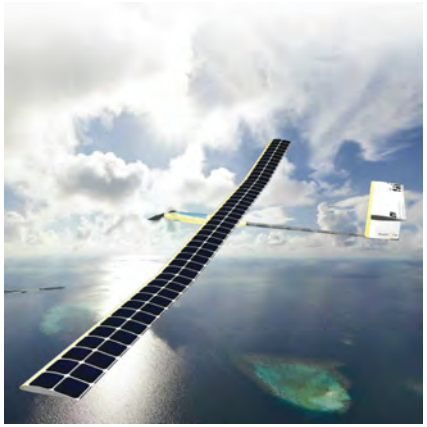
PX4 FLIGHT CORE






http://px4.io

pixhawk STUDENT PROJECT

- Student team 2009, research since 2011
- EMAV 2009 Competition: 1st
- IMAV 2010 Competition: 2nd

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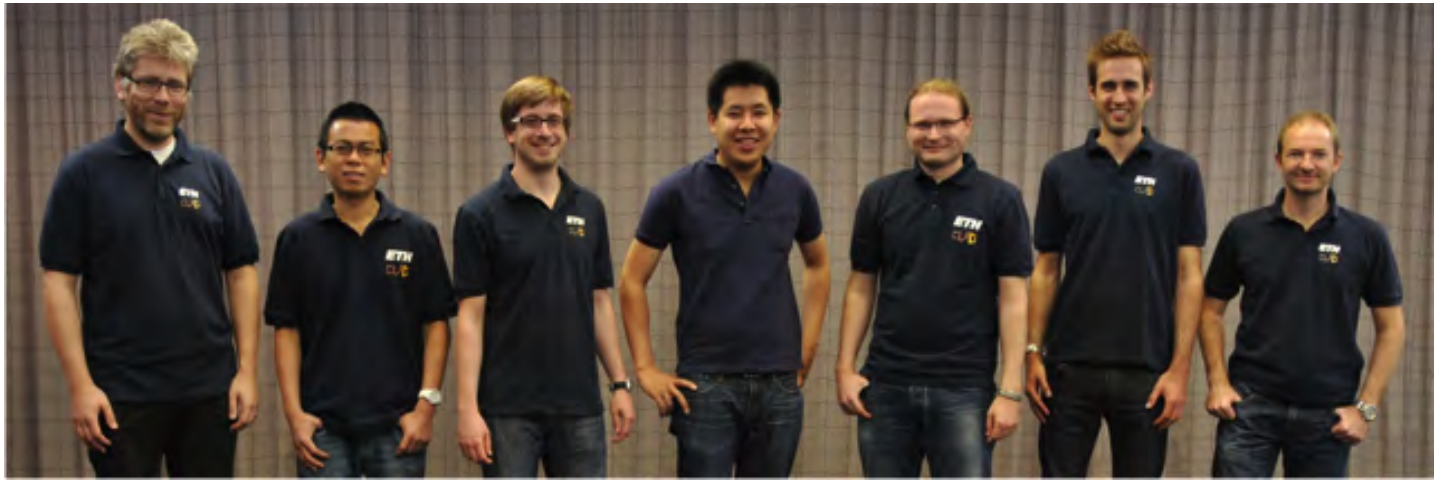
COMPUTER VISION AND GEOMETRY LAB

- Institute for Visual Computing, Computer Vision and Geometry Group (Prof. Marc Pollefeys)
- PIXHAWK (2008-) and sFLY (2008-2011) projects
- Using Asctec and PX4 hardware



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SWISS LOVE DRONES

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DRONES LOVE SWITZERLAND

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PERSONAL TIMELINE

PX4 autopilot

pixhawk

QGROUNDCONTROL
GROUND CONTROL STATION FOR SMALL AIR - LAND - WATER AUTONOMOUS UNMANNED SYSTEMS

MAVLINK
MICRO AIR VEHICLE COMMUNICATION PROTOCOL

PX4 inside

2008 2010 2011 2013 2015

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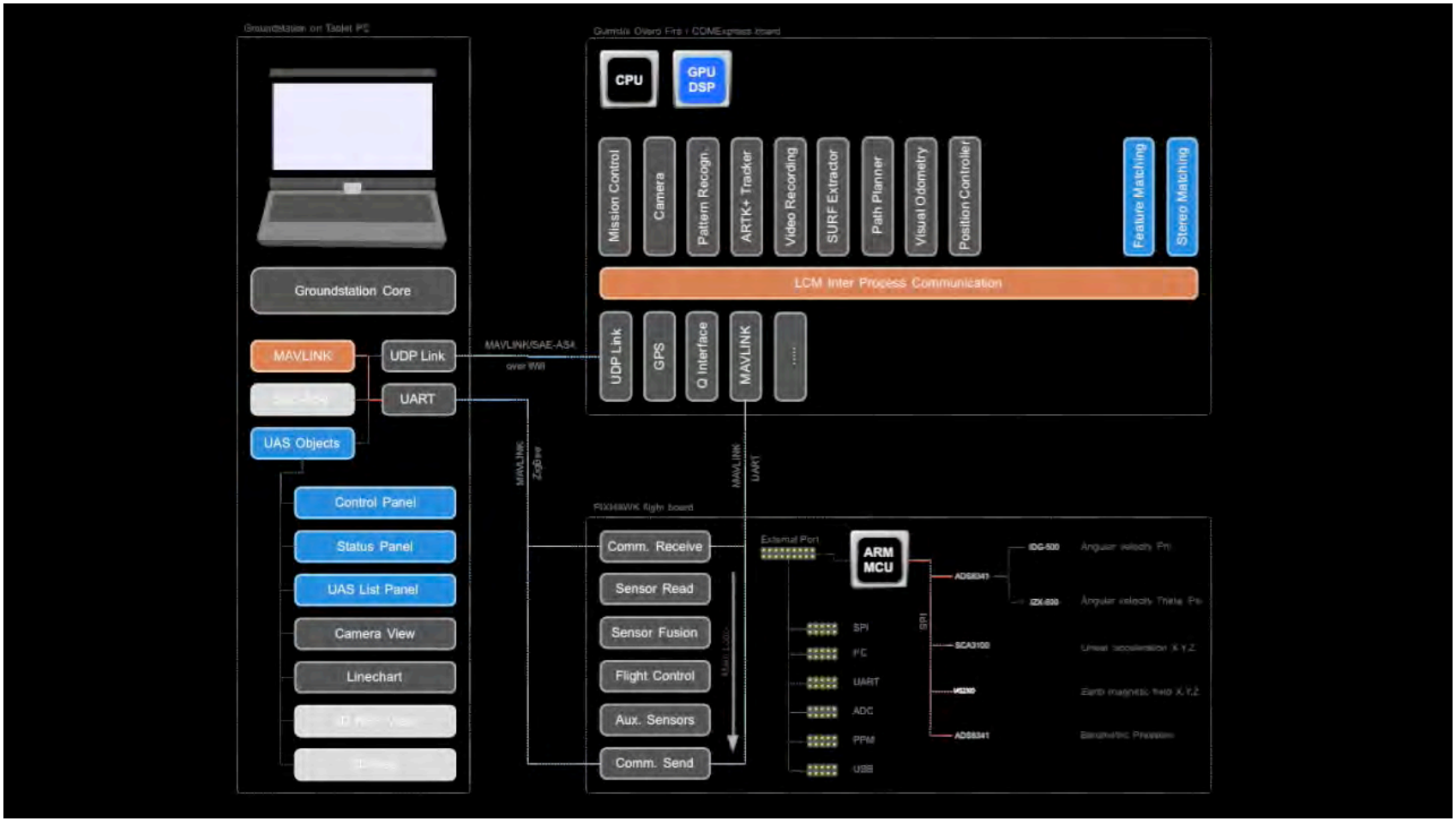
LINUX IN 2008



