

Hardware

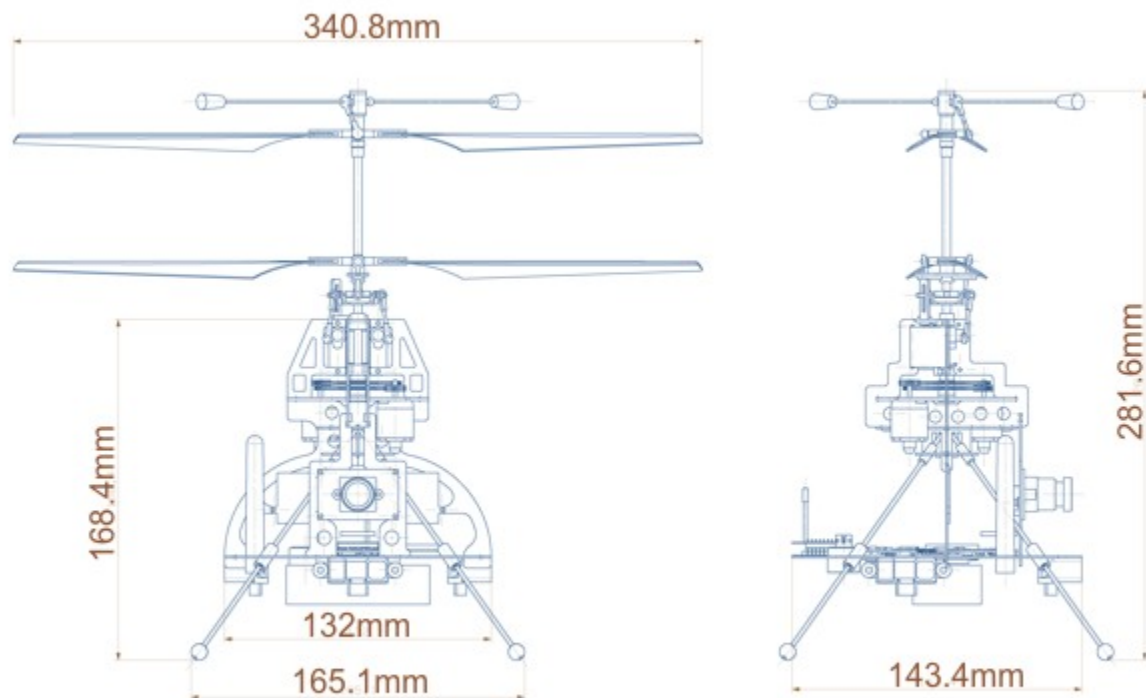
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General Specifications

The CoaX® helicopter has the following general specifications:

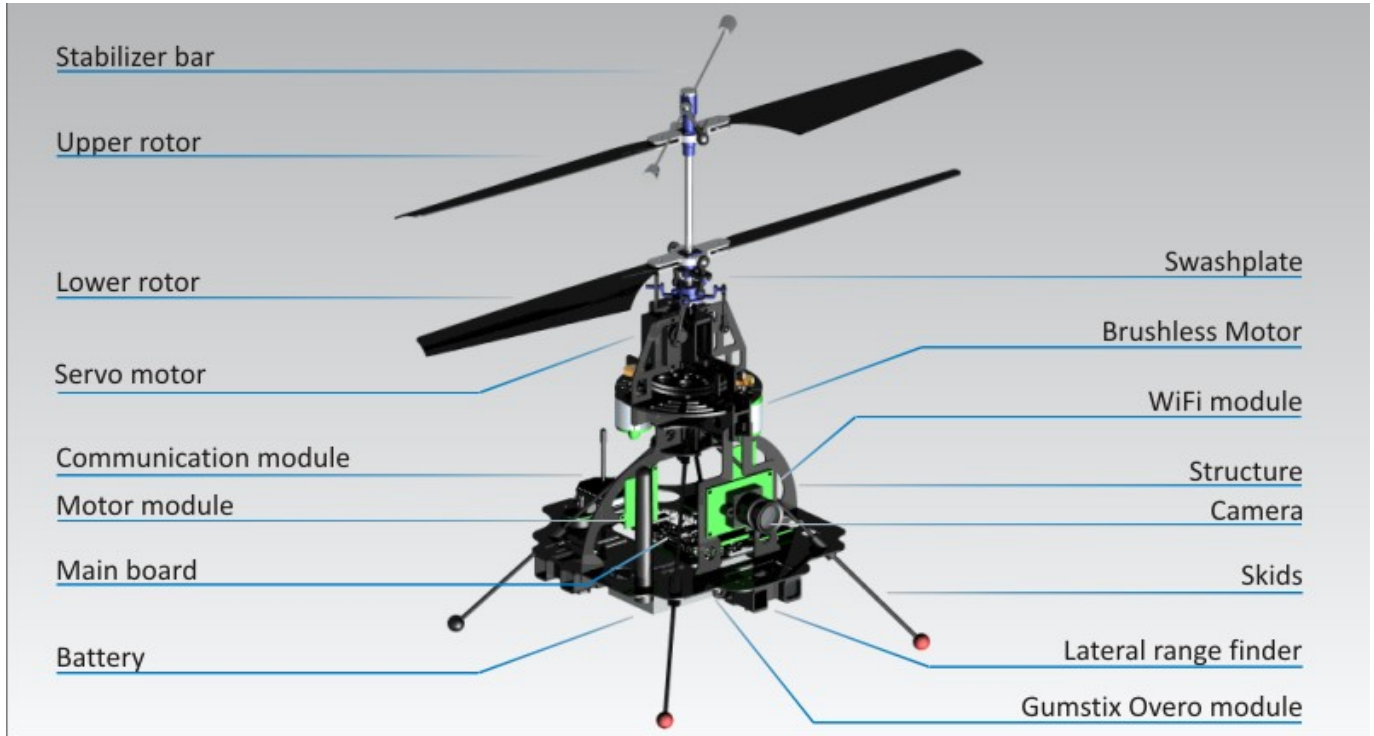
- Span: **340.8mm** (13.4in)
- Height: **168.4mm** (6.6in)
- Width: **165.1** (6.5in)
- Autonomy: **20min** - up to
- Mass: **280g** (9.8oz) - of the basic configuration
- Mass: **340g** (12oz) - of the full configuration
- Max height: **6m** (19.6ft) - from ground, if only the sonar is used
- Max altitude: up to the user - if the pressure sensor is used



