Unmanned Aerial Vehicle (Drone) Special Interest Group

Agenda

Welcome and Overview of the Drone SiG and Open Source Drone Ecosystem

- John Glossner (Optimum Semiconductor Technologies)

Interference Detection and Localization

- Yifeng Zhou (CRC)

Using Drones to Elevate RF Measurements

- Tom Brinkoetter (RadioSiteTest)

UAS Spectrum sharing in the 5GHz band for BVLOS

- Mark Gibson (Commscope)

Wireless Drone Networking

- David Murotake (Honorary Lifetime WInnForum Member)

Drone Special Interest Group

Target Audience

Wireless Telecommunications Regulators

Autonomous vehicle manufacturers

- Unattended Airborne Vehicles UAV
- Unattended Ground Vehicles UGV
- Unattended Submersible Vehicles USV
- etc.

Aviation Electronics Suppliers

Automotive Electronics Suppliers

Defense Electronics Manufacturers

Wireless Networking System Integrators

Commercial Applications

- autonomous ground transportation systems
- drone taxis
- drone delivery of packages and medical supplies
- allowing safe operation in, or under, controlled airspace
- which can be approved by transportation regulators

Defense Applications

- aerial refueling
- reconnaissance swarm
- armed escort swarm
- autonomous counter-air/counter-drone operations
- swarming reconnaissance/ communications satellite swarms
- That can safely fly in, under or over controlled airspace of host nations
- Can be the subject of future joint/multinational development and procurement efforts.

WInnForum Standards™

WIRELESS INNOVATION FORUM®

Work Products

Provides

- a survey of existing open source projects
- interference detection and localization

Future

- recommendations for Spectrum Sharing in V2V applications
- a survey of commercial and open-source application programming interface (API) models for autonomous networking software
- a description of potential commercial and tactical business models
- a survey of key intellectual property to date

Open Source

Can you build a drone ecosystem entirely from open-source and open standards?

WINNF-TR-2010: Drone Open-Source Ecosystem

- 146 hyper links
- 15 References

Components of Drone Systems

Flight Supervision

- Unmanned Traffic Managements (UTM)
- UAS flight management
- Flight safety and authorization
- Remote identification

