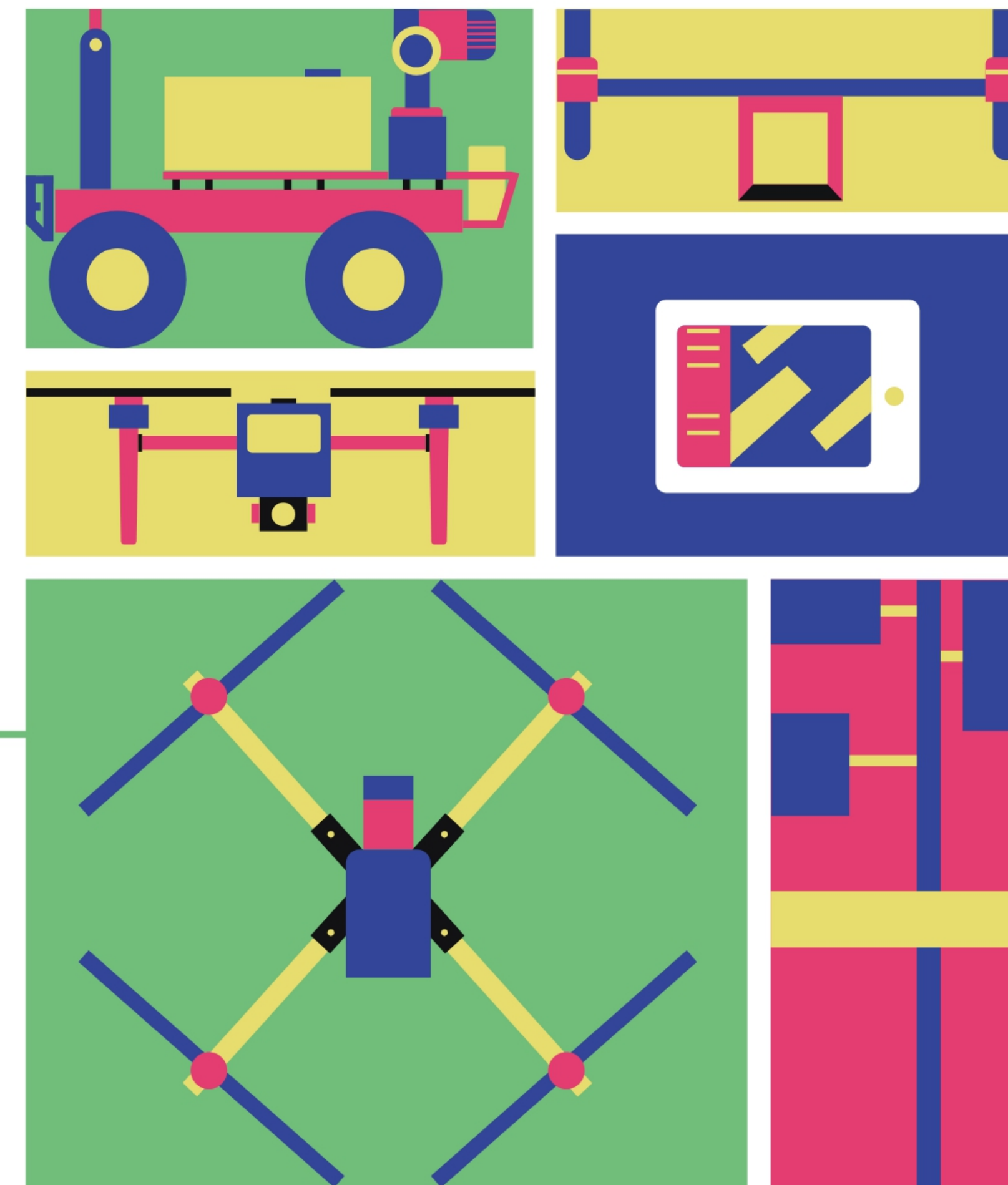


Basic Principles and System Introduction of XAG 2024 Agricultural Drones



Overview

- XAG 2024 agricultural drones (referred to as "drone") are mainly composed of the following parts: aircraft (including flight platform, application system), propulsion system (main ESC, main motor, propeller, etc.), power system (Smart SuperCharge Battery, Intelligent SuperCharger, Supercharge Station), GNSS RTK high precision positioning system (SRC4 remote controller with screen, ACS4 ControlStick and XRTK6 rover, cloud base station), sensor system (SUPERX5 Pro flight control, obstacle avoidance radar, Pilot Sight Livestream visual image), application system (RevoSpray system: liquid tank, impeller pump, liquid transport tube, centrifugal nozzle; RealTerra system: RealTerra module; RevoCast system: granule container, screw reducer pair, spreading disc motor; RevoCargo/RevoSling system), operation management monitoring system.



Agricultural Drone



Control System



GNSS RTK High Precision
Positioning System



Power System

A large, black and white agricultural drone with four rotors is shown in flight against a background of a cloudy sky and a hilly landscape. The drone has a white tank mounted underneath. The text 'Table of Contents' is overlaid on the image in a white, sans-serif font.

Table of Contents

01 | Drone Structure

02 | Introduction to Drone System
and Principle

A close-up photograph of a drone's propeller and motor assembly. The propeller is black and has some water droplets on its surface. It is mounted on a black motor housing. Below the motor, a red handle or part of the drone's frame is visible. The background is blurred.

01 | Structural Composition of an Agricultural Drone

P150 Drone Structure

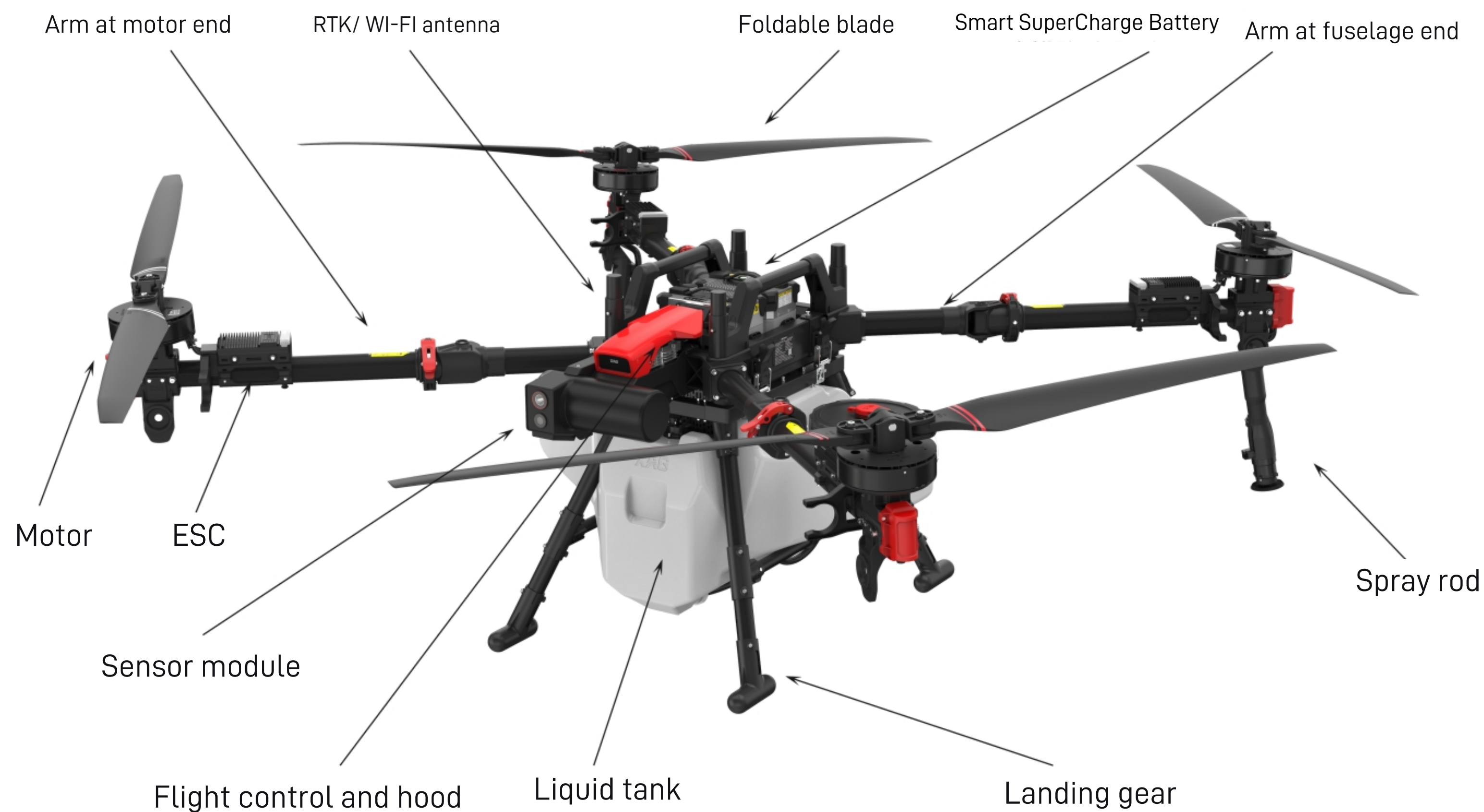


P150 Drone Structure



P150 Drone Structure

- The visible parts on the exterior of the P150 Agricultural Drone include: foldable propeller, high-performance motor, centrifugal nozzle, foldable arm, hood, airframe, obstacle avoidance radar, Pilot Sight Livestream camera, application system, flight control, Smart SuperCharge Battery, etc.



Note: The figure shows the P150 Agricultural Drone. Except for the difference in the number of batteries, the P60 and the P150 have largely the same overall structure and system.

ADVANCING AGRICULTURE

P150 Drone Application System

- The application system of the P150 and P60 Agricultural Drones includes RevoSpray, RevoCast, RevoCargo/RevoSling, and integrates spraying, spreading, mapping and transportation features.



Revo Spray 4



Revo Cast 4

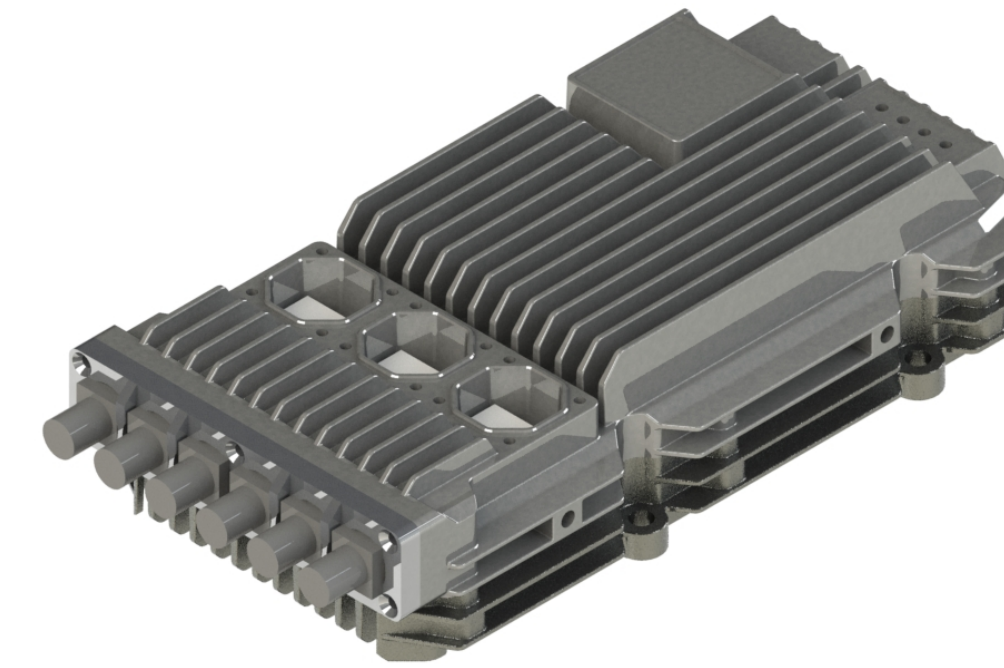


RealTerra 3

A close-up photograph of a drone's propeller and motor assembly. The propeller is black and has some water droplets on its surface. It is mounted on a black motor housing. Below the motor, a red handle or part of the drone's frame is visible. The background is blurred.

