

Building castles in the sky

Open Source :: Drones
FOSSASIA 2016

Ong Jiin Joo
Garuda Robotics

Public Service Announcement

Obey Drone Laws CAAS Fly It Safe

DOs



DON'Ts



Planning for non-recreational flight?
Be a Licensed UAV Operator

@jiinjoo

I build software around the drone ecosystem

My Guiding Principles

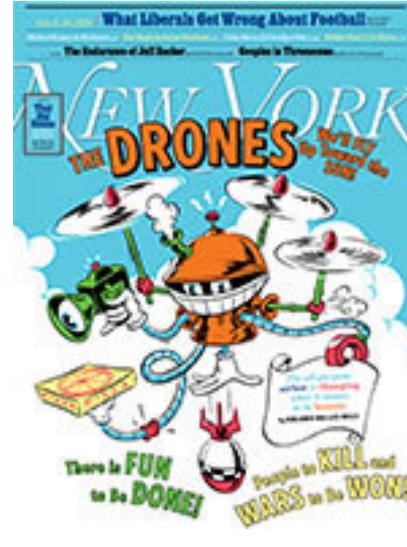
- Don't reinvent the wheel => FOSS
- Trust nobody => Lives are at stake

Drones At Work



We fly drones for data





WHAT'S UP IN DRONE LAND

Drone state of the world



Drone state of the world

The Drone Market Environment 2015

DRONE INDUSTRY INSIGHTS

Drone Manufacturer (Consumer/Commercial)

Coalitions/Organizations/Initiatives

User Groups/Networks

Universities/Institutes/Research Programs

Services/Software/Systems/OS/Mapping/3D Modeling

Suppliers

Media/News/Blogs/Magazines

Components/Systems

Drone Operator Marketplace

Education/Training

Conferences/Events

Insurance

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Drone state of the world

Rank	Company	Category	
1	Parrot	Hardware	84%
2	DJI	Hardware	71%
3	Ehang	Hardware	13%
4	3D Robotics	Hardware	13%
5	Zano	Hardware	12%
6	esri	Software	10%
7	Aegis	Hardware	9%
8	Yuneec	Hardware	6%
9	SkyWard	Software	6%
10	Nixie	Hardware	6%
11	CyPhy	Hardware	6%
12	Aeryon	Hardware	6%
13	FLIR	Hardware	6%
14	Syma Toys	Hardware	5%
15	Hubsan	Hardware	5%
16	Helico Aerospace	Hardware	4%
17	Airware	Software	4%
18	AGI	Software	4%
19	Microdrones	Hardware	4%
20	Sabre	Hardware	4%

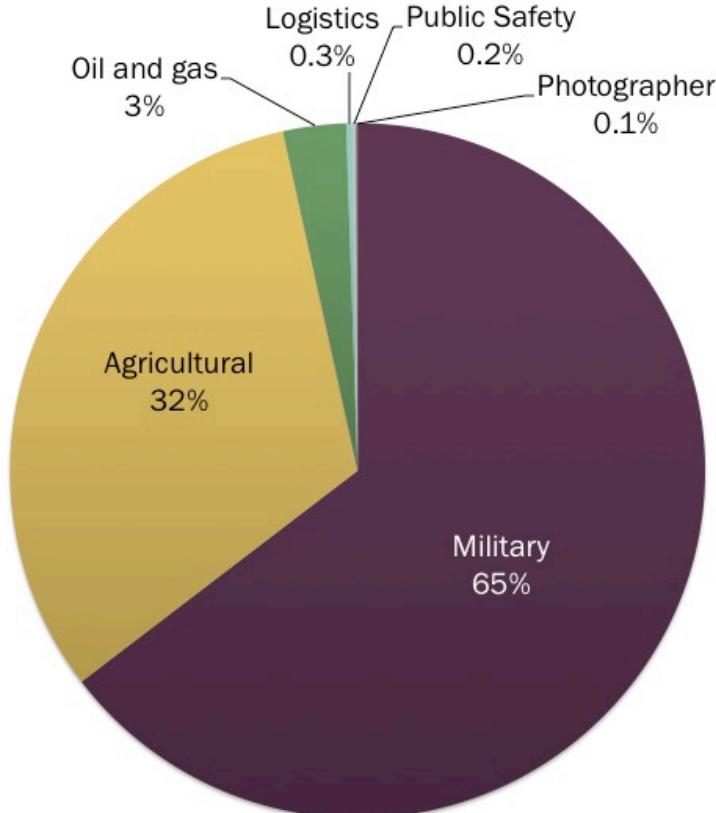
It's a big mess, but shake-off is happening

Hardware commoditizing quickly

Innovation backed by real dollars
for full stack systems
(hardware + software + services)

Drone state of the world

Projected US Commercial UAV Hardware Market
By Industry in 2020



The US equivalent
to an operator
permit to certify
your drone to be
airworthy (for
professional work)

We are beginning to see OSS standards

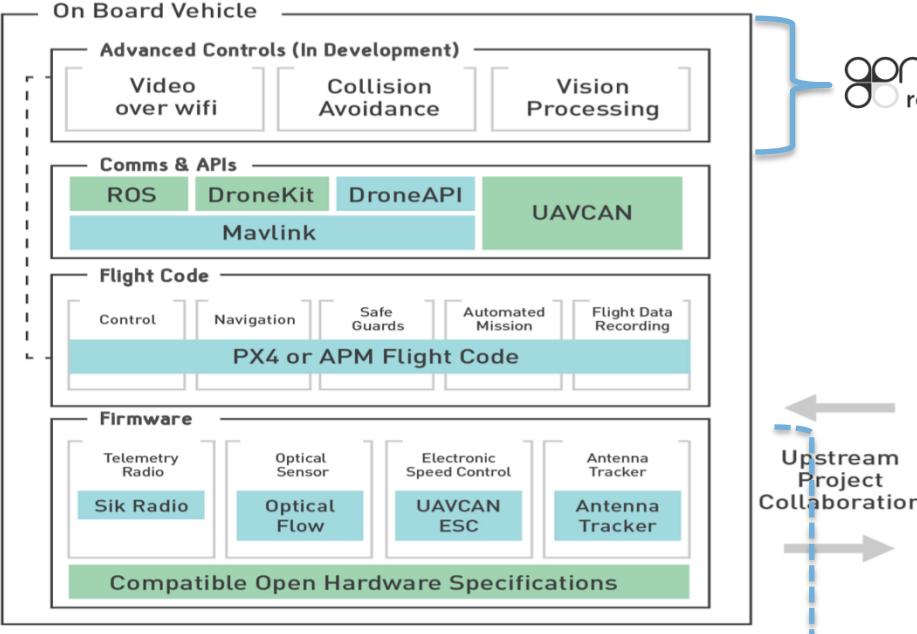


- To create a common, shared, open source platform for drones



- Linux Foundation provide governance to ensure interoperability.
- Current status...