Command and Control

- APIs
- Autopilots

Simulation

- Flight modeling
- Traffic modeling
- Wireless communications modeling

Operating Systems / Hardware

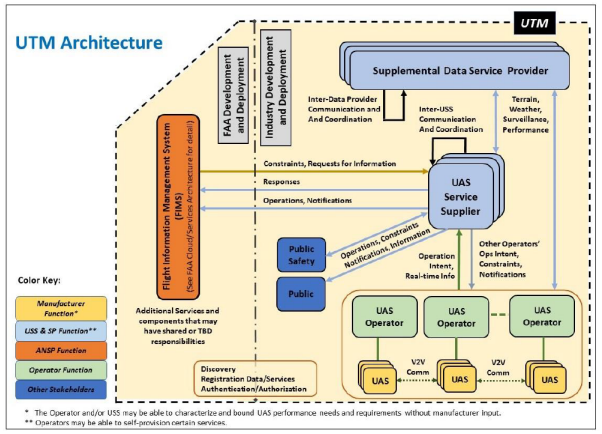
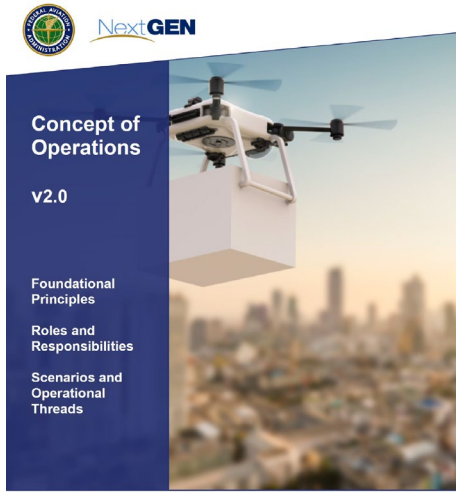
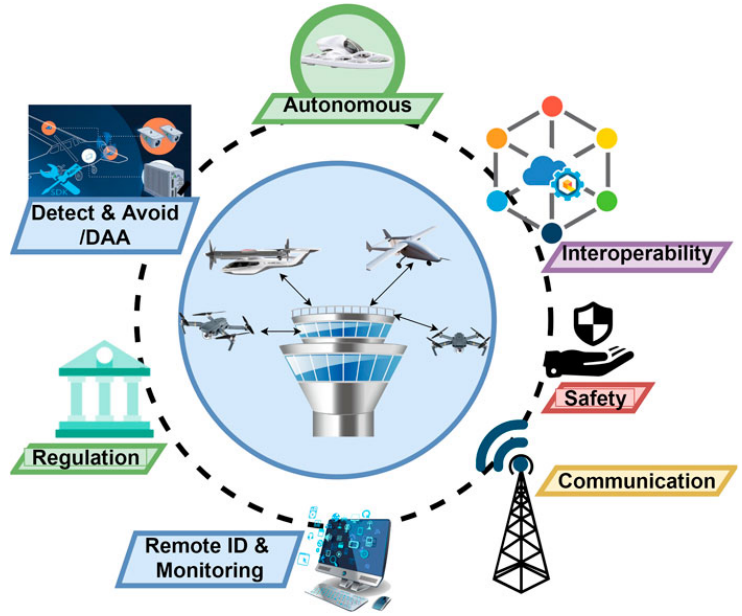
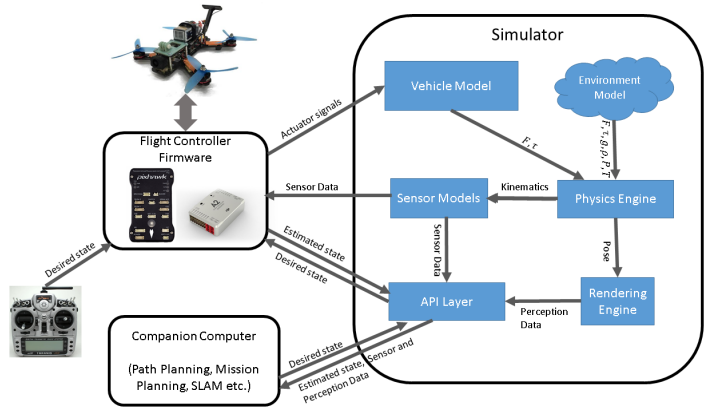


Figure 3. Notional UTM architecture





Front. Future Transp., 26 April 2021 | https://doi.org/10.3389/ffutr.2021.626935



Flight Supervision

- Unmanned Traffic Managements (UTM)
- UAS flight management
- Flight safety and authorization
- Remote identification

Flight Supervision: Unmanned Traffic Management (UTM)

InterUSS Platform

- Linux foundation
- Code on github
- Apache 2.0
- Wing, Uber, Airmap…
- UAS Service Supplier (USS) discovery
- Constrain synchronization and validation

Global UTM Association

- World-wide interoperable UTM focus
- Code and open protocols on github
- Apache 2.0

