

Designing an open source drone solution that's business friendly

NXP reference design for developing Small Autonomous Vehicles

Iain Galloway iain.galloway@nxp.com

Drone Program Lead,
Systems Innovation Automotive
NXP Semiconductors
Austin, TX

July 2019 | External Audience



SECURE CONNECTIONS
FOR A SMARTER WORLD

NXP Drone and Rover Program



Tricopter



Quadcopter



Hexacopter



Octocopter -Flat



Octocopter - Coax



Multicopter



Plane



Flying Wing



VTOL
Pusher prop

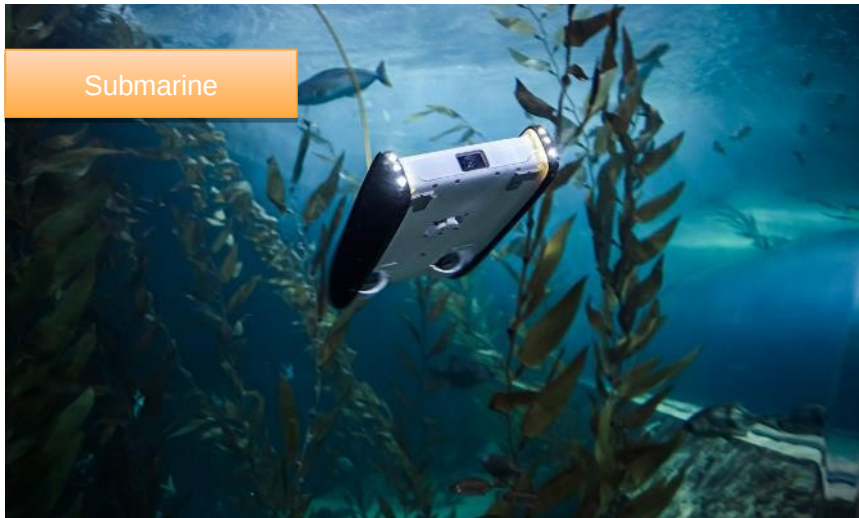
Long flight Duration



VTOL transitioning Wing



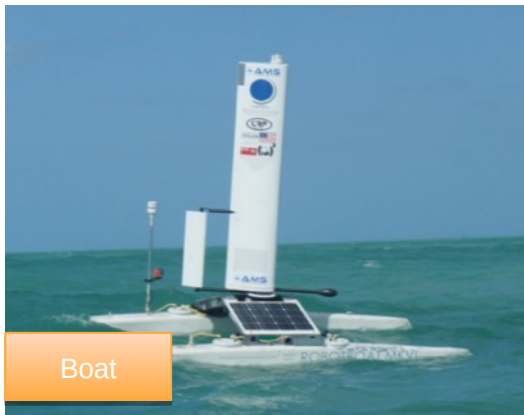
Airship



Submarine



Delivery rover



Boat

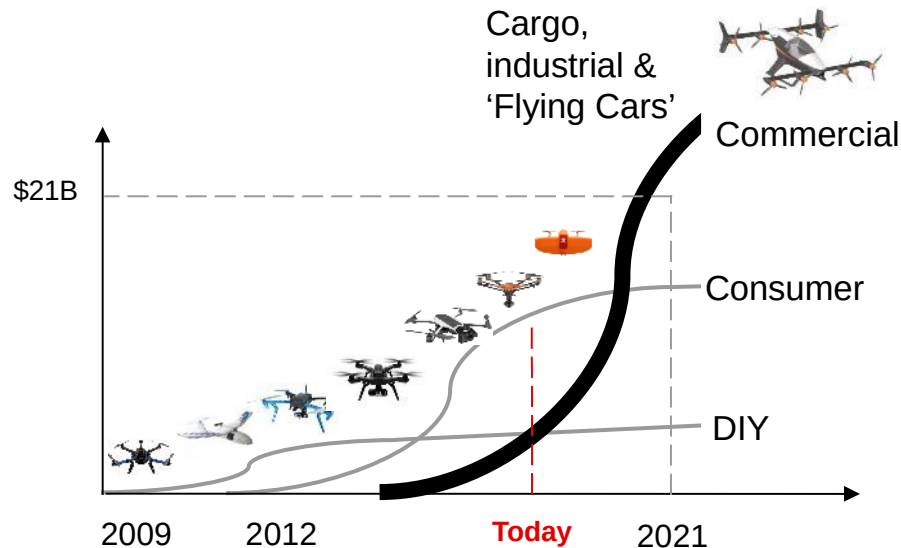


Security

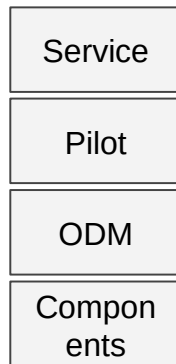


Lawnmower or Agricultural?

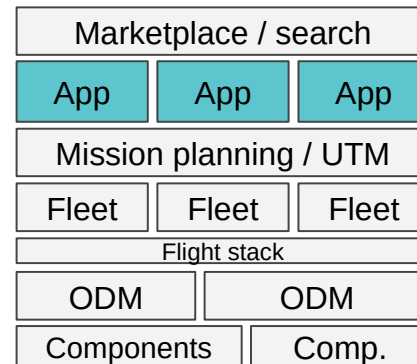
Industry Trends: Commercial Application Taking Off and Industry Becoming Horizontally Integrated



Vertical



Horizontal





LuftTaxi
AirTaxi

VTOL reduction in greenhouse gas Emissions:

- 52% @60miles+ compared to ICE cars

- 6% @60 miles+ BEV

Starting for trips > 22 miles

<https://www.nature.com/articles/s41467-019-09426-0>

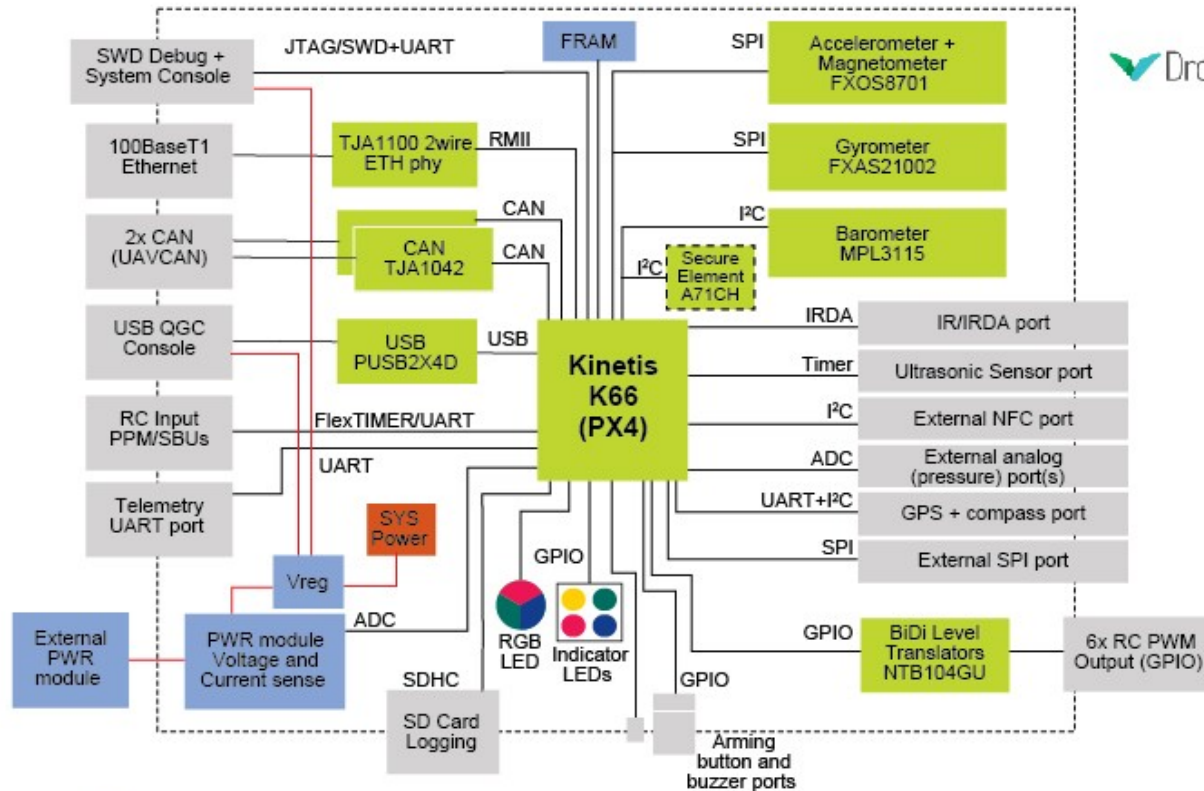
NXP Drone Reference design

Kit-HGDroneK66

- Complete low cost 'hobby' drone platform, but really an open design robot.
- 500mm size big enough for easy experimentation
- Complete system to test new components such as motor controllers with UAVCAN or secure authentication of battery
- Reuse of components for ground Rovers