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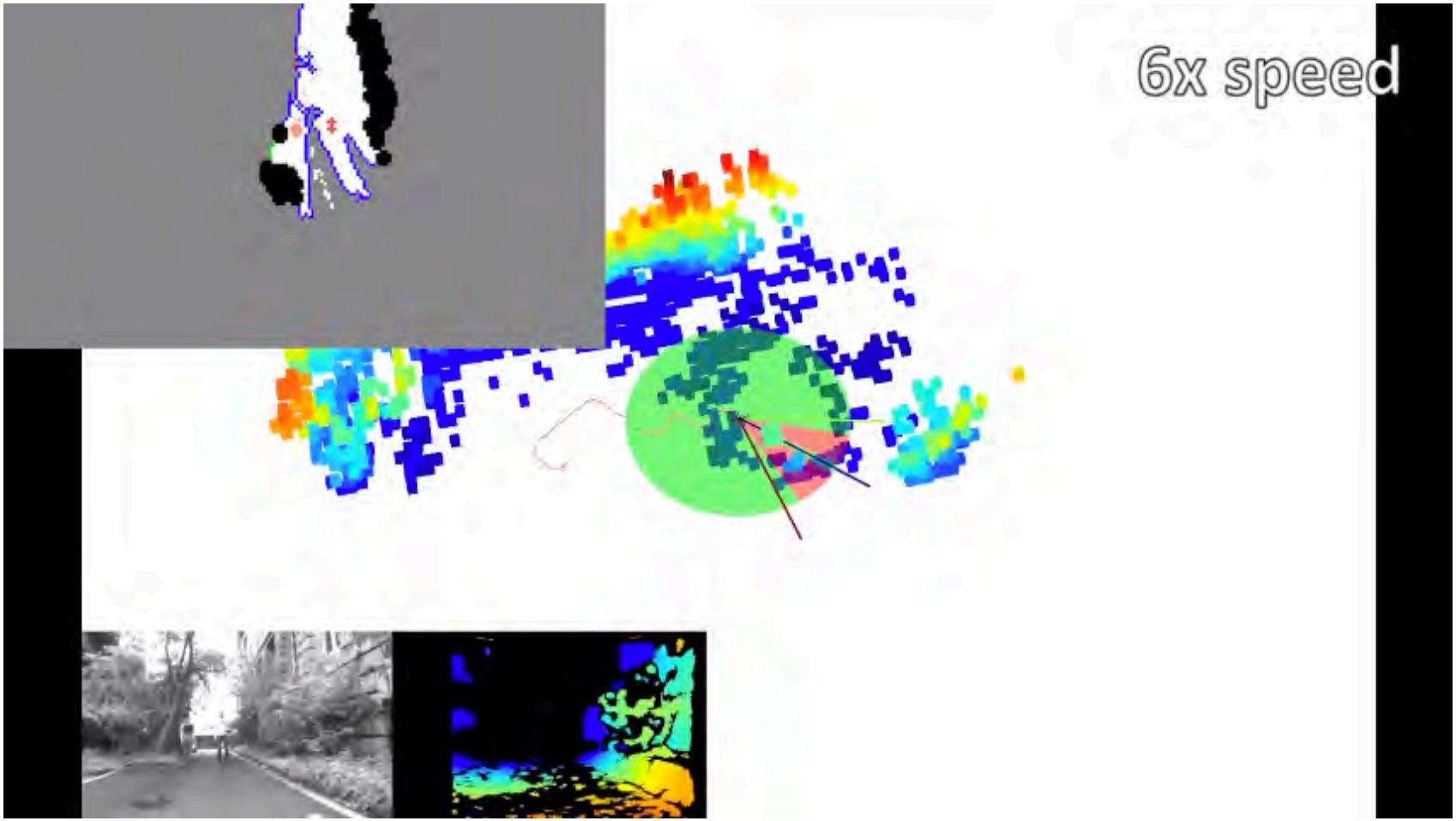
AUTONOMY TAXONOMY

- ALFUS Autonomy levels definition:
  - LEVEL 5: Autonomous (providing a description)
  - LEVEL 4: Human Aided (providing a goal)
  - LEVEL 3: Human Directed (waypoints)
  - LEVEL 2: Tele-operation (tablet control)
  - LEVEL 1: Remote Control (model airplane)

AUTONOMOUS EXPLORATION



IROS 2012, Friedrich Fraundorfer, Lionel Heng, Dominik Honegger, Gim Hee Lee, Lorenz Meier, Petri Tanskanen, and Marc Pollefeys

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NEW FRONTIERS FOR LINUX

- Obstacle detection and avoidance
  - Lidar
  - IR / Thermal
- GPS denied navigation
  - Optical flow
  - Visual inertial odometry
- Airframes beyond quadrotors
  - VTOL
  - Others

