11 ROLES OF GCS OPERATOR

This chapter discusses the role/s of GCS Operator, and some incidents recorded that should be well avoided in the future.

1. Thou must be knowledgeable of how drones do the work; the parts and respective function of each
2. Thou must be attentive at all times, from start to end.
3. Thou must be prompt and a quick thinker especially when an abnormality regarding the flight status occurs.
4. Thou must be calm and composed even during times of pressure.
5. Thou must know how to assemble the drone and be able to replace parts in the field.
6. Thou must be keen to details and has an innate desire to do things right the first time, for great effectiveness and efficiency.
7. Thou must be strategic in planning to ensure a safe and successful flight.
8. Thou must understand the importance of his/her role in the success of the project.
9. Thou must be the first to follow the rules and regulations and must be able to lead his/her teammates to do their respective tasks PROPERLY and ORDERLY.

Sample of incidents and countermeasures:

1. Motor Failure (Parts Failure)

Some parts that are available in the market and are installed on our plane are usually Made in China with no affirmed reliability status. This alone poses a need to bring spare parts in the field. If in case, during the manual takeoff or during the flight itself, the motor suddenly burns out, on the spot changing of parts should be implemented. Ensure that the motor is attached correctly with tight screws and lots of glue, and connected to the reinforcement, carbon plate. Screw in the propeller and tighten it well with washer. Reconnect it to ESC. Double check everything and if everything is good to go, get ready for take off.

It is a MUST that the GCS operator should always be attentive, and ready enough if such incidents occur. Moreover, the operator's rule of thumb is to know where the position of the plane so that in case the motor suddenly fails during the flight, there could be a greater chance of locating the plane.

An example of indication of abnormality during flight is the sudden rapid change of throttle value. This is often reflected as a value of ch3. Normal value must only hold to 20%-50%. Sudden spikes to a greater value, say 70% and above most likely indicates an unlikely situation midair.

*Planes tend to crash due to electronic and technical problem.

2. Assembly Failure

Connection of wires to ports between APM and devices must be well checked prior to test flight. Wrong orientation of installed parts, needless to say, may well be a perfect recipe for disaster.
Always verify if the installed parts are functioning as desired or planned.

3. Engineering Failure

It takes a great deal of research before a specific design will be implemented. Always make sure that all devices are within operating range/specification before installation. This reduces waste of cost and time, of course.
Drone flight performance and reliability must be maintained to 99.99999% rating.

4: Rx/Tx Communication Failure

In case of Rx/Tx failure in which Pilot cannot switch to manual mode, please do the following:

Everyone **must memorize to do this**, you cannot do this in the field by reading step by step unless the bird has about 30% or more juice for your trial and error. And you need to do all this steps quick.
1. Make sure telem has good LOS with plane.
2. Set "right-click to map" > "fly to here alt" to a safe altitude, between 200-150 meters or 100m above obstructions such as trees or cell towers
3. Set "fly to here" to an area where the drone can be easily retrieved and will cause minimal damage to both drone and property, note that the plane will do 45m loiter radius
4. Gradually descend the drone by changing alt, use "change alt" below HUD, if it does not work, use "fly to here alt" and do "fly to here" command again
5. Always bserve the wind direction
6. Move the "fly to here" point about 300m along the wind direction
7. Select "actions" tab below the HUD, select "manual" on the third dropdown menu but DO NOT CLICK "set mode" yet, you only need to prepare this
8. Confirm the location of the plane with everyone and with the safety pilot.
10. Once the plane is headwind and directly facing the previous "fly to here" point, switch to "manual" by clicking "set mode" and then rapidly change it to "stabilize" and then click "set mode". you only have split second to respond and do that two mode change, if you fail to do so its either crash or you need to repeat from step 2 and i'm fucking serious that you need to repeat from step 2, and that is a very terrible to happen if the plane has low battery.
11. The plane will then glide, depending on weather condition and thermals, it may glide farther than 300m so be prepared to repeat step 2 and move it farther than 300m to land in the exact spot you want it to land.
12. Hard to do? ok fine, just add auto landing procedure in every mission as redundancy. please refer to manual. for X8 you need a gradient of -10% for landing, while surfer can tolerate -20% gradient
13. Still hard to do? then go read next item. This allows the GCS to control the plane but with higher latency than Tx, also remember that gamepad has springs on the joysticks that sets it to center position so always remember to pull the "throttle" stick down or you'll overspeed in if the throttle is left on middle stick position. it is required that the GCS operator can fly the plane in FBWA mode.

