♦ Related downloads

♦ Freeman 2100/2300 user guide download

http://fw.makeflyeasy.com/Freeman/

♦ Freeman 2100/2300 parameters download

http://fw.makeflyeasy.com/Frame_params/

♦ MP download

http://fw.makeflyeasy.com/Mission_Planner_VTOL_Survey/

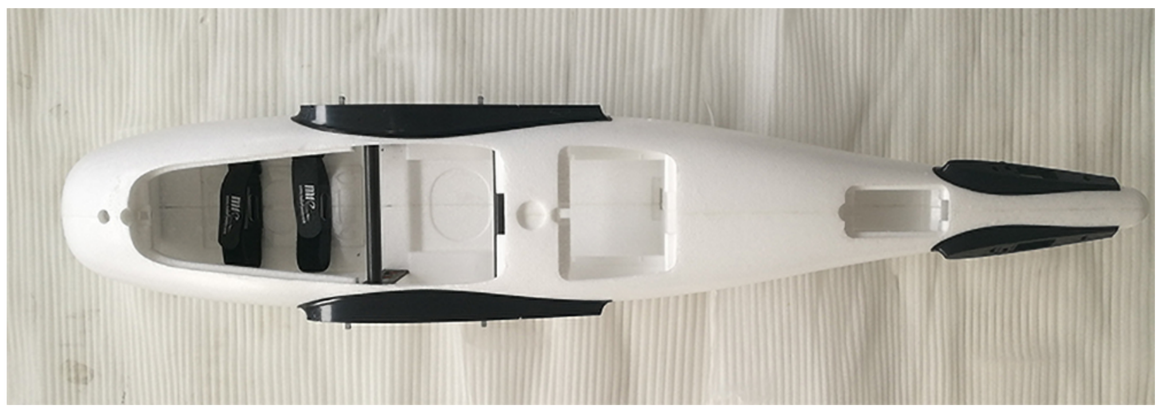
♦ Freeman Fixed Wing Installation Notes

♦ Assembly and notes

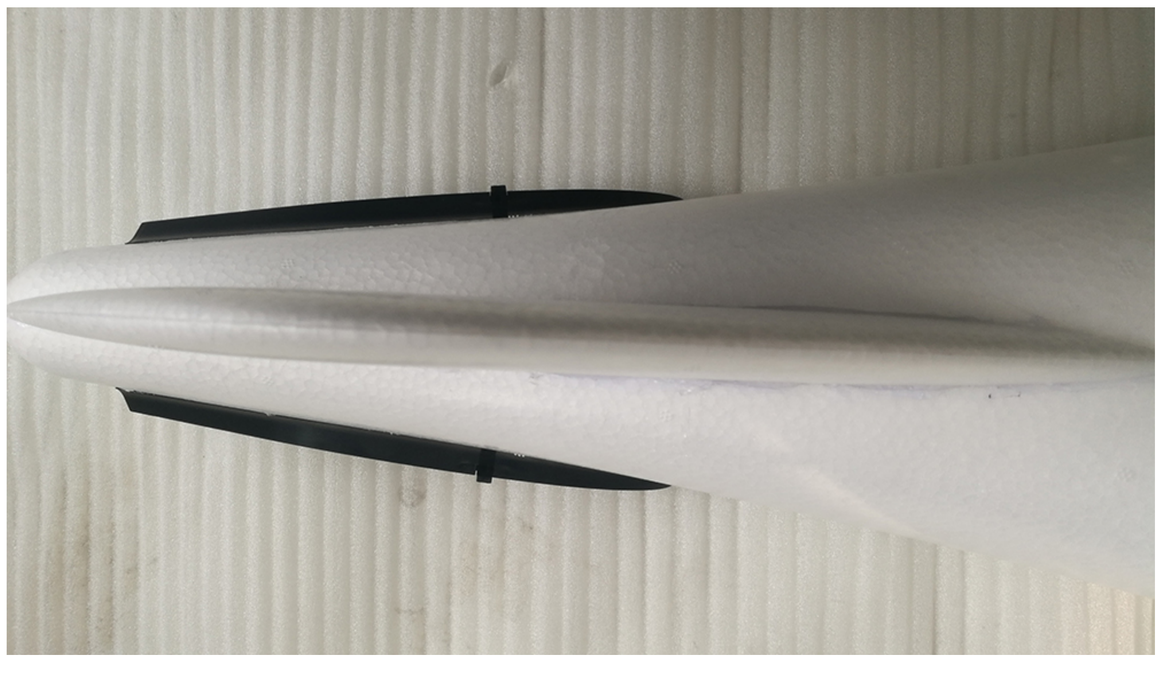
- I use the Freeman 2300 for installation, and the Freeman 2100 is similar, only the wing is 20cm longer, the fuselage and tail section is the same.

1.1 Fuselage tail section

- Fuselage assembly can refer to Believer Hand Throw Fixed Wing Installation Notes, Check whether the parts to be embedded are installed before closing the mold.



- To increase the longitudinal stability of the aircraft, I cut a vertical tail by hand and glued it on with hot melt glue. This way the flight path offset is smaller.



- The part of the wing docking is the metal locking hook, pay attention to the installation of flat, to ensure smooth plugging and unplugging.

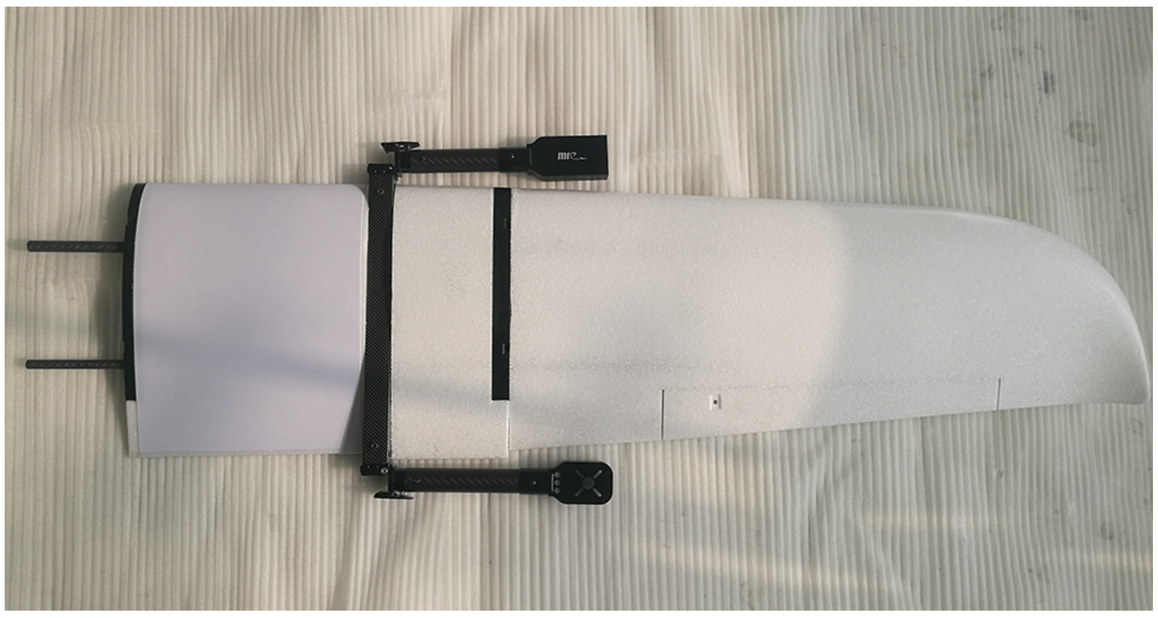
- After the fuselage is bonded, it is recommended to increase the strength of the aircraft with fiber adhesive to improve the durability of the aircraft.

- Before the tail is installed, it is recommended that the rudder surface is repeatedly folded by hand several times to reduce the resistance of the rudder surface rotation.

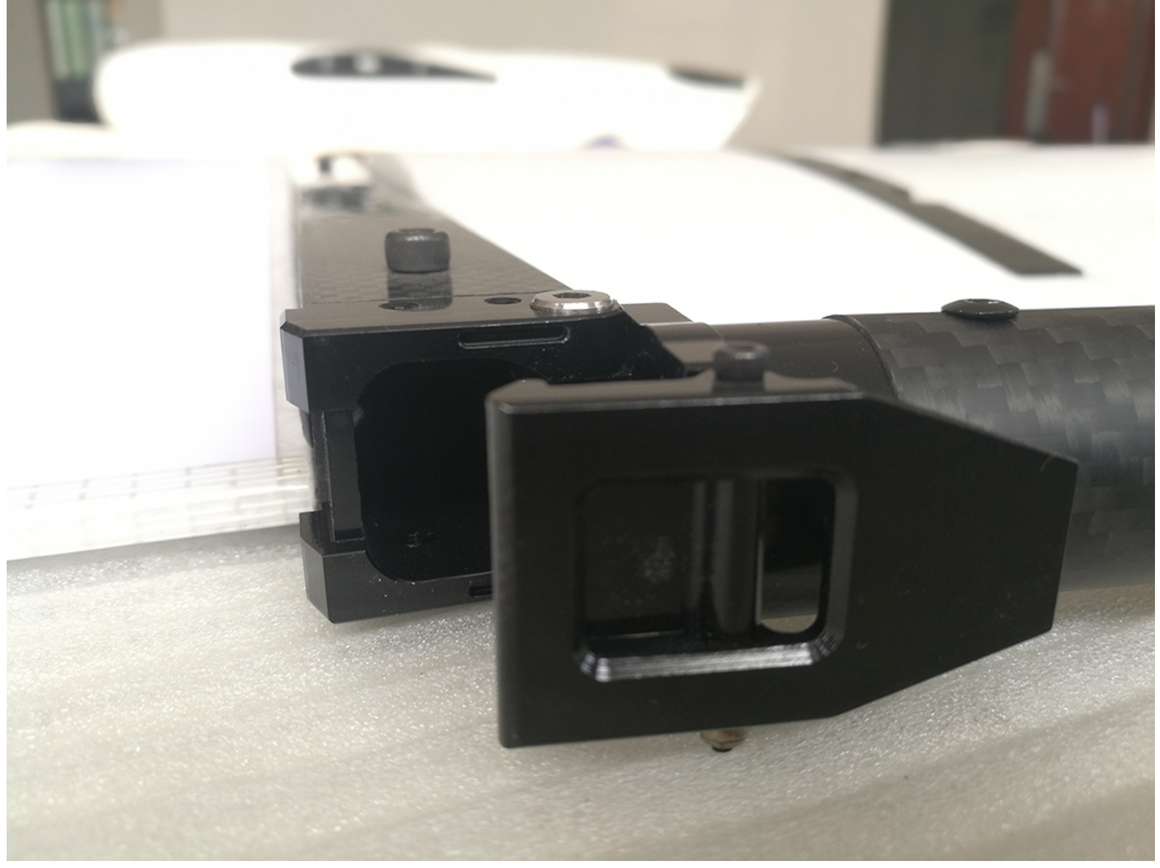
- The rudder surface of the tail can also be reinforced with fiber adhesive to increase the strength of the rudder surface and improve the precision of control.

1.2 Wing section

- The rudder surface of the wing also needs to be manually folded several times repeatedly to reduce the resistance of the rudder surface rotation.

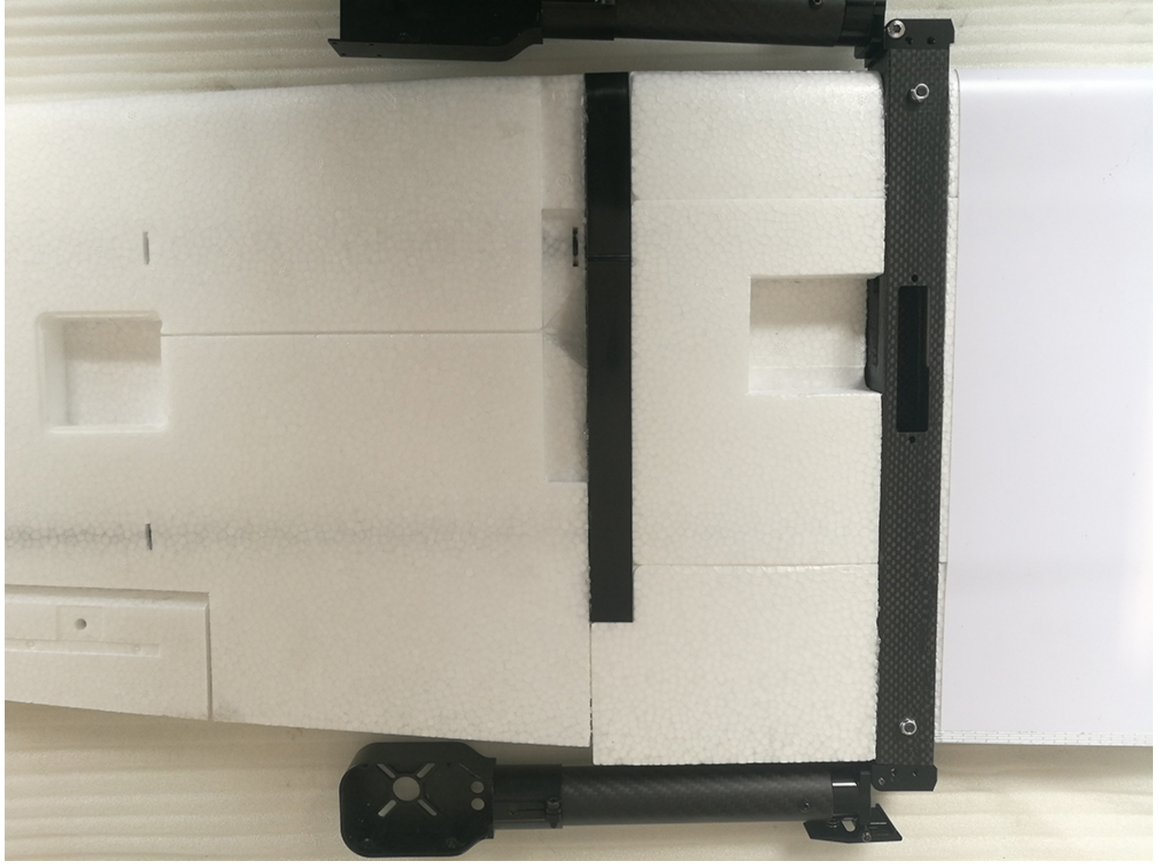


- Check whether the screws of the folding machine arm are tightened.

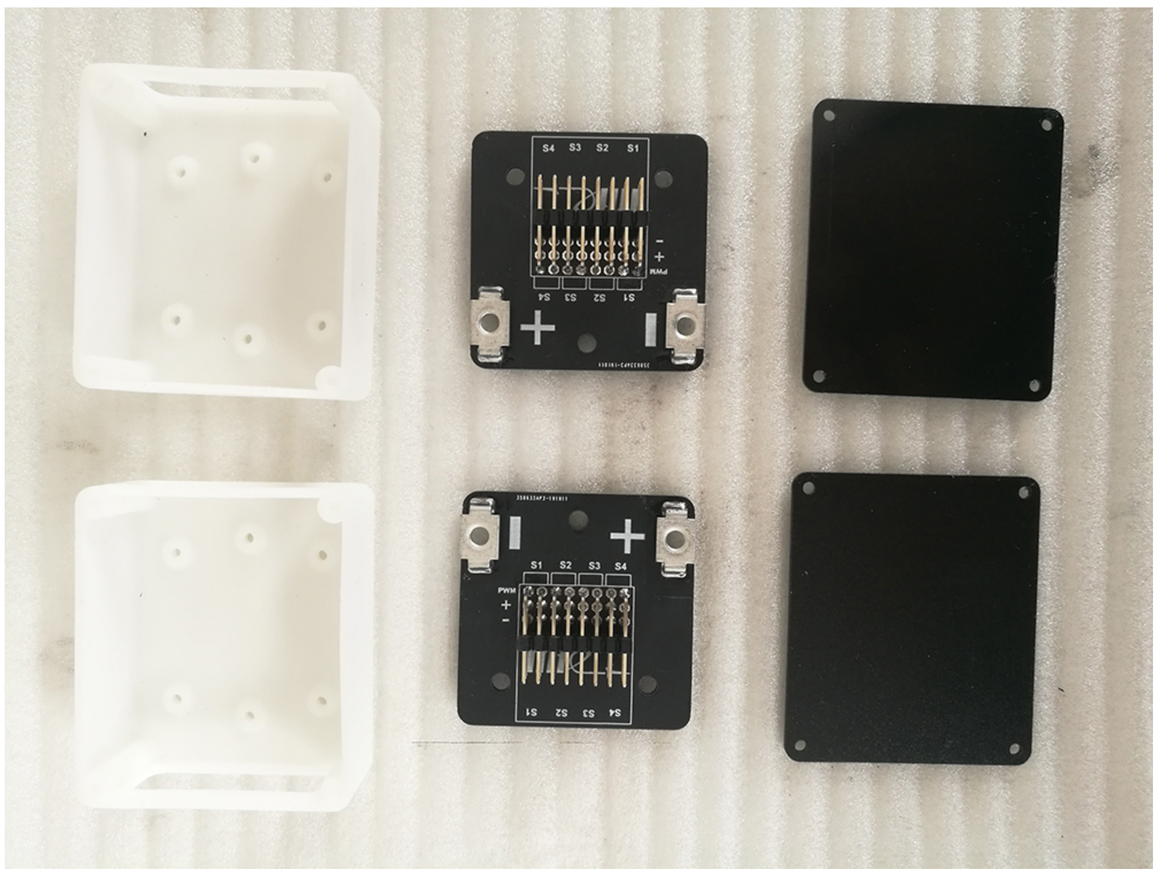


- I installed a waterproof and dustproof version of the motor mount, the internal space of this motor mount can accommodate Lotte 40A and Lotte 60A ESC (Attention to thermal conductivity and heat dissipation during ESC installation).

- For quick assembly and repair, I dug a hole in the wing and hand-made an adapter plate for modification(The official version does not have this thing, hope to add later).



- I first 3D printed a mounting base to facilitate the installation of the adapter plate, and then CNC machined a cover plate so that the appearance looks more beautiful.

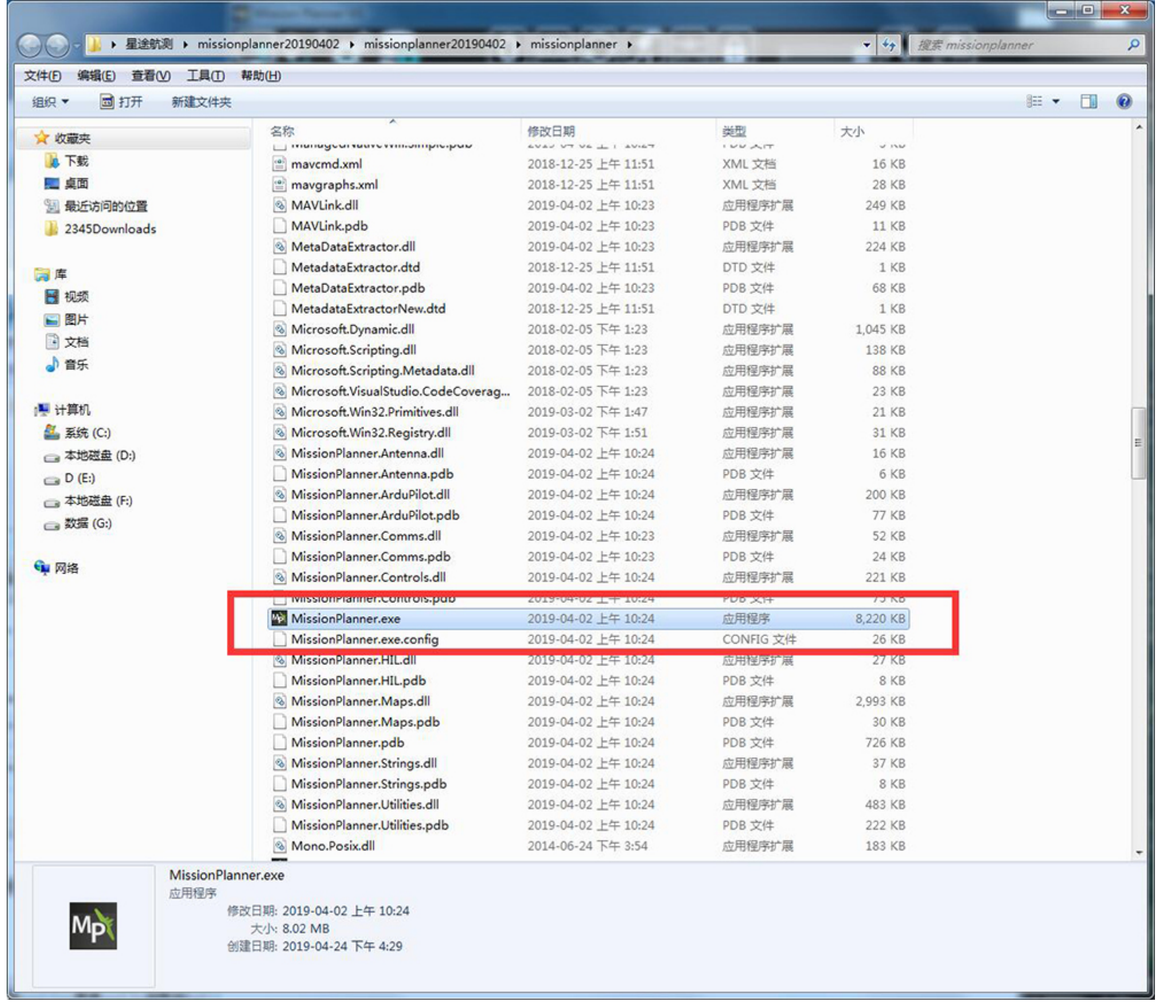


- Pre-install it first and see how it works(If there is no adapter plate, you need to directly solder the line, some connectors need to be cut and then soldered together, the effect is the same).

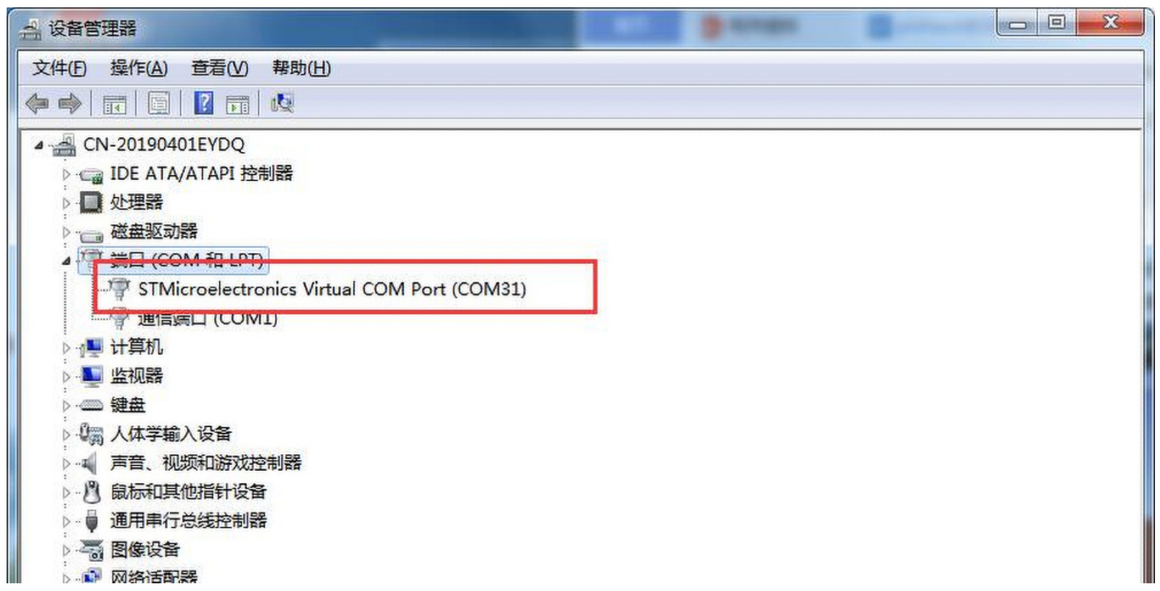
♦ Initial setup of flight control system

2.1 Installation of mission planer ground station

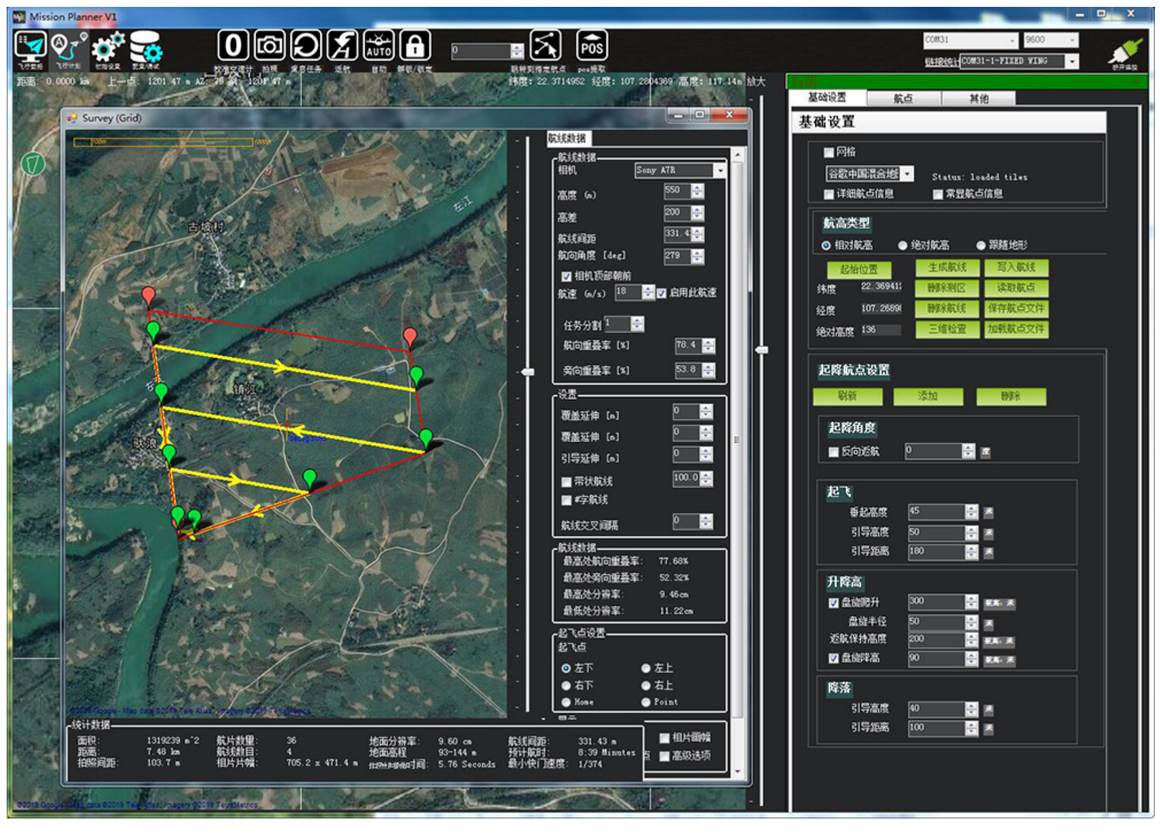
- I use Mission planer modified ground station, Mission planer VTOL suvey is also permanently free to use, specifically optimized for VTOL fixed wing.