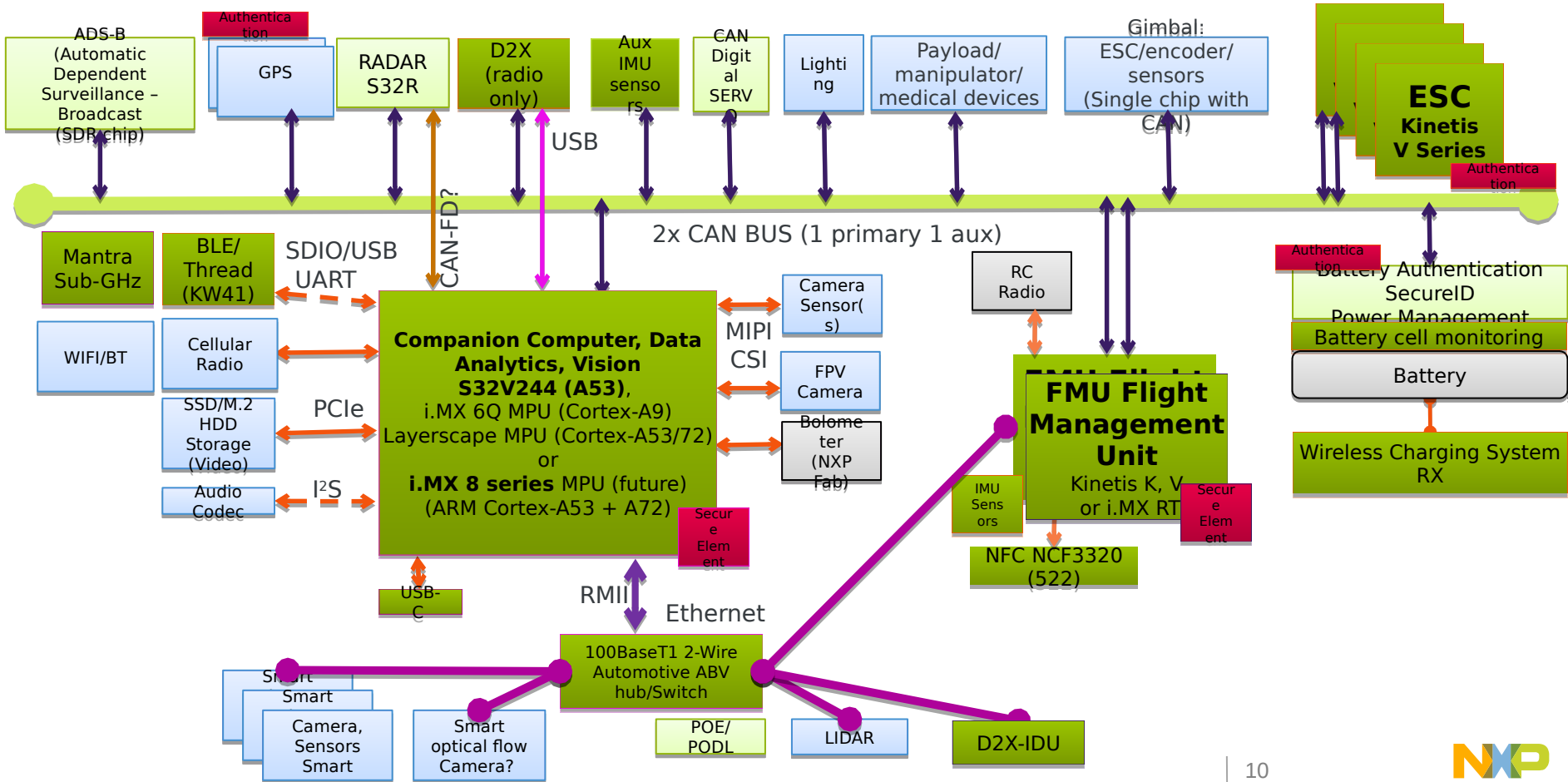


Complexity: FMU - Flight management Unit



■ NXP Part ■ Non-NXP Part ■ Interface — Power — Signal

More Complexity: Industrial Grade Drone - Modular with CAN and Ethernet



How do we manage this complexity?

We're a semiconductor company, not a drone company

We want best in class, but we also want to provide accessible solutions



Look for the a well designed open source solution with **best in class**...

- ✓ Software
- ✓ Project management
- ✓ Ecosystem
- ✓ Governance
- ✓ Community
- ✓ Enterprise grade support

PX4 is an integrated open source software ecosystem



Vehicle	Communication	Ground Control Station	Hardware
Firmware	 MICRO AIR VEHICLE COMMUNICATION PROTOCOL	 QGroundControl	 <i>pixhawk</i>
Autonomy	Middleware	API	
Vision based localization and avoidance	ROS2 	<code><dronecode/sdk></code>	NXP RDDRONE FMUK66 Intel Aero