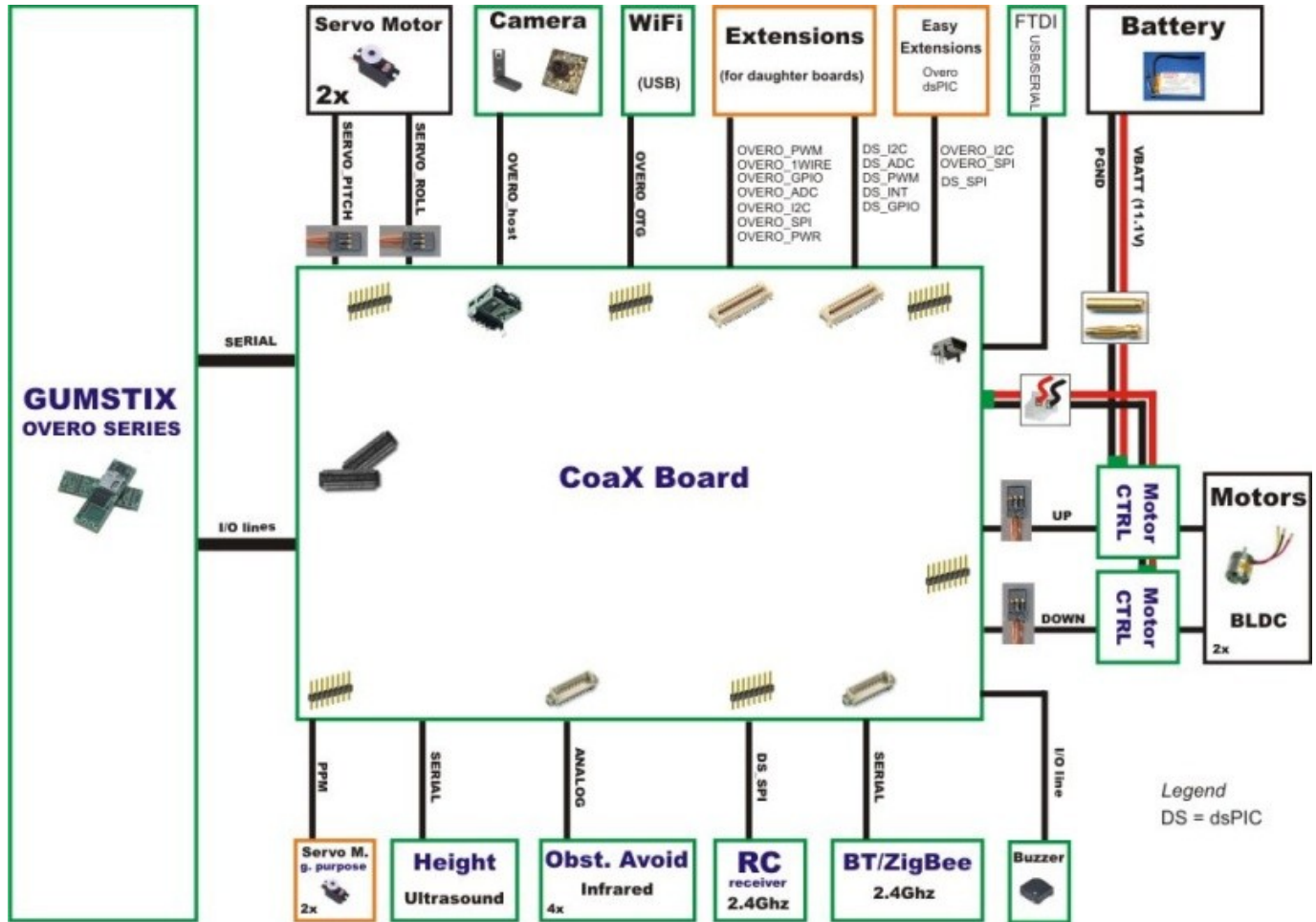
The main dimensions of CoaX®

Main Components

This picture shows the CoaX with all the possible options (peripherals) mounted on the helicopter. So, the picture can be slightly different from your CoaX, if you did not order all the options.



Electronics



CoaX® ports and peripherals

The CoaX® system was built around the CoaX® board, a highly integrated piece of electronics with an important connectivity to peripherals and extension modules. The picture at the right shows a diagram of the different peripherals and how they are connected to the CoaX® board. The main peripherals are:

- *Gumstix Overo™* connected through two 70-pin AVX connectors, directly at the bottom of the CoaX® board.
- **Camera** connected to the highly standard USB A connector available on the CoaX board and linked to the USB OTG interface of the Overo™.
- **WiFi** connected through a standard header to the USB HOST interface of the Overo™.
- **FTDI** the standard USB B connector of the CoaX board offers direct access to the console of the Overo™. The FTDI chip (UART to USB converter) is embedded on the CoaX board.