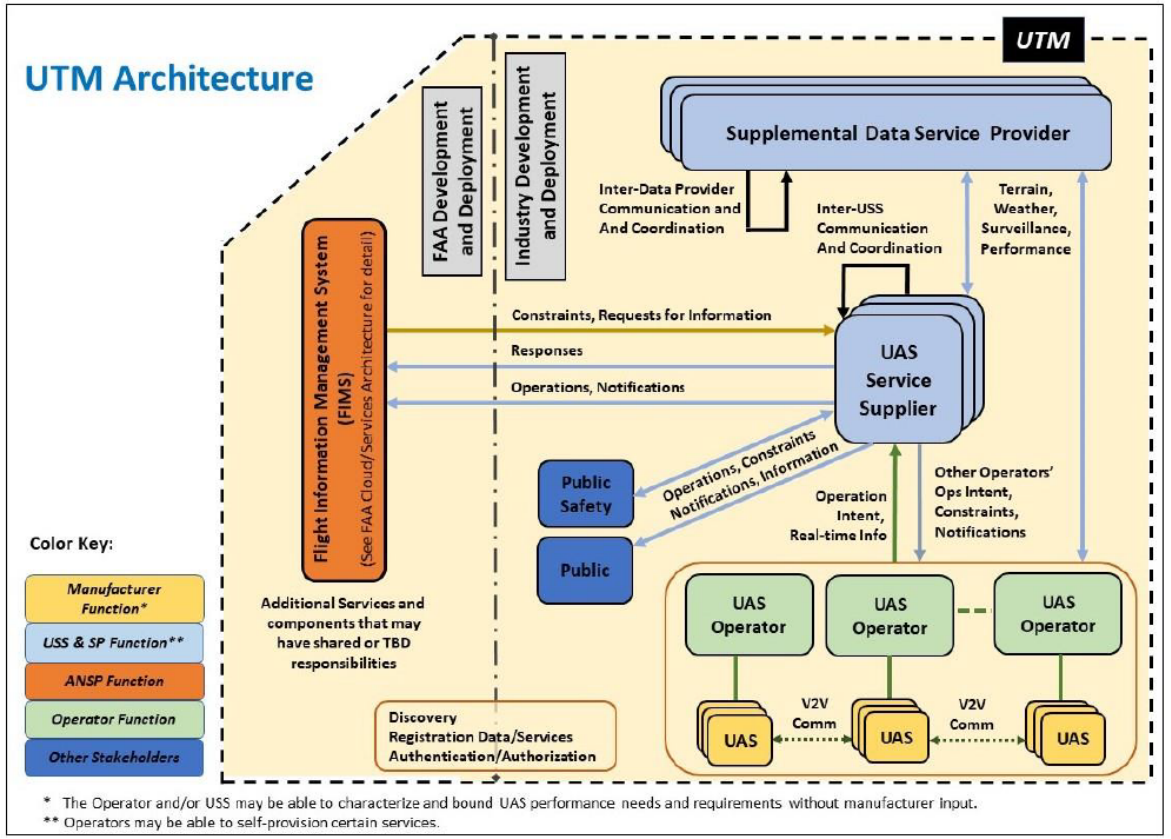
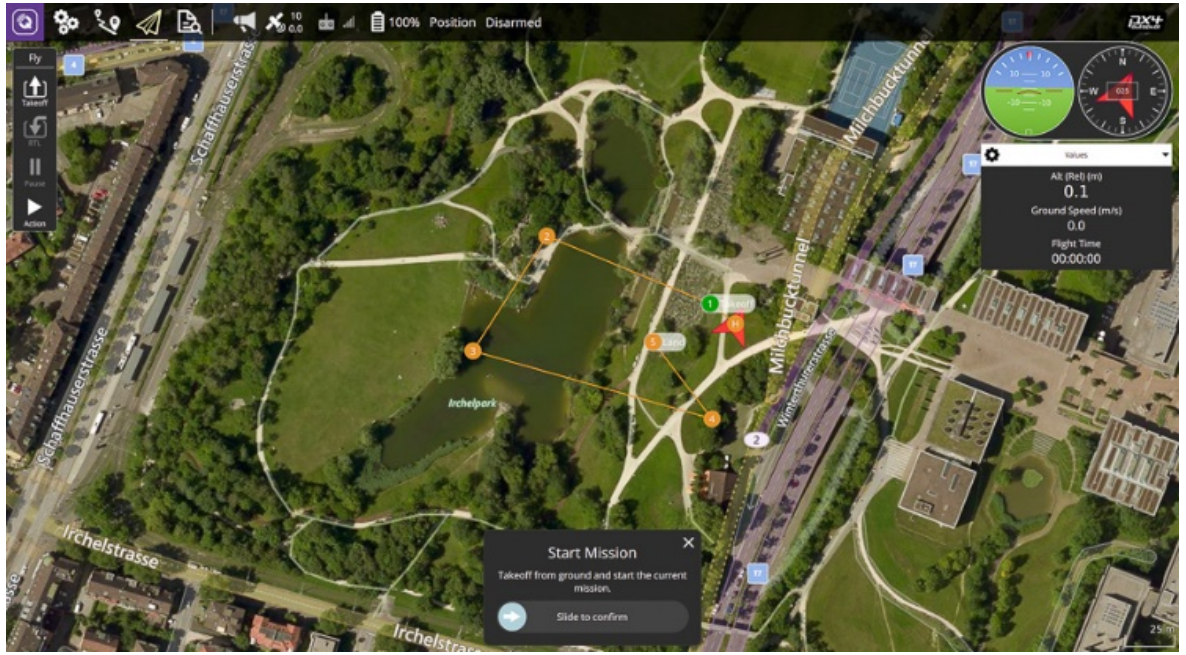


Figure 3. Notional UTM architecture

Flight Supervision: Flight Management

Ground Control Station (GCS)

- QGroundControl
  - Linux DroneCode foundation
  - GPLv3 and Apache 2.0
- MAVProxy
  - GPLv3
  - ArduPilot maintains
- Others
  - APM Planner
  - Mission Planner
  - Tower



Position, flight track, waypoints, geofence, instruments, etc.

