

# ANATOMY OF A UAV

March 2016

## About this Publication

This fact sheet is intended to provide information to farmers wanting to explore the use of Unmanned Aerial Vehicles (UAV) or “drones” as a tool to support their farming system. It has been generated as part of a project delivered by Leighton Pearce of Growing Solutions through funding from the Australian Government’s National Landcare Programme and the South Australian Murray-Darling Basin Natural Resources Management Board.

The information is general in nature and provided as reference material only and is not intended to be relied upon as, or be a substitution for specific professional advice.

Information was true and correct as of March 2016, however as this is an area of such rapid growth, it is advisable that information, particularly that relating to CASA rules & regulations, is double-checked before any action is taken.

## About the author

Leighton Pearce of Growing Solutions has 18 months’ experience in flying UAVs in an agricultural setting. He has delivered many demonstrations to farmers groups, covering approximately 1,300 individuals, and is a recognised expert in the field in South Australia. He has an Operators Certificate and a Remote Pilot Aerial Systems licence, as well as appropriate insurances to work in this field. This knowledge and experience of UAVs is supported by his Bachelor of Applied Science in Agriculture, and his Advanced Diploma of Business Management.

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# The art of flying

## The Law

No matter who you are, the law applies to all users of UAV in Australia. The governing body of our airways, Civil Aviation Safety Authority (CASA), is undertaking an update of the laws governing UAV users. According to CASA regulations, farmers are currently considered hobbyist and do not require licencing, but must act within the law.

From a farmer's point of view, all the laws below must be adhered to. In addition, the UAV can only be flown on the operator's own property, and operators should not fly over roads to access other paddocks, but rather re-launch.

A summary of current (March 2016) regulations:

- Do not fly over populated areas, including townships, houses, schools, any kind of sporting activity etc.
- Do not fly above 400 feet (120 metres), use telemetry to monitor this
- Do not fly within 3nm (5.5km) from and aerodrome.
- To operate a UAV greater than 2kg outside of your private property, you are required to hold the appropriate licence.
- If you are to gain reward (cash or other reward) for delivering UAV services, you must also hold an Operator Certificate issued by CASA.
- All bystanders or observers must remain 30 metres from the person in control of the UAV.
- You must not operate your UAV in a way that creates a hazard to another aircraft, another person, or property.
- You must keep line of sight of the UAV.
- You can only fly in daylight.



# The art of flying (cont...)

## Hints

- Practice in large field, away from people, trees, power lines, buildings and structures. This will minimise risk to yourself, others and damage to your UAV or structures.
- At each site, assess the best launch and landing positions.
- Only fly in wind that your UAV can handle.
- Once launching, ensure that your UAV (Multirotor) can hover at 2m above ground level (AGL), that the yaw, forward, backwards, left and right levels are working.
- Do not fly close to power lines or power stations that can affect the electrical system of the UAV.
- Practice flying out of GPS mode, in the case of lost communication with the satellites, the GPS may not work.
- If flying a multi rotor, colour either the two rear arms or two front arms to help you identify the front of the multi rotor from the back. This is important, as when the UAV is facing you, all directional controls reverse (forward becomes backwards and left become right). Some people use different coloured propellers to distinguish the front from the rear of a UAV. In some products available you can initiate Intelligent Orientation Control (IOC) that will ensure when you move the UAV left it will move left despite the way the UAV is facing.
- Using a battery charge checker, check each battery / cell to ensure that each battery is fully charged and no more than 0.2 Volts difference between each cell.
- When learning, hover your UAV, make minor left / right, back and forward movements and time the flight until your battery alarm sounds, this will help you to determine approximate expected flight times
- Set yourself a pre-flight checklist and post-flight checklist. This should include the monitoring the state of the propellers, motors, flying platform, battery voltage, the temperature of motors, electronic speed controllers, connections of leads, propellers wear and landing gear.
- Once the UAV has landed, you should turn off the transmitter or ensure that it is safe to approach the UAV. Do not let others approach the UAV. Only approach once all propellers have stopped rotating. Disconnect the battery from the UAV immediately.
- When launching, face the UAV into the wind. With experience you can face it in the direction you plan to travel. Stand back directly behind the UAV and initiate start-up sequence once you are confident that there are no dangers in the immediate area.
- Always fly the UAV in front of you; do not let it go behind you. Do not turn around as this will change your position and turn left into right in relation to your radio transmitter.