- **BT/ZigBee** the provided Bluetooth® or ZigBee® module is directly interfaced to the CoaX board through a PICOBLADE connector.

- **Daughter boards** developed by the users can be added thanks to two variable height stacking connectors, already available on the top of the CoaX board.
- **Easy extensions** is a set of standard 2.54mm (100mil) connectors, available for the user for an easy and quick interfacing of sensors or other peripherals.
- **Obst. avoid** sensors can be connected through dedicated PICOBLADE connectors.
- **Two additional servo** motors can be interfaced through standard 2.54mm (100mil) headers available on the CoaX board.

Main board

Camera USB port (Overo HOST)

Obstacle avoid. sensor (left)

2.4Ghz receiver connector

Battery plug

General purpose Servo (2x)

Pressure sensor (absolute)

Motors (Up & Down)

3D accelerometer

Servo (Roll & Pitch)

1D Gyroscope (Z axis)

WiFi USB port (Overo OTG)

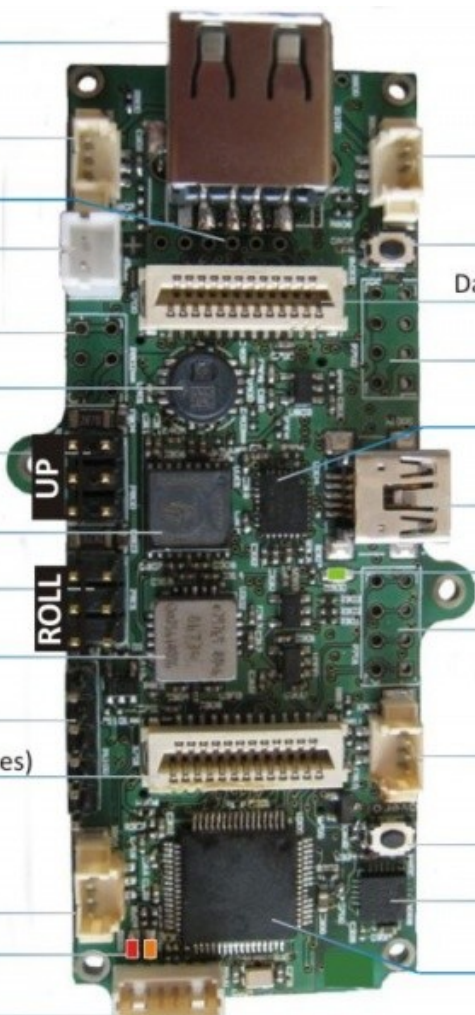
Daughter boards connector (dsPIC lines)

Obstacle avoid. sensor (back)

Red & Orange LEDs (main dsPIC)

Serial port (for BT or ZigBee, etc.)