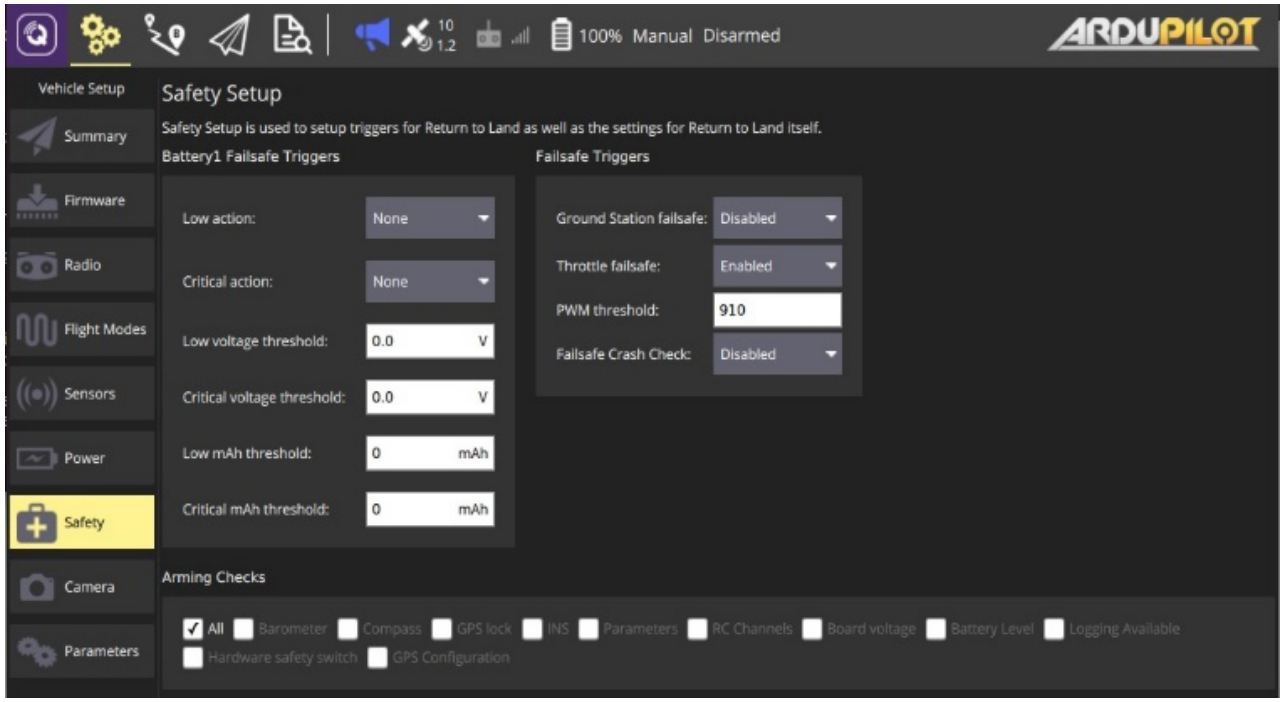
Flight Supervision: Flight Safety / Authorization

AutoPilots Provide Safety Failsafe

- Low battery
- Loss of remote-control signal
- Data link failures
- Geofence violations

Authorization

- FAA UAS Low Altitude Authorization and Notification Capability (LAANC)
  - Controlled airspace authorization
  - API public
- Google Wing Opensky
  - NOT open source (but free)
  - When and where it is safe to fly
  - LAANC submissions