NEW FULL 3D ROS SIMULATION

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VTOL CONTROL

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HARDWARE AND SOFTWARE

Autopilot Hardware

http://pixhawk.org

Autopilot Platform

http://px4.io

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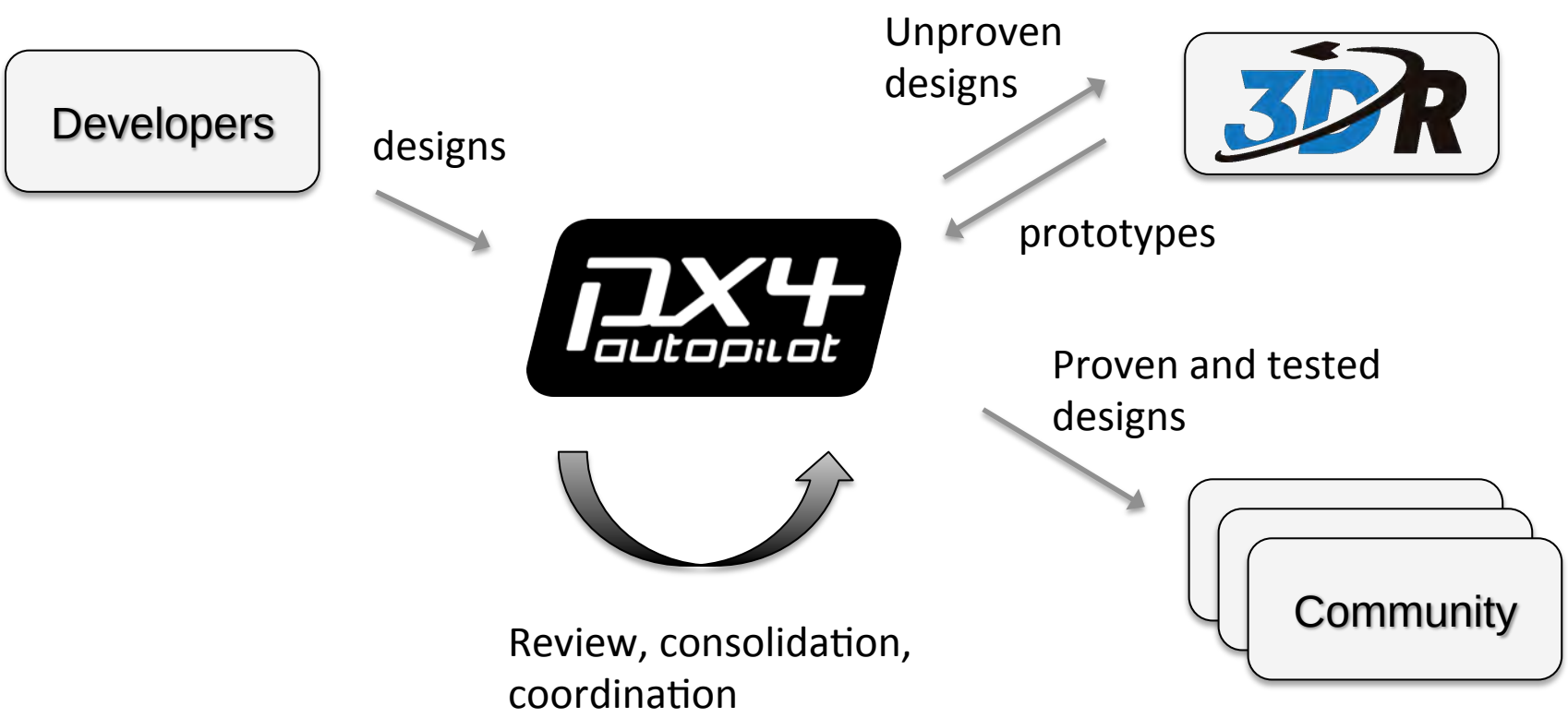
IMPACT

- Widely used in academia (ETH, CMU, UZH, DLR, MIT, ...)
- Platform for third-party autopilots (e.g. APM)
- Widely adopted hardware
  - 3D Robotics (hardware development partner)
  - 3rd party producers of Pixhawk
  - 3rd party derived designs (Gumstix AeroCore)

OPEN HARDWARE WORKFLOW



OPEN SOURCE COLLABORATION

- APM Dev team on middleware
- OSRF / ETH Zurich on ROS Simulator
- Paul Riseborough on EKF Fusion framework
- Pavel Kirienko on UAVCAN

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AUTOPILOT – PIXHAWK

- Flight Management Unit – Autopilot + Mission Manager
- 168 MHz Cortex M4F (FPU, 192 KB RAM, 1 MB flash)
- 10 DOF sensors
- Lots of connectivity (including CAN)

