RoboMaster 2019 aerial robot rack open source document

During the RoboMaster 2018 Competition, the aerial robot have shown great importance by playing a vital role in the battlefield. Sometimes it is a sudden thrust that alters the final outcome at the last stage of the game. For the 2019 competition, we will continue to highlight the unreplaceable position of the aerial robot and give it a more powerful fire output. Therefore, we have tried to adopt a rack structure with greater load and power; the open source rack solution is for your reference.

I. Overview of Aerial robot

Figure 1. Three-dimensional model of Aerial robot

Figure 2: Aerial robot in practical

Specifications of Aerial robot	
Dimensions mm (Length x Width x Height)	1200 x 1200 x 750 (protection pols are 300mm higher than blade surface)
Mass (Kg)	9.7 (TB47D/bullet excluded;referee system included)

Systems

1. Power: Compared with the 2018 design, the E2000 Pro power system is replaced by the E2000 power system. The E2000 power system Pro version is concentrated under the motor, which saves space and weight. E2000 power system single shaft maximum pull force is 5.1Kg, for that a 48V voltage power is needed so 4 batteries is equipped in this design

2. Navigation: N3 flight control along with Guidance navigation control system is used.

3. Gimble: Yaw axis motor is driven by 6020 gimble motor, Pitch axis motor is regulated by GM3510 motor, friction wheel launching motor is driven by snail motor, and the wheel is driven by 2006 motor.

Flight time test data under E2000 Pro				
Takeoff weight	TWR	Maximum flight duration (TB47D)	Maximum flight duration (TB48D)	Comments
11.2Kg	1.82	10'10''	11'30''	Mass of drone is 9.2 Kg. Referee system and projectile is not included
12.7Kg (weight loaded)	1.61	7'02''	7'12''	12.7Kg is close to the limit value of the drone. At this time, the power motor is seriously heated, the voltage fluctuation is large, and the circuit efficiency is low. Also, the weight of the aircraft is 10.35Kg, and the rule said the mass of drone can't exceed 10Kg. If the E2000 Pro power system is used, the recommended weight is 9.5Kg or less, that is, TWR is greater than 1.72.

Note: The flexibility of the air drone can be measured by the thrust-to-weight ratio (TWR). The greater the thrust-to-weight ratio, the better the flexibility of the drone. Generally, the

drone with TWR greater than 2 has better flexibility. Students who are interested in can conduct research on their own.