The main board of CoaX® (top view)



Obstacle avoid. sensor (front)

dsPICs reset button

Daughter boards connector (Overo lines)

Easy extension (Overo lines)

2D gyroscope (X, Y axes)

FTDI interface (Overo console)

Green LED (IMU dsPIC)

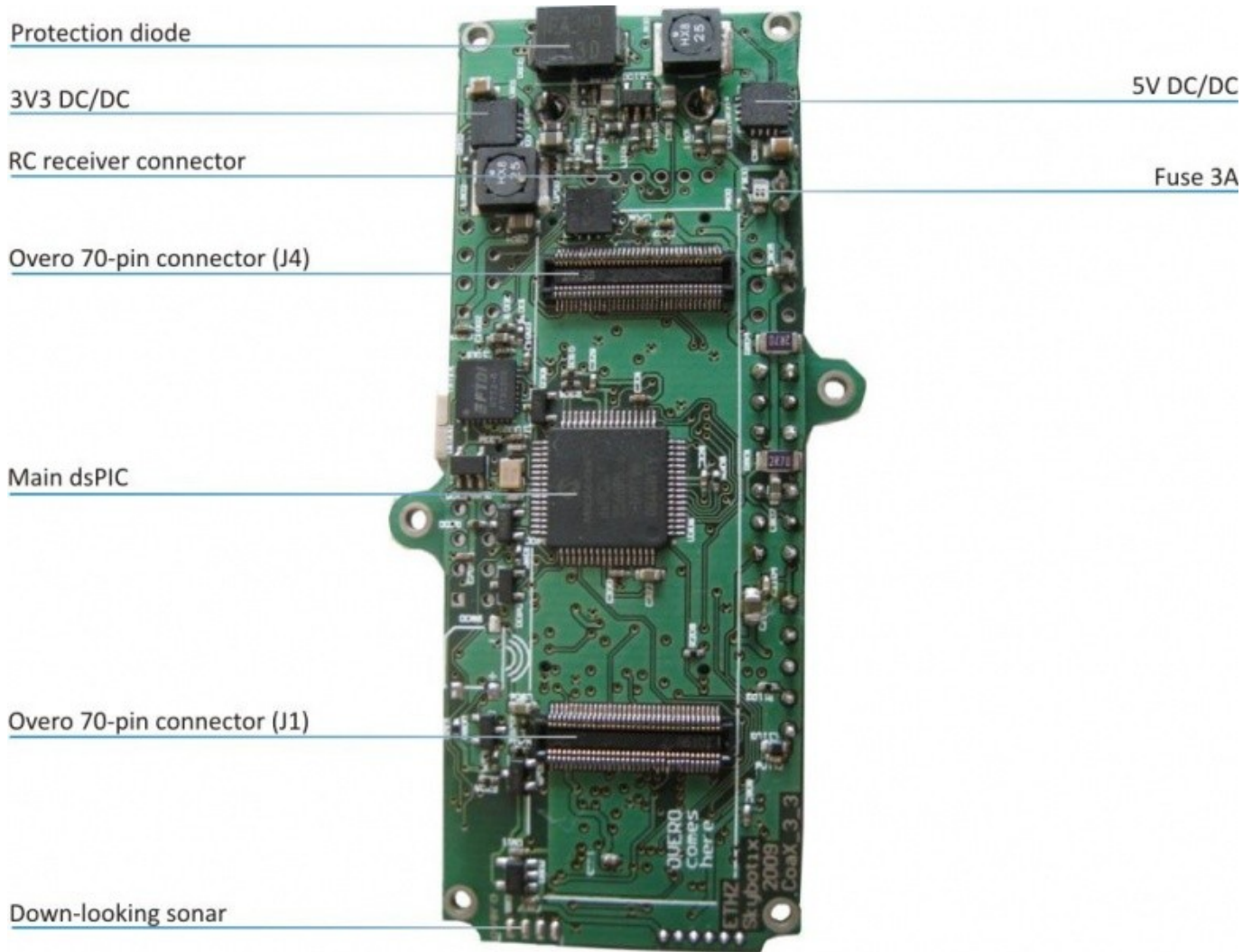
Easy extension (dsPIC lines)

Obstacle avoid. sensor (right)

Overo reset button

3D Magnetometer

dsPIC of IMU



The main board of CoaX® (bottom view)

The CoaX board is the master piece of the CoaX system. It is an integrated piece of electronics, comprising several sensors and chips which must be handled with care. The main elements of this board are explained here after:

