/ADS-B antenna
- 1x GNSS antenna
- 1x JST cable ready to use with Pixhawk/PX4-compatible flight controllers
- 1x USB-C cable

7.2 Atom UAV OEM

- Atom UAV OEM module, in antistatic bag

8 Recommended Accessories

The following components are recommended for system integration:

- FLARM/ADS-B antenna: JIAXING BEYONDOOR ELECTORNICS CO., LTD BY-868-915-PCB(62X15) with MCX connector (2x)
- GNSS antenna: u-blox ANN-MS with MCX connector
- Wi-Fi antenna: Inventek W24P-U with U.FL connector

For the FLARM antennas, other models can also be used. Important parameters are:

- Frequency: 868-869 MHz (EU), 902-928 MHz (USA), 868-928 MHz (all regions).
- Gain: 1 dBi max
- Polarization: linear (vertical)

9 Troubleshooting and Servicing Information

Many problems and issues can be related to one of the following causes:

- Improper antennas or antenna cables used
- Incorrect antenna or antenna cable installation
- Incorrect configuration
- Aging or breaking of components under normal or abnormal wear (device, cables, antennas, connectors, connector pins)
- No valid GNSS position (e.g., aircraft is inside)

Configure the system using FLARM Hub (see Section 4.1).

If an error is indicated, a list of error codes can be found in Appendix A. Many issues can also be resolved by consulting the FAQ:

https://support.flarm.com/

For support requests it is recommended to create a support package according to Section 4.4.

Atom UAV may only be repaired by FLARM Technology Ltd or its authorized service partners.

10 Warranty Information and Terms of Use

Any warranty is immediately void should the device be opened, misused, or installed incorrectly. EULA including Terms of Use is applicable. The latest version available when this manual was published can be found in Appendix B.

11 Release Notes

11.1 FLARM Hub

11.1.1 Version 1.82 (26682fc6)

Published 03.02.2026

- Maintenance Release.

11.1.2 Version 1.81 (04c6ace5)

Published 07.11.2025

- Fixed an issue that caused a 1.5–2.5 second interruption in RemoteID signal transmission every 62.5 seconds.
- Improved flight detection accuracy, with better resilience to long-term barometric altitude drift.
- Added reporting of FLARM firmware version (SWVER) and Hub firmware version (HUBVER) to the MAVLink parameter protocol.

11.1.3 Version 1.66 (503aa725)

Published 11.07.2025

- Added transmit status to MAVlink heartbeat message.
- Improved wording in Hub Remote ID settings.
- Added input validation on Remote ID Operator ID for EN 4709-002 compliance.
- Fixed MAVlink PARAM_SET parameter names
- Fixed wrong ICAO manufacturer ID transmitted over Remote ID since version 1.65
- Fixed MAVlink Open Drone ID ARM status.
- Fixed connectivity issues with MAVlink introduced in Hub 1.65
- Made LED behavior consistent with Hub

11.1.4 Version 1.65 (1c07b3db)

Published 13.09.2024

- Atom UAV can now act as a MAVLink Open Drone ID TX/RX component.
- Added Remote ID configuration validation for EU and US.
- Increased Remote ID packet transmission rate from 1Hz to 2Hz.
- Measured time pulse offset is now available over MAVLink.

11.1.5 Version 1.62 (50be234e)

Published 06.02.2024

- Remove force flight state injection via MAVlink and JSON
- Improve UAV take off detection, use MAVlink arm state when possible
- Stop sending Remote ID without GPS fix
- MAV_STATUS_FLIGHT_TERMINATION treated as Remote ID emergency
- Fix support package creation

11.1.6 Version 1.61 (93cd15c)

Published 28.11.2023

- Improve UAV take off detection
- Set Remote ID status from MAVLink HEARTBEAT messages
- Emit Remote ID arm status over MAVLink
- Maintain Remote ID when WiFi Access Point is disabled

11.1.7 Version 1.60 (498800f)

Published 15.09.2023

- Added configuration over MAVLink
- Added WiFi Beacon Frame Remote ID
- Added French WiFi Beacon Frame Remote ID
- Added configurable LED brightness

11.1.8 Version 1.44 (a01b52a)

Published 15.02.2023

- Automatically subscribe to all necessary MAVLink messages (SYSTEM_TIME and GPS_RAW_INT).