02 | Agricultural Drone System and Principle

Flight Control System - Principle



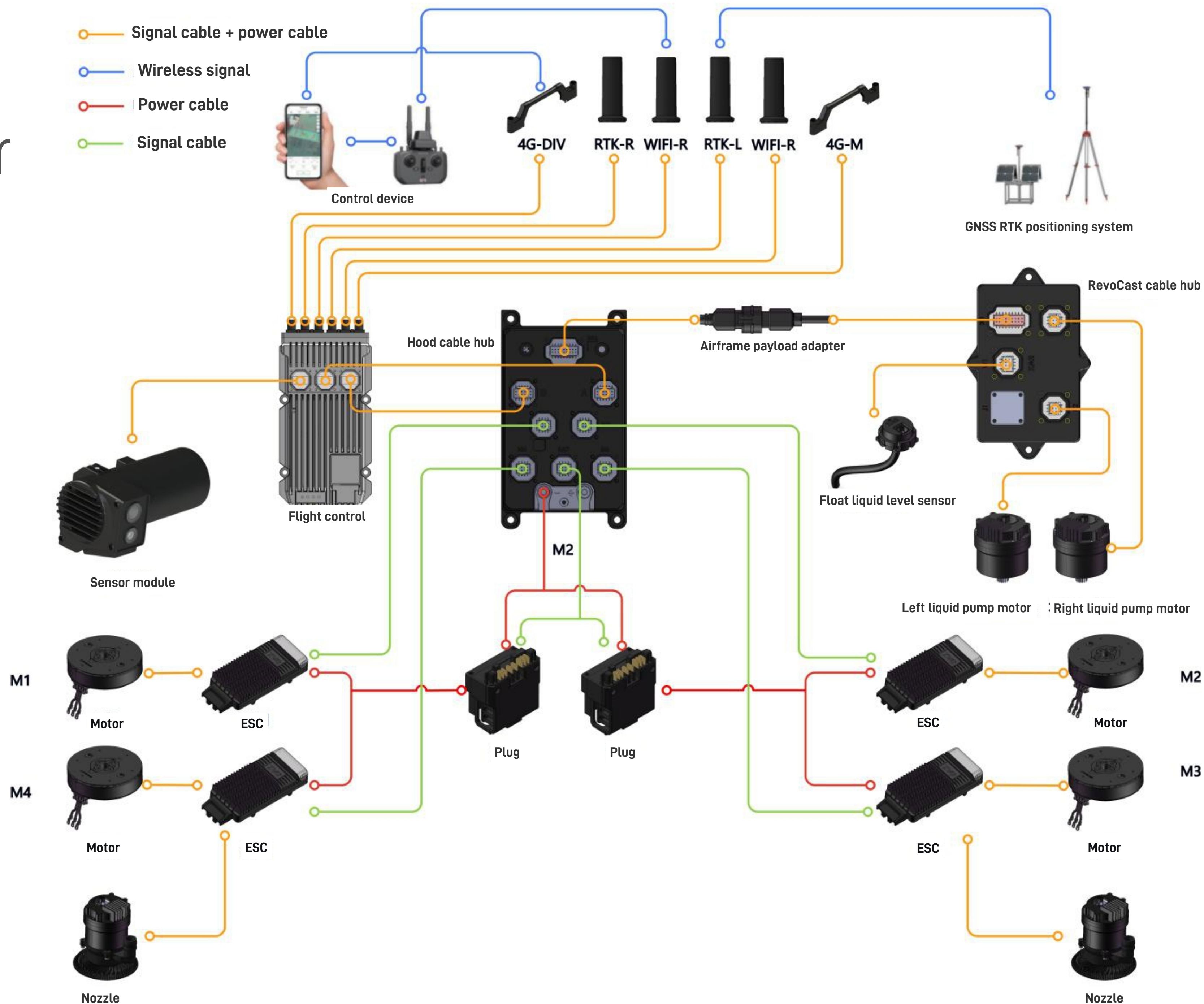
Principle description

- The flight control system (hereinafter referred to as the flight control) is equivalent to the "brain" of the drone. It is the core system of the entire flight process of the drone, including takeoff, flight in the air, performing tasks, and landing. The system can ensure the stability of the drone flight, reduce the operating difficulty of the operator, improve the ability to perform tasks and flight quality, enhance flight safety, and reduce the operator's burden.
- The flight control's principle for controlling the quad-rotor agricultural drone is as follows: First, the flight control contains multiple sensors, such as accelerometers, gyroscopes, and magnetometers, to collect data. The accelerometer measures acceleration, the gyroscope detects angular velocity, and the magnetometer provides heading information. Then, the data is fused through algorithms such as complementary filtering or Kalman filtering, and then the attitude calculation is carried out to obtain the pitch, roll angle and yaw of the drone. Then, based on the difference between the set target attitude and the current attitude, the flight control uses PID and other control algorithms to calculate the control outputs, adjust the motor speed, and achieve precise control of the drone's attitude and position, ensuring its stable flight and the completion of various tasks.
- The obstacle avoidance module and application module on the agricultural drone also rely on the flight control for normal operation. The flight control cooperates with these modules to enable functions such as obstacle avoidance, constant flowrate, quantitative seeding, and autonomous flight.

Flight Control System

Connection to each system module (RevoSpray)

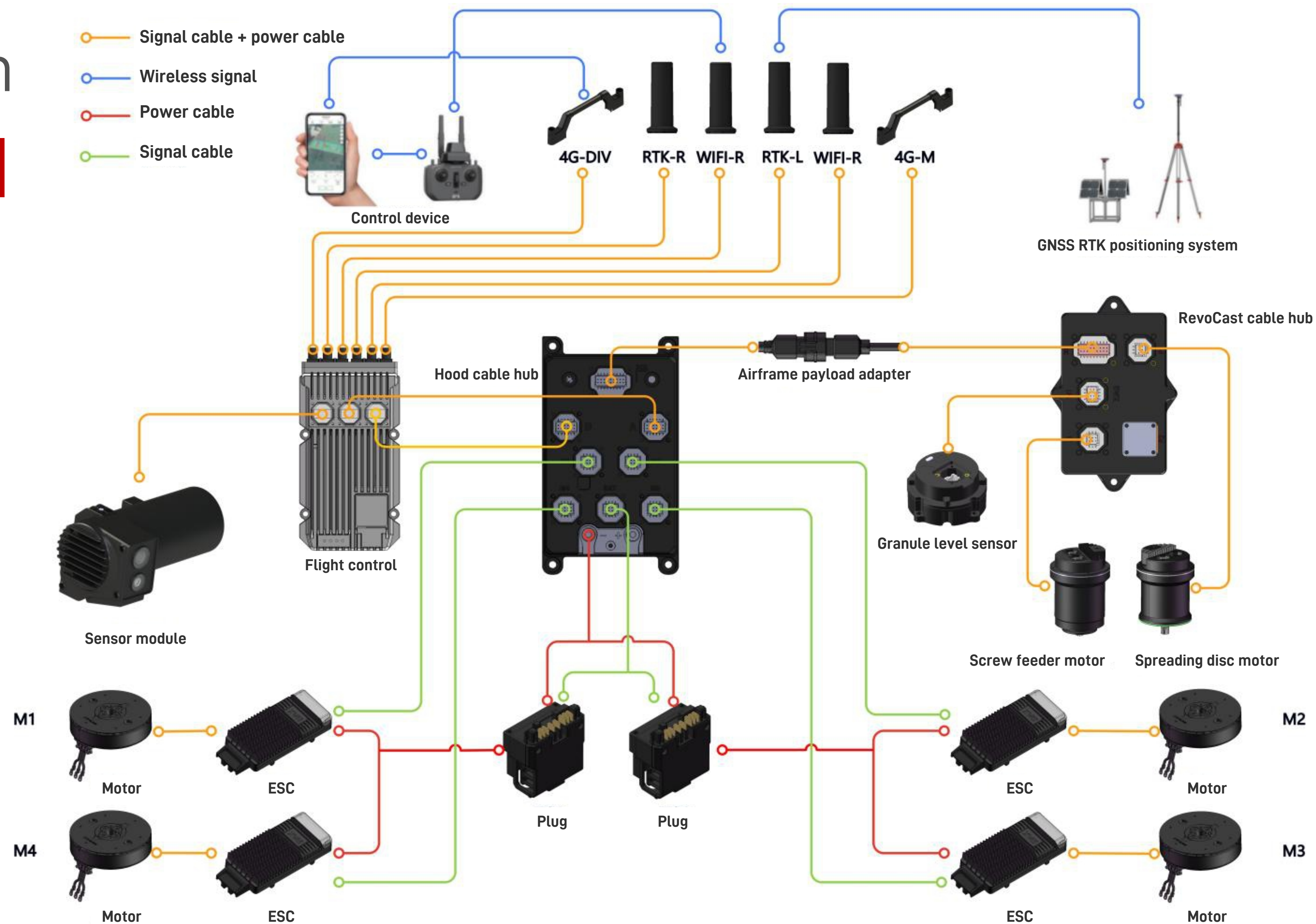
- The flight control system of the drone cooperates with various system modules, and integrates flight control, navigation, sensor data processing, communication, safety protection and other functions, so that the drone can achieve safe and reliable flight in various complex environments. The principle diagram is as follows:



Flight Control System

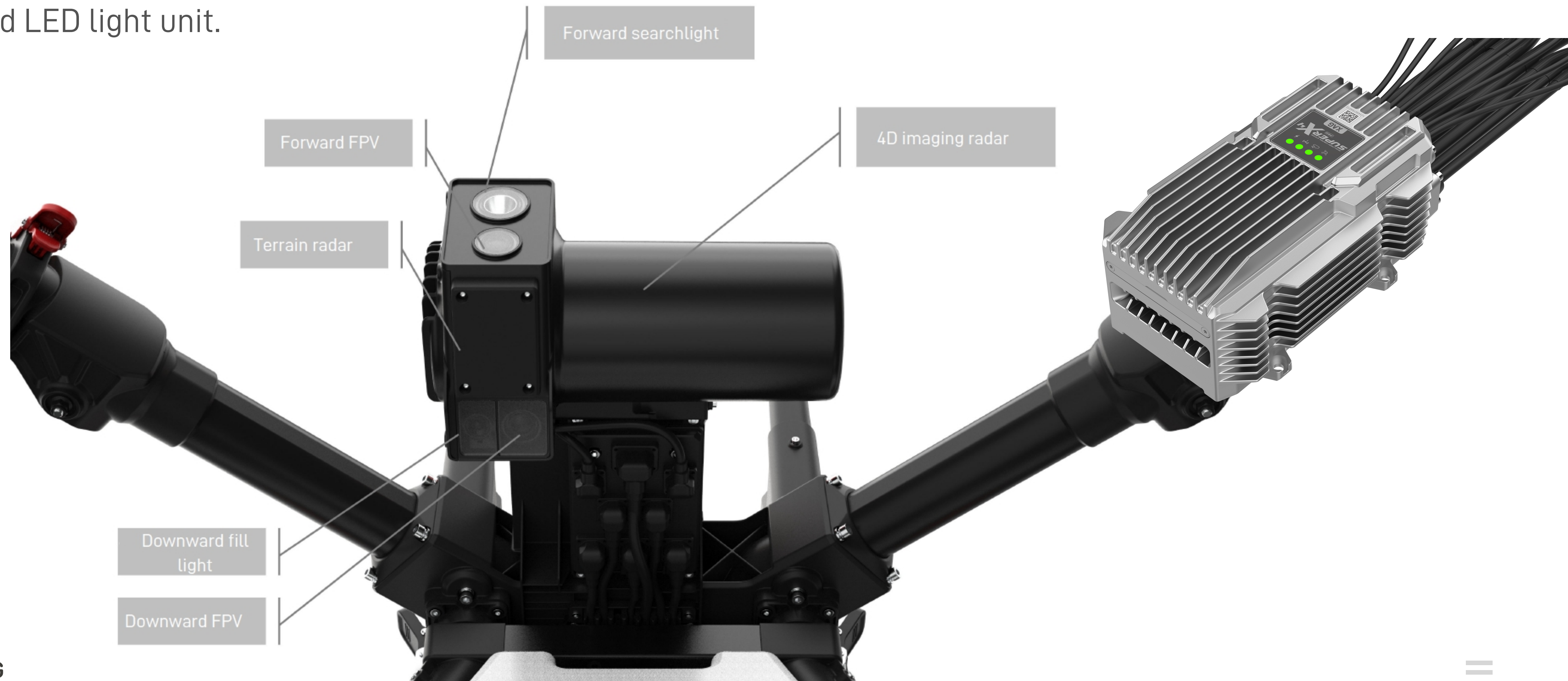
Connection to each system module (RevoCast)