ArduPilot failsafe triggers

Flight Supervision: Remote Identification

A Unique ID for UAVs

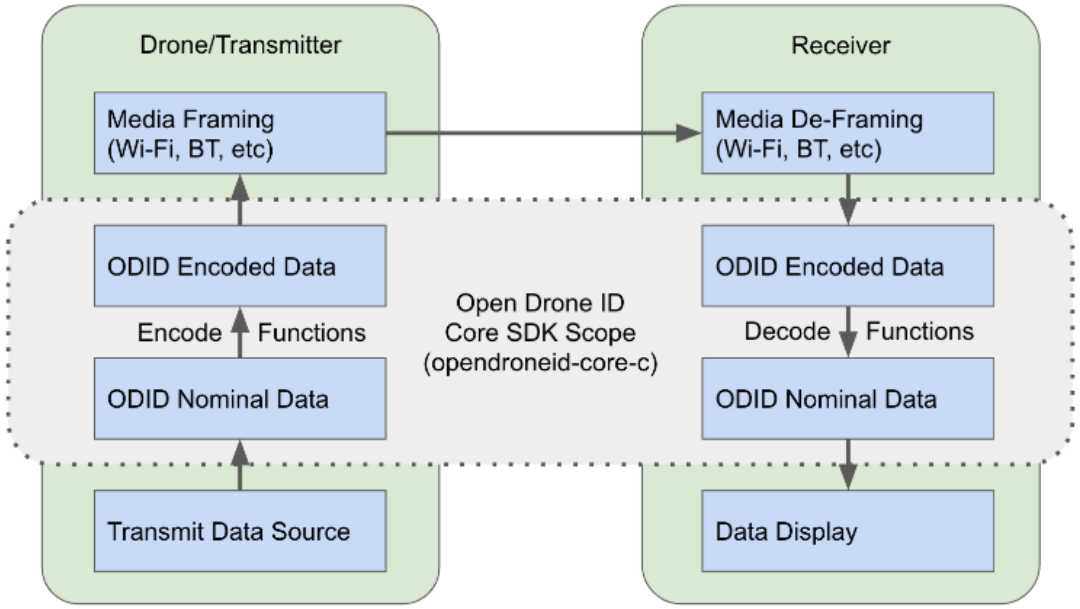
- Similar to license plate
- Direct broadcast RID: limited to reception range of signal
  - Required by 2023
  - sUAS < 0.55lbs excluded
- Networked RID: possible. Not required.

Altitude Angel Scout

- Network RID
- Open-source HW/firmware for cellular network to send/receive position reports
- Apache 2.0

Open Drone ID

- Direct broadcast beacon capability
- Based on American Society for Testing Materials (ATSM) RID standard
  - Compatible with European ASD-STAN RID and MAVLink
- Bluetooth 5 long range, WiFi
- Apache 2.0



Open Drone ID Architecture

Command and Control

- APIs
- Autopilots

Command and Control: APIs

Controlling UAV flight by sending signals (commands) to the UAV

Micro Air Vehicle Communications Link (MAVLink)

- Supported by most manufacturers
- DroneCode Foundation provides SDK
- Publish-subscribe and point-to-point
- XML
- Header-only with many programming languages supported
  - C/C++, C#, Python, Java, JavaScript, Lua, Swift, Go…
- Developed since 2009
- MIT license

parrot.drone.groundsdk.mavlink

Class	Description
ChangeSpeedCommand	MAVLink command which allows to change the drone speed.
CreatePanoramaCommand	MAVLink command which allows to create a panorama.
DelayCommand	MAVLink command which allows to delay the next MAVLink command execution.
LandCommand	MAVLink command which allows to land.
MavlinkCommand	A MAVLink command.
MavlinkFiles	Utility class that provides methods to generate a MAVLink file from a list of MAVLink commands, and conversely, parse a MAVLink file.
MountControlCommand	MAVLink command which allows to control the camera tilt.
NavigateToWaypointCommand	MAVLink command which allows to navigate to a waypoint.
ReturnToLaunchCommand	MAVLink command which allows to return to home.
SetRoiCommand	MAVLink command which allows to set a Region Of Interest.
SetStillCaptureModeCommand	MAVLink command which allows to set the still capture mode.
SetViewModeCommand	MAVLink command which allows to set the view mode.
StartPhotoCaptureCommand	MAVLink command which allows to start photo capture.
StartVideoCaptureCommand	MAVLink command which allows to start video capture.
StopPhotoCaptureCommand	MAVLink command which allows to stop photo capture.
StopVideoCaptureCommand	MAVLink command which allows to stop video capture.
TakeOffCommand	MAVLink command which allows to take off.