II. Electronics

1. Connection Diagrams
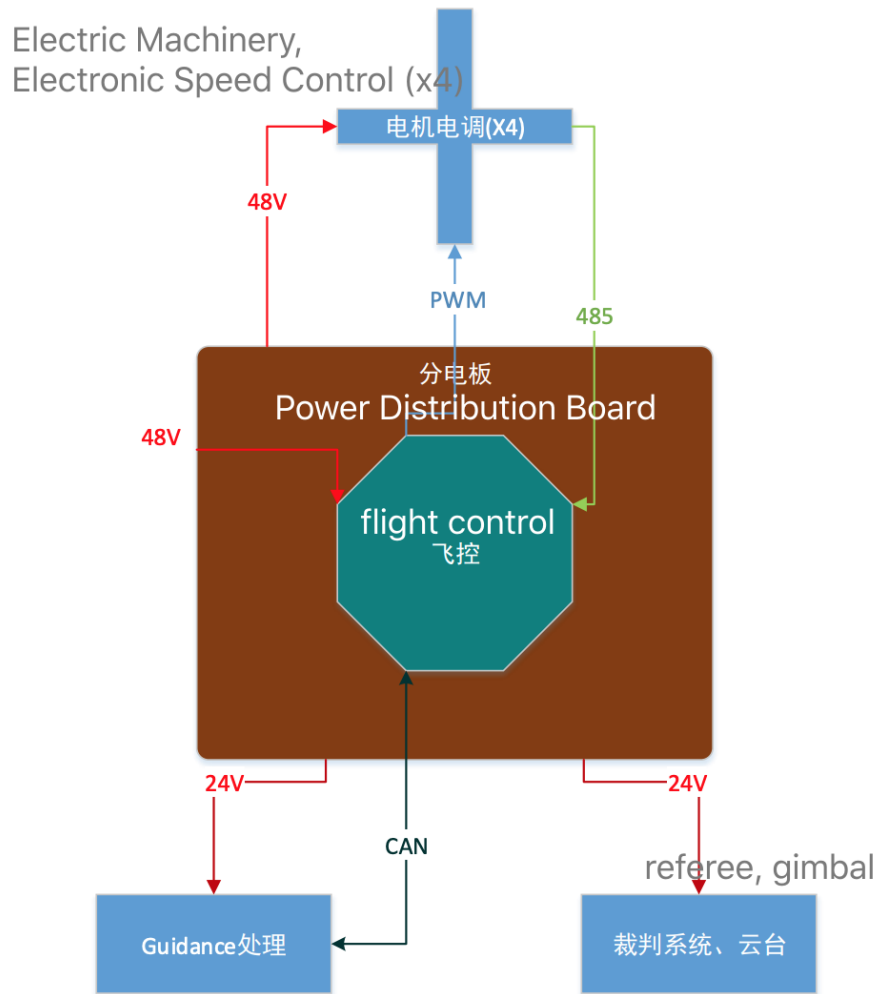
Note:
1. The communication between Guidance and N3 Flight Control is through CAN rather than API. Don't connect to API port on N3.
2. Connect E2000 Power system smart ESC to Flight Control iESC port through 485_hub smart communication conversion cable in N3 flight control package.
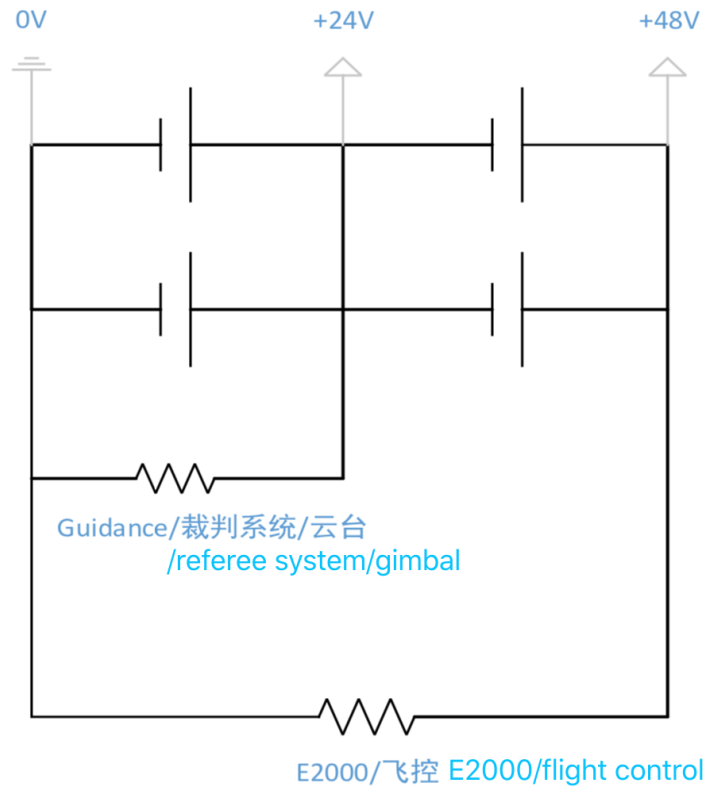
Figure 3. Connection Diagram for the Chassis

Figure 4. Connection diagram for the power supply

Note:
1. We did not add power switch in the power connection part because current E2000 flight power system is too big. Please select switches with larger current if you wish to add power switch
2. In the circuit shown above, the sequence of connecting power might have Guidance/referee system/gimbal suffer reversed voltage for a short time. After testing, there will be no serious effects. However, please take care.

