

A photograph of a man standing in a grassy field, operating a quadcopter drone. The drone is in flight in the upper left foreground. The man is wearing a blue t-shirt and dark pants, holding a remote control device. In the background, there is a dense forest of tall trees.

Ground control station | Benchmark Study

September 2015



Purpose

Study the current state of UI related to drone flights to find positive aspects and improvements areas on them. By doing so we hoped **to identify best practices and gaps** that the community can address to improve overall user experiences.



14 tools were analyzed through **video tutorials, technical specifications, actual usage** and **reviews from users.**

Any tools and applications, **mobile or desktop**, which deal in **some way with flight planning and monitoring**. They are not necessarily Ground Control Stations.

Methodology

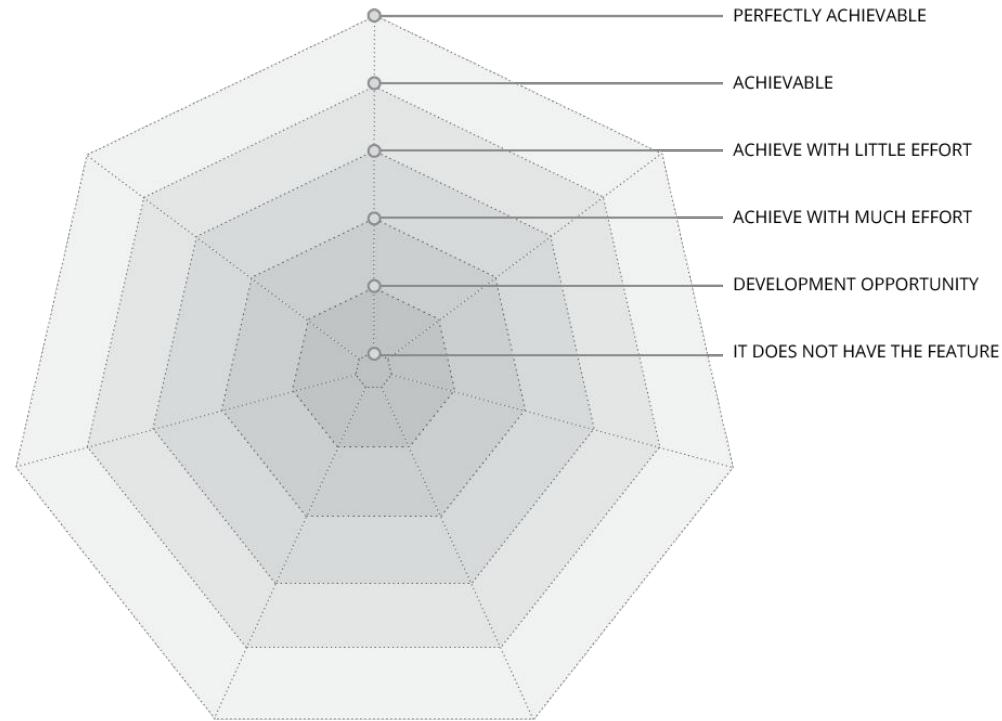
It was done on **September, 2015**. The features evaluated were the ones available until that.

If you find any mistake on this document, please **report it to us**.



Methodology

The experience
were evaluated
accordingly with
how they
support users
achieving goals



Goals evaluated

First use

Group of tools that help you on your first usage of the system, providing tips and guidance to keep the main concepts of it easily understandable

Setup

Procedures to execute before the flight to ensure the hardware and software are correctly configured and working properly

Plan

Helps to plan the flight, drawing a path to follow and specifying other tasks that the drone should perform

Flight

Tools that help users monitor the flight in real-time and switch flight modes

Analysis

Tools to analyse and debug the flight and its data when it is done

Executive summary

General information

	QGroundcontrol	Mission Planner	APM Planner	Tower	AndroPilot **	UGCS	Drone Deploy
MAVLink compatible	✓	✓	✓	✓	✓	✓	✓
Open source	✓	✓	✓	✓	✓	✗	✗
APM compatible	✓	✓	✓	✓	✓	✓	✓
PX4 compatible	✓	✓	✓	✗	✓	✓	✓
Platform	macOS, Linux, Windows, Android	Windows ***	macOS, Linux, Windows	Android	Android	macOS, Linux, Windows	macOS*, Android

* mobile

** development stopped

*** run on Mac and Linux using Mono



Executive summary

General information

	OpenPilot	DJI Ground Station	DroidPlanner2	Solo	FreeFlight3	DJI Go	Hover
MAVLink compatible	✗	✗	✓	✓	✓	✗	✗
Open source	✓	✗	✓	✗	✗	✗	✗
APM compatible	✗	✗	✓	✗	✓	✗	✗
PX4 compatible	✗	✗	✓	✓	✗	✗	✗
Platform	macOS, Linux, Windows	macOS, Windows	Android	macOS, Android	Windows*, macOS*, Android*	macOS*, Android	macOS*, Android

* mobile



Executive summary

FIRST USE

QGround Control
Mission Planner
APM Planner
UGCS
OpenPilot
DJI Ground Station
Tower
AndroPilot
Drone Deploy
DroidPlanner 2
Solo
FreeFlight3
DJI Go
Hover



[Access the GCS Analysis Tool for more comparisons](#)



Executive summary

SETUP

QGround Control
Mission Planner
APM Planner
UGCS
OpenPilot
DJI Ground Station
Tower
AndroPilot
Drone Deploy
DroidPlanner 2
Solo
FreeFlight3
DJI Go
Hover



[Access the GCS Analysis Tool for more comparisons](#)