OPTICAL FLOW MODULE

400 Hz optical flow, 3 m/s/m velocity (ICRA 2013 paper)

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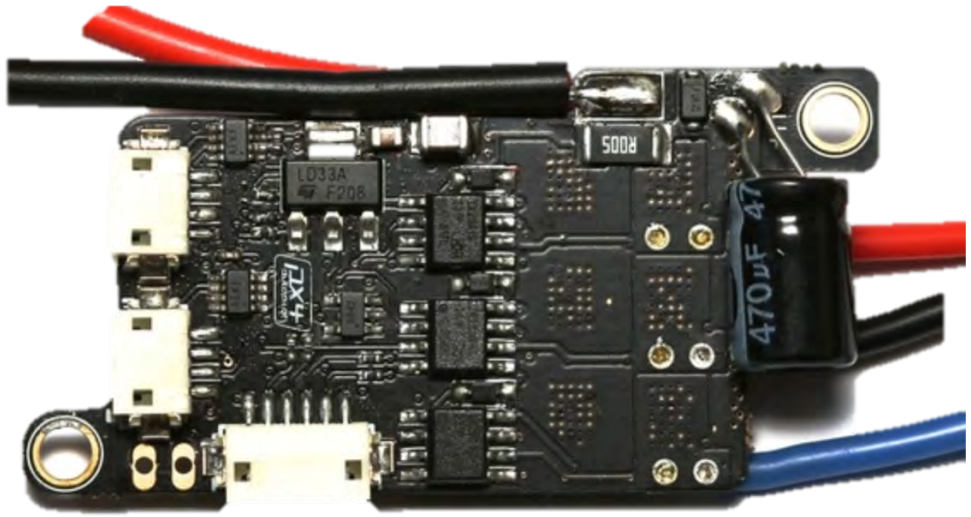
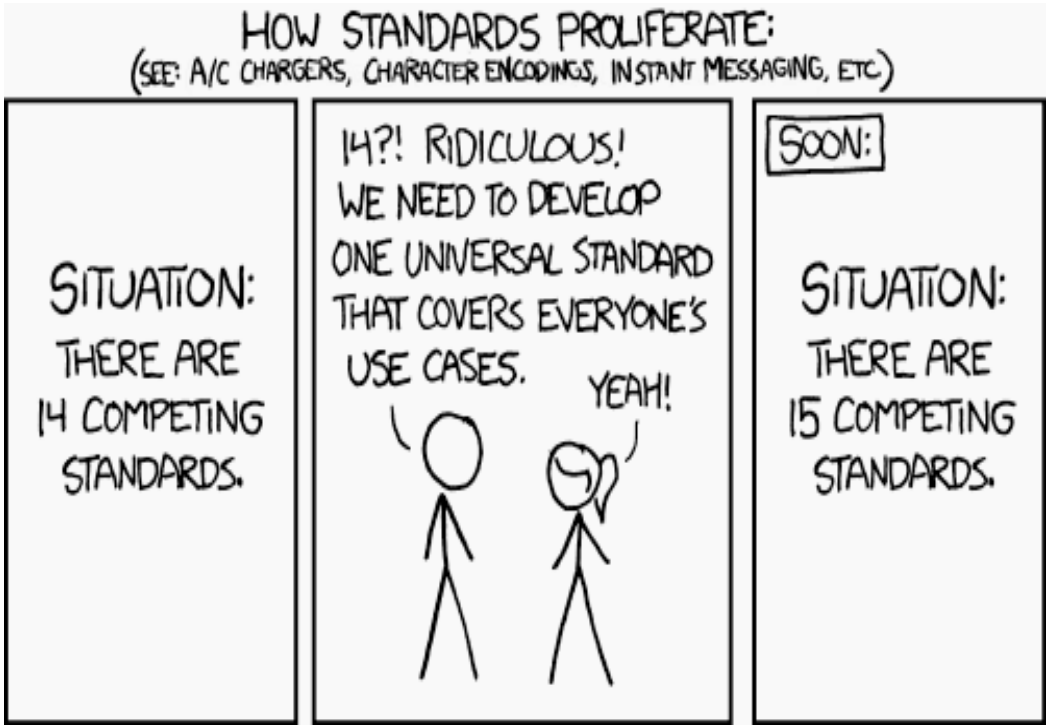
CAN ECOSYSTEM – PIXHAWK ESC

- Current embedded buses (PWM, I2C) are limited:
  - Signal integrity (not differential)
  - Bandwith
  - Feedback
- Pixhawk ESC design based on CAN, open hardware



PX4 SOFTWARE DESIGN

- Reusing existing standards
- MAVLink
- UAVCAN comms
- POSIX-style threading
- POSIX-style C and driver API
- Publish / subscribe design
- BSD



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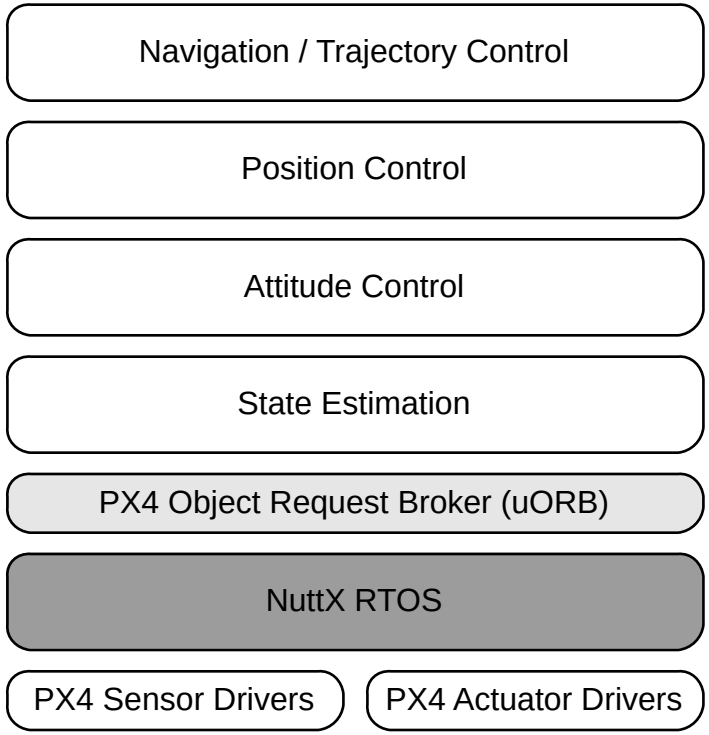
PX4 SOFTWARE ARCHITECTURE

- Layer model
- Multiple applications per layer
- pub() / sub() application interface
- Generalized I/O interface (supports e.g. CAN or PWM)



SAFETY REQUIREMENTS

Safety Requirements

- Prevent midair collisions (separation, transponder)
- Prevent injuries on ground (parachute)
- Limit the scope of certification (safety module)

Safety Block reuse

- Pixhawk offers dedicated safety processor
- Certifying this part would make any system comply

