DARPA Bay Area Hackfest

Chris Anderson, 3DR CEO

NASA AMES Conference Center

November 15, 2017
Neglected Dimension of Innovation #1: Crazy Cheap

The traditional view of the market (Aerospace version)
Neglected dimension #1: Crazy Cheap
• 85,000+ registered members
• 2 million page views/month
• 10,000 blog posts
• 50,000 discussion threads
• 150,000 comments/year
And it kept going..

First 3DR and DJI products launch

And it kept going..
DIY ("tech")
- Community
- Amateurs
- "Fast, Cheap, Out of Control"
- Unregulated
- Code/components

Consumer ("toy")
- Ease of use
- Low cost
- Fun
- Killer app (video)
- Vertical integration

Commercial ("tool")
- Utility/ROI
- Reliability
- Integration
- Reg compliance
- Data!
- Cloud platforms

Aerospace/military
- Relatively low tech (remotely piloted)
- Export controlled
- VERY expensive

FAA only allows recreational use
FAA allows commercial use

1950s-2000s
2007
2012
2016
2020
Units
### DIAMETRICALLY DIFFERENT WORLDS

<table>
<thead>
<tr>
<th></th>
<th>Aerospace industry</th>
<th>Open innovation</th>
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<tr>
<td><strong>Cost</strong></td>
<td>High</td>
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<td>High</td>
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<td><strong>Pace of innovation</strong></td>
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<td><strong>Number of customers</strong></td>
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Price Elasticity Works
(“cost plus accounting” is vulnerability of aerospace industry)

SpaceX vs the United Launch Alliance (traditional aerospace)
When you leave this session I want you to remember three things (1 min, Lorenz & Ramon):
- Tough and Competent: Safety & Excellence

Dronecode is the 2nd, more open ecosystem - open to collaborate on standards with anyone, including DJI.

We will support you in integrating your products and services - if you reach out to us.
A neutral place where industry and ecosystem developers can work together to build the world’s leading open UAV software platform
Dronecode members
Full Software Stack

Vehicle
- PX4 pro

Communication
- MAVLink

Ground Segment
- QGroundControl

Autonomy
- Vision based localization and avoidance

Middleware
- DDS

Programming Interface
- Drone/core
## Full Software Stack

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Drone Market 3.0

$21B^1

2009 2012 Today 2021

Commercial Cargo & Flying Cars

Consumer

DIY
PX4 platform portability

- PX4 Flight Core Apps
- Company Apps
- PX4 Middleware
  - NuttX OS
  - Linux
  - DSP / QuRT
- Pixhawk + Companion Computer
- System on Chip (CPU + DSP)
PX4 has a well established software development workflow balancing agility and high speed with solid quality assurance. The entire platform development is driven by industry feedback.
THE COMPLETE "END-TO-END" OPEN SOURCE UAV PLATFORM

Dr. Lorenz Meier
Ramon Roche
Drone Market 3.0

Today

Commercial Cargo & Flying Cars

Consumer

DIY

$21B

2009 2012 2021

Today
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Why does the full software stack matter?

90% solution in flight control  
90% solution communication  
90% solution on the API  
Bad user experience

0.9 * 0.9 * 0.9 = 0.73

The user experiences the stack, not components
Today and Tomorrow

**Today**
- 6-month release cycle
- 20+ supported hardware platforms
- Daily flight testing of master
- Versatile groundstation
- API (Dronecore)
- Airspace integration

**Tomorrow**
- Computer vision as default
- Certified distribution and releases
- High reliability hardware
- High reliability software (cybersecurity & safety)
- LTE connectivity
Heterogeneous Onboard Computing

STM32 F7

Unified pub/sub Middleware

OcPoc

Intel Aero

Nvidia TX2

NXP i.MX

Snapdragon Flight

Industrial Hardware

- Short integration sprints with multiple component manufacturers
- Better inertial sensors
- Better GPS
- Better airspeed
- More compute
- Higher reliability (HW & SW)
Computer Vision and AI

- Partnership with ETH Zurich
- Vision-based navigation (VIO)
- Vision-based avoidance
- Development effort: 18 months, several man-years
- First release: v1.7
Ecosystem and Contributors
Contributors

Contributors
Leading products and platforms based on Dronecode PX4
Europe’s first live demonstration of U-space (UTM) capabilities -

September 14th, Geneva

Continuous Integration - SITL / HITL

- Official builds
  - Stable
  - Beta
  - Development
- Daily master
- Pull requests
  - Unit and integration tests
  - Build targets (platforms)
  - Verifies code style
Flight Testing

- Testing all platforms (multicopter, fixed wing, VTOL)
- Over 10,000 flights
- ~2500 hours
- 20 platforms (and growing)
- PX4 flight review: https://logs.px4.io
- Targeting average 1k flights/month
- Github @PX4TestFlights
MAVLink API Library for the Dronecode Platform
DroneCore - Overview

- MAVLink
- C++ static library
- Easy to use core API for vehicle control
- Extensible by plugins (building blocks)
- Fully tested
- Layer on top of flight controller
- API Utilities for Control and Telemetry
- [http://dronecore.io](http://dronecore.io)
- [https://docs.dronecore.io](https://docs.dronecore.io)
- [https://github.com/dronecore/DroneCore](https://github.com/dronecore/DroneCore)
DroneCore - Easy to Use

- Setup a connection

```c
#include <dronecore/dronecore.h>

DroneCore dc;

DroneCore::ConnectionResult ret = dc.add_udp_connection();
ASSERT_EQ(ret, DroneCore::ConnectionResult::SUCCESS);
```
DroneCore - Event Based

- Wait for device

```cpp
Device &device = dc.device();
dc.register_on_discover([&discovered_device](uint64_t uuid) {
    // found device with uuid
});
```
DroneCore - Sync / Async

- Arm the device through the Actions plugin

```cpp
const Action::Result arm_result = device.action().arm();
if (arm_result != Action::Result::SUCCESS) {
    // better luck next time!
}

device.action().arm_async([](Action::Result result) {
    EXPECT_EQ(result, Action::Result::SUCCESS);
});
```
A device can consist of multiple components such as an autopilot with a gimbal and camera.

The device class can access plugins like `dronecore::Action` or `dronecore::Telemetry` because it is based on `DevicePluginContainer`.

```cpp
Device &device = dc.device();
device.action();
device.action().arm();
device.action().takeoff();
device.action().land();
```
DroneCore - Key Advantages

- **Yuneec SDK**
  - Distribution of DroneCore
  - Collection of plugins to manage customisations
  - Payloads, Vehicle specific attributes

- **DroneCore**
  - MAVLink comms
  - Vehicle state is kept
  - Event based callbacks

- **PX4**
  - Flight control algorithms