Motley crew, assemble!



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robotics

Dronecode Projects
Affiliated Projects

Project Management Stewardship

(Onboarding, Developer engagement etc.)

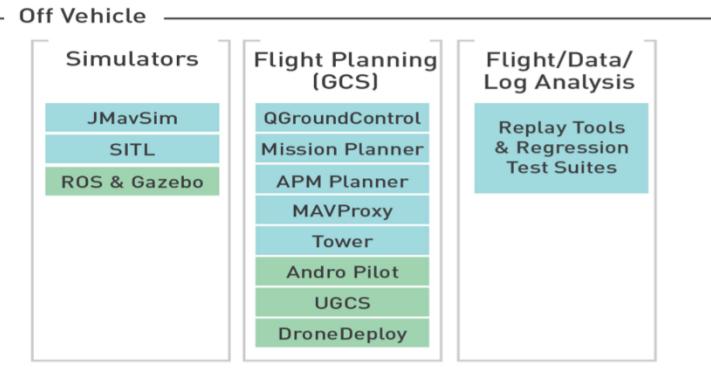
Infrastructure & Documentation

(Development servers, developer resources, certifications, etc.)

Deployment, Release & Testing

(Coverity code testing, etc.)

New Requirements, Feature Evaluation & Development



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Upstream Project Collaboration

Driven by the community, the tinkerers

DIY DRONES
The Leading Community for Personal UAVs



HobbyKing.com

NEW STOCK ARRIVING EVERY DAY!

NEW PRODUCTS / FLASH SALE

f t y Search HK GO

RC Groups.com

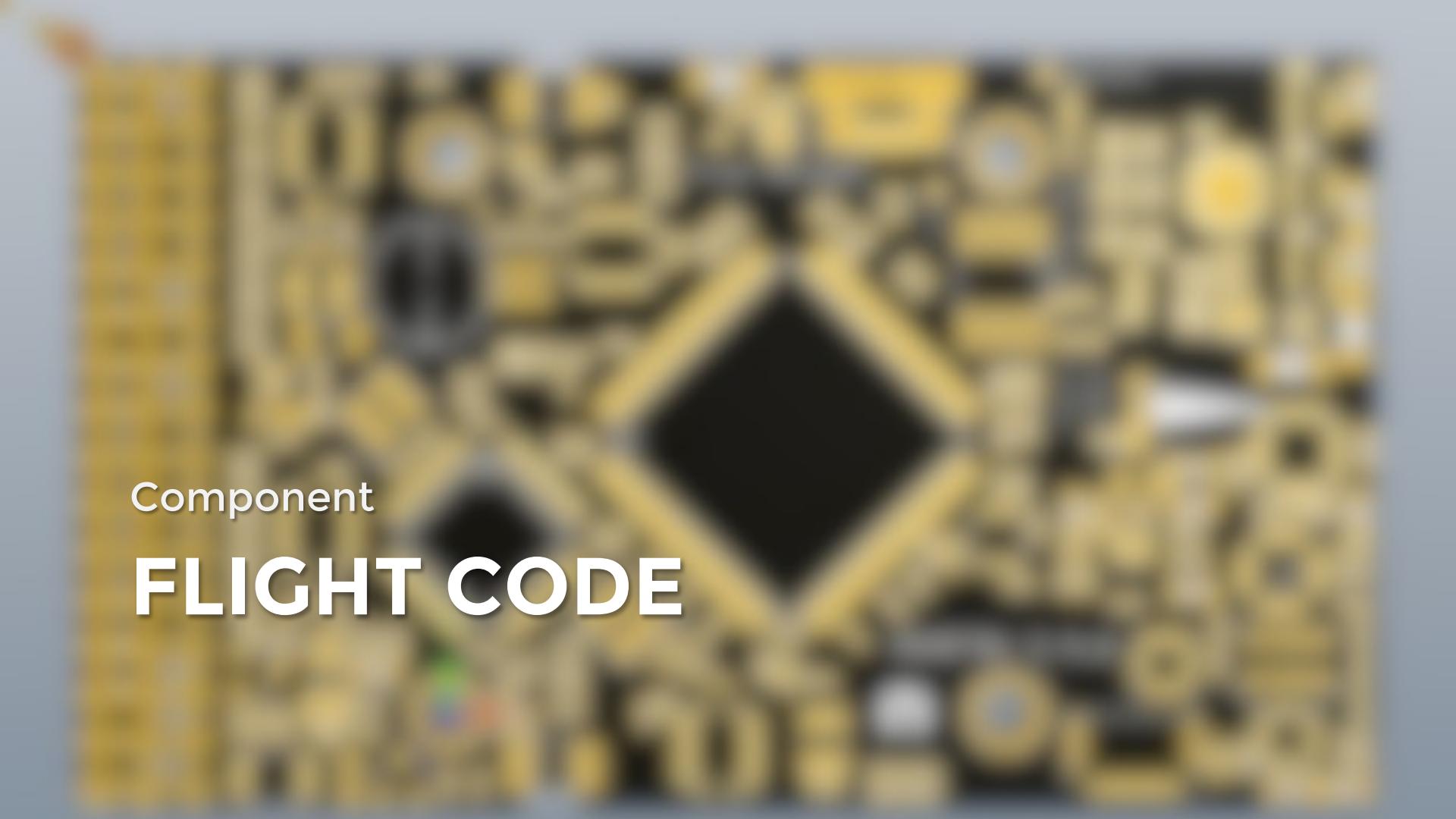


- Vibrant community at the forefront of what is possible
- Sharing of mistakes increases the overall quality of drones built
- Many “home made” version of bleeding edge technologies

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robotics

Today's workshop

- 1 Open source flight controller firmware
e.g. ArduPilot, OpenPilot ...
- 2 Open source ground control station
e.g. Mission Planner, Tower ...
- 3 “Drone APIs” to the not so open systems
e.g. Dronekit, Parrot/DJI Developer API ...