The power supply of the whole machine is composed of 4 TB47 or 48 batteries, which are used to supply 24V and 48V electrical appliances. It should be noted that the 24V electrical appliance should be consistent with the GND potential of the 48V electrical appliance, otherwise there will be problems because of the potential difference generated by the two appliances.

It is recommended that you design your own PCB to save more space, or you can also search for "植保机" and "分电板"(power distribution boards for octocopters) on Taobao for more options.

- 24V appliances include Guidance, referee system and gimbal system
- 48V appliances include paddle motor and flight control (flight control uses 48V in order to measure the voltage)

The N3 does not support communication with the TB47. Its battery capacity can only be calculated by measuring the voltage. Also, please do not connect the signal lines of batteries of different potentials together.

2. Notices on N3 and Guidance
- Use N3 together with Guidance
- Version 1.4 is used for Guidance firmware
- There is no requirement for N3's firmware, both versions(2017 and 2018) should work. If all methods used and it is not correctly operating, try to update to the latest firmware.
- It is recommended that you use the RS 485 hub to enable communication between the ESC and the flight controller, and enable the DJI smart ESC function in the flight control settings.
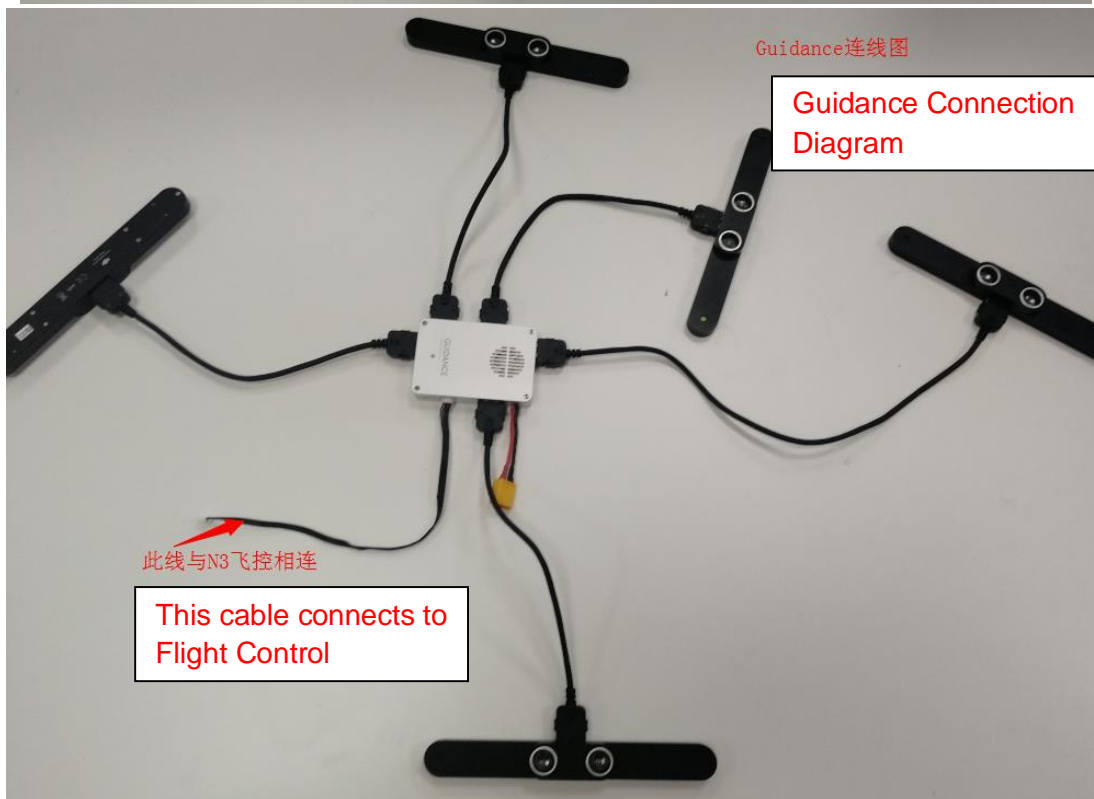
3. Connecting N3 and Guidance

