Unmanned Aerial Vehicle

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Robotic Hardware System

History

Unmanned Aerial Vehicle

- The earliest recorded use of an unmanned aerial vehicle for warfighting occurred in 1849. Significant development of drones started in the 1900s, and originally focused on providing practice targets for training military personnel. Development continued during World War I, when the Dayton-Wright Airplane Company invented a pilotless aerial torpedo.

History

Unmanned Aerial Vehicle

- In 1940 Denny started the Radioplane Company and more models emerged during World War II – used both to train antiaircraft gunners and to fly attack-missions. Nazi Germany produced and used various UAV aircraft during the war, like the Argus As 292 and V-1 flying bomb with a jet engine.

History

Unmanned Aerial Vehicle

- After World War II development continued in vehicles such as the American JB-4 and Teledyne Ryan Firebee I. In 1959 the U.S. Air Force began planning for the use of uncrewed aircraft. Planning intensified after the Soviet Union shot down a U-2 in 1960. In 1973 the U.S. military confirmed that they had been using UAVs in Southeast Asia. The USAF 100th Strategic Reconnaissance Wing flew about 3,435 UAV missions during the Vietnam War. During the 1973 Yom Kippur War, Israel developed the first UAV with real-time surveillance.

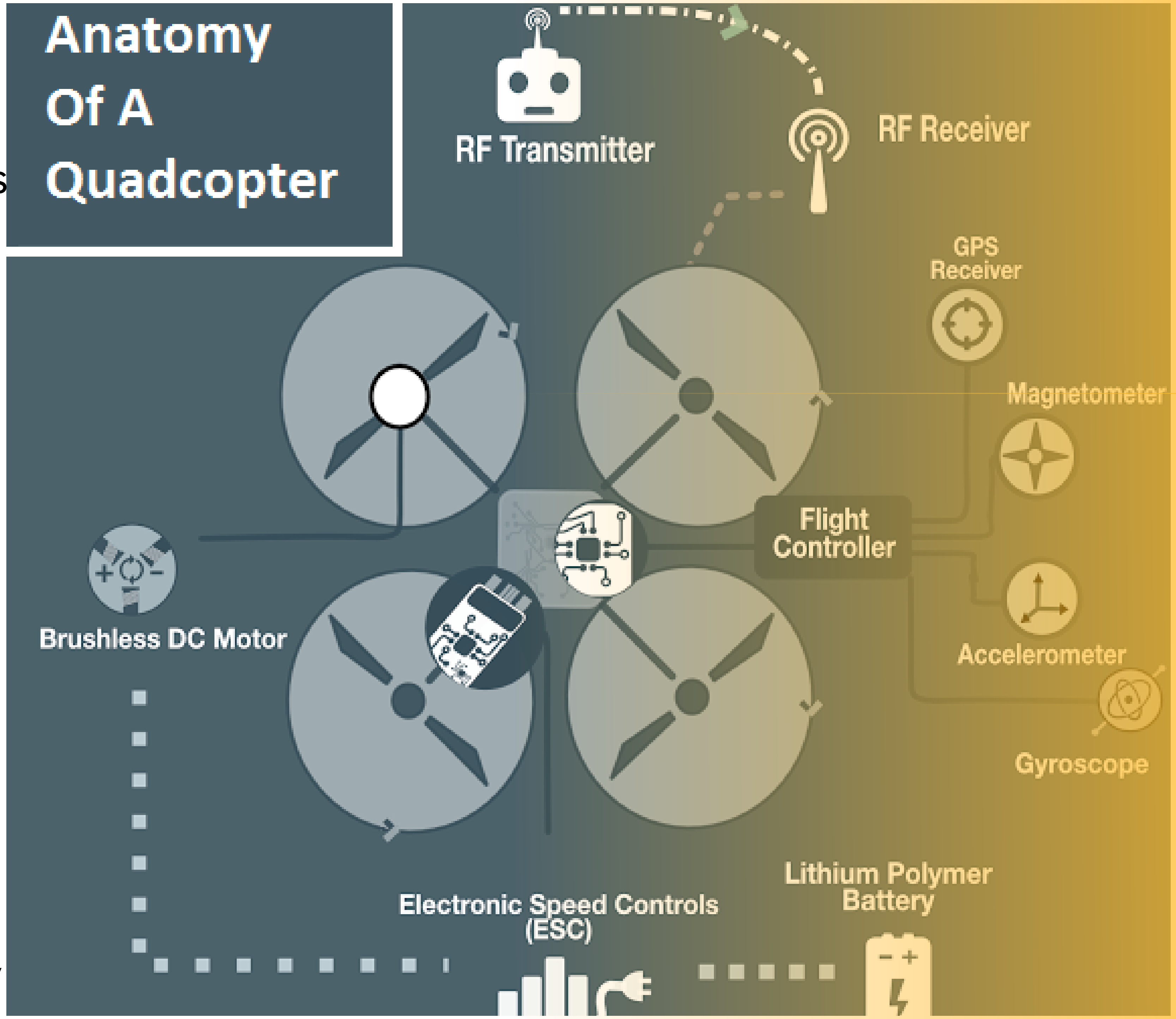
History

Unmanned Aerial Vehicle

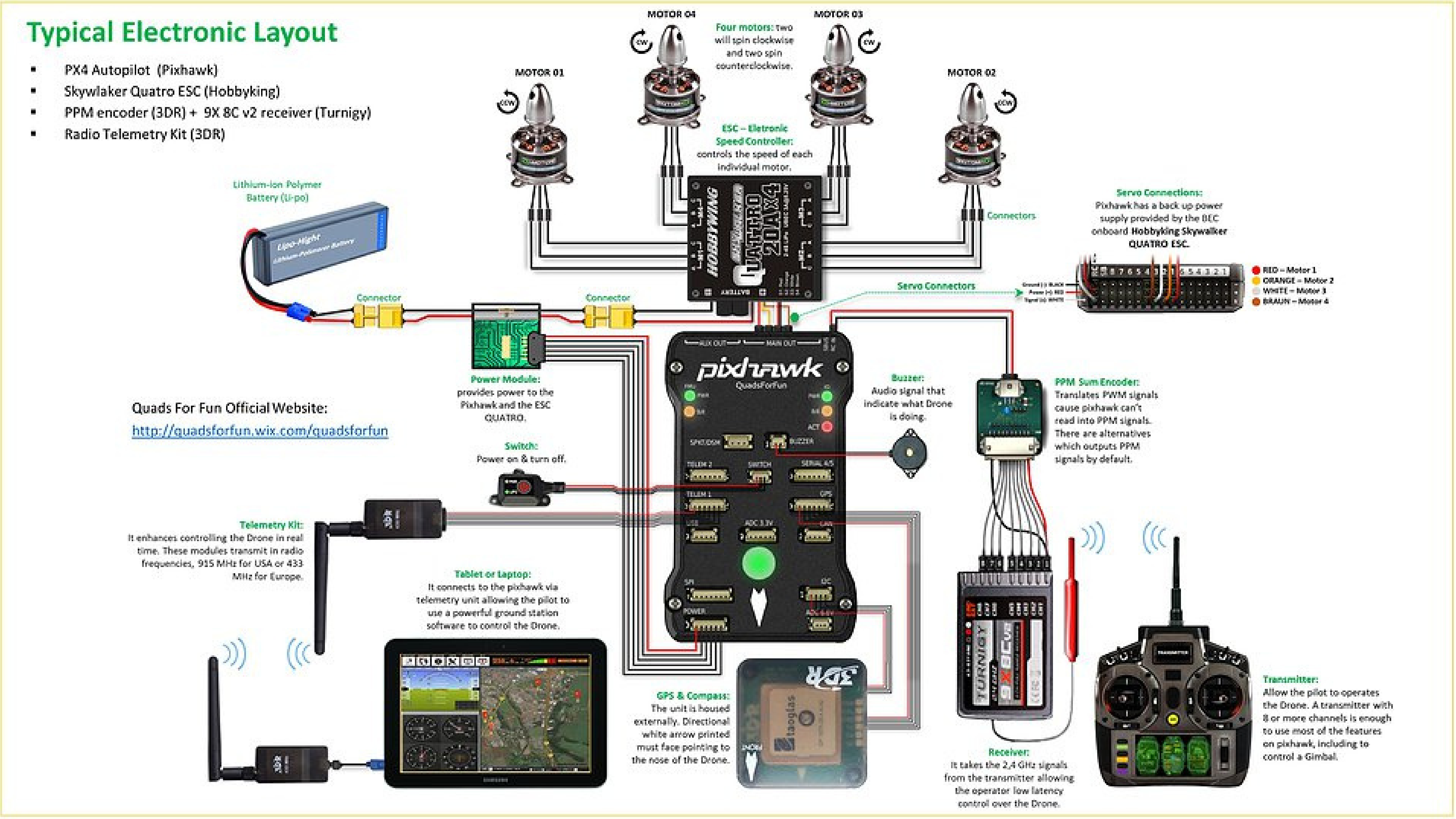
- Interest in unmanned aerial vehicles (UAVs) grew in the 1980s and 1990s. As of 2012, the United States Air Force employed 7,494 UAVs – almost one in three USAF aircraft. The use of drones in commercial and general aviation is limited by a lack of autonomy and regulatory environments.

