MOTION UAV

Open Source Autopilots

Presented by:

Iman Shirdareh

Outline

- Why, How, What?
- Basics of Pixhawk project
- Pixhawk FMU hardware overview
- Basic concepts
- Control theory
- Estimation theory
- Pixhawk Software overview
- Operational Software Guide
- Operational Assembly Guide
- Flying Guide
- Flight Log Analysis Guide
- Advanced Guides

Why, How, What?

History Of open source autopilot projects

Autopilot.com since 2001

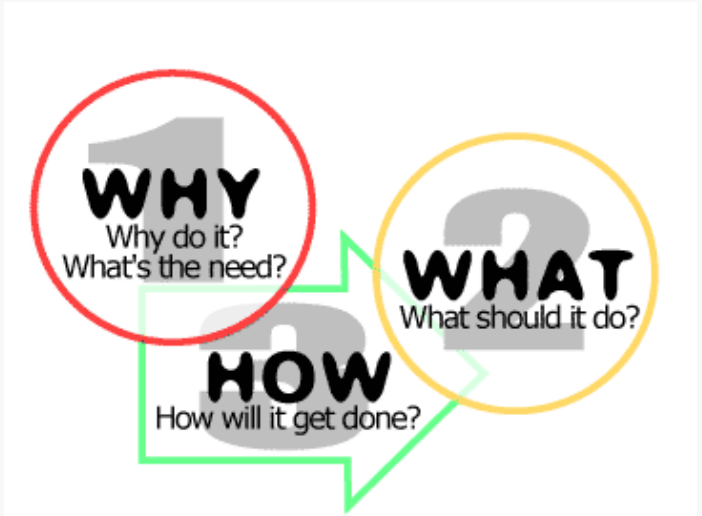
- RC to servo
- inertial sensor (3 gyros, 3 accels)
- GPS positioning

Availble at:

source forge

Why, How, What?

Purpose of open-source



- ❑ To understand and learn:
  - Electronics (sensors, EMI, RF,...)
  - Automatics (data fusion, control loops)
  - Software (airborne systems, datalink, HMI,...)
  - Flight mechanics and aerodynamics
- ❑ To have fun
- ❑ To take part in flight competitions

Why, How, What?

Purpose of open-source

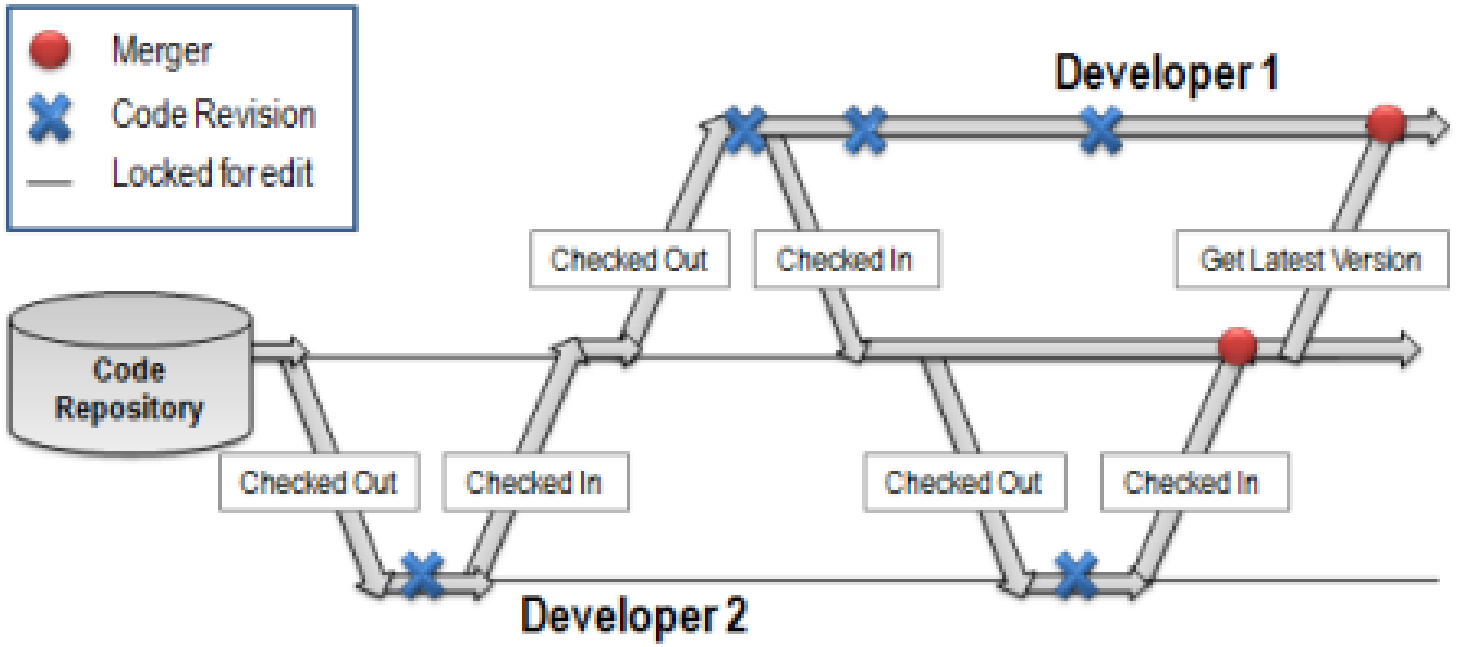
- ❑ Safety First!

How about Security? (Terrorists worries)

Why, How, What?

Purpose of open-source

- Source Version Control (SVC)



Why, How, What?