FLYING WITH A JOYSTICK/GAMEPAD

This article explains how you can fly with a Joystick/Gamepad via Mission Planner.

This article demonstrates how to control Copter using a joystick/gamepad. The approach uses Mission Planner to set appropriate Remote Control (RC) overrides based on Joystick/Gamepad input.

Other GCSs may also support "RC overrides" but they are not covered in this article

TIP
Even if flying with a joystick, you should keep a regular transmitter/receiver connected and ready for use as a backup. In future versions of Copter, after more failsafe testing has been completed we may change this recommendation.

WHAT YOU WILL NEED

You will need the following equipment:

- USB joystick or Gamepad such as the Logitech F310
- A telemetry connection between your ground station and vehicle.
- A laptop computer running Mission Planner.

Setup with the Mission Planner

- Connect your USB joystick/gamepad to the laptop computer
- Open the Mission Planner Flight Data screen. On the Actions tab push the Joystick button

- Ensure the Logitech joystick appears in the drop-down
- The Enable button, once pushed, will tell the mission planner to start sending commands to the vehicle so for the initial setup do not push it.
- On the "Roll" row, click the Auto Detect button and then waggle the control you wish to use for roll, left and right.
- The channel can be reversed with the Reverse checkbox
- The Expo number should be in the range of -100 to 100
-
- 0 = no expo
- 100 = low response around the middle, very fast response at the edges
- -100 = very fast response around the middle, less response at the edges (very few people use negative expo)
- Repeat for Pitch, Throttle and Rudder and push the Save button
- You will likely want to set-up other buttons for Arm and Disarm
- Instead of setting up a stick or button for ch5 (the flight mode channel), it is better to set individual buttons to initiate a flight mode by selecting Change Mode and then push the Settings button and select the flight mode from the drop-down (see pic above)
- When done, push the Save button
- In the CONFIG/TUNING | Full Parameter List, check that the SYSID_MYGCS parameter matches the system ID of your GCS. This parameter limits which GCS can send override signals to the vehicle.

TIP

For Mission Planner the default GCS system ID is 255. The default system ID for APM Mission Planner 2 is 252 (but the GCS will automatically set its ID to match SYSID_MYGCS for RC Override commands).

NOTE

If you get an error PreArm: RC not calibrated (following calibration) you will additionally need to manually change RC1_MIN to 1101 and RC1_MAX to 1901 (and then repeat for RC2_, RC3_ and RC4_ max/min parameters).

This error is caused because Mission Planner maps the Joystick exactly to the 1100 - 1900 range, but the pre-arm checks assume that if the values are not at least 1 pwm off the century value, that calibration has not been done.

TESTING THE CONTROLS BEFORE FLYING

Before flying for the first time you should test that all features work well.

To check the above controls move in the correct direction:

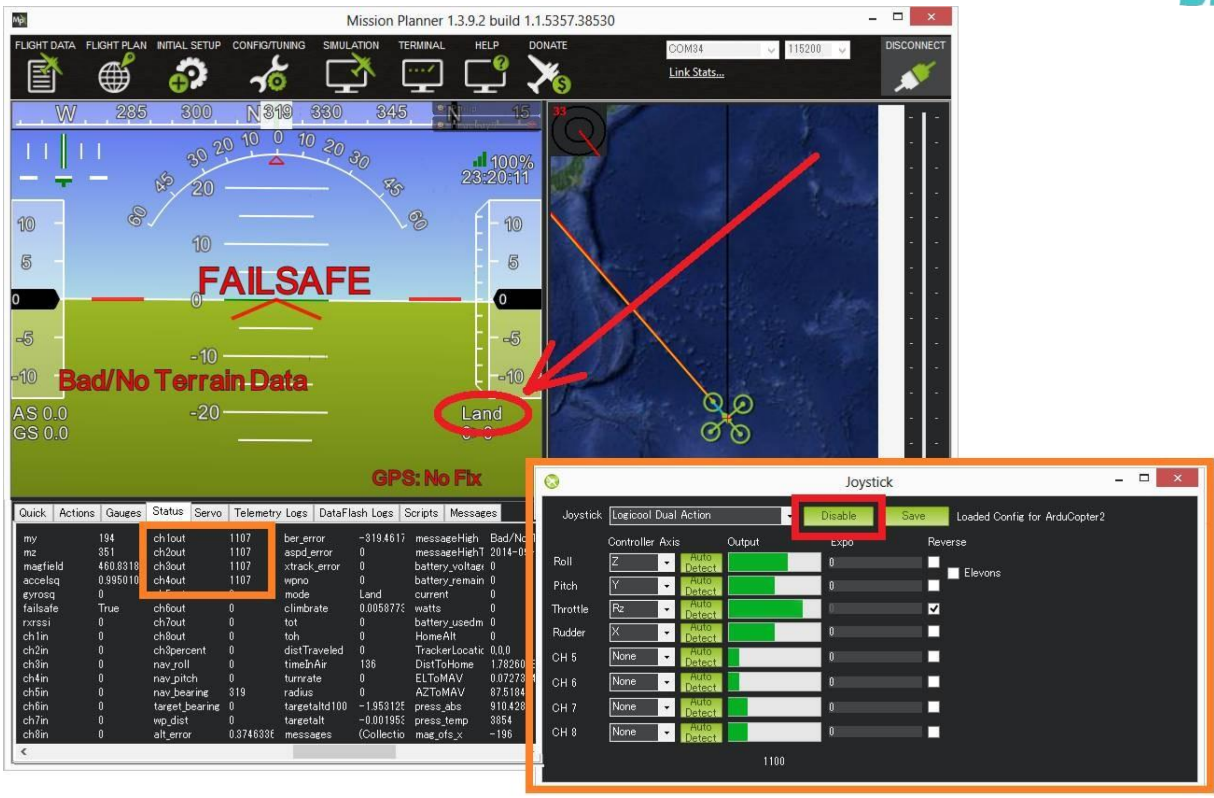
- Click the Enable button on the Joystick setup screen to enable sending messages to the vehicle
- Connect your flight controller to the computer with a USB cable
- Push the Mission Planner's Connect button
- Go to the Initial Setup | Mandatory Hardware | Radio Calibration screen and ensure the green bars all move in the correct direction. Remember the bars move in the same direction as the sticks except for Pitch which moves in the opposite direction.
- If any controls are reversed, check the Reverse checkbox on the Joystick setup screen.
- Next test you are able to arm, disarm and switch into the various flight modes (not need to connect the battery)

TESTING THE FAILSAFES

All of these tests should be performed on the ground with the battery disconnected or at least with the propellers off the vehicle.

Simulate disabling the joystick in flight with transmitter off (i.e. no failover to regular transmitter):

- Turn regular transmitter off
- Connect with the mission planner, push Joystick window's Enable button and ensure RC overrides are being sent to the vehicle (use Radio Calibration screen) or Flight Data's status screen.
- Arm vehicle, switch to Stabilize or Loiter mode and raise the throttle
- Ensure the motors are spinning by checking the Flight Data screen's “ch1out” ~ “ch4out”
- Push Joystick screen's Disable button
- “Failsafe” should appear on the HUD and the vehicle should switch to “LAND” or “RTL”
- Repeat the above test but at step #5 actually disconnect the joystick from the computer. The results should be the same.



SIMULATE FAILING OVER TO THE REGULAR TRANSMITTER/RECEIVER

- Turn the regular transmitter on and ensure you can control the vehicle (perhaps by checking the Radio calibration page or the Flight Data screen's Status tab's "ch1in" ~ "ch8in").
- With the regular transmitter leave the vehicle in AltHold mode and raise the throttle to mid
- On the Joystick screen push the Enable button
- Arm the vehicle in STABILIZE mode and raise throttle to full (with the Joystick).
- Check the throttle is at full in the Flight Data screen's Status tab by checking "ch3in" is very high (around 1900 usually)
- On the Joystick screen push the Disable button and check the "ch3in" has dropped to a mid value (around 1500)
- The vehicle should remain in it's current flight mode (Stabilize) but controls have been returned to the transmitter. The pilot's inputs should be reflected in the "ch1in" ~ "ch8in" values. Switch the vehicle to AltHold mode by moving the flight mode switch.