1- Red Cable
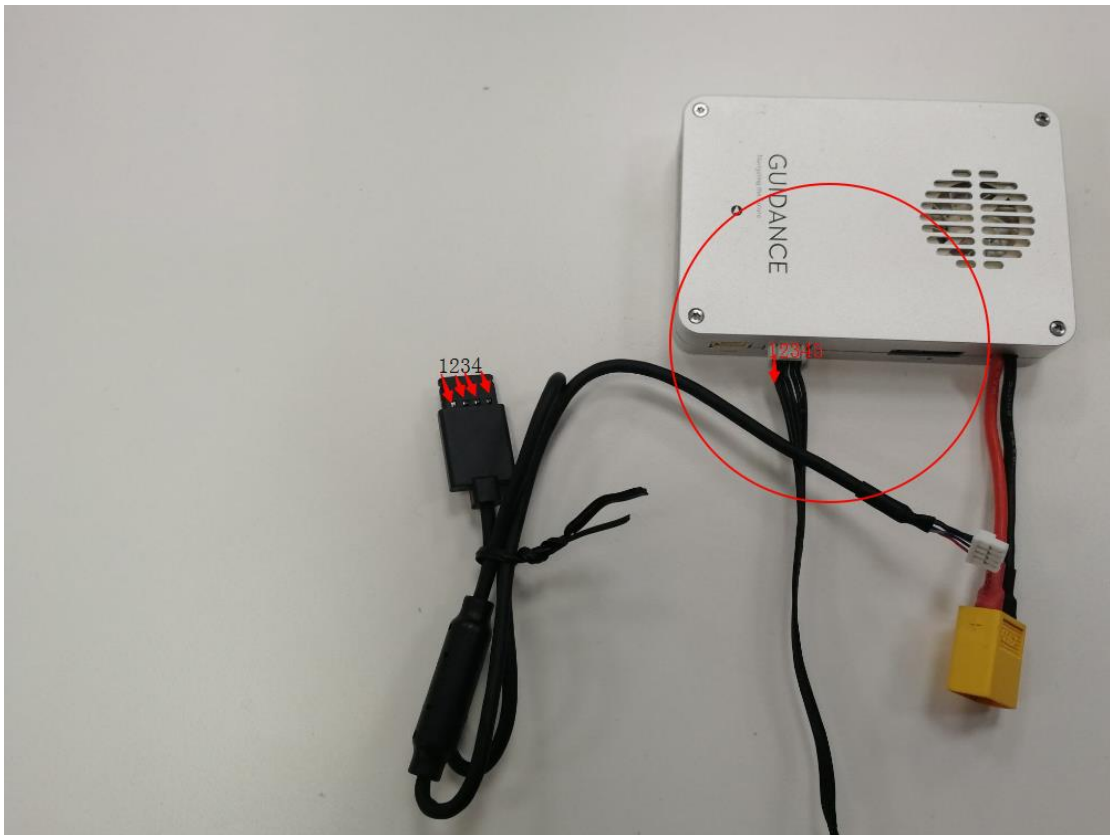2- Shield Cable
3- Grey Cable
4- Blue Cable
5- Not connected