Leading commercial products and dev platforms based on PX4

YUNEEK



YUNEEK



IMPOSSIBLE
AEROSPACE



UAV



FREELY



NXP



DHL



amazon
Prime Air



QUALCOMM



INSPIRED FLIGHT



TEAL



SONY



sentera



VERTICAL
technologies



ALTI



FlightWave



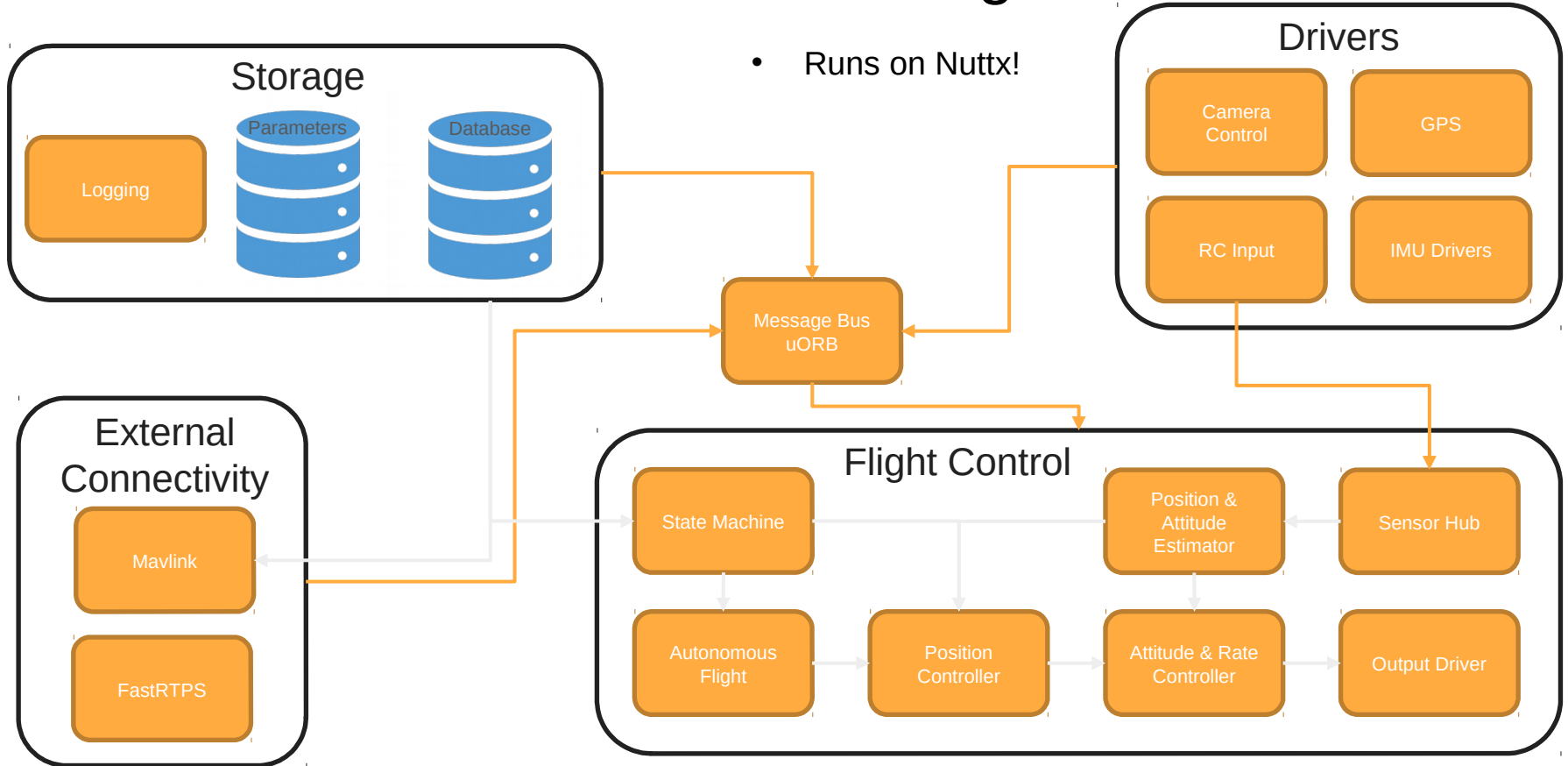
AIRDOG



wingtra



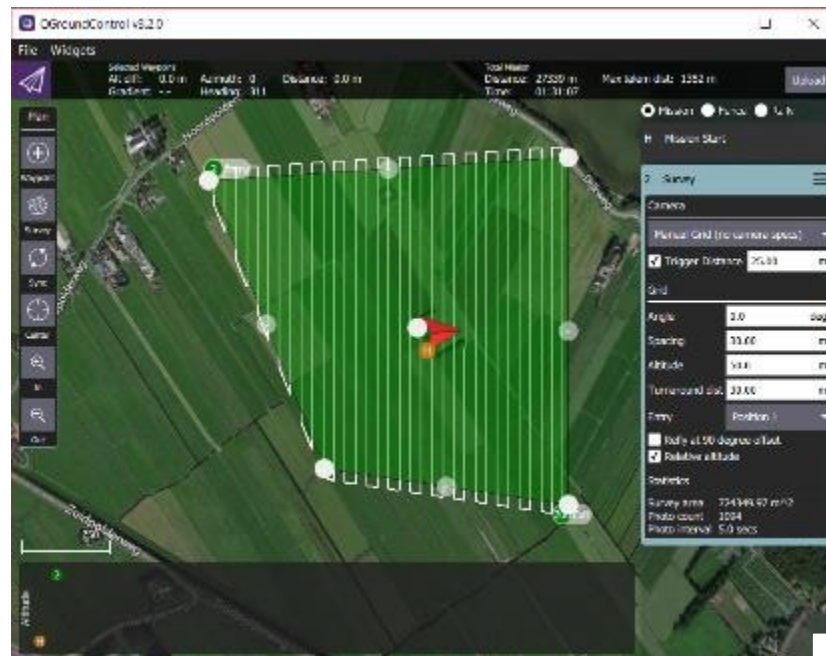
PX4 software stack is well designed



QGroundControl:

The opensource Ground Control Station

- Android, iOS, Windows, Linux and Mac
- For flying and mission planning
- Survey, mapping support
- Digital video streaming support
- UTM integration
- Open source and customizable



- Fly
- Land
- RTL
- Pause
- Action



Altitude-rel (m)
2.5
Ground Speed (m/s)
0.0
Flight Time
00:00:16
●●●●

Goto Location ✕

Move the vehicle to the location clicked on the map.

Slide to confirm

10 m

QGroundControl v3.5.2

Manual Entschärf

Vehicle Setup

Fluggerätetyp Einrichtung ist zur Auswahl der Art des Fluggeräts welches zu Deinem passt. Im Anschluss werden einige Flug-Abstimmungsparameter eingestellt. Du hast ein 5500 verbunden. Um die Konfiguration zu ändern, wähle den gewünschten Fluggerätetyp unten und wähle dann "Anwenden und Neustarten".

Summary

Firmware

Fluggerätetyp

Sensors

Radio

Flugmodi





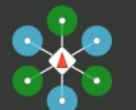

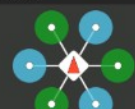
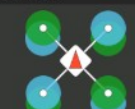
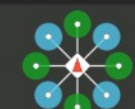
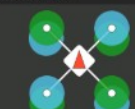
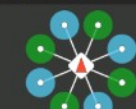


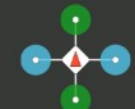
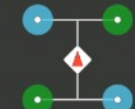


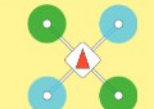

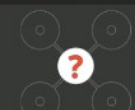
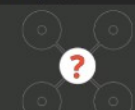

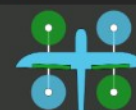






Power

Sicherheit

Tuning

Parameters

Anwenden und Neustarten

Coaxial Helicopter	Dodecarotor cox	Flying Wing	Helicopter	Hexarotor +	Hexarotor Coaxial
 Esky (Big) Lama v4	 Generic Dodecarotor cox geometry	 Generic Flying Wing	 Blade 130X	 Generic Hexarotor + geometry	 Generic Hexarotor coaxial geometry
Hexarotor x	Octo Coax Wide	Octorotor +	Octorotor Coaxial	Octorotor x	Plane A-Tail
 Generic Hexarotor x geometry	 Steadidrone MAVRIK	 Generic Octorotor + geometry	 Generic 10" Octo coaxial geometry	 Generic Octorotor X geometry	 Applied Aeronautics Albatross
Plane V-Tail	Quadrotor +	Quadrotor H	Quadrotor Wide	Quadrotor asymmetric	Quadrotor x
 X-UAV Mini Talon	 Generic 10" Quad + geometry	 Reaper 500 Quad	 Team Blacksheep Discovery	 Spedix S250AQ	 5500
Rover	Simulation (Copter)	Simulation (Plane)	Standard Plane	Standard VTOL	Tilt-Quad
 Generic Ground Vehicle	 HIL Quadcopter X	 HILStar (XPlane)	 Standard Plane	 HIL Standard VTOL QuadPlane	 Tilt-Quadrotor
Tricopter Y+	Tricopter Y-	VTOL Duo Tailsitter	VTOL Quad Tailsitter	VTOL Tiltrotor	
					

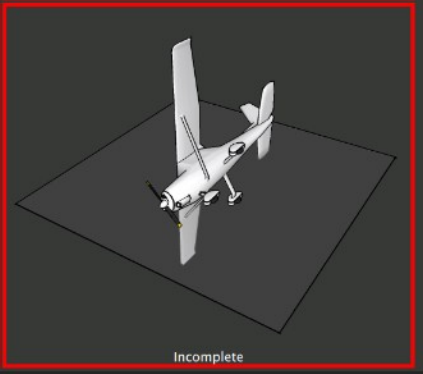
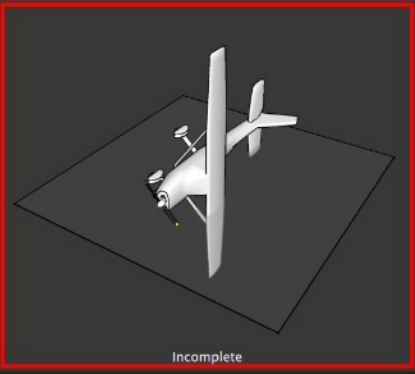
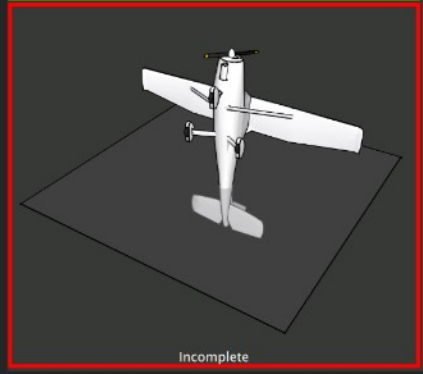
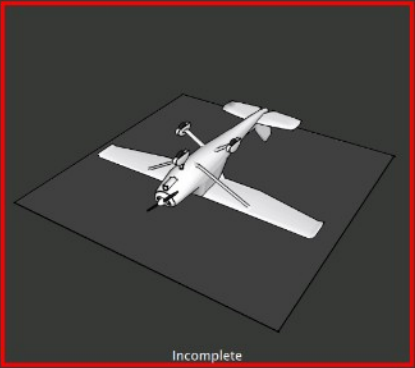
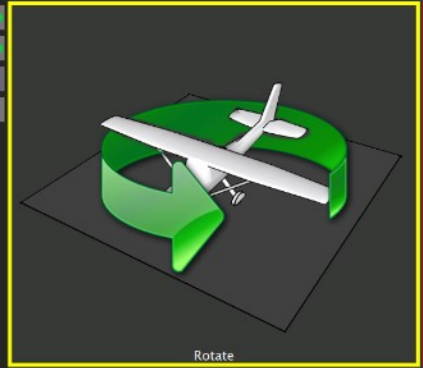
- Vehicle Setup
- Summary
- Firmware
- Fluggerätetyp
- Sensors**
- Radio
- Flugmodi
- Power
- Sicherheit
- Tuning
- Parameters

Sensors Setup

Sensors Setup is used to calibrate the sensors within your vehicle.