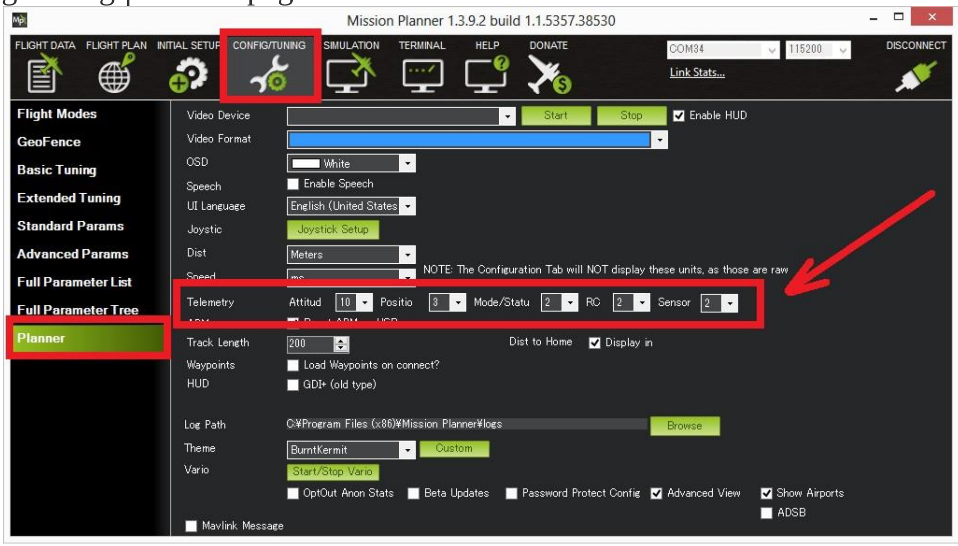
SIMULATE LOSS OF RADIO CONTACT:

If radio contact is lost, the vehicle should respond as if the Joystick was "Disabled" or disconnected from the PC. You can test this by repeating the test above but instead of pushing the Disable button on the Joystick screen, disconnect the radio. In order to see the status of the vehicle you will need to connect two Mission Planner's separately (only possible on Pixhawk). The Mission Planner with the Joystick should be connected through telemetry and the 2nd Mission Planner should be connected through a USB connection.

REDUCING LAG IN THE CONTROLS

It is nearly impossible to make the Joystick as responsive as a regular transmitter but lag can be reduced by:

- Reducing the rate of other telemetry data being sent between the vehicle and GCS from the MP's Config/Tuning | Planner page



Telemetry

The telemetry modules are the actual radio devices that transmit and receive the data. You will have one on-board your drone, and one on the ground plugged onto your ground station device. The most important thing when using telemetry modules for your given autopilot, is that they will often need to be paired together so they can communicate.[1]

There are multiple ways to get telemetry data, such as embedding it in the video stream of your FPV system (called On-Screen Display). Planes can have their own radio link like the 3DR Telemetry kit wherein data arrives in a full digital form that can be displayed, logged and analyzed by the Mission Planner.

Although it's possible to control the aircraft via the telemetry stream, most people use RC due to the superior reliability of that dedicated radio link and controller (as well as the need for a second control system for safety).

How to ensure good Telemetry?[2]

1. Pair the two telemetry modules mounted on the UAV, and the one connected to the Ground Station. Settings should be the same for both modules. Refer to Folder UAV_Surfer_Components ---> Telemetry.pdf

2. Mount the air module securely to your vehicle keeping the antenna clear of any propellers or moving components. Ensure that the antenna is oriented vertically for maximum range. (

This applies to both the antenna in the UAV and the antennas in the GCS.

3. Maximize RF range by considering several factors. Proper consideration during installation will help enhance the signal strength and range ensuring reliable operation.