# The art of flying (cont...)

## Safety

- Ensure you have appropriate failsafes installed on your radio receiver; these may include (note, not all flight controllers will allow all of these failsafes to be installed):
  - ◆ Return to home
  - ◆ Intelligent orientation control
  - ◆ Home lock
  - ◆ Course lock
- When launching, launch from a clean area, free from weeds and dust. Many users launch from a launch mat to ensure that no dust or foreign object affect the UAV's flight.
- Having data fed back to your ground control station or radio transmitter via telemetry provides the UAV pilot with additional information concerning the number of satellites, wind speed, battery power and altitude. All of this information is vital to ensure safe flying.



# Batteries

## About

Lithium Polymer (LiPo) batteries are the battery of choice in the UAV device market. These batteries are lightweight, inexpensive (in general terms, for power output) and powerful. Each battery is rated in units of milli Amp hours (mAh); the amount of mAh is a measure of the charge capacity (endurance) of the battery. In addition, each battery contains a series of cells. In general terms, the batteries used in UAVs are 4 - 6 cells. As battery capacity increases, so does the weight, size and cost. The aim is to find the "sweet spot" to maximise flight time. Each fully charged cell stores 4.2 Volts. A battery at 3.2 Volts will not have enough power to fly.



UAV Battery

## Hints

- LiPo battery voltage checker with a LCD screen is a must.
- LiPo battery audible alarm should be fitted to your UAV unless you have telemetry on your radio transmitter that indicates battery charge.
- Balance charging at 1C rate each cycle will maximise the life, efficiency and duration of flights.
- Do not run your batteries flat; your batteries will have a longer life if partially discharged (to around 30%). To maximise efficiencies between flying time and charging, I set alarms at 3.6 Volts per cell.
- Have plenty of batteries on hand to ensure maximum flying periods under ideal conditions.
- You get what you pay for - this is important with chargers, 12 Volt power supplies and batteries.
- Charging at 1C rate can take up to 2 hours to charge a battery. Battery chargers that allow you to charge multiple batteries are ideal.
- Label each battery and keep a record of the number of discharges and recharges it has. This will provide information on each individual battery and evidence in case of an incident.
- Allow batteries to return to room temperature prior to recharging.
- Never cross the polarity or leads of a battery or charger.



LiPo batteries can self-combust

# Batteries (cont...)

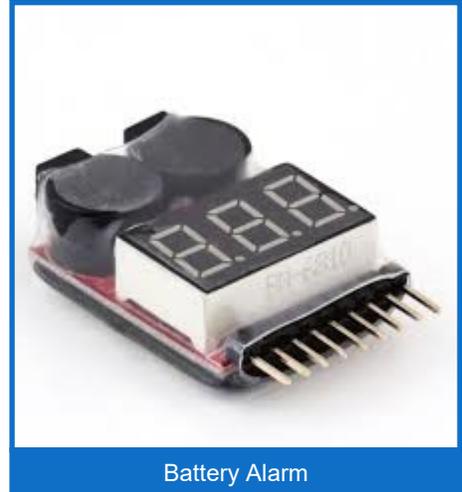
## Terms & Language

The “C” rating on a battery is the rate that the battery charges or discharges, relative to its capacity. C ratings range from 1C - +70C. The higher the C rating, the faster it will be to recharge the battery, although it is recommended to charge at the 1C rating, e.g. a 10,000 mAh battery should not be charged above 10Amps (1C rating), where a 4,000 mAh battery should not be charged above 4 Amps.

A battery with a higher C rating allows for increased power to more and bigger motors, leading to increased flight time, heavier lifting capabilities and enjoyable responsive flying.

