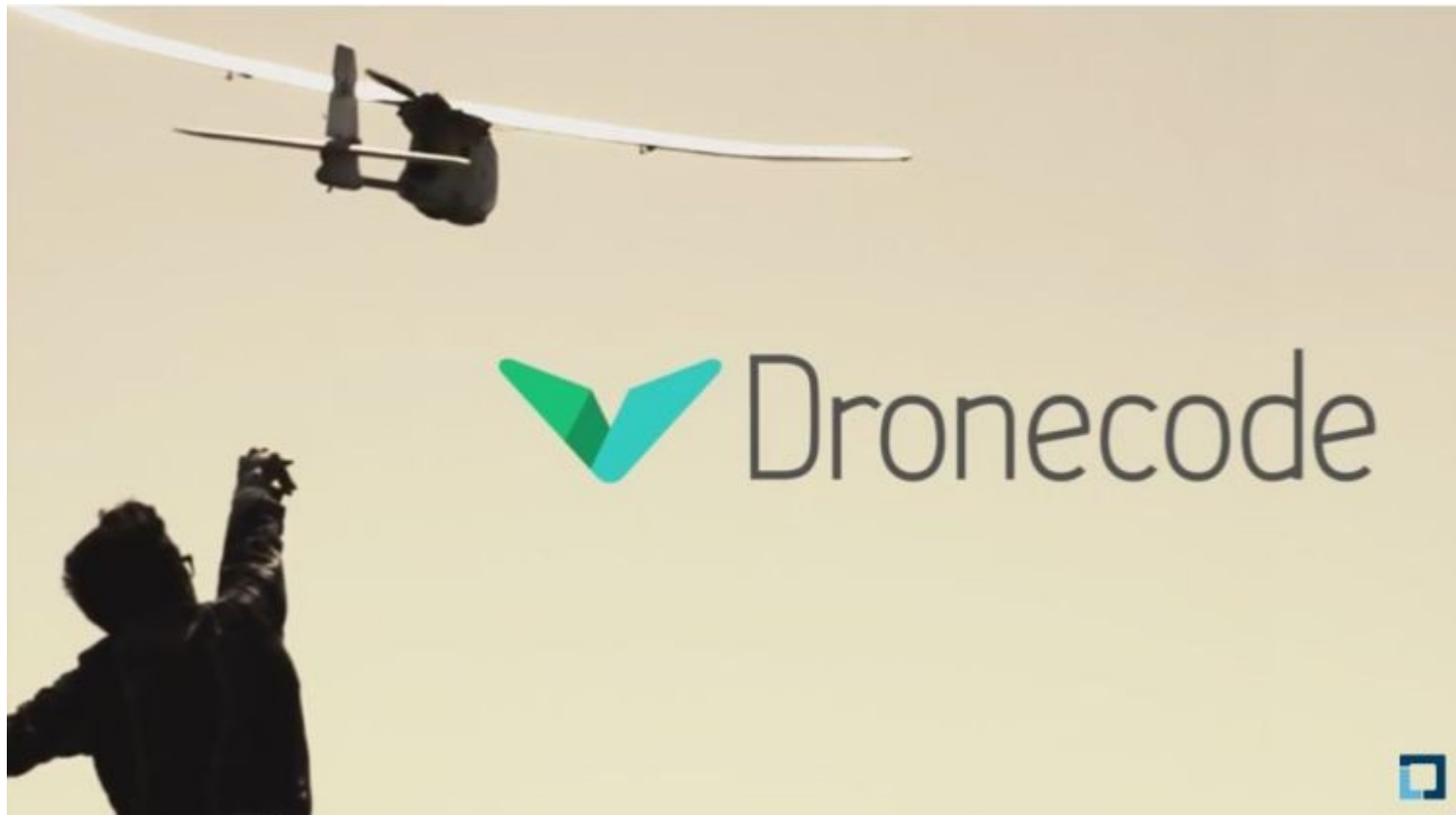
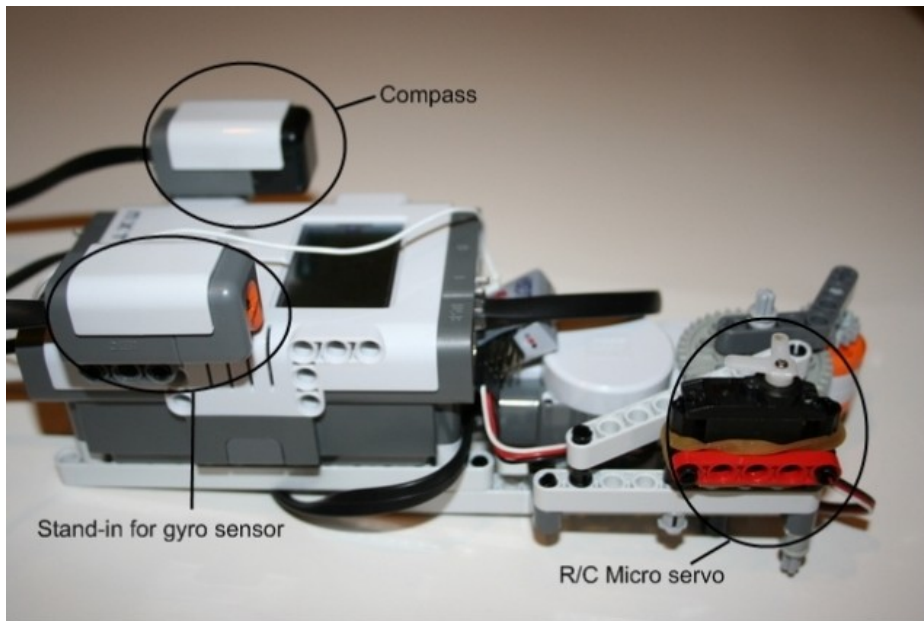