Purpose of open-source

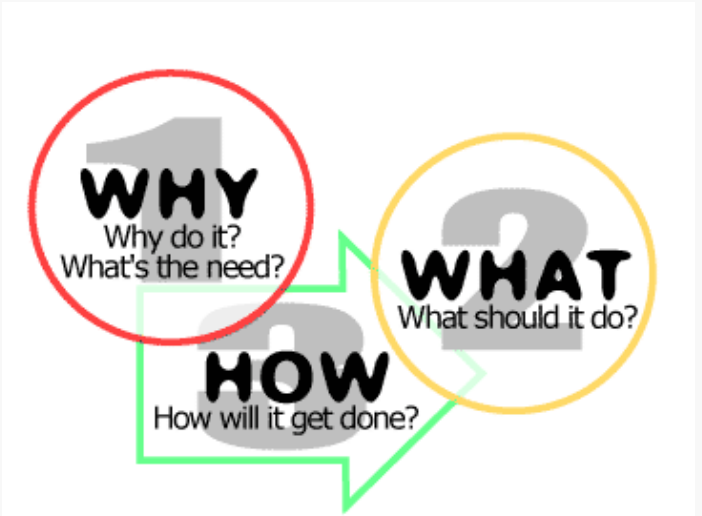
- Source Version Control (SVC)

Why, How, What?

Purpose of open-source

- Licenses

GNU,GPL, BSD, MIT, Apache, Open Software License, zLib …



Why, How, What?

Purpose of open-source

- Pixhawk Licenses: BSD3

Permissions	Limitations	Conditions
✔ Commercial use	✘ Liability	ⓘ License and copyright notice
✔ Modification	✘ Warranty	
✔ Distribution		
✔ Private use		

Why, How, What?

List of major projects

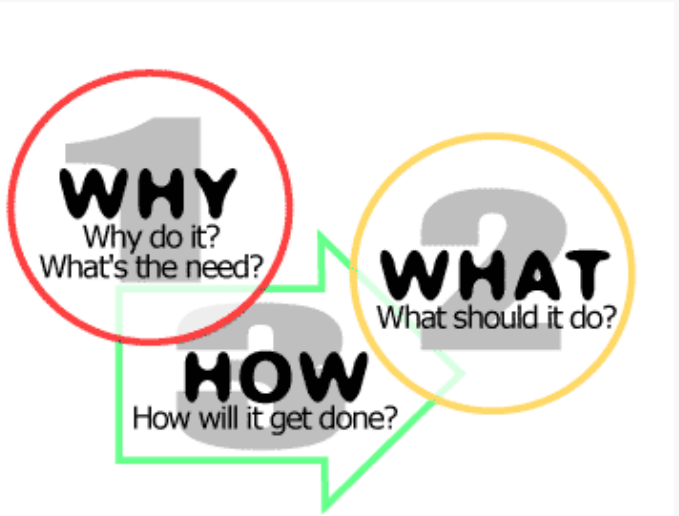
MicroPilot®
World Leader in Professional UAV Autopilots

ITAR 100% NON-ITAR PRODUCTS ISO 9001 : 2015 QUALSAR REGISTERED Since 1994

Going, Going, Gone...

Make sure that your autopilot isn't next!

3DR
openpilot
AttoPilot www.AttoPilot.com
advanced subsonics
CARVEC remote system control
DYNON AVIONICS
MAVIONICS
NRI NEURAL ROBOTICS
UNAV, LLC
O·NAVI
PICO PILOT
Crossbow®
ROTOMOTION,LLC
UAV Flight Systems, Inc.
Geneva Aerospace At the core of UAV control



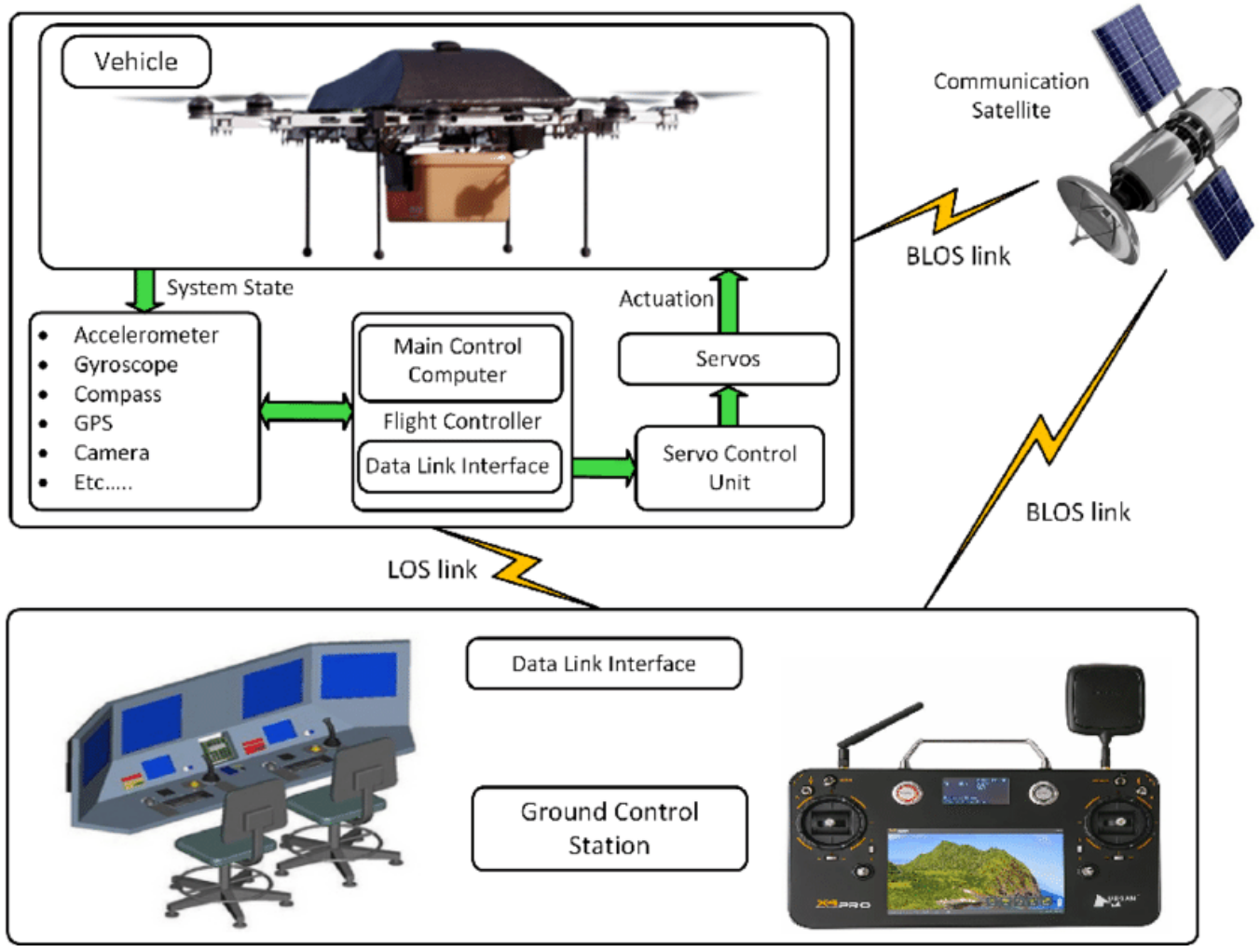
Why, How, What?