Basic System Architecture

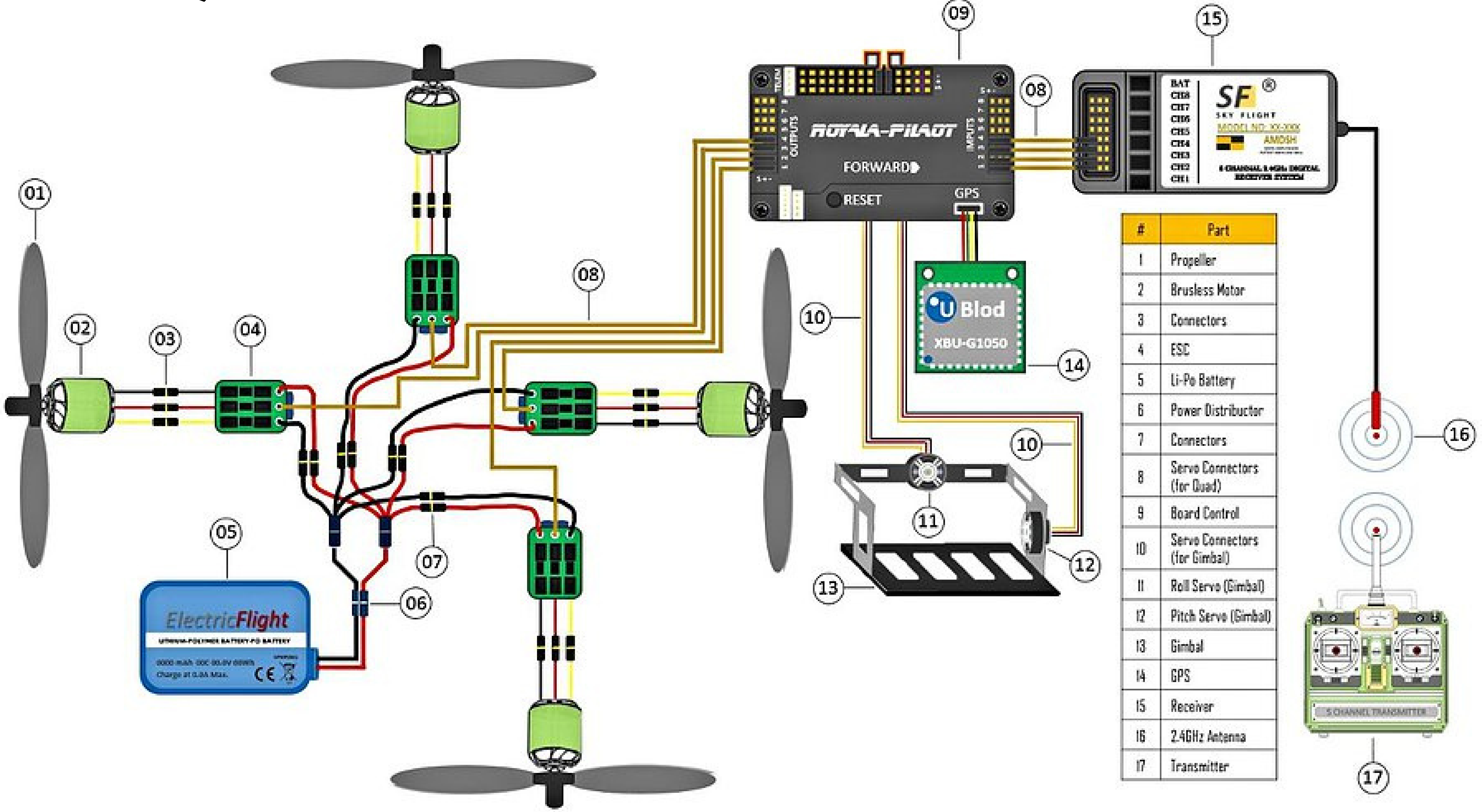
A UAV operates in 6 degrees of freedom and must be able to communicate movement information for each of those dimensions. UAVs have a unique requirement of needing to distinguish between a ground reference frame and an air reference frame. UAVs require location and attitude sensing which they can get from Global Positioning Systems (GPS) and Inertial Measurement Units (IMU). A UAV requires, not only ground speed, but also air speed, angle of attack, barometric pressure, and, as airspace integration continues, it will need to sense or communicate location data with other aircraft. A UAV could use Radio Detection and Ranging (RADAR) or Automatic Dependent SurveillanceBroadcast (ADS-B) to detect other aircraft in the area for avoidance purposes. In addition to these inputs, a UAV has numerous outputs. Depending on the widely varied types of aircraft, different control surfaces need to be commanded and manipulated, as well as various types of propulsion. UAVs also typically have other peripherals that are needed to complete whatever task or mission they are currently attempting. Peripherals may include cameras, gimbals, and dropping/releasing items or ordnances.