Component

FLIGHT CODE

Open Source Flight Code



<https://github.com/diydrones/ardupilot>



<https://github.com/PX4/Firmware>



<https://github.com/openpilot/OpenPilot>



PIXHAWK



PX4



NAVIO+



ERLE BRAIN2



CC3D



PARROT BEBOP

Or invest in a clone 😊



HKPilot32

RTFhawk



Fixhawk



ArduRover v2.4.2



ArduPlane V2.74b



ArduCopter V3.0.1



ArduCopter V3.0.1



ArduCopter V3.0.1

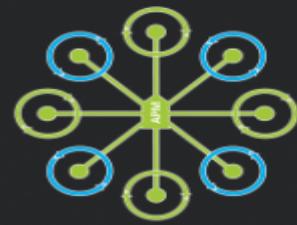
Please click the images above for "Flight versions"



ArduCopter V3.0.1



ArduCopter V3.0.1



ArduCopter V3.0.1

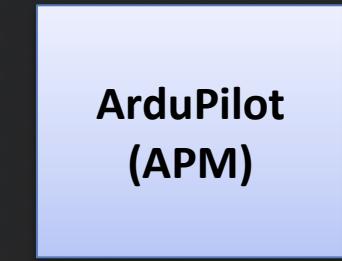
Download firmwares

PX4IO Firmware

Beta firmwares

Load custom firmware

Pick previous firmware



 [HIL SIMULATOR](#) [PLANE](#) [QUAD](#) [HELI](#)



APM:Copter

ROTORCRAFT UAV WITH FULL AUTONOMOUS CAPABILITY
APM:COPTER CAN TRANSFORM A WIDE RANGE OF HELICOPTER AND MULTIROTOR AIRCRAFT INTO AUTONOMOUS FLYING VEHICLES



APM:Plane

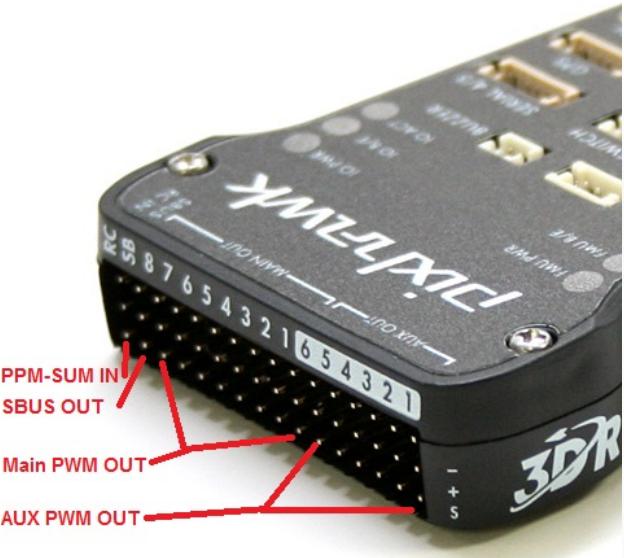


APM:Rover

Nerve center for flight

Side connects to ESCs/motors

Top connects to sensors,
comms, power, etc.



System Architecture

<http://dev.ardupilot.com>

Start with Example Sketches

```
cd libraries/AP_GPS/examples/GPS_AUTO_test
```

```
make px4-clean
```

```
make px4-v2
```

```
make px4-v2-upload
```

```
mavproxy.py --setup --master \
```

```
/dev/serial/by-id/usb-3D_Robotics_PX4_FMU_v2.x_0-if00
```

Then narrow into the part you want to customize.

Rarely need to customize the firmware.