Executive summary

PLAN

QGround Control
Mission Planner
APM Planner
UGCS
OpenPilot
DJI Ground Station
Tower
AndroPilot
Drone Deploy
DroidPlanner 2
Solo
FreeFlight3
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Hover



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Executive summary

FLIGHT

QGround Control
Mission Planner
APM Planner
UGCS
OpenPilot
DJI Ground Station
Tower
AndroPilot
Drone Deploy
DroidPlanner 2
Solo
FreeFlight3
DJI Go
Hover



[Access the GCS Analysis Tool for more comparisons](#)



Executive summary

ANALYSIS

QGround Control
Mission Planner
APM Planner
UGCS
OpenPilot
DJI Ground Station
Tower
AndroPilot
Drone Deploy
DroidPlanner 2
Solo
FreeFlight3
DJI Go
Hover



[Access the GCS Analysis Tool for more comparisons](#)



Executive summary

Some GCS interfaces already present good ideas about communicating to users crucial information concerning the operation of drones: incompatibility alerts, usage instructions or safety checkages, that prevent the user from flying with problems in the drone.

Some apps already show good initiatives about learning / support material. Most of them appear in mobile apps targeting basic drone users (consumers).

Executive summary

Clear yet complete mission drawing tools are present mostly in mobile apps for use in autonomous missions, focusing video recording or mapping.

There is one interesting approach to showing quick alerts about problems in drone systems that come from airplane interfaces.



Executive summary

Besides graphs, some apps have rerun mission features that are very interesting for representing visually the data collected during flights, and that make it easier to perceive where and when problems occur.

Flight data UIs gather a lot of numeric data that (should) represent the attitude and performance of the drone, but the amount and the way in which data is presented sometimes may have the opposite effect.

Executive summary

Drone links can be configured in a couple of different ways, and some GCs do not accept more than one type of connection. Having information about the link is crucial to do anything with the drone, but most interfaces do not present instructions or link the user to troubleshooting information about it.

Lack of feedback in configuring routines, vague instructions and application performance make it difficult for users to setup the drone without having to repeat the procedure a couple of times.



Executive summary

Occur especially in applications that try to accomplish all the tasks required to run a mission. Generally they present mission planning tools with hard-to-use interfaces (place points by coordinates, complementary controls spread all over the screen , etc).



The background of the slide is a blurred photograph of a workspace. It features a stack of papers, a calculator, a pen, and a yellow sticky note. The overall color palette is muted and earthy.

Positive aspects

Pre-flight checkages - summary

Some GCS interfaces already present good ideas about communicating to users crucial information concerning the operation of drones;

- incompatibility alerts
- usage instructions or safety checkages, that prevent the user from flying with problems in the drone.

The following slides detail 'best pre-flight checks' by app? (tool?)

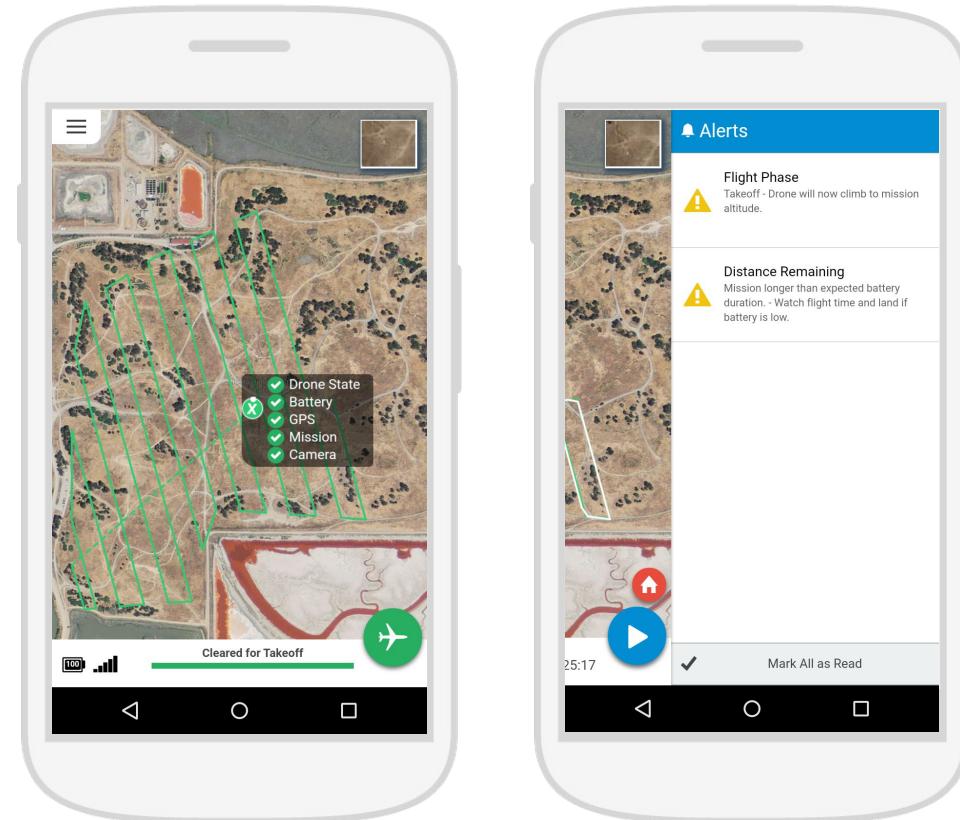
Positive aspects

Pre-flight checkages

DroneDeploy

There is a pre-takeoff checkage that is performed before clearing the drone for takeoff.

Besides having feedback about all flight phases (pre-takeoff, takeoff, flight and landing), it also warns users if the mission will exceed battery time and asks people to make the path shorter (<3 <3 <3).