11.1.9 Version 1.43 (1a3fcb5)

Published 11.10.2022

- Fix support package creation

11.1.10 Version 1.42 (d3acfd3)

Published 14.07.2022

- Fixed ‘MAVLink’ settings page not being shown
- Enabled NoTrack settings for FLARM
- Remote ID enabled by default

- When creating support package, adding flash content is a configurable option (can take a long time)
- Improved JSON output by using fixed precision for floating point numbers
- Improved Wi-Fi performance by avoiding overlapping channels
- Improved color balance of amber LEDs

11.1.11 Version 1.41 (eafefff0)

Published 18.01.2022

- Fixed invalid JSON in traffic message

11.1.12 Version 1.40 (41bed2cf)

Published 30.11.2021

- Matched Hub Status page LEDs with the device LEDs
- Improved and aligned branding for Atom UAV
- Corrected symbology for ground traffic in Traffic Monitor

11.1.13 Version 1.34 (66ebbfe4)

Published 01.10.2021

- Added Remote ID functionality
- Added configuration for GNSS source
- Enabled data output on USB port
- Added MAVLink configuration and status page
- Cleaned up UI and added Atom UAV branding

11.1.14 Version 1.32 (804f5880)

Published 16.09.2021

- Added Radio Diversity feature

11.2 FLARM Atom

11.2.1 Version 7.43 (cf1d2dd40)

Published 06.02.2026

- Improved 1090 receiver module robustness by automatically recovering from intermittent communication issues

11.2.2 Version 7.40 (ac94bd680)

Published 28.04.2025

- Disable firmware expiration (reported expiration date is January 1st, 2099)
- Add resilience in handling of radio address collisions

11.2.3 Version 7.24 (ab6c756fe), expires 01/03/2026

Published 30.04.2024

- Maintenance release

11.2.4 Version 7.22 (6076cde9d), expires 01/03/2025

Published 28.11.2023

- Activate SBAS for compliance with RemoteID Standard

11.2.5 Version 7.21 (050d97247), expires 01/11/2024

Published 12.05.2023

- Maintenance release

11.2.6 Version 7.09 (0066993ec), expires 01/03/2024

Published 14.11.2022

- Maintenance release

11.2.7 Version 7.08 (716185bc9), expires 01/02/2024

Published 01.09.2022

- Maintenance release

11.2.8 Version 7.07 (fb2bfe817), expires 01/12/2023

Published 11.05.2022

- Maintenance release

11.2.9 Version 7.06 (b6811a5b6), expires 01/10/2023

Published 26.01.2022

- Maintenance release

11.2.10 Version 7.05 (421df442f), expires 01/05/2023

Published 06.10.2021

- Added GNSS source selection for Atom

12 Conformity Declarations

12.1 Atom UAV (FLATMUAVW)

12.1.1 CE Declaration of Conformity

Declaration of Conformity

Manufacturer:
Flarm Technology Ltd.
Hinterbergstrasse 15
6330 Cham, Zug
Switzerland

Flarm Technology Ltd. declares under our sole responsibility that:

Product Name: Atom UAV
Product Model(s): FLATMUAVW

Complies with the following European Directives:
2014/30/EU Electromagnetic Compatibility (EMC)
2014/53/EU Radio Equipment Directive (RED)
2014/45/EU Low Voltage (LVD)
2015/863/EU on the Restriction of Hazardous Substance (RoHS3)

Conforms to the Following Standards:
EN 301 489-1 V2.2.3/ EN 301 489-3 V2.1.1/ EN 301 489-17 V3.2.4/EN 301 489-19 V2.1.1 (EMC & IMMUNITY)
EN 300 220-1 V3.1.1/ EN 300 220-2 V3.1.1 (RF)
EN 62368-1:2014+A11:2017 (LVD)
EN 50663:2017/ En 62311:2020 (RF EXPOSURE)
EN 63000:2018 (RoHS)

The technical documentation required to demonstrate that the products meet the requirements of the aforementioned directives has been compiled and is available for inspection by the relevant enforcement authorities.