## Safety

- Ensure that your batteries' power output does not exceed the sum total of the Electronic Speed Controllers (ESC's) power requirement.
- LiPo batteries can cause serious damage and potentially self-combust. Care must be taken in storage, use in the field, handling, travelling and charging.
- LiPo carry bags are ideal for placing batteries in during charging, storage and transporting to contain any potential combustion.
- LiPo batteries should not be transported in airplanes.
- A puffy battery is a sign of overcharging, damage or age; these batteries should not be used and should be disposed of using the correct method.
- When charging batteries, always ensure you are close to the station, in case something goes wrong.
- If batteries are not to be used for longer than three weeks, they should be put into storage mode at around 3.8 V per cell.



Battery Alarm



Battery Checker

# Motors

## About

Motors are rated in units of KV. The KV rating for a motor identifies its “no-load” rpm rating or the amount of rpm the motor will produce for each volt of current. Motors used in UAVs generally are brushless. Fully enclosed motors are ideal for the agricultural industry to keep out dust and foreign objects.

## Hints

- Low KV motors are best suited to larger propellers turning a lower rpm.
- After installing new motors, ensure that all motors turn in the correct direction according to the type of UAV you are using. If one motor is turning in the wrong direction, this can be easily remedied by switching any two wires to the electronic speed controllers.
- You get what you pay for; better quality motors tend to be more expensive.

## Safety

- When working on your UAV testing motors, ensure you remove all propellers.



# Flight Controllers

## About

The flight controller is the “brain” of the UAV. The flight controller provides the stabilisation the UAV requires. Flight controllers can be programmed to perform different flight operations to aid pilots in flying.

## Hints

- The more you spend, the better the product and the more options to program the flight controller are available.
- Flight controllers will have a LED unit connected to the UAV. This LED unit will emit different coloured alternating lights depending on the point at which the UAV is preparing to launch as well as, but not limited to, attaining a GPS lock, compass calibration and/or changing modes. Become aware of the different light sequences and their meanings.



# Flight Modes

## About

**GPS and attitude hold modes** maintain the UAVs position both vertically and laterally. GPS mode requires a start up procedure to access satellites; this mode can take longer to start than all other modes. Attitude mode uses the barometric sensors on board the UAV to detect small changes in barometric pressure

**Orientation modes** change the orientation of the UAV in respect to the pilot's position. This mode is very useful for beginning pilots; regardless of the position of the UAV in respect to the pilot, moving the forward lever will move it forward, even if it is facing you. To ensure that this mode is working, you must have a GPS lock prior to launching.

Within orientation controls, you can have either course lock or home lock. When course lock is engaged, the UAV moves in the direction that the pilot moves the radio transmitter lever, regardless of which way it is facing, whereas in home lock, the UAV will return directly to the pilot when the radio transmitter lever is pulled back.

**Failsafe mode:** in the case the operator loses orientation or experiences control issues, this switch can be engaged. Care must be taken to ensure that no obstacles are in the travel path of the UAV as the pilot has no control of it in failsafe mode until it has been disengaged. Some UAVs are set up with auto return to home, in the case there are communications issues.

**Autonomous mode** involves minimal pilot control. GPS waypoints are programmed into the flight controller prior to flight, and the pilot has no control/input during the flight. This flight mode can be changed to another flight control mode, in which the pilot can take control, by the flick of a switch. This mode is most often used when the operator requires a set flight pattern.

**Manual mode** provides maximum pilot control, used by experienced pilots

## Hints

- Beginners should use GPS mode in preference to manual mode.
- Use autonomous mode when undertaking a pre planned repeatable flight mission.
- As part of the pre-flight checklist, ensure flight modes are working.
- Label switches on the radio transmitter to easily identify different flight modes.

## Terms & Language

GPS mode may also be called loiter mode, depending on the brand of the equipment. Attitude mode is sometimes called altitude mode. Autonomous flight modes can also be called auto or waypoint modes. Orientation modes can be called intelligent orientation controls or free orientation mode. Failsafe modes can also be called return to home.

## Safety

When using orientation control, ensure there are no obstacles in the flight path.

# Radio Transmitters

## About

Radio transmitters are individually bound to UAVs. In general terms an operator would have one transmitter per UAV, although many custom-made UAV's now can be programmed to operate a number of UAV (not at the same time though). For instance, I have had four different UAV's bound to my radio transmitter at once.

Transmitters with inbuilt telemetry provide the user with additional safety measures including battery performance, altitude & wind speed.