- The flight control system of the drone cooperates with various system modules, and integrates flight control, navigation, sensor data processing, communication, safety protection and other functions, so that the drone can achieve safe and reliable flight in various complex environments. The principle diagram is as follows:



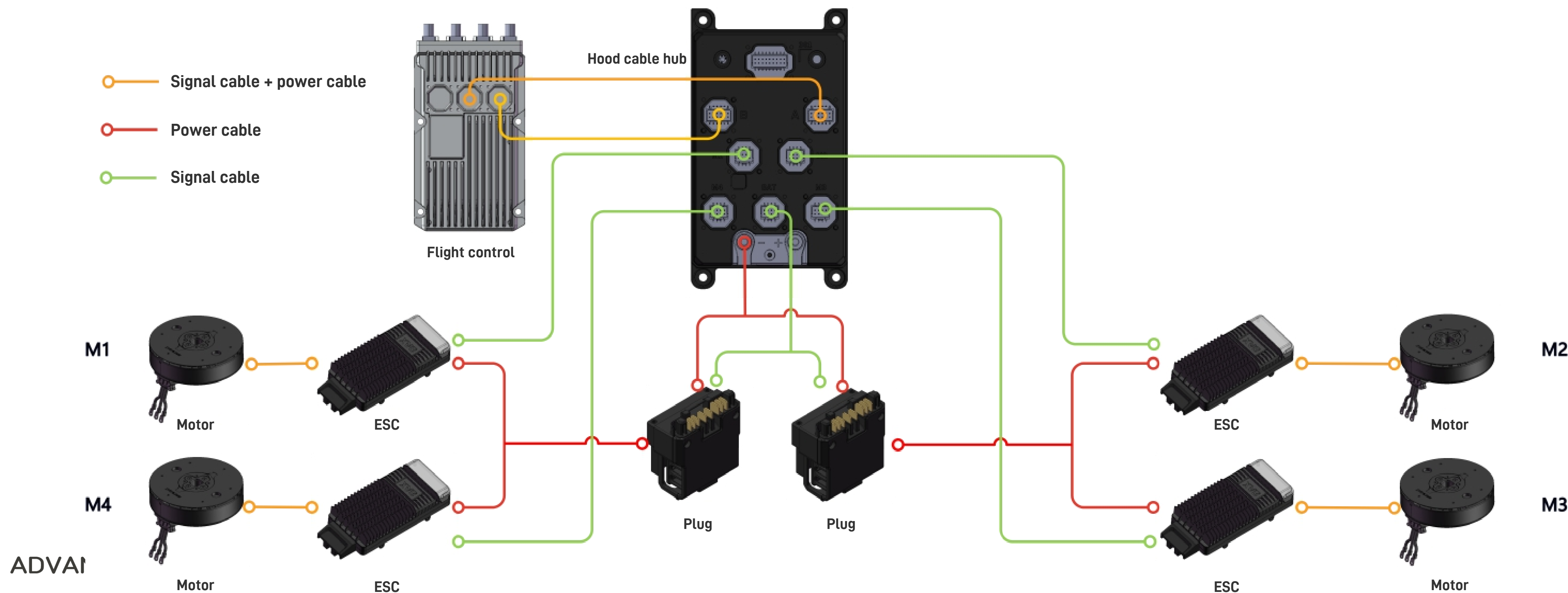
Sensor System

- The sensor system mainly includes the following modules: Pilot Sight Livestream camera, terrain radar, 4D imaging radar and LED light unit.



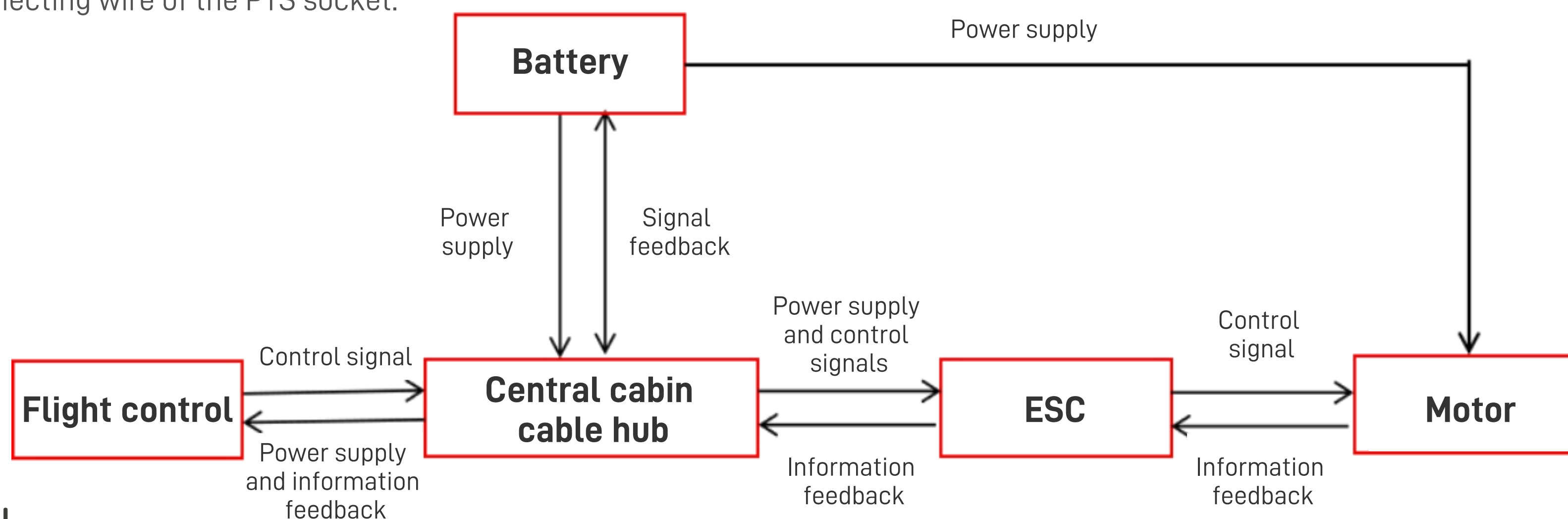
Propulsion System

- The propulsion system of the agricultural drone is mainly composed of the cable hub, main ESC, main motor and propeller and provides power output for the drone. Among them, the cable hub is responsible for distributing the flight control signal and battery current to the ESC; the ESC is responsible for controlling the magnitude of the motor current and the motor speed according to the flight control signal; while the motor is responsible for driving the propeller to rotate, generating lift to enable the drone to fly.



Propulsion System

- The control of the propulsion system in the XAG 2024 Agricultural Drones is mainly realized through two links. One is the power output link, which distributes power to each motor, so that the motor drives the propeller to make the drone fly; the other link is the signal transmission link, which allows the flight control to obtain the status information of the ESC and send the control information to the ESC at the same time, and the ESC adjusts the motor speed to change the drone's flight attitude.
- Power output link:** The battery serves as the power source for the flight of the drone. First, the battery supplies power to the power distribution cable hub through the battery plug, and the power distribution cable hub distributes the current to each ESC through the Y-cable connection, and then the ESC transmits the current to the motor to drive the motor to rotate.
- Signal transmission link:** The flight control transmits the control signal to the cable hub through the connecting wire of the PTS socket, and the cable hub distributes the power signal of each ESC to the corresponding ESC, and the ESC will control the motor speed by adjusting the output current; Flight control acts as the flight controller of the drone and requires real-time access to parameters of the propulsion system. The current, motor speed, ESC power, temperature and other information are fed back to the flight control through the connecting wire of the PTS socket.



Introduction to Propulsion System Module

Cable Hub

- It is mainly used to supply power to the flight control and application system, and can distribute the control signal of the flight control to the ESC and collect the feedback information of the ESC for the flight control.



Introduction to Propulsion System Module

Main ESC

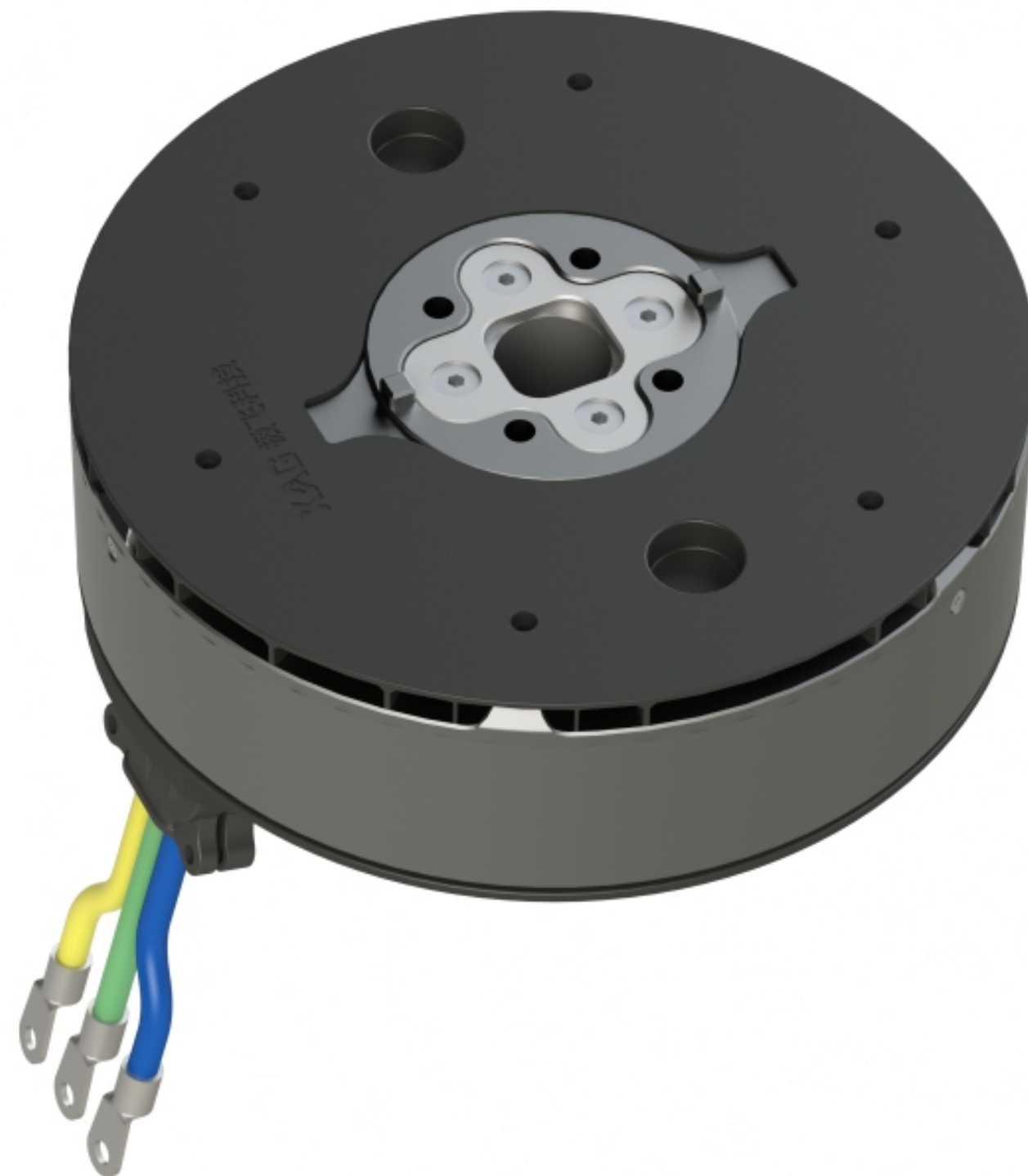
- The ESC based on field-oriented control (also called vector control) is a technique that uses a variable frequency drive (VFD) to control three-phase AC motors. It controls the power output of the motor by adjusting the output frequency, as well as the magnitude and angle of the output voltage of the VFD.



Introduction to Propulsion System Module

Main motor

- The XAG 2024 Agricultural Drones adopt brushless DC motors. These motors are provided with semiconductor switching elements for electronic commutation, instead of traditional contact commutators and electric brushes.