LIGHTWEIGHT ORB – PUBLISHING

- Flat address space in NuttX
- uORB, lightweight object request broker

- publish:

```
topic_handle = orb_advertise(ORB_ID(random_integer), &rd);
```

- subscribe:

```
topic_handle = orb_subscribe(ORB_ID(random_integer));
```

SHELL AND SYSTEM STARTUP

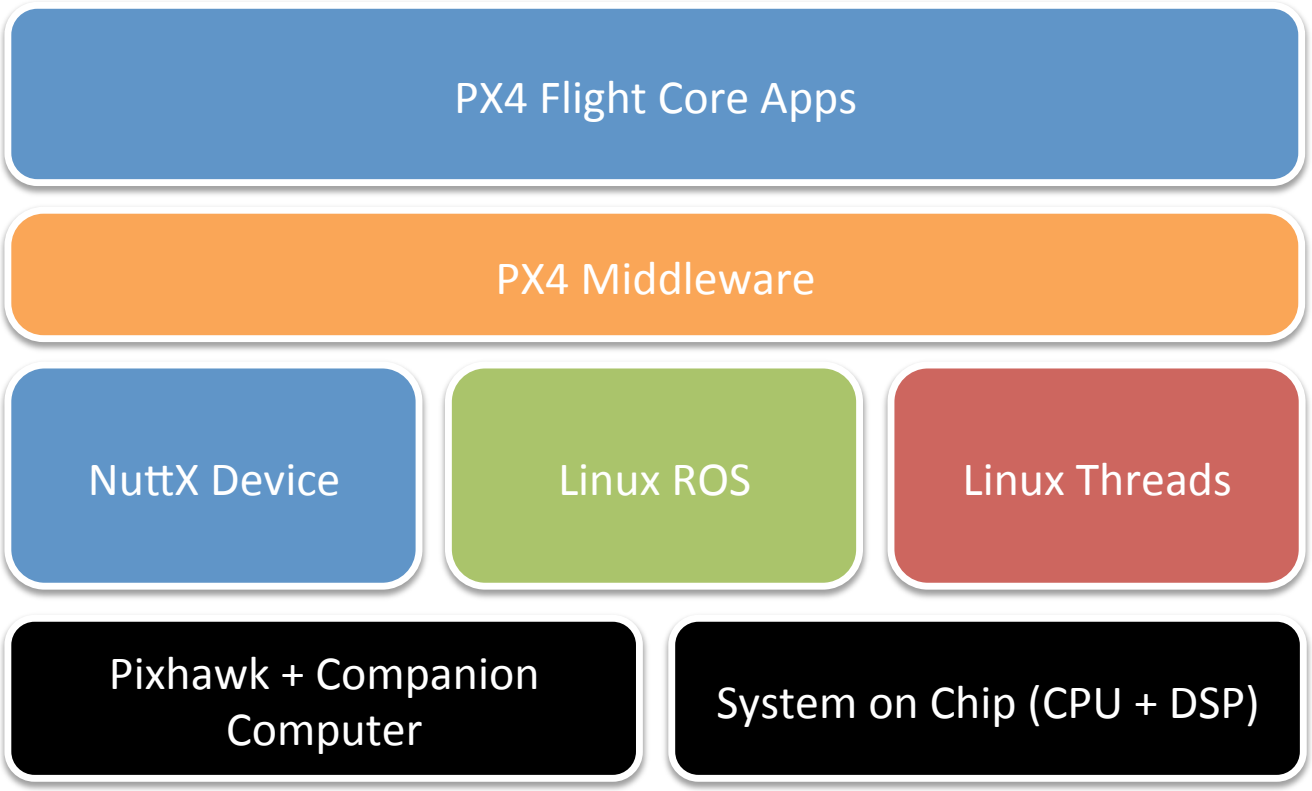
- Shell via UART / USB
- Runtime configurable
- Bash-like startup scripts
- Automatic detection of peripherals and sensors ("plug and play")
- Supports custom configurations

```
#!nsh

# mount microSD
Mount /dev/mmcsd0 /fs/microsd

# start uORB
uorb start
```

PX4 PLATFORM PORTABILITY



COMMUNICATION – MAVLINK

- Low-bandwidth protocol
  - 8 bytes overhead, up to 255 systems
  - One to one and swarm support
- Widespread use in low-cost UAVs
  - PX4
  - ArduPilotMega
  - UAVDevBoard
  - Paparazzi Port

COMPANION COMPUTER

- Pixhawk project runs distributed estimation & control on Linux and autopilot since 2009
- Higher level flight control on companion computer
- Lower level flight control on autopilot

ROS Enabled

MAVLINK
MICRO AIR VEHICLE COMMUNICATION PROTOCOL

http://wiki.ros.org/mavros

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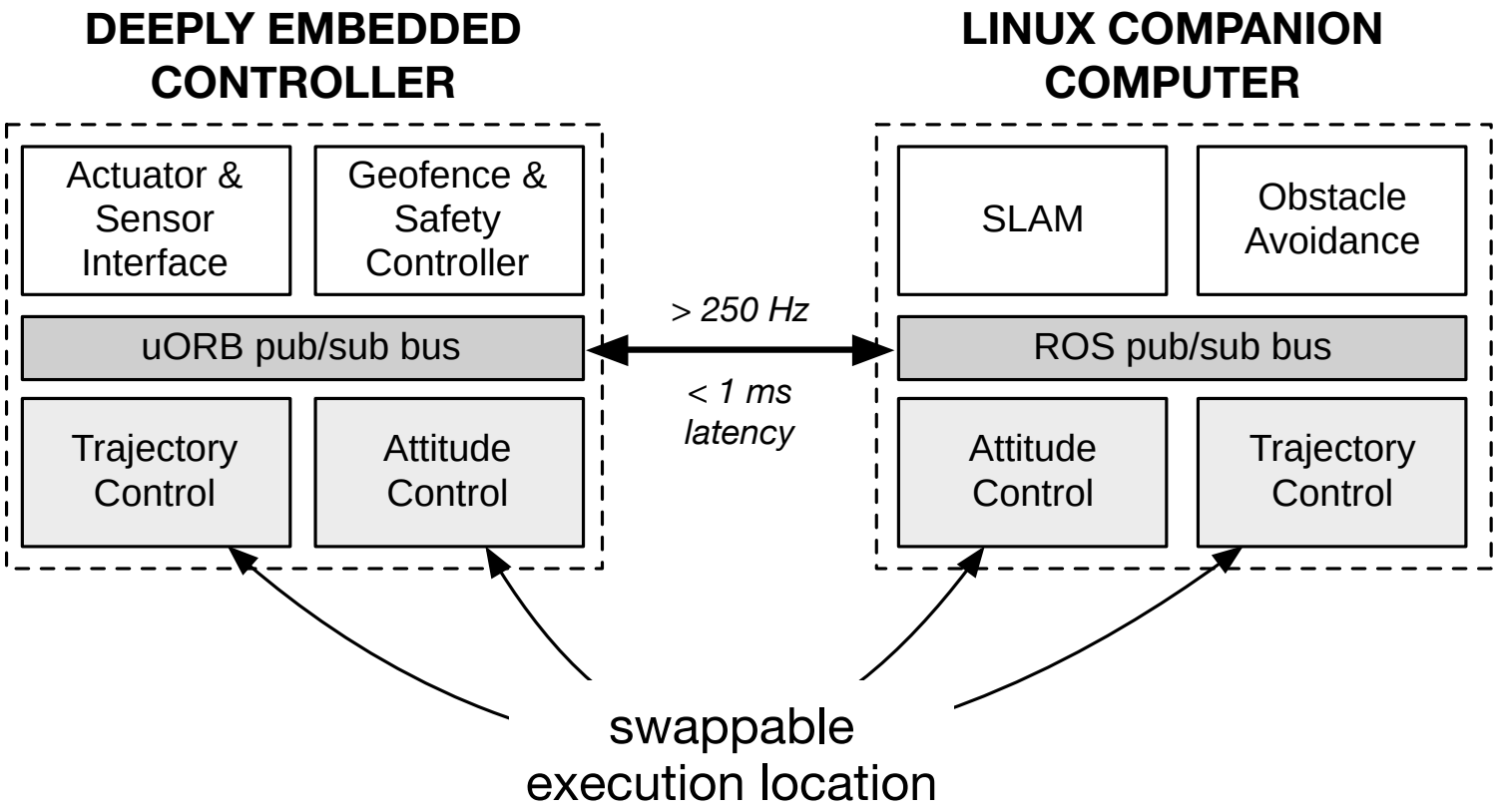
ARCHITECTURE FLEXIBILITY