Signed: Urban Mäder

Title: CEO

Date: 19.01.2022

FLARM Technology Ltd.
Hinterbergstrasse 15
CH-6330 Cham
www.flarm.com
VAT CHE-112.876.620

12.1.2 FCC Compliance Statement

FCC ID: 2AXJM-FLATMUAVW

Contains FCC ID: 2AC7Z-ESP32WROOM32E

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

(1) this device may not cause harmful interference, and
(2) this device must accept any interference received, including interference that may cause undesired operation.

CAUTION: The manufacturer is not responsible for any changes or modifications not expressly approved by the party responsible for compliance. Such modifications could void the user's authority to operate the equipment.

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy, and if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

RF exposure statement

This equipment complies with the FCC RF radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with a minimum distance of 20cm between the radiator and any part of your body.

Professional Installation Statement

This equipment is intended for professional installation only.

12.1.3 ISED Compliance Statement

IC: 10154A-FLATMUAVW

Contains IC: 21098-ESPWROOM32E

This device contains license-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada license-exempt RSS(s). Operation is subject to the following two conditions:

(1) This device may not cause interference.
(2) This device must accept any interference, including interference that may cause undesired operation of the device.

L'émetteur/récepteur exempt de licence contenu dans le present appareil est conforme aux CNR d'Innovation, Sciences et Développement économique Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes:

(1) L'appareil ne doit pas produire de brouillage;
(2) L'appareil doit accepter tout brouillage radio électrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

RF exposure statement

This equipment meets the exemption from the routine evaluation limits in section 2.5 of RSS-102. It should be installed and operated with a minimum distance of 20cm between the radiator and any part of your body.

Cet équipement est conforme à l'exemption des limites d'évaluation habituelle de la section 2.5 de la norme RSS-102. Il doit être installé et utilisé à une distance minimale de 20 cm entre le radiateur et toute partie de votre corps.

12.1.4 Supplier's Declaration of Conformity

47 CFR § 2.1077 Compliance Information

Product Name: Atom UAV
Product Model: FLATMUAVW
Manufacturer:
Flarm Technology AG
Industriestrasse 49
6300 Zug, Zug, Switzerland
info@flarm.com
www.flarm.com

Modular Components Used:

NAME: Wi-Fi & Bluetooth Internet of Things Module
MODEL: ESP32-WROOM-32E
FCC ID:2AC7Z-ESP32WROOM32E

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:

(1) This device may not cause harmful interference, and
(2) this device must accept any interference received, including interference that may cause undesired operation.

12.2 Atom UAV OEM (FLATMUAOW)

12.2.1 CE Declaration of Compliance

Declaration of Conformity

Manufacturer:
Flarm Technology Ltd.
Hinterbergstrasse 15
6330 Cham, Zug
Switzerland

Flarm Technology Ltd. declares under our sole responsibility that:

Product Name: Atom UAV OEM
Product Model(s): FLATMUAOW

Complies with the following European Directives:
2014/30/EU Electromagnetic Compatibility (EMC)
2014/53/EU Radio Equipment Directive (RED)
2014/45/EU Low Voltage (LVD)
2015/863/EU on the Restriction of Hazardous Substance (RoHS3)

Conforms to the Following Standards:
EN 301 489-1 V2.2.3/ EN 301 489-3 V2.1.1/ EN 301 489-17 V3.2.4/EN 301 489-19 V2.1.1 (EMC & IMMUNITY)
EN 300 220-1 V3.1.1/ EN 300 220-2 V3.1.1 (RF)
EN 62368-1:2014+A11:2017 (LVD)
EN 50665:2017/ En 62311:2020 (RF EXPOSURE)
EN 63000:2018 (RoHS)

The technical documentation required to demonstrate that the products meet the requirements of the aforementioned directives has been compiled and is available for inspection by the relevant enforcement authorities.