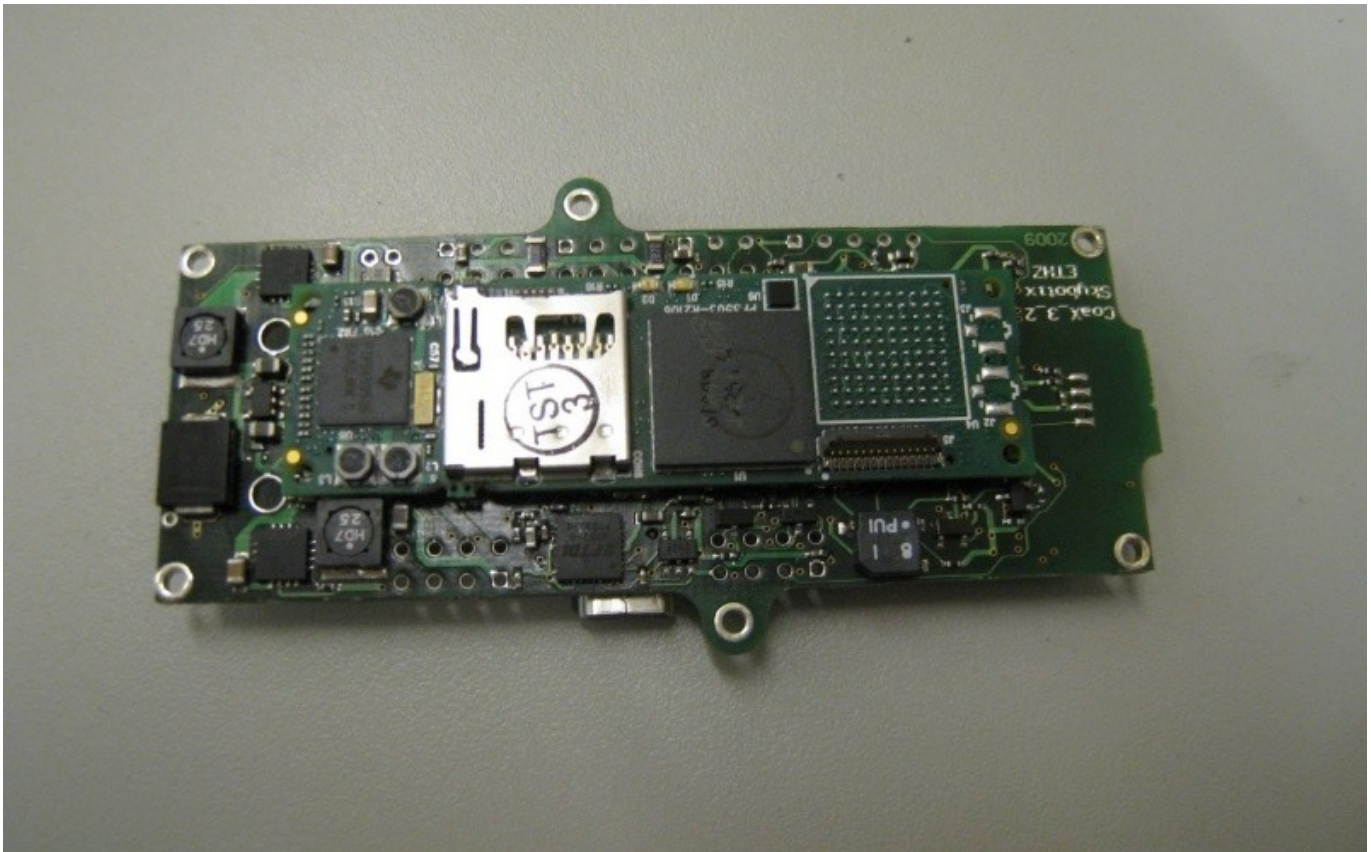
- **Camera USB port (Overo HOST)** - Standard USB 2.0 host port of the Overo, used for connecting the camera of CoaX (both options).
- **Obstacle avoid. sensor (front, left, right)** - Connector for an IR range finder Sharp GP2Y0A02YK0F, used for obstacle avoidance
- **2.4Ghz receiver connector** - Connector for the RC receiver. This connector is not accessible to users. The receiver is directly soldered to the CoaX board
- **Battery plug** - Main connector for power supply. The default voltage is 11.1V, corresponding to a 3S Lithium battery
- **General purpose Servo (2x)** - Connector for two (02) additional servo motors available for the users
- **Pressure sensor (absolute)** - High accuracy absolute pressure sensor SCP1000 from VTI, with a resolution of a 1.5Pa.
- **Motors (Up & Down)** - Connector to the two brushless motors of the CoaX
- **3D accelerometer** - Linear acceleration sensor on (X,Y,Z axes). This is the SCA3000_E01 from VTI