Introduction to Propulsion System Module

Propeller

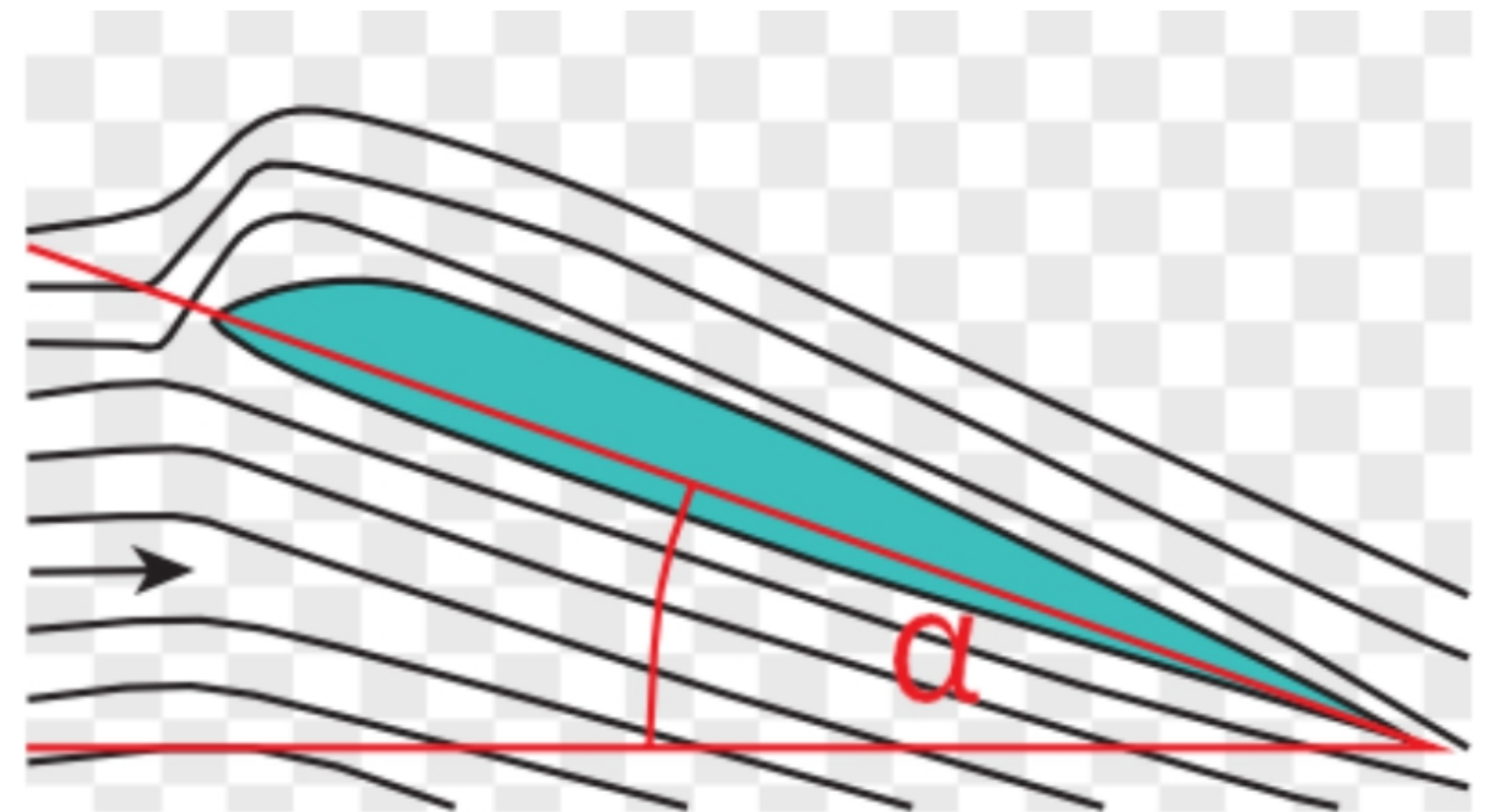
- The P150 2024 Agricultural Drone features foldable propellers and utilizes 63-inch high-performance blades, while the P60 utilizes 60-inch high-performance blades.



Propulsion System

Principle of drone lift

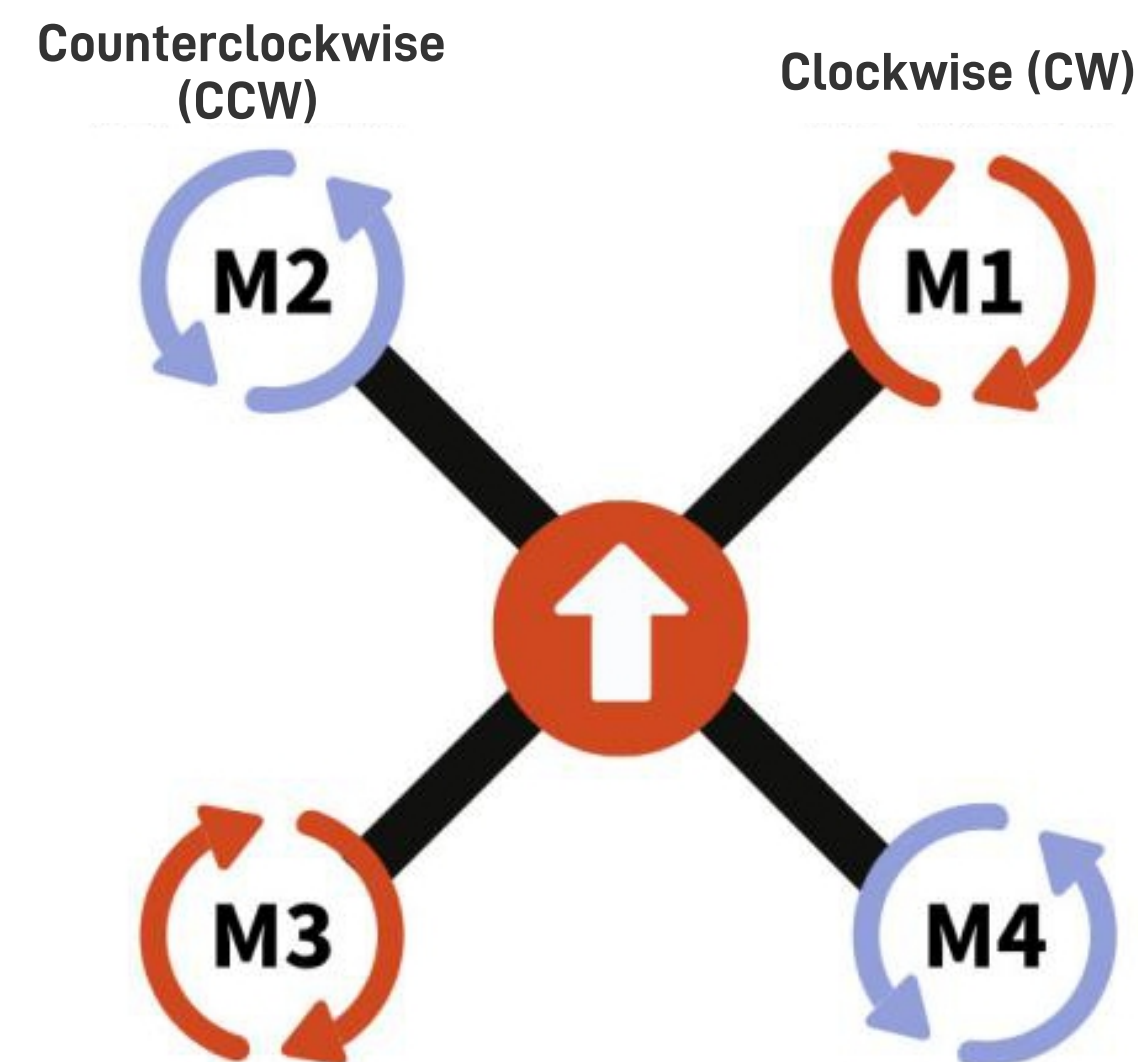
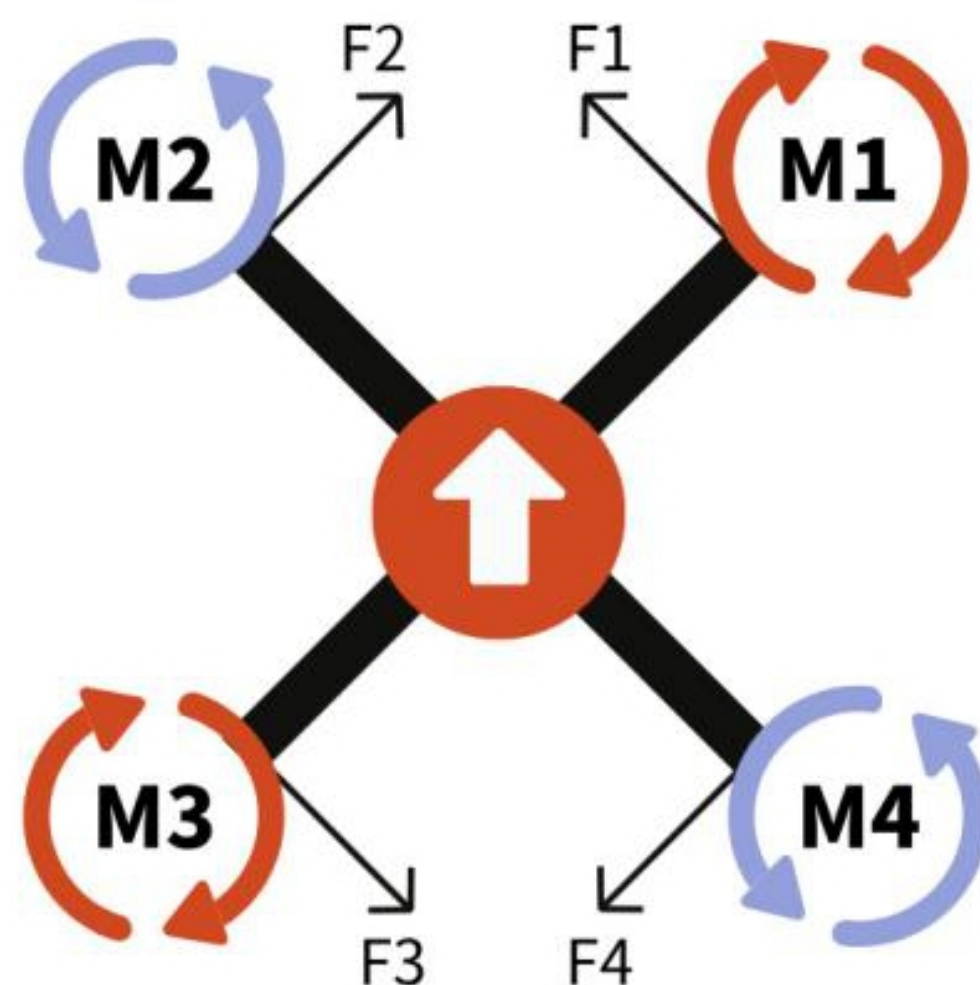
- Lift refers to the upward force generated on an object moving through a fluid (such as air) due to the pressure difference exerted by the fluid on the object. For drones, lift is mainly generated by their wings. When the air contacts the wings of the drone, it will create different flow velocities and pressures on the upper and lower surfaces of the wings, thus generating lift.
- As shown in the right figure, the rotating propeller has an angle of attack α relative to the air (the propeller typically rotates along the direction of the angle of attack, which can be used to determine the propeller's rotation direction). At this time, the air flow velocity on the upper curved surface of the propeller is high, resulting in low pressure, while the air flow velocity on the lower flat surface is slow, resulting in high pressure. This creates a pressure difference between the upper and lower surfaces of the propeller, generating an upward aerodynamic force that supports the drone's flight.



Propulsion System

Propeller arrangement principle

- In the P-series agricultural drone, the propellers are arranged symmetrically at four corners. The counterclockwise-rotating propeller is called a counterclockwise propeller (CCW), while the clockwise-rotating propeller is called a clockwise propeller (CW). The propellers driven by the M2 and M4 motors are counterclockwise propellers, while those driven by the M1 and M3 motors are clockwise propellers.
- When a drone flies normally, according to Newton's third law of motion - action and reaction, the motor drives the propeller to rotate, and the propeller also brings a torque opposite to the rotation direction to the motor, as shown in the figure. Since the motors are fixed on the arms, this counter-torque acts on the arms. When the counter-torques are balanced (F1, F2, F3, and F4 cancel each other out), the drone's heading remains stable.



