#ACS - Ground Station Software

This document provides instructions on using the Health Monitor and Swarm Commander Ground Control Station (GCS) software.

##Background

When just a few users control large numbers of unmanned aircraft simultaneously, we found it beneficial to segment the tasks into two ground stations with different purposes, rather than have multiple ground control stations having similar functionality. The Swarm Commander is responsible for issuing swarm commander and giving high-level direction to groups of aircraft. The Health Monitor monitors the health of individual planes and responds to alerts as they occur. This is further facilitated by the fact that there is a separate tool for the flight launch crew called the Flight Tech Interface (FTI) which alleviates the need for the Health Monitor to be involved in preflight operations when planes are aloft. The FTI is documented elsewhere.

In this was the NPS ARSENAL lab was able to safely field 50 UAVs simultaneously with 2 ground operators (though there were supplementary flight techs, a safety pilot, and a mission commander monitoring the air as well).

###SITL

In order to test either Swarm Commander or the Health Monitor with simulated aircraft it is necessary to start up one or more software in the loop (SITL) instances for the ground system to connect to. Documentation for SITL setup is elsewhere in the acs_docs repository and is outside the scope of this document.

##ACS Health Monitor

The ACS Health Monitor is the GCS that was created to monitor unmanned planes during swarming operations. It uses an alert-based system that is intended to allow the operator to quickly respond to individual planes if they exhibit unexpected behavior.

###Starting the Health Monitor

If using the Health Monitor with simulated planes, first start the necessary SITL instances (details covered elsewhere). This command entered at a terminal will start 3 simulated planes:

```
multi-sitl-start.bash -B 3
```

Note that due to the networking setup, root privileges are required on the machine.

After the SITLs have started start the Health Monitor by entering the following at the prompt:
You should see two windows open, one containing a Map and one containing the controls for the Health Monitor. If you like, drag the map with the mouse to move the aircraft on the runway to the center of the window. You can also zoom in and out with the mouse wheel. The window is also resizeable so you can make the map as large or small as you like.

You should see 3 aircraft in a table that are likely highlighted in red. The red indicates an error condition is present. Click on any aircraft to investigate further. When you do so, you will see the ID number, name of the aircraft, the mode it is in and several short color-coded lines of text indicating the status of the aircraft.

**Status Indicators**

- **ARM** - Indicates whether the aircraft motor has been armed. Yellow when disarmed. Green When Armed.

- **AS** - Indicates whether preflight airspeed appears to be in an error state. This has become the responsibility of the flight launch crew since its introduction and remains grey -- the Health Monitor operator need not worry about this field. The indicator will likely be removed in a future version of the Health Monitor.

- **BATT** - Indicates battery state. Green indicates OK, Yellow indicates approaching bingo fuel, Red at bingo fuel.

- **LINK** - Indicates communication link state. Green mean OK, Yellow when communication link has become poor, Red when link has been lost.

- **FENC** - Indicates fence state. Grey indicates disabled, Green indicates enabled and OK, Red indicates a fence breach.

- **GPS** - Indicates GPS state. Green indicates OK, Red indicates GPS has been lost.

- **INS** - Indicates INS state. Green indicates OK, Red indicates an error condition.

- **MAG** - Indicates magnetometer state. Green indicates OK, Red indicates an error condition.

- **READY** - Indicates whether flight launch crew has marked the plane as ready for flight. Green indicates flight ready, Red indicates not flight ready.

- **AS_CAL** - Indicates whether airspeed sensor calibration has been completed by the flight launch crew. Green indicates calibration complete, Red indicates calibration incomplete.

- **GYRO** - Indicator for gyro health. Not yet implemented.

- **FW** - Indicates whether the expected firmware exists on the autopilot. Green indicates the expected version is present, Red otherwise.
• MISS - Indicates whether the flight launch crew has uploaded a mission. Green indicates a mission has been setup, Red otherwise.