Basic System Architecture



Basic System Architecture



#	Part
1	Propeller
2	Brusless Motor
3	Connectors
4	ESC
5	Li-Po Battery
6	Power Distributor
7	Connectors
8	Servo Connectors (for Quad)
9	Board Control
10	Servo Connectors (for Gimbal)
11	Roll Servo (Gimbal)
12	Pitch Servo (Gimbal)
13	Gimbal
14	GPS
15	Receiver
16	2.4GHz Antenna
17	Transmitter

Basic System Architecture

Brushless Motor

- The Brushless motor selection dictates the whole power system of the quadcopter, therefore it should be carefully selected. The following items are the key drivers for selecting a motor.
- kV Rating
- For multi-rotor application, a 600-1200kV motors are ideal and anything below 600kV is even better, as low kV rating translates to motor being able to handle bigger propellers, and bigger propellers means it can move more air which gets you more thrust.
- If you have 600kV motor and 3S LiPo battery to supply power, speed (rpm) of motor at no load would be 600 x 11.1(3S battery) = 6660 rpm.

Maximum current

- Max current rating is another important factor while selecting motor as the selection of ESC and battery depends on this value. The motor should be able to run on both 3S and 4S Li-Po battery.

Shaft diameter

- Shaft diameter helps you selecting propeller.
- Thrust
- In a quadcopter, the In most cases, you will see value of the thrust motor can produce with suggested prop on the vendor’s website, but if that data is not available, try the Fly Brushless link.
- If the lift required is 3000 grams, the quadcopter need to produce 2 to 3 times the thrust (ie 6000 grams thrust), leaving each motor requiring to produce about 1500 grams of thrust so that it will lift off the ground. This extra 2 times thrust is necessary to be factored into the calculation due to motor mechanical inefficiency, flight altitude and air temperature.

Weight

- To choose a motor we first need to how much weight you are planning to take, and then to work out the thrust required to lift the quadcopter. A general rule is that you should be able to provide 2 times as much thrust than the weight of the quadcopter. If the thrust provided by the motors are too little, the quad will not respond well to your control, even has difficulties to take off. But if the thrust is too much, the quadcopter might become too agile and hard to control.
- Although you can choose the motors for the weight you want to carry, it’s always a good idea to carry as little weight as possible. Lightness is very important to all aircraft because any excess weight could reduce your battery life and maneuverability.

Brushless motors are commonly used in RC. Brushless motors have three wires. These wires control the motor’s three phases. When connecting the motor to its ESC (Electronic Speed Controller), it doesn’t actually matter how you connect the wires to let it spin because you want two motors to rotate CW and other two to rotate CCW. So it is just by trial and error method you fix these wires.The wire color is normally the same – red, black and white. If it has a J-Connector, the pinout for that brushless motor must be as follows.

	COMPLETE SYSTEM ARCHITECTURE	System Connectivity, Wiring Diagram (Power/Data)
	ROBOTICS HARDWARE COMPONENTS	
1	Robot Body Design vs Tasks	Body shapes and materials use for different application (Underwater, Ground, Air, Space). Regulation, Certification and Compliant Needed?
2	Actuators/Locomotions	Types of actuator. To move the main body of the robot (Tires, motors, rotor, drivers n etc). Add on accesories to the robot (Manipulator, End Effector, Custom/Specific task, Servo, Dyanmixal Servo, DC/AC Motor, Hydraulics, Pneumatic, Linear actuator etc). Bearing, Sliders, Gears, Pulley System, Slip Ring, Linear etc)
3	Navigation System & Controller	Types of sensors/controller for perception and navigation. (Types of Computer (Edge AI, Industrial PC, PC104, DAQ, Controller) Sensor (LIDAR, Camera IR/Color/Thermal, Depth Camera, Radar, Ultrasonic, Laser, Bumper Sensor, Magnetic Guide, IMU, Encoder etc)
4	Data Collection	Types of Instruments for data collections. (Remote Sensing, Mapping, Surveillance, etc)
5	Data Transmission	Types of communication devices and protocols. Cables (Digital vs Analog, RS232/485/422, BUS, CAN, HARP, I2C, ISP, Ethernet, OPTIC etc) vs Wireless (IR, Bluetooth, WIFI, BLE, RF, Satellite, Telco 4G/5G, GPRS & etc)
6	Power System Management	Types of power supply. AC, DC cables. Batteries. Engin. Renewable Energy.