- Compass
- Gyroscope
- Accelerometer
- Level Horizon
- Cancel
- Set Orientations

Rotate the vehicle continuously as shown in the diagram until marked as Completed



QGroundControl v3.5.2

Manual Entschärft

Tools

Vehicle Setup

Search: Clear

Summary Standard

Battery Calibration

Firmware

Fluggerätetyp

Sensors

Radio

Flugmodi

Power

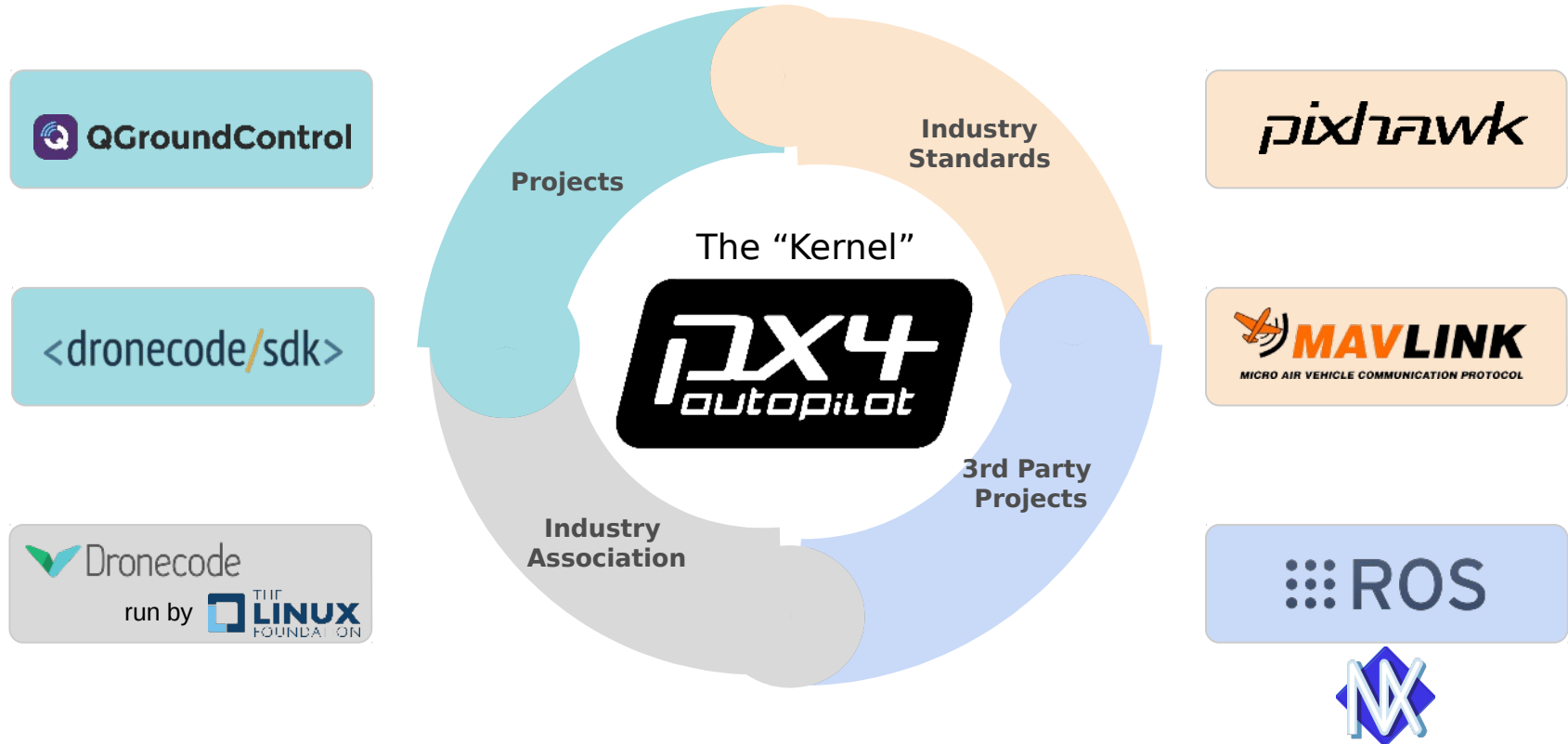
Sicherheit

Tuning

Parameters

Data Link Loss	EKF2_GYR_B_NOISE	0.001000 rad/s**2	Process noise for IMU rate gyro bias prediction
EKF2	EKF2_GYR_NOISE	0.0150 rad/s	Rate gyro noise for covariance prediction
Events	EKF2_HDG_GATE	2.6 SD	Gate size for magnetic heading fusion
Failure Detector	EKF2_HEAD_NOISE	0.30 rad	Measurement noise for magnetic heading fusion
Follow target	EKF2_HGT_MODE	Barometric pressure	Determines the primary source of height data used by the EKF
GPS	EKF2_IMU_POS_X	0.000 m	X position of IMU in body frame
	EKF2_IMU_POS_Y	0.000 m	Y position of IMU in body frame
GPS Failure Navigation	EKF2_IMU_POS_Z	0.000 m	Z position of IMU in body frame
Radio Calibration	EKF2_MOVE_TEST	1.0	Vehicle movement test threshold
Radio Switches	EKF2_NOAID_NOISE	10.0 m	Measurement noise for non-aiding position hold
Return Mode	EKF2_NOAID_TOUT	5000000 uSec	Maximum lapsed time from last fusion of measurements that constrain velocity drift before the EKF will report the horizontal nav solution as invalid
Return To Land	EKF2_OF_DELAY	5.0 ms	Optical flow measurement delay relative to IMU measurements Assumes measurement is timestamped at trailing edge of integration period
SD Logging	EKF2_OF_GATE	3.0 SD	Gate size for optical flow fusion
Sensor Calibration	EKF2_OF_N_MAX	0.50 rad/s	Measurement noise for the optical flow sensor
Sensors	EKF2_OF_N_MIN	0.15 rad/s	Measurement noise for the optical flow sensor when it's reported quality metric is at the maximum
Serial	EKF2_OF_POS_X	0.000 m	X position of optical flow focal point in body frame
Custom	EKF2_OF_POS_Y	0.000 m	Y position of optical flow focal point in body frame

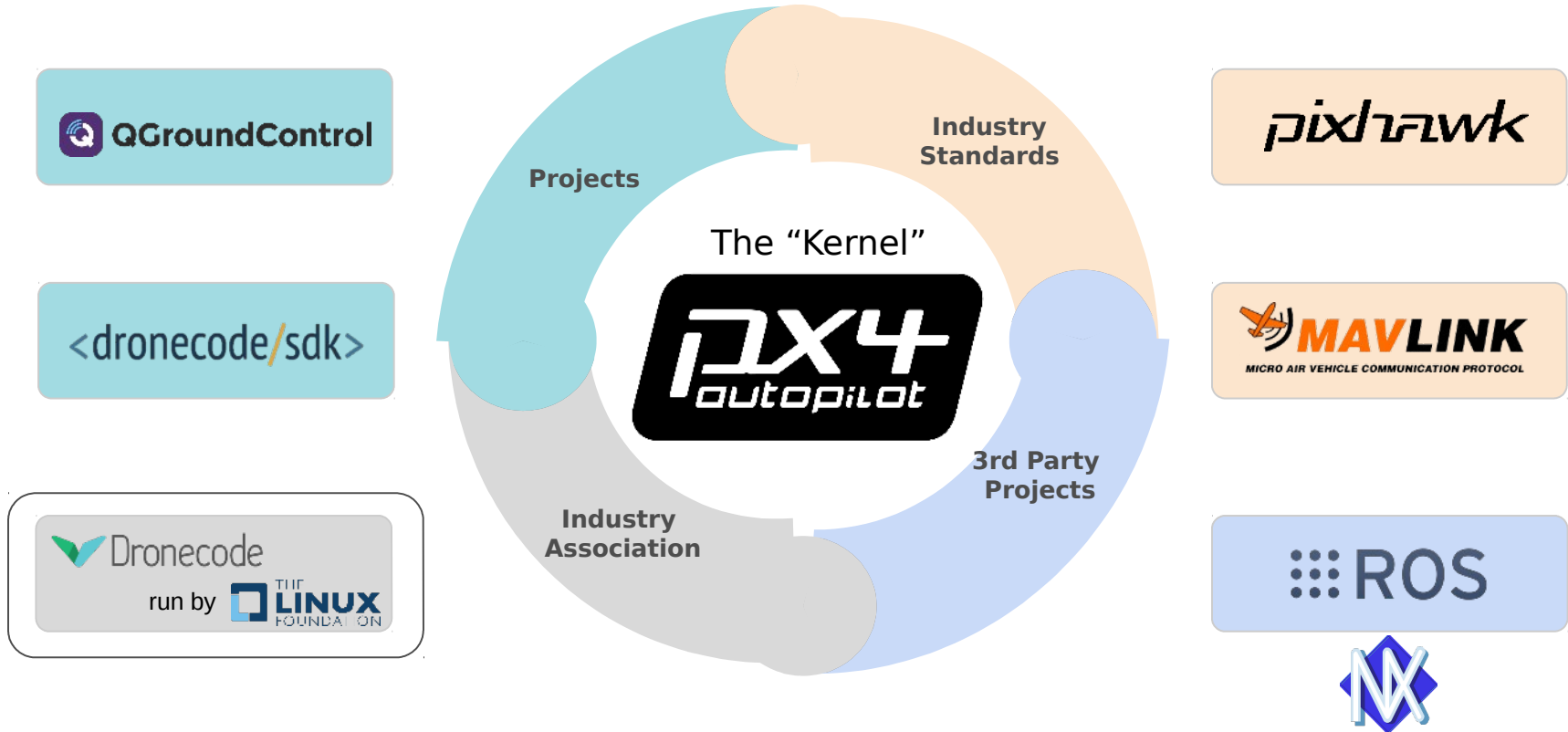
What's the relationship between these parts?



