An Open Instrumentation Platform: Getting The Most From MAVLink, ArduPilot, and BeagleBone

Presentation Outline

Autopilots, Copters, and Drones

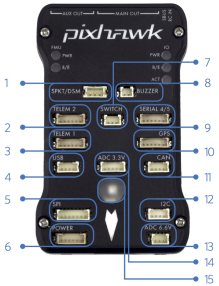
- (RC) Copters are not drones
  - Drones have an autopilot and are (or at least can be) autonomous
  - RC copters (even with an IMU) are generally not fully autonomous
- An autopilot has programmable firmware
  - Usually a microcontroller (typically AVR or ARM)
  - Lots of I/O ports (I2C, SPI, UARTs)
  - Ardupilot, OpenPilot/LibrePilot, PX4, UAVCAN
- Open source autopilot boards and host machines
  - Ardupilot - PixHawk, PX/4, AUAV-X2, PXFmini, BBBMINI Cape/BeaglePilot
  - LibrePilot - CopterControl, CC3D, Revo/Nano, OPLink Mini
  - Some autopilots support dual firmware: VRBRAIN 4
  - Price range $20 - $200 and up
  - Smart Drone Kit Using PXFmini and RaspberryPi Zero

https://www.hackster.io/12590/pi0drone-a-200-smart-drone-with-the-pi-zero-4fec08

Supported Platforms and Flight Models

- Original (software) vehicle models in ArduPilot and MAVLink
  - Copter
  - Rover
  - Plane
  - Antenna tracker
- New vehicle / flight models in MAVLink v1.0/v2.0
  - Generic micro air vehicle
  - Fixed-wing aircraft
  - Single/multi-rotor copters
  - Antenna tracker / ground control station
  - Airship
  - Free balloon
  - Rocket
  - Ground rover
  - Surface vessel, Submarine
  - Flapping wing

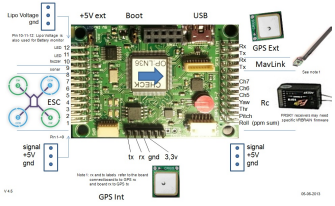
Autopilot Examples



1 Spektrum DSM receiver
2 Telemetry (radio telemetry)
3 Telemetry (on-screen display)
4 USB
5 SPI (serial peripheral interface) bus
6 Power module
7 Safety switch button
8 Buzzer
9 Serial
10 GPS module
11 CAN (controller area network) bus
12 I²C splitter or compass module
13 Analog to digital converter 6.6 V
14 Analog to digital converter 3.3 V
15 LED indicator

PixHawk Connectors (top)