- **1D Gyroscope (Z axis)** - Low drift, vertical axis gyroscope. This is the popular ADXRS610 sensor from Analog
- **WiFi USB port (Overo OTG)** - Standard USB 2.0 OTG port of the Overo, used for connecting the WiFi module of CoaX.
- **Daughter boards connector (dsPIC lines)** - One of the two connectors used for receiving "stackable" boards the user would design by himself. These connectors serve also for the removable programming board (used to program the dsPICs).
- **Red & Orange LEDs (main dsPIC)** - The two LEDs connected to the main dsPIC. The functions of these LEDs are described in the page Software of this wiki
- **Serial port (for BT or ZigBee)** - TTL level, full serial port used to connect any UART compatible communication module. The CoaX comes with either a BT or a ZigBee module plugged on this connector
- **dsPICs reset button** - Reset push-button for both dsPICs of the CoaX board
- **Easy extension (Overo lines)** - Easily reachable (pitch 100mil/2.54mm) connector for a couple of I/O lines of the Overo board. A similar connector is available for some dsPIC lines
- **2D gyroscope (X, Y axes)** - Dual axis gyroscope for Roll and Pitch axes. This is the IDG500 from Invensense
- **FTDI interface (Overo console)** - Mini USB-B connector of the FTDI (UART-USB) interface, provides access to the console of the Overo board
- **Green LED (IMU dsPIC)** - The LED connected to the IMU dsPIC. The function of this LED is described in the page Software of this wiki
- **3D Magnetometer** - State of the art 3 axis magnetic sensors and an ASIC in a single package, with digital interface. This is the HMC5843 from Honeywell
- **dsPIC of IMU** - One of the two dsPICs of the CoaX board. Runs all the data fusion algorithms
- **RC receiver connector** - Connector for the 2.4Ghz RC receiver
- **Overo 70-pin connector (J4)** - One of the two 70-pin connectors of the Overo board. This is the J4
- **Main dsPIC** - One of the two dsPICs of the CoaX board. Runs all the low level controllers, handles the communication with the Overo and the BT (or ZigBee) module, etc.
- **Overo 70-pin connector (J1)** - One of the two 70-pin connectors of the Overo board. This is the J1
- **Down-looking sonar** - Connector of the sonar used for height control
- **Fuse 3A** - 3A protection fuse

Gumstix Overo™ module



Gumstix Overo™



Overo™ on CoaX® board

The CoaX® helicopter supports the popular Gumstix Overo™ series of powerful computer on modules. With only 17mm x 58mm x 4.2mm in size, and only 6g in mass, the Overo™ motherboard is the tiniest, lowest-cost Linux computer available today from Gumstix for the open-source community. Overo™ is based on the ultra-fast OMAP35x processor, and exists in four (04) different variants, all supported by CoaX. The Overo™ module is simply plugged below the CoaX® board. The necessary Overo I/O lines are routed through the CoaX board and made available for the CoaX users.

The following Overo™ interfaces are thus available directly from the CoaX board:

- **USB Host** used in general for the embedded camera.
- **USB OTG** configured as host by default and used in general for the external wifi module (if any).
- **I2C bus** level-shifted to **3V3** for a more convenient use.
- **SPI bus** level-shifted to **3V3** for a more convenient use.
- **UART interface 1** TTL level, shifted to **3V3** and directly connected to the embedded DSP of the CoaX board.
- **UART interface 3** directly connected to the **embedded FTDI** interface of the CoaX board.
- **Analog Input 2,3** made easily available to the user.
- **Various GPIO lines** made easily available to the user.
- **PWM lines** made easily available to the user.
- **1Wire interface** made easily available to the user.

Detailed technical information about the Overo™ modules are provided directly by Gumstix Inc.

- Gumstix Inc. website
- Overo™ page on Gumstix Inc. website
- Gumstix Developers portal

WiFi module

The CoaX® helicopter can be equipped with two types of WiFi modules.

- **External WiFi module (802.11n)** connected through the USB (OTG) interface of the Gumstix Overo™ board - This is the **default** option. The 802.11 (n) standard offers higher power and longer range compared to legacy (g) standard. This allows CoaX® to stream high resolution images at high frame rate. The WiFi module used on CoaX® is the Netgear® WNDA3100. This WiFi module is dual band (802.11n) and (802.11g). Its use in (802.11n) requires a compatible access point. If this is not available, one can simply connect through a (802.11n) router like the Netgear® WNR2000 available for less than a \$100.
- **Internal WiFi module (802.11g)** of the Gumstix Overo™ "Air" or Overo™ "Fire" - These two models of the Overo™ can be mounted on the CoaX board. For this, an external dipole antenna should be added. This integrated solution saves space and mass, however, the Overo™-integrated modules do not seem able to achieve high data-transfer rate, and thus they should be avoided if real-time video streaming is needed on CoaX®.

Camera

The CoaX® helicopter can be equipped with two types of cameras. Both of them are used usually at a standard resolution of **640x480** and a frame rate of **15fps**. This corresponds to a data rate of about 37Mbps, effectively sent through the WiFi connection. A maximum lies around 25fps, so about 60Mbps for VGA resolution. Tests have shown that it is possible to go up to 90Mbps with the n-standard WiFi module.