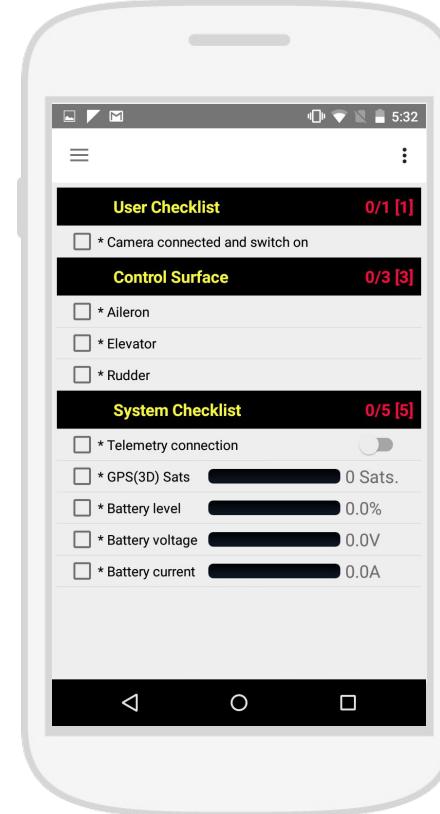
Positive aspects

Pre-flight checkages

Tower/DroidPlanner 2

These apps contain a pre-flight checklist, which is a very useful tool for mitigating the problems that can occur during drone flight.

Currently it is only a list and has no automated features, but the initiative towards the implementation of safety checkages in the flow is very positive.

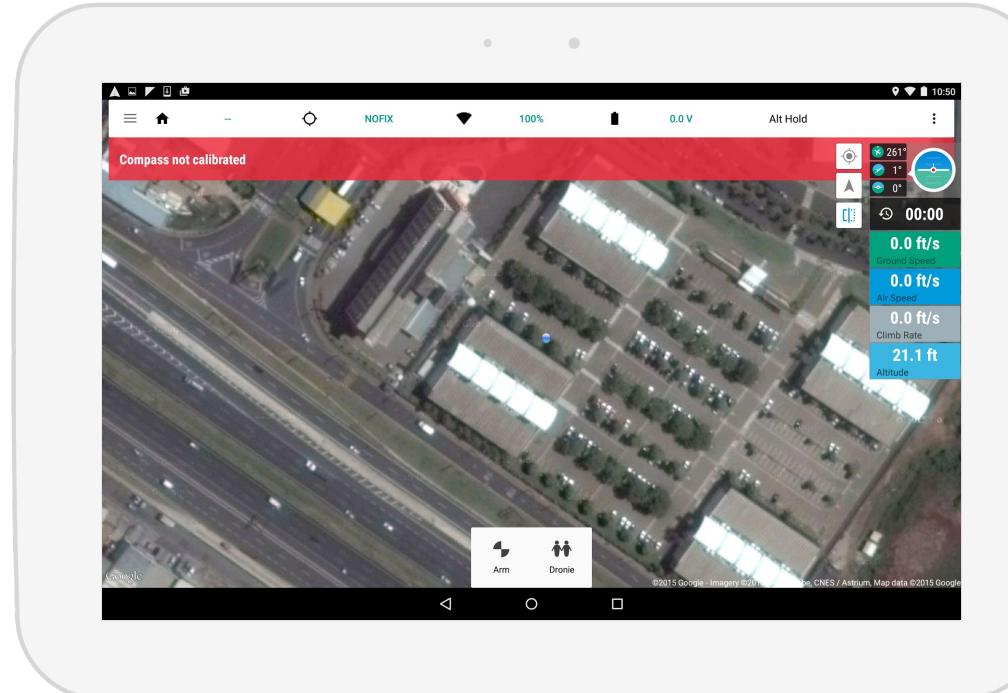


Positive aspects

Pre-flight checkages

Tower/DroidPlanner 2

Very clear alerts about calibration problems that prevent the drone from flying.



Support material

Some apps already show good initiatives about learning / support material. Most of them appear in mobile apps targeting basic drone users (consumers).

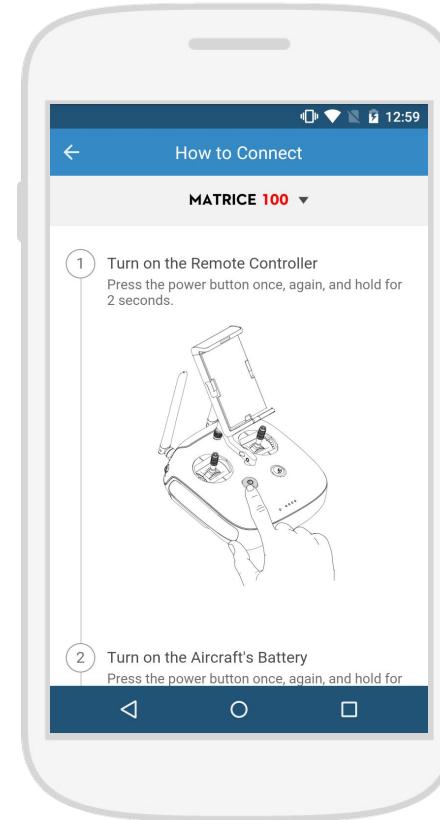


Positive aspects

Support material

DJI Go

The app contains step-by-step instructions with images about drone connection.