- **CLEAR RF PATH OF OBSTRUCTIONS**

Make sure the RF path is clear of obstructions. Antennas should be installed where they can "see" each other as much as possible. Make sure the antennas are high enough above any obstructions in the RF path.[2]

SUGGESTED HEIGHT CLEAR OF OBSTRUCTIONS

Range	2.4 GHz	900 MHz	868 MHz
1000 ft (300 m)	5.5 ft (1.7 m)	8 ft (2.5 m)	8.5 ft (2.6 m)
1 mi (1.6 km)	10.5 ft (3.2 m)	16 ft (5 m)	19.4 ft (5.9 m)
5 mi (8 km)	—	34 ft (10.5 m)	46.6 ft (14.2 m)
10 mi (16 km)	—	47.5 ft (14.5 m)	61 ft (18.6 m)

- **KNOW YOUR OVERALL SYSTEM GAIN REQUIRED TO MEET THE DISTANCE**

The more the distance between the radios, the more the overall system gain needs to be. A quick rule of thumb for the overall system gains vs. distance is as below:

Radio Frequency & Wattage	300 ft(100 m)	1000 ft(300 m)	1 mile(1.6 km)	5 miles(8 km)	10 miles(16 km)
2.4 GHz, 60mW	2.1 dB	>6 dB	>10 dB	—	—
900 MHz, 1W	2.1 dB	2.1 dB	>3 dB	>6 dB	>10 dB

Note: RF signal is lost across cables and connections. Refer to Tip 4 to know the impact of cable lengths and connections and how to select the antenna gain to compensate for the signal loss.

- **KNOW YOUR SIGNAL LOSSES AND THE REQUIRED ANTENNA GAIN**

Signal is lost across cables and connectors. The longer the antenna cable and the more the number of connections, the more the signal loss. A larger antenna gain is necessary to compensate for these losses and to meet the required distance. As a rule of thumb, the RF range will be reduced by half for every 6 dB signal loss.

The lost signal has to be compensated by choosing a proper antenna gain. B&B's 900 MHz Zlinx and Zlinx Xtreme radios come standard with a 3 dBi Omni antenna and the 2.4 GHz radios come with a 2.1 dBi gain Omni antenna. If more gain is necessary, choose a higher gain antenna depending on your system requirement.

The table below shows the signal loss across cables and connections.

- **SIGNAL LOSS ACROSS COMPONENTS**

	Signal Loss	
	868/900 MHz	**2.4 GHz**
Antenna Cable (LMR400)	-3.9 dB/100 ft	-6.8 dB/100 ft
Connectors (RP-SMA/N-Type)	-0.5 dB	-0.5 dB
Lightning Arrestors	-1 dB	-1 dB

ReferenceS http://www.hdtvprimer.com/ANTENNAS/GlossaryG.html#jointenna
http://www.cisco.com/c/en/us/support/docs/wireless-mobility/wireless-lan-wlan/82068-omni-vs-direct.html
http://slideplayer.com/slide/4683611/
http://www.ttu.ee/faculty-of-information-technology/centre-for-biorobotics-2/study-4/student-projects-3/?id=52243
http://www.bb-elec.com/Learning-Center/All-White-Papers/Wireless-Cellular/Wireless-Antenna-Installation-Guide-10-Tips-for-Ma.aspx

Choosing a telemetry module:

a. Determine the parameters of the radio link (frequency, power). A trade-off must be made when choosing the transmission frequency: the lower the frequency, the better the signal passes through and around obstacles, but the narrower are legal bands and the bigger is the radio equipment. The compromise choice was the 869.40...868.65 MHz band that allows unlicensed use of up to 500 mW transmitters. This enables communication in 4 km radius even when the base station is hidden in vegetation.[1]

Note:

500 mW signal at the chosen frequency can be received at the distance of tens of kilometers, given line-of-sight, and even further in some atmospheric conditions. To minimize radio interference by the UAV and, more importantly, to remain unnoticed in the sky, it is a good idea to constrain radio emissions to a very narrow beam directed at the base station. For that, a directional antenna is used, that combines radio waves from different parts of the antenna into a narrow beam. Traditionally, a directional antenna has a fixed radiation pattern. To move the pattern, whole antenna has to be rotated. However, the antenna moving mechanism is slow, massive and sensitive to rough landings, and thus it is advisable to use an electronically directed phased array antenna. [2]

References
1 http://www.dronetrest.com/t/beginners-guide-to-drone-autopilots-and-how-they-work/1380
2 https://3dr.com/wp-content/uploads/2013/10/3DR-Radio-V2-doc1.pdf