

# BYOD? - Putting The Pieces Together For An Open Source Drone



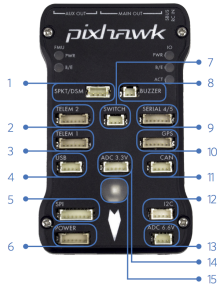
# Presentation Outline

<b>Autopilots, Copters, and Drones</b>	<b>3</b>
<b>Autopilot Examples</b>	<b>4</b>
<b>Ardupilot / APM</b>	<b>5</b>
<b>MAVLink and MAVConn</b>	<b>6</b>
<b>Ground Control</b>	<b>7</b>
<b>MAVLink System Architecture</b>	<b>8</b>
<b>The MAVLink Software Stack</b>	<b>9</b>
<b>MAVLink Message Protocol Routing</b>	<b>10</b>
<b>Open/Supported Hardware</b>	<b>11</b>
<b>GPS, IMUs, Sensors, and More</b>	<b>12</b>
<b>Computer Vision, Cameras and Metadata</b>	<b>13</b>
<b>Airframes and Kits</b>	<b>14</b>
and Why You Should Not BYO Airframe	14
<b>Other Vehicles and Software/Firmware</b>	<b>15</b>
<b>Useful (and fun) Drone Applications</b>	<b>16</b>
<b>Resources</b>	<b>17</b>
<b>References and Specifications</b>	<b>18</b>
<b>License and Thanks!</b>	<b>19</b>

# Autopilots, Copters, and Drones

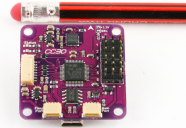
- (RC) Copters are not drones
  - Drones have an autopilot and are (or at least can be) autonomous
  - RC copters (even with an IMU) are not fully autonomous
- An autopilot has programmable firmware
  - Usually a microcontroller (typically AVR or ARM)
  - Lots of I/O ports (I2C, SPI, UARTs)
  - Ardupilot,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

# Autopilot Examples

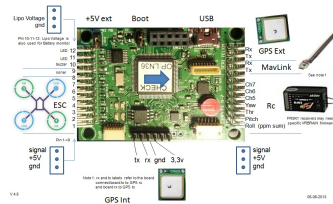


*PixHawk Connectors (top)*

- 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 I/C splitter or compass module
- 13 Analog to digital converter 6.6 V
- 14 Analog to digital converter 3.3 V
- 15 LED indicator



*CopterControl3D*



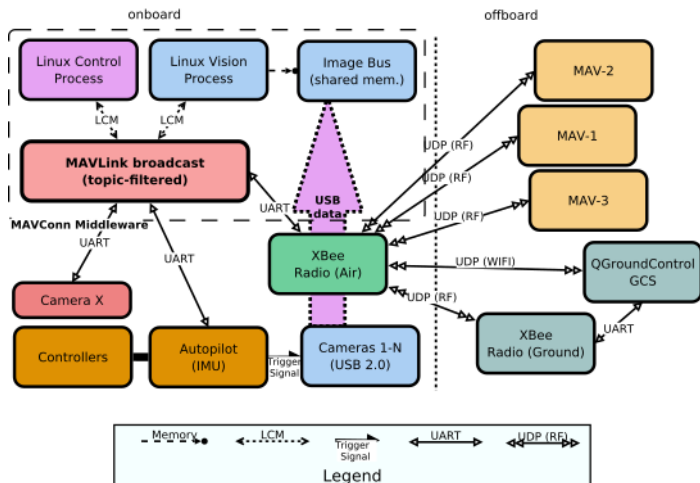
*VR BRAIN 4/5 Connections*

# Ardupilot / APM

# MAVLink and MAVConn

# Ground Control

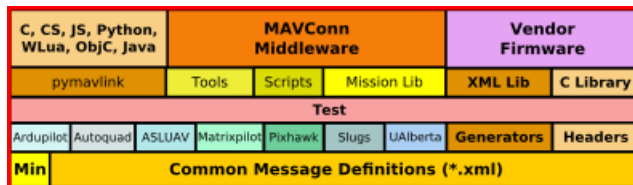
# MAVLink System Architecture



- Full MAVLink 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

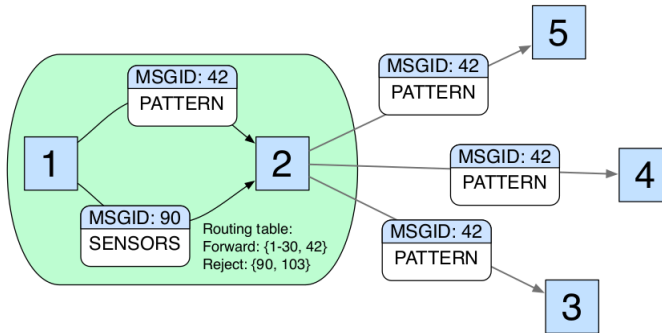


# The MAVLink Software Stack



- MAVLink "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 MAVLINK broadcast message format includes action, status and command messages, which can be used both for onboard and offboard communication
- Messages are identified 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**

# Other Vehicles and Software/Firmware

- UAVCAN <https://github.com/uavcan>
- ROS <https://github.com/ros>
- Other repositories <https://github.com/Dronecode>

# Useful (and fun) Drone Applications

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# Resources

## Ardupilot and MAVLink

- <http://copter.ardupilot.com/>
- <https://github.com/mavlink/mavlink>
- [https://github.com/mavlink/c\\_library](https://github.com/mavlink/c_library)
- <https://github.com/mavlink/qgroundcontrol>
- [https://github.com/mavlink/c\\_uart\\_interface\\_example](https://github.com/mavlink/c_uart_interface_example)
- <https://github.com/pixhawk/mavconn>
- <https://github.com/diydrones/ardupilot>

## 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!

**Author:** Stephen L Arnold

**Contact:** [answers@vctlabs.com](mailto:answers@vctlabs.com)

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