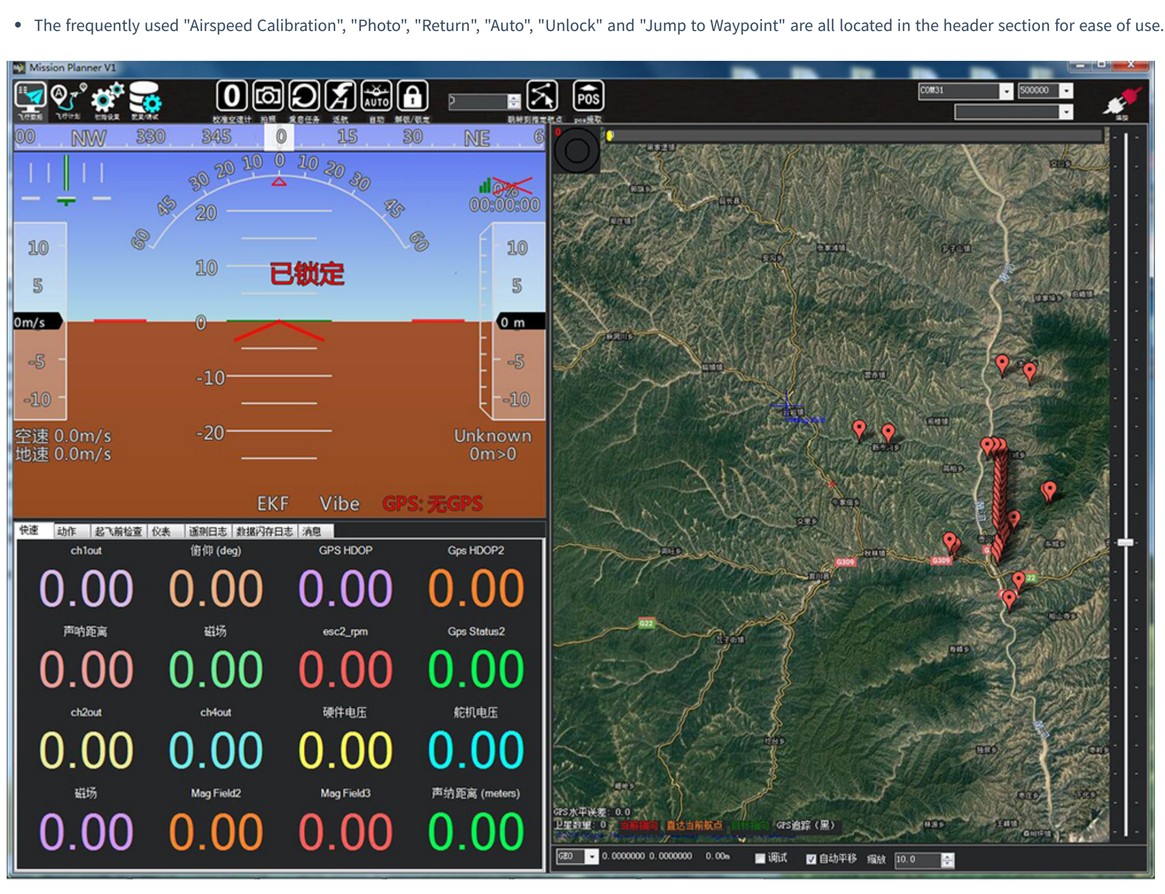
- If the port number is not correctly recognized after inserting the flight control, you need to load the driver manually.



- The VTOL fixed-wing route design has been heavily optimized to facilitate rapid route generation.



- The frequently used "Airspeed Calibration", "Photo", "Return", "Auto", "Unlock" and "Jump to Waypoint" are all located in the header section for ease of use.

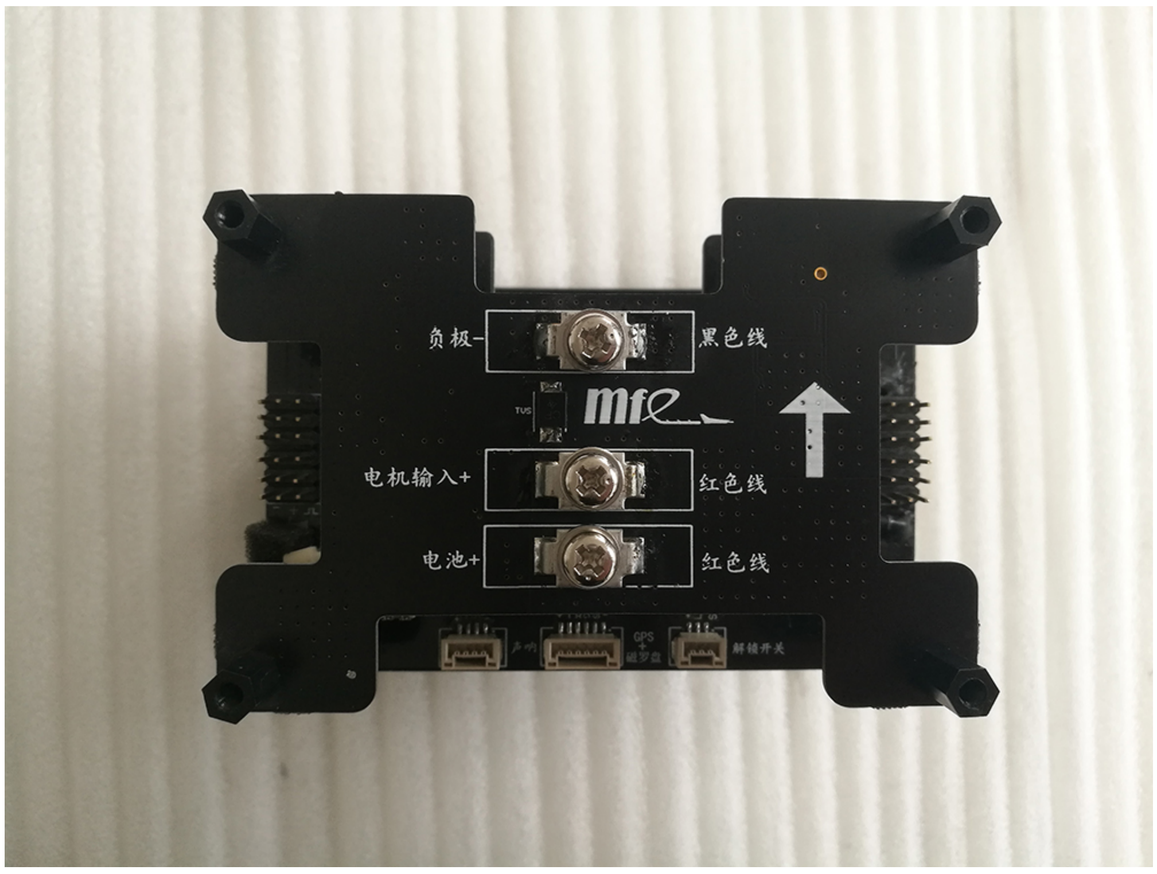


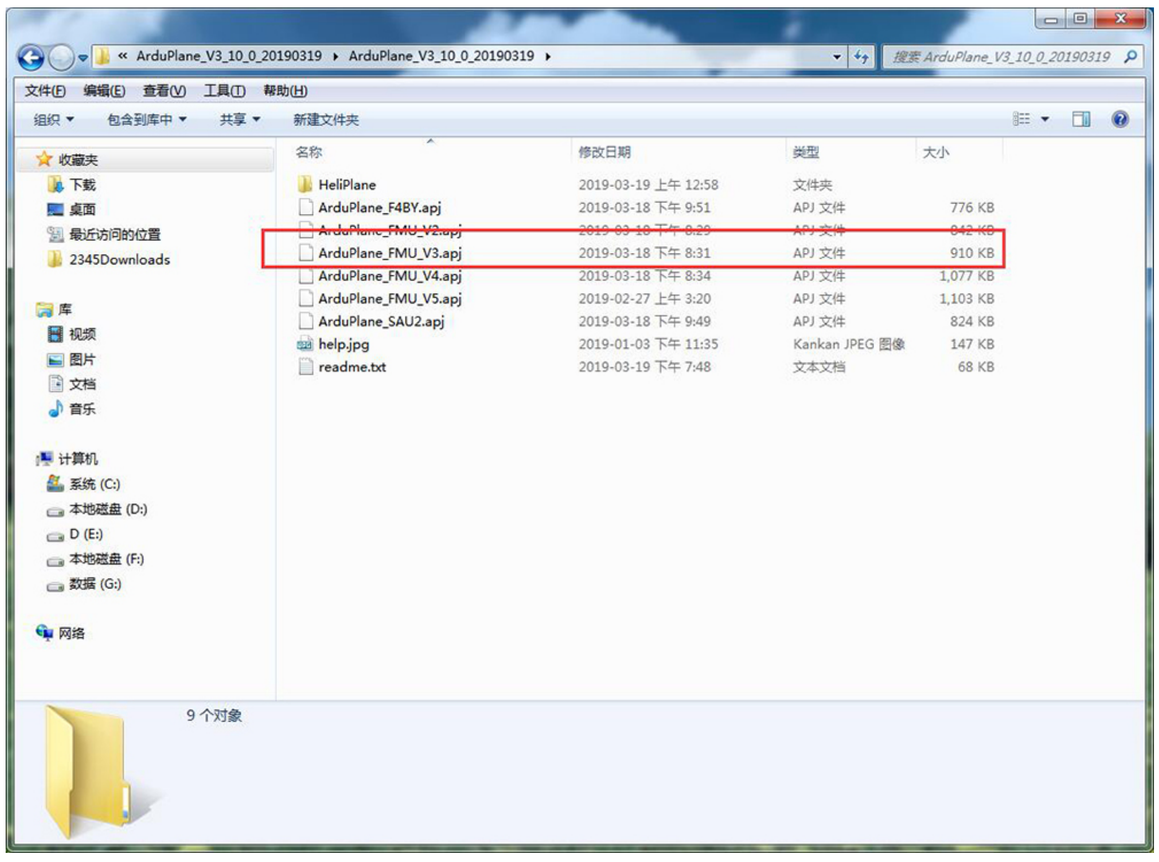
2.2 Program flight control firmware

- Tilting VTOL fixed wing can program the official Ardupilot firmware, or the Kris version, which has a smoother transition between multi-rotor and fixed wing. I use Kris20190319 version here as an example to load custom firmware, for the sake of disassembly and assembly convenience, I use a flight control based

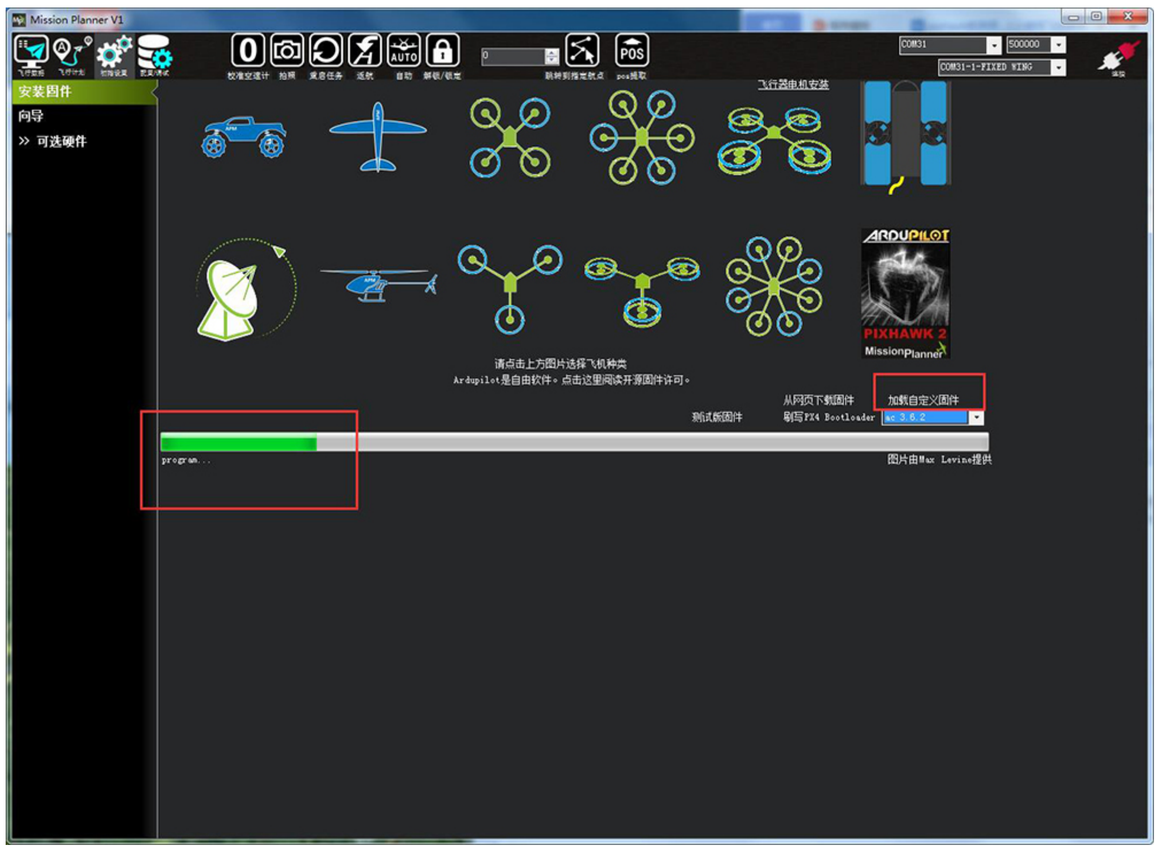
on Pixhawk V3 version flight control for system integration, named Pixsuvey.

The process of programming the firmware is the same as for the CUAV's Pixhack V3 and the HEX's PIXHAWK2.



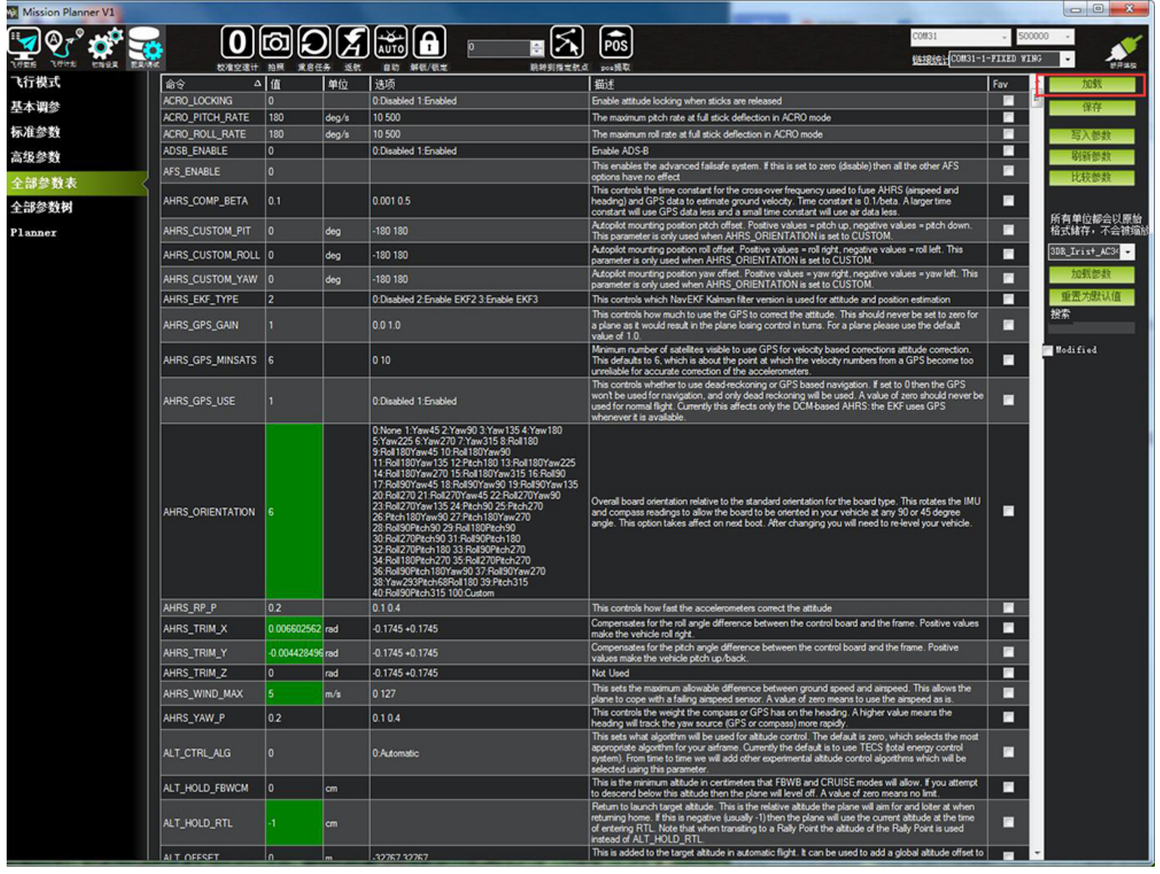


- Reboot after programming the firmware to check if the programming was successful.

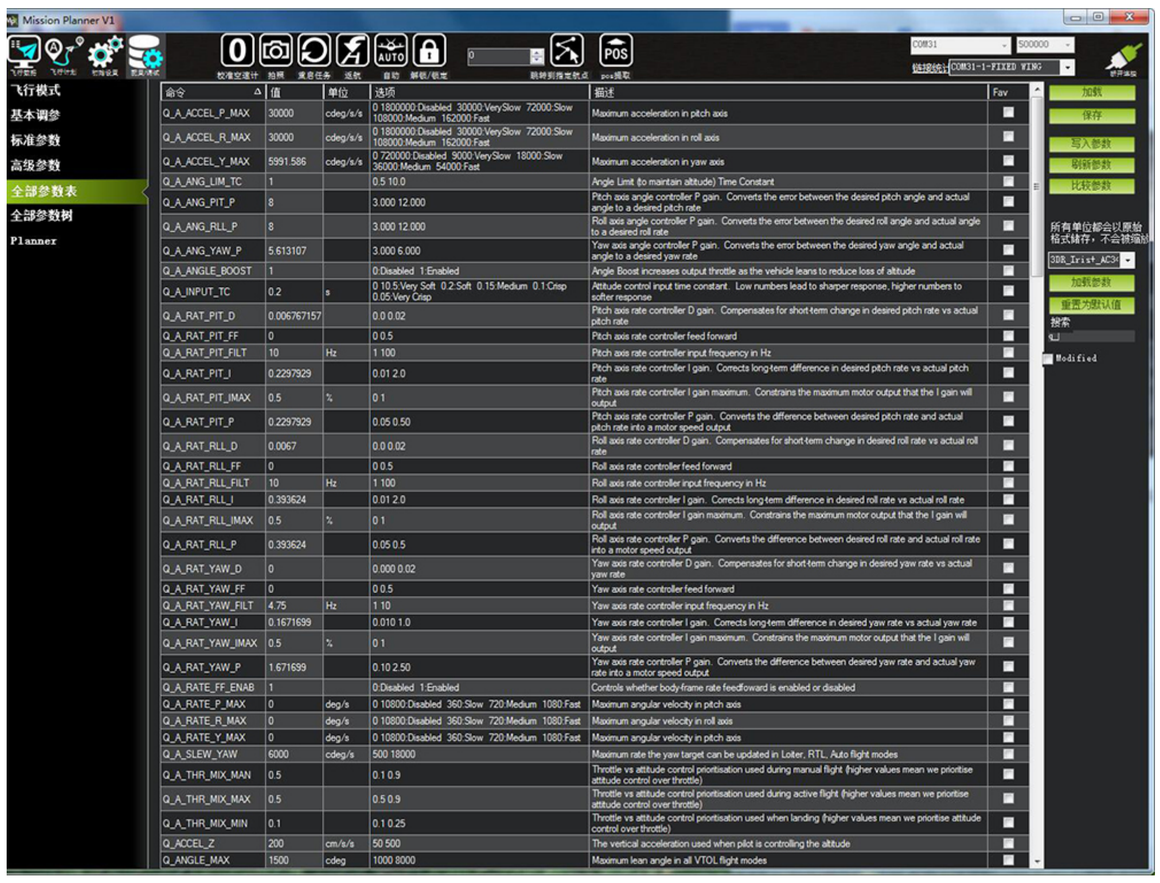


2.3 Write configuration parameters

- Tilting VTOL fixed wing parameters can refer to my parameters, or you can configure yourself individually.



- The parameters need to be swiped twice, the first time q_enable is enabled, after restarting the flight control, the hidden parameters at the beginning of q_ can be loaded. The parameters at the beginning of q_ are written successfully only after the second swipe.