When using a transmitter, it can either be setup as mode 1 or mode 2. With fixed wing UAVs, mode 1 is most commonly used while mode 2 is used for multi rotors. Please note that these can be altered. The difference between mode 1 and mode 2 involves different responses from lever action.



Radio Transmitter

## Hints

- Programming of radio transmitters is a specialist skill, and should only be undertaken by those with knowledge in this area.
- Neck straps can be useful to minimise fatigue in the field.
- Adjust trim to requirements; a balanced UAV should have all trims at a 0 value.

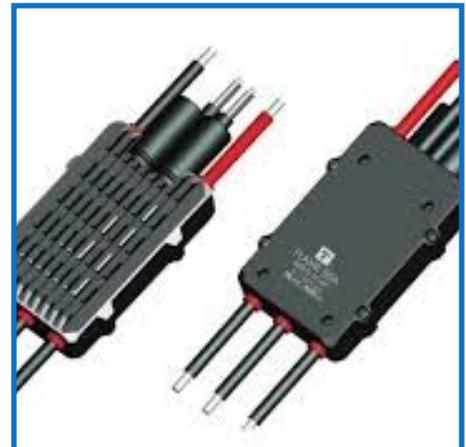
# Electronic Speed Controllers (ESC)

## About

The Electronic Speed Controller (ESC) regulates power to the motors from the power management unit.

## Hints

- Ensure they are securely fitted to your flying platform.
- Make sure that they have adequate airflow to cool them down.
- Allowing the UAV to cool down between flights will improve the effectiveness and efficiency of the ESCs.



Electronic Speed Controllers (ESC)



Electronic Speed Controller (ESC)

# GPS and Satellite receivers

## About

To fly successfully in GPS mode, a minimum of four satellites will be required.

## Hints

- Frequent calibration of your compass is required to ensure that your GPS is operating correctly.
- If flying more than 100km from areas that you normally fly in, the compass should be recalibrated according to manufacturers' recommendations and instructions.



# First Person View (FPV)

## About

According to CASA regulations, FPV must not be used in the course of sport or recreational flying. Line of sight must be maintained at all times. To get over this, you may consider a video downlink system, a small screen that will allow you to frame a scene.

FPV involves the user seeing what the UAV's on board camera is seeing,. Depending on the model of UAV, this can be achieved by using a screen, smartphone or tablet, or most frequently, a set of goggles. In first person view you are not watching the UAV in the sky, but rather the view from the UAV. This can a difficult concept to master as many users with goggles are oblivious to their immediate surroundings and can get motion sickness.

Each FPV system consists of a mini video camera, a video signal transmitter, a video receiver and a video monitor or goggles.

## Hints

- Start small with this initially; it's not for everybody.
- Practice in a field with plenty of room, learn how the camera distorts distances.



FPV Kit with goggles



FPV Kit with screen

# Propellers

## About

One of the most critical components of flight, propellers must be high quality and balanced to minimise any issue in flight. Any propellers that are damaged need to be discarded and replaced. The quality of propellers can drastically affect flight performance.

Propellers are classified in terms of their length and pitch angle. A 1047 propeller is 10 inches in length and has an angle (pitch) of 4.7 degrees to the horizon.

Propellers are made of a number of materials from plastic, timber and carbon fibre. Carbon fibre propellers are more expensive, but preferred over other propellers as they are lightweight, robust, highly responsive and efficient.

Propellers are either manufactured as clockwise turning or counter clockwise turning. It is important to ensure that the correct propeller is placed on the correct motor, otherwise the propeller will not spin correctly and result in significant damage.



## Hints

- When beginning, use lightweight cheap propellers, until you are ready to add extra component to your UAV (gimbals and cameras). At this point use high quality carbon fibre propellers.
- Propellers that show any wear or damage should be discarded and not used.
- All propellers should be balanced.

## Safety

- Remove when performing maintenance on the UAV.
- Ensure all screws or propeller adapters are tightened prior to flying.

# Insurance

## About

A UAV is considered to be an aircraft is not covered by traditional business policies, and the traditional liability insurance held by most businesses is insufficient in the case that your UAV causes damages or injury. Therefore, UAVs must be insured under aviation insurance.



Appropriate insurance is vital