DroneCode and ArduPilot

Andrew Tridgell



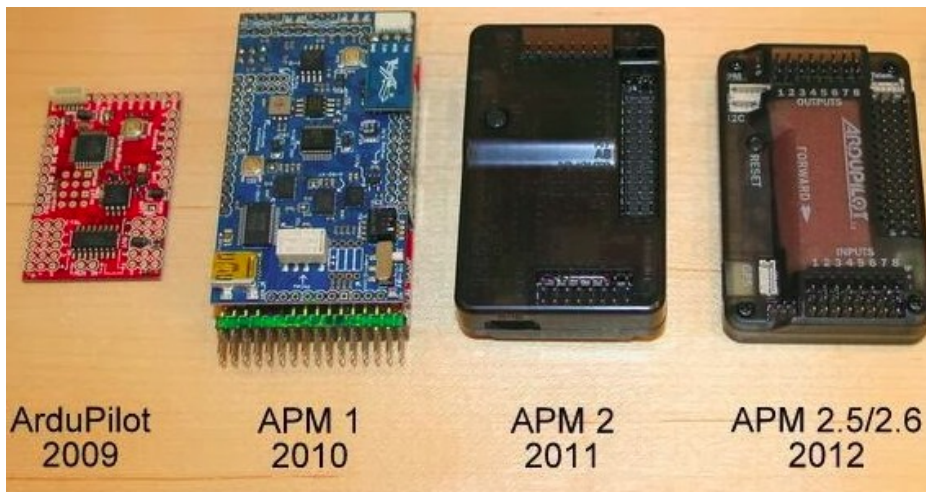
Lego Autopilot



- The beginnings of DiyDrones
 - built in 2007 by Chris Anderson
 - Lego Mindstorms
 - fixed wing aircraft
 - simple compass navigation

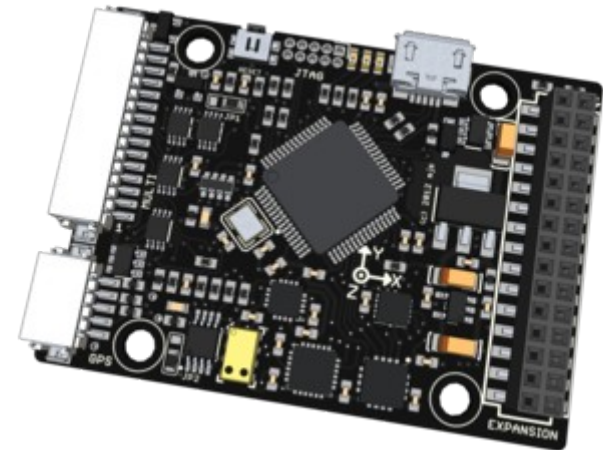
The Arduino Era

- Moved to AVR boards in 2009
 - Based on an Arduino 'sketch'
 - stretched the limits of the AVR architecture
 - Community flourished, growing to over 50,000 members
 - Still works, but now at end of life