Propulsion System

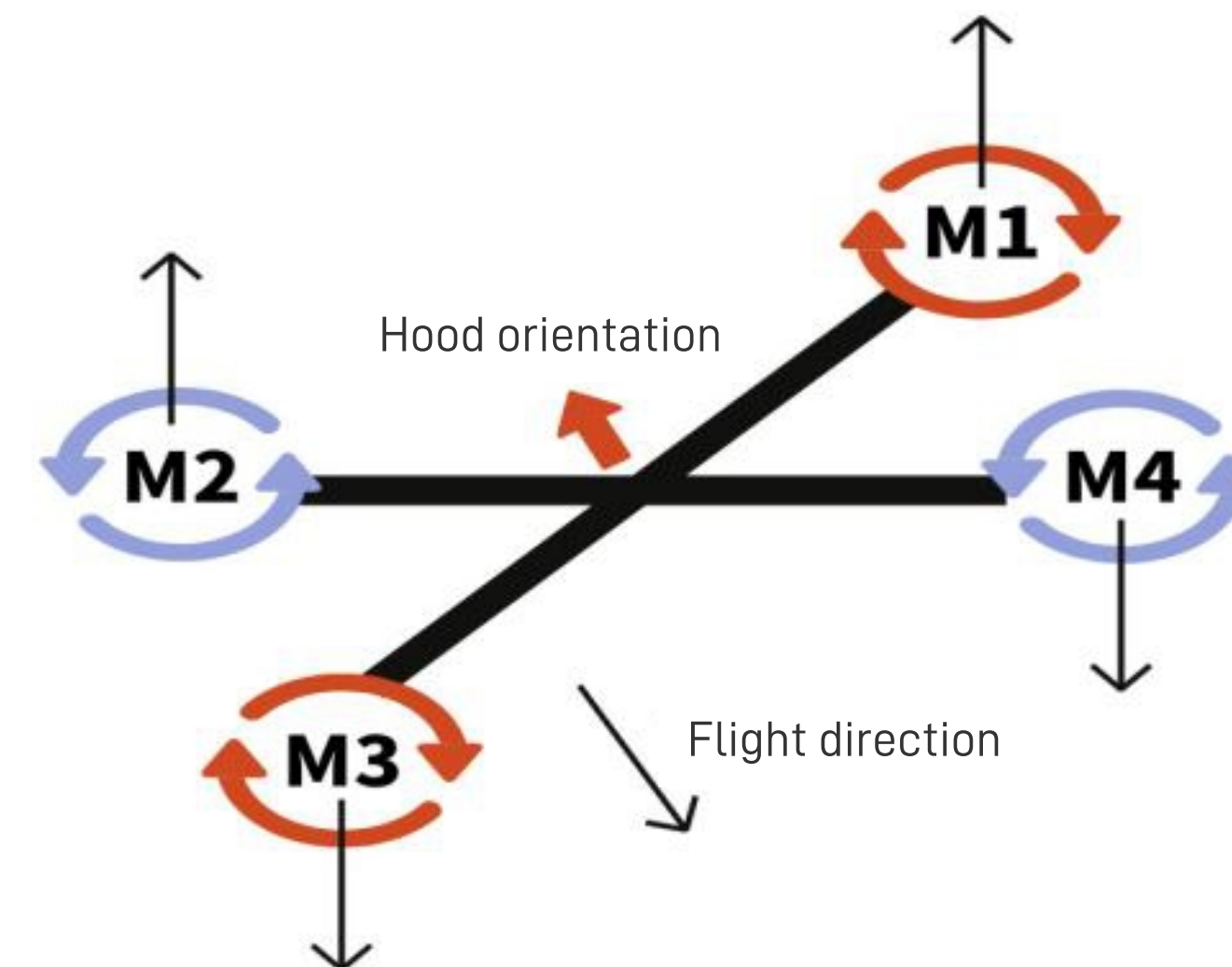
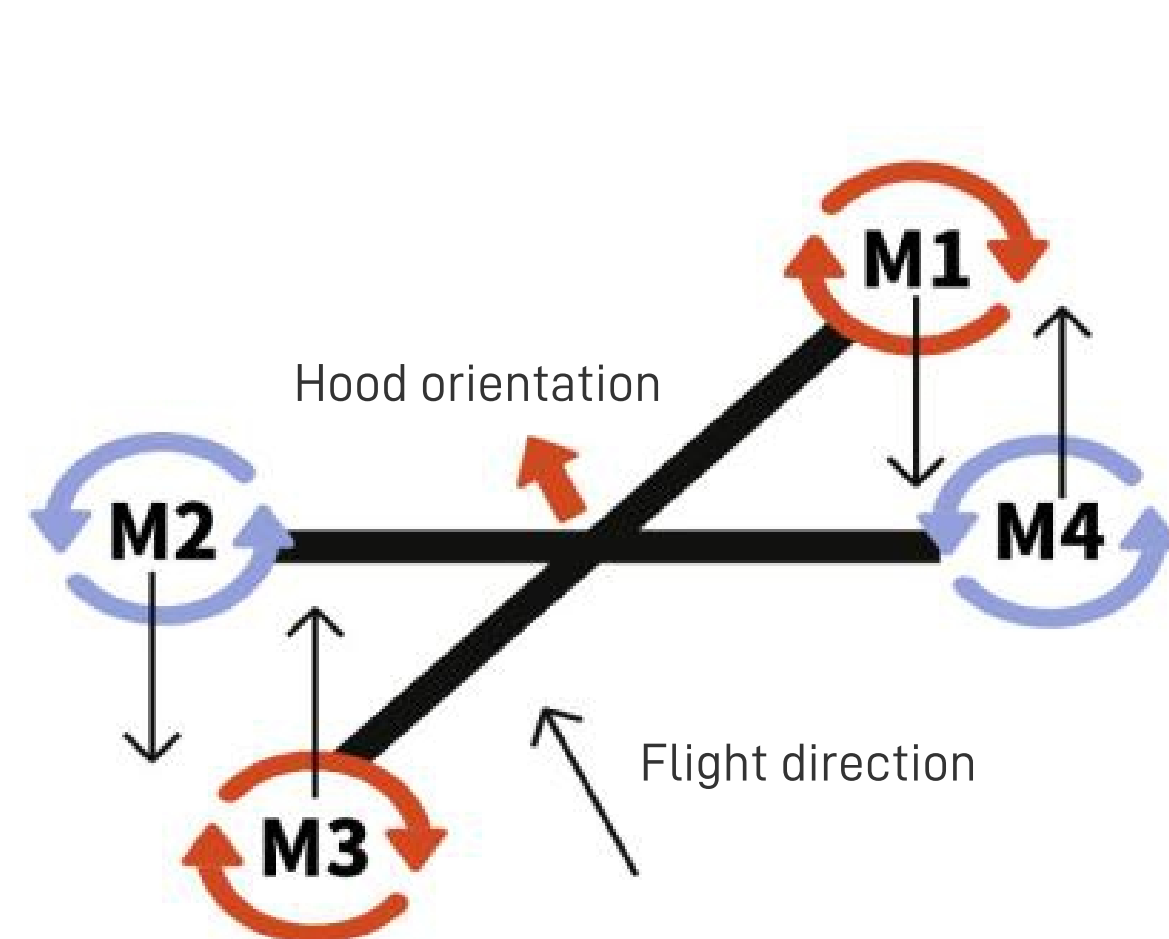
Drone attitude control principle - ascending and descending

- The P-series drone adjusts the rotational speed of its four motors to change the rotor speed, thereby altering the lift and controlling the drone's attitude and position.
- For the P150 and P60 agricultural drones, when the vertically upward lift equals the drone's weight, the drone maintains a constant altitude; when the vertically upward lift exceeds the drone's weight, the drone ascends; when the vertically upward lift is less than the drone's weight, the drone descends.

Propulsion System

Principle of drone attitude control - forward and backward motion

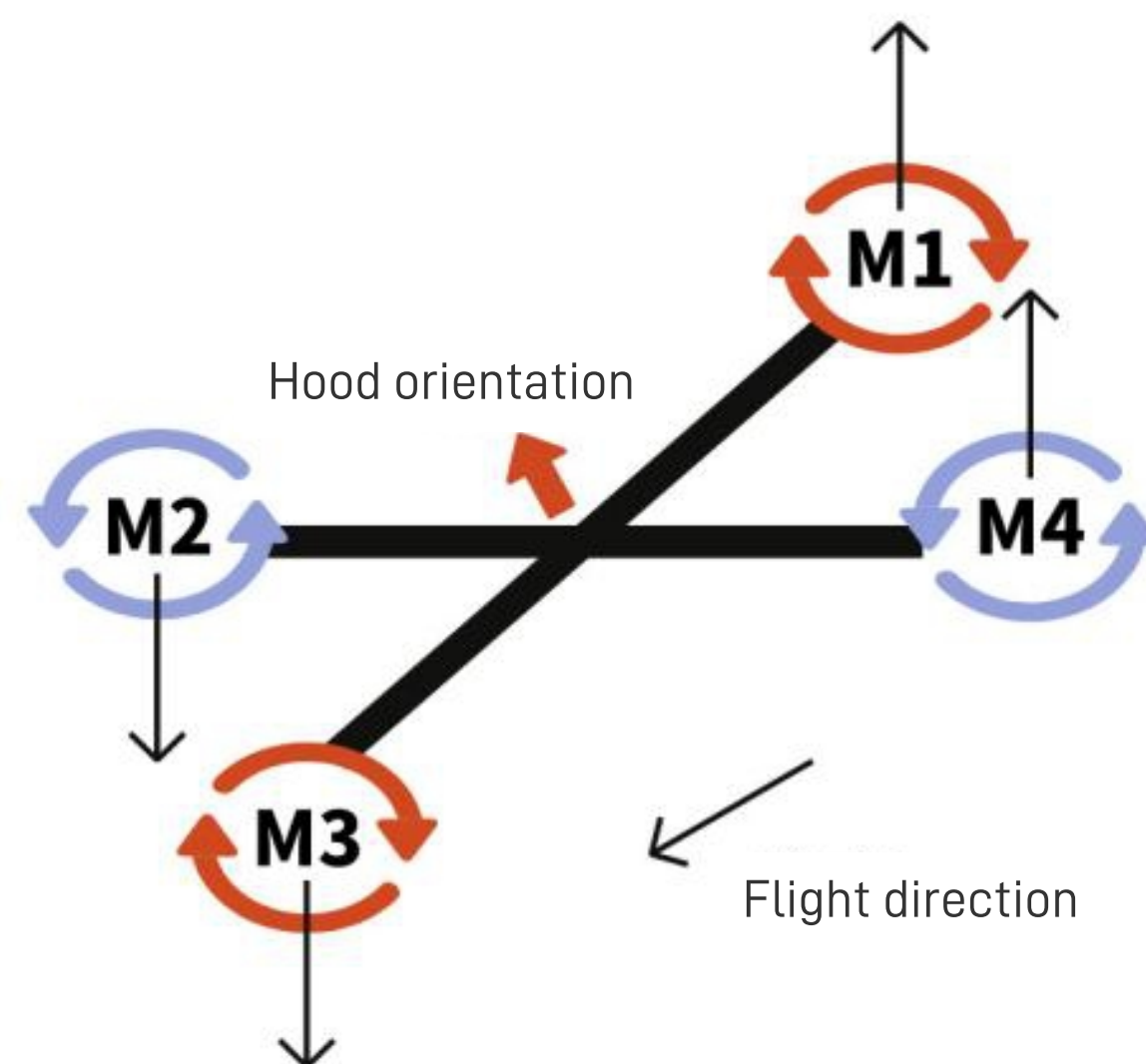
- For the P150 agricultural drone, when the rotational speed of the M3 and M4 motors is greater than that of the M1 and M2 motors, the front side of the drone tilts downward. At this time, the lift F perpendicular to the propeller's rotational plane also tilts, generating a vertical component F_1 and a horizontal component F_2 . The vertical component F_1 balances the drone's weight, while the horizontal component F_2 pulls the drone forward.
- For the P150 agricultural drone, when the rotational speed of the M1 and M2 motors is greater than that of the M3 and M4 motors, the rear side of the drone tilts downward. At this time, the lift F perpendicular to the propeller's rotational plane also tilts, generating a vertical component F_1 and a horizontal component F_2 . The vertical component F_1 balances the drone's weight, while the horizontal component F_2 pulls the drone backward.