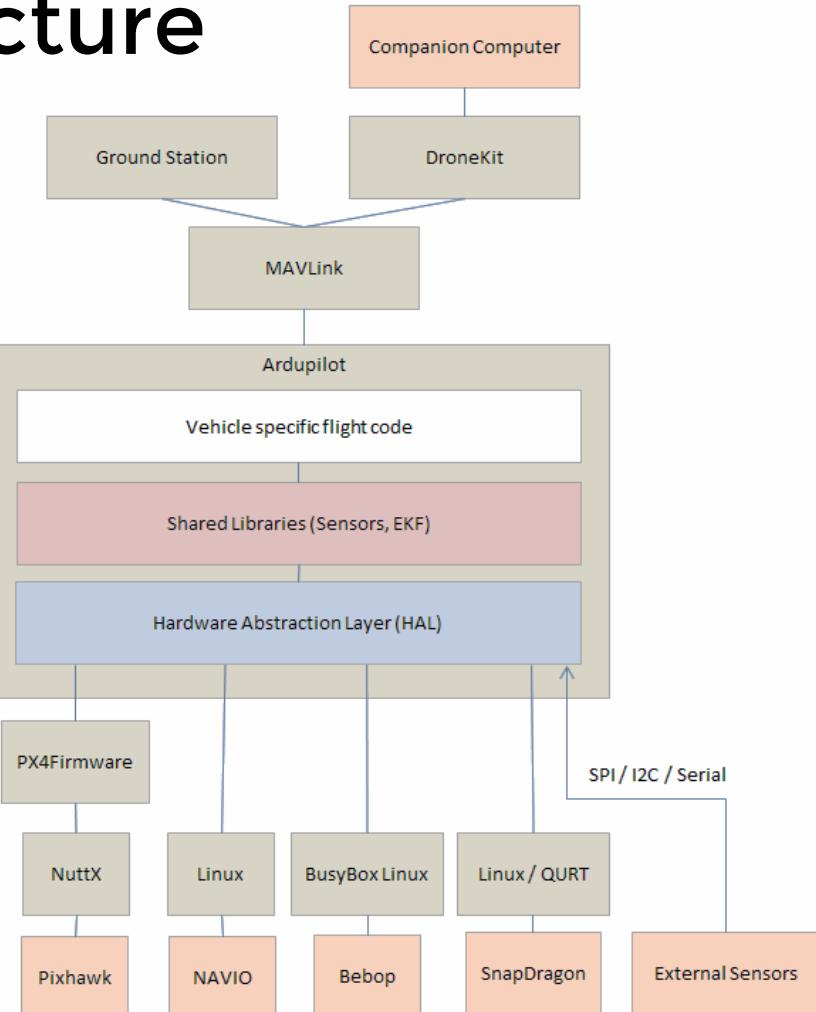
UI / API

Communications Layer

Flight Code

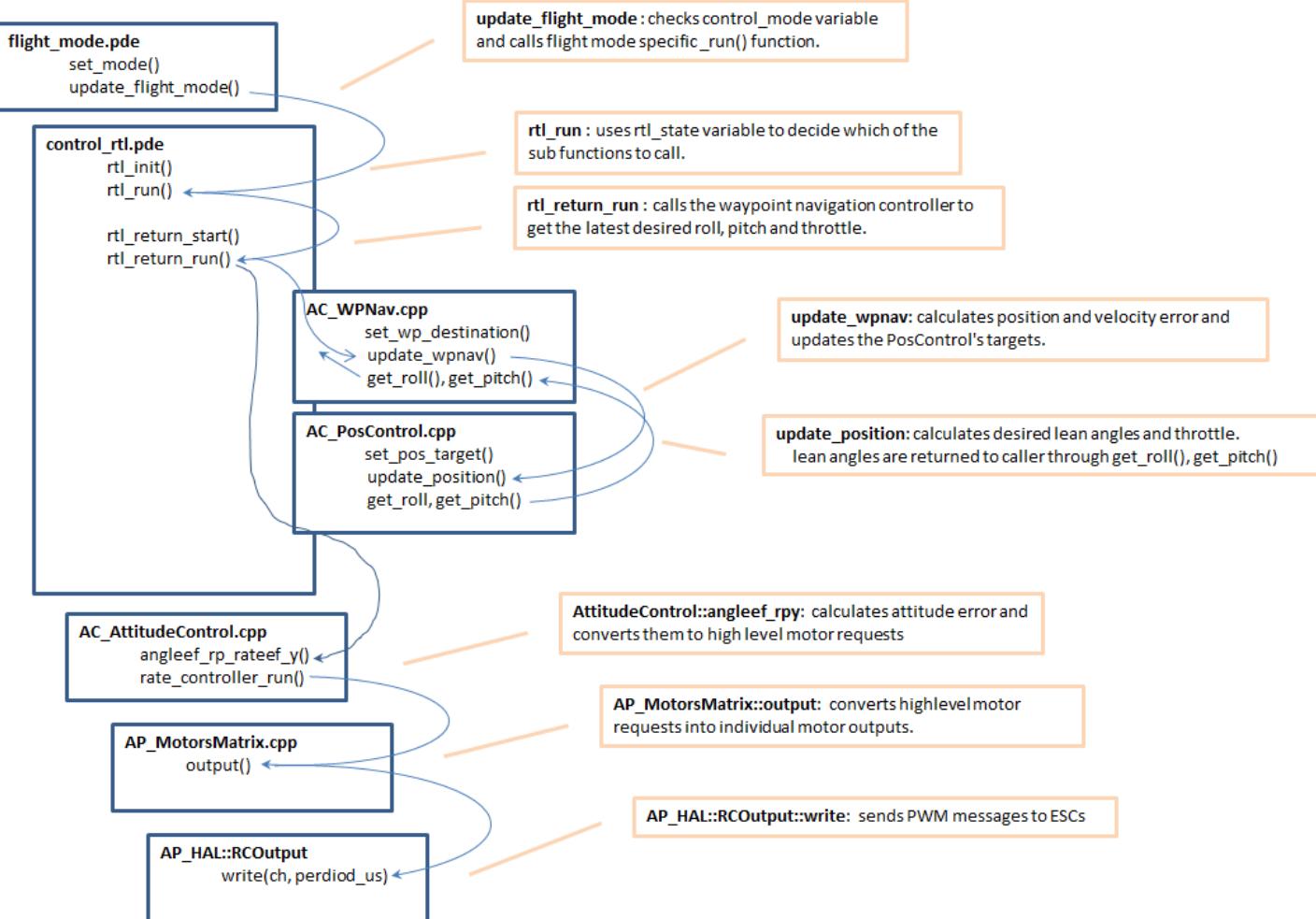
OS

Hardware



Sample callstack of Copter (Vehicle Specific)

AutoPilot flight modes such as AltHold, RTL, Auto



Suitability

GROUND CONTROL





Altitude (m)	GroundSpeed (m/s)
0.00	0.00
Dist to WP (m)	Yaw (deg)
0.00	0.00
Vertical Speed (m/s)	Distance to Home (m)
0.00	0.00



GEO 0.000000 0.000000 0.00 Tuning Auto Pan Zoom 1.9



Distance: 0.7989 km
 Prev: 522.46 m AZ: 67
 Home: 462.94 m



Zoom

Action

GEO -35.040907
 117.832741
 11.40

Grid [View KML](#)

[GoogleSatelliteMap](#)

Status: loaded tiles

[Load WP File](#)

[Save WP File](#)

[Read WPs](#)

[Write WPs](#)

[Home Location](#)