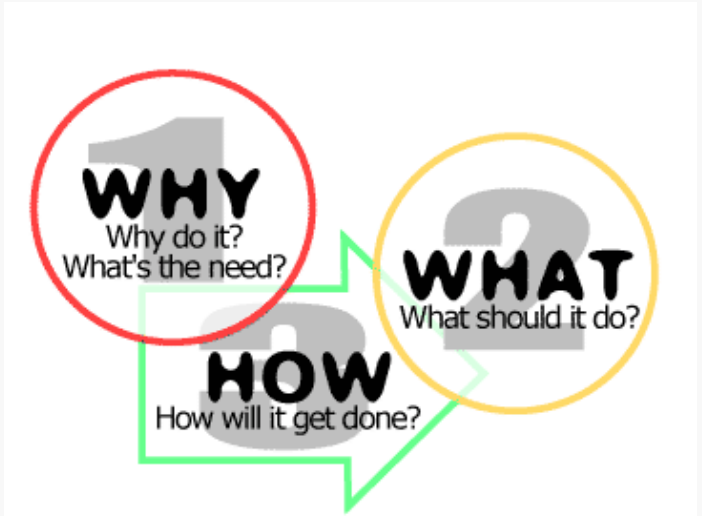
List of major projects

Who are still alive?

Why, How, What?

General overview of a UAV autopilot



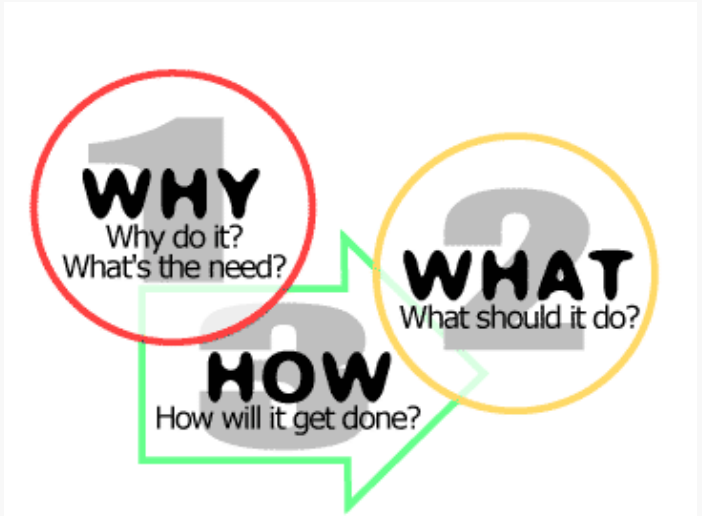


Why, How, What?

Is this possible to use it on manned planes!?

L3HARRIS™

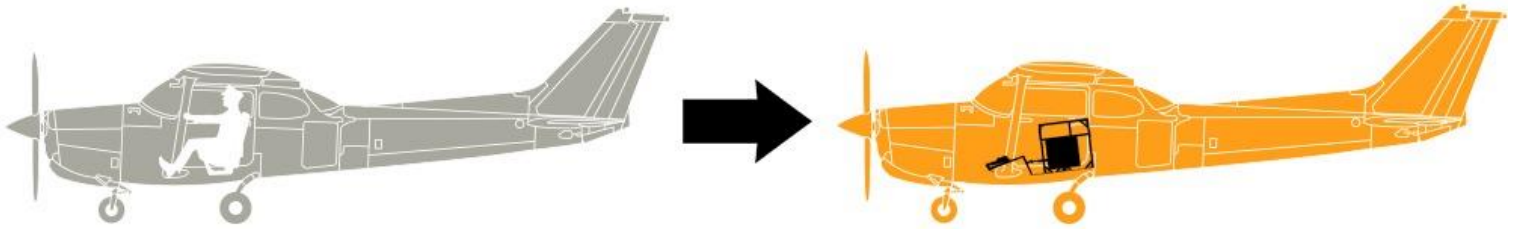
SNOWBIRD



Why, How, What?

Is this possible to use it on manned planes!?

SNOWBIRD Mission



converting a Cessna 172 aircraft to unmanned operation!

Why, How, What?