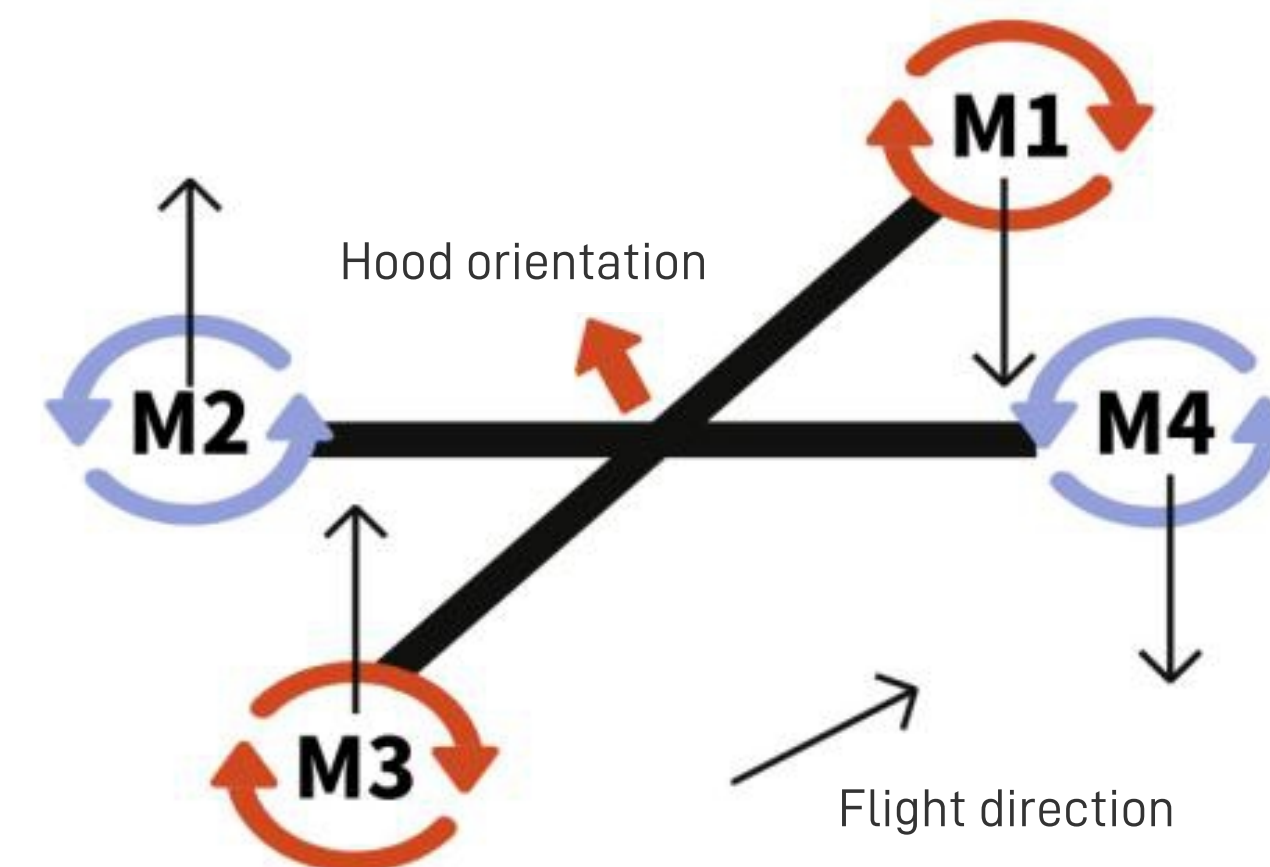
Propulsion System

Drone attitude control principle - left and right motion

- For the P150 agricultural drone, when the rotational speed of the M1 and M4 motors is greater than that of the M2 and M3 motors, the left side of the drone tilts downward. At this time, the lift F perpendicular to the propeller's rotational plane also tilts, generating a vertical component F_1 and a horizontal component F_2 . The vertical component F_1 balances the drone's weight, while the horizontal component F_2 pulls the drone to the left.
- For the P150 agricultural drone, when the rotational speed of the M2 and M3 motors is greater than that of the M1 and M4 motors, the right side of the drone tilts downward. At this time, the lift F perpendicular to the propeller's rotational plane also tilts, generating a vertical component F_1 and a horizontal component F_2 . The vertical component F_1 balances the drone's weight, while the horizontal component F_2 pulls the drone to the right.



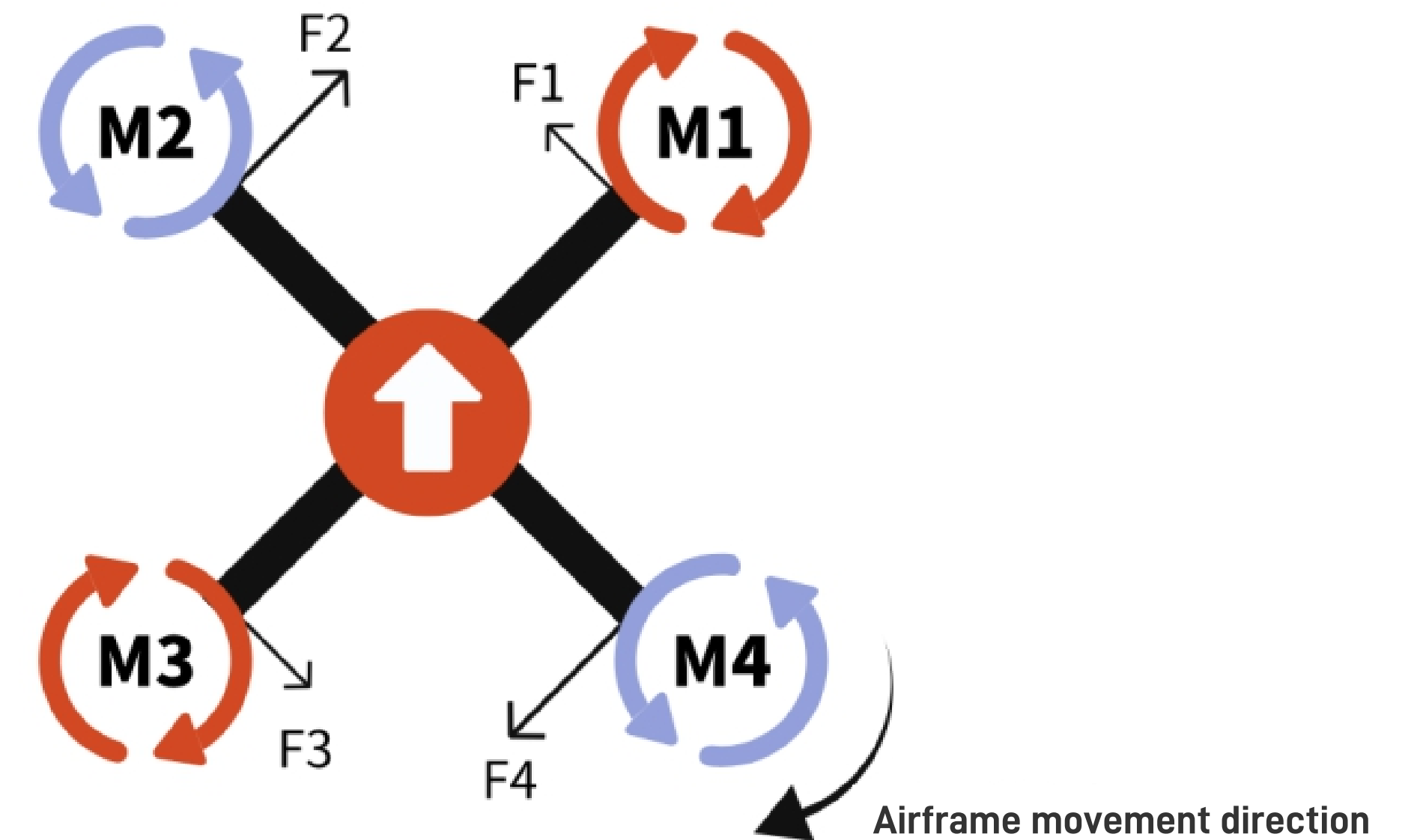
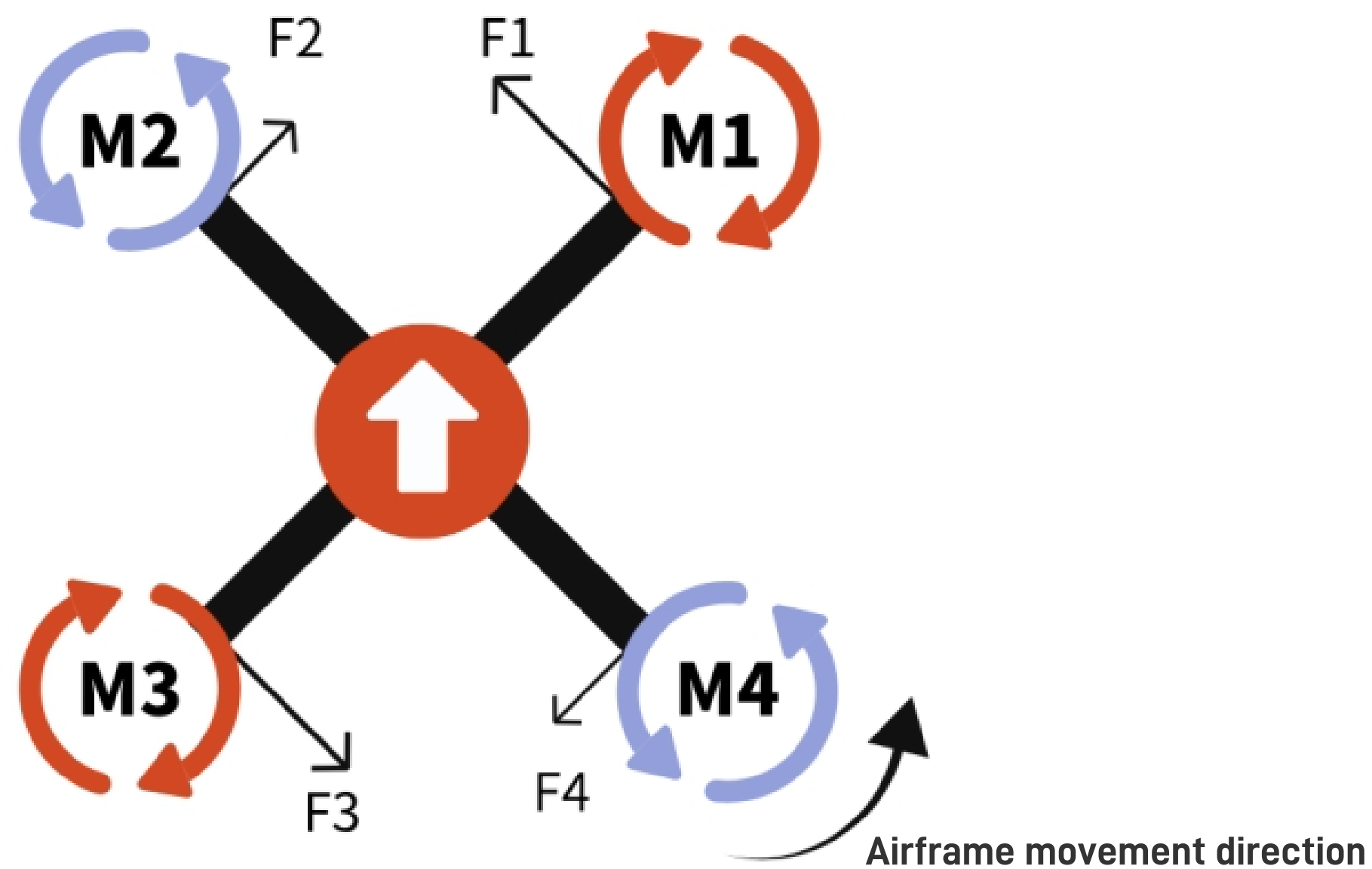
XA.COM