Signed: Urban Mäder

Title: CEO

Date: 19.01.2022

FLARM Technology Ltd.
Hinterbergstrasse 15
CH-6330 Cham
www.flarm.com
VAT CHE-112.876.620

12.2.2 FCC Compliance Statement

FCC ID: 2AXJM-FLATMUAOW

Contains FCC ID: 2AC7Z-ESPWROOM32UE

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

(1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

CAUTION: The grantee is not responsible for any changes or modifications not expressly approved by the party responsible for compliance. Such modifications could void the user's authority to operate the equipment.

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy, and if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

RF exposure statement

This equipment complies with the FCC RF radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with a minimum distance of 20cm between the radiator and any part of your body.

Professional Installation Statement

This equipment is intended for professional installation only.

12.2.3 ISED Compliance Statement

IC: 10154A-FLATMUAOW

Contains IC: 21098-ESPWROOMUE

This device contains license-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada license-exempt RSS(s). Operation is subject to the following two conditions:

(3) This device may not cause interference.
(4) This device must accept any interference, including interference that may cause undesired operation of the device.

L'émetteur/récepteur exempt de licence contenu dans le present appareil est conforme aux CNR d'Innovation, Sciences et Développement économique Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes:

(3) L'appareil ne doit pas produire de brouillage;
(4) L'appareil doit accepter tout brouillage radio électrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

RF exposure statement

This equipment meets the exemption from the routine evaluation limits in section 2.5 of RSS-102. It should be installed and operated with a minimum distance of 20cm between the radiator and any part of your body.

Cet équipement est conforme à l'exemption des limites d'évaluation habituelle de la section 2.5 de la norme RSS-102. Il doit être installé et utilisé à une distance minimale de 20 cm entre le radiateur et toute partie de votre corps.

12.2.4 Supplier's Declaration of Conformity

47 CFR § 2.1077 Compliance Information

Product Name: Atom UAV OEM
Product Model: FLATMUAOW
Manufacturer:
Flarm Technology AG
Industriestrasse 49
6300 , Zug, Switzerland
info@flarm.com
www.flarm.com

Modular Components Used:

NAME: Wi-Fi & Bluetooth Internet of Things Module
MODEL: ESP32-WROOM-32UE
FCC ID: 2AC7Z-ESP32WROOM32UE

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:

(1) This device may not cause harmful interference, and
(2) this device must accept any interference received, including interference that may cause undesired operation.

Atom UAV OEM in ESD bag with label

12.3 Atom UAV MMCX (FLATMUACW)

12.3.1 FCC Compliance Statement

FCC ID: 2AXJM-FLATMUACW

Contains FCC ID: 2AC7Z-ESPWROOM32UE

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

(1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

CAUTION: The grantee is not responsible for any changes or modifications not expressly approved by the party responsible for compliance. Such modifications could void the user's authority to operate the equipment.

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy, and if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

RF exposure statement

This equipment complies with the FCC RF radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with a minimum distance of 20cm between the radiator and any part of your body.

Professional Installation Statement

This equipment is intended for professional installation only.

12.3.2 Supplier's Declaration of Conformity

47 CFR § 2.1077 Compliance Information

Product Name: Atom UAV MMCX
Product Model: FLATMUACW
Manufacturer:
Flarm Technology AG
Industriestrasse 49
6300 , Zug, Switzerland
info@flarm.com
www.flarm.com

Modular Components Used:

NAME: Wi-Fi & Bluetooth Internet of Things Module
MODEL: ESP32-WROOM-32UE
FCC ID: 2AC7Z-ESP32WROOM32UE

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:

(3) This device may not cause harmful interference, and
(4) this device must accept any interference received, including interference that may cause undesired operation.