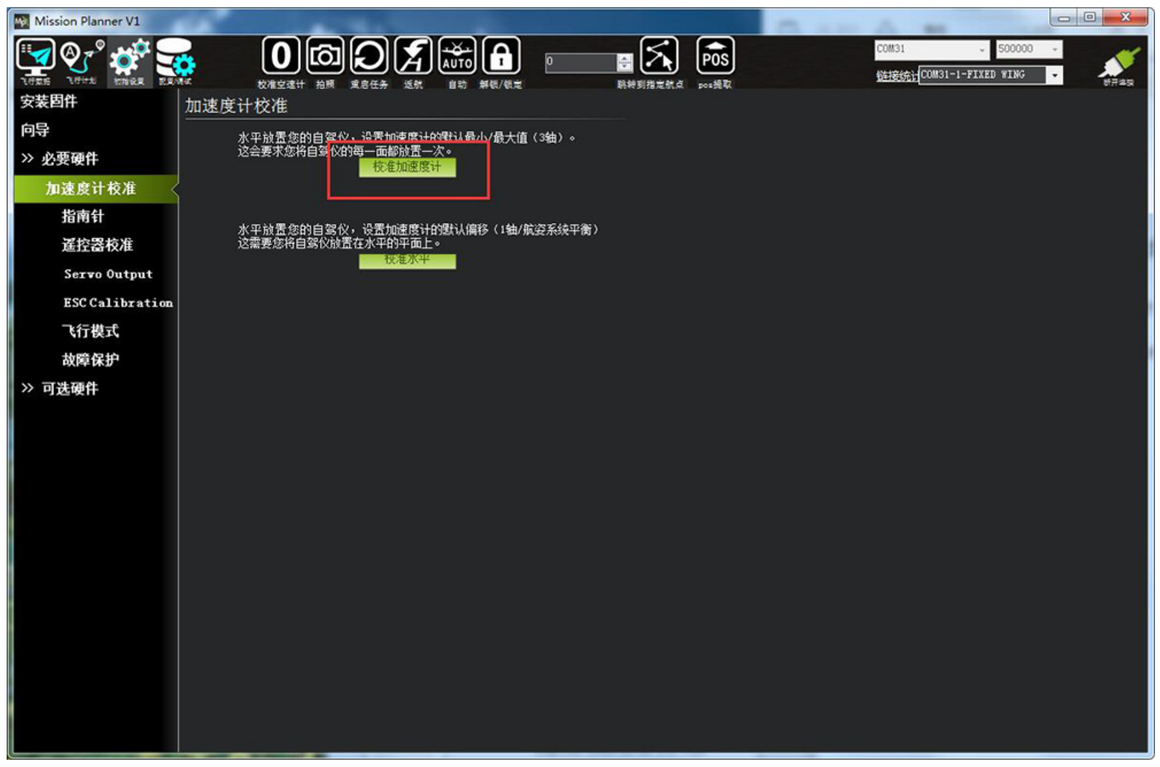


2.4 Six-sided method for accelerometer calibration

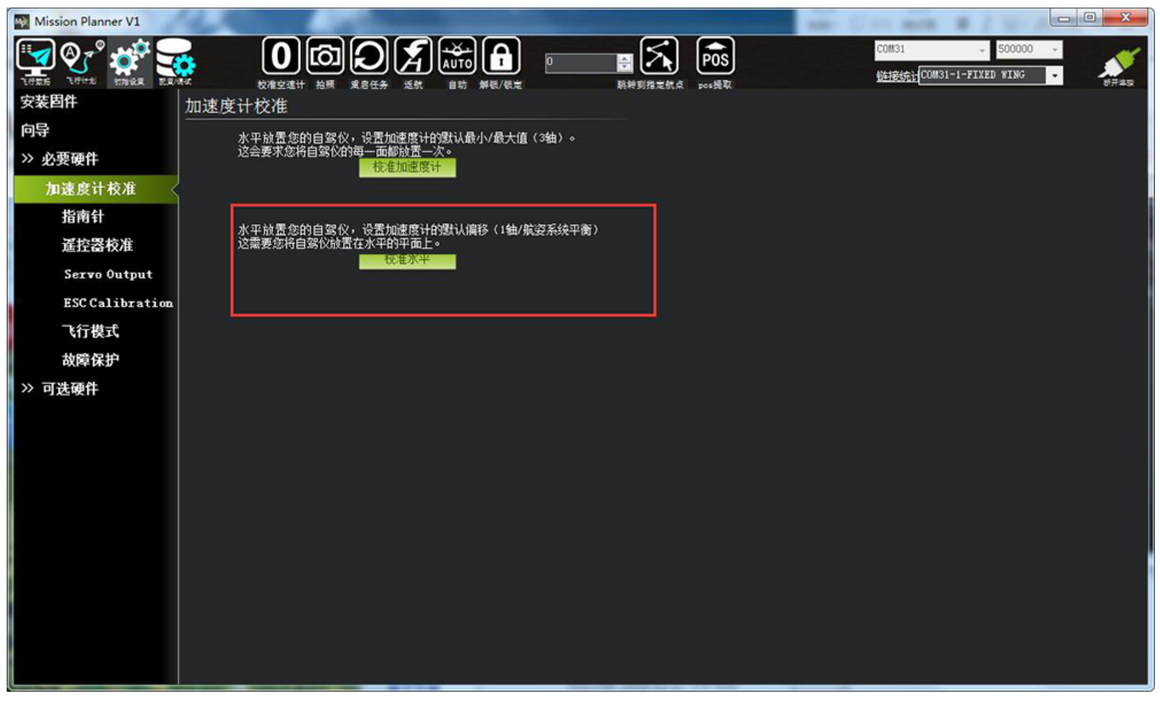
- This calibration must be done, and the horizontal calibration is only a small angular fine adjustment compared to the initial calibration of the accelerometer.

Acceleration calibration sequence:

> Placed horizontally - left tilt 90 degrees - right tilt 90 degrees - low head 90 degrees - tilted head 90 degrees - placed horizontally upside down



- Many aircraft course deviations have a lot to do with the aircraft not being calibrated level(Keep the level of flight control in line with the level of the aircraft).



2.5 Configure and calibrate the magnetic compass

- Because the VTOL fixed wing has a multi-rotor part, so it need to configure the external compass, I am disabling the built-in compass, because the built-in compass inside the flight control, the cabin electromagnetic environment is more complex, power wires, BEC may have interference with the compass.

- I use field calibration, the nose points north, rotate 360 degrees along the pitch axis, then rotate the nose horizontally by 90 degrees, and then rotate 360 degrees in a horizontal roll to complete the calibration.Generally, when using the field calibration outdoors, you need to remove the keys, cell phones, belt buckles and other iron-containing items from your body, and keep the aircraft away from sources of interference such as aircraft support bays and vehicles during calibration.

Compensation parameters:

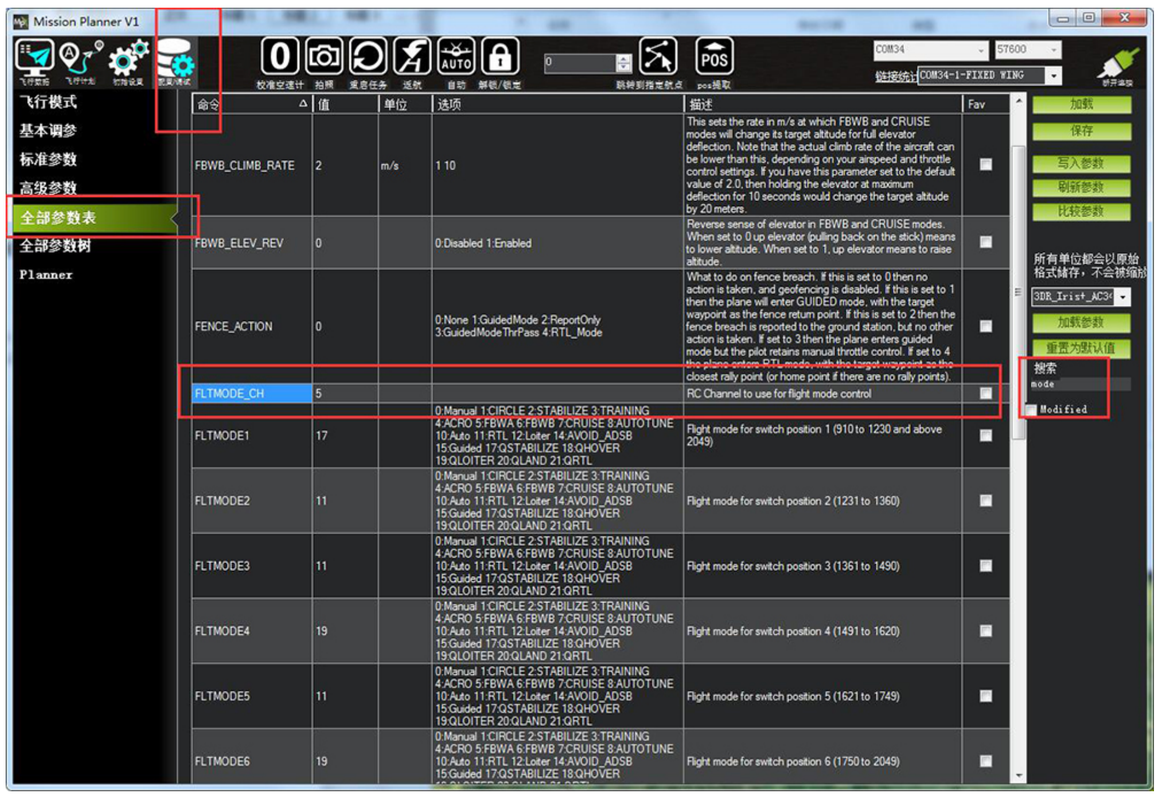
> In the northern hemisphere, the compensation of Z should be positive, the compensation value of pitch low X should be increased, and the compensation value of cross roll right Y should be increased.

Common compass error messages:

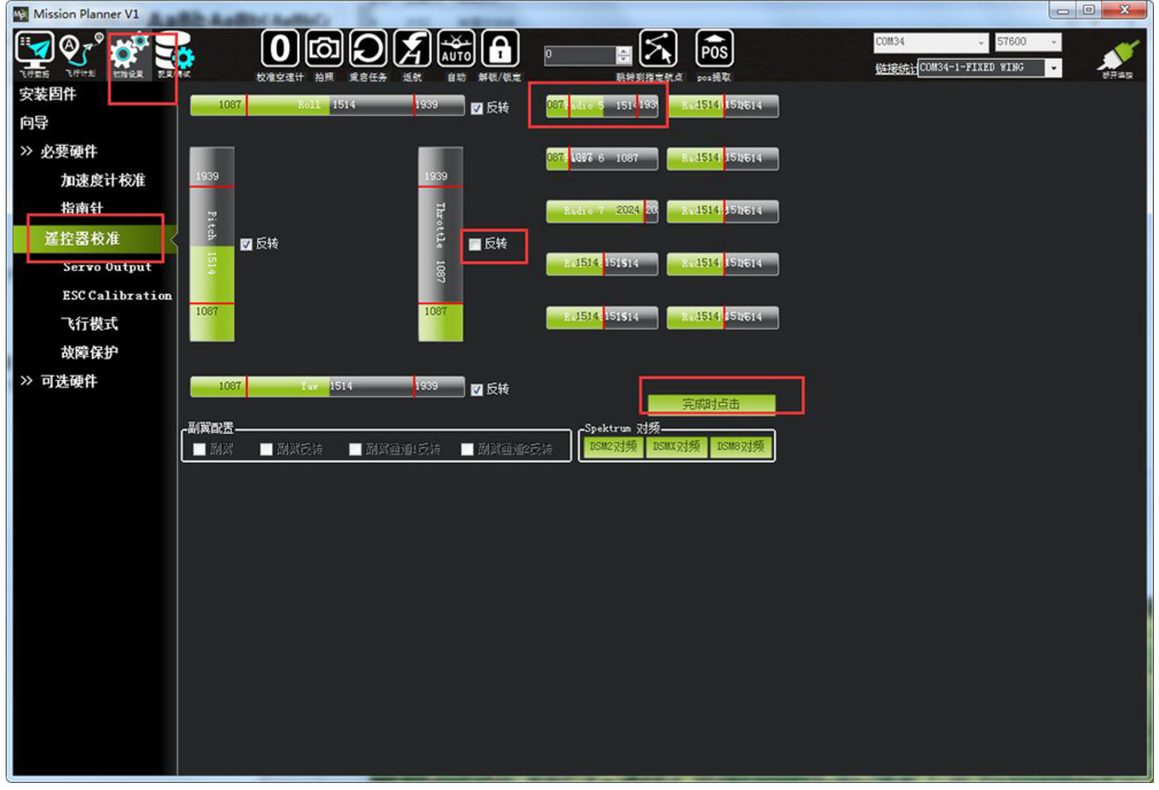
> Compass Unhealth: The compass did not send a signal for at least half a second.
> Compass Variance:In the EKF path, the compass heading does not match the heading estimates from the other inertial sensors. Clicking on the EKF button on the mission planning screen will display the specific error.
> Compass Not Calibrated: The compass needs to be calibrated.
> Compass Offsets High: One of your compass offsets is more than 600，Indicates possible magnetic interference, check the source of interference and recalibrate.

2.6 Configure and calibrate the remote control

- Set the mode switch channel, I use the WFT07 remote control, configure channel 5 three-segment switch as the mode switch.



- Calibrate the remote control, hit the maximum and minimum values for each channel as prompted, and finally keep the throttle at low and all other channels at neutral. This way the flight control completes the recording of the maximum, minimum and median values Save.



- Click "Reverse" is to modify the remote control channel positive and negative, more convenient. This operation and directly modify the remote control channel output positive and negative is the same effect.

2.7 Configure and check GPS

- Connect GPS to check if the search satellite is normal, I am connected indoors, so the number of satellites is very small, and the EKF red color has not disappeared, the GPS is not completely locked.

About GPS

- Most civilian GPS receivers use pseudo-orange data (C/A code) on the GPS L1 channel (1575.42 MHz) and can also optionally receive SBAS DGPS corrections to obtain meter accuracy.
- Advanced and expensive civilian GPS receivers can use previous methods plus carrier phase smoothing, carrier phase correction (RTK), and L2 channel P(Y) code semi-coded tracking (1227.60 MHz) for real-time local ionospheric correction, providing centimeter or even millimeter accuracy.
- Some of the more advanced GNSS receivers can combine DGPS and RTK correction with the ability to receive other GNSS satellites GLONASS and GALILEO) and other channels (L2C, L5 .....) to improve accuracy and reliability.
- The military GPS receiver is capable of decoding the P(Y) codes available on the L1 and L2 channels, providing 10 times the real-time accuracy compared to the basic decode of pseudo-orange.

About GPS multi-Paths

- Multi-paths make GPS positioning errors difficult to detect and compensate for. Multiple GNSS receivers are better suited for filtering out multi-paths due to the availability of more visible satellites at the same time.

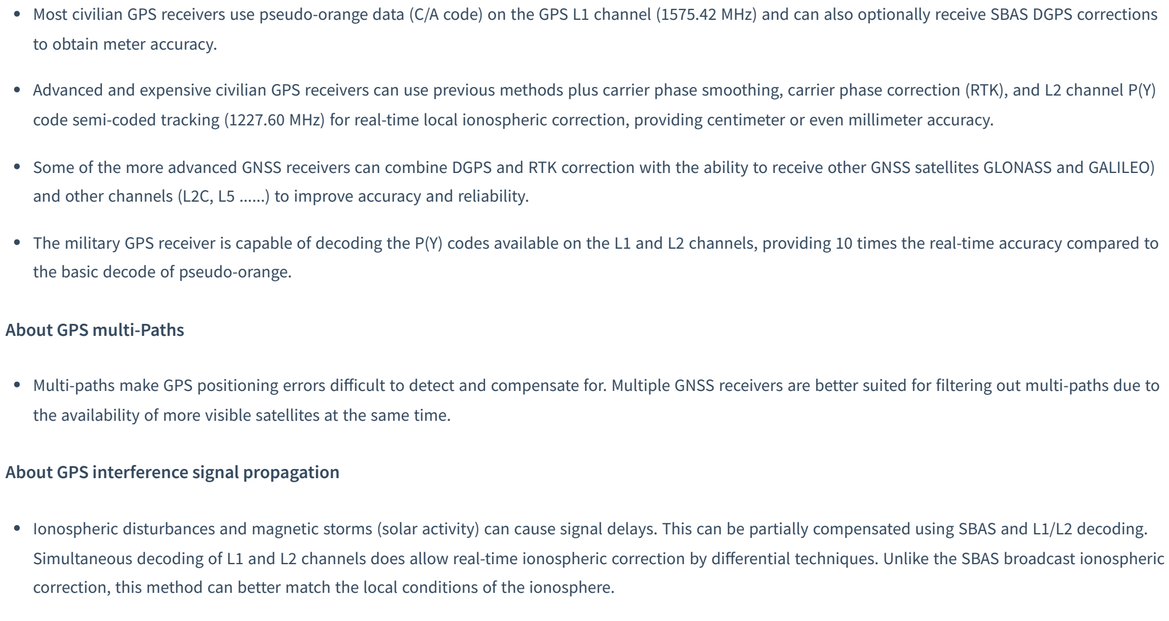
About GPS interference signal propagation

- Ionospheric disturbances and magnetic storms (solar activity) can cause signal delays. This can be partially compensated using SBAS and L1/L2 decoding. Simultaneous decoding of L1 and L2 channels does allow real-time ionospheric correction by differential techniques. Unlike the SBAS broadcast ionospheric correction, this method can better match the local conditions of the ionosphere.

2.8 Configure and check the digital transmission

- I prefer to use the RFD900 digital transmission, there are several advantages:

> 1.The transmission distance is relatively long, more than 40km is used in Xinjiang region.
> 2.The digital transmission ID can be modified directly through the ground station, and multiple aircraft can work simultaneously.
> 3.It is also convenient to modify the baud rate, transmit power, and transmission mode, without the need to connect other software separately.

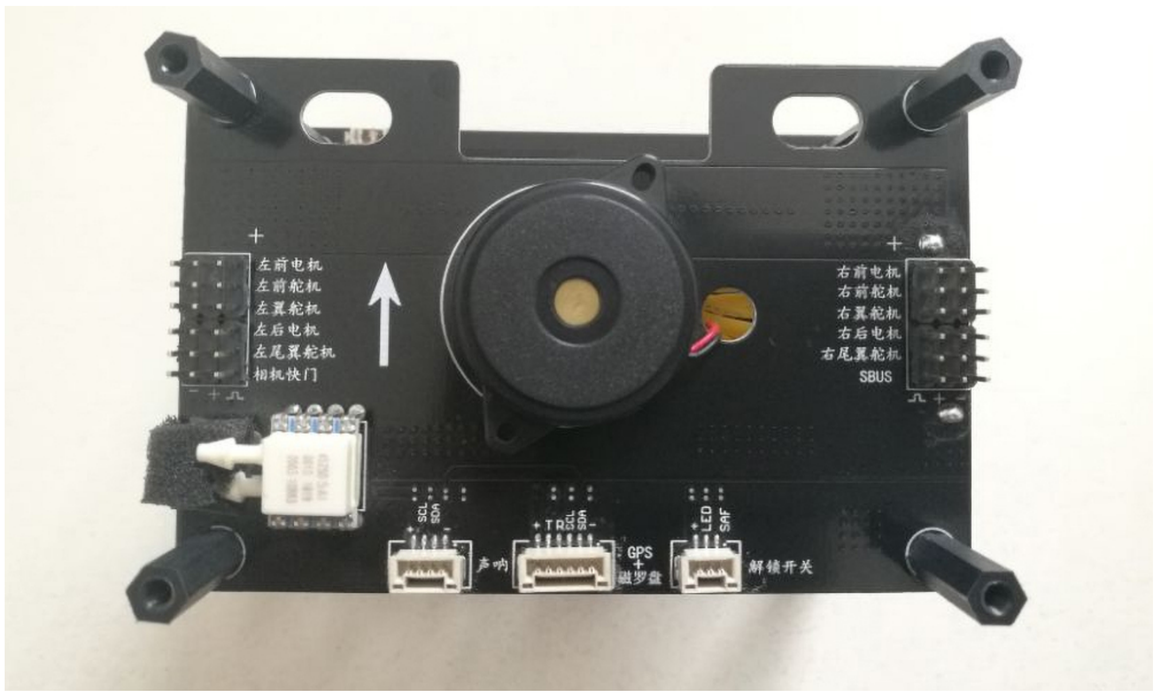


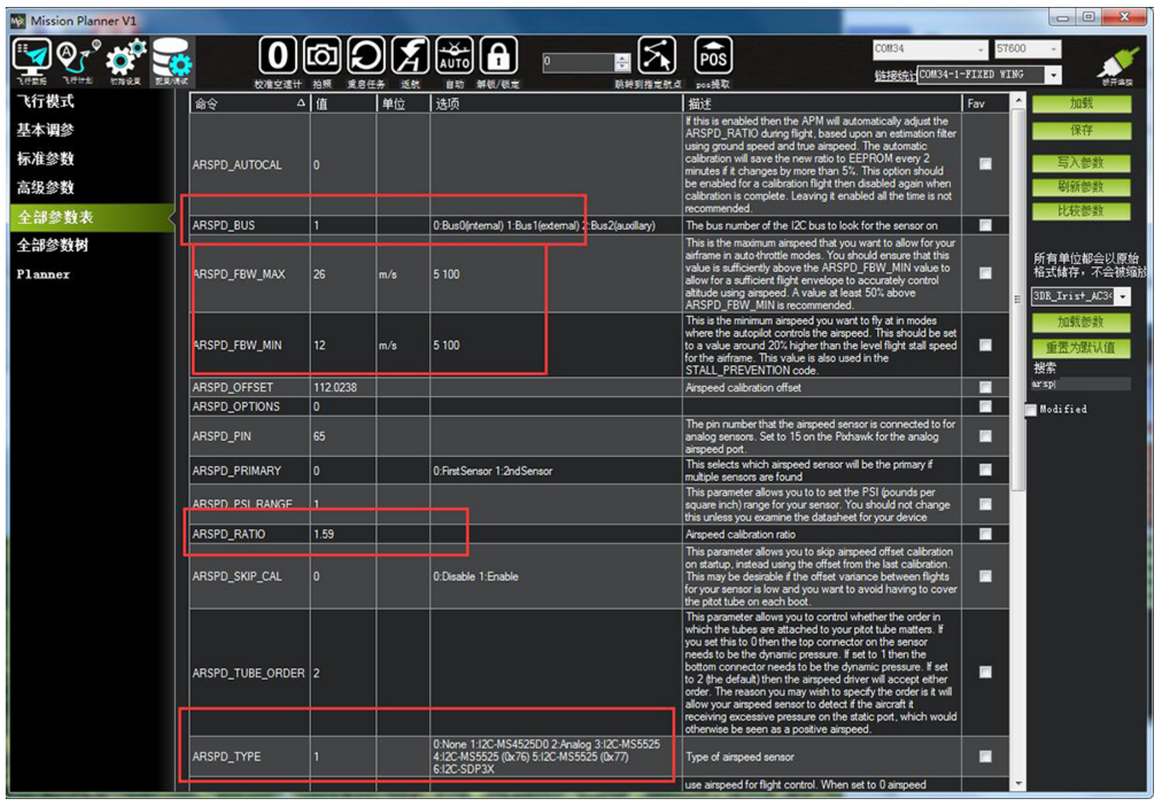
2.9 Configure and check the current-voltage module

- I use the Pixhawk V3 version, set the detection of voltage and current mode, the common power module on the market can only detect 60A, there may be over-range, I DIY a current meter can detect up to 99A, to meet the maximum current detection in the multi-rotor tilt state.
  Set the battery capacity, so that the battery estimates the percentage of power to be relatively accurate.

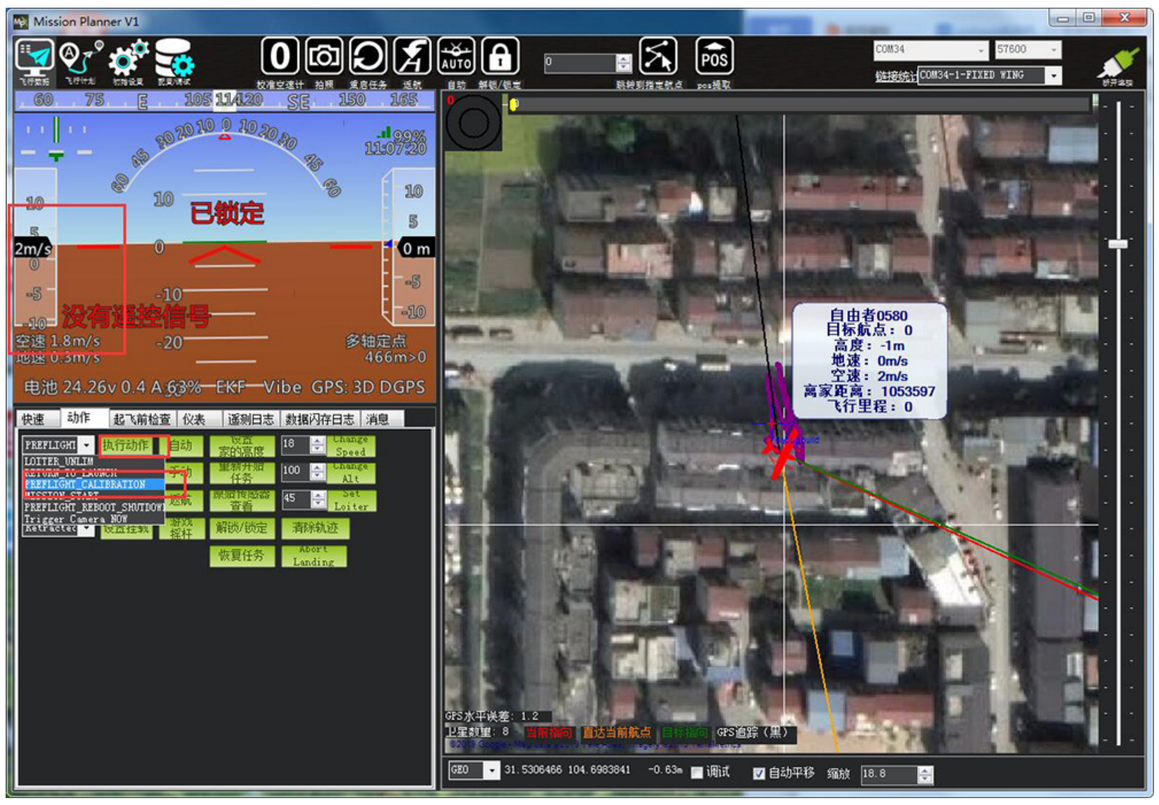
2.10 Configure and check the airspeed meter

- I use a 4525D0 airspeed meter with I²C interface and configured interface.When airspeed proportional correction, to observe the airspeed and ground speed difference is not large in the absence of wind. If the airspeed is larger than the ground speed, reduce the ratio, if the airspeed is smaller than the ground speed, increase the ratio. I used the airspeed extension tube, my ARSPD_RATIO = 1.59 is more appropriate, note that the above is the dynamic pressure tube.