1-红色线 5-不接
2-屏蔽线
3-灰色线
4-蓝色线

Guidance端接线，N3端接线是相互对应的
端口1------------------端口1
端口2------------------端口2
端口3------------------端口3
端口4------------------端口4

ports on these two kinds of wire are
corresponding and can be connected
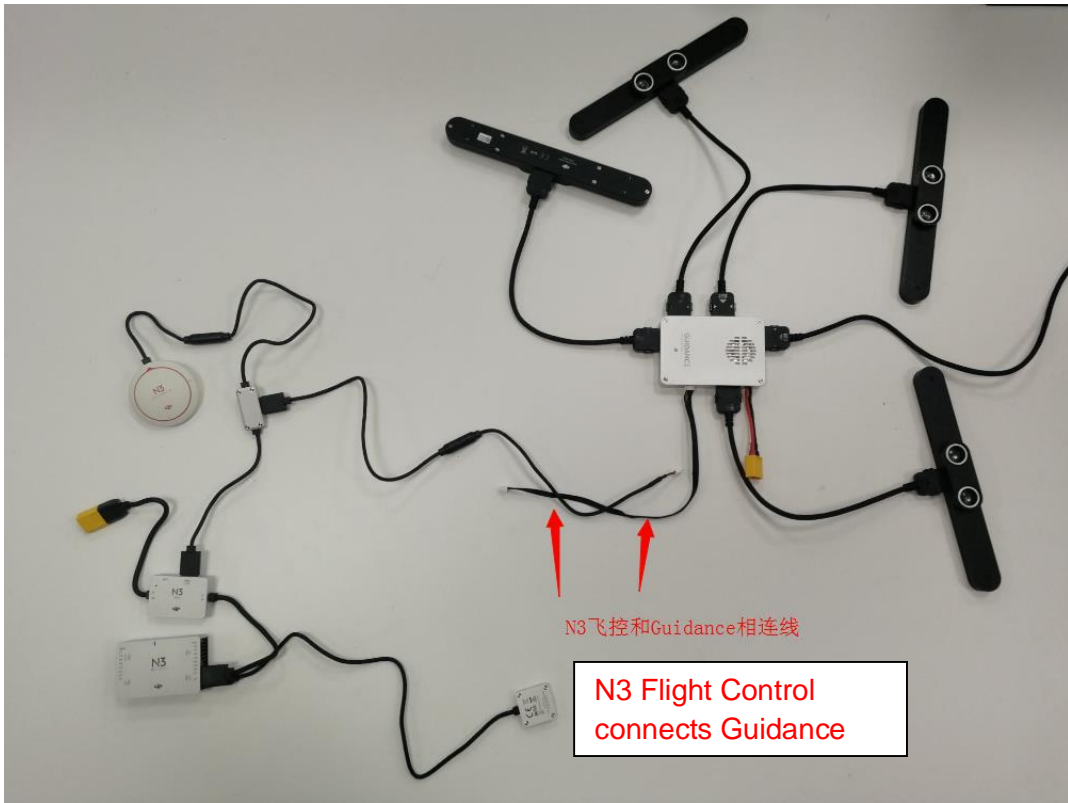
Figure 5. Diagram of connection wires of N3 and Guidance (for the wires on the left, the rightmost port can be left not connected with wire)

N3飞控连线图

N3 Flight Control
Connection Diagram

此线与Guidance相连

This cable connects to
Guidance

N3

N3

Guidance连线图

Guidance Connection
Diagram

此线与N3飞控相连

This cable connects to
Flight Control

N3飞控和Guidance相连线

N3 Flight Control
connects Guidance

1234

1234G

1234 correspond to 1234 from N3 Flight Control Cable. Cable 5 is removed

此处1234分别对应N3飞控连接线的1234   5号线去掉

Note:

1. N3 connects with Guidance as shown above. Left port connects 5-pin GH 1.25 self-locking port (please note it is not UART port). Right port is suggested to connect to CAN expansion port on N3 flight control GNSS_compass module.

2. The two connectors in the figure are from left to right and are named as ports 1, 2, 3, and 4. When wiring, just connect the same port number to the same line. It is worth noting that the left guidance is originally a 5pin interface. The farthest route header in the figure has been removed and is not connected.