Command and Control: Autopilots

PX4

- DroneCode Foundation
- BSD-2 license
- Multi-frame support
  - Multicopters, fixed wing, VTOL
- MAVLink to send controls
- Pre-flight check
  - sensor calibration, position lock, etc.
- In-flight sensor monitoring
- Autonomous modes (w/GPS): Mission, Takeoff, Land, Return, and Follow me

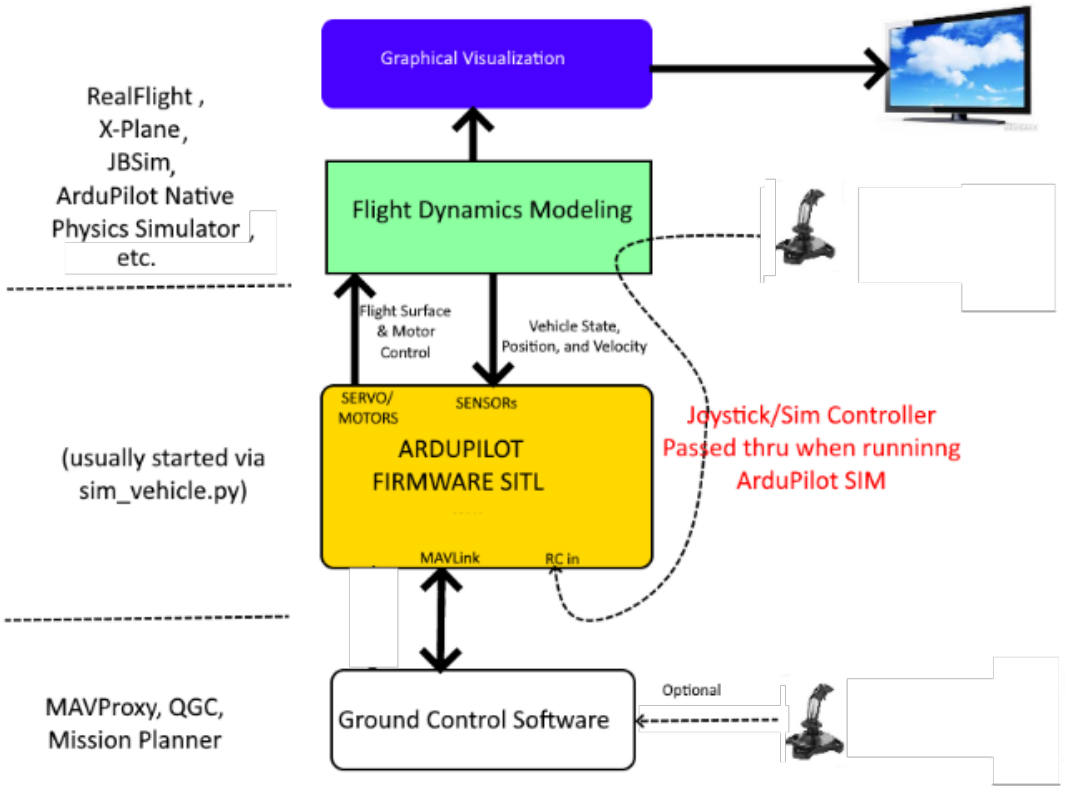
ArduPilot

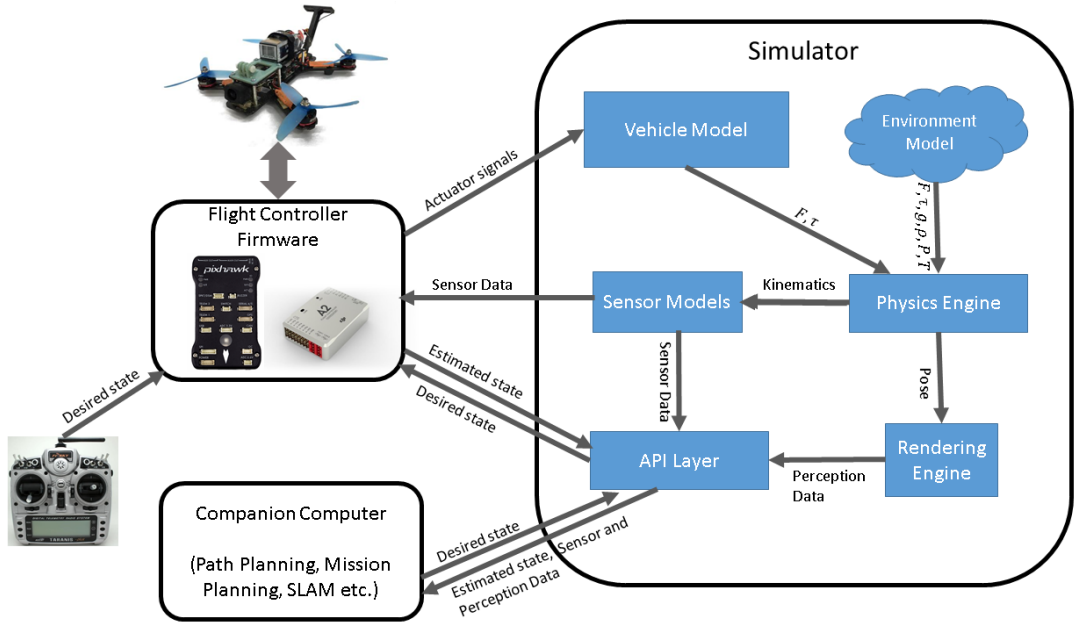
- GPLv3
- Multi-frame
  - PX4 + boats (sail/motor), submarines, ground vehicles
- MAVLink to send controls
- Pre-flight checks
- In-flight monitoring
- Autonomous, Semi-autonomous modes
- Installed on a large number of hardware controllers (e.g. Pixhawk)