Lat -35.04173272

Long 117.8277683

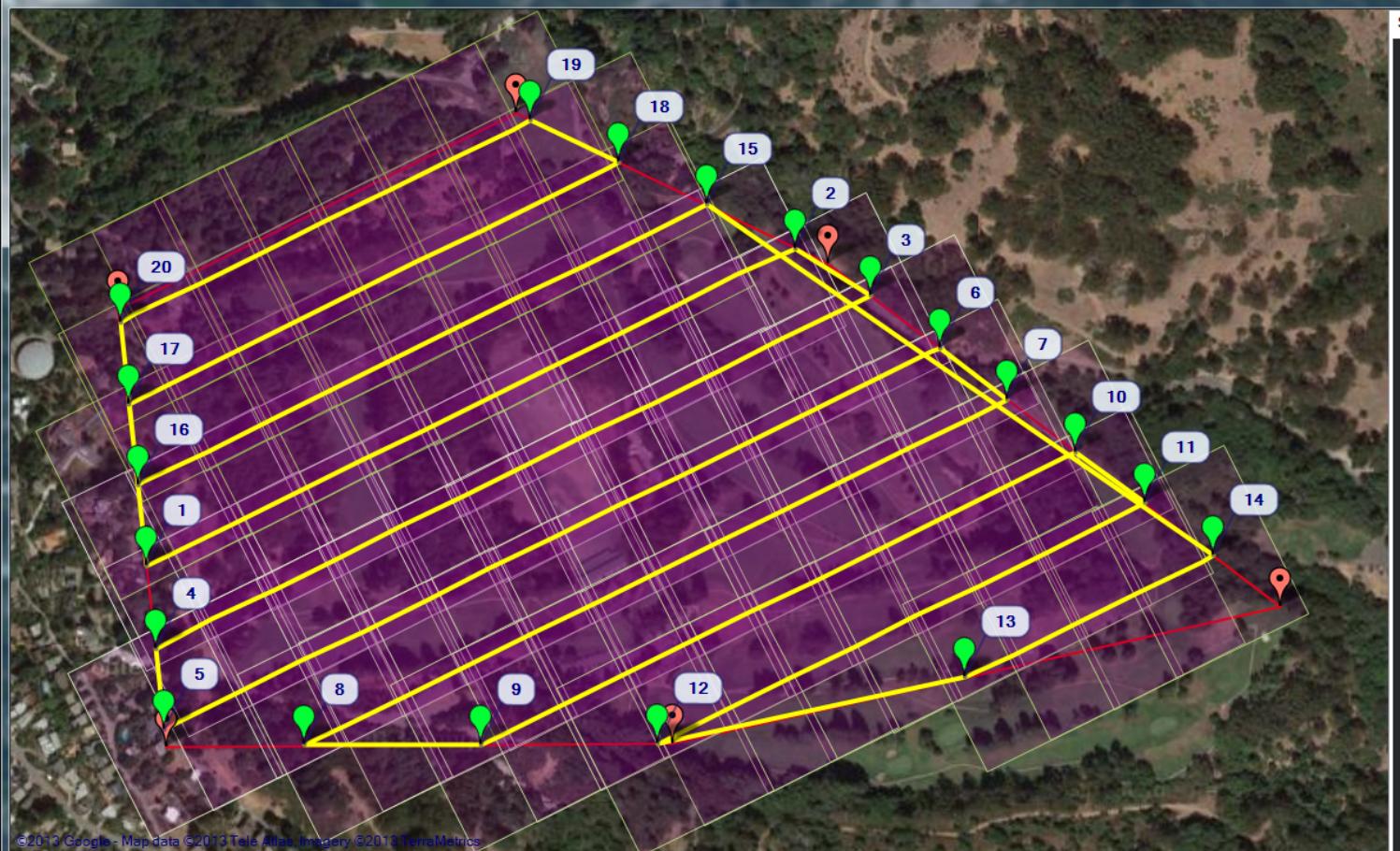
Alt (abs) 38

©2014 Google - Map data ©2014 Tele Atlas, Imagery ©2014 TerraMetrics

Waypoints

WP Radius 2 Loiter Radius 60 Default Alt 100 Absolute Alt Verify Height [Add Below](#) Alt Warn 20

	Command				Lat	Long	Alt	Delete	Up	Down	Grad %	Dist	AZ
1	WAYPOINT	0	0	0	-35.0407928	117.8277898	100	X			95.7	104.5	1
2	WAYPOINT	0	0	0	-35.0406786	117.8260410	100	X			0.0	159.7	275
3	WAYPOINT	0	0	0	-35.0417239	117.8251612	100	X			0.0	141.2	215
4	WAYPOINT	0	0	0	-35.0428395	117.8259873	100	X			0.0	145.1	149
5	WAYPOINT	0	0	0	-35.0427165	117.8274572	100	X			0.0	134.5	84



Simple

Simple Options

Camera

Canon SX260-SX280

Altitude [m]

150

Angle [deg]

63

 Camera top facing forward

Accept

Display

 Boundary Markers Grid Internals Footprints Advanced Options

©2013 Google - Map data ©2013 Tele Atlas, Imagery ©2013 TerraMetrics

Stats

Area:	541011 m ²	Pictures:	91
Distance:	8.46 km	No of Strips:	10
Distance between images:	76 m	Footprint:	205.7 x 151.7 m
Ground Resolution:	5.06 cm	Dist between lines:	82.27 m

Progress

Got + 679 samples

Compass 1 error: 0.23

Compass 2 error: 0.27

Compass 3 error: 99

more data needed Aim For Yellow-Green

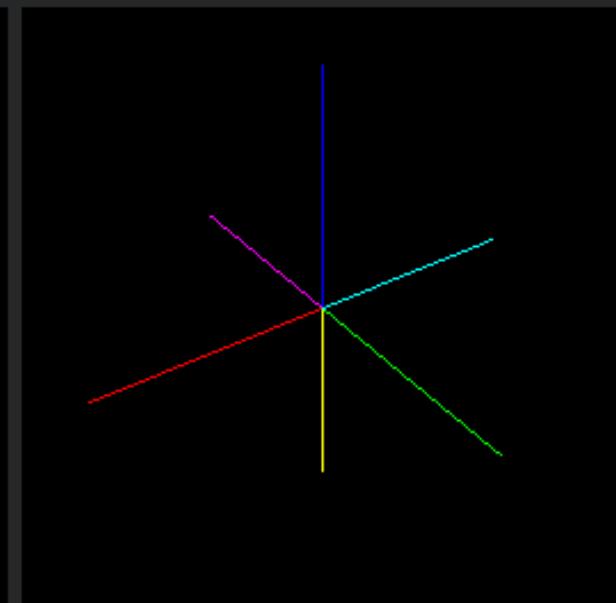
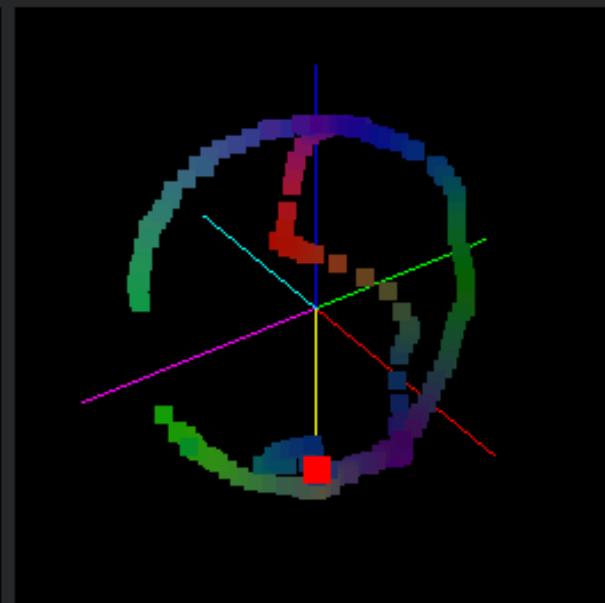
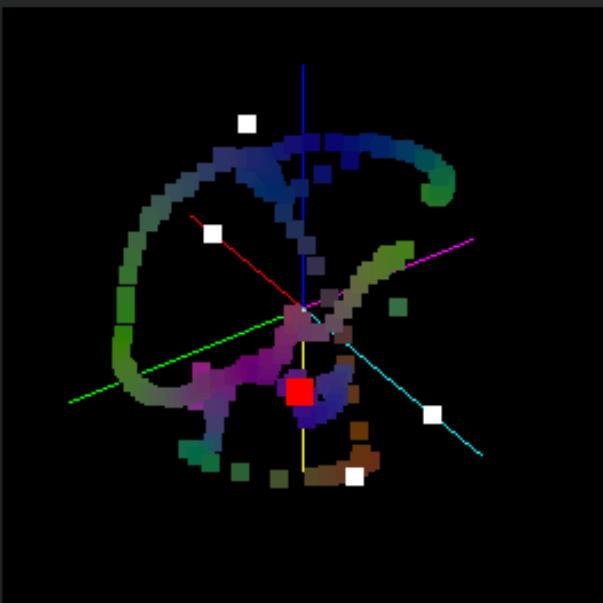
Aim for the White dots.

Please point the autopilot north, and rotate around
the pitch axis until level.

then

Turn the autopilot 90 degrees, and rotate around the
roll axis until level.

This method should hit every white dot.