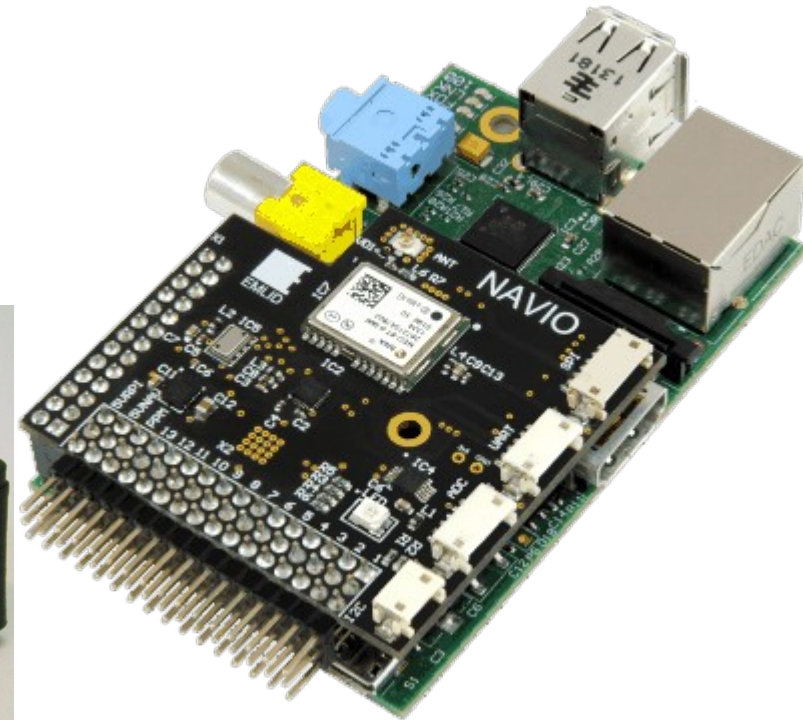
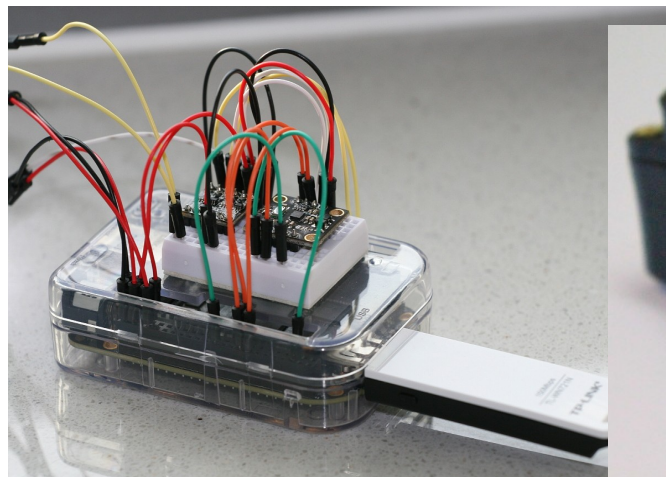
The PX4

- In 2012 started collaboration with PX4 project
 - 32 bit STM32 processors
 - NuttX RTOS operating system (posix-like)
 - PX4Firmware middleware
 - huge improvement in performance and capability



Native Linux Ports

- Native Linux port started in 2013
 - built on top of generic I2C/SPI interfaces
 - using Preempt/RT kernels
 - On BeagleBoneBlack, RaspberryPi and Odroid