- The calibration of airspeed is done in the main interface, and it is normal for the value of airspeed to fluctuate within 3.



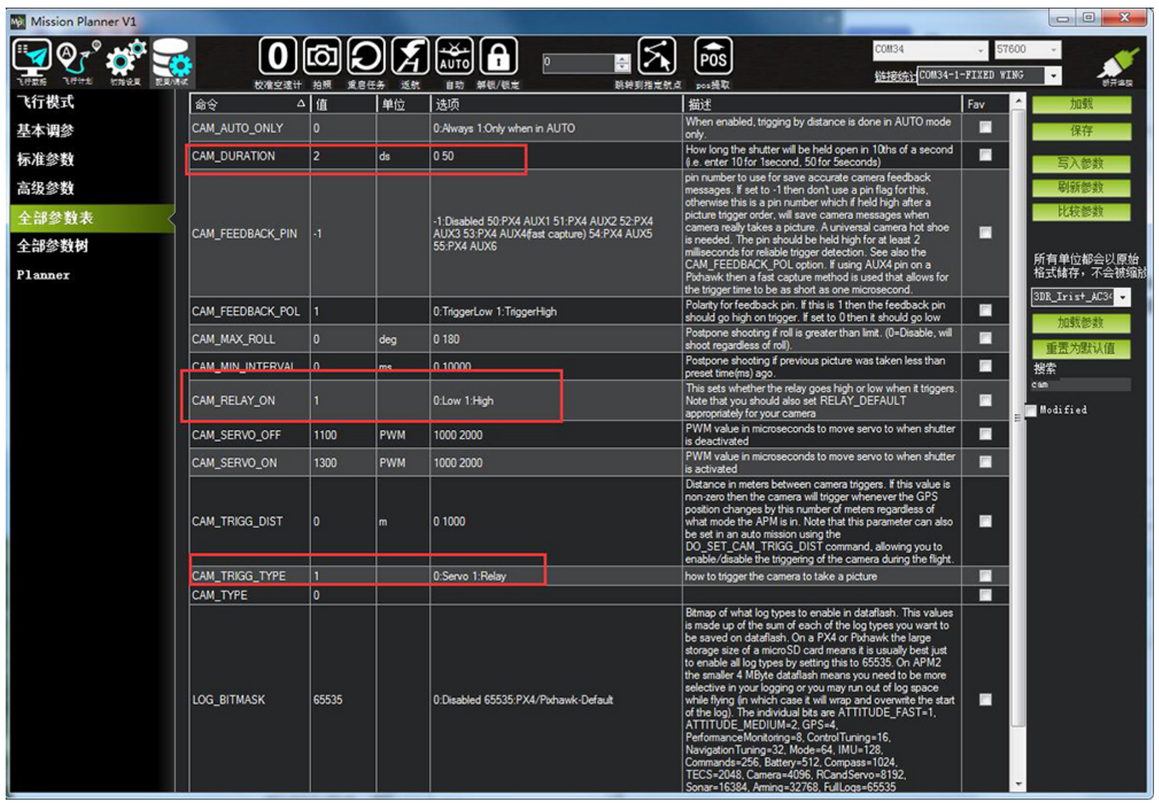
2.11 Configure and check the camera shutter

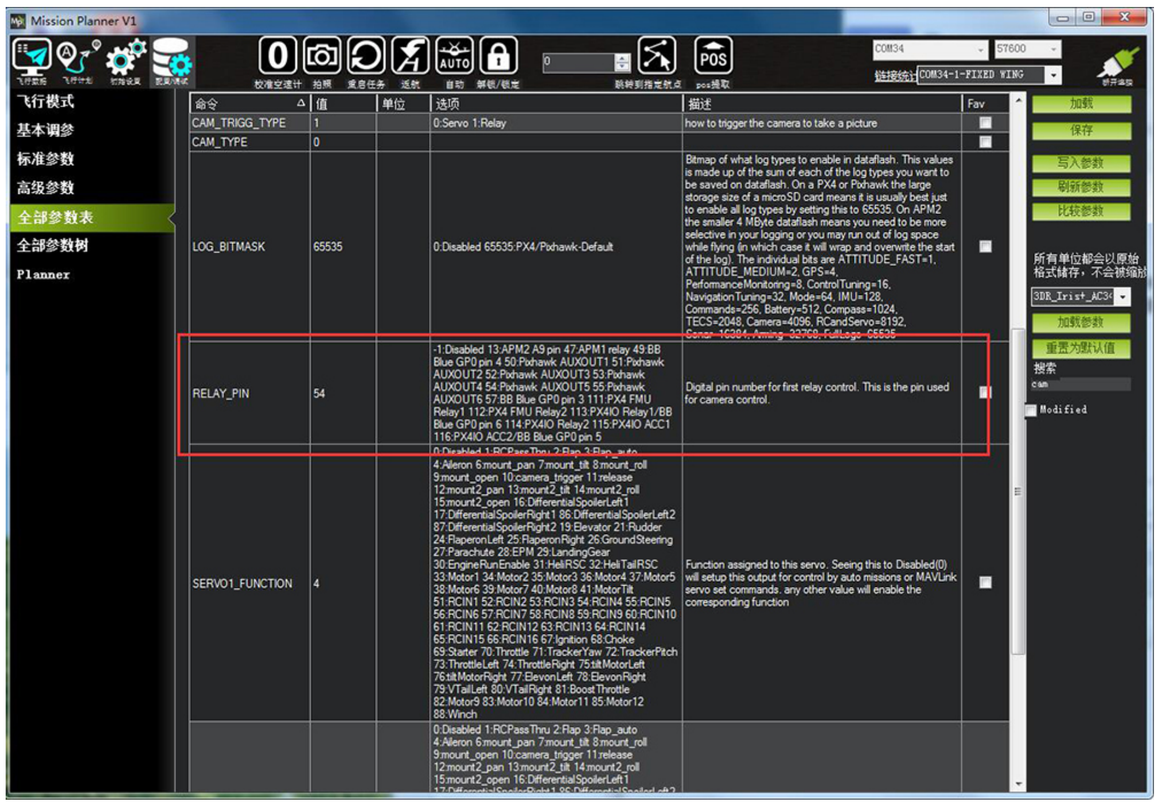
- The camera shutter uses a relay trigger mode, which requires careful configuration of the parameters of the flight control correctly.

> CAM_DURATION=2 represents a high level duration of 0.2S .
>
> CAM_RELAY_ON=1 The default is low and the trigger is high.

CAM_TRIGG_TYPE=1 The camera uses a relay trigger mode.

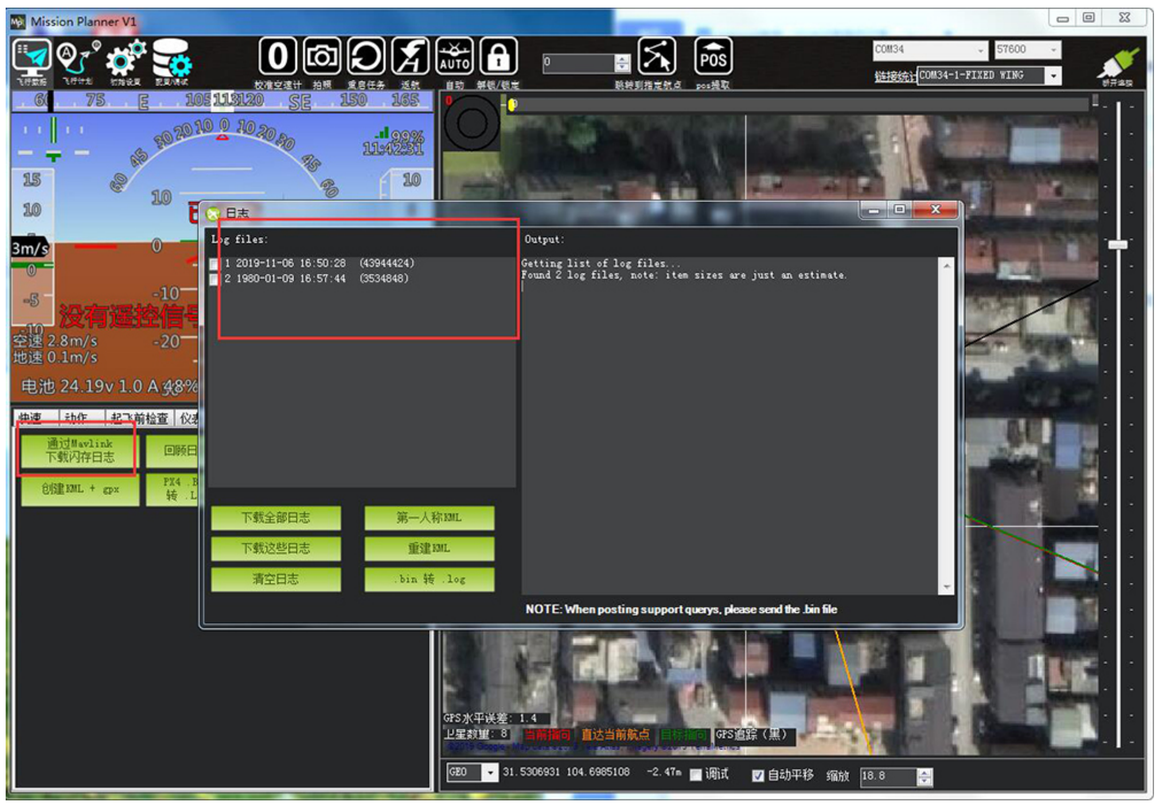
RELAY_PIN=54 AUX5 The channel is a relay channel.





2.12 Configure and check whether SD card records are normal

- The SD card of the flight control must be replaced with a high-speed card, be sure to check the card equipped with the flight control manufacturer, otherwise there will be BAD LOG or POS data recording is incomplete, resulting in logs somehow directly not recorded.
  MP support online download logs, but the number of slow transmission, I usually take the card directly.



♦ Power system installation and commissioning

3.1 Battery voltage check and charge/discharge

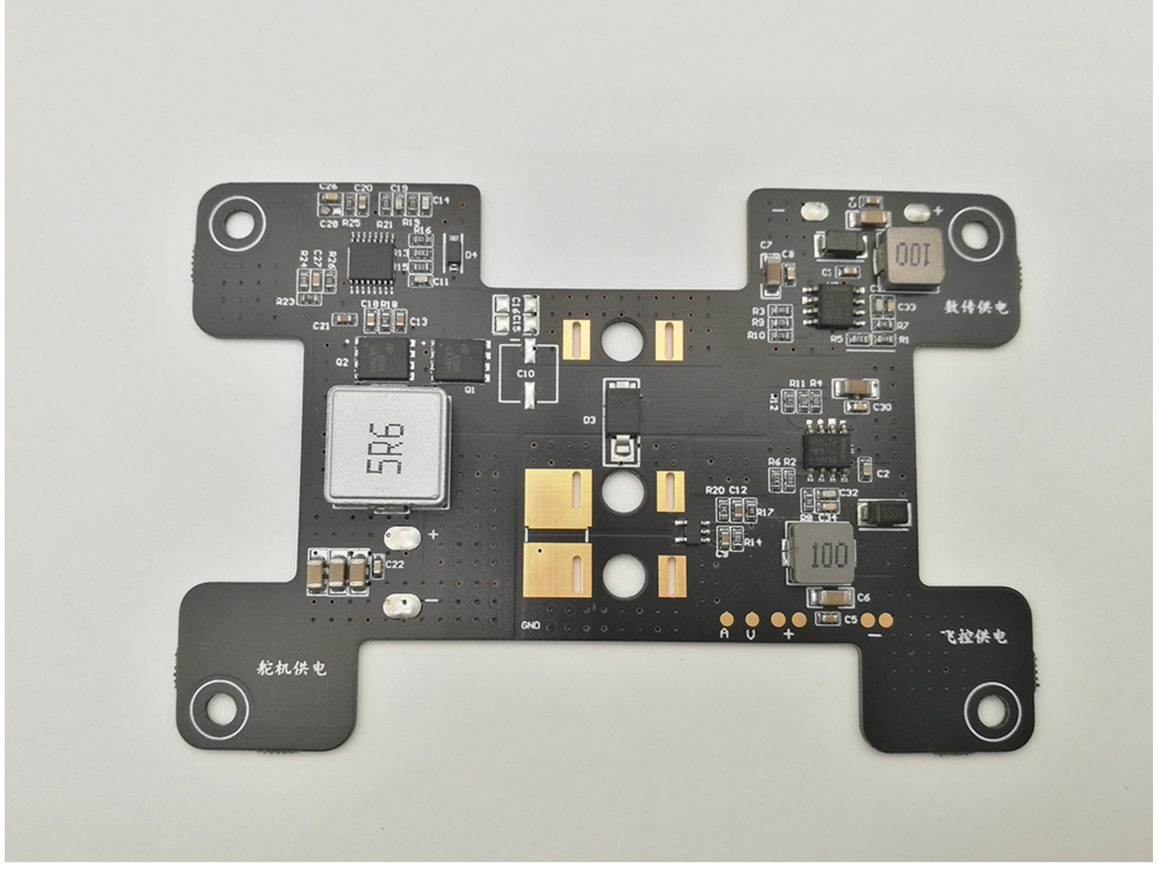
- When testing, pay attention to the battery do not over-discharge, the minimum voltage of 22.2V, fully charged 25.2V, long-term non-use, battery storage voltage of 23V or so, extend battery life.

3.2 Flight control power supply check

- Mainly check the flight control power supply module, the voltage is generally 5.3V, different versions of the flight control mixed, pay attention to the order of current and voltage detection pins, the order of VCC and GND.

3.3 Servo power supply check

- The main check is whether the voltage of the BEC supplying power to the servo is within 6V, more than 6V, the Silverbird ES3054 servo will burn. The curr-
- ent supply capacity of BEC shall be more than 10a， avoid multiple servos working at the same time, otherwise the power supply of servos is insufficient. Note that the power supply of the servo BEC can not be used as a digital transmission power supply, the ripple of the servo BEC is very large, will directly burn the digital transmission.



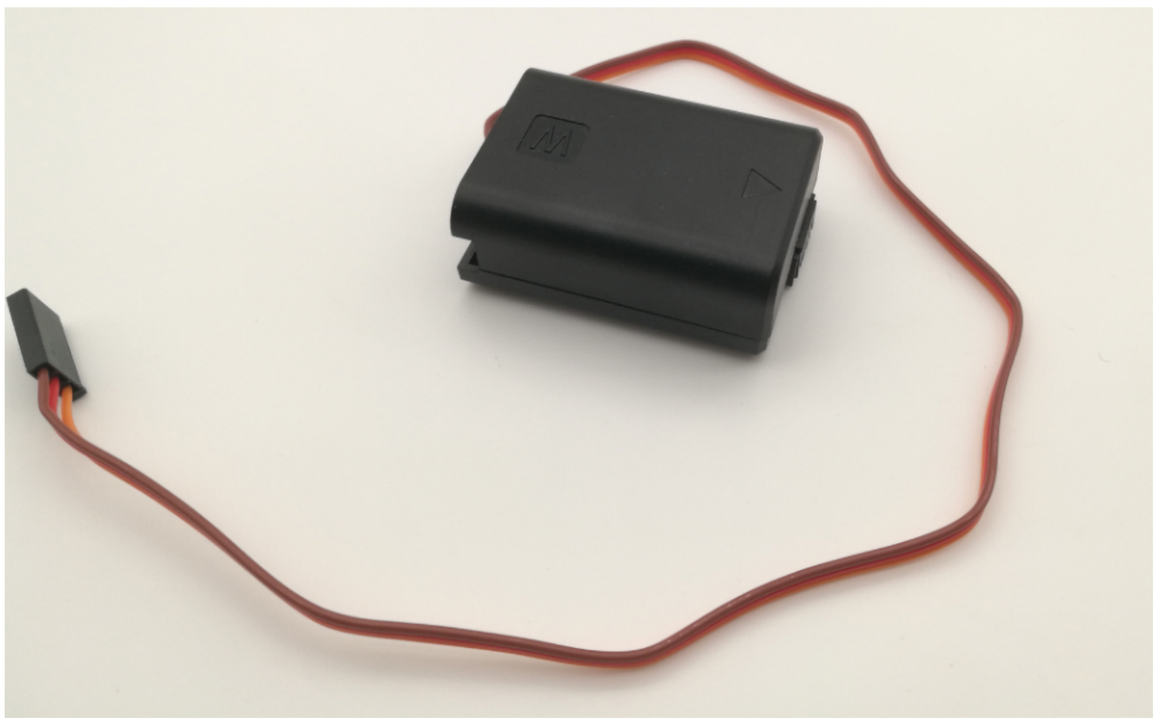
3.4 Digital transmission power supply check

- To improve the stability of the power supply, the digital transmission I powered separately for 2 main reasons:

> 1. Digital transmission directly in the flight control to take power, digital transmission transmit instantaneous power is relatively large, will lead to increased ripple and voltage fluctuations in the flight control power supply.
> 2. Many manufacturers produce the flight control power supply module for the flow capacity of the nominal 3A, some PCBA 3A can not reach, the test directly burned.

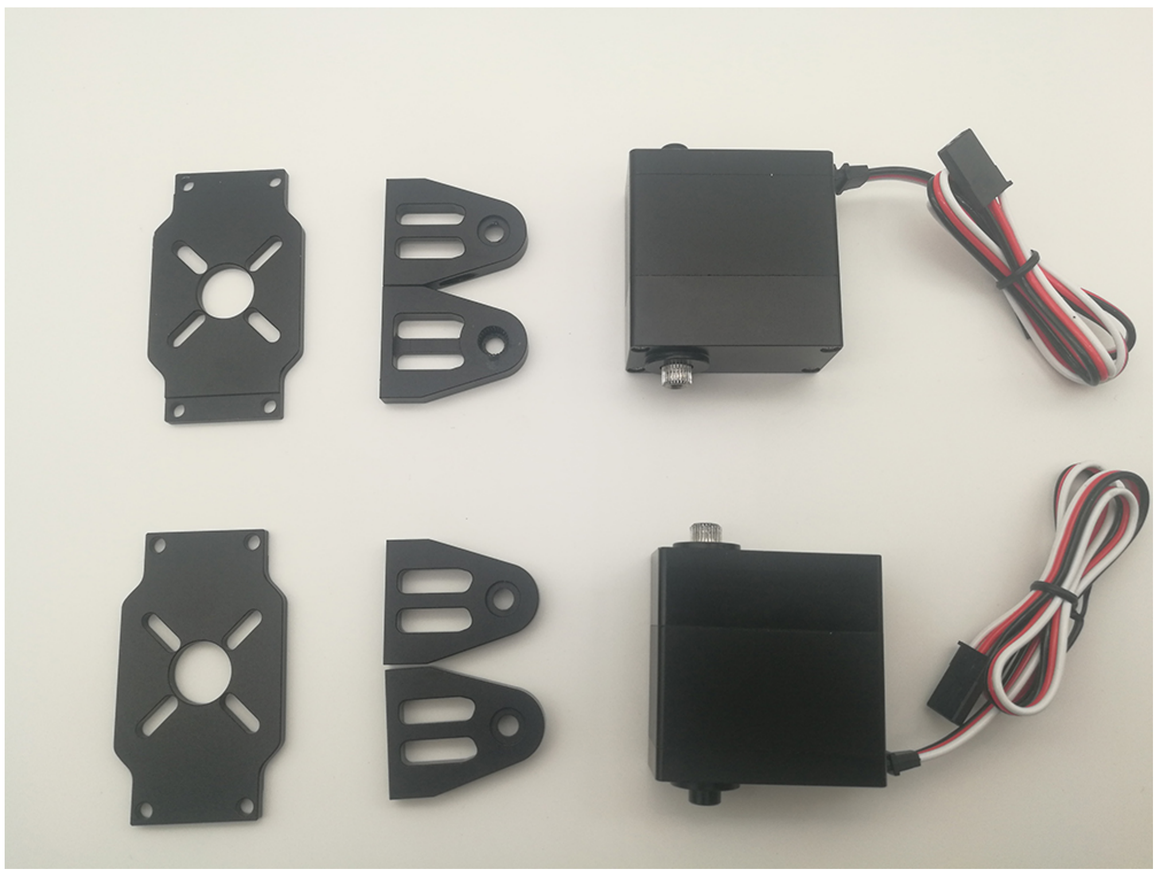
3.5 Camera potassium battery power check

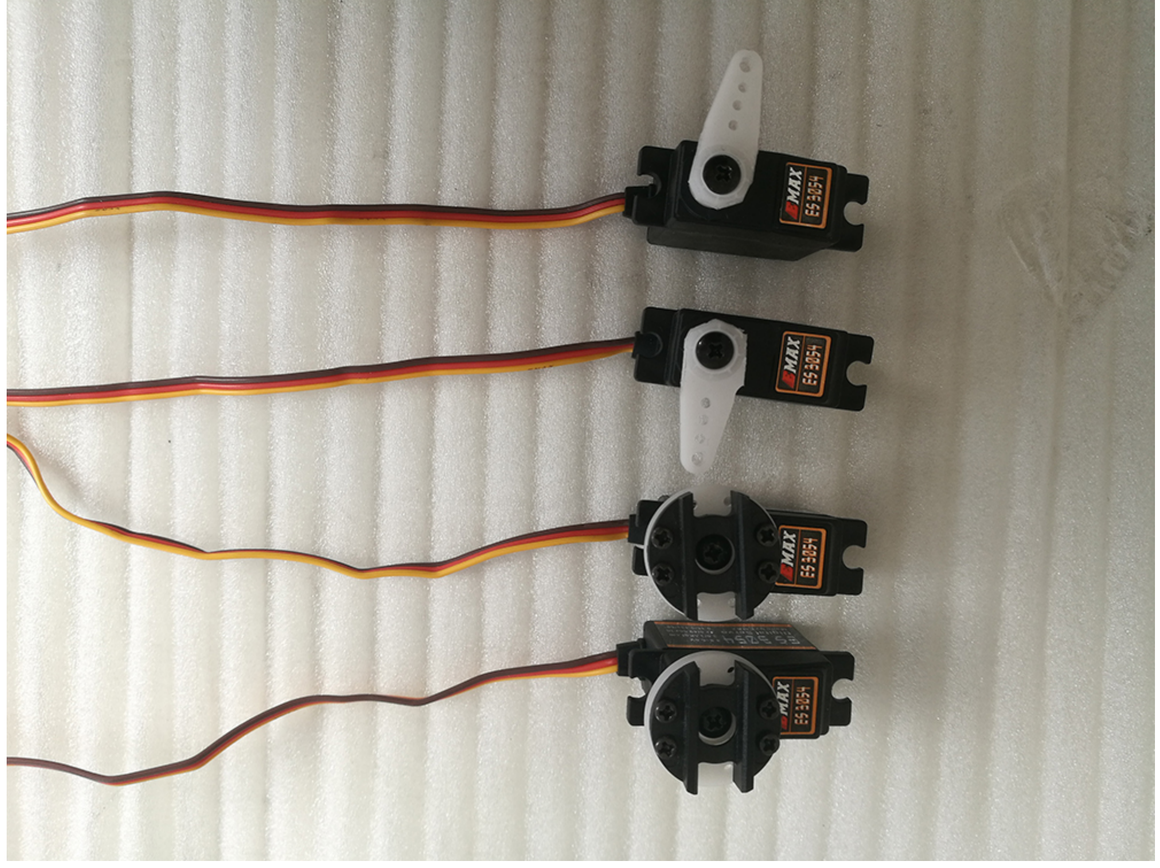
- Potassium batteries are checked before leaving the factory, mainly to exclude some small probability events, the potassium battery supply voltage is 12-26V, the output voltage of about 8V. Provide full range for the camera.



3.6 Installation and check of the servo

- The rudder is also checked to rule out small probability events. Servo power supply is generally 5-6V, using a servo tester, the servo can swing normally.