3. Before use, it is recommended to calibrate the Guidance. Guidance debugging software can be found in the DJI official website guidance product module. After the calibration is completed and the Guidance and N3 are connected to each other, the remote control is turned on. If the LED light effect of N3 is double flashing green, the connection is successful. If the light is not working properly, please check the wire and recalibrate.

4. During the debugging process, we found that the guidance communicates with the N3, which is also related to the power-on time. If the guidance is more advanced than the flight control power-on time, communication may fail. It is recommended to power on at the same time

5. If the FT7 is used in the aircraft remote control, it needs to be refreshed to the aircraft firmware to communicate with the N3 flight controller. Otherwise, the remote control channel data cannot be seen in the assistant assistant. If the receiver uses the DR16 receiver, it needs to be brushed as the aircraft firmware.

6. It is recommended to read the guidance of guidance and flight control carefully, pay attention to guidance, guidance vision module, N3 flight control, GNSS module have installation orientation requirements, guidance master and N3 master control as far as possible installed in the center of gravity of the aircraft, while paying attention to heat dissipation.

N3 Flight Control Parameter Tuning Software Download Link: https://www.dji.com/cn/n3/info?site=brandsite&from=insite_search#downloads

Guidance Parameter Tuning Software Download Link : https://www.dji.com/cn/guidance/info#downloads

DT7 Controller and DR16 Receiver must be upgraded. Controller can be switched between drone and ground vehicle by yourselves. However, receiver can only be shipped to committee for upgrade. Controller update software download link:

https://bbs.robomaster.com/forum.php?mod=viewthread&tid=7719&page=1&extra=#pid86478

III. Rack installation details
1. The plain shaft is inserted into the 2.5mm hole on the carbon pipe of the mechanical arm to affix position and the level measurer is used to adjust position manually.

光轴定位
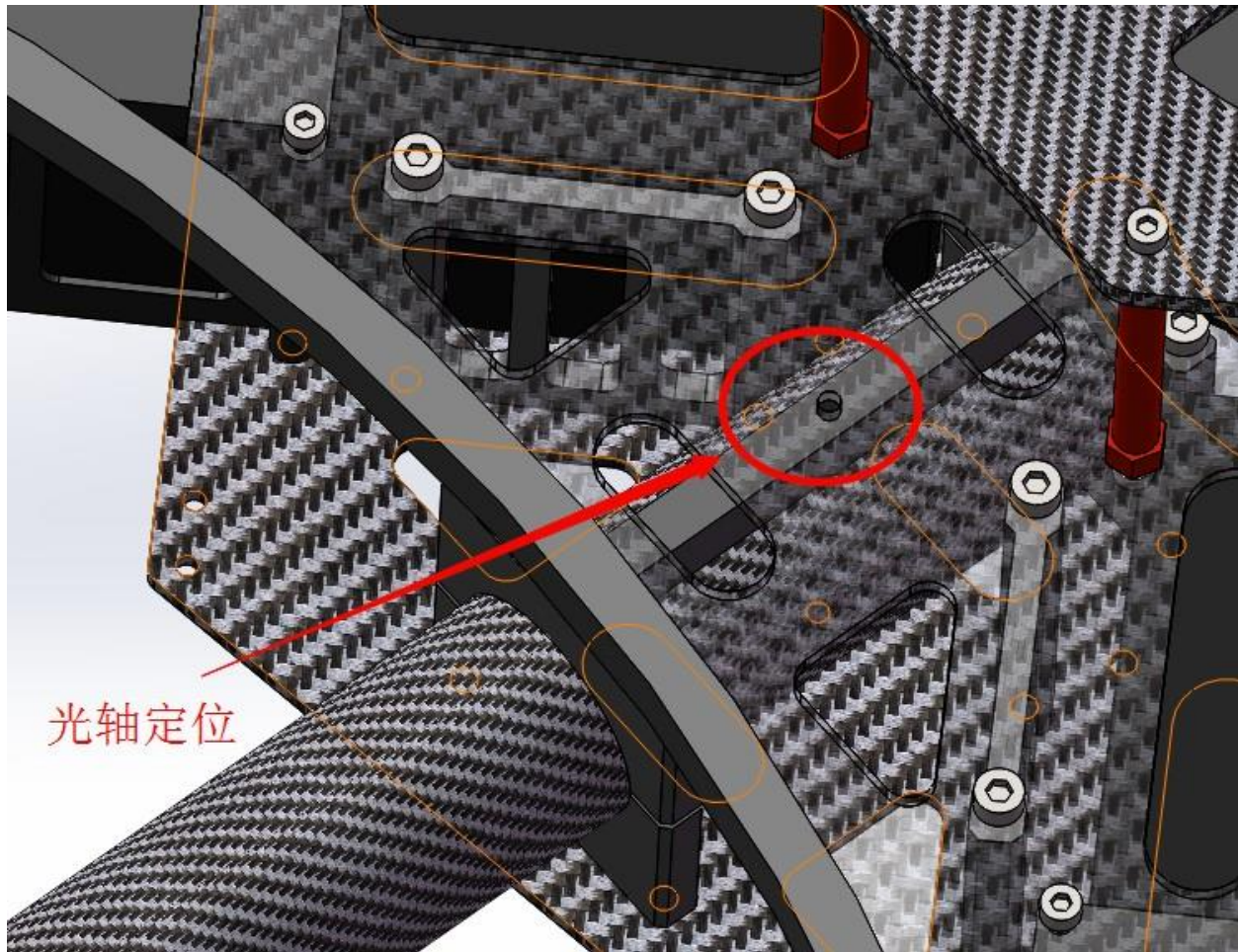
2. The mechanical arm clip tightens the position vertically.Hence, be careful to mind the order of the carbon board when assembling.