• RAL - Indicates whether the flight launch crew has uploaded a rally point. Green indicates a rally point is present and setup, Red otherwise.

• FEN - Indicates whether the geofence has been uploaded by the flight crew. Currently this check is not configured for the simulator so this indicator will always remain red in simulation. Green when fence has been configured, Red otherwise.

• PRM - Indicates whether the expected autopilot parameters exist on the aircraft. Not yet implemented.

• SW - Indicates whether the expected version of the companion computer software is on the payload computer. Green indicates the expected version is present, Red otherwise.

Also shown is the aircraft's airspeed (AS), groundspeed (GS), relative altitude from launch point (REL), and absolute mean sea level altitude (MSL).

###Clearing Initial Status with the FTI

The Health Monitor does not typically launch aircraft nor is it responsible for preflight checks. However, in simulation a flight launch crew is not typically available. We'll briefly start up the FTI to provide the simulated aircraft the required inputs to indicate they have been prepared for flight. In a new terminal window type:

```python
fti.py -d sitl_bridge_1 -z
```

This will bring up the Flight Tech Interface (FTI) used by the launch crew. The `-z` option provides some debugging buttons to speed up preflight for multiple planes. These buttons are near the bottom right of the FTI. Push the "CAL PRESSURE ALL" button and then click OK on the resulting dialog boxes. This should cause the AS_CAL indicator to become green on all planes. Then Push the "FLIGHT READY ALL" button in the FTI. This will cause the READY indicator to become green in all aircraft.

At this point the red backgrounds in the table of aircraft should have become yellow. The planes are nearly ready for flight. You will note that the MISS RAL and FEN indicators are still red. In simulation it is not strictly necessary to setup a mission via the FTI as the default mision will do, however to clear all possible alert indicators it is necessary to configure all aircraft.

Should you wish to setup a mission via the FTI you can set a Stack Number (1 or 2) and an altitude and press the Send Config button. The purpose of this configuration step is to ensure that aircraft are laterally or altitude deconflicted prior to launch.

Once aircraft are prepared to your liking you may exit the FTI and close the terminal window you opened it with.
Launching an aircraft

Select an aircraft in the Health Monitor's table. Then push the "Arm" button. At this point, if a mission has been configured by the FTI the background of the aircraft's row in the table becomes green, indicating it is ready for flight.

Now use the "Mode" drop down and switch to AUTO mode. Once the plane is aloft the background of the aircraft's row in the table switches to white. The plane icon should also be moving in the map.

Testing Alert Conditions

If an aircraft enters an unexpected state during flight its background changes from white to yellow or red. For severe alerts, a description of the alert also appears in the Alerts section at the right of the Health Monitor. The section demonstrates how to simulate some possible alert conditions.

Several xterm windows will have opened when you started up the sitls. Find one of them titled "sim_vehicle.sh ..." -- the xterm title should also include the ID of the aircraft. This is a MAVProxy GCS prompt and allows you to send very specific commands to the aircraft that the Health Monitor does not need. It is an excellent test tool.

At the MAVProxy prompt you have selected enter:

```
param fetch BATT_CAPACITY
```

Record the number that is given back by MAVProxy (likely 10000) on a piece of paper. Then enter

```
param set BATT_CAPACITY 0
```

Note the behavior in the Health Monitor; the plane's row in the table turns red, the BATT indicator turns red, an alert is shown in the Aircraft Alerts section and the plane begins to autoland. If you wish to terminate the landing, set the current waypoint (WP) in the Health Monitor to 1. Note that if you do so after the plane has landed it is possible to relaunch the plane by then clicking the "Arm" button.

Be sure to restore the battery parameter we modified earlier, e.g.,

```
param set BATT_CAPACITY 10000
```

TODO: finish Health Monitor

When finished testing the Health Monitor type

```
multi-sitl-cleanup.bash -B
```
at a terminal prompt.