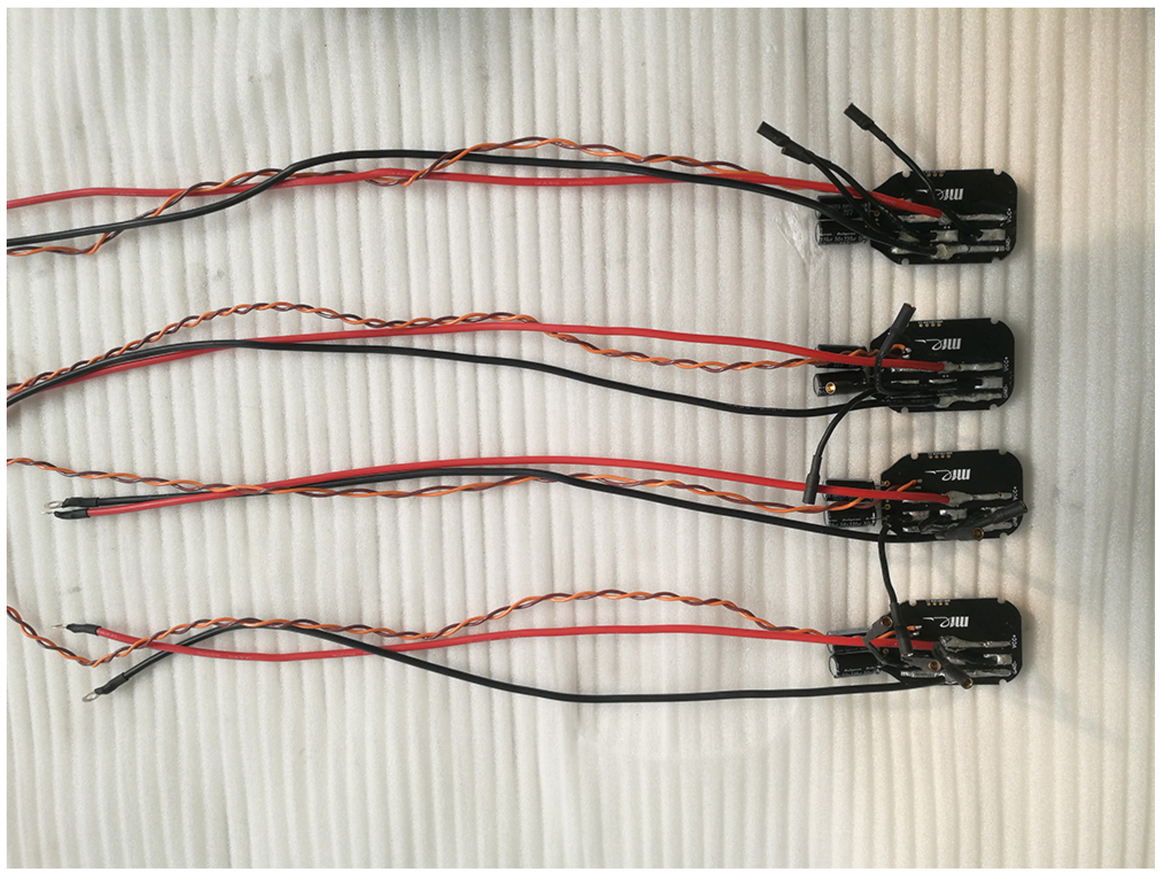




3.7 Installation and check of electric ESC

- The check of the motor ESC is also mainly to exclude small probable faults and check whether the motor and ESC can work properly.
- In order to facilitate the assembly, I DIY a few 60A ESC, they are perfectly matched with the motor mount(The official standard is HAOYING's 60A/40A ESC).
- ESC calibration：

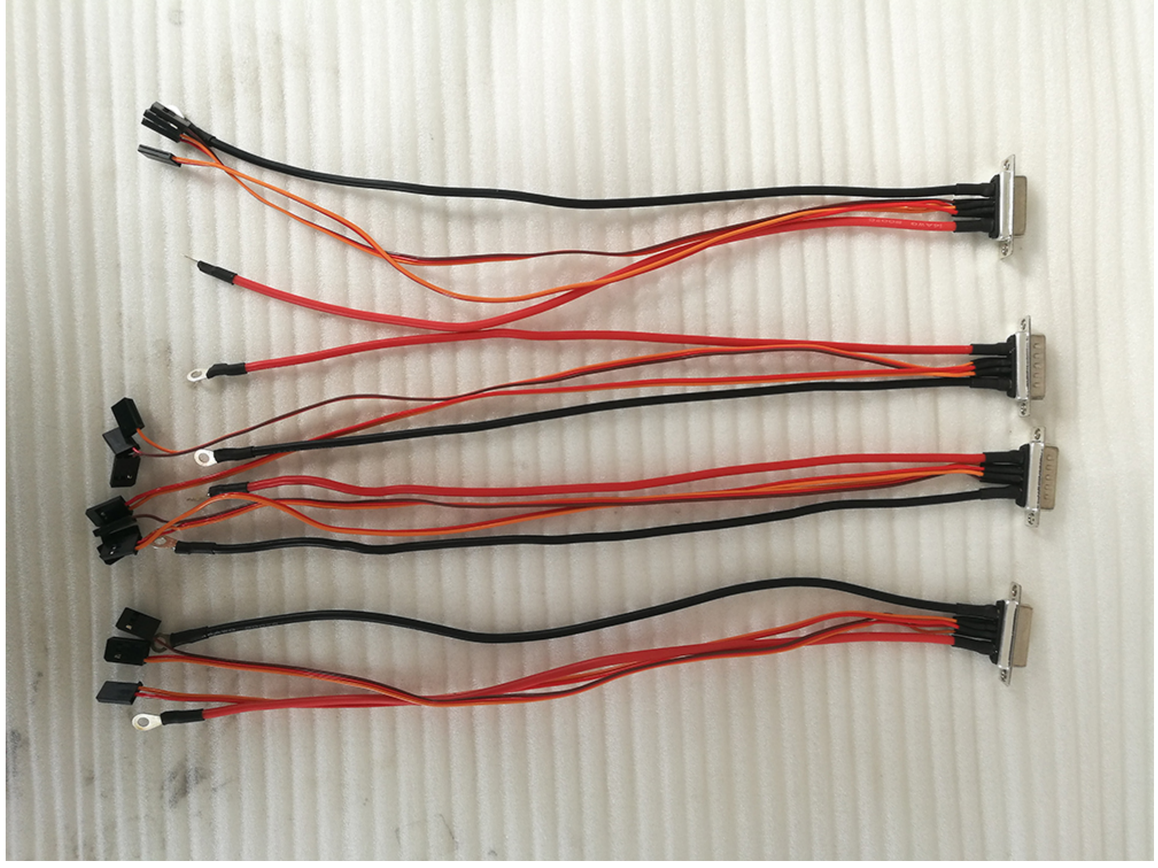
> 1. Only power up the flight control, do not power up the motor ESC. If your flight control and motor power supply can not be cut off independently, then you can use the USB wire to power the flight control.
> 2. When setting Q_ESC_CAL=1, flight mode switch to QSTABILIZE, unlock flight control, at this time the ESC PWM input is equal to the remote control throttle value, remote control throttle push to the maximum, then power up the ESC, etc. When the ESC ticks, indicating that the ESC recognizes the maximum throttle value, and the throttle is pulled to the minimum, you should hear a tick, indicating that the ESC recognizes the throttle travel.
> 3. The purpose of the parameter Q_ESC_CAL=1 is that it can be used to test the response of the motors. You can control all rotor motors directly by throttling. Also you can use the tachometer to test the speed of the motors at different throttle values.



3.8 Soldering of connector wire

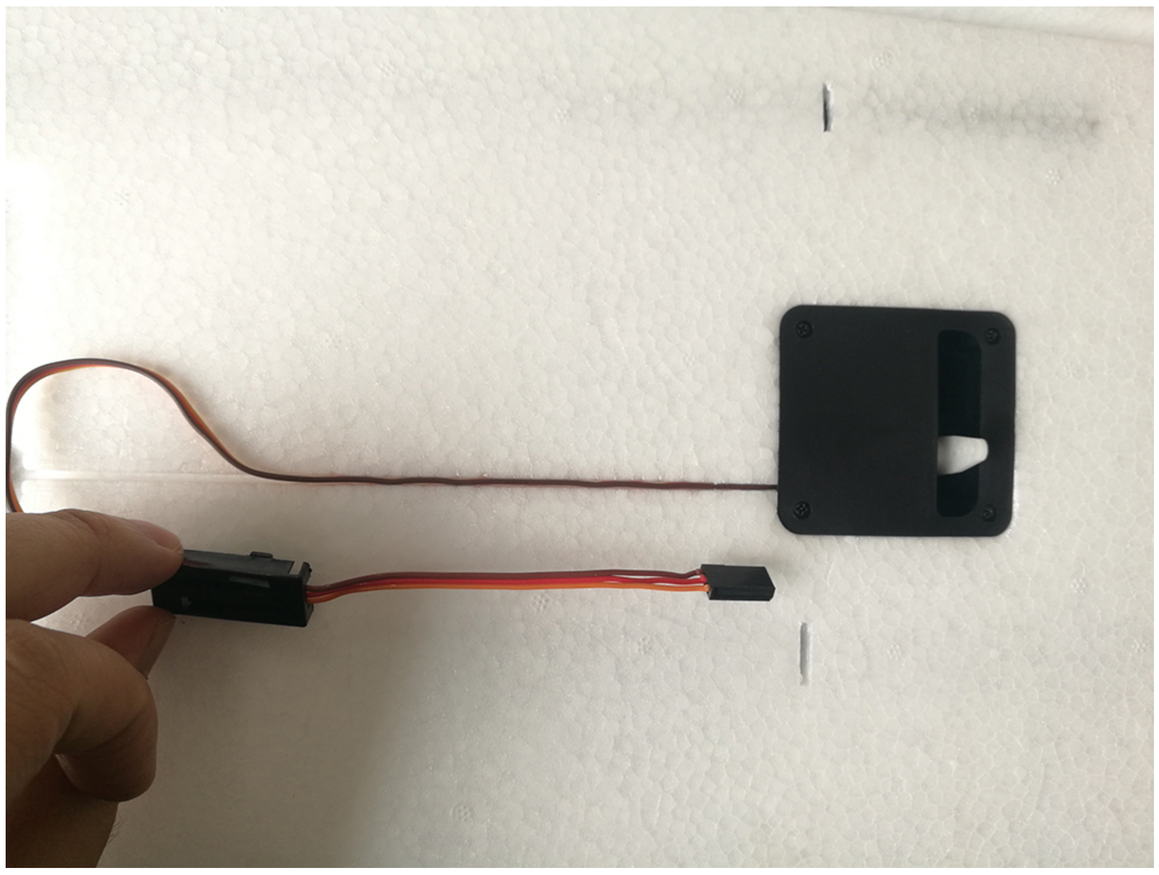
- For wiring convenience, I used a 14 size red and black silicone wire with 2.5-4 cold crimp terminal, screwed directly into place.
- My connector wiring sequence:

> A1-Power supply negative terminal
> A2-Power supply positive terminal
> 1—Aileron servo signal wire 60 core（**橙色**）
> 2—Servo power supply 60 core（**红色**）
> 3—Rear motor signal wire 30 cores（**棕色**）
> 4—Tilt servo signal wire 30 cores（**红色**）
> 5—Front motor signal wire 30 cores（**橙色**）

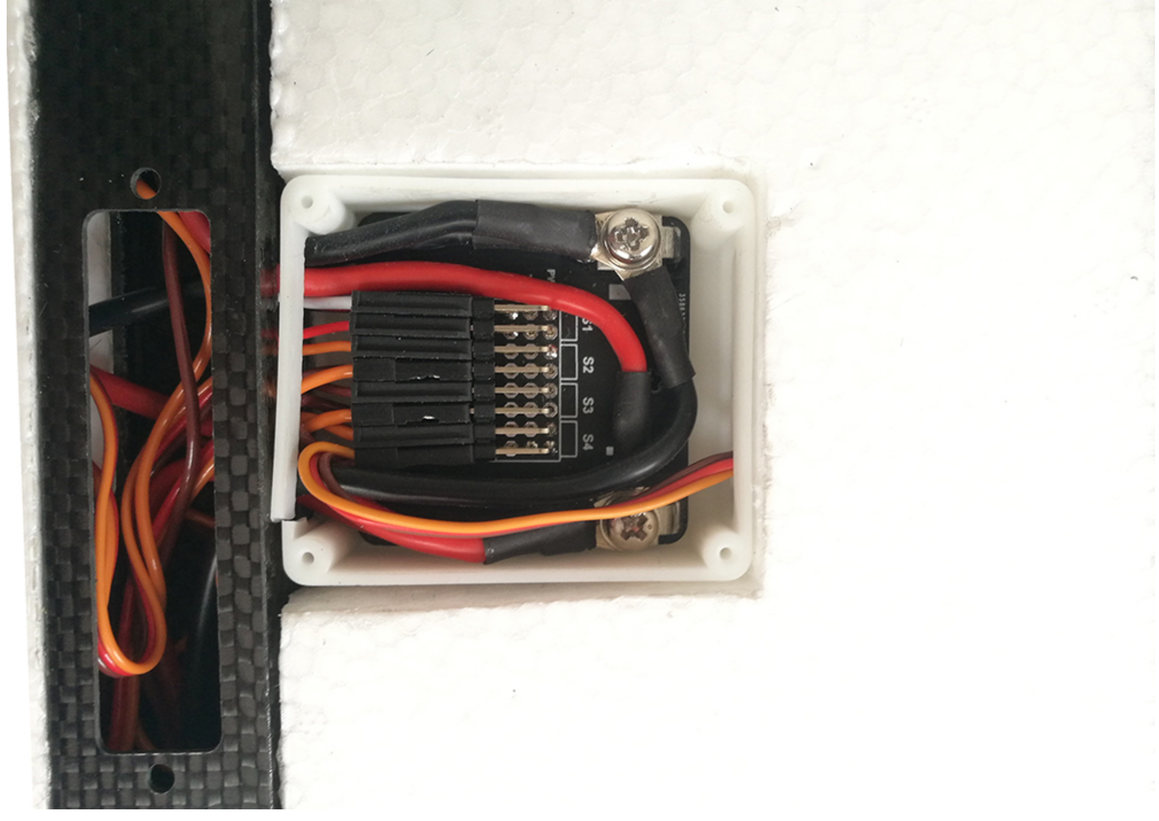


3.9 Installation of wing power section

- ES3054 servo original wire length is not enough, I put 10CM long Y wire minus 1 male part, as an extension cable, with a bayonet fixed.

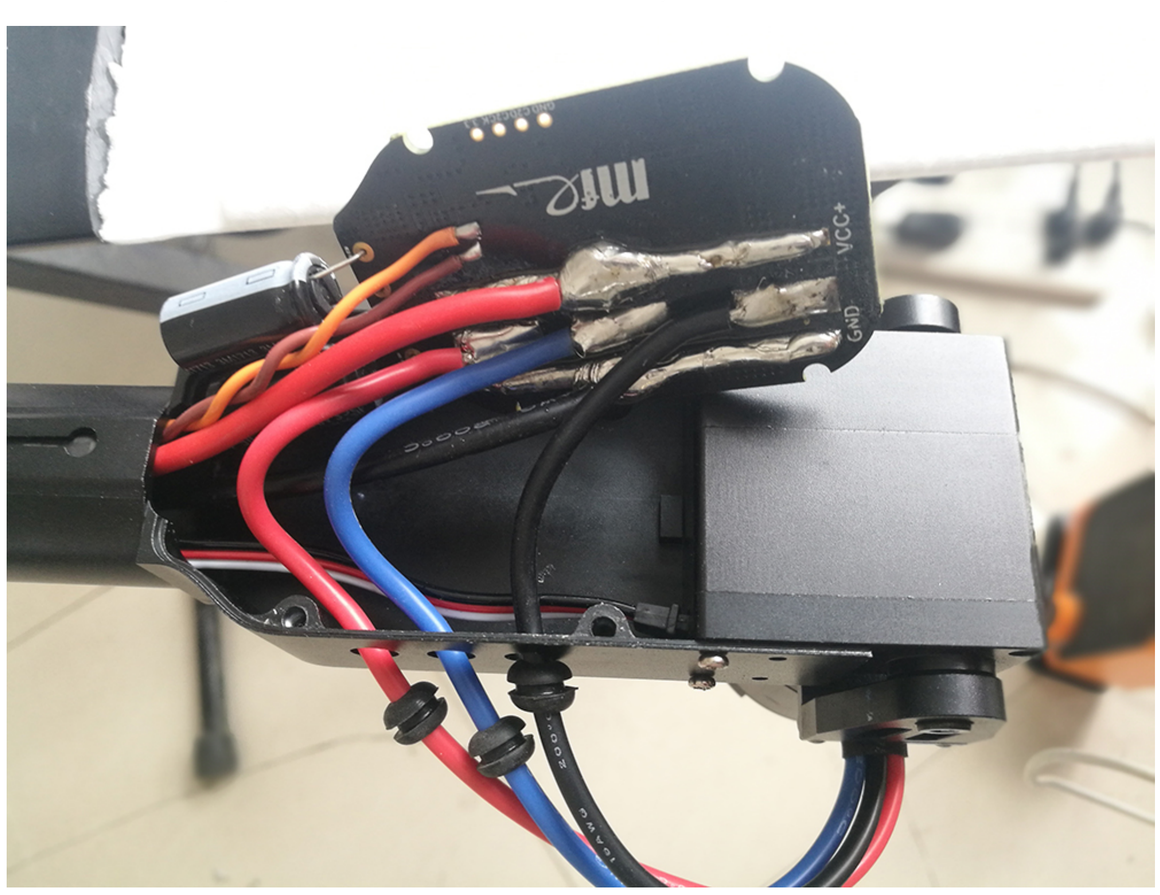


- The tail servo also needs to be fixed directly with 1 self-tapping screw.



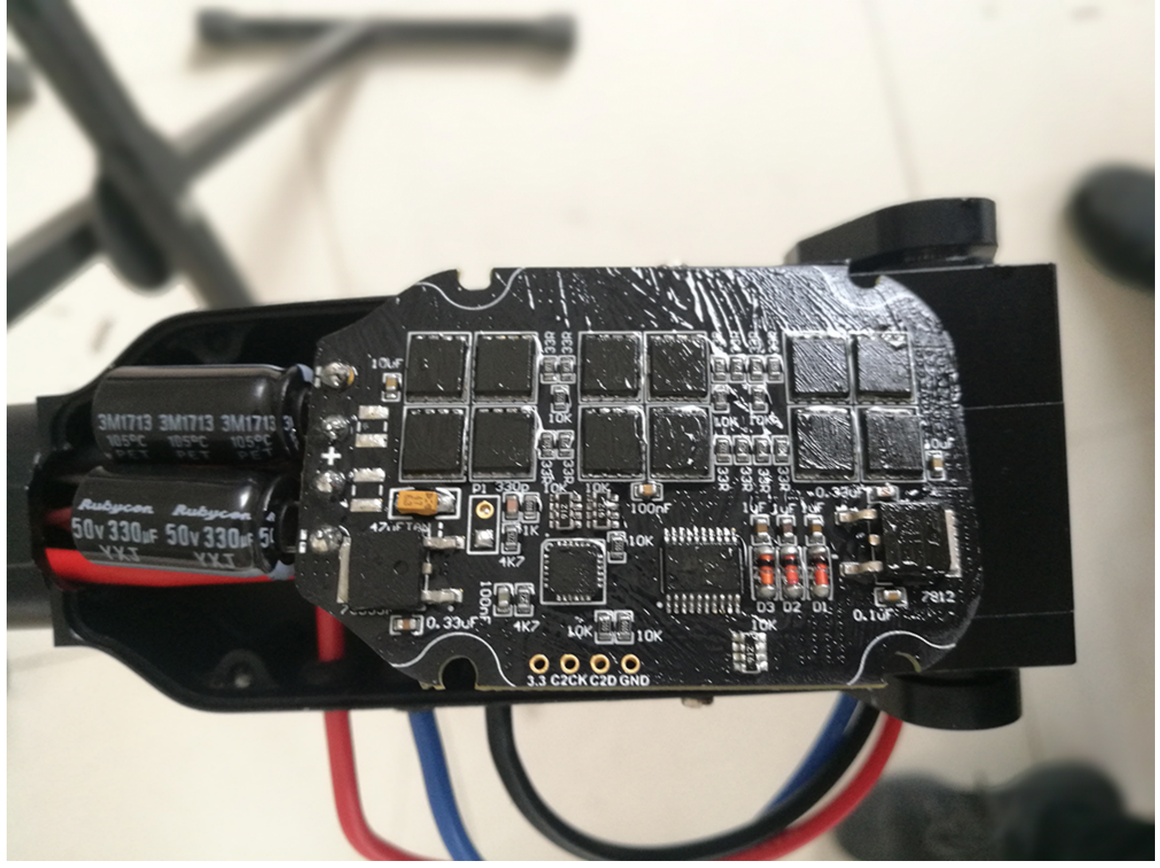
- Adapter plate S1 S2 S3 S4 were connected in parallel with the 2-way row of pins, the adapter plate is only the role of the adapter, in order to install the co-nvenience of the machine, it is the same effect as the direct soldering.

- The connector for the body is also installed, and I used a female connector for the body.

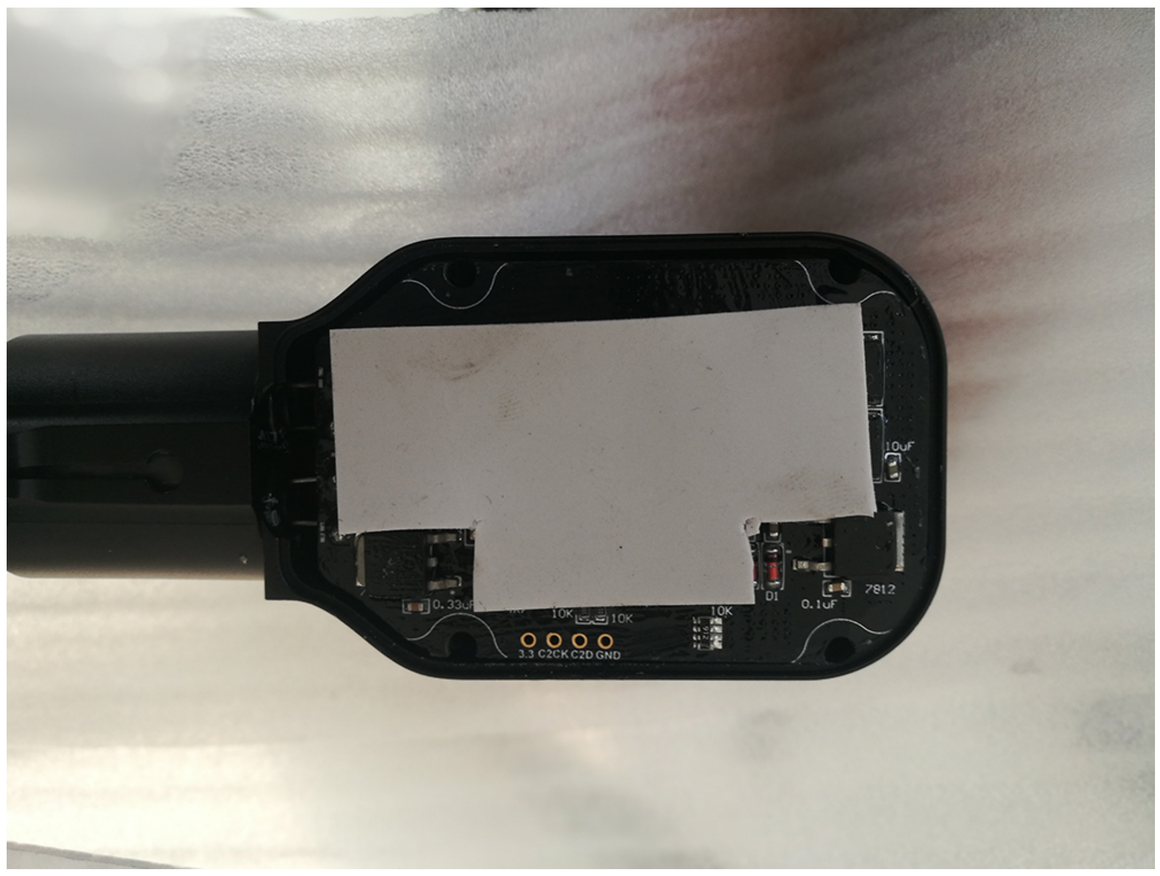


- When the ESC is installed, you need to check the forward and reverse rotation first, and remember to put on the silicone sheath.