Atom UAV MMCX in ESD bag with label

12.4 Remote ID Declaration of Conformity (all models)

Declaration of Conformity

Manufacturer:
FLARM Technology AG
Industriestrasse 49
6300 Zug
Switzerland

FLARM Technology AG declares under our sole responsibility that:

Product Names: Atom UAV, Aurora
Product Models: FLATMUAVW, FLATMUAOS, FLATMUACW, FLATMUAWW, FLATMUASW
Class: Add-On for all UAS Classes

Comply with the following European Directives:
2019/945/EU Part 6 and Part 11

Comply with the following US Directives:
FAA-2019-1100 (14 CFR Parts 1, 11, 47, 48, 89, 91, and 107)

Conform to the Following Standards:
EN 4709-002 P1 (October 2021)
ASTM F3411-19 (December 1, 2019)

FLARM Technology AG
Industriestrasse 49
CH-6300 Zug
www.flarm.com
CHE-112.876.620

Signed: Thomas Kaufmann

Title: CTO
Date: 18.8.2023
Location: Zug, Switzerland

Appendix A – List of Error Codes

The table below lists the error codes that can be indicated and their meaning. The hexadecimal value of the error code is shown. Some displays may instead indicate the decimal value and/or a text description. The possible error code range is from 0 to FFF.

Error Code (Hex)	Meaning
11	Firmware expired (requires valid GNSS information, i.e., will not be available during the first minutes after power-on)
12	Firmware update error
21	Power (e.g., voltage below minimum)
22	UI error
23	Audio error
24	ADC error
25	SD card error
26	USB error
27	LED error
28	EEPROM error
29	General hardware error
2A	Transponder receiver Mode-C/S/ADS-B unserviceable
2B	EEPROM error
2C	GPIO error
31	GNSS communication
32	Configuration of GNSS module
33	GNSS antenna
41	RF communication
42	Another FLARM device with the same Radio ID is being received. Alarms are suppressed for the relevant device.
43	Wrong ICAO 24-bit address or radio ID
51	Communication
61	Flash memory
71	Pressure sensor
81	Obstacle database (e.g., incorrect file type)
82	Obstacle database expired
91	Flight recorder
93	Engine-noise recording not possible
94	Range analyzer
100	Generic error
101	Flash File System error
110	Failure updating firmware of external display
120	Device is operated outside the designated region; the device does not work
F1	Other

Appendix B - End User License Agreement (EULA)

By purchasing or using a FLARM device or by downloading, installing, copying, accessing, or using any FLARM Technology Ltd, Cham, Switzerland (hereafter "FLARM Technology") software, firmware, license key, or data, you agree to the following terms and conditions. If you do not agree with the terms and conditions do not purchase or use the FLARM device and do not download, install, copy, access, or use the software, firmware, license key, or data. If you are accepting these terms and conditions on behalf of another person, company, or other legal entity, you represent and warrant that you have full authority to bind that person, company, or legal entity to these terms and conditions.

If you are purchasing or using a FLARM device, the terms "firmware", "license key", and "data" refer to such items installed or available in the FLARM device at time of purchase or use, as applicable.