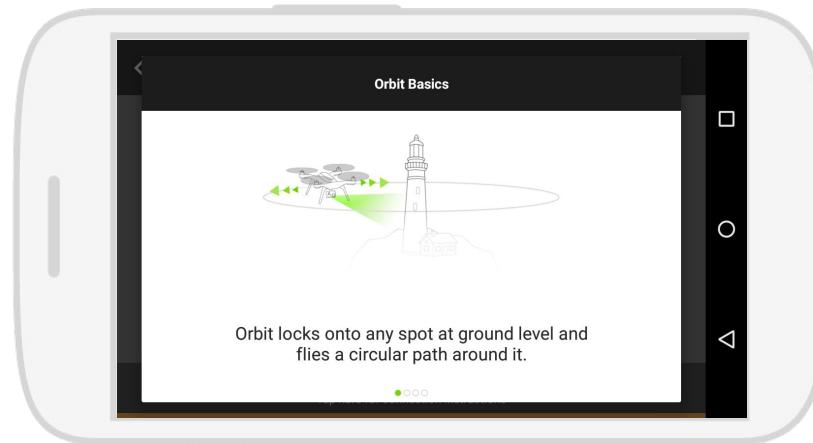


Positive aspects

Support material

Solo

The app contains a small library with information on drone vocabulary.



Mission drawing tools

Clear yet complete mission drawing tools are present mostly in mobile apps for use in autonomous missions, focusing video recording or mapping.



Positive aspects

Mission drawing tools

Tower/DroidPlanner 2

Tower and DroidPlanner 2 have both a very similar mission planning tool. Easy waypoint insertion by toggling the corresponding icon and clicking on the screen. The list below show all created waypoints in order, and waypoint action can be changed by clicking either on the pin or on the item in the list.

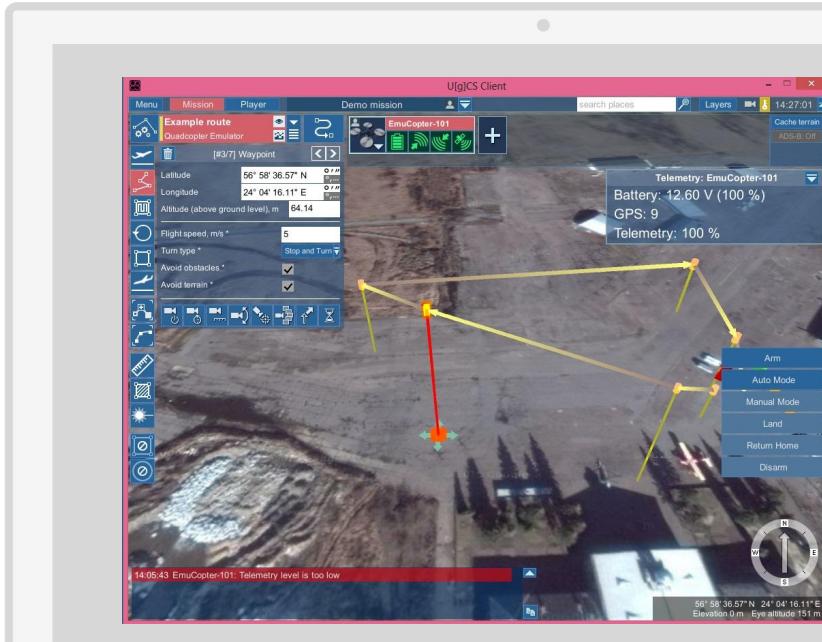


Positive aspects

Mission drawing tools

UGCS

Disregarding the amount of panels over the map, this program has an interesting 3D mission planning tool, since this type of visualization makes it easier to understand the trajectory of the drone during the flight. Also, there are a lot of auxiliary drawing tools that can be relevant for this task (area measurement, elevation profile, etc).



In flight problem alerts

There is one interesting approach to showing quick alerts about problems in drone systems that come from airplane interfaces.

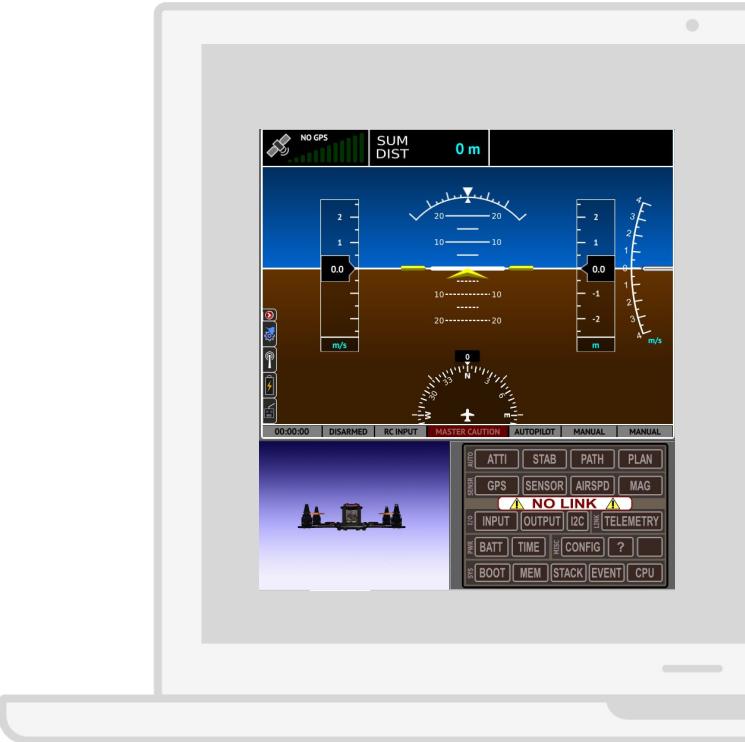


Positive aspects

In flight problem alerts

OPENPILOT

The lower right panel contains a series of alerts that are triggered whenever there is a problem with that system. In fact, this kind of information is quicker to perceive than values, because it cuts down the analysis part that would be done by the user. It's a very common standard for alerts in airplanes. Also, there is an interesting 3D representation of the drone that reflects its attitude while flying.