> SERVO9_FUNCTION = 33
> SERVO10_FUNCTION = 34
> SERVO11_FUNCTION = 35
> SERVO12_FUNCTION = 36
> SERVO5_FUNCTION = 75
> SERVO6_FUNCTION = 76
>
> Channel AUX1(CH9)- Right front motor (counterclockwise rotation)
> Channel AUX2(CH10)-Left rear motor (counterclockwise rotation)
> Channel AUX3(CH11)-Left front motor (clockwise rotation)
> Channel AUX4(CH12)-Left rear motor (clockwise rotation)
> Channel CH5-Left-tilting servo
> Channel CH6-Right-tilting servo



- After the completion of the soldering, I gave the PCB a layer of three-proof paint, mainly insulation, dust-proof role.



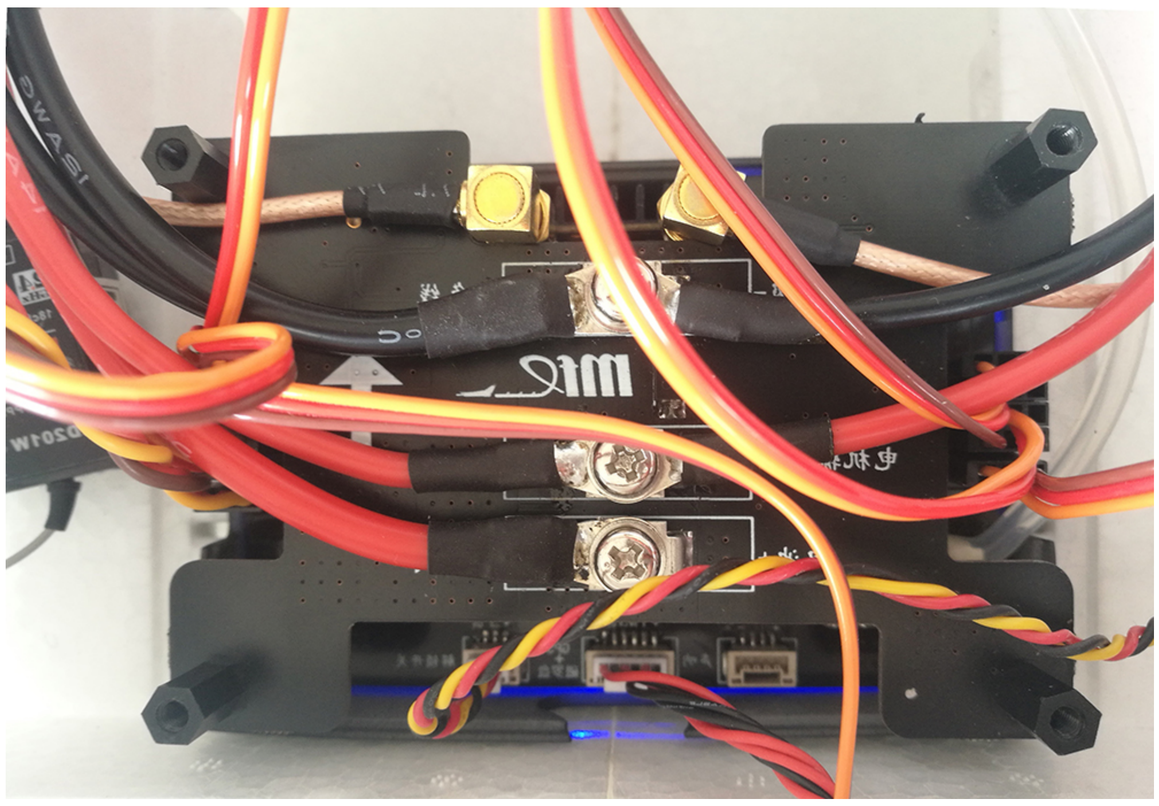
- I cut a piece of heat-conductive silicone paste, heat can be quickly transferred to the aluminum to accelerate heat dissipation.

- Adjust the length of the motor wire，ensure that the motor horizontal and vertical state wire length is appropriate.

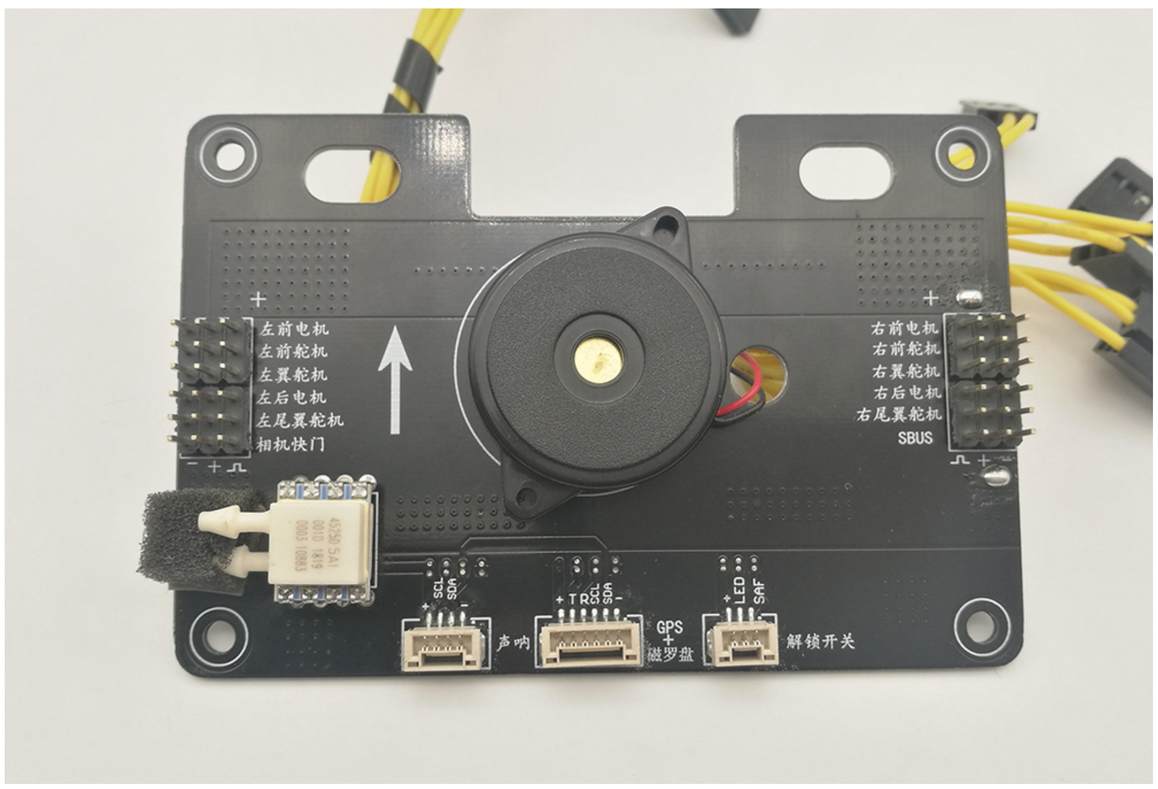
- Tilt servo, out of the wire end of each side of 2 screws can be unscrewed, and then fixed directly on top of the mount.

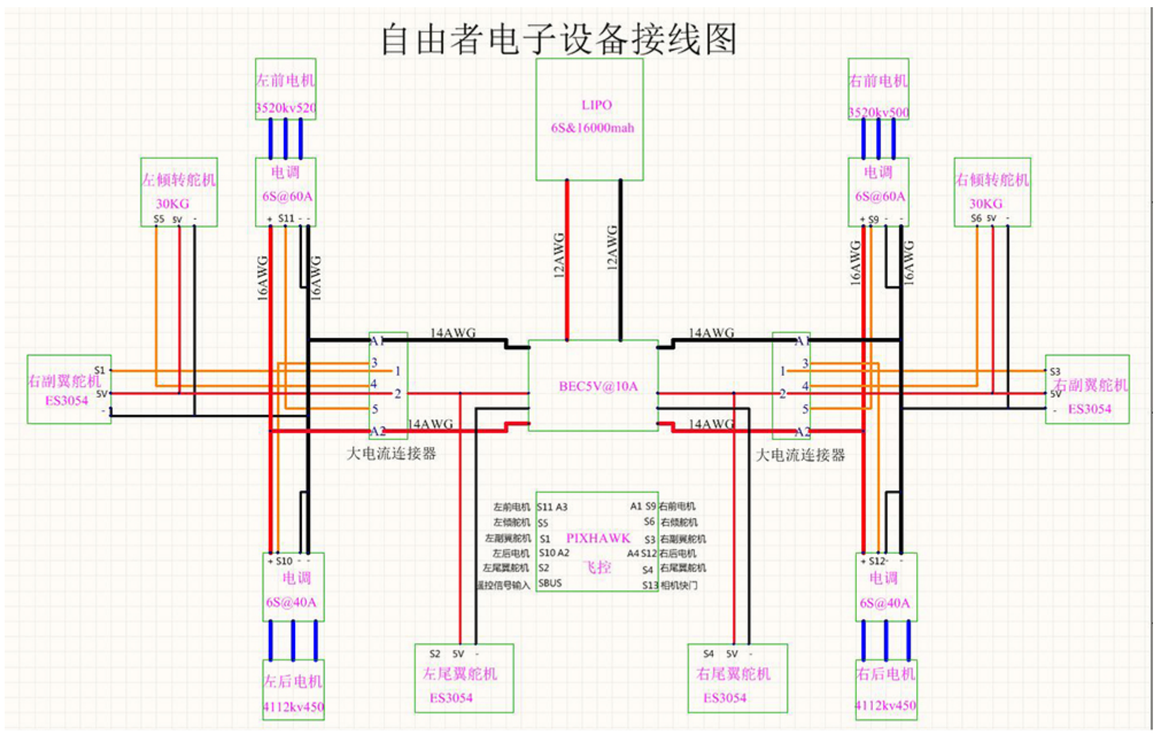
♦ Installation and commissioning of avionics equipment

4.1 Installation and commissioning of flight control



- The flight control box is fixed in the EPO flight control compartment with hot melt adhesive, and the wires are fixed directly according to the wiring sequence of the flight control.





4.2 Installation of GPS & magnetic compass

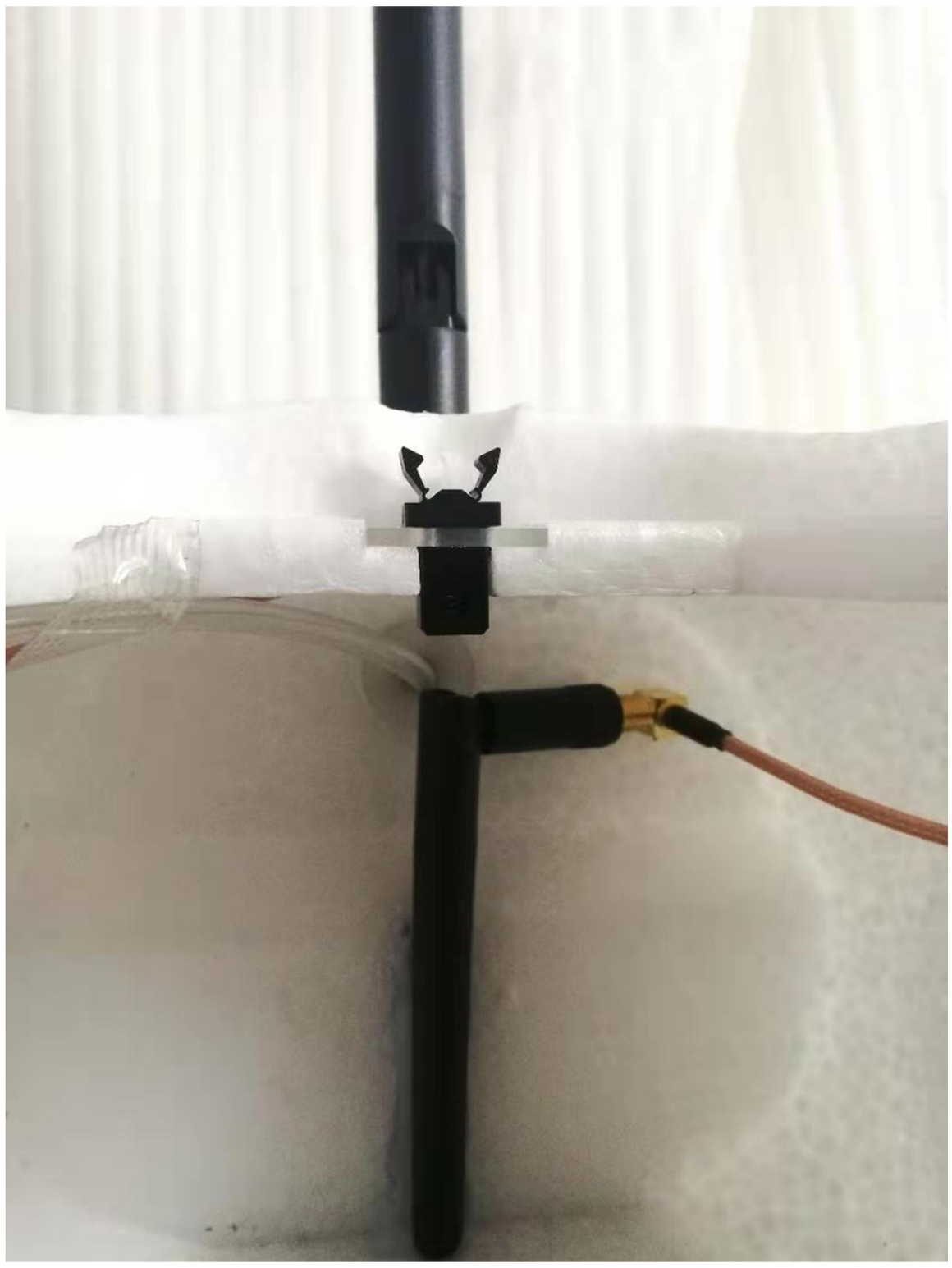
- The installation of the compass needs to pay attention to the installation direction, I use the default installation, as far away from the sub-power board as possible.

4.3 Airspeed tube installation and wiring

- The airspeed tube is installed in the head position, mainly to avoid the influence of airflow.

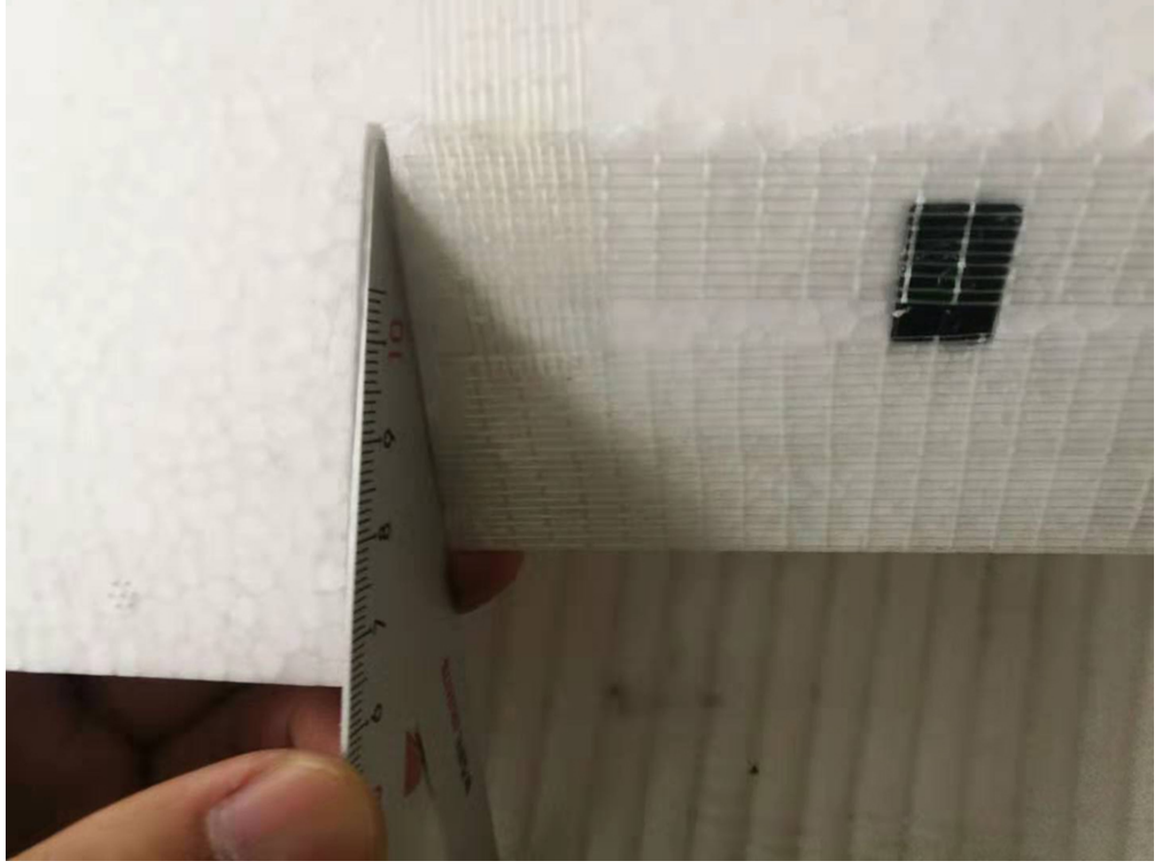
4.4 Installation of digital transmission antenna

- The two digital transmission antennas I use the vertical installation, mainly because the aerial survey aircraft generally fly higher and farther.



4.5 Adjust the flatness of the rudder surface

- In manual mode, the rudder surface should be flat, the rudder in the upper and lower rudder angle I generally control at 30 degrees, 30 degrees within the rudder surface efficiency is very high.



- The angle of the rudder control can be adjusted by adjusting the maximum and minimum output range of the corresponding channel.

4.6 FBWA check rudder direction

- First of all, check whether the direction of the remote control rudder surface is correct in manual mode.

Remote control input channel	Actions performed by the corresponding rudder surface
Roll channel toggle the rocker to the right	Downward movement of left aileron, upward movement of right aileron
Roll channel toggle the rocker to the left	Left aileron moves upward, right aileron moves downward
Pitch channel toggle down the rocker	Upward movement of the left tail fin, upward movement of the right tail fin
Pitch channel toggle the rocker upwards	Downward movement of the left tail fin, downward movement of the right tail fin
Directional channel toggle the rocker to the left	Downward movement of the left tail fin, upward movement of the right tail fin
Directional channel toggle the rocker to the right	Upward movement of the left tail fin, downward movement of the right tail fin

- Check again in FBWA mode if the rudder surface of the flight control correction is oriented correctly.

Aircraft tilt direction	Rudder action situation
Tilt to the right on a horizontal roll	Left aileron moves upward, right aileron moves downward
Tilt to the left on a horizontal roll	Downward movement of left aileron, upward movement of right aileron
Pitch upward tilt	Downward movement of the left tail fin, downward movement of the right tail fin
Pitch down tilt	Upward movement of the left tail fin, upward movement of the right tail fin
Direction horizontal movement to the left	Upward movement of the left tail fin, downward movement of the right tail fin
Direction horizontal movement to the right	Downward movement of the left tail fin, upward movement of the right tail fin

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♦ Pre-takeoff Checks

- The pre-takeoff check is performed outdoors to check for hidden problems before takeoff and to minimize the probability of failure in the air.

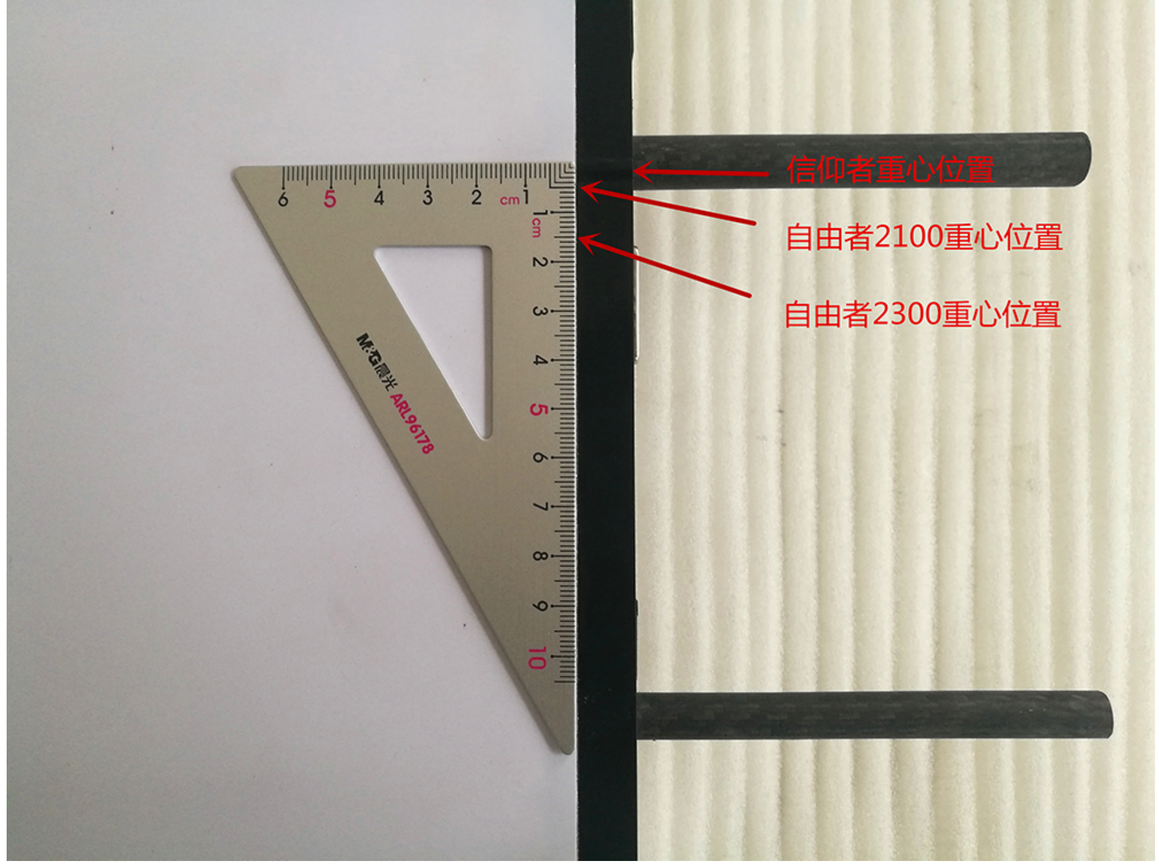
5.1 Check the magnetic compass

- When the flight control is powered on and started, do not move the aircraft, the flight control is self-testing until you hear the 1-2-3 sound, which means the flight control is started successfully. First point the nose to the north, check the actual direction and the aircraft nose direction error. The error is generally acceptable within 3 degrees, if there is a large deviation, you need to calibrate the compass again outdoors in accordance with the previous steps.
- The aircraft's compass has too much error at the time of multi-rotor, which will lead to unstable multi-rotor motor output and the aircraft nose flap.
- Too much error in the aircraft's compass when it is fixed wing will cause the aircraft to be on a straight course with the overall trajectory left or right.
- After calibrating the compass, simulating a large angle turn left and right and a large angle pitch on the ground, the compass part of the display EKF, which does not show red, does not show yellow, and always keeps the green part.

5.2 Check the center of gravity of the aircraft

- When checking the center of gravity, you need to break the front motor all to the horizontal position, and the center of gravity of the aircraft is based on the fixed wing. The center of gravity of the Freeman 2100 and 2300 is slightly different, please note the difference between:

> **Freeman 2100 center of gravity - located at the lower projection of the wing root plastic part shifted by 5mm in the direction of the tail**
>
> **Freeman 2300 center of gravity - located at the lower projection of the wing root plastic part moves 15mm in the direction of the tail.**



5.3 Check if the tilting servo is shaking

- Switch the aircraft to q_stable mode (multi-axis stabilization), you need 2 people to hold the aircraft wings down, press the flight control safety switch, unlock the motor, then push the throttle, the motor starts to rotate, the throttle is generally controlled between 40%-80%, observe whether the tilting rudder is swinging back and forth and other abnormal conditions.
- Possible causes if the tilting servo is jerking:

> **1.Troubleshoot digital transmission antenna interference to the tilt servo signal wire.**
> **2.The rocker screw of the tilting servo is screwed too tightly, resulting in a large load even when the servo is stationary, causing power fluctuations.**
> **3.Check the servo power supply BEC, in the case of high current discharge of the battery, resulting in relatively large fluctuations in BEC output.**
> **4.Switch the flight control to manual mode, under normal circumstances aileron and tail servo will not have a noise, if there is a noise, usually caused by the continuous force on the tilting steering gear when the front motor is horizontal.**

5.4 Check if tilting after reaching airspeed

- The main purpose is to check if the tilt function of the rudder is normal. Note that this needs to be done with the propeller removed.