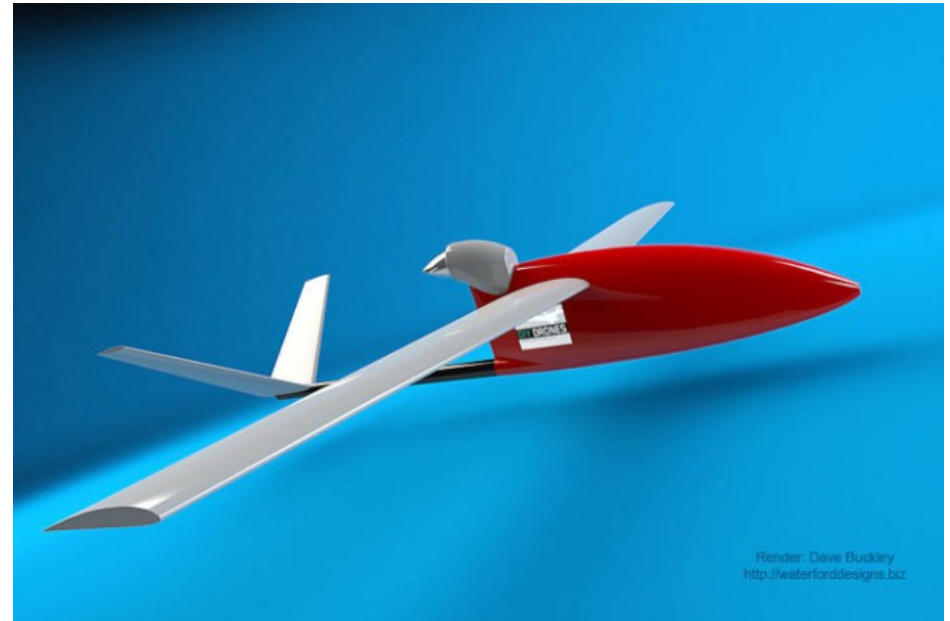


AP_HAL for Hardware Abstraction

- AP_HAL in ArduPilot
 - creates hardware abstraction layer
 - allows porting to many OSes and CPU architectures
 - each HAL provides minimal system level glue
- Current ports
 - AP_HAL_AVR (8 bit AVR2560)
 - AP_HAL_SITL (SITL simulator)
 - AP_HAL_PX4 (PX4 based autopilots)
 - AP_HAL_Flymaple (low cost ARM autopilot)
 - AP_HAL_VRBrain (ARM32 autopilot)
 - AP_HAL_Linux (embedded Linux port)
 - AP_HAL_Empty (very useful!)

DiyDrones Community

- ArduPilot/PX4 have spawned a lot of interesting projects
 - experimental aircraft
 - drone image systems
 - disaster management
 - search and rescue
 - agricultural applications



Experimental Aircraft

(TeamTiltrotor)



Machine Vision

Balloon Popper - Randy Mackay



Precision Landing

Daniel Nugent



Optical Flow (no GPS)

(Paul Riseborough)



Extreme Flight

(NTNS - North Texas Near Space)



Lohan Rocket Plane

(Register Special Projects)



TradHeli and Rover

(Rob Lefebvre and Grant Morphett)