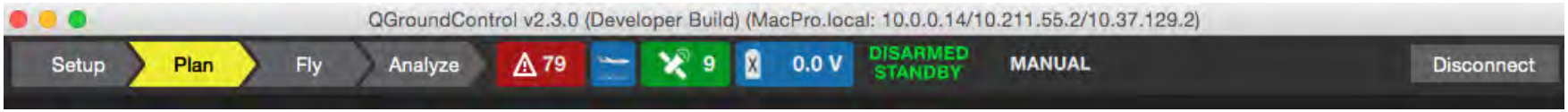
CONTINOUS INTEGRATION

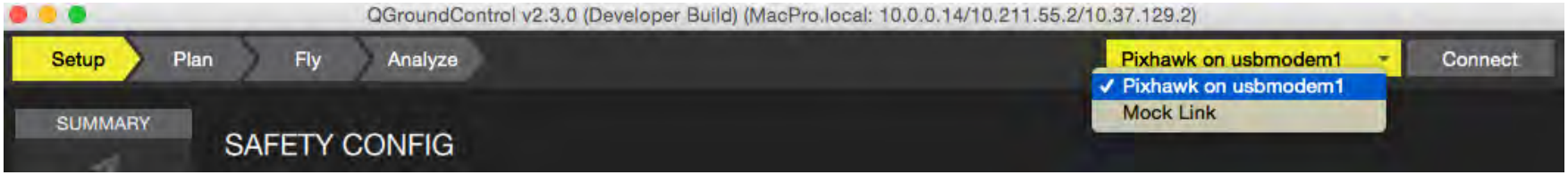
- Unit testing on Travis

- Hardware testing in Hans

- Software-in-the-Loop testing in Jenkins

EXCURSION: QGROUNDCONTROL 2.3





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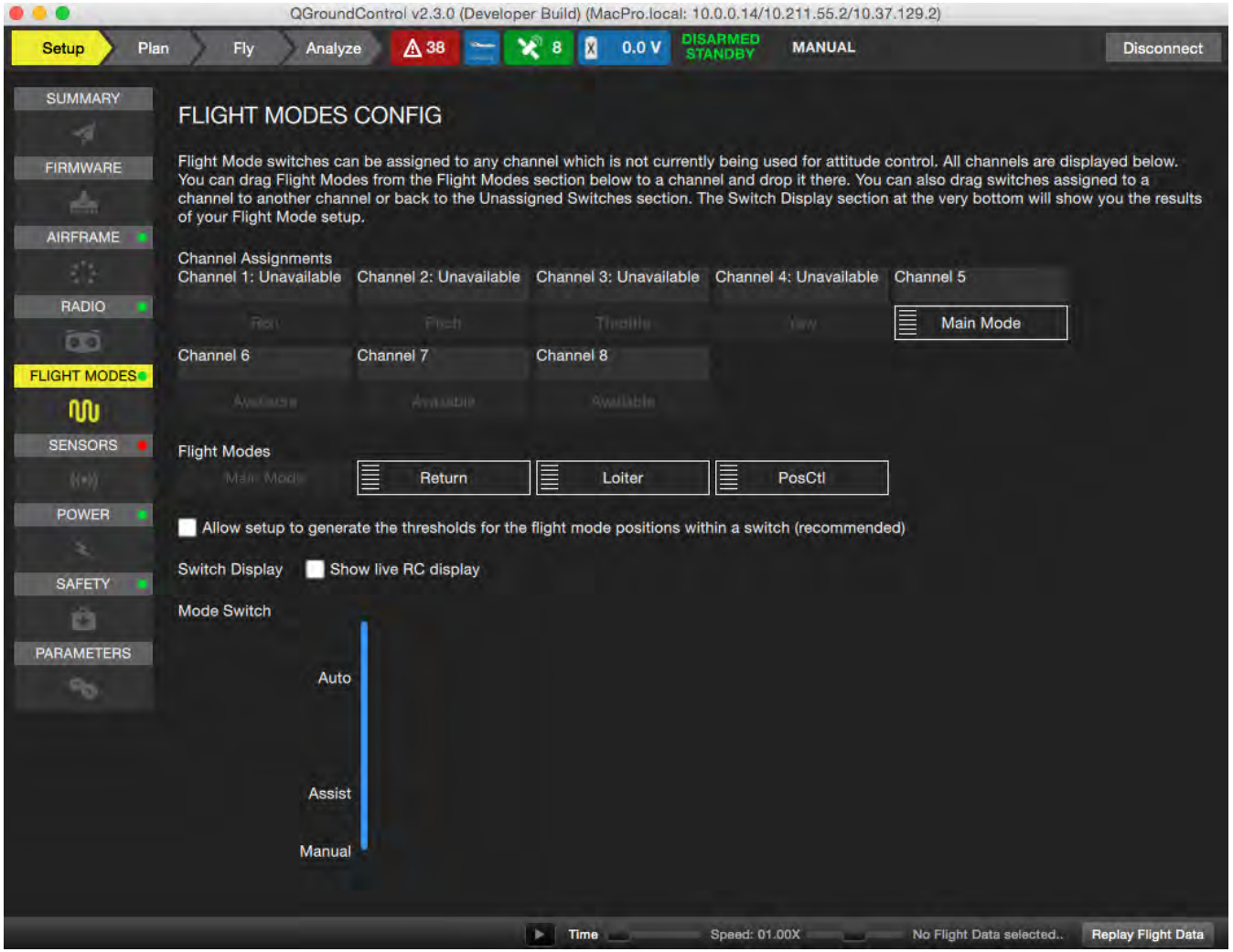
SETUP EXPERIENCE