1) Robot Design Vs Task

How Drone Technology Is Changing Industries

Drones are becoming commonplace in both the commercial and non-profits sectors. In the near future their use will be even more widespread.

Here are some of the many ways unmanned aircraft can revolutionize how we get things done. It's easy to see why drone degree programs, like Cal U's two-year associate's degree are more relevant than ever.

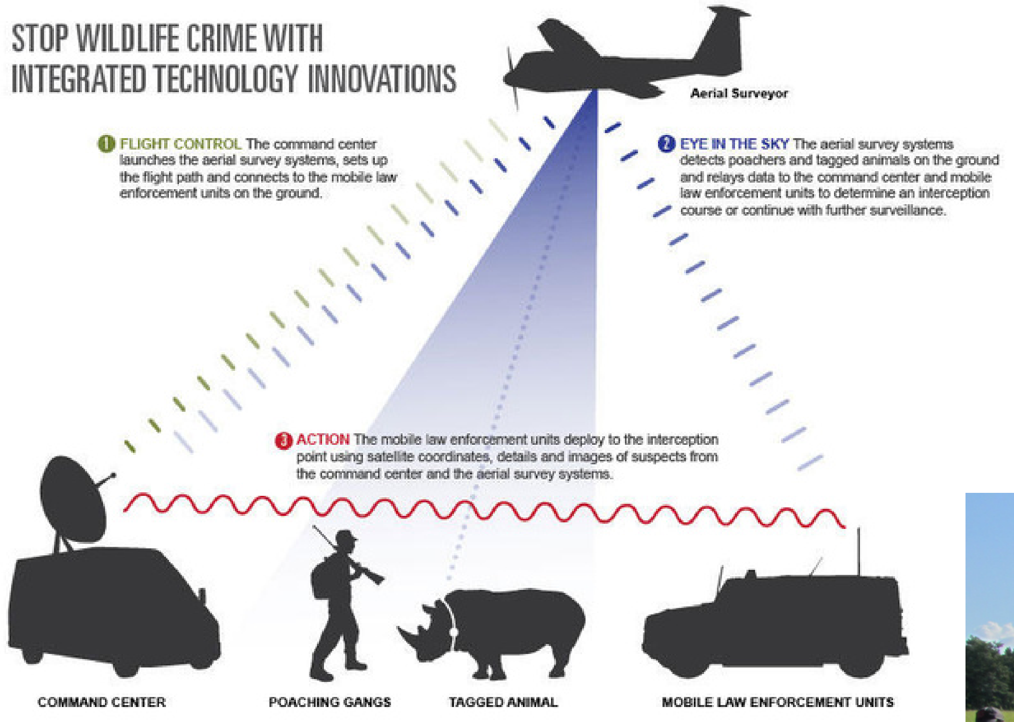
- Agriculture: The Environmental Protection Agency already utilizes drones technology to manage livestock and survey crops. In the future farmers and ranchers could use unmanned aircraft to strategically monitor and spray their crops.
- Conservation: Unmanned aircraft are being used to monitor endangered species and map the changes in various ecosystems around the globe. As drone technology advances, the use and impact of unmanned aircraft in conservation efforts will expand.
- Delivery/fulfillment: Anything the postman can carry can also be delivered by drone. Food, prescriptions, that last-minute birthday gift for your dad—in the near future, there will be big changes in the way packages arrive to our doors.
- Disaster mitigation and relief: Drones can go places that humans can't access, so they are an ideal solution for dangerous search and rescue efforts, as well as for delivering emergency supplies to remote locations and disaster areas.
- Logistics: Heavy-duty drones can replace trucks for inventory management and moving goods between warehouses. This is likely to decrease the number of semis you see on the road.
- Filmmaking and photography: Low-budget filmmakers are already using drones to capture the aerial shots and Hollywood will soon be hiring full crews of drone Unmanned aircraft are also gaining ground with photojournalists who want to capture breaking news from above.
- ISPs: Big tech companies like Facebook and Google are experimenting with solar powered drone technology to beam Internet to remote locals. This could transform connectivity as we know it.
- Law enforcement: In Seattle and Miami, police forces have already applied for permits to use drones, and we'll likely begin to see unmanned aircraft supplementing police presence at large public events.
- Real Estate: Real Estate listings are poised to change completely with high-definition videos capture by drones that fly through neighborhoods, and into every room in a listed house.

1) Robot Design vs Design

a) Agriculture drone

I) Robot Design vs Design

b) Conservation drone