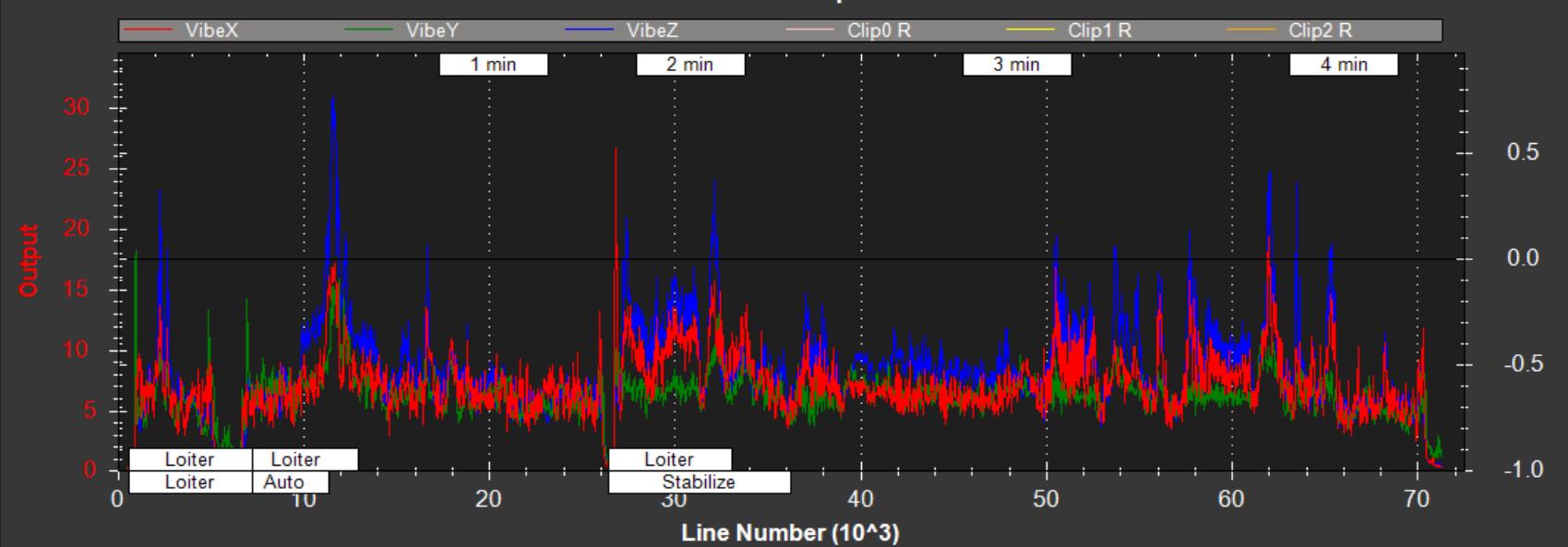
Rotate with each data point

Use Auto Accept

Done



Value Graph



Graph this data Left Graph this data Right Clear Graph Load A Log

Show Map Use Time None

							Type	Length	Name
0	2015-06-26 10:0...	FMT	128	89	FMT	BBnNZ	Type		
1	2015-06-26 10:0...	FMT	129	31	PARM	QNF	TimeUS	Name	Va
2	2015-06-26 10:0...	FMT	130	49	GPS	QBIHBcLLeeEef	TimeUS	Status	GM
3	2015-06-26 10:0...	FMT	131	49	IMU	QfffffIffBB	TimeUS	GyrX	Gy
4	2015-06-26 10:0...	FMT	132	75	MSG	QZ	TimeUS	Message	
5	2015-06-26 10:0...	FMT	133	39	RCIN	Qhhhhhhhhhhhh...	TimeUS	C1	C2
6	2015-06-26 10:0...	FMT	134	35	RCOU	Qhhhhhhhhhhhh	TimeUS	Ch1	Ch
7	2015-06-26 10:0...	FMT	136	25	BARO	Qffff	TimeUS	Alt	Pre
8	2015-06-26 10:0...	FMT	137	17	POWB	QCCCH	TimeUS	Vcc	Vcc

- + RCIN
- + RCOU
- + STRT
- + UBX1
- + UBX2
- + UBX3
- + VIBE
 - TimeUS
 - VibeX
 - VibeY
 - VibeZ
 - Clip0
 - Clip1
 - Clip2

Other common GCS



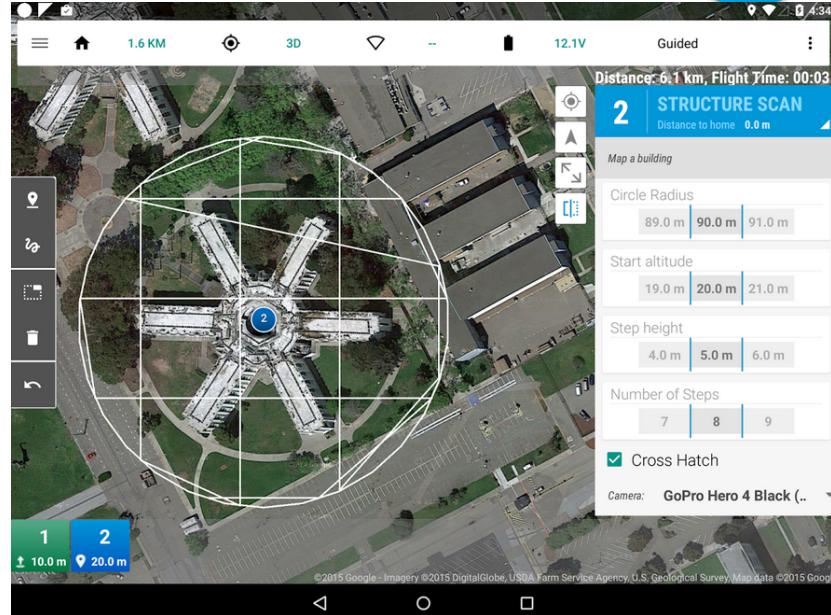
Windows, Mac, Linux
(originally by MAVLink author)

APM Planner



Windows, Mac, Linux
Similar to Mission Planner
Less features

Tower (previously DroidPlanner)



Android (by 3DR)

Ground to air communication protocol



<https://github.com/mavlink/mavlink>

It packs C-structs over serial channels,
tested on PX4, Pixhawk, APM etc.