Visual tools for flight analysis

Besides graphs, some apps have rerun mission features that are very interesting for representing visually the data collected during flights, and that make it easier to perceive where and when problems occur.

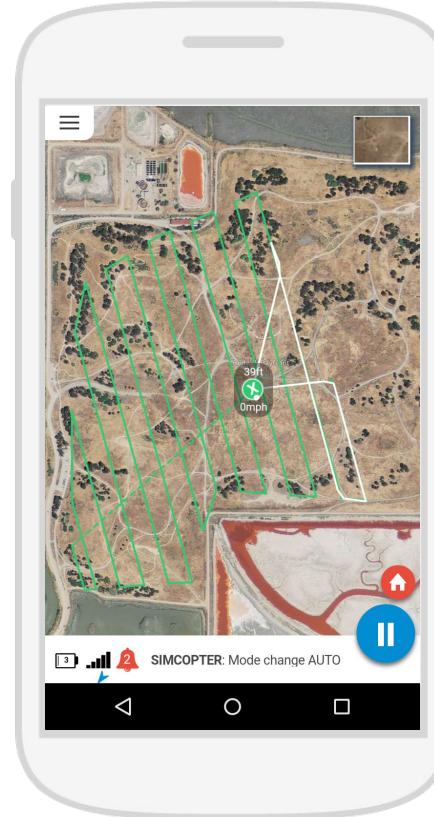


Positive aspects

Visual tools for flight analysis

Droidplanner

Its mission player tool enable users to control mission progress by clicking a play/pause button, like a video player. This feature has potential to be used to rerun missions for analysis purposes in conjunction with data from graphs, in order to help people absorb all the flight information in an easier way.

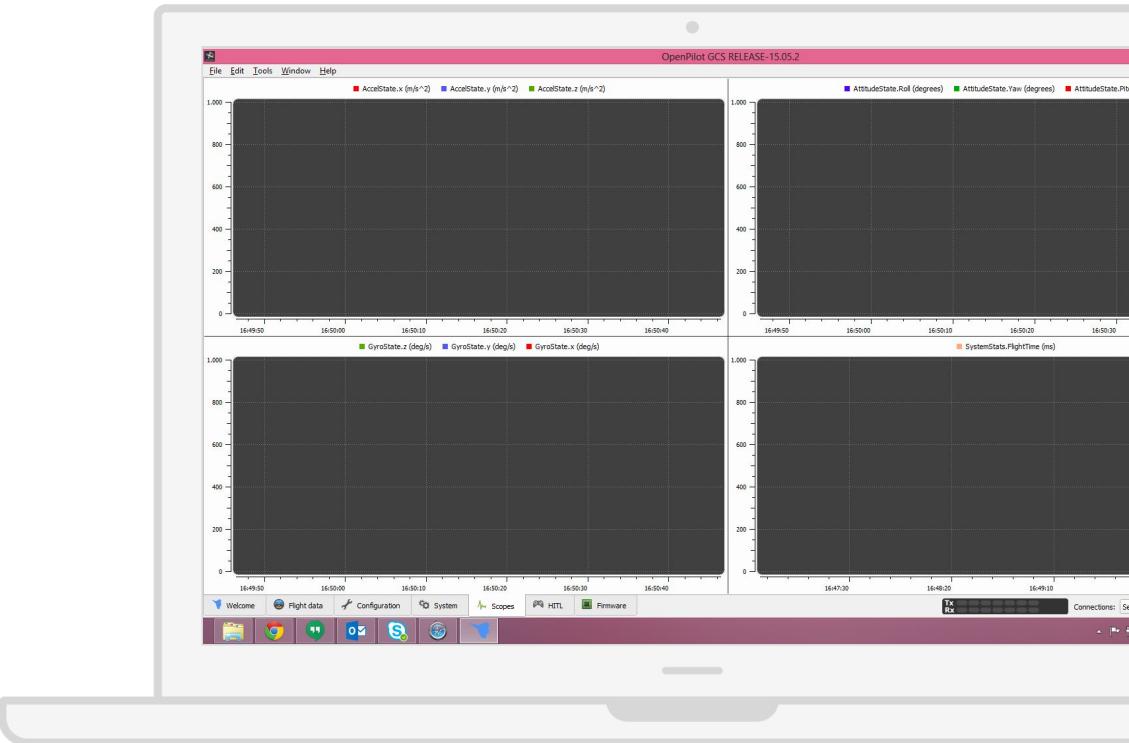


Positive aspects

Visual tools for flight analysis

OPENPILOT

Openpilot's log screen contains separate graphs for different drone parameters, which can be useful for comparing a lot of information about drone flights with not all data in the same graph.



Improvements



Hard-to-use mission planning tools in broader solutions

Occur especially in applications that try to accomplish all the tasks required to run a mission. Generally they present mission planning tools with hard-to-use interfaces (place points by coordinates, complementary controls spread all over the screen , etc).