1. **License and Limitation of use**
   - 1.1. **License**. Subject to the terms and conditions of this Agreement, FLARM Technology hereby grants to you a non-exclusive, non-transferable right to download, install, copy, access, and use the software, firmware, license key, or data in binary executable form solely for your own personal or internal business operations. You acknowledge that the software, firmware, algorithms, license key, or data and all related information are proprietary to FLARM Technology and its suppliers.
   - 1.2. **Limitation of use**. Firmware, license keys, and data may only be used as embedded in and for execution on devices manufactured by or under license from FLARM Technology. License keys and data may only be used in the specific devices, by serial number, for which they were sold or intended. Software, firmware, license keys, and data with an expiration date may not be used after the expiration date. Right to download, install, copy, access, or use software, firmware, license key, or data with an expiration date does not imply right to upgrade or extension of the license beyond the expiration date. No other licenses are granted by implication, estoppel or otherwise.
2. **Terms of use of FLARM**
   - 2.1. Every FLARM installation must be approved by licensed Part-66 certifying staff or the national equivalent. A FLARM installation requires an EASA Minor Change Approval or the national equivalent.
   - 2.2. FLARM must be installed according to the Installation Instructions and the EASA Minor Change Approval, or the national equivalent.
   - 2.3. FLARM cannot warn in all situations. In particular warnings may be incorrect, late, missing, not being issued at all, show other threats than the most dangerous or distract the pilot's attention. FLARM does not issue resolution advisories. FLARM can only warn of aircraft that are equipped with FLARM, SSR transponders (in specific FLARM devices), or of up-to-date obstacles stored in its database. The use of FLARM does not allow a change of flight tactics or pilot behavior. It is the sole responsibility of the pilot in command to decide upon the use of FLARM.
   - 2.4. FLARM may not be used for navigation, separation, or under IMC.
   - 2.5. FLARM does not work if GPS is inoperative, degraded, or unavailable for any reason.
   - 2.6. The most recent Operating Manual must be read, understood, and followed at all times.
   - 2.7. The firmware must be replaced once per year (every 12 months). The firmware must also be replaced earlier if a Service Bulletin or other information is published with such instruction. Failure to replace the firmware may render the device inoperable or incompatible with other devices, with or without warning or notice thereof.
   - 2.8. Service Bulletins are published as a Newsletter by FLARM Technology. You are required to sign up for the Newsletter on www.flarm.com to ensure that you are informed of published Service Bulletins. If you are entering into this agreement in a form where your email address is available (e.g., online shop) you may be automatically signed up for the Newsletter.
   - 2.9. After power-up, FLARM performs a self-test which must be monitored by the pilots. If a malfunction or defect is observed or suspected, FLARM must be disconnected from the aircraft by maintenance before the next flight and the device inspected and repaired, as applicable.
   - 2.10. The pilot in command is solely responsible to operate FLARM according to applicable national regulations. Regulations might include, but are not limited to, airborne usage of radio frequencies, aircraft installation, safety regulations, or regulations for sports competitions.
3. **Intellectual Property**. No part of the software, firmware, license keys, data (including obstacle databases), the FLARM radio protocol and messages, and the FLARM hardware and design may be copied, altered, reverse engineered, decompiled, or disassembled without an explicit and written approval by FLARM Technology. Software, firmware, license keys, data (including obstacle databases), the FLARM radio protocol and messages, the FLARM hardware and design, and the FLARM logos and name are protected by copyright, trademark, and patent laws.
4. **Manipulation**. It is forbidden to intentionally feed artificially generated signals to the FLARM device, its GPS antenna, or the external/internal GPS antenna connections, unless agreed with FLARM Technology in writing for limited R&D activities.
5. **FLARM Data and Privacy**
   - 5.1. FLARM devices receive, collect, store, use, send, and broadcast data to enable the system to work, improve the system, and to enable troubleshooting. This data may include, but is not limited to, configuration items, aircraft identification, own positions, and such data of other aircraft. FLARM Technology may receive, collect, store, and use this data for said or other purposes including Search and Rescue (SAR).
   - 5.2. FLARM Technology may share data with its partners for aforementioned or other purposes. FLARM Technology may in addition publicly make available data from a FLARM device (Flight Tracking). If a FLARM device has been configured to limit tracking, SAR and other services may not be available.
   - 5.3. Data sent or broadcast by FLARM devices may only be used at own risk and under the same conditions as the FLARM device itself, and is encrypted partially to ensure message integrity, system safety and provide protection for the relevant content against eavesdropping, namely by article 3 of the Budapest Convention on Cybercrime as signed and ratified by most countries respectively its national implementations. FLARM Technology is not responsible for any third-party device, software, or service receiving, collecting, storing, using, sending, broadcasting, or making publicly available data regardless of whether legally or illegally.