Simulation

- Flight modeling
- Traffic modeling
- Wireless communications modeling

Simulation: Flight Modeling





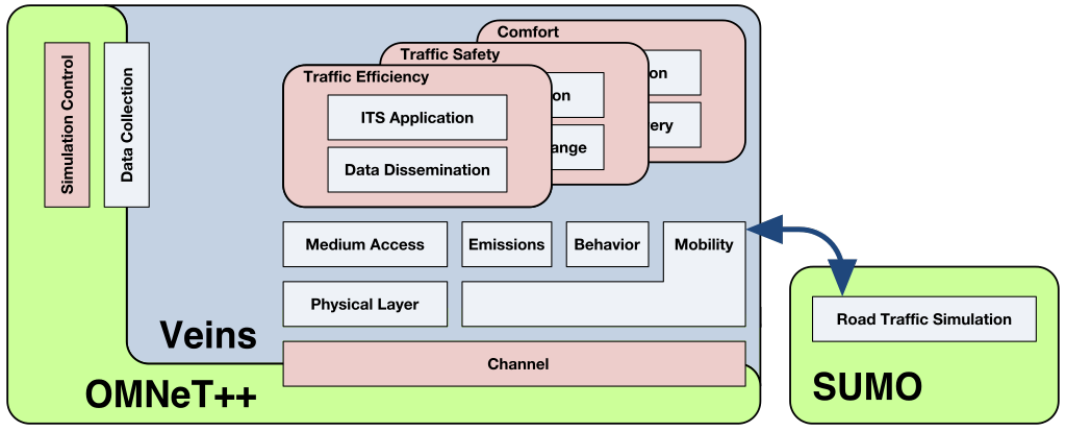
ArduPilot SITL

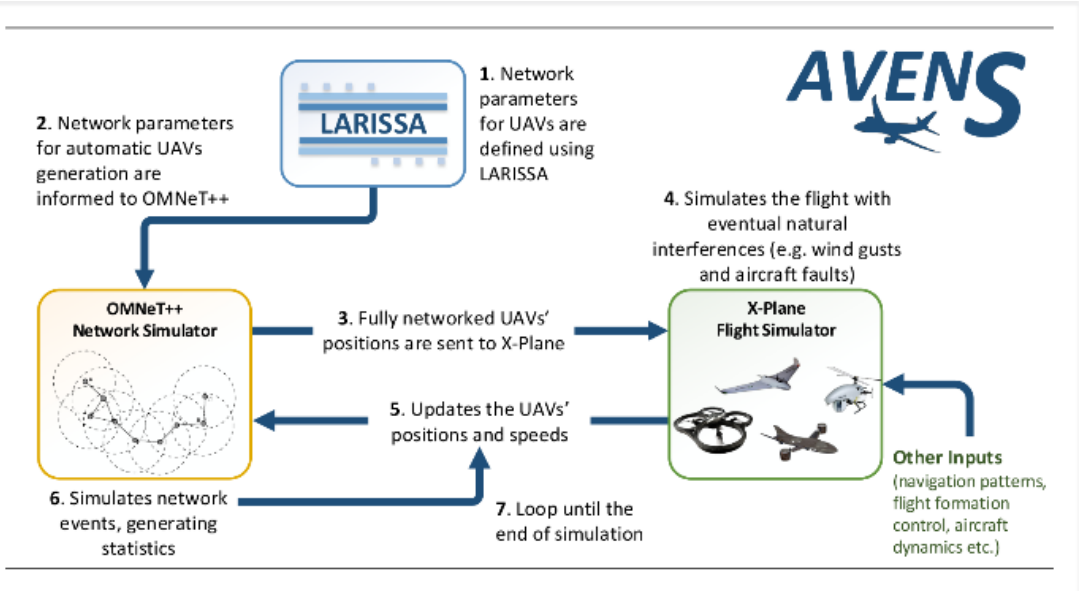
- Gazebo plugin with ROS available
- Uses Unreal Engine for Rendering