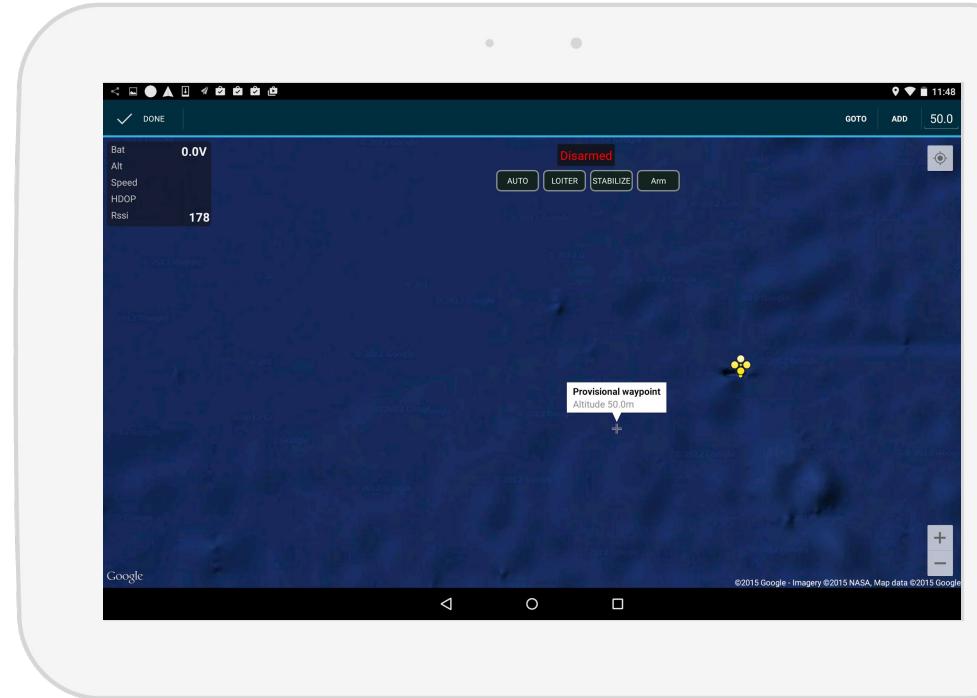


Improvements

Hard-to-use mission planning tools in broader solutions

Andropilot

No hints about how to place waypoints in the map (also, long press sometimes did not work properly). After this, trying to click on the WP icon didn't produce any result. The upper blue bar is the waypoint configuration tool, but there is no indication of it and no hint about what fields could be adjusted.

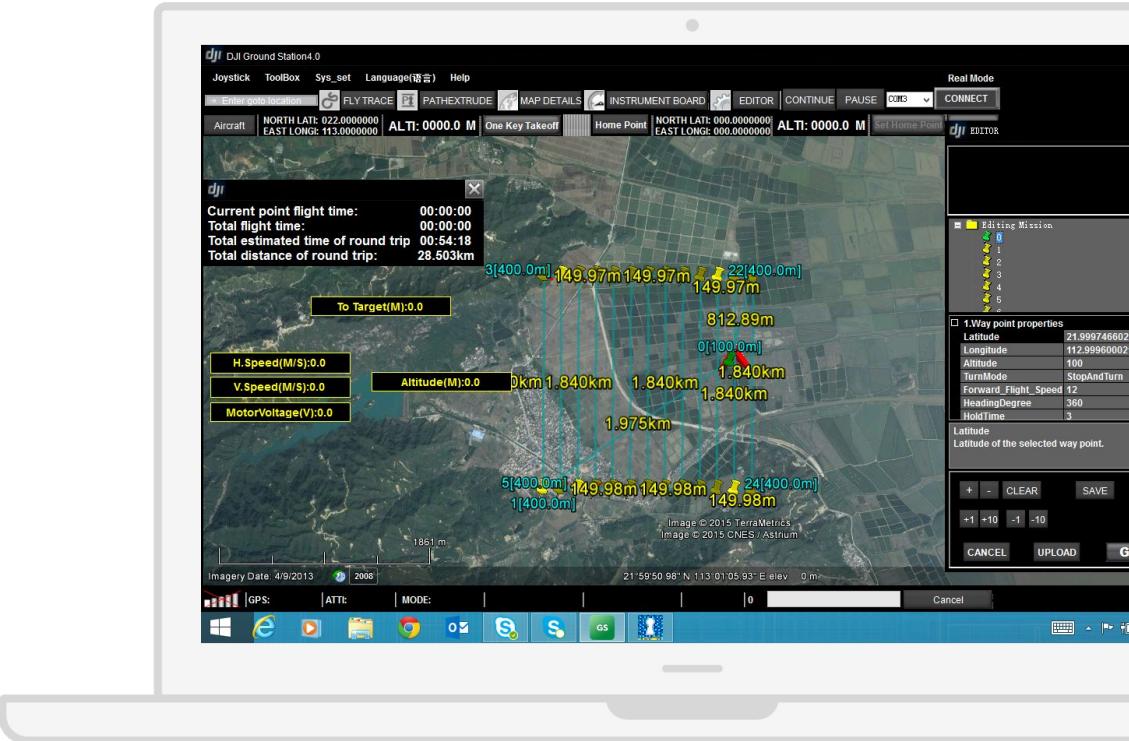


Improvements

Hard-to-use mission planning tools in broader solutions

DJI Groundstation

Waypoints are inserted through the panel placed at the right side of the screen, by typing the coordinates. There is no sort of tool that uses map clicks to accomplish this task.



Confusing setup tools

Lack of feedback in configuring routines, vague instructions and application performance make it difficult for users to setup the drone without having to repeat the procedure a couple of times.