Look for the a well designed open source solution with **best in class...**

- ✓ Software
- ✓ Project management
- ✓ Ecosystem
- ✓ **Governance**
- ✓ **Community**
- ✓ Enterprise grade support

What's the relationship between these parts?





A neutral place where industry and community developers can work together to build the world's leading open UAV software platform

Look for the a well designed open source solution with **best in class...**

- ✓ Software
- ✓ Project management
- ✓ Ecosystem
- ✓ Governance
- ✓ Community
- ✓ **Enterprise grade support**

1

**Auterion
Enterprise
PX4**

2

**Auteri
on
Ground
Station**

3

**Auterion
Cloud
Insights**



Back to the drone design...

We're a semiconductor company, not a drone company

HoverGames Drone

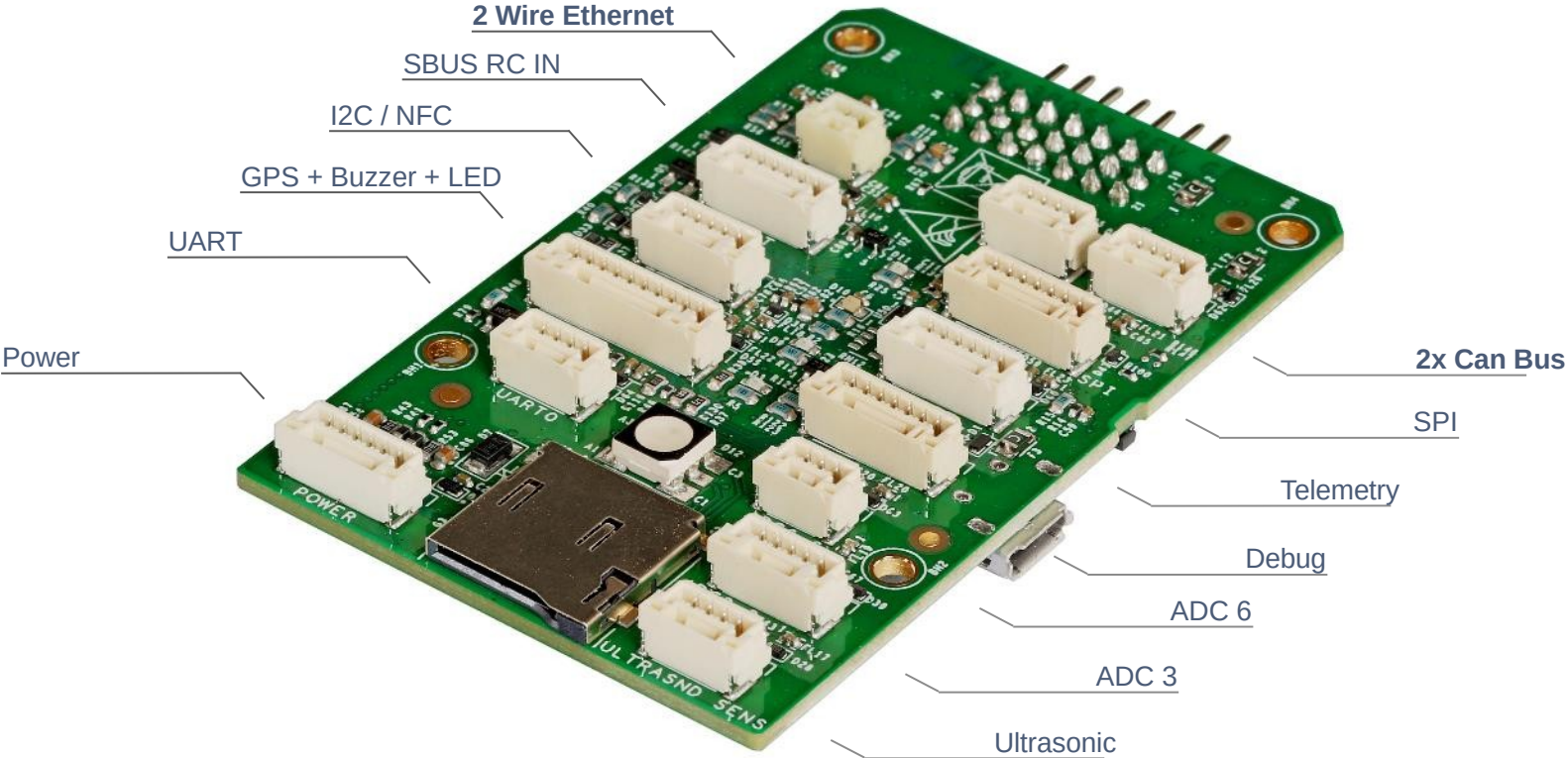


Additional Components

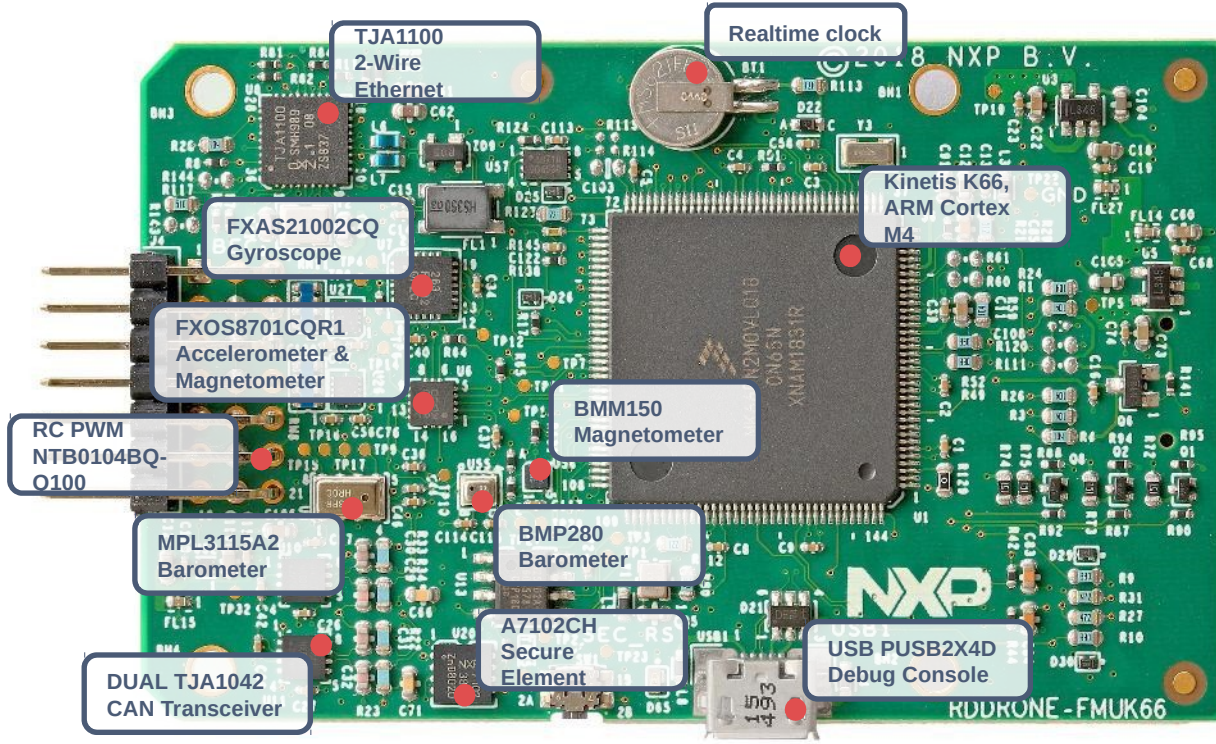
- Segger Jlink Mini EDU
 - FTDI serial cable
 - RC Remote RX/TX
 - Telemetry Radio
 - LiPo Battery Charger
-
- FCC, CE, RoHS, REACH
 - Available direct and through distribution



RDDRONE-FMUK66 Flight Management Unit



RDDRONE-FMUK66



Working with opensource community allowed us to overcome significant challenges

We were introducing a **new processor** and modified architecture into the ecosystem