CopterControl3D



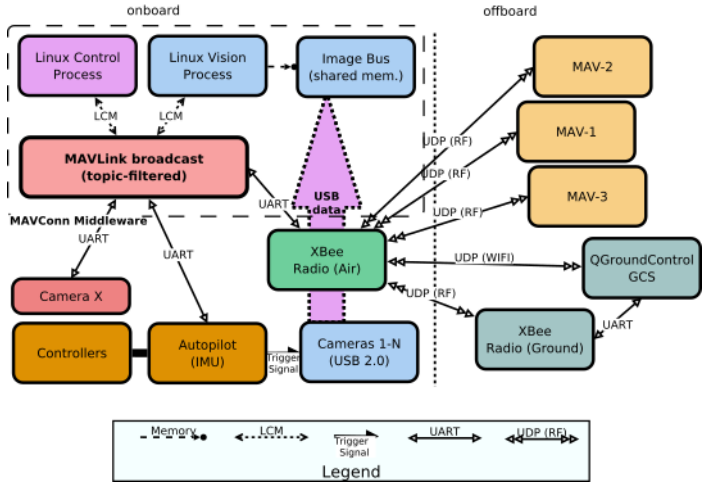
VR BRAIN 4/5 Connections

Ardupilot / APM

MAVLink and MAVConn

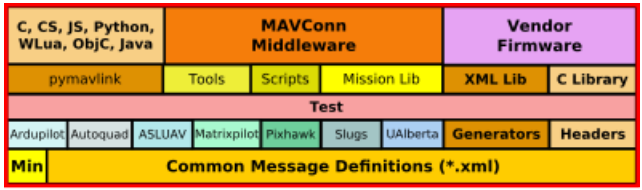
Ground Control

MAVLink System Architecture



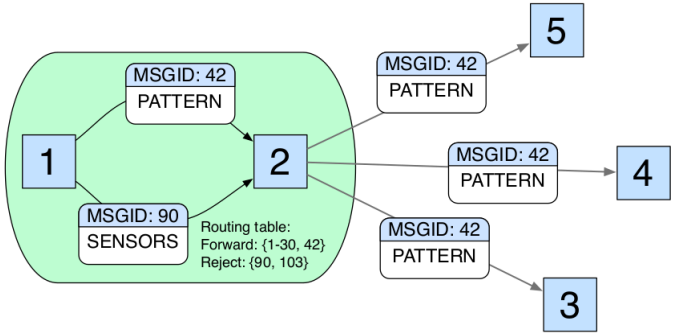
- Full MAVLink/MAVConn vehicle configuration
- Linux host system and integrated machine vision/object tracking
- Uses multiple transport/physical layers and redundant GCS links
- Camera X is a third-party camera connected via serial link

MAVLink Software Stack



- MAVConn "middleware" typically runs on onboard Linux host
- Host connects to autopilot and onboard cameras
- MAVLink supports multiple OS/IPC Mechanisms/Interfaces
- MAVLink common messages are extended by autopilot firmware

MAVLink Message Protocol Routing



- The MAVConn message broadcast includes action, status and command messages, which can be used both for onboard and offboard communication
- Messages are identified and filtered by content instead of recipient addresses
- Routing nodes (node 2) filter messages that belong only to a particular subset (nodes 3, 4, and 5)

Open/Supported Hardware

GPS, IMUs, Sensors, and More

Computer Vision, Cameras and Metadata

Airframes and Kits

and Why You Should Not BYO Airframe

Because it's hard...

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Other Vehicles and Software/Firmware

- Autonomous 3D-printed Drone http://tinyurl.com/3D-printed-drone
- UAVCAN https://github.com/uavcan
- ROS https://github.com/ros
- Other repositories https://github.com/Dronecode

Useful (and fun) Applications

- BeagleBone NDVI Cape http://tinyurl.com/beaglebone-ndvi
- SeaSlug (long-deployment mobile marine sensor platform) http://tinyurl.com/SeaSlug-pdf

Resources

Ardupilot and MAVLink

- http://copter.ardupilot.com/
- https://github.com/mavlink/mavlink
- https://github.com/mavlink/c_library
- https://github.com/mavlink/qgroundcontrol
- https://github.com/mavlink/c_uart_interface_example
- https://github.com/pixhawk/mavconn
- https://github.com/diydrones/ardupilot
- http://tinyurl.com/FLIR-TIFF-MAVLink

Additional Resources

- https://www.dronecode.org/
- https://www.librepilot.org/
- http://dev.ardupilot.com/wiki/building-px4-for-linux-with-make/
- http://copter.ardupilot.com/wiki/build-your-own-multicopter/
- http://www.instructables.com/id/DIY-Drones/

References and Specifications

Huang, Olson and Moore, Lightweight Communications and Marshalling for Low-latency Interprocess Communication. MIT CSAIL Technical Report, 2009.

Lorenz Meier, Petri Tanskanen, Lionel Heng, Gim Hee Lee, Friedrich Fraundorfer, and Marc Pollefeys. Pixhawk: A micro aerial vehicle design for autonomous flight using onboard computer vision. Autonomous Robots (AURO), 2012.

The canonical MAVLink Common Message Set is common.xml, which defines both the software interface and the MAVLINK Common Message Set documentation.

The ArduPilot "Copter" interface variant is defined in the ArduCopter GCS_Mavlink.cpp source file.

The Exif 2.3 Specification - Exchangeable image file format for digital still cameras: Exif Version 2.3, Revised on December, 2012, Camera & Imaging Products Association.

The XMP 1.0 Specification - XMP Specification, Part 1 (April, 2012), Part 2 (November 2014), Part 3 (November 2014), Adobe Developers Association.

License and Thanks!

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Revision:	0.1
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