> - The flight control is powered on, the remote control cut to q_stable mode, press the safety switch, unlock the motor, the motor starts to rotate, throttle to about 60%, switch to FBWA mode, you can see the tilt rudder starts to tilt to a fixed angle, the angle of tilt is controlled by Q_TILT_MAX, I set 35 degrees, is the angle of tilt and vertical, the rate of tilt is controlled by Q_TILT_ RATE_DN control, I set it to 10 degrees per second, tilt 35 degrees, it takes about 3.5S.
> - Then we blow air into the airspeed tube, you can see the airspeed increase, Q_ASSIST_SPEED I set is 14, when the airspeed reaches 14m/s, Q_TRANSITION_MS duration after 3S, the tilt rudder starts to turn to fixed wing mode.
> - When the airspeed is below 14m/s, the tilting rudder returns to the 35 degree multi-axis acceleration forward.
> - Q_ASSIST_ANGLE is the protection angle when the aircraft is switched to multi-rotor acceleration state, I set it to 45 degrees. When the aircraft is flying in FBWA, AUTO mode, and encounter high wind, the aircraft attitude tilt more than 45 degrees, the multi-axis protection will work.

5.5 Multi-rotor vectoring function

- Multi-rotor vectoring is mainly to improve the wind resistance of the aircraft in multi-rotor mode, and the front two motors can be vectored up and down.
- After the flight control is powered on, switch to q_stable mode, press the flight control safety switch, be careful not to unlock, push the throttle to about 30%, the motor does not turn. Hit the rudder of the remote control, we can see that the front and rear two servos are still differential.
- Q_TILT_YAW_ANGLE parameter controls the angle of the rudder vector, I set it to 10 degrees, the angle should not be too big, otherwise the paddle will easily cut to the carbon tube.

5.6 Fixed wing vectoring function

- The fixed wing vectoring function I usually turn off, mainly 2 parameter system: Q_TILT_FIX_ANGLE control angle, Q_TILT_FIX_GAIN control sense, can be simply understood as the control of tilt fast and slow. Vector can assist fixed-wing rudder surface correction, rudder failure still has some control ability.
- Test method： Temporarily set the following 2 parameters

> **Q_TILT_FIX_ANGLE=10(Fixed wing vector angle,0=off,10=10 degrees)**
> **Q_TILT_FIX_GAIN=100(Fixed wing vector sense,0=off,100=100%)**

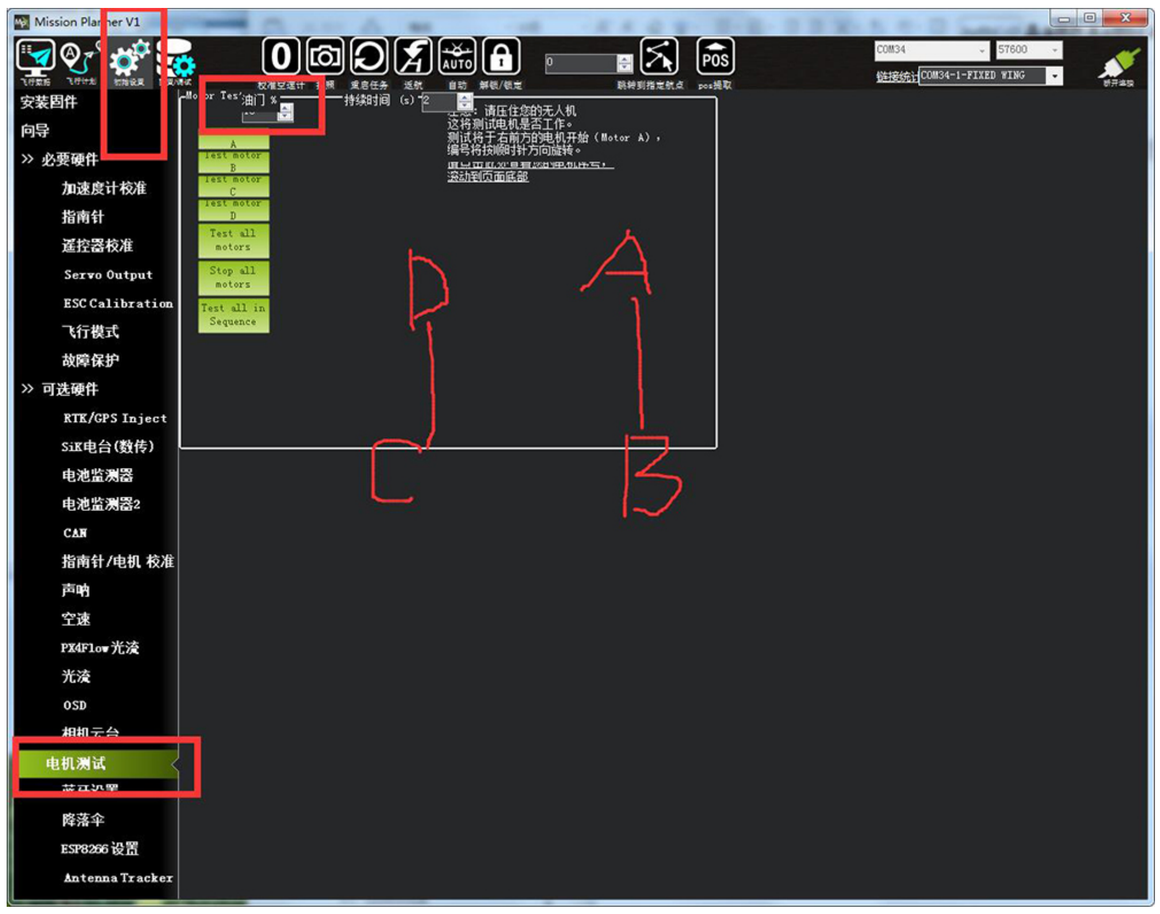
- Switch to manual mode, push the throttle (do not unlock), hit the elevator to try the angle (will be the same as above and below), hit the aileron to try the angle (will be a front and a back)
- Switch to FBWA mode, push the throttle (do not unlock), tilt the fuselage forward, then the rudder angle up, tilt the fuselage to the right, then the rudder angle up.

♦ Low altitude multi-rotor test

The low-altitude multi-rotor test focuses on testing the stability of the multi-axis portion of the aircraft.

6.1 Motor steering test

- If the motor steering is wrong, the multi-rotor will not fly and the plane will roll on the ground. Be sure to check the motor steering and the direction of the paddles before taking off.
- Motor test input throttle 10%-15%, test motor ABCD, motor start in the order of right front A - right rear B - left rear C - left front D.
- If the motor rotates in the wrong direction, you need to manually swap any 2 motor wires.
- Set motor start idle speed parameters:
  Q_M_SPIN_ARM=0.1



6.2 Roll PID commissioning

The roll is controlled by a 2-stage series type PID.

- The parameters of the outer ring are generally adjusted first:

> Q_A_ANG_RLL_P=8 indicates the error gain between the actual roll angle and the desired angle, and the phenomenon is that the larger the value, the stronger the aircraft correction.

- If the aircraft is not easy to adjust the stability, you need to adjust the inner ring parameters:

> Q_A_RAT_RLL_D=0.006 indicates differentiation.The cross-roller axis starts high-frequency small-amplitude oscillation, that is, this value is on the large side, debugging the parameters of the 0 more, pay attention not to enter the wrong.
> Q_A_RAT_RLL_I=0.3 indicates integration. This value generally does not exceed the corresponding P value. For example, multi-axis state I hit the roll 15 degrees (the angle limit at 15 degrees Q_ANGLE_MAX=1500 after hit the rocker), but the aircraft has been stable at 14 degrees will not go up, in this case, you need to increase the I value.
> Q_A_RAT_RLL_P=0.3 indicates the ratio. The higher the value, the stronger the motor output, and the larger the value, **the greater the low frequency oscillation** of the aircraft.

- As far as the frame allows, the same aircraft can be tuned with multiple sets of parameters from large to small sensitivities.

6.3俯仰PID调试

Pitch is controlled by a 2-stage series-type PID.

- The parameters of the outer ring are generally adjusted first:

> Q_A_ANG_PIT_P=6 indicates the error gain between the actual pitch angle and the desired angle, and the phenomenon is that the larger the value, the stronger the aircraft correction.

- If the aircraft is not easy to adjust the stability, you need to adjust the inner ring parameters：

> Q_A_RAT_PIT_D=0.006 means differentiation. The pitch axis starts **high-frequency small-amplitude oscillation** , that is, this value is on the large side, the debugging parameters of the 0 more, pay attention not to enter the wrong.
> Q_A_RAT_PIT_I=0.3 indicates integration. This value generally does not exceed the corresponding P value. For example, multi-axis state I play pitch 15 degrees (after hitting the rocker, the angle is limited to 15 degrees Q_ANGLE_MAX=1500), but the aircraft has been stabilized at 14 degrees will not go up, in this case you need to increase the I value to eliminate the stability error.
> Q_A_RAT_PIT_P=0.3 indicates the ratio. The larger the value, the stronger the motor output. If the value is too large, the aircraft will have **large oscillations at low frequencies** , and if the value is too small, the aircraft will be soft and have poor wind resistance.

- As far as the frame allows, the same aircraft can be tuned with multiple sets of parameters from large to small sensitivities.

6.4 Directional PID commissioning

The pitch is controlled by a 2-stage series-type PID.

- The parameters of the outer ring are generally adjusted first:

> Q_A_ANG_YAW_P=5 indicates the error gain between the actual direction angle and the desired direction angle, and the phenomenon is that the larger the value is, the stronger the aircraft correction is.

- If the aircraft is not easy to adjust the stability, you need to adjust the inner ring parameters:

> Q_A_RAT_YAW_D=0.001 means differentiation. The direction axis starts **high-frequency small-amplitude oscillation** , that is, this value is on the large side, debugging parameters of the 0 more, pay attention not to enter the wrong.
> Q_A_RAT_YAW_I=0.16 indicates integration. This value usually does not exceed the P value. For example, if I hit the direction 5 degrees in the multi-axis state, I release the stick, but the aircraft direction will go back to 4 degrees, and you can see this obvious change in the air. In this case it is necessary to increase the I value to eliminate the stability error.
> Q_A_RAT_YAW_P=0.16 indicates the ratio. The larger the value, the stronger the motor output. If the value is too large, the plane will **oscillate at low frequencies** , and if the value is too small, the plane will not steer much.

- As far as the frame allows, the same aircraft can be tuned with multiple sets of parameters from large to small sensitivities.

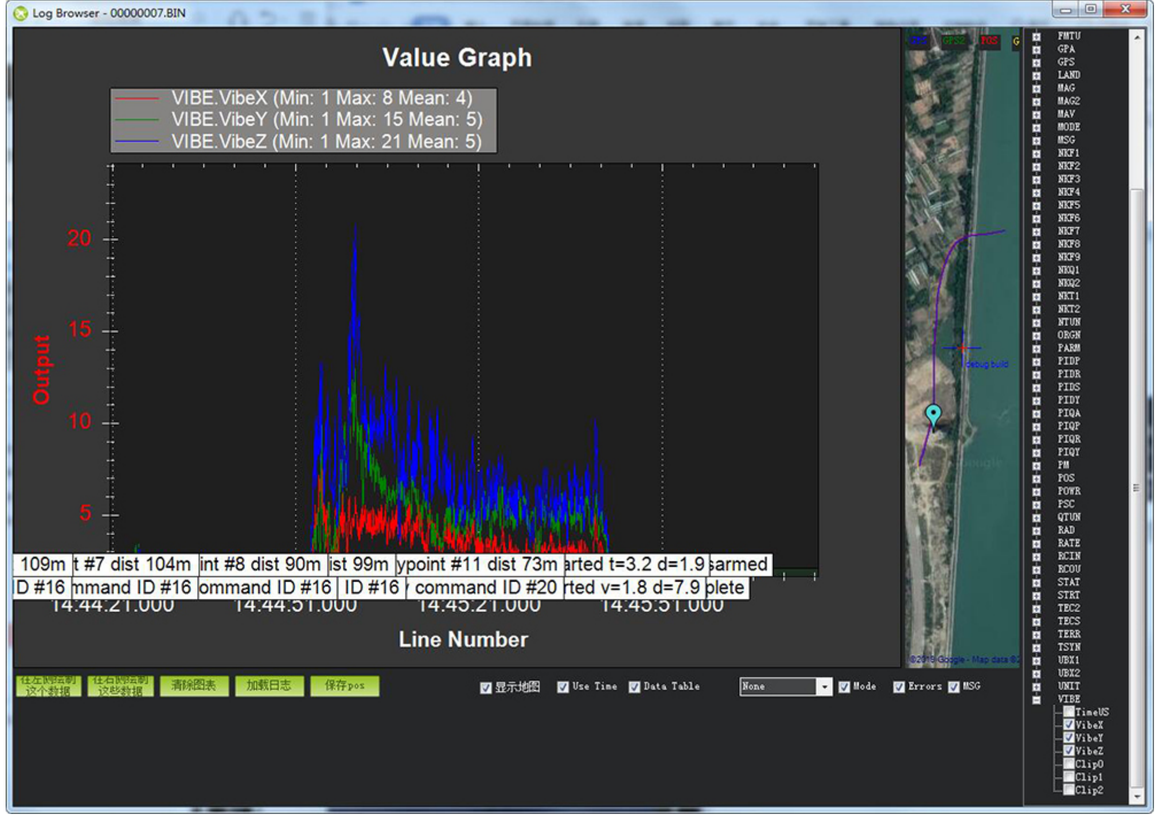
6.5 Several parameters the remote control multi-axis need to adjust

- In q_loiter mode,

> Q_LOIT_BRK_ACCEL=100 Maximum acceleration in cm/s/s when braking (e.g. rocker back to center), higher values make the aircraft stop faster.
> Q_LOIT_BRK_DELAY=0.5S The delay time to start braking when the rocker is back in the center, in seconds.

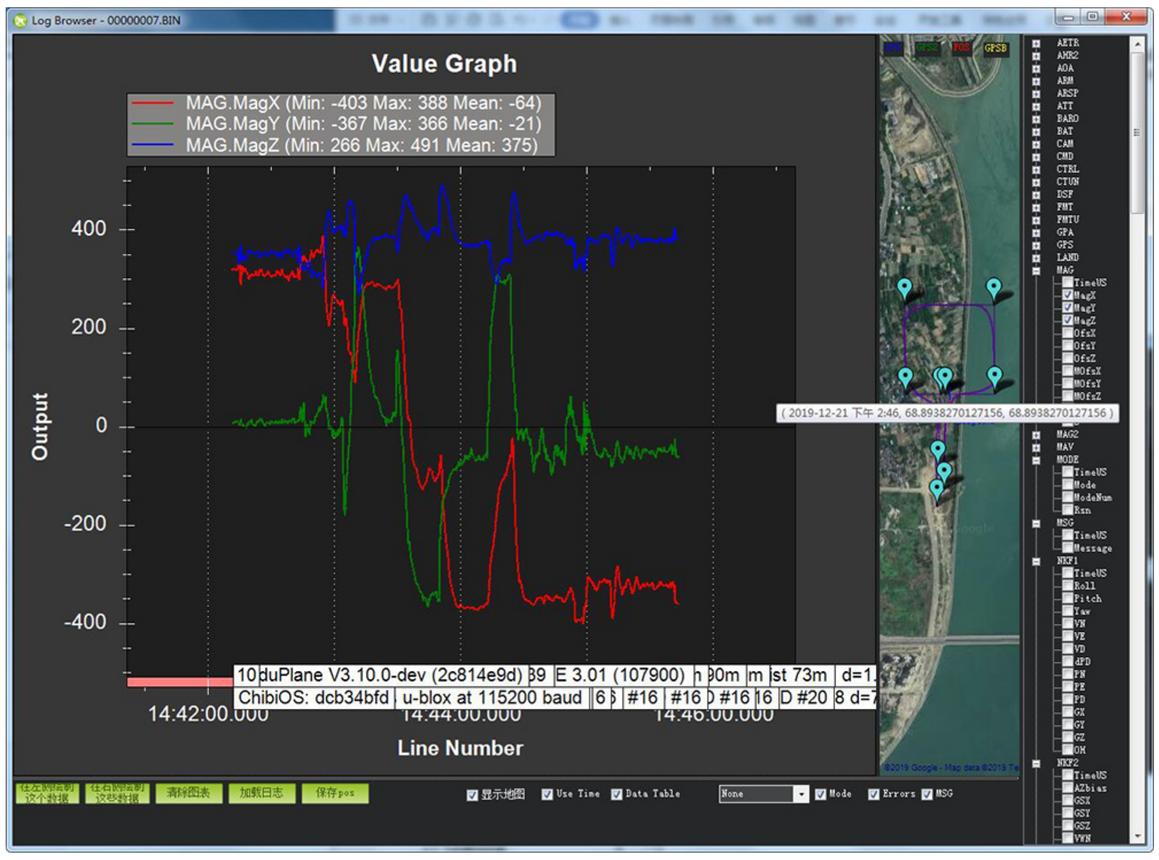
6.6 Flight control vibration check

- Vibe1,Vibe2,Vibe3 these three parameters are within 30 is normal.



6.7 Magnetic compass interference check

- Here check the magnetic compass interference, mainly check whether the air flight process compass is normal. Under normal circumstances, MagX, MagY, MagZ values within 600 are normal.

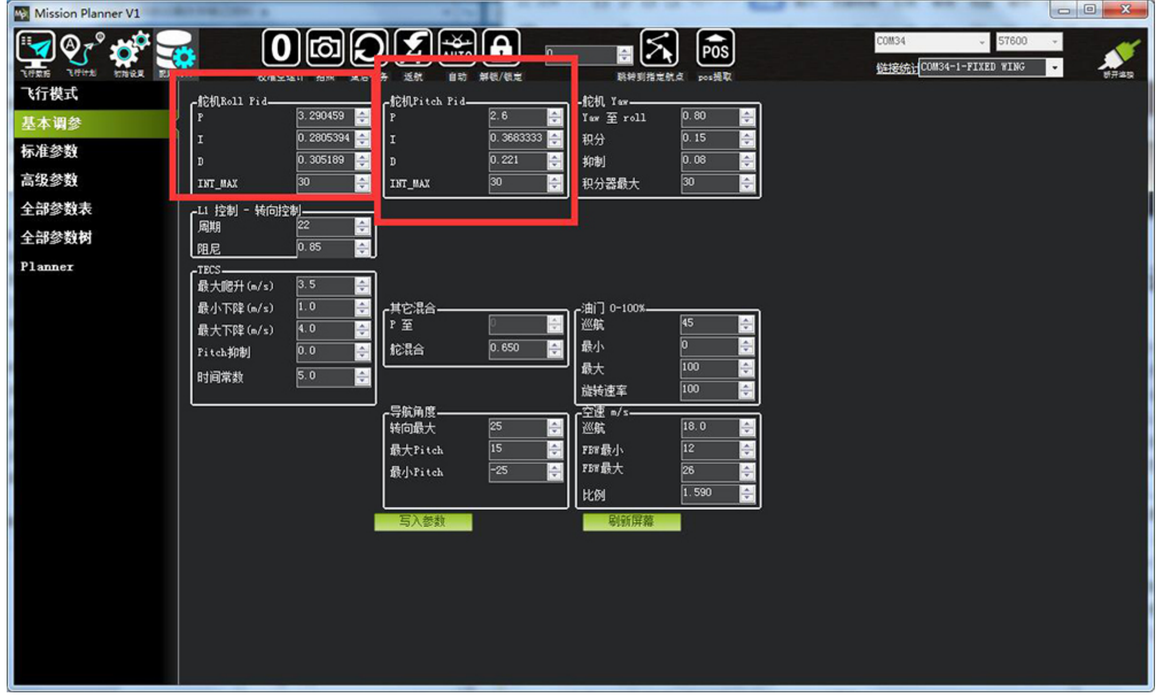


♦ Aerial remote control flight

7.1 Fixed-wing automatic parameter adjustment

The tuning parameter for fixed wing is the same as the hand thrower part. the higher the value of AUTOTUNE_LEVEL=6, the higher the gain of the aircraft and the faster the response of the aircraft.

- First manual takeoff, flying to 60-80 meters to switch to "AUTOTUN" mode, now the roll and pitch have a little stabilizing effect, but not very suitable, may not be good to fly, do not panic.
- Automatically adjust the parameters to calibrate the roll, quickly toggle the roll rocker's to the left to the end, and then to the right to the end, toggle 20 times in a row, as long as the aircraft does not fall, quickly toggle the stick to play rudder, slowly you will find that the roll stability of the aircraft is improved. If you don't think so, repeat a few more times.
- Auto tuning parameters to calibrate the pitch, it is recommended to fly the aircraft higher first, so as not to save the height of the aircraft is not enough, quickly dial the pitch rocker top to bottom, 20 times in a row, you can see the aircraft flying wave line, back to the center gradually find that the aircraft pitch has improved, if not improve continue to calibrate.
- After the calibration is completed, switch to FBWA mode and feel the handling state of the aircraft until you are satisfied.
- Each aircraft's remote control travel is different, the rudder's neutral position is different, the position of the connecting rod to the rudder surface is different,the takeoff weight of the aircraft is different and other factors, resulting in slight differences in the PID of each aircraft after the automatic parameter adjustment, which is normal.
- Note: The parameter value after the fixed-wing parameter adjustment, generally large, may be out of range, you can change the appropriate smaller.



7.2 Multi-rotor to fixed-wing switching

- First I use q_loiter multi-axis fixed point mode takeoff, in order to prevent falling high when tilting. You can climb to 40-50m. Switch to FBWA mode, this time the aircraft accelerates forward, the remote control can not control the aircraft aileron and pitch, do not panic! You must push the throttle to complete the switch automatically. The distance needed for the switching process is about 100-200 meters.After the switch is completed, the aircraft control and fixed-wing FBWA feeling is the same.
- You can switch between q_loiter and FBWA modes several times in the air to feel if there are any abnormalities in the switching process of the aircraft.
- If everything is normal in FBWA, reduce the throttle and intentionally let the aircraft stall speed below 14m/s, and observe whether the aircraft switches to multi-axis assist mode.
- With everything normal in FBWA, reduce the throttle, pull the stick and deliberately stall the aircraft and roll it over. If the roll angle is greater than 45 degrees, observe if the aircraft switches to multi-axis assist mode.

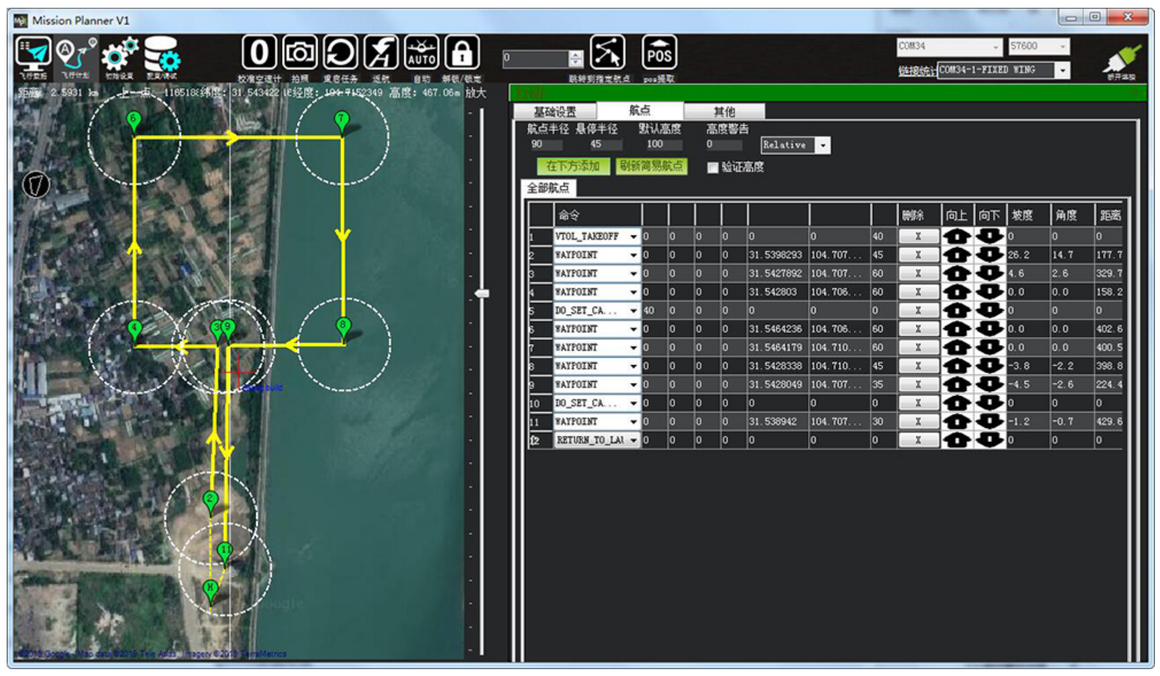
♦ MP Auto Flight

8.1 VTOL route test

The VTOL route mainly tests whether the aircraft is normal under automatic takeoff and landing.