Full command specification

<https://pixhawk.ethz.ch/mavlink/>

Some examples:

MAVLINK_MSG_ID_HEARTBEAT

MAVLINK_MSG_ID_REQUEST_DATA_STREAM

MAVLINK_MSG_ID_PARAM_REQUEST / LIST

SET_MODE

MAVLINK_MSG_ID_MISSION_REQUEST / ACK

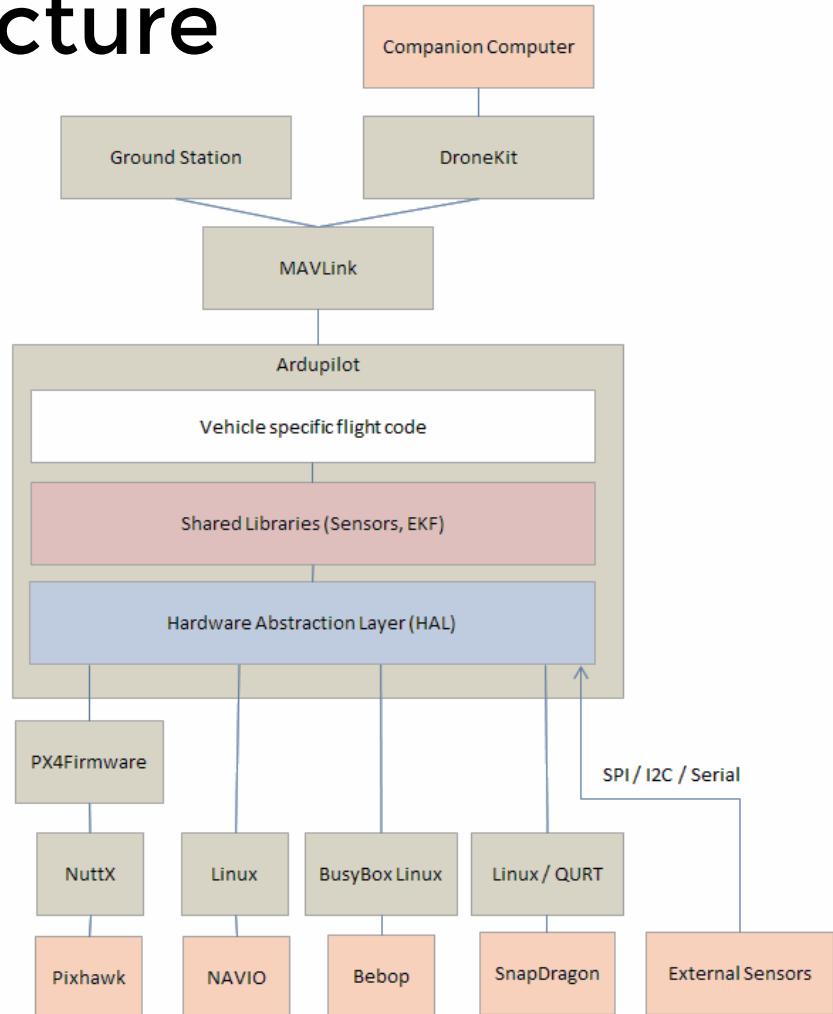
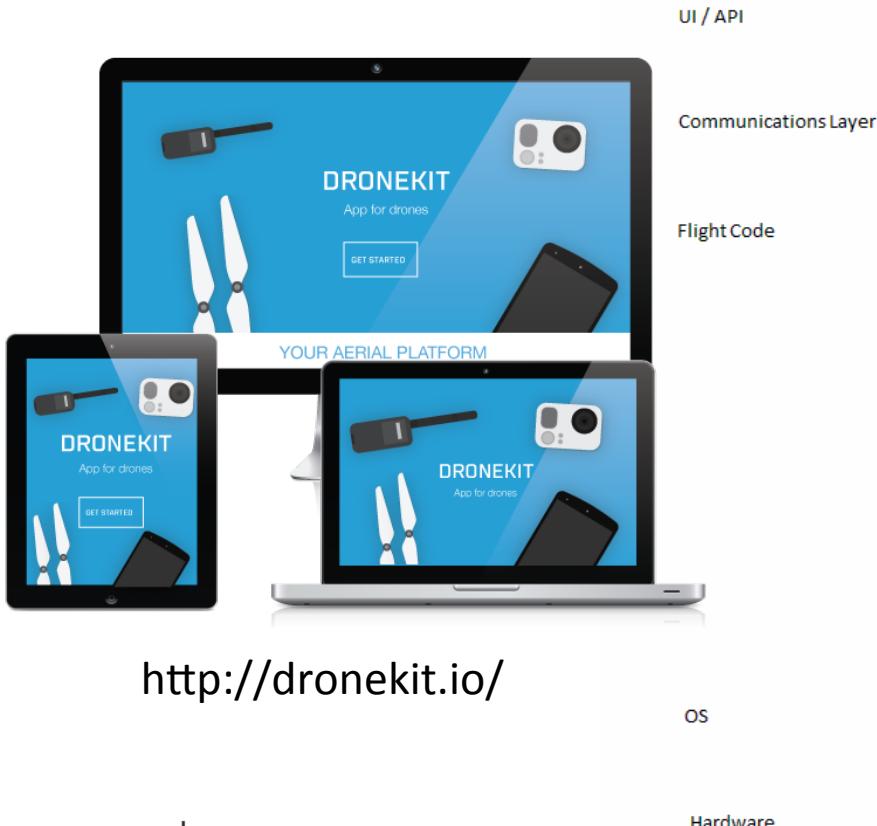
MAVLINK_MSG_ID_RADIO / STATUS