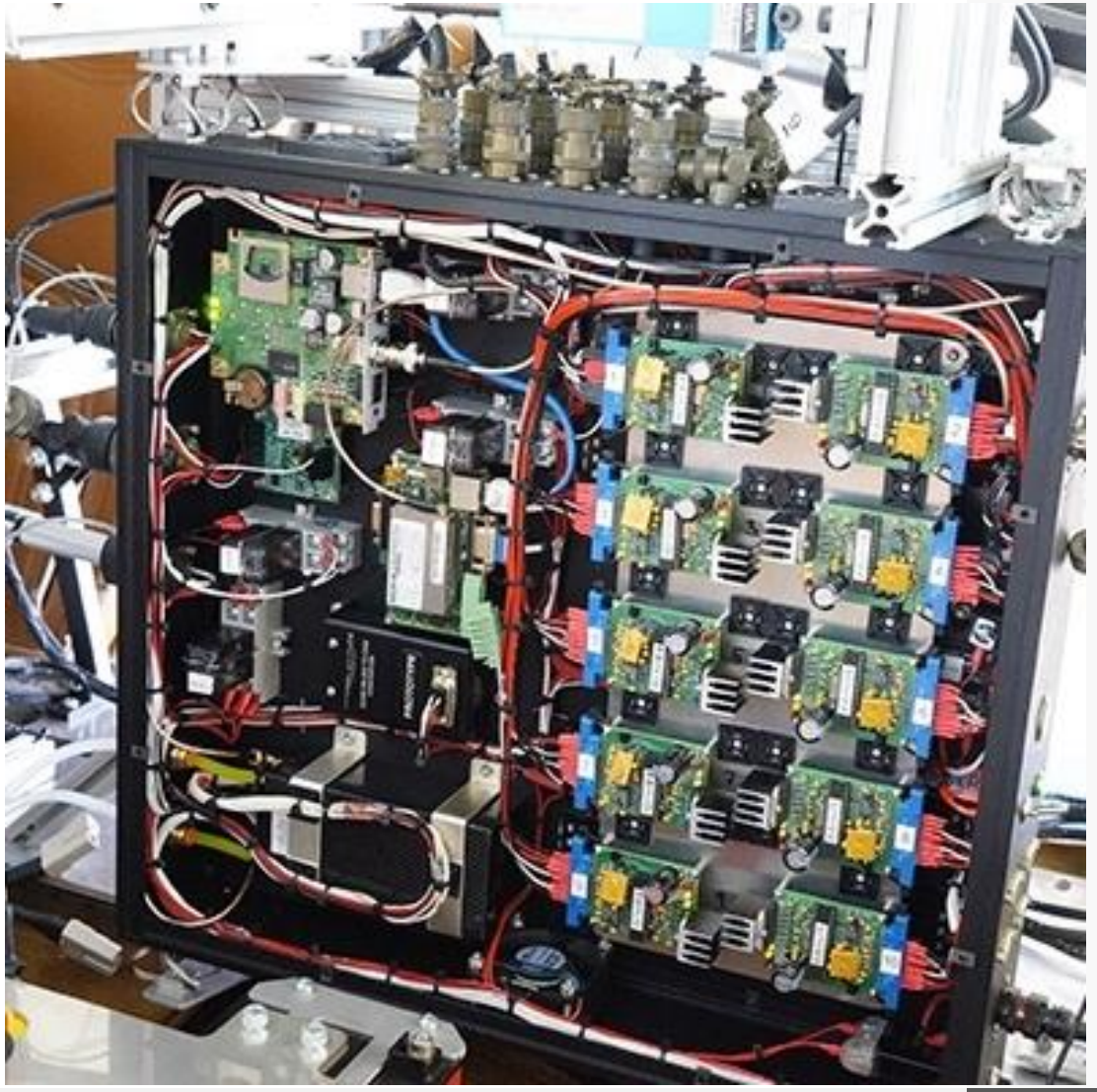
Is this possible to use it on manned planes!?

Why, How, What?

Is this possible to use it on manned planes!?

Why, How, What?

Is this possible to use it on manned planes!?



Why, How, What?

Is this possible to use it on manned planes!?

Why, How, What?

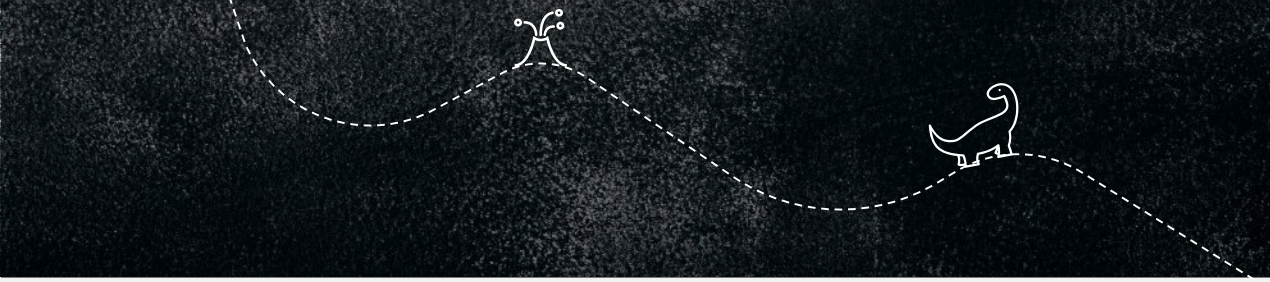
Is this possible to use it on manned planes!?

ESTIMATED PERFORMANCE SPECS

Expected Endurance	30+ hrs		No Reserve
Payload	100 lbs	45 kg	At Full Endurance
Cruise Speed	140 mph	225 km/hr	maximum
Stall Speed	55 mph	85 km/hr	At Gross Weight
Useful Load	1500 lbs	680 kg	(130% Ferry Weight)

Cost of complete unit	Under $250,000, expected (ready to fly, no payload).
Crew	Minimally, one. Practically, two, in shifts.
Anti-Icing	Thermawing™ supplied by RDD Enterprises.
Emergency Recovery	Ballistic Parachute from BRS.