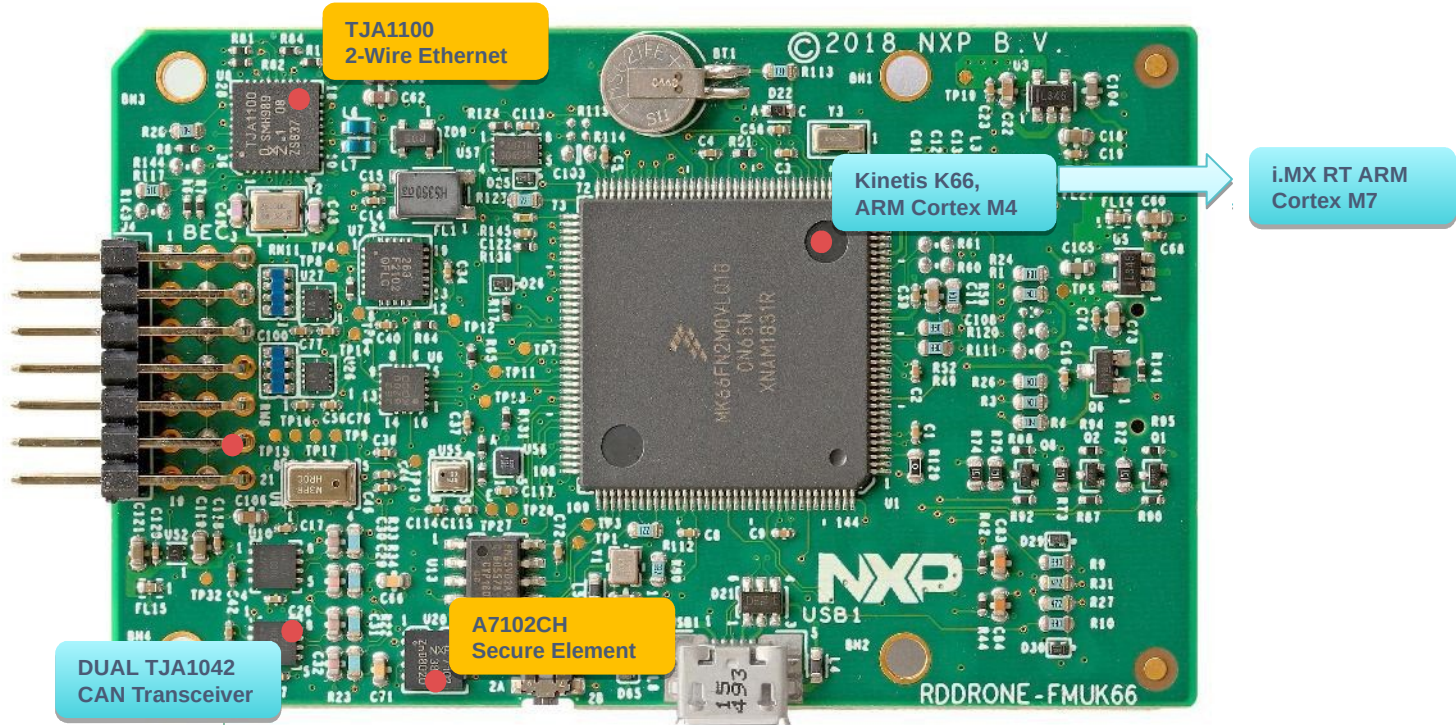
Needed support for underlying NuttX RTOS

NXP joined to support the community:

- ✓ Easily identify and hire experts
- ✓ Ease of engagement with experts
- ✓ Community feedback
- ✓ Rigorous flight testing program

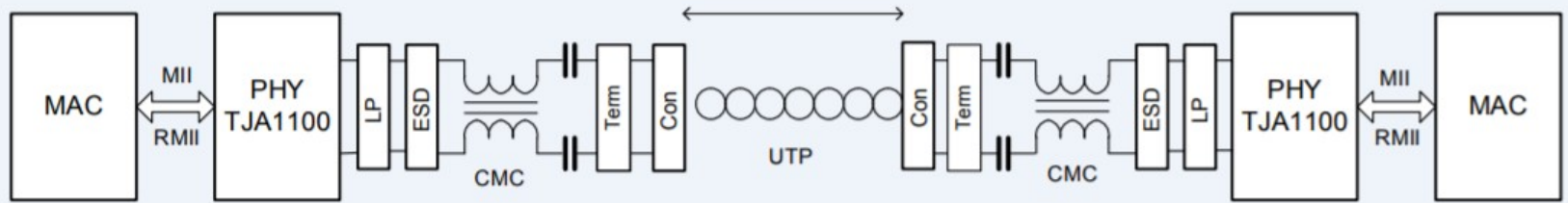
Feedback: RDDRONE-FMUK66

Open and frank dialog helps
Understand community needs



UAVCAN V1 requests CAN-FD

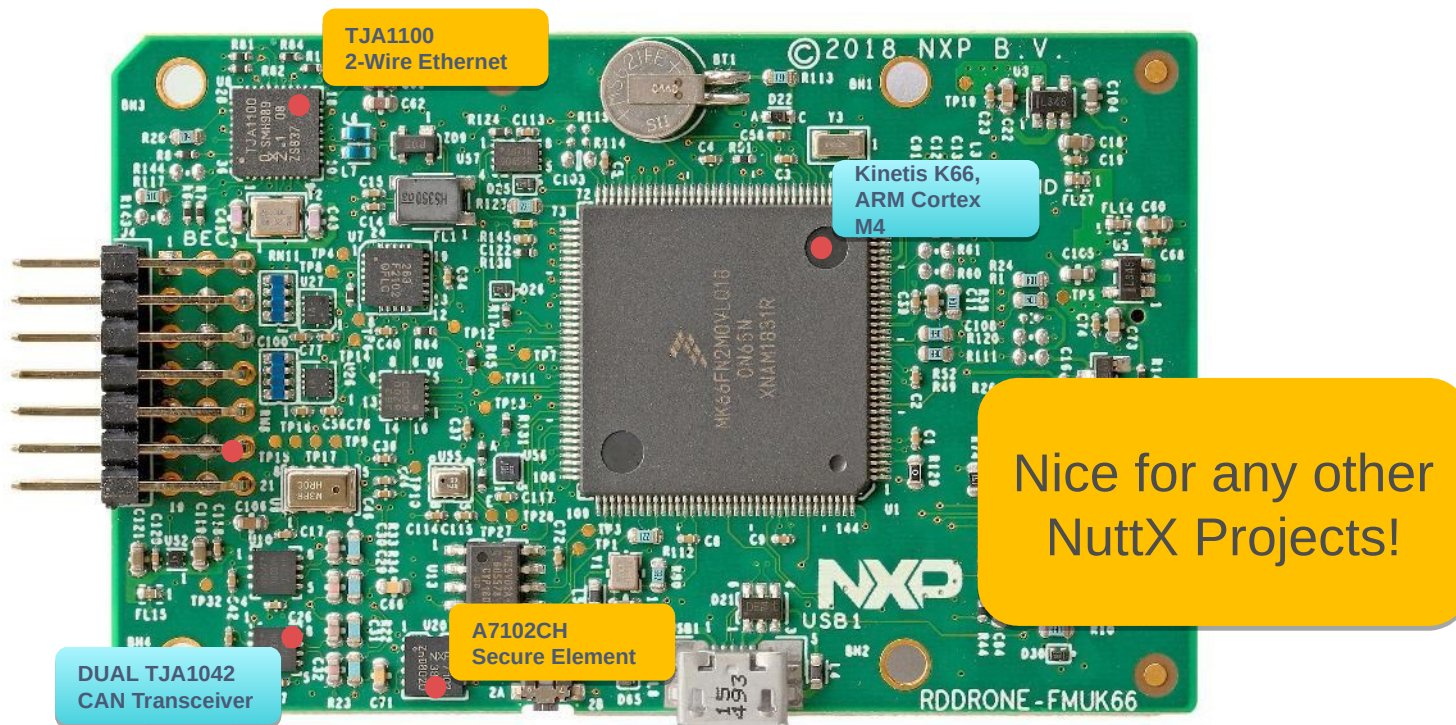
100BaseT1 “2 wire ethernet”



- Automotive Rugged, robust, high ESD
- Lightweight connectors, wires, no magnetics
- 15 meter distance
- Automotive ethernet switch available
- Still regular ethernet - media conversion by switch or back to back PHYs
- Attractive for high speed IP/Socket programming

- Higher bandwidth cameras or sensors
- Standard IP connection between FMU and Companion computer
- Tethered operation

Feedback: RDDRONE-FMUK66



Nice for any other NuttX Projects!



UAVCAN V1 requests CAN-FD



NXP's Future development with NuttX and PX4

Our engagement has been positive

We want to give back – where can we add value?