3. The protection sheath and the footstool of the carbon pipe are fixed via glueing and hole punching.

4. Due to the limited space within the rack, it is important to plan ahead the wires' path to better circumvent later issues.

5. Although GPS does not operate inside the room, installing it is a must; it contains compass module to allow the initial take off of the air robot. Also,make sure to keep a distance from the high power and magnetic modules to avoid disturbance.

IV. Safety Precautions

1. The modified aerial robot blade has a large size of 21 inches. It is necessary to remove the blade debugging program and blades firstly to avoid safety problems.

2. The blades have directions (CW and CCW), and the diagonal blades have the same direction. Be careful when installing them, otherwise there is a risk of the aircraft shaking during takeoff.

3. Guidance, power board and N3 module has relatively large heating problem. Be sure to leave enough space while wiring to avoid potential safety hazards.

4. Minimize the installation of screws and reduce the weight when designing by yourself. It is recommended that the aircraft quality be 9.5Kg or less. (Without the referee system and projectiles), if the load is relatively large, the heating problem of the power system motor will be more serious, and the power system will be inefficient and this will affects the endurance. At the same time, it is recommended that everyone holds the line of the mass and the blade. Otherwise, it is hard to control during flight, and the aircraft shakes a lot.

5. Due to the large size of the 21-inch blade and airflow, shakings more likely to happen closer to the walls ; it's recommended to conduct tests both in open grounds and by the walls


Appendices

1. Material List

Part Name	Expected Number	Method of Purchase
N3 Standard	1	DJI Store
Guidance	1	DJI Store
E2000 Professional Pack	4	DJI Store/Offline Purchase
TB47D/48D Battery	4	DJI Store
Remote Controller DT7&DR16	2	Offline Purchase
Referee System	1	RM website/Offline purchase
Snail Motor	0-2	DJI Store
Snail ESC	0-2	DJI Store
Power Board	1	buy/build on your own
M2006 Motor	0-1	DJI Store/RM website
C610 ESC	0-1	DJI Store/RM website
6020 Motor (with ESC)	0-2	RM website/Offline