Basics of Pixhawk project



Basics of Pixhawk project

Become familiar with names and their roles

Pixhawk Key Founder

Lorenz Meier

ETH zürich

auterion

https://auterion.com/

Basics of Pixhawk project

Become familiar with names and their roles

3DR CEO& Co-Founder

Chris Anderson

3D Robotics UAV TECHNOLOGY

3DR

APM

Basics of Pixhawk project

Become familiar with names and their roles

Dronecode Co-Founder

Jordi Muñoz

Dronecode

THE LINUX FOUNDATION

Basics of Pixhawk project

Become familiar with names and their roles

Dronecode Partners

Basics of Pixhawk project

Become familiar with names and their roles

Dronecode Partners

Basics of Pixhawk project

Become familiar with names and their roles

- Websites

  http://pixhawk.org/

  https://docs.px4.io/en/

  https://dev.px4.io/en/

  https://www.dronecode.org/

  http://ardupilot.org/

Basics of Pixhawk project

Become familiar with names and their roles

Branching Model

The PX4 project uses a three-branch Git branching model:

master is by default unstable and sees rapid development.

beta has been thoroughly tested. It's intended for flight testers.

stable points to the last release.

Basics of Pixhawk project

Pixhawk/Ardupilot history, differences, benefits

- Differences

VS

Basics of Pixhawk project

Pixhawk/Ardupilot history, differences, benefits

- Differences

APM Stands for:

ArduPilot Mega

Arduino

Basics of Pixhawk project

Pixhawk/Ardupilot history, differences, benefits

- Arduino Mega

https://www.arduino.cc/en/Main/Products

Basics of Pixhawk project

Pixhawk/Ardupilot history, differences, benefits

- Arduino Mega Schematic vs an AVR microcontroller

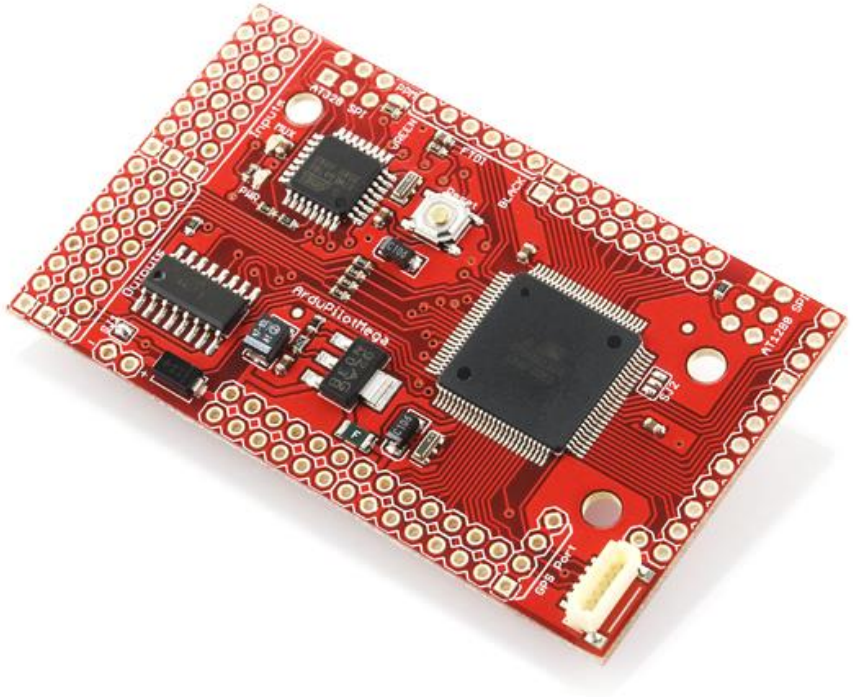
https://store.arduino.cc/usa/mega-2560-r3

Basics of Pixhawk project

Pixhawk/Ardupilot history, differences, benefits

- Ardupilot mega v1 controller(2009)