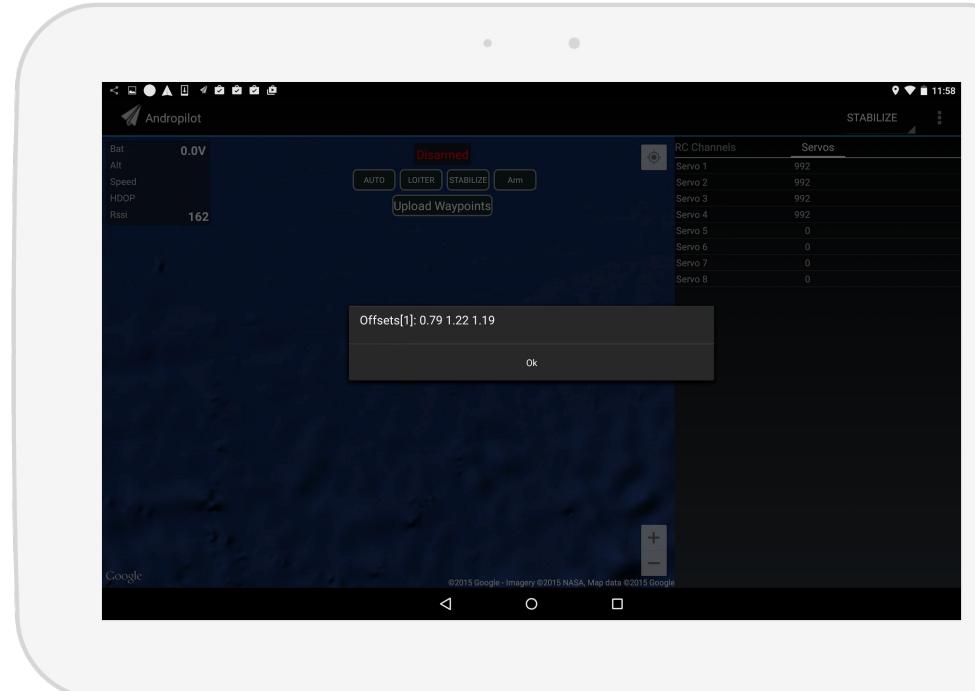


Improvements

Confusing setup tools

Andropilot

As an example, the accelerometer configuration displays a series of dialog boxes, each one containing one separate feedback about the configuration, making it really hard to apprehend the overall status of it.

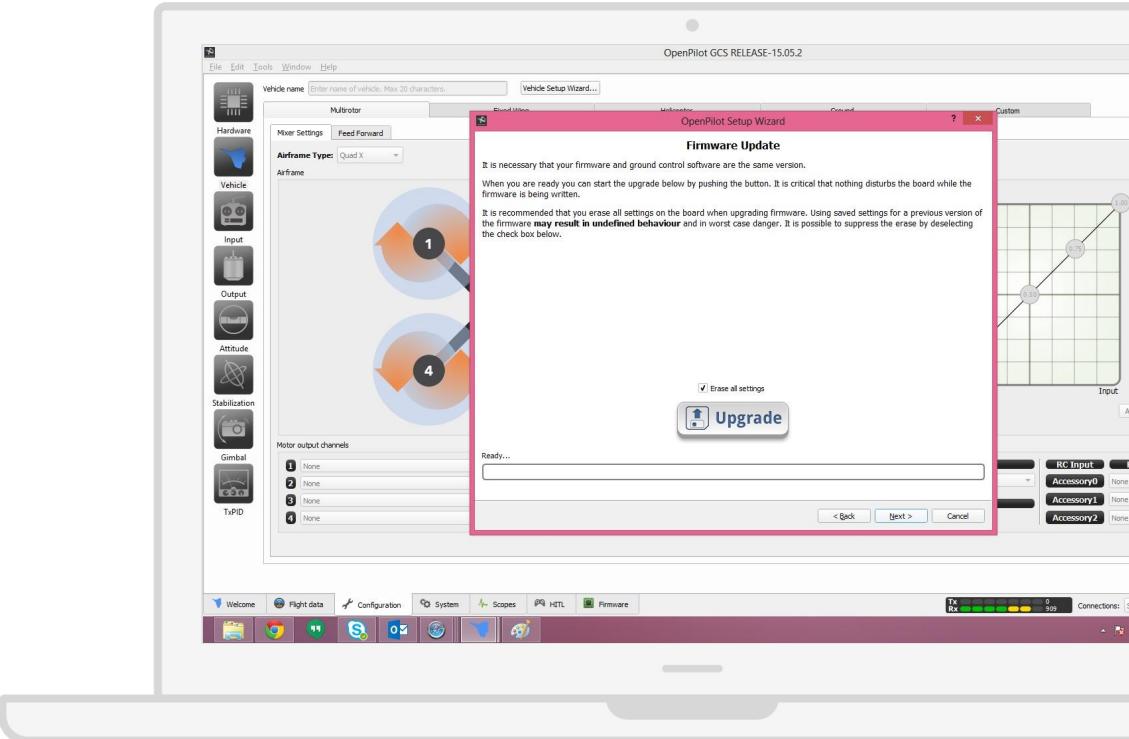


Improvements

Confusing setup tools

OpenPilot

The setup panel provides information about what to care about when configuring the drone, but there is no information about compatibility with flight stacks and boards, and you keep trying to troubleshoot the operation until you find some external information that tells you something about it (OpenPilot is compatible only with its own flight stack).



Lack of information about drone links

Drone links can be configured in a couple of different ways, and some GCs do not accept more than one type of connection. Having information about the link is crucial to do anything with the drone, but most interfaces do not present instructions or link the user to troubleshooting information about it.