AirSim

- Microsoft Research
- MIT license
- Uses Unreal Engine for Rendering (proprietary license)

Simulation: Traffic Modeling





Veins: Vehicular network simulation framework

- GPLv2 suite of simulation models
- models lower protocol layers

SUMO: Simulation of Urban Mobility

- Intermodal: cars, bus, trains, pedestrians…
- Every entity simulated (unlimited size)
- Emissions
- C2X

OMNeT++: Event-based network simulator

- Interacting with a road traffic simulator (SUMO)

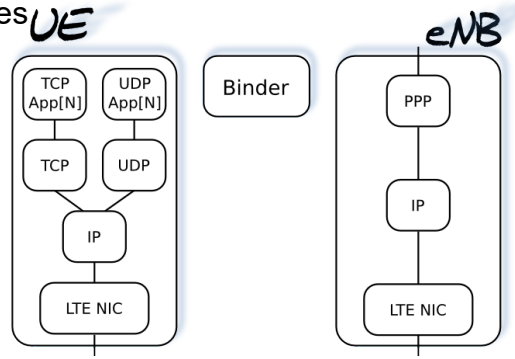
Avens

- GPLv3
- Extends Veins to UAVs
- LARISSA defines network parameters
  - Autogenerated OMNeT++ parameters
- X-Plane flight simulator (proprietary) receives OMNeT++ generated location data

Simulation: Wireless Communications Modeling (VEINS INET)

Veins INET SimuLTE/5G

- LGPLv3
- 3GPP Release 8 and beyond
- PHY
  - Transmit diversity using SINR curves
  - Channel feedback computation
  - Realistic Channel Model
- User Terminals
  - Mobility
  - Interference
  - All types of traffic
  - Handover
- eNode-B
  - Macro, micro, pico
  - Inter-eNB Coordination
  - Handover
  - Coordinated Multipoint transmission/reception (CoMP)
  - Scheduling: Proportional Fair, Round Robin…
  - eNB's connected via X2 interface
- Radio Link Control (RLC)
  - Segmentation and reassembly
  - Retransmissions
- MAC
  - Buffering
  - Protocol Data Unit (PDU) concatenation
  - Channel Quality Indicator (CQI) reception
  - Transport format selection and resource allocation



OpenCV2X - Open Cellular Vehicle To Everything (V2X)

- 3GPP standard CV2X (Rel 14) Mode 4
- Uses SimuLTE
- Directly integrated with Veins

IEEE 802.11p and IEEE 1609.4 DSRC/WAVE

- QoS channel conformant (4 queues)
- Accurately captures frame timing, modulation and coding, channel modes
- Channel hopping (CCH, SCH)
- WSM: Wave short message handling and periodic beaconing

Obstacle shadowing

- Building shadowing
- Vehicle shadowing
- Calibrated against real-world measurements

Antenna patterns

- Angle dependent gains
- Antenna type, mount point, roof topology

Operating Systems / Hardware

Pixhawk

Robot OS (ROS)

- Open Robotics Foundation
- GSD3 license
- Message passing interface for inter-process communication
- Synchronous services using RPC
- Robot-specific features
  - Message format
  - Geometry library for moving connected parts
  - Universal robot description language
  - Pose estimation
  - Localization and mapping
  - Mobile navigation
- ArduPilot and PX4 support
  - MAVROS BSD licensed MAVLink node

Pixhawk

- Open standards for drone hardware
  - Pin-out definitions
  - Architectural block diagram
  - PCB layout guidelines
  - Connector specifications
- PX4 autopilot support
- QGroundControl integration

Conclusions

Is it possible to build a complete drone eco-system from open-source software?

- ALMOST !!!

THANK YOU!

Questions???