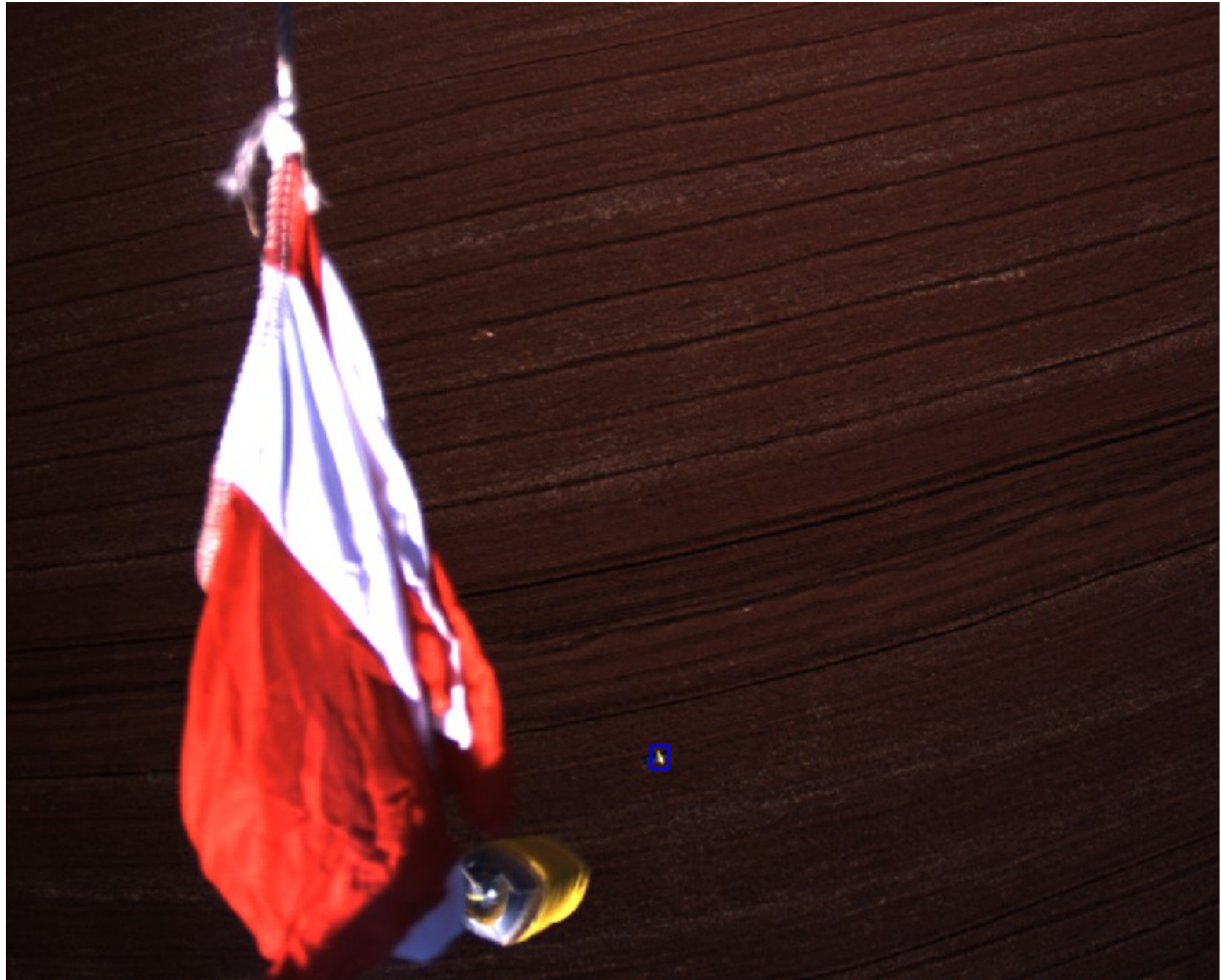


Rover

Outback Challenge 2014

(CanberraUAV)