ARM7TDMI (NXP LPC214x, LPC2378,)
ARM920T (Freescale i.MX1)
ARM926EJS (NXP LPC31xx)
ARM Cortex-A9 (NXP/Freescale i.MX6)
ARM Cortex-M0 (NXP/Freescale KL25Z, KL26Z)
ARM Cortex-M3 (NXP LPC17xx,)
ARM Cortex-M4 (NXP LPC43xx/LPC54xx, Freescale Kinetis K20/K28/K40/60/64/66)
ARM Cortex-M7 (NXP **i.MX RT**)

Freescale M68HCS12

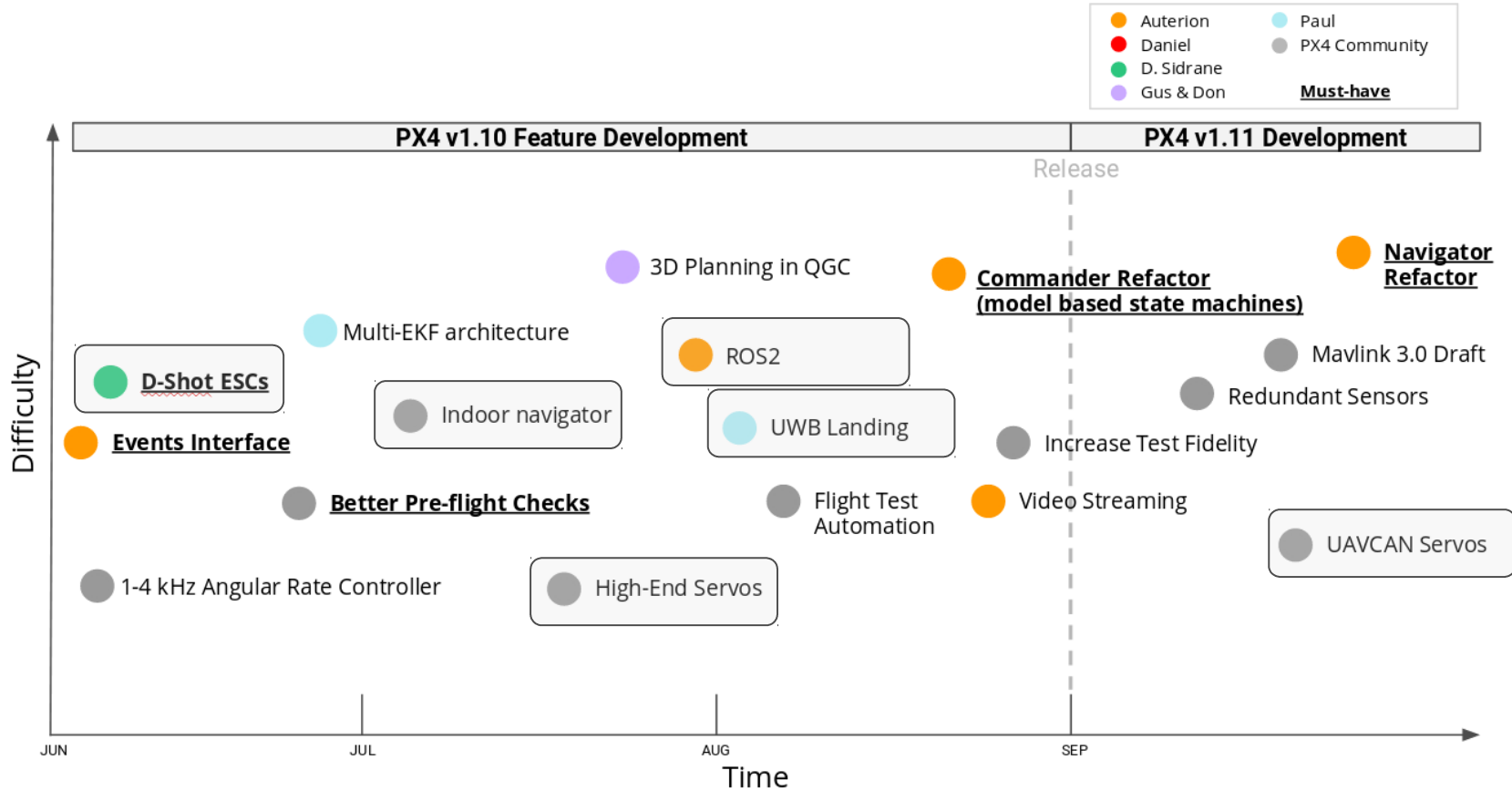


Automotive S32K
ARM M4, M7 ?

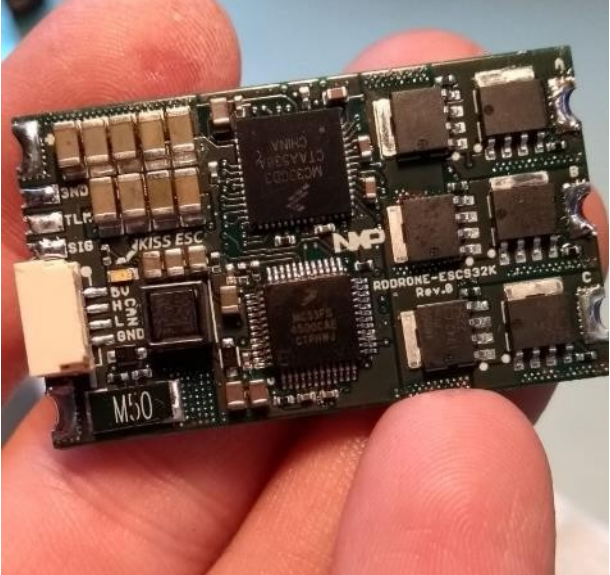
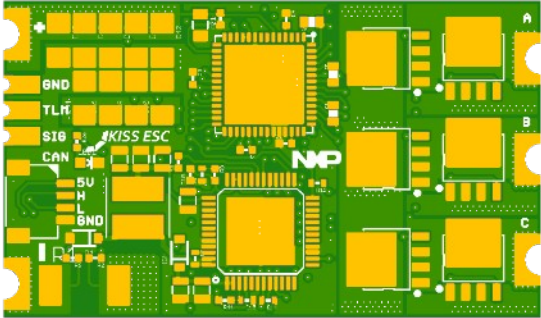
NXP RISC-V ?
(RI5CY core)

NXP LPC5500, i.MX 600 ?
(M33 core)