  Sparkfun AVC winner



Basics of Pixhawk project

Pixhawk/Ardupilot history, differences, benefits

- Ardupilot mega v1 Sensor hat

Basics of Pixhawk project

Pixhawk/Ardupilot history, differences, benefits

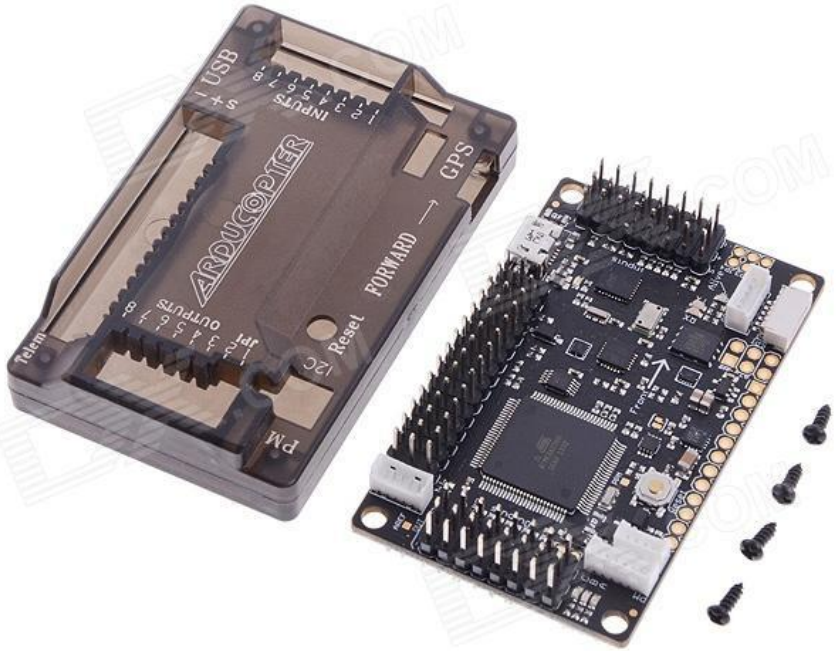
- Ardupilot mega v1 Specs

- Controller designed to be used with autonomous aircraft, car or boat.
- Based on a 16MHz Atmega2560 processor.
- Built-in hardware failsafe that uses a separate circuit (multiplexer chip and ATMega328 processor) to transfer control from the RC system to the autopilot and back again. Includes ability to reboot the main processor in mid-flight
- Dual-processor design with 32 MIPS of onboard power
- Supports of 3D waypoints and mission commands (**limited only by memory**)
- Has 16 spare analog inputs (with ADC on each) and 40 spare digital input/outputs to add additional sensors
- Four dedicated serial ports for two-way telemetry
- Can be powered by either the RC receiver or a separate battery
- Hardware-driven servo control, which means less processor overhead, tighter response and no jitters
- Eight RC channels (including the autopilot on/off channel) can be processed by the autopilot.
- LEDs for power, failsafe status, autopilot status and GPS lock
- 40mm x 69mm

Basics of Pixhawk project

Pixhawk/Ardupilot history, differences, benefits

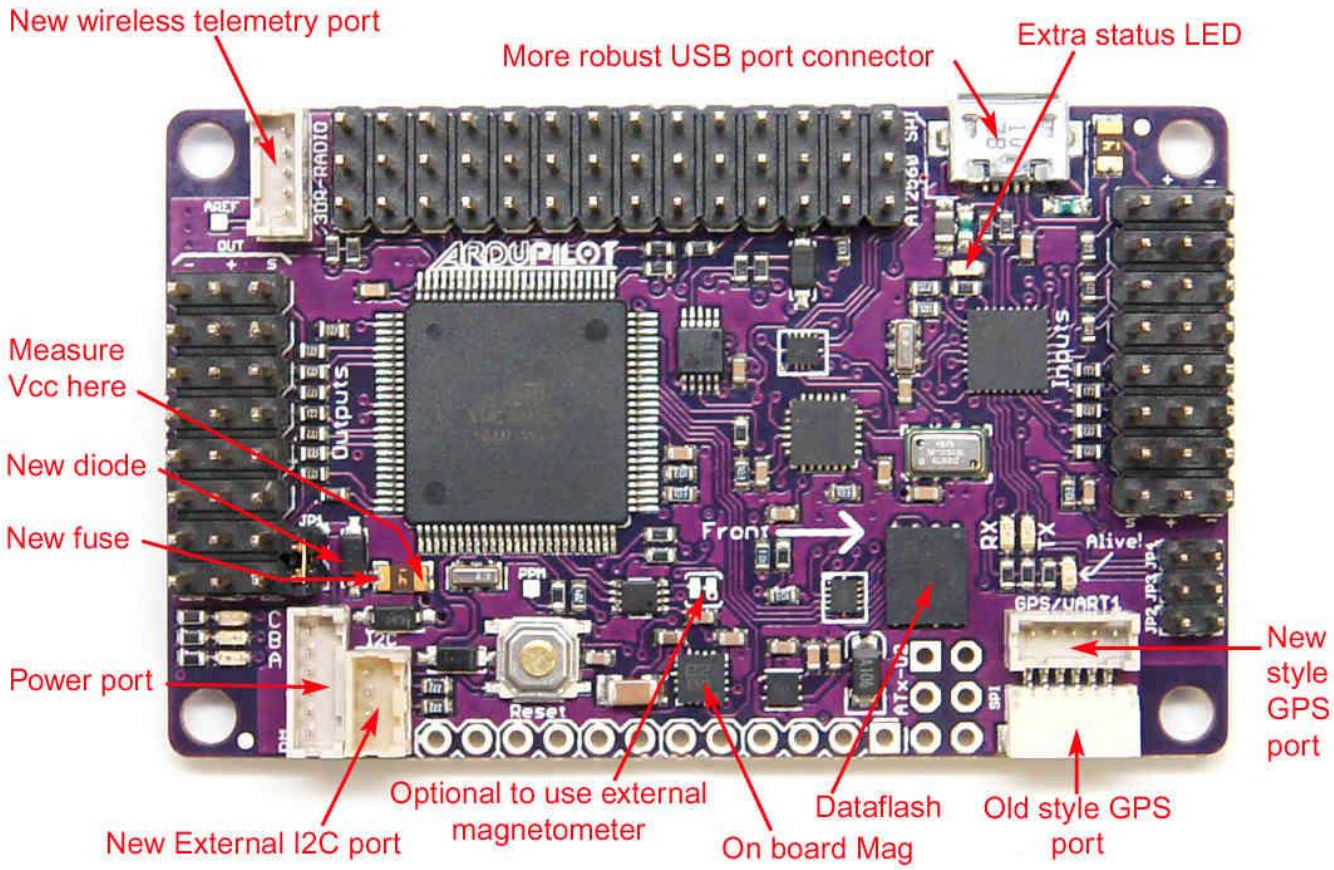
- Ardupilot mega v2 (2010)