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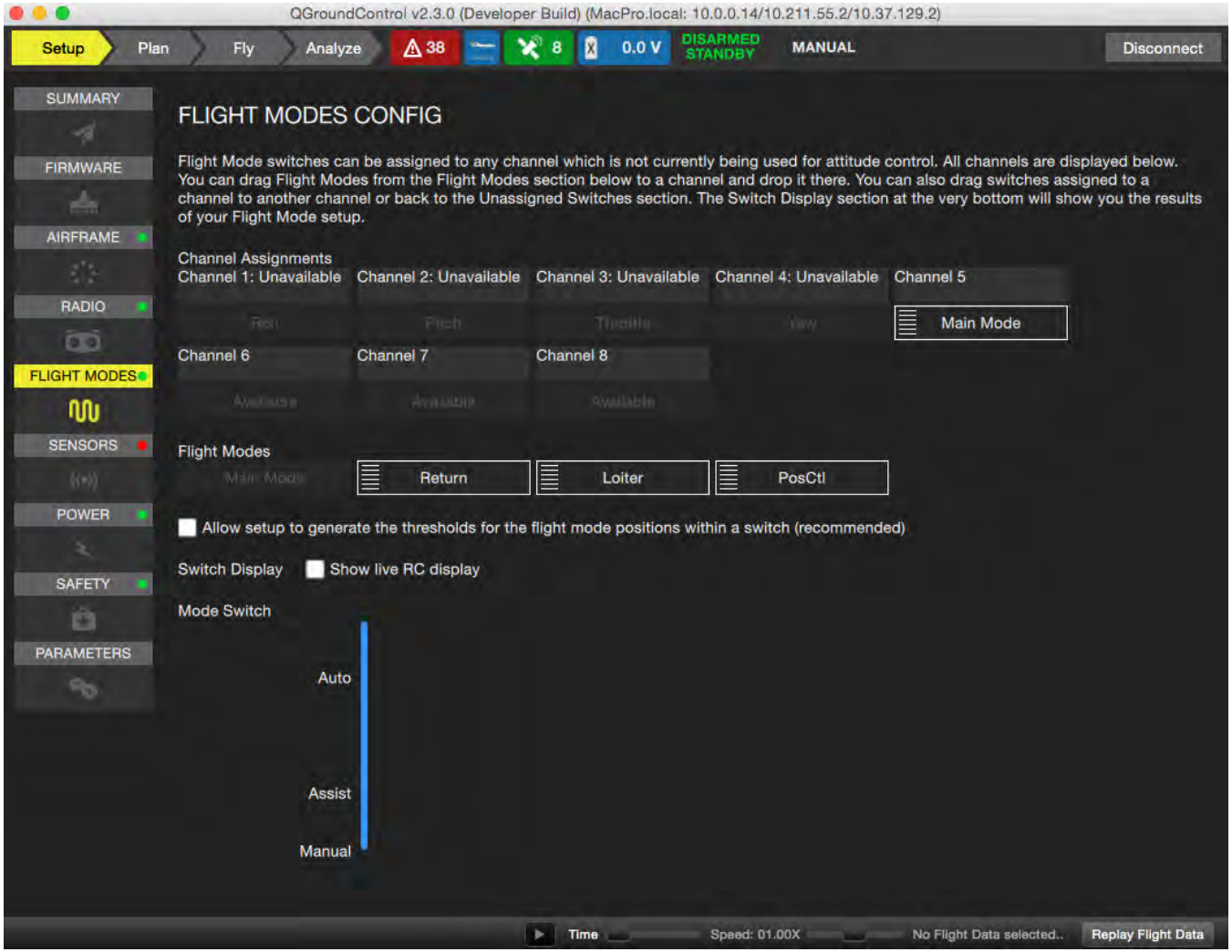
RC CONFIGURATION