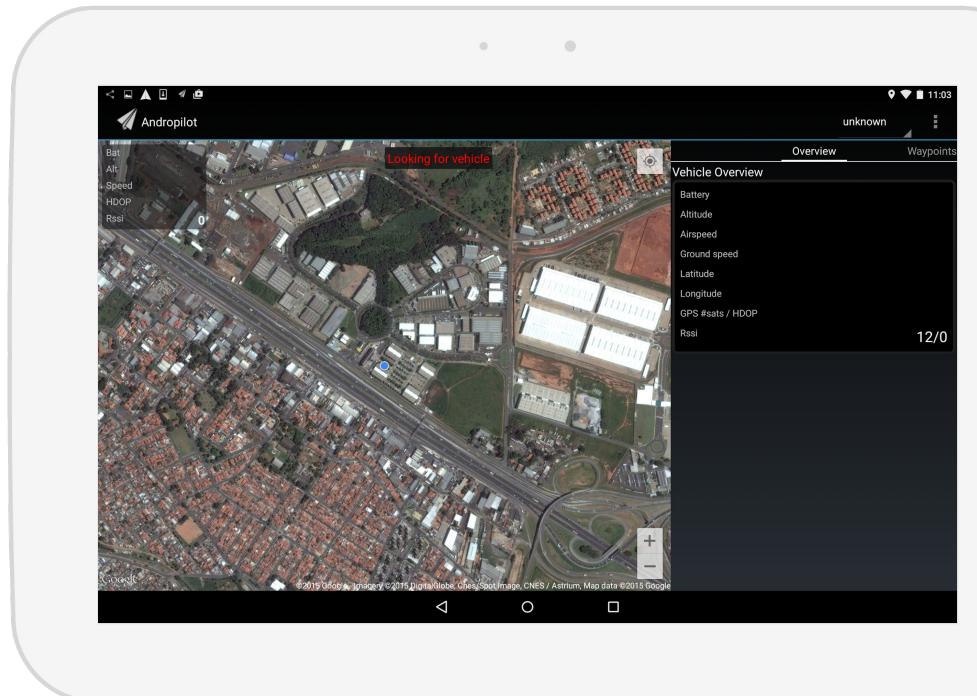


Improvements

Lack of information about drone links

Andropilot

The program requires a radio connection to a Radio Controller (RC) in order to get access to drone parameters and functionality, but there is no information anywhere about this requirement. Only by testing and using other GCS softwares, or by looking particularly for this information is that unfamiliar users are able to connect the drone in this program.

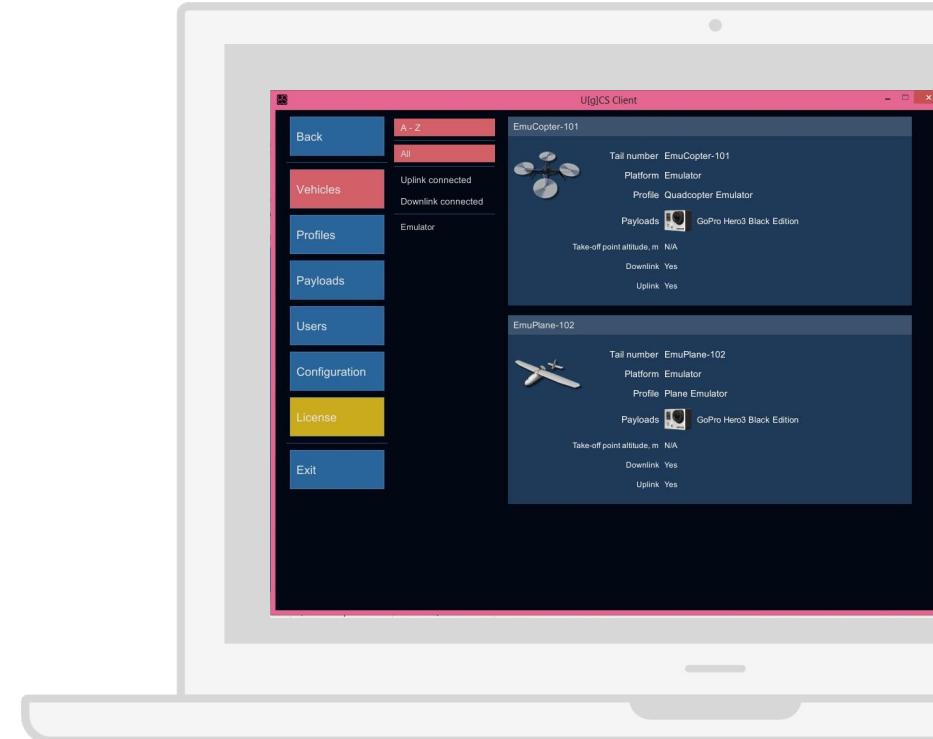


Improvements

Lack of information about drone links

UGCS

This application presents a lot of lists of cameras, vehicles, etc, but no information about how to connect the drone to it. There are no buttons or instructions to help the user accomplish the task.



Flight data overflow

Flight data UIs gather a lot of numeric data that (should) represent the attitude and performance of the drone, but the amount and the way in which data is presented sometimes may have the opposite effect.



Improvements

Flight data overflow

Mission Planner

Mission Planner's flight data interface presents a lot of information distributed in controls and numeric values that could be translated into simpler visual tools that easily represent statuses, dangerous situations or drone attitude.



Improvements

Flight data overflow

UGCS

There are a lot of panels over the map, and the criteria for grouping the information is not very clear. It seems that there is valuable flight data information spread in different panels.



Conclusion

There are already a couple of popular GCS programs out there that range from simple to complex with a varying number of features and tools embedded.

But on this benchmark we verified that **none of them have a complete feature set and is user-friendly**, which **creates the opportunity to add design expertise and take the GCS softwares to the next level**.

Thank you

Beatriz Palmeiro
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Carlos Felipe

Guilherme Paes
Juliana Cavalheiro
Ronaldo Silva