Basics of Pixhawk project

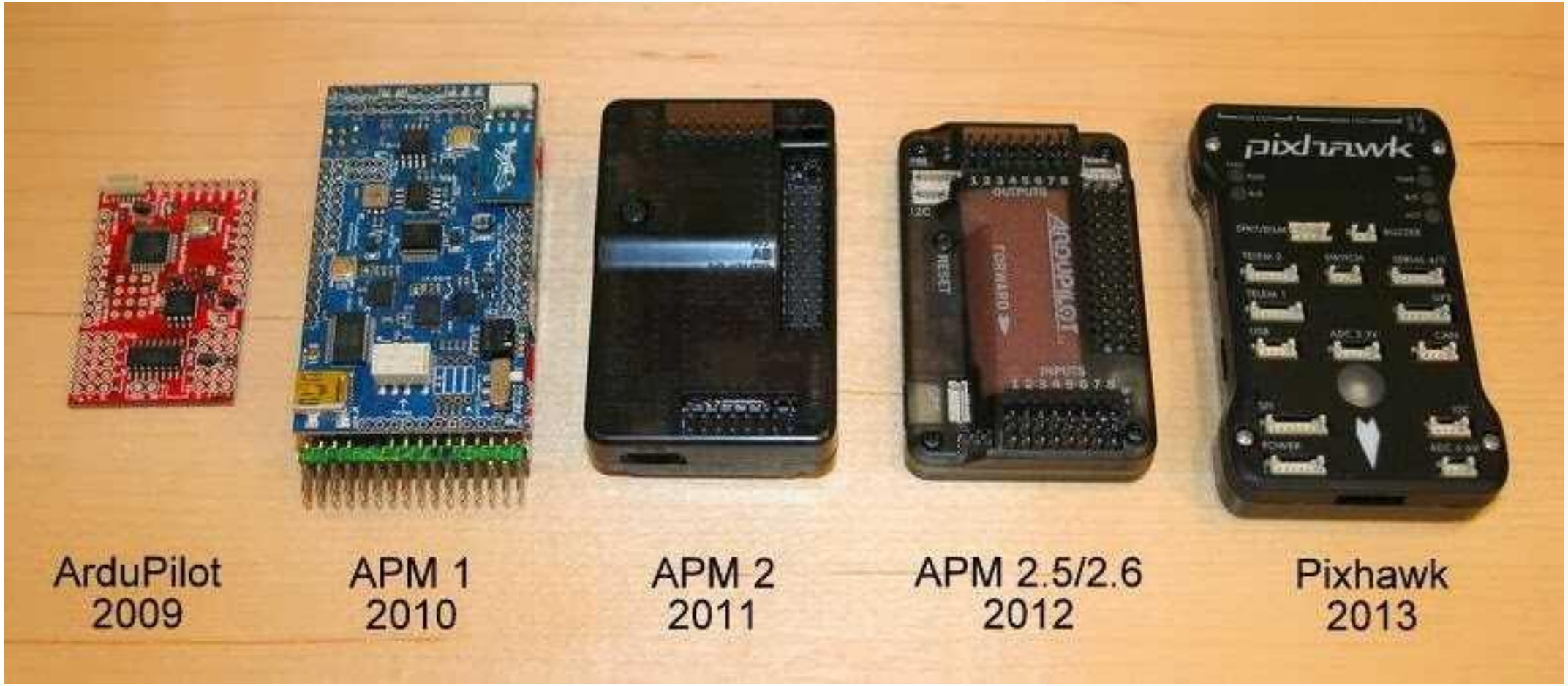
Pixhawk/Ardupilot history, differences, benefits

- Ardupilot mega v2 difference



Basics of Pixhawk project

Pixhawk/Ardupilot history, differences, benefits



Basics of Pixhawk project

Pixhawk/Ardupilot history, differences, benefits

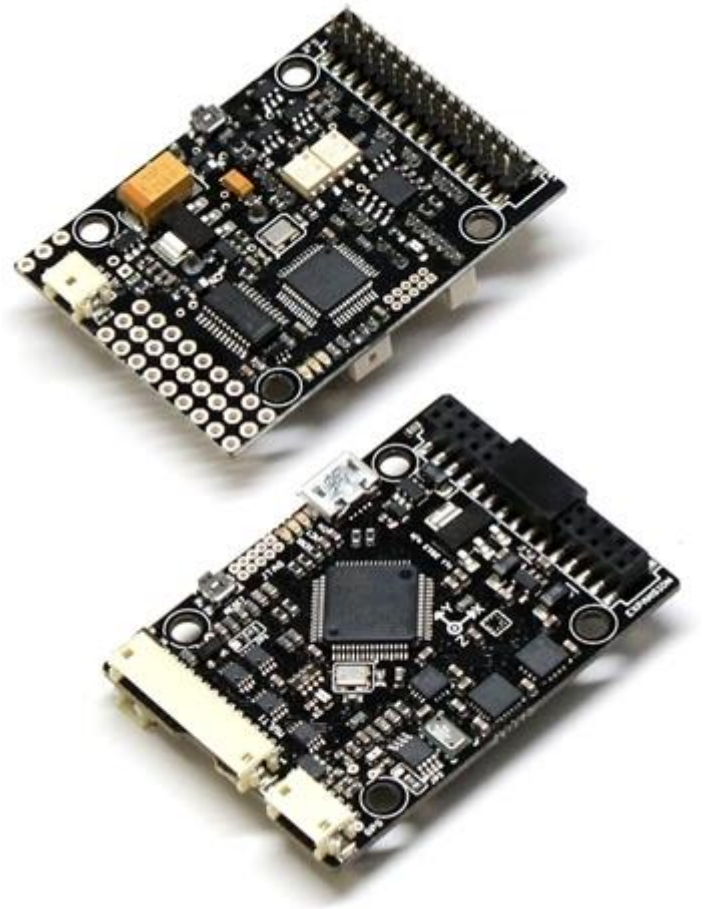
- Make ardupilot better

Features	STM32F103	ATMEGA328
Clock Frequency	72 Mhz	16 Mhz
I2C Buses	2	1
SPI Buses	2	1
CAN Bus	Yes	No
Analog Channel	10	8
PWM Channel	15	6
USART Buses	3	1
GPIO's	32	24
On Board RTC	Yes	No
Architecture	ARM Cortex M3 32 bit	AVR RISC 8 bit
ADC Resolution	12 bit	10 bit
Quantization Level	4096	1024
Flash Memory	64KB	32KB
SRAM	20KB	2KB
Debugging	Serial, JTAG	Serial
PWM Resolution	16 bit	10bit
Price	**110**	**115**