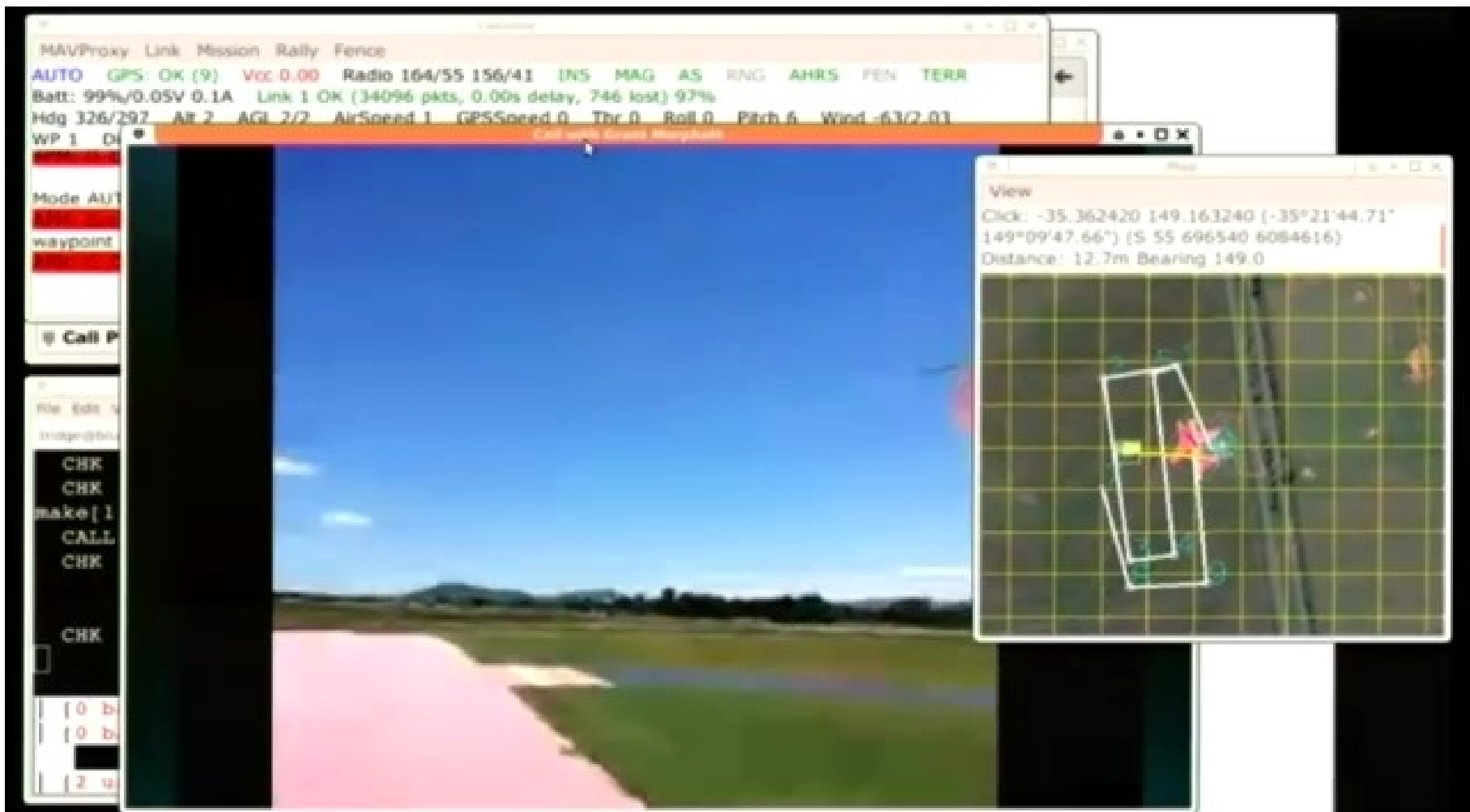


Live Demo

(at Drone BOF 6:30pm tonight)

Live demo from Canberra, Australia

- BeagleBoneBlack with PXF cape
- 3.8 Preempt RT kernel
- Compiling Linux kernel while flying on same CPU



Demo Setup

- BeagleBoneBlack running Debian
 - 3.8.13-RT kernel
 - ArduPilot 3.3-devel
- Sensors
 - MPU9250 accel/gyro on SPI
 - MS5611 barometer on SPI
 - Ublox Lea6H GPS on 38400 UART
 - HMC5883 compass on I2C
 - MS4525DO airspeed sensor on I2C
- IO
 - SBUS input via PRU2
 - PWM output via PRU1
 - telemetry radio plus 3G link
 - EMMC and microSD for storage



I2C and SPI

- Fast sensors on SPI
 - using `/dev/spidev` interface, user-space drivers
 - works very well!
 - able to handle 4k SPI transactions per second with 25% CPU load on BBB
 - no DMA used due to DMA overhead for small transfers (typically a transfer is around 20 bytes)
- Slower sensors on I2C
 - using `/dev/i2c` smbus API, drivers in user space
- Why user space?
 - common drivers across multiple operating systems, using AP_HAL abstraction
- Moving to uavcan in future to replace most I2C



Scheduling

- 6 realtime (FIFO scheduled) threads
 - timer thread (1kHz timer, for regular tasks)
 - UART thread for all UART serial operations
 - RCIN thread for processing RC input pulses
 - main thread for core autopilot code
 - tonealarm thread for buzzer sounds
 - IO thread for all filesystem IO (logging, parameters and terrain data)

BeagleBoneBlack PRUs

- PRU1 used for RC Input
 - watches for state change on 1 pin
 - writes timing of state changes to a ring buffer
 - ARM code consumes entries from ring buffer, calling `process_rc_pulse()`
 - just 70 lines of C code on PRU
- PRU2 used for PWM output
 - shared buffer of PWM channel pulse width frequency
 - continuously reads shared buffer and updates 12 channels
 - just 235 lines of C on PRU

DroneCode.org

- New umbrella organisation for free software UAV development
 - Part of Linux Foundation Collaborative Projects
 - Forum for collaboration between projects, users and companies using the technology
- Collaborative development of core UAV projects
 - MAVLink
 - ArduPilot
 - PX4
 - MAVProxy
 - DroneAPI



More information

- Key sites
 - DroneCode: <http://dronecode.org/>
 - ArduPilot: <http://ardupilot.com/>
 - PX4: <http://px4.io/>
 - MAVLink: <http://mavlink.org/>
 - DiyDrones: <http://diydrones.com/>

Questions?