Propulsion System

Principle of drone attitude control - spin motion

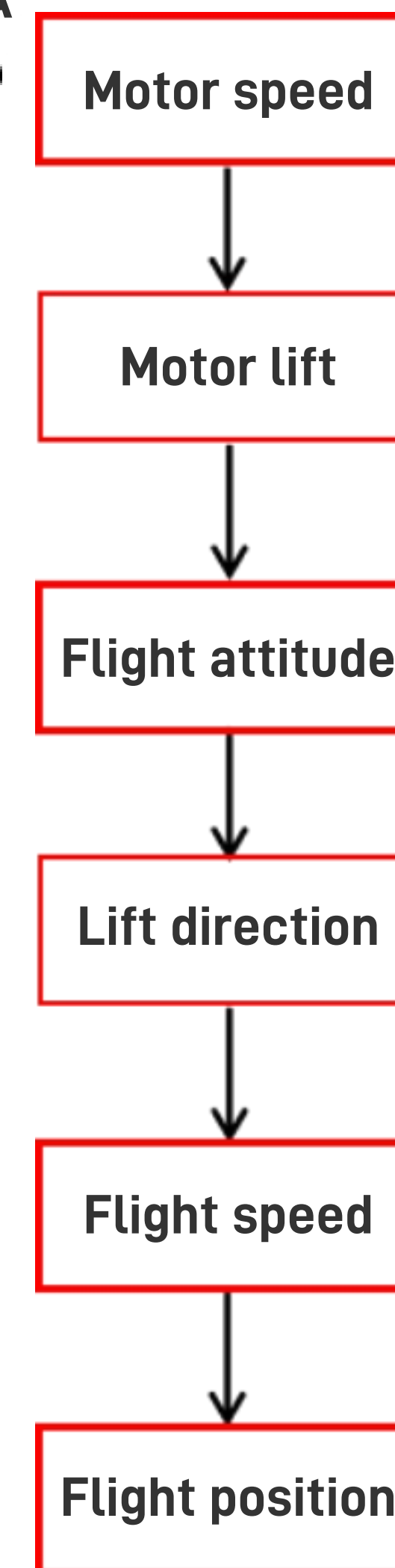
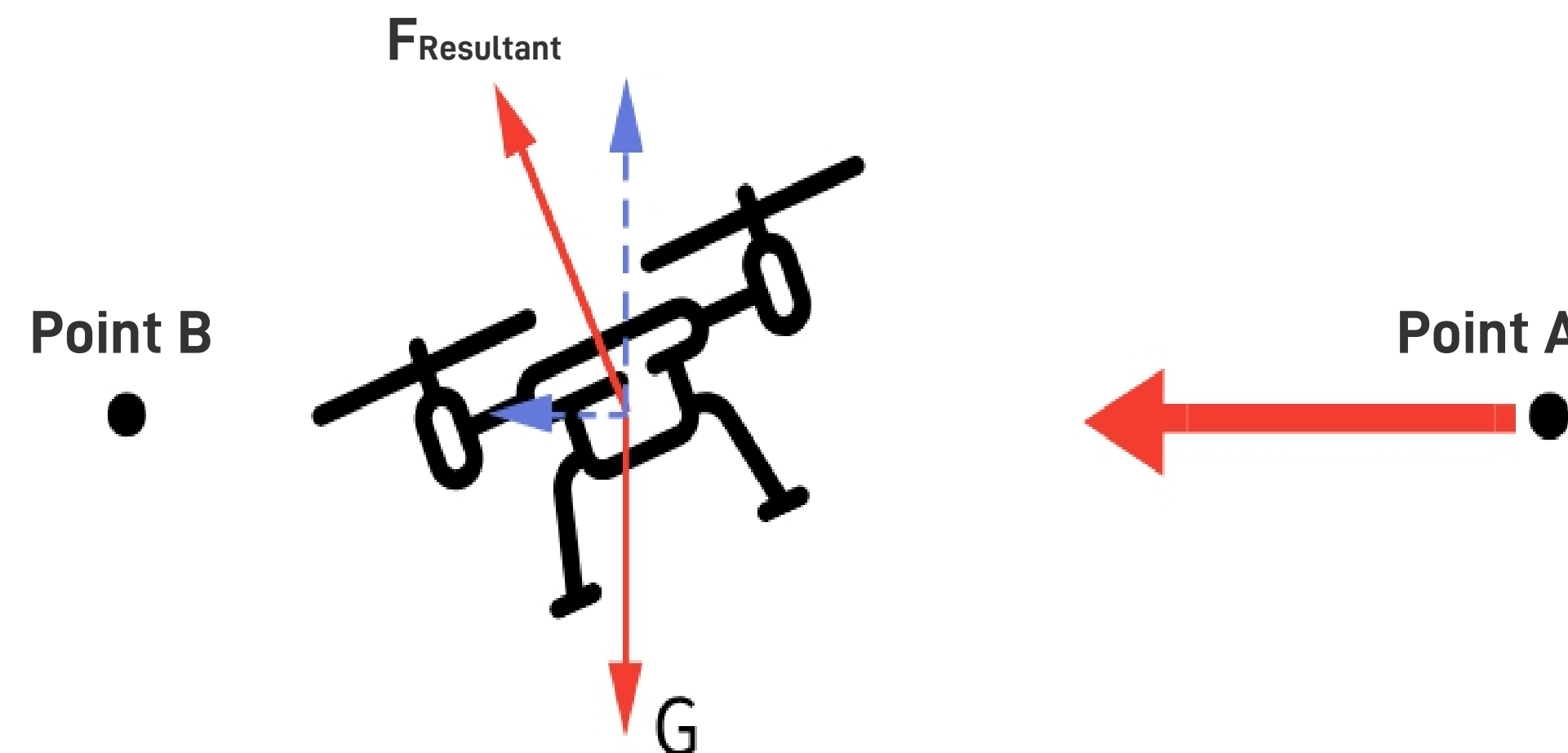
- When the overall rotational speed of the M1 and M3 motors is higher than that of the M2 and M4 motors, the combined force of F1 and F3 is greater than that of F2 and F4, causing the drone to rotate counterclockwise.
- When the overall rotational speed of the M2 and M4 motors is higher than that of the M1 and M3 motors, the combined force of F2 and F4 is greater than that of F1 and F3, causing the drone to rotate clockwise.



Propulsion System

Integrated motion flight control

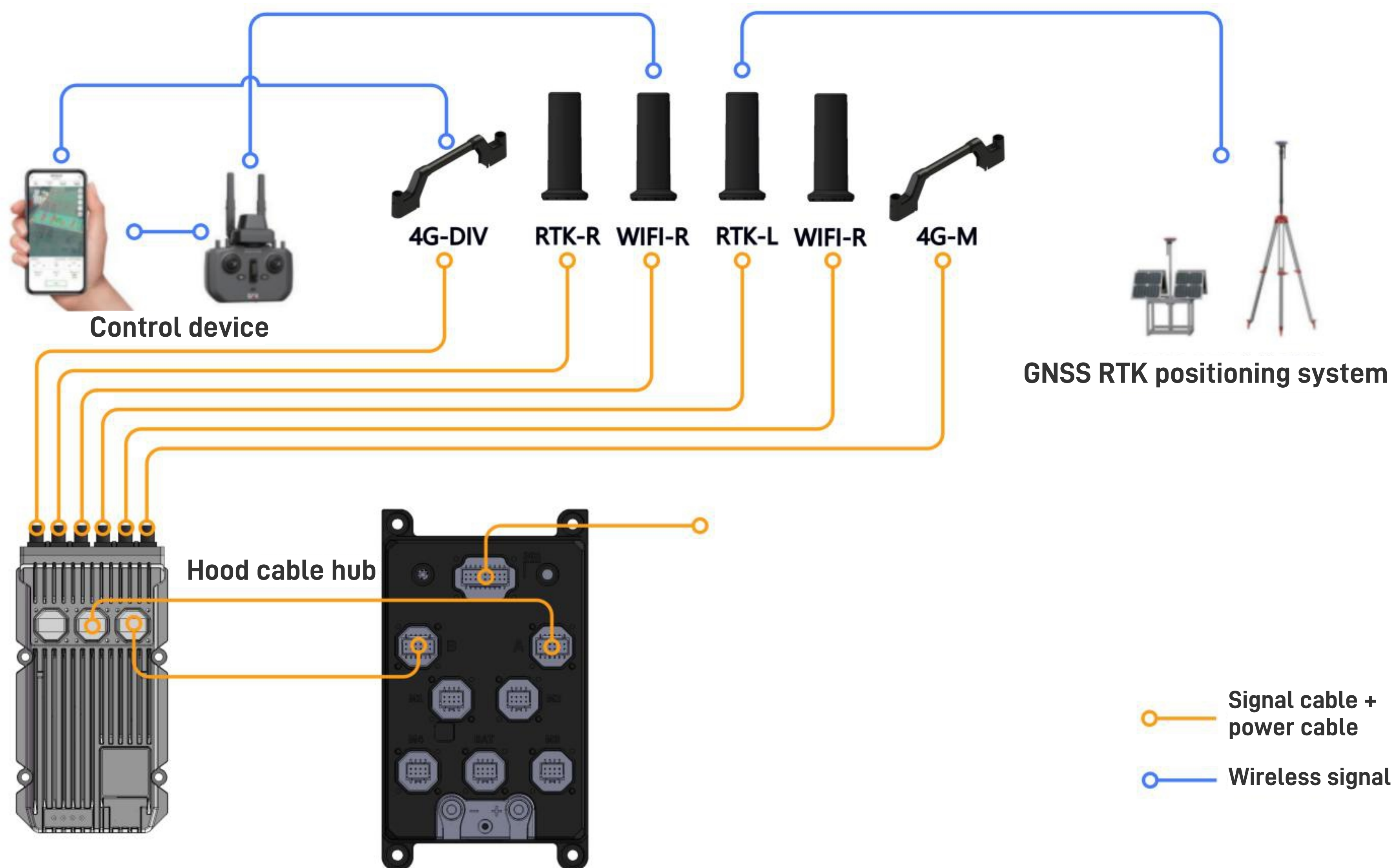
- When the drone needs to fly from point A to point B, the motion process of the drone is as follows:
- Adjust the motor speeds so that the two motors closer to point A rotate faster than the two motors closer to point B.
- The difference in motor speeds results in a change of motor lift difference, with the side closer to point A generating more lift than the side closer to point B.
- The change of motor lift difference causes a change in the drone's attitude, which results in tilting the side closer to point B downward.
- The change in attitude alters the direction of the total lift (as shown in Figure 1, the direction of the lift $F_{\text{Resultant}}$ tilts toward point B), generating a horizontal component of force. Simultaneously, the overall motor speeds are adjusted to maintain a constant vertical component of force (balancing the drone's weight).
- The horizontal component of force creates a horizontal acceleration, which in turn generates a horizontal velocity, ultimately changing the drone's position and enabling it to move from point A to point B.



GPS System

Working principle of RTK

- The RTK positioning system consists of a rover, a portable station, and a fixed station. It provides centimeter-level high precision positioning for field mapping and drone flight operations, enabling both centimeter-level route planning accuracy and flight along centimeter-level high-precision routes. The drone is equipped with a dual-antenna RTK module, where two antennas operate simultaneously, ensuring a high level of flight safety.



Power System

Smart battery

- The Smart Battery mainly provides power for the flight of drones, with the motors relying on it for operation. It also supports the flight control system, video transmission system, RTK antenna, and other electronic components, ensuring the normal operation of all systems.



Power System

Mist cooling box

- In farm operations, the charging efficiency of drones is particularly important. The water mist cooling solution enables the drone batteries to be charged immediately upon landing, significantly improving operational efficiency.



Power System

Supercharge station

- The XAG GC4000+ Auto SuperCharge Station consists of several major modules, including a generator frame, fuel tank, engine assembly, engine controller, and charge controller. The SuperCharge Station can convert the chemical energy of gasoline into electrical energy in field conditions without access to utility power, enabling efficient and rapid charging for XAG's Smart SuperCharge Battery.