- **Standard USB 2.0 color webcam (default)** directly mounted on the USB A connector of the CoaX board (USB OTG interface of the Overo board). This camera can be tilted to have it forward, downward or side looking. The main technical specifications are:
 - Resolution: up to 1280 x 1024 (1.3M pixel)
 - Frame rate: up to 30 fps
 - Function: Auto white balance, auto-exposure control
 - Microphone: Built in
 - Image Sensor: CMOS SXGA
 - Focus: 30 cm to infinity
- **Research grade camera (b/w)** from Point Grey plugged through a cable to the USB A connector of the CoaX board (USB OTG interface of the Overo board). This camera is equipped with a standard 12mm s-mount lens holder, on which we mount a 150deg fisheye lens by default. The main technical specifications are:
 - Resolution: up to 752x480 (0.36M pixel)

- Frame rate: up to 60 fps
- Function: trigger mode, partial image mode, gain control, synchronization line, etc.
- Microphone: no
- Image Sensor: Micron 1/3" global shutter CMOS
- Focus: adaptable

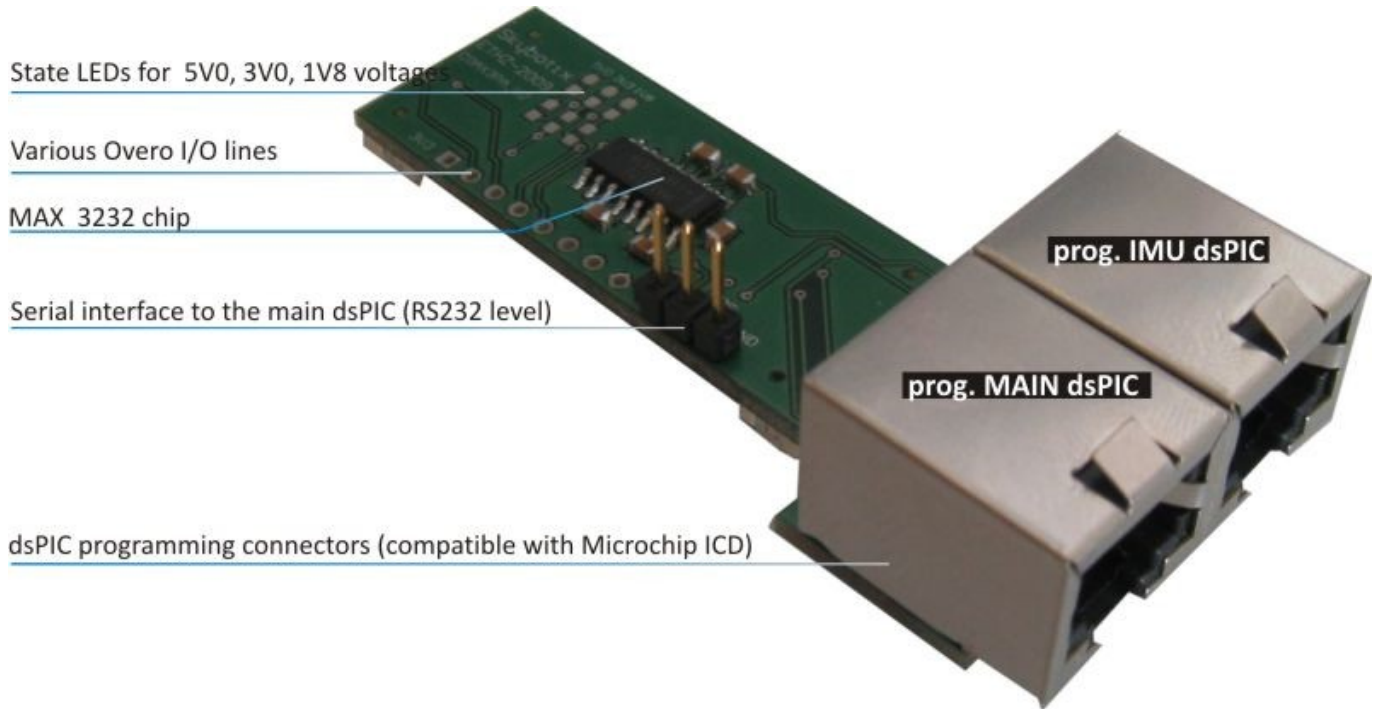
Wireless communication module

The CoaX® helicopter can be equipped with two types of wireless communication modules, directly connected to the serial port of the CoaX board.