- Several commands are required:

> VTOL_TAKEOFF Multi-rotor mode takeoff with 40m height setting
>
> RETURN_TO_LAUNCH Return



- If the multi-rotor takeoff elevation speed is too fast, you can adjust this parameter Q_VELZ_MAX = 150 . I set the multi-axis climb speed is 1.5m / s. Multi-axis to fixed-wing tilt if dropped high, you can change these parameters.

> Q_TILT_THR_DN=90 A downward tilting throttle can increase
> Q_TILT_MAX=35 Downward tilt acceleration angle can be changed to smaller
> Q_TILT_RATE_DN=10 Downward tilting rate of 10deg/s

- Fixed wing to multi-axis if climbing high, you can change the following parameters:

> Q_TILT_RATE_UP=60 Upward tilting rudder rate can be reduced
> Q_TILT_THR_UP=15 The throttle size for upward tilting can be reduced

- Return fixed-wing to multi-axis hover position if more than HOME point, indicating that the aircraft braking strength is not enough, you can change the foll-owing parameters:

> Q_TRANS_DECEL=4 The higher the value, the stronger the braking force

- The speed of the multi-axis descent and the speed of the ascent are controlled by the same parameter:

> Q_VELZ_MAX=150 Multi-axis ascending and descending speed is 1.5m/s

- Set the altitude and speed parameters for multi-rotor secondary landing:

> Q_LAND_FINAL_ALT=6 Secondary landing speed at 6 meters from the ground
> Q_LAND_SPEED=40 The speed of secondary landing is 0.4m/s

- Parameters for getting the aircraft locked up quickly after landing is complete:

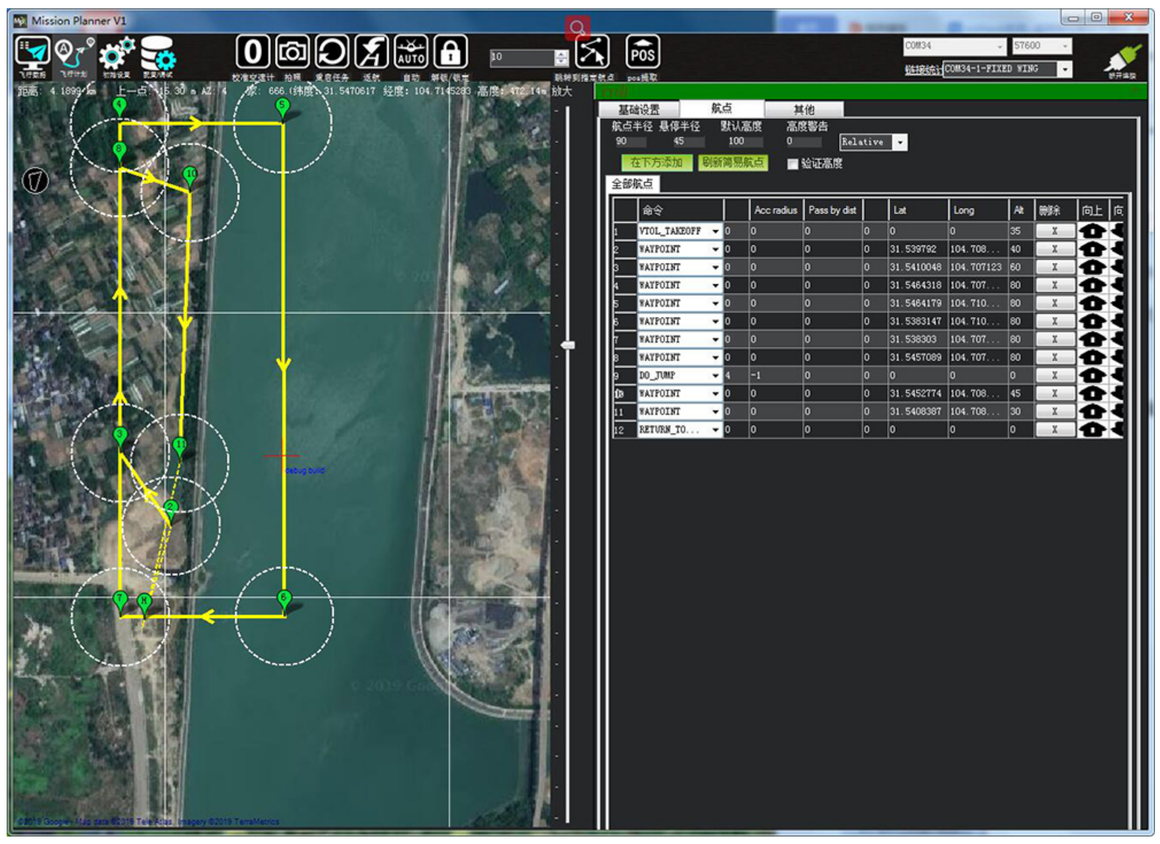
> Q_LAND_DETECT=3

- After the locking is complete, parameters that let all rudder surfaces return neutral

> LAND_THEN_NEUTRL=1

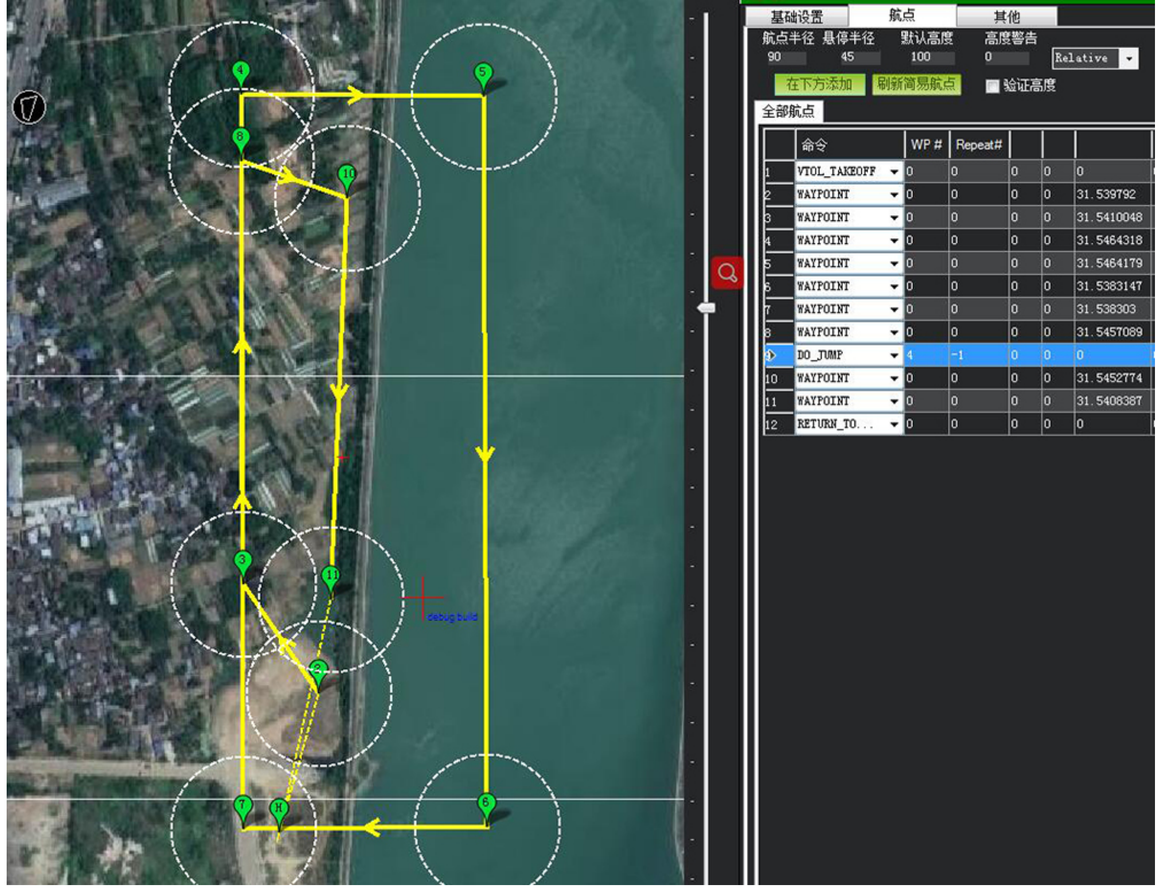
8.2 Rectangular infinite loop route test

The rectangular route mainly tests whether the aircraft is on a straight route and it overlaps the route accurately.



- In this route, I used the jump command DO_JUNP
  #4 stands for: after #8, automatically jumps to #4 -1 stands for: infinite loop

- Inside this waypoint, I designed a return route #10 and #11 so that when I want the plane to come down, I can set a jump command to point #10 and lift the infinite loop.



- This is a function to jump to a specified waypoint:

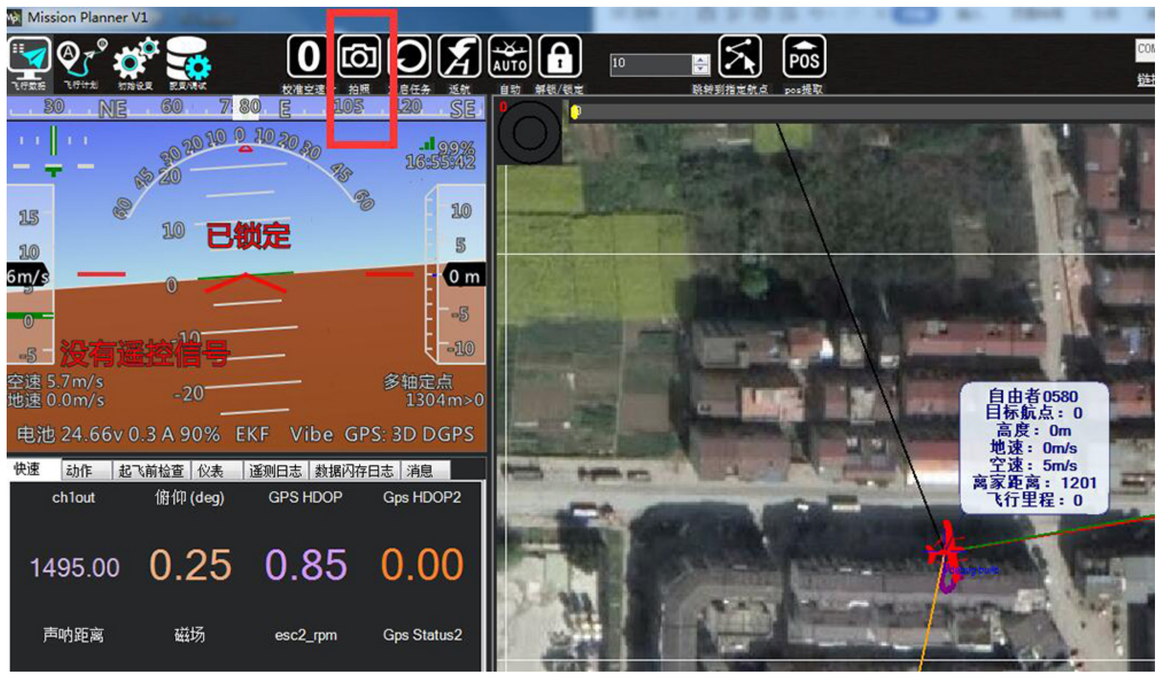
- In the event of an actual track and course offset, check in the following order:

> 1.Manual mode to check if the tail and pitch rudder surface are level and the ventral fin is installed vertically.
> 2.Is the motor installed horizontally in fixed wing mode
> 3.Is the compass abnormal, is the GPS completely fixed before taking off.
> 4.Whether the aircraft was moved during the aircraft power-on self-test.
> 5.Is the acceleration level of the flight control calibrated correctly.

8.3 Camera photo test

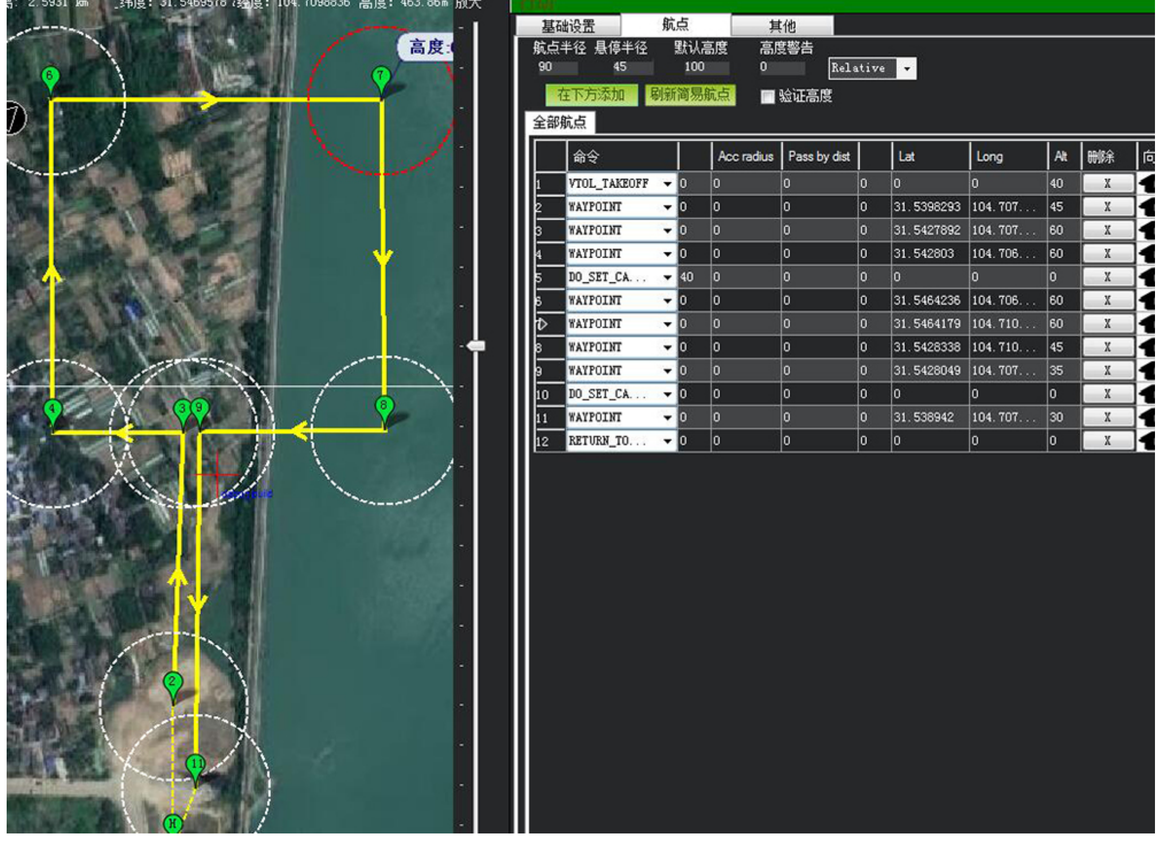
The camera photo test is mainly to confirm whether the photo function of the aircraft is normal, whether the camera mount is fixed properly, and whether the number of POS data and photo data are consistent.

- Check whether the camera SD card has enough space, whether it is a high-speed card, check the shutter setting 1/1000S, check the manual photo taking, check whether the camera works properly.
  Connect the battery and shutter wire, and click "take picture" on the ground station to see if you can hear the shutter sound of the camera.

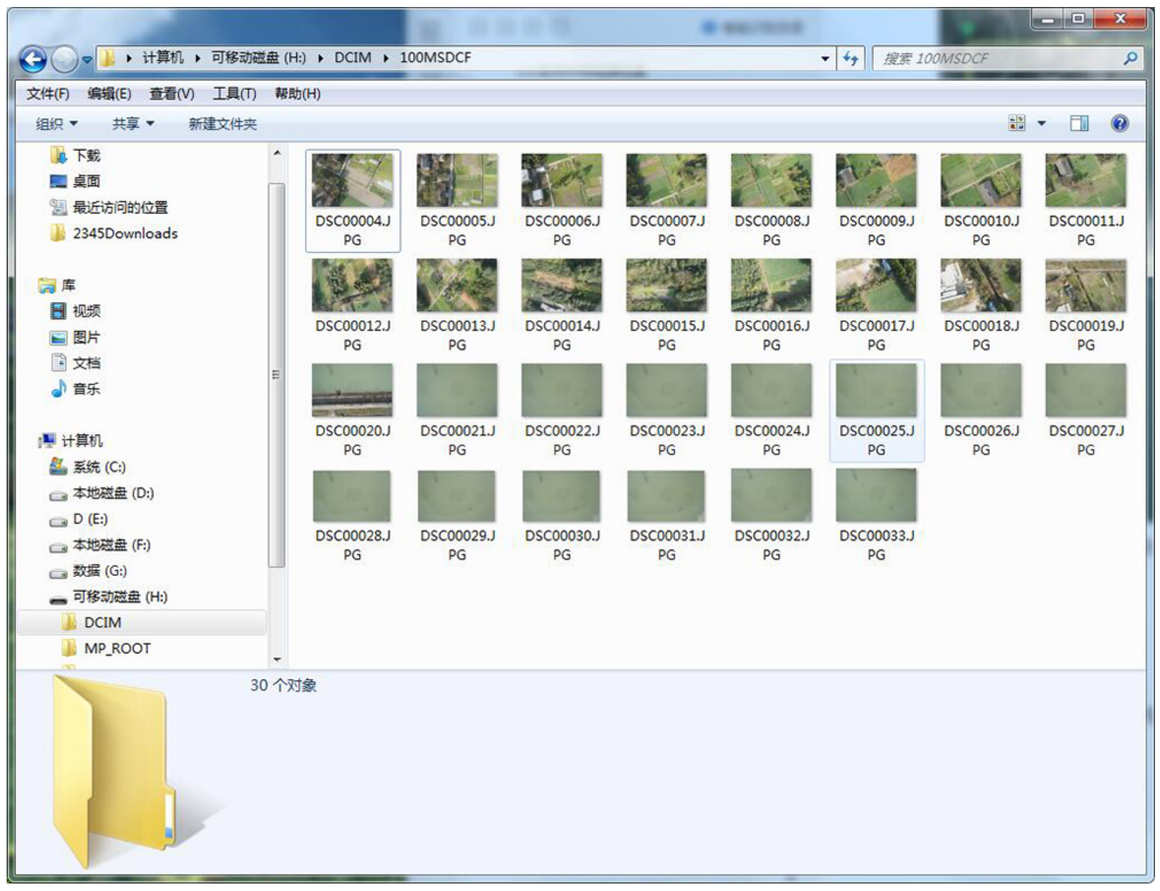


- After checking, you can use the Take off and landing route add photo command, and you can automatically take photos on the route.

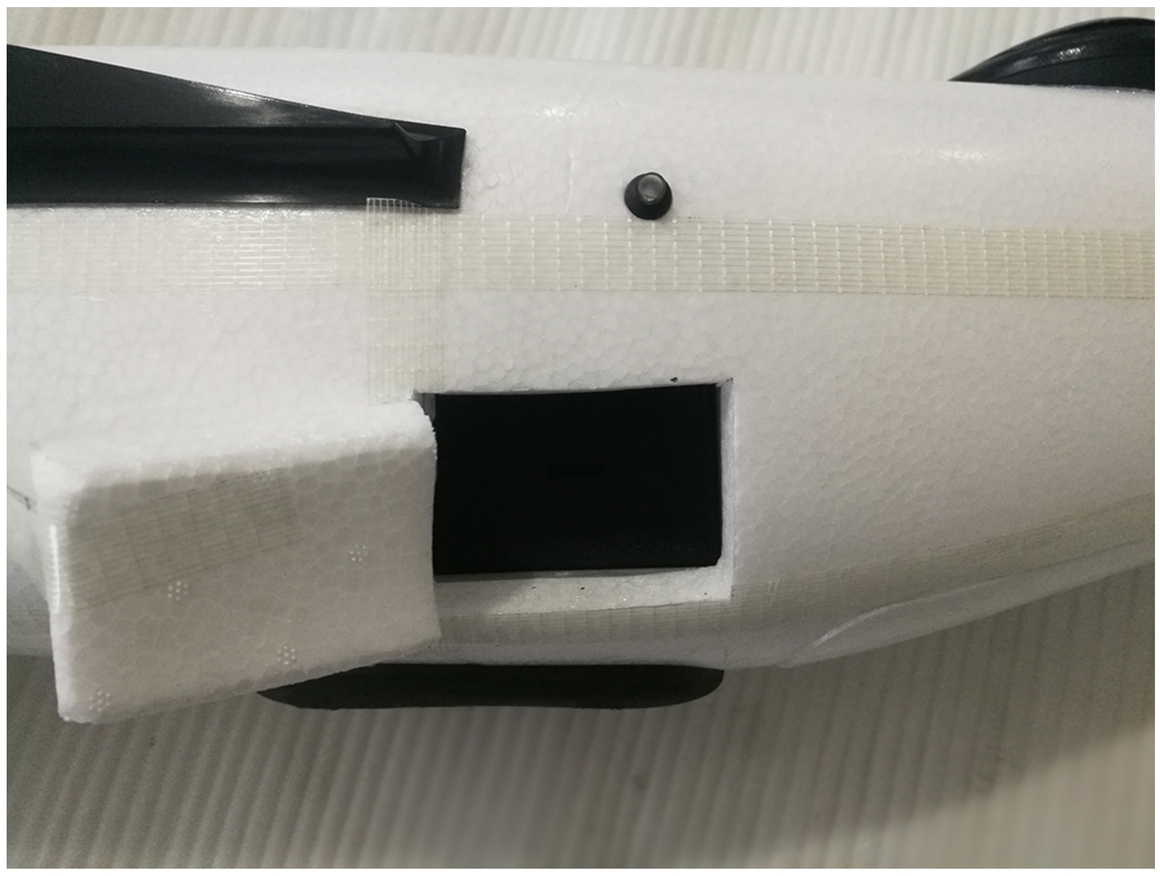
> DO_SET_CAM_TRIGG_DIST=40 means 40 meters isometric photo once
>
> DO_SET_CAM_TRIGG_DIST=0 means close the photo command



- After the takeoff and landing is completed, first check the number of photos 30 (only the part in the air, not on the ground).

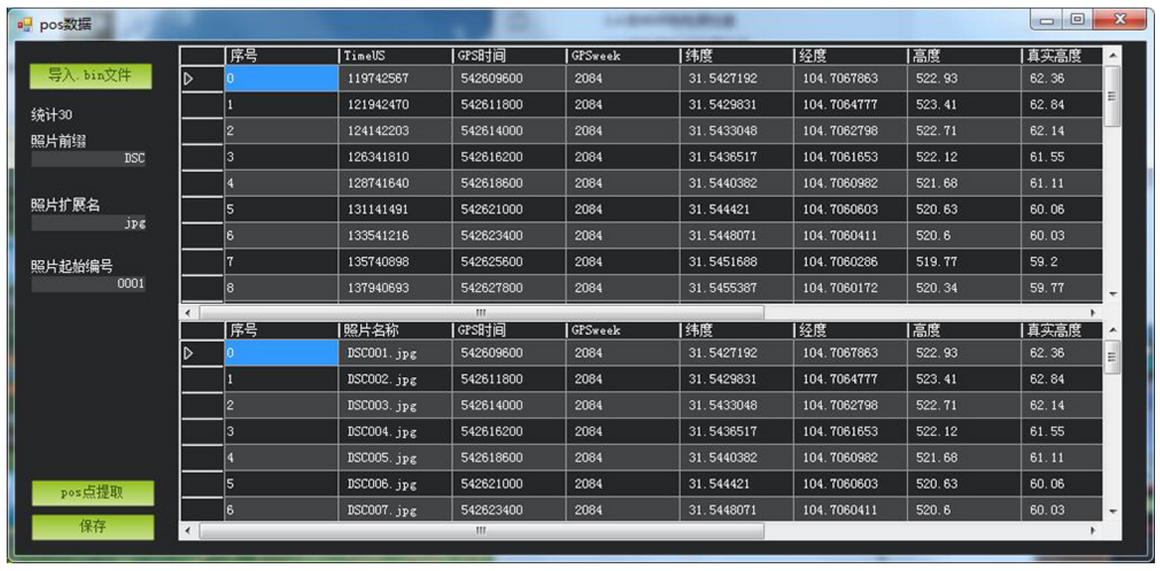


- I cut a hole in the body to make it easy to take the memory card.



- Next click on the ground station "POS Extraction" - import the .bin file - click on POS point extraction - save .Then you can save the required POS data.

- The number of POS is also 30 sheets, which just matches.



♦ Ending

Here the whole assembly and commissioning of the VTOL is completed. In the actual flight process, we will encounter various problems, some are caused by hardware equipment, some are caused by imperfect flight control software, and some are caused by improper commissioning and use.

No matter when and where, always full of love and reverence for flying, encounter problems must be solved, do not let go of any safety hazards, constantly sum up experience, and constantly progress forward.

Finally, I wish all drone enthusiasts a great flight every day!