		Purchase
GM3510 Motor (With ESC)	0-1	Offline Purchase
Development Board	0-1	DJI Store/RM website/Offline Purchase
Red Dot Laser	0-1	RM website/Offline Purchase
Manifold 2/Mini PC	0-1	DJI Store/buy on your own

Appendix 1. Material List

2. Endurance Calculation Reference

For the E2000 power system, the working curve of a single power paddle is as follows:
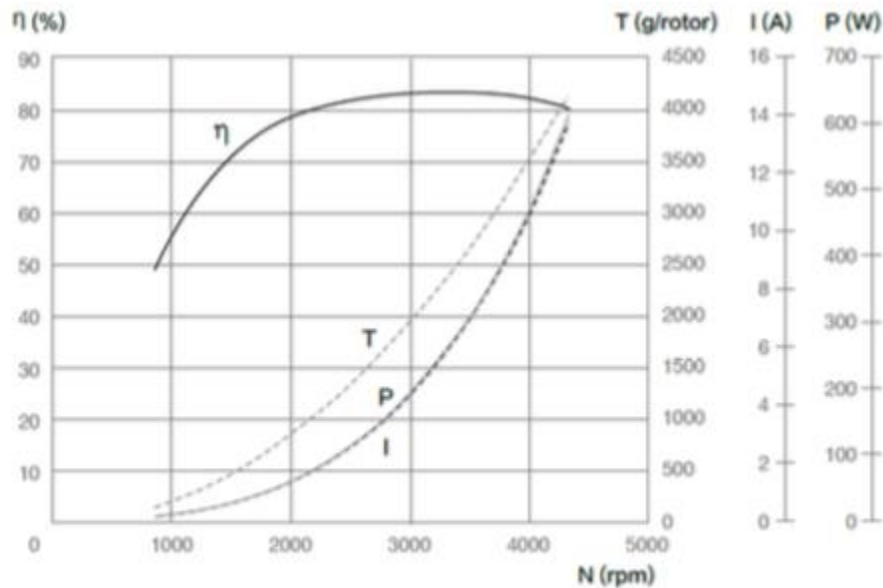
η- 电效率，T- 拉力，I- 电流，P- 输入功率，N- 转速

以上数据均为电调输入电压 44.4 V、室温 25℃、海平面高度的环境下，变化油门输入调节转速测得。

η- Electrical Efficiency; T-Pull, I-Current; P-Input Power; N-Rotating Speed

The above data is measured when the input voltage of the ESC is 44.4V, room temperature is 25 C, at sea level, and variable throttle input adjust speed

(1) Procedure for Calculating the Endurance

Assume that the TB47 battery is used and the take-off weight is 11kg. Four TB47 connected in series by pairs are equivalent to a 9000mAh 12s power supply (the unit is 4500mAh). The take-off weight is 11kg, and the single-axis load is 2.75kg.

According to the above graph, the current is about 8A under the load of 2.75kg; the total current of the four motors is about 32A, and the whole power supply can work under the discharge of 32A.

$$\frac{9\ Ah}{32\ A} = 0.28\ h = 16.8\ min$$

(2) Feedback of the Testing Questions

Due to the movement of the aircraft, the motors need to consume more power to provide more lift, and the power consumption of the gimbal, flight control, and Guidance needs also to be considered. The final measured flight time is 10 min, which is about 60% of the calculated result. You can use this as a reference.

Note 1: When the load is 11kg, the battery can consume 80% of its charge before the aircraft automatically drops, whereas with the load of 13kg it can only consume 60% of the charge (heating causes the resistance to increase and therefore cause more voltage division), if the consumable capacity of the battery is considered, the final measured result is about 75% of the calculated result.

Note 2: The newness of the battery and the rationality of the circuit structure will also affect the voltage. It is recommended to consider these aspects in the design process.