PX4 v1.10: Release September, 2019



RDDRONE-ESC32K
NXP-Flyduino/FETTEC S32K based “automotive” motor controller



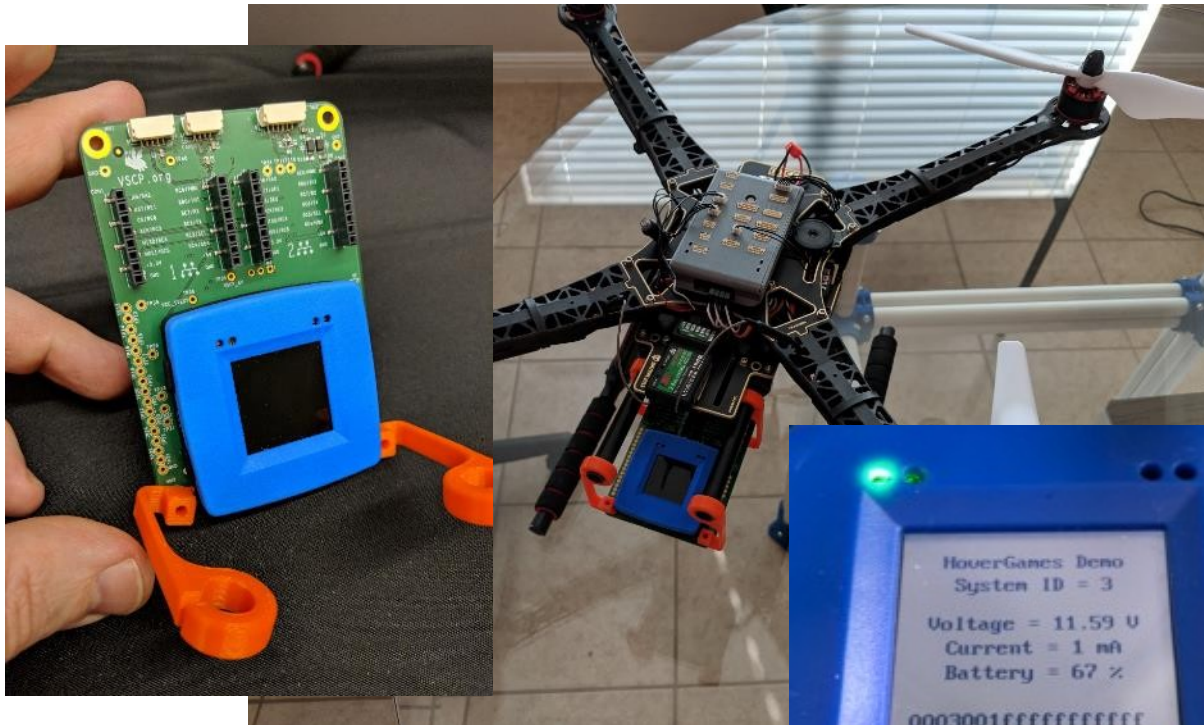
UAVCAN initiative

RDDRONE-IOT

HoverGames enables mobile IoT

Integration with Rapid IOT Platform

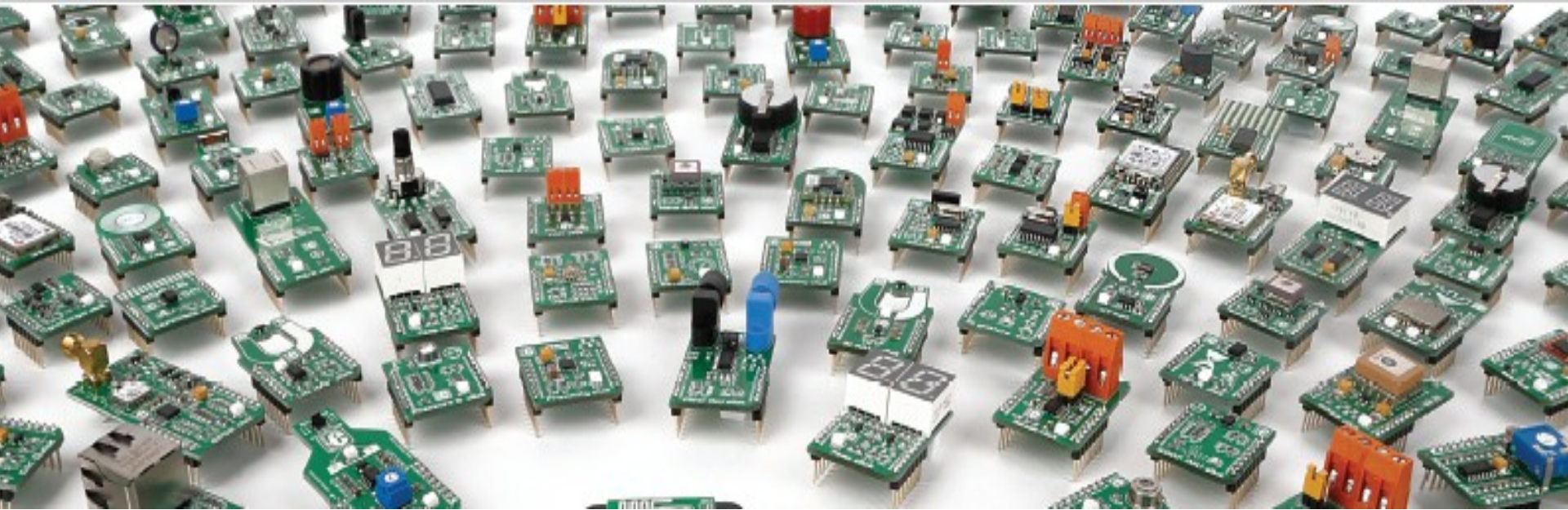
- CAN BUS **UAVCAN** connectors
- VSCP.org project
- MAVLINK example software
- Color graphics LCD
- Touch, Capsense, buttons
- **Onboard 802.15.4 Radio**
- IPV6, 6lowpan, Thread radio
- Bluetooth, Zigbee, KW41
- Pluggable “Click” modules



UAVCAN initiative

MikroElektronika Ecosystem

Over 450+ Click boards™ with mikroBUS™ connector and drivers



Gas Sensors, UV, IR, LORA, SigFox, Cellular, Lighting...

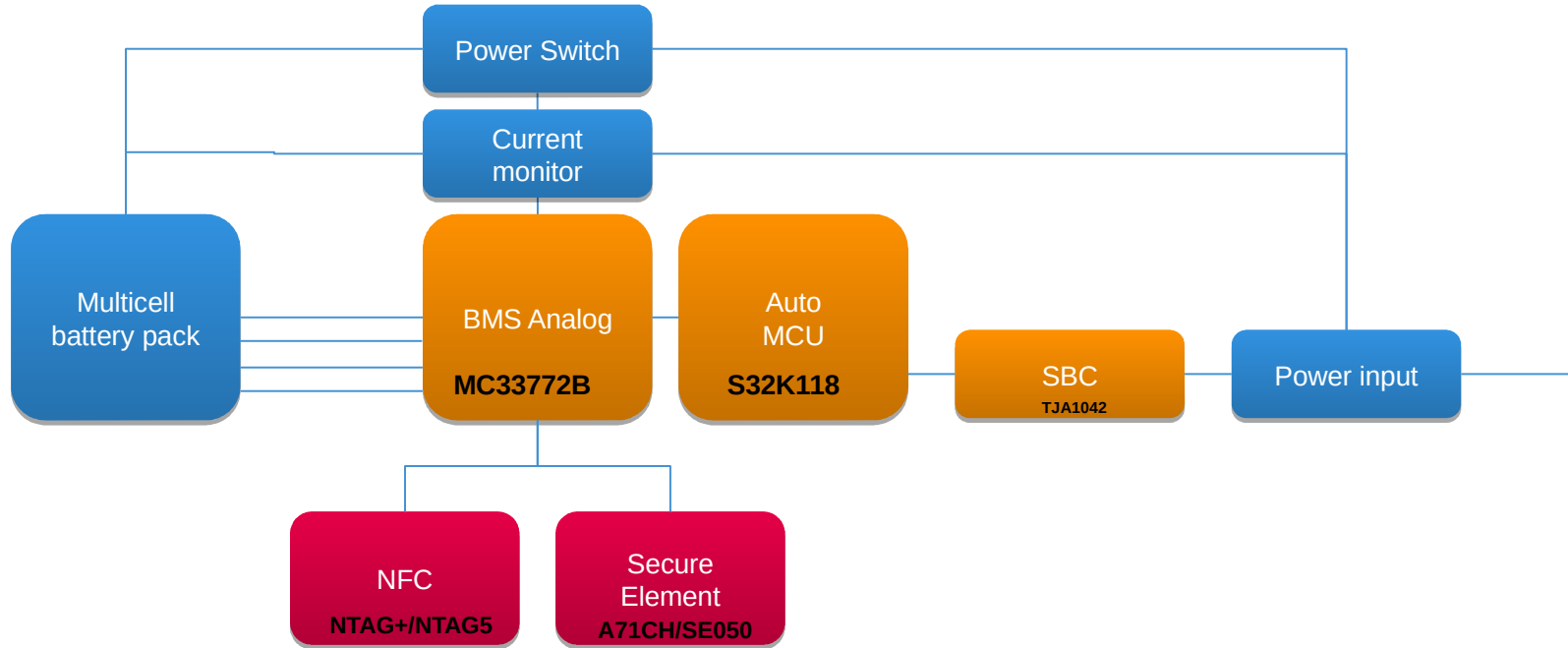
RDDRONE-BMS772 (Automotive)

Intelligent Battery Management for Small Systems



- Automotive S32K MCU development
- Auto and consumer grade BOM
- Low Cost ~\$20
- Up to 6S battery (25.2V)
- 75A continuous 200A peak
- CAN-FD/UAVCAN V1.0
- **Secure authentication**
- Secure event count and flags
- **NFC for manifest log and settings**
- NuttX ??

RDDRONE-BMS772 BMS Module



HoverGames

For Inspiration!



Hovergames Challenges

- Coding challenges with societal impact theme
- Challenge 1 theme is “Fight fire with Flyers”
- Introduction to NuttX and the PX4 opensource community
- Learning opportunity using a complete autonomous development platform and infrastructure
- Desirable new technologies are continually introduced and enabled



NXP

HOVERGAMES

FIGHT FIRE WITH FLYERS

<https://www.hackster.io/contests/hovergames>

Whether man-made or natural, fires are difficult to predict and control. Fires cause billions in damage, destroy entire towns and forests and put countless lives in danger, including first responders at the front line.

HOVERGAMES IS YOUR OPPORTUNITY TO HELP

The objective of this contest is to build a solution that enables your HoverGames drone to assist fire fighters in their duties – in any way you can imagine, from wildfires to urban fires.



Rapid IoT +
RDDrone-IOT
adapter
board



PixyCam
2



Heat
Sensor

First Flyers for Hovergames Challenges

Internal NXP participants 180 engineers and programmers

- 50 Teams
- 30 countries

Great exposure to NuttX RTOS and PX4 internal to the company



Iain Galloway iain.galloway@nxp.com

www.HoverGames.com