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.
Methodology

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.
## Methodology

### Goals evaluated

<table>
<thead>
<tr>
<th><strong>First use</strong></th>
<th><strong>Setup</strong></th>
<th><strong>Plan</strong></th>
<th><strong>Flight</strong></th>
<th><strong>Analysis</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>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</td>
<td>Procedures to execute before the flight to ensure the hardware and software are correctly configured and working properly</td>
<td>Helps to plan the flight, drawing a path to follow and specifying other tasks that the drone should perform</td>
<td>Tools that help users monitor the flight in real-time and switch flight modes</td>
<td>Tools to analyse and debug the flight and its data when it is done</td>
</tr>
</tbody>
</table>
## Executive summary

## General information

<table>
<thead>
<tr>
<th>MAVLink compatible</th>
<th>Open source</th>
<th>APM compatible</th>
<th>PX4 compatible</th>
<th>Platform</th>
</tr>
</thead>
</table>
| ✓                  | ✓           | ✓              | ✓              | 🍌Windows/android/§§§ | *
| ✓                  | ✓           | ✓              | ✓              | 🍌Windows/android/§§§ | ** development stopped
| ✓                  | ✓           | ✓              | ✓              | 🍌Windows/android/§§§ | *** run on Mac and Linux using Mono
| ✓                  | ✓           | ✓              | ✓              | 🍌Windows/android/§§§ | ✓

* mobile
** development stopped
*** run on Mac and Linux using Mono

<table>
<thead>
<tr>
<th>QGroundcontrol</th>
<th>Mission Planner</th>
<th>APM Planner</th>
<th>Tower</th>
<th>AndroPilot**</th>
<th>UGCS</th>
<th>Drone Deploy</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Drone Deploy</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓</td>
</tr>
</tbody>
</table>

Intel symbol
### Executive summary

## General information

<table>
<thead>
<tr>
<th>MAVLink compatible</th>
<th>OpenPilot</th>
<th>DJI Ground Station</th>
<th>DroidPlanner2</th>
<th>Solo</th>
<th>FreeFlight3</th>
<th>DJI Go</th>
<th>Hover</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>❌</td>
<td>❌</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>❌</td>
<td>❌</td>
</tr>
<tr>
<td>Yes</td>
<td>✔️</td>
<td>❌</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>No</td>
<td>❌</td>
<td>❌</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>❌</td>
<td>❌</td>
</tr>
<tr>
<td>Yes</td>
<td>✔️</td>
<td>❌</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✗</td>
<td>✗</td>
</tr>
</tbody>
</table>

- **Platform**
  - **OpenPilot**: Apple, Windows
  - **DJI Ground Station**: Apple, Windows
  - **DroidPlanner2**: Android
  - **Solo**: Apple, Android
  - **FreeFlight3**: Windows, Android
  - **DJI Go**: Apple
  - **Hover**: Apple

*mobile
Executive summary

Access the GCS Analysis Tool for more comparisons
Executive summary

Access the GCS Analysis Tool for more comparisons
Executive summary

Access the GCS Analysis Tool for more comparisons
Executive summary

FLIGHT

Access the GCS Analysis Tool for more comparisons
Executive summary

ANALYSIS

Access the GCS Analysis Tool for more comparisons
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).
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.
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.
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.
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).
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?)
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).
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.
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).
Support material

DJI Go
The app contains step-by-step instructions with images about drone connection.
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.
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.
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.
Visual tools for flight analysis

Droidplanner

Its mission player tool enables 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.
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).
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.
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.
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.
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.
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.
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.
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
Fabrício Novak
Carlos Felipe
Guilherme Paes
Juliana Cavalheiro
Ronaldo Silva