MAVLINK_MSG_ID_DIGICAM_CONFIGURE

Abstraction

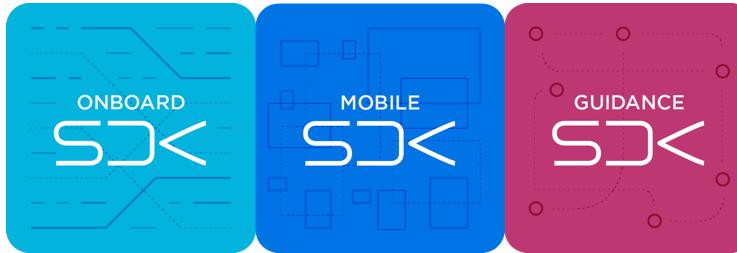
DRONE API

System Architecture



<http://dronekit.io/>

Other proprietary platforms also expose APIs



<http://developer.dji.com/>



<http://developer.parrot.com/>

Ushering much development around UAVs

New algo



INTELLIGENT PATH
PLANNING

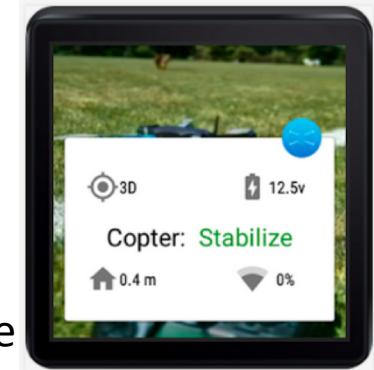


AUTONOMOUS
FLIGHT



LIVE TELEMETRY

New data capture



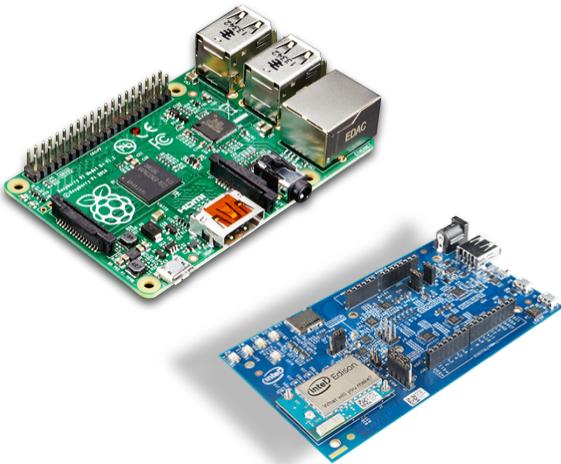
New device

DroneKit-Python

Can be executed from
within Mission Planner

or

Do stuff on board drones



```
print "Start simulator (SITL)"
from dronekit_sitl import SITL
sitl = SITL()
sitl.download('copter', '3.3', verbose=True)
sitl_args = ['-I0', '--model', 'quad', '--home=-35.363261,149.165230,584,353']
sitl.launch(sitl_args, await_ready=True, restart=True)

# Import DroneKit-Python
from dronekit import connect, VehicleMode

# Connect to the Vehicle.
print "Connecting to vehicle on: 'tcp:127.0.0.1:5760'"
vehicle = connect('tcp:127.0.0.1:5760', wait_ready=True)

# Get some vehicle attributes (state)
print "Get some vehicle attribute values:"
print " GPS: %s" % vehicle.gps_0
print " Battery: %s" % vehicle.battery
print " Last Heartbeat: %s" % vehicle.last_heartbeat
print " Is Armable?: %s" % vehicle.is_armable
print " System status: %s" % vehicle.system_status.state
print " Mode: %s" % vehicle.mode.name      # settable

# Close vehicle object before exiting script
vehicle.close()

# Shut down simulator
sitl.stop()
print("Completed")
```

DroneKit-Android

Listens for events from
3DR services

Can potentially write
background services while
user is using Tower in the
front

Other APIs e.g. DJI provides
Obj-C libraries for iOS as
well

```
@Override
public void onDroneEvent(String event, Bundle extras) {
    switch (event) {
        case AttributeEvent.STATE_CONNECTED:
            alertUser("Drone Connected");
            updateConnectedButton(this.drone.isConnected());
            break;

        case AttributeEvent.STATE_DISCONNECTED:
            alertUser("Drone Disconnected");
            updateConnectedButton(this.drone.isConnected());
            break;

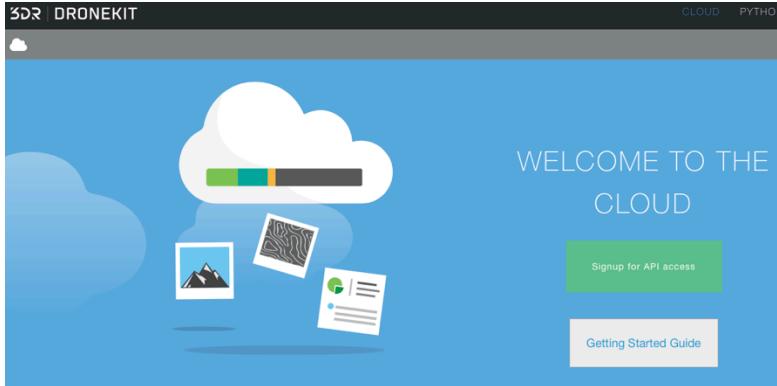
        case AttributeEvent.STATE_VEHICLE_MODE:
            updateVehicleMode();
            break;

        case AttributeEvent.TYPE_UPDATED:
            Type newDroneType = this.drone.getAttribute(AttributeType.TYPE);
            if (newDroneType.getDroneType() != this.droneType) {
                this.droneType = newDroneType.getDroneType();
                updateVehicleModesForType(this.droneType);
            }
            break;

        case AttributeEvent.SPEED_UPDATED:
            updateAltitude();
            updateSpeed();
            break;

        case AttributeEvent.HOME_UPDATED:
            updateDistanceFromHome();
            break;
    }
}
```

DroneKit-Cloud



Signup disabled

REST based API

An example of the potential: <http://www.droneshare.com>
(source: <https://github.com/dronekit/droneshare>)

Today we will demo with **Garuda Plex** (not yet for public consumption)

Small

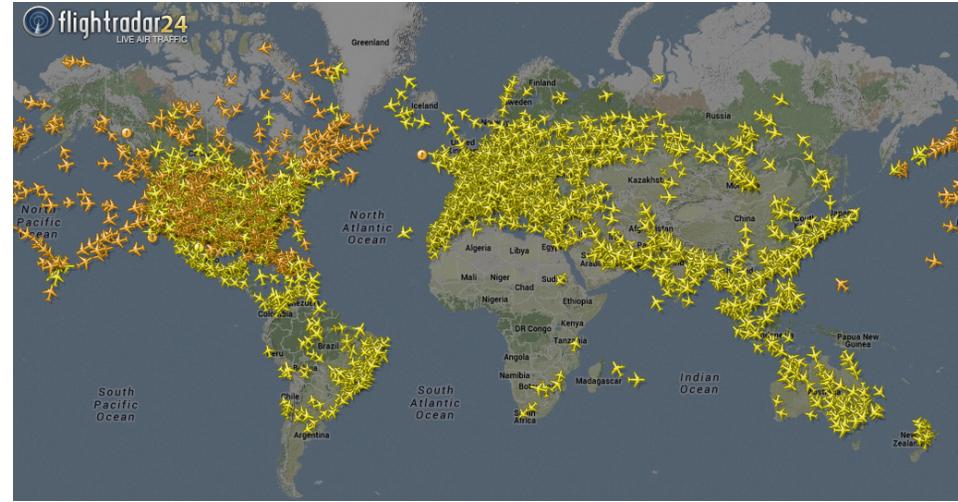
DEMO

Things to build



Your own Ground Control Station

- Most common to extend
- Most dangerous (especially autonomous missions)



Your own Cloud Solutions

- Vast number of use cases waiting for you!
- Examples of what we built:
 - GIS, Image Analytics, Asset Library, Live Streaming, Flight Scheduling

Things to build



Your own Payload / sensors

- Can be related to flight or not, e.g. precision landing
- Examples: camera, thermal camera, LiDAR, sonar, etc.



Your own drone / full stack robotics solution

- Much commercial use cases to solve
- Example: video of Garuda DragonFly

Closing Thoughts

- OSS drone code is quite messy now, but therein lies the opportunity
- A good response to tighter drone regulations is writing better and safer software
- We should take full advantage of our affordances to see from the sky to do good



Thank You!

HAPPY BUILDING