- **Bluetooth module 2.0 (default module)** - A transparent replacement of a serial cable. This compact, Class 2 module offers easy wireless connectivity to PC, Smartphones or Laptops up to several meters (depends on the obstacles). Its main technical specifications are:
 - Complete Bluetooth 2.0 Stack
 - Protocols: L2CAP, RFCOMM, SDP
 - Profiles: GAP, SDAP, SPP
 - Supporting up to 7 active Bluetooth data links and 1 active SCO link
 - UART port speed up to 921.6kbits/s

- **ZigBee module** - A versatile and easy to use module, based on the Xbee® module from DIGI. Different versions of the Xbee® module are available and can simply adapted to the CoaX. In general, these modules offer higher range compared to the Bluetooth module, but lower data rate. The popular XBee 2mW Series 2.5 with Wire Antenna, available at Sparkfun has the following specifications:
 - 3.3V @ 40mA
 - 250kbps Max data rate
 - 2mW output (+3dBm)
 - 400ft (120m) range
 - Built-in antenna
 - Fully FCC certified
 - 6 10-bit ADC input pins
 - 8 digital IO pins
 - 128-bit encryption
 - Local or over-air configuration
 - AT or API command set

Programming board



CoaX® programming board (top view)

The internal DSPs of the CoaX® board can be programmed through a provided programming interface, which can be plugged on the CoaX board for programming and removed during normal operation. The interface connects to a serial programming device like the Microchip ICD. This interface includes a UART TTL-RS232 converter and offers also access to some of the I/O lines of the CoaX-board internal DSPs.

- dsPIC programming connectors - These are RJ-11 connectors, compatible with the standard Microchip debugging connector. One is used to program the MAIN dsPIC and the other one to program the IMU dsPIC
- State LEDs - 3 separate LEDs to indicate if the 5V0, the 3V3 and the 1V8 are available on the CoaX board
- Various Overo I/O lines - Several I/O lines of the Overo available for the user
- Serial interface to the main dsPIC - This is an RS232 level, serial port connected to the main dsPIC. This is the same UART port on the dsPIC that is also connected to the Overo.

CAUTION: The programming board should be removed before starting a serial communication between the MAIN dsPIC and the Overo

Structure

The structure of CoaX is an assembly of several water-cut, 2D carbon sheets. This makes it not only very robust and lightweight, but also very easy to modify or repair. The main carbon plate holds the CoaX board and is compatible with all the configurations of CoaX helicopter. Thus, there is no need to modify the structure after a change of a sensor or an actuator supported by the CoaX. On the other hand, the four (04) legs of CoaX are made of 2mm carbon skids, fixed with a special shrinking material, removable by simple heating.

Battery & Charger

The CoaX is equipped by default with a Lithium Polymer battery of **11.1V** and **1350mAh**. The optional charger ThunderPower LiPo TP-610C is ordered separately. The TP610C can charge various types of batteries, it can Balance, discharge and cycle batteries and report back full data. It is capable of up to 10 amps (80 watts total) for charging.

2.4Ghz Remote control



The remote control unit of CoaX®

CoaX® is delivered with a 4channels, 2.4Ghz remote control (RC) unit. At power up, the CoaX receiver reduces its sensitivity to check only for RC emitters that are close to it (<1m distance). The CoaX receiver selects then the strongest signal to pair with it. Once the pairing is done, it remains until the helicopter or the RC is turned off. In flight, the range can be several tens of meters even indoors. However, this depends on the obstacles between the RC and the helicopter.

In **MANUAL** mode, the RC offers several functions described as follows:

- **Kill switch** - Used to stop all the motors in any situation or any control mode
 - kill position: **left**
- **Manual/Automatic switch** - Selects the manual or the automatic flight modes
 - Manual position: **down**
 - Automatic position: **up**
- **Height setpoint stick** - Sets the desired height of the helicopter from the ground. The lowest position makes the CoaX to land. The uppermost point represents the maximum authorized height (set by software) to be reached by the CoaX.
- **Yaw-rate setpoint stick** - Sets the desired yaw-rate (rotational speed around the vertical axis) of the helicopter. This stick goes back to its neutral point (null speed) as soon as it is released.
- **Swashplate Roll (or Pitch) angle stick** - Controls directly the angle of the servo-motor responsible for the rolling (or pitching) of the CoaX. This stick goes back to its neutral point (null angle) as soon as it is released.
- **Roll (or pitch) trim slider** - Sets the trim points of the Roll (or Pitch) angles of the swashplate (just like on traditional RC).
- **Battery level indicator** - Indicates the level of the battery using different colors.
 - Green: **level ok** - flight is possible
 - Orange: **level intermediate** - replace the batteries asap
 - Red: **level low** - do not fly

In **AUTOMATIC** mode, the RC offers almost the same functions, except that the 2 sticks are disabled by default, but can be enabled in software (see API documentation in the Software page)).

Lateral range finders

The CoaX can be equipped with 3 lateral IR range finders. The CoaX supports the Sharp GP2Y0A02YK0F sensor, which works until ~1.2m (4ft) with a precision of a couple of centimeters, with a quite directive beam (a couple of centimeters beam rad. at 1m distance). The use of lateral range finding on a helicopter is quite tricky. It depends a lot on the environment, the application and the flight itself (height, etc.). Thus, the kit of three (03) sensors is to be ordered separately. The code of the main dsPIC provides already a library to read this sensor. However, any obstacle avoidance functionality has to be programmed by the user himself.