6. **Warranty, Limitation of Liability, and Indemnification**
   - 6.1. **Warranty**. FLARM devices, software, firmware, license keys, and data are provided on an "as is" basis without warranty of any kind — either expressed or implied — including, without limitation, any implied warranties of merchantability or fitness for a particular purpose. FLARM Technology does not warrant the performance of the device, software, firmware, license key, or data or that the device, software, firmware, license key, or data will meet your requirements or operate error free.
   - 6.2. **Limitation of Liability**. In no event shall FLARM Technology be liable to you or any party related to you for any indirect, incidental, consequential, special, exemplary, or punitive damages (including, without limitation, damages for loss of business profits, business interruption, loss of business information, loss of data or other such pecuniary loss), whether under a theory of contract, warranty, tort (including negligence), products liability, or otherwise, even if FLARM Technology has been advised of the possibility of such damages. In no event will FLARM Technology's total aggregate and cumulative liability to you for any and all claims of any kind arising hereunder exceed the amount of fees actually paid by you for the device, license keys or data giving rise to the claim in the twelve months preceding the claim. The foregoing limitations will apply even if the above stated remedy fails of its essential purpose.
   - 6.3. **Indemnification**. You will, at your own expense, indemnify and hold FLARM Technology, and all officers, directors, and employees thereof, harmless from and against any and all claims, actions, liabilities, losses, damages, judgments, grants, costs, and expenses, including reasonable attorneys' fees (collectively, "Claims"), arising out of any use of a FLARM device, software, firmware, license key, or data by you, any party related to you, or any party acting upon your authorization.
7. **General terms**
   - 7.1. **Governing Law**. This Agreement shall be governed by and construed in accordance with the internal law of Switzerland (to the exclusion of Swiss Private International Law and of international treaties, in particular the Vienna Convention on the International Sale of Goods dated April 11, 1980).
   - 7.2. **Severability**. If any term or provision of this Agreement is declared void or unenforceable in a particular situation, by any judicial or administrative authority, this declaration shall not affect the validity or enforceability of the remaining terms and provisions hereof or the validity or enforceability of the offending term or provision in any other situation. To the extent possible the provision will be interpreted and enforced to the greatest extent legally permissible in order to effectuate the original intent, and if no such interpretation or enforcement is legally permissible, shall be deemed severed from the Agreement.
   - 7.3. **No Waiver**. The failure of either party to enforce any rights granted hereunder or to take action against the other party in the event of any breach hereunder shall not be deemed a waiver by that party as to subsequent enforcement of rights or subsequent actions in the event of future breaches.
   - 7.4. **Amendments**. FLARM Technology reserves the right, in its sole discretion, to amend this Agreement from time to time by posting an updated version of the Agreement on www.flarm.com, provided that disputes arising hereunder will be resolved in accordance with the terms of the Agreement in effect at the time the dispute arose. We encourage you to review the published Agreement from time to time to make yourself aware of changes. Material changes to these terms will be effective upon the earlier of (i) your first use of the FLARM device, software, firmware, license key, or data with actual knowledge of such change, or (ii) 30 days from publishing the amended Agreement on www.flarm.com. If there is a conflict between this Agreement and the most current version of this Agreement, posted at www.flarm.com, the most current version will prevail. Your use of the FLARM device, software, firmware, license key, or data after the amended Agreement becomes effective constitutes your acceptance of the amended Agreement. If you do not accept amendments made to this Agreement, then it is your responsibility to stop using the FLARM device, software, firmware, license key, and data.
   - 7.5. **Governing Language**. Any translation of this Agreement is done for local requirements and in the event of a dispute between the English and any non-English versions, the English version of this Agreement shall govern.