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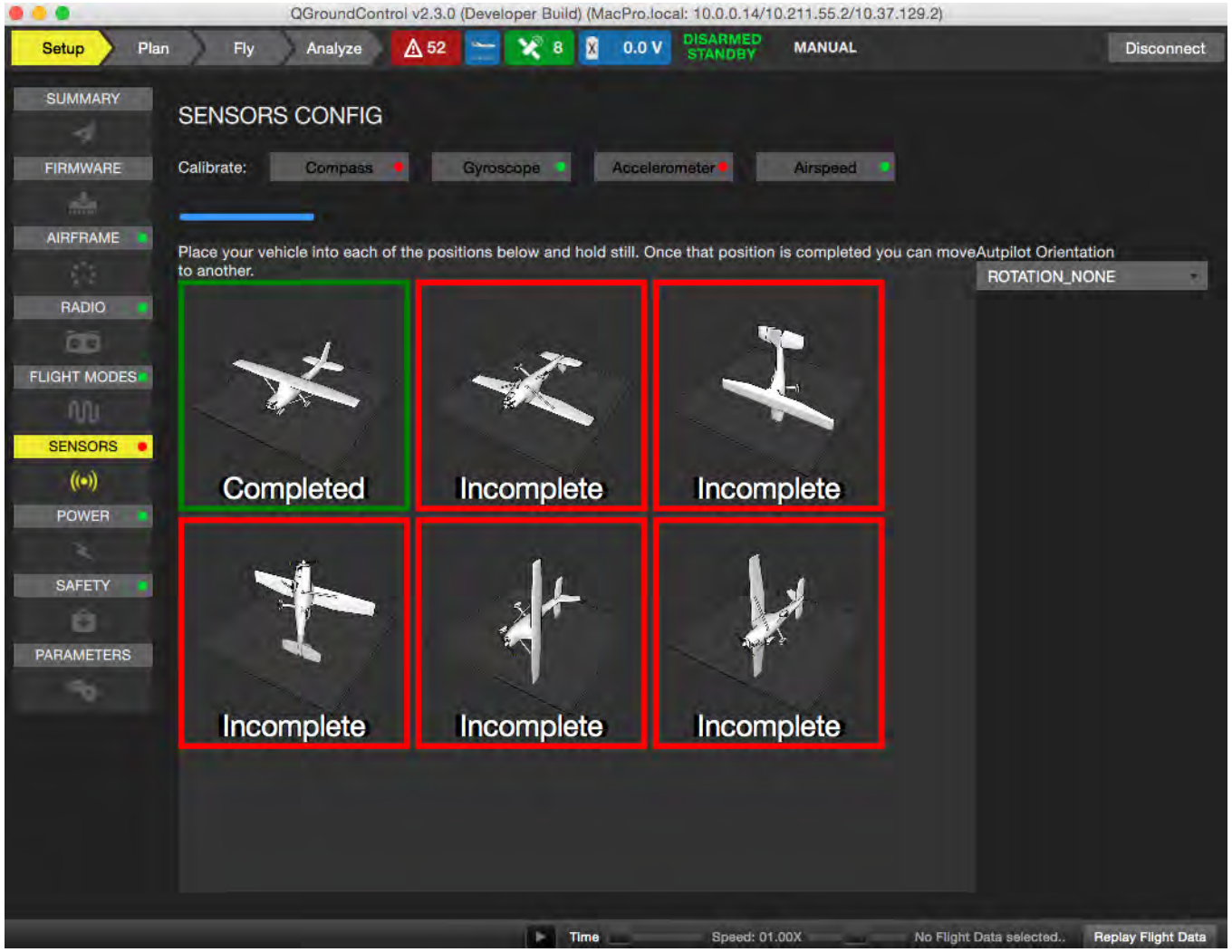
SENSOR CONFIGURATION



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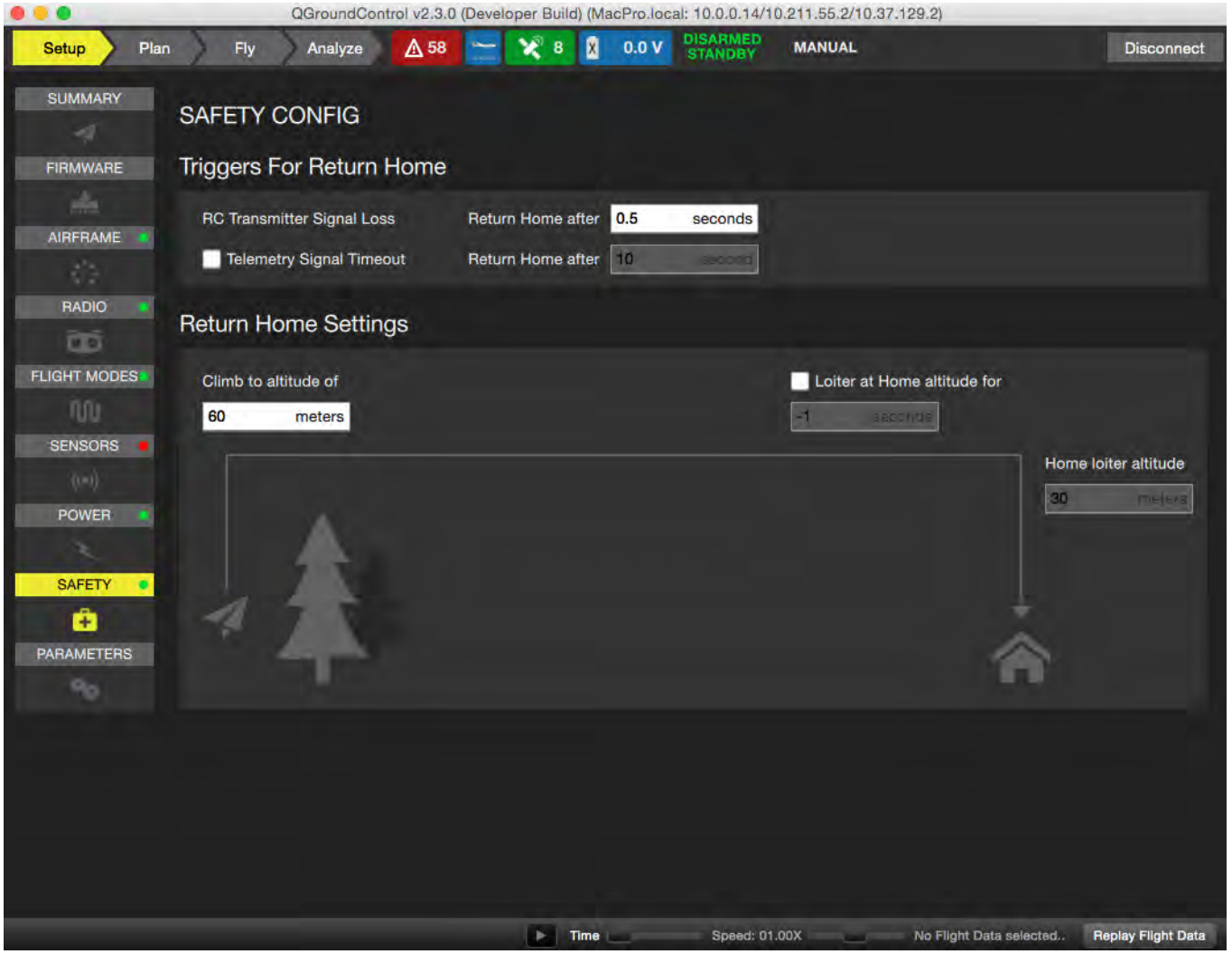
RTL CONFIGURATION



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Dronecode FRONTIERS

- Documentation
- Link Security / Safety Standard
- Convergence on simulation environment
- Convergence on post-flight data processing

THANKS!

http://px4.io

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