Power System

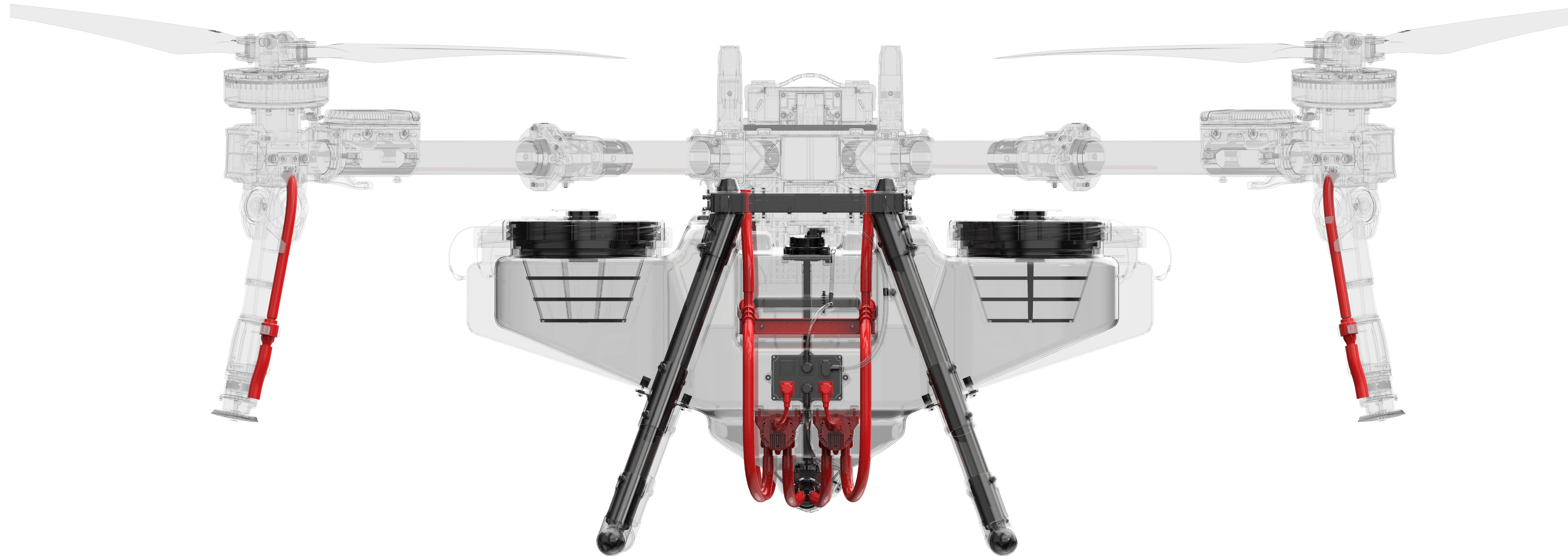
Charger

- The XAG charger features a wide-voltage, self-cooling design and includes functions such as under-voltage protection, over-voltage protection, over-temperature protection, and fault isolation. As a medium-power charger, it can monitor the status information of all smart batteries in real time during the charging process.



Spraying System

- The spraying system of the P150 agricultural drone consists of a liquid tank, spray tubes, a flexible impeller pump, and centrifugal nozzles and continues to use XAG's leading intelligent centrifugal atomization technology to atomize the liquid to the optimal droplet size, thus to improve the pesticide utilization.



Spraying System

Flexible impeller pump

- The flexible impeller pump operates by driving the liquid to rotate at high speed through the working impeller, transferring mechanical energy to the liquid, thereby achieving the purpose of liquid transportation. The impeller of the pump is installed inside the pump housing and is driven by the impeller pump motor to rotate the pump shaft. The liquid enters the pump through the inlet pipe, is accelerated and transported by the rotation of the impeller, and is finally discharged from the pump outlet.



Spraying System

Centrifugal atomizing nozzle

- The centrifugal nozzle consists of a centrifugal motor and a centrifugal spray disc. The motor provides the centrifugal force for atomization, delivering high torque during high-speed rotation. The centrifugal spray disc provides an acceleration channel, ensuring that water droplets do not spill while passing through the channel, thereby achieving effective atomization.



Spraying System

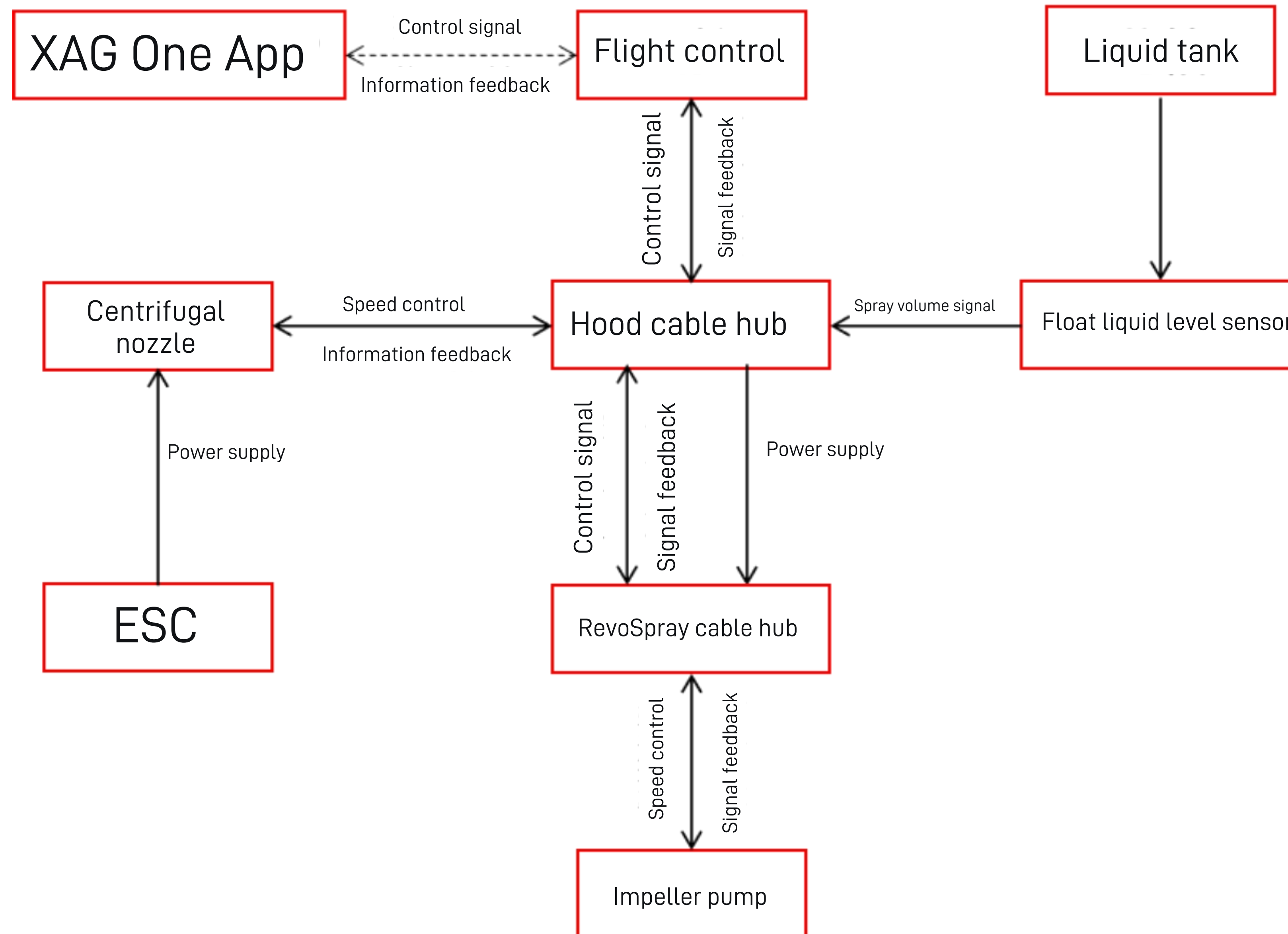
RevoSpray system liquid transfer process

The RevoSpray system primarily achieves its functionality through two links. One is the liquid tank circulation link: a link through which the liquid flows from the liquid tank to the nozzle. The other is the spray control link: a link that controls the spray volume and coverage of the drone to ensure precise spraying. Liquid tank circulation link: through the pressure effect, the liquid in the liquid tank enters two impeller pumps. The liquid passes through the impeller pumps, passes through the check valve and flows into the nozzle, where it is sprayed out.



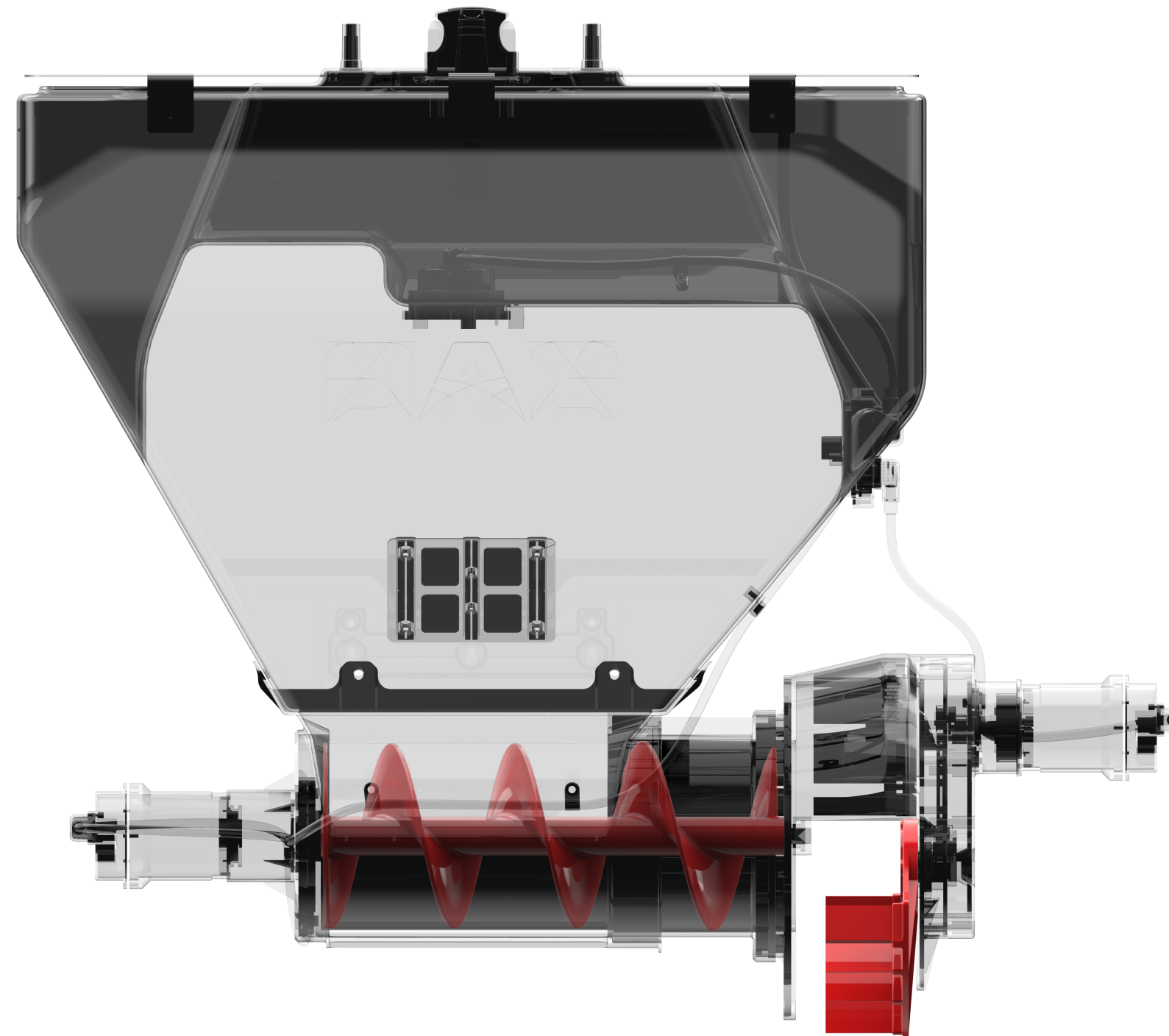
Spraying System

RevoSpray system signal transfer process



Spreading System

- P150 Spreading System is mainly composed of: a granule container, a screw feeder and a spreading disc. It can precisely spread seeds and solid granules to the desired positions. The screw feeder design allows for even distribution of the granules being spread on the ground without clumping or adhesion, meeting the needs of precise spreading.



Spreading System

Granule level sensor

- It is used to assist the seeding system in judging the granule condition in the granule container.



Spreading System

Screw feeder

The screw feeder features a spiral structure and is available in large, medium, and small sizes. Whenever the screw feeder rotates, it pushes the solid granules inside the screw feeder to the spreading disc. By controlling the rotation speed of the screw feeder, the amount required for each spreading can be precisely controlled.



Screw feeder motor

Parameter Specification of Corresponding Screw Feeder Models of 2024 XAG RevoCast 4			
Model			
	Large-sized screw feeder (L)	Medium-sized screw feeder (M)	Small-sized screw feeder (S)
Pushing speed	P150:74.6~280kg/min P60:50.6~190kg/min	1.9-40kg/min	0.25-5.3kg/min
Granule parameter	Suitable for granules with a diameter of 1-10mm	Suitable for granules with a diameter of 1-6mm	Suitable for granules with a diameter of 1-3mm
Example	Fertilizers, shrimp feed, etc.	Rice seed, powder, etc.	Rapeseed, etc.
			

THE END