Basics of Pixhawk project

Pixhawk/Ardupilot history, differences, benefits

- Make ardupilot better



Basics of Pixhawk project

Pixhawk/Ardupilot history, differences, benefits

- Arduino DUE

Microcontroller	AT91SAM3X8E
Operating Voltage	3.3V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-16V
Digital I/O Pins	54 (of which 12 provide PWM output)
Analog Input Pins	12
Analog Output Pins	2 (DAC)
Total DC Output Current on all I/O lines	130 mA
DC Current for 3.3V Pin	800 mA
DC Current for 5V Pin	800 mA
Flash Memory	512 KB all available for the user applications
SRAM	96 KB (two banks: 64KB and 32KB)
Clock Speed	84 MHz
Length	101.52 mm
Width	53.3 mm
Weight	36 g

ARDUINO™

Basics of Pixhawk project

Pixhawk/Ardupilot history, differences, benefits

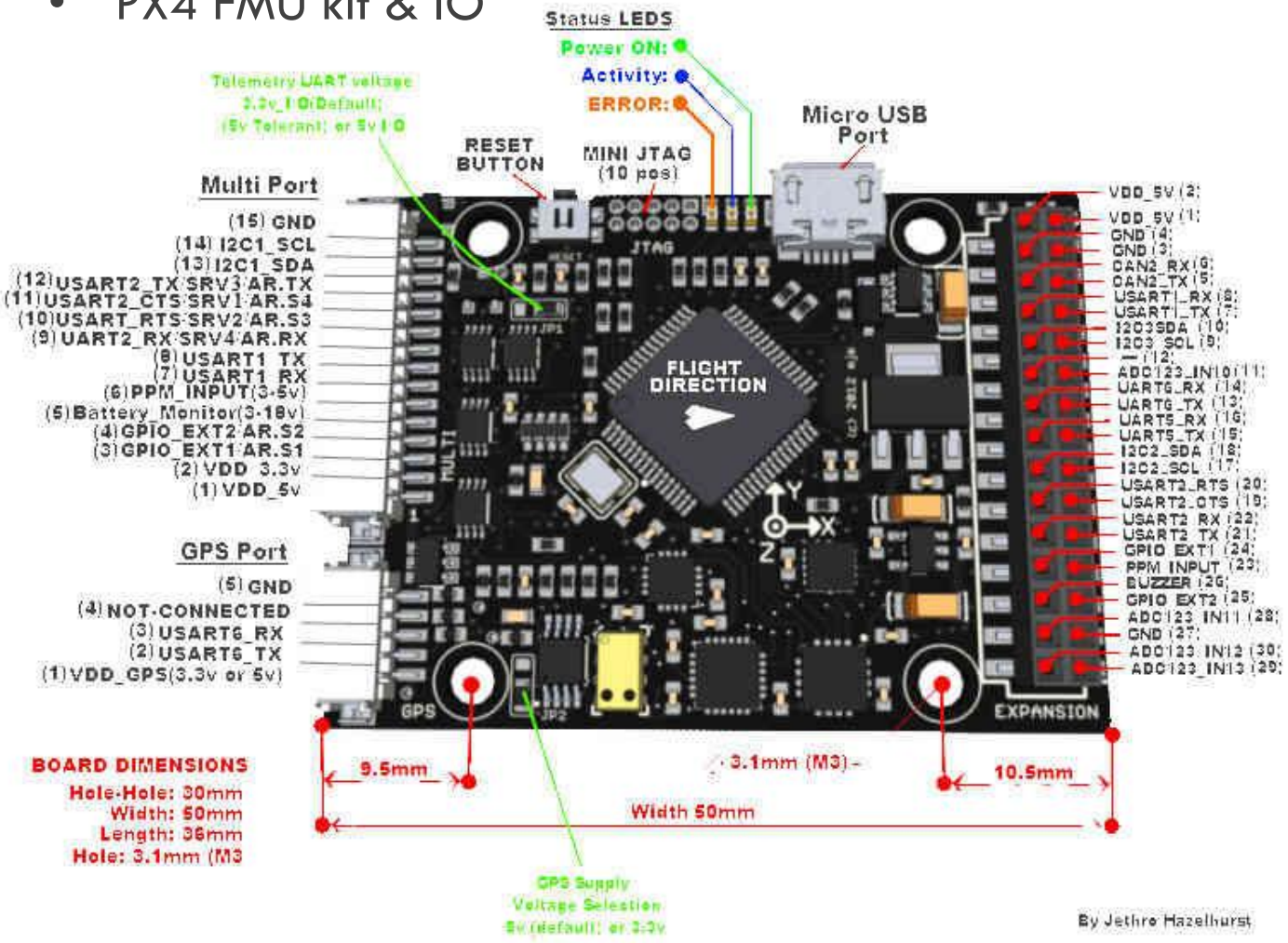
- Make ardupilot better

Microcontroller	STM32F4
Operating Voltage	3.3V
Digital I/O Pins	24 (8 PWM)
Analog Input Pins	12
Analog Output Pins	0 (DAC)
DC Current for 5V Pin	500mA
Flash Memory	1024KB
SRAM	192KB
Clock Speed	168 MHz
Length	36 mm
Width	50 mm
Weight	9.62 g

Basics of Pixhawk project

Pixhawk/Ardupilot history, differences, benefits

- PX4 FMU kit & IO



Basics of Pixhawk project

Pixhawk/Ardupilot history, differences, benefits

- PX4 FMU kit & IO

Basics of Pixhawk project

Ardupilot stack system overview

- http://ardupilot.org/dev/docs/learning-ardupilot-introduction.html

Basics of Pixhawk project

Pixhawk stack system overview

- https://dev.px4.io/en/concept/architecture.html
- https://dev.px4.io/en/concept/dronecode_architecture.html

Basics of Pixhawk project

Ardupilot & Pixhawk compatibility & limitations

- http://ardupilot.org/copter/docs/common-autopilots.html
- https://docs.px4.io/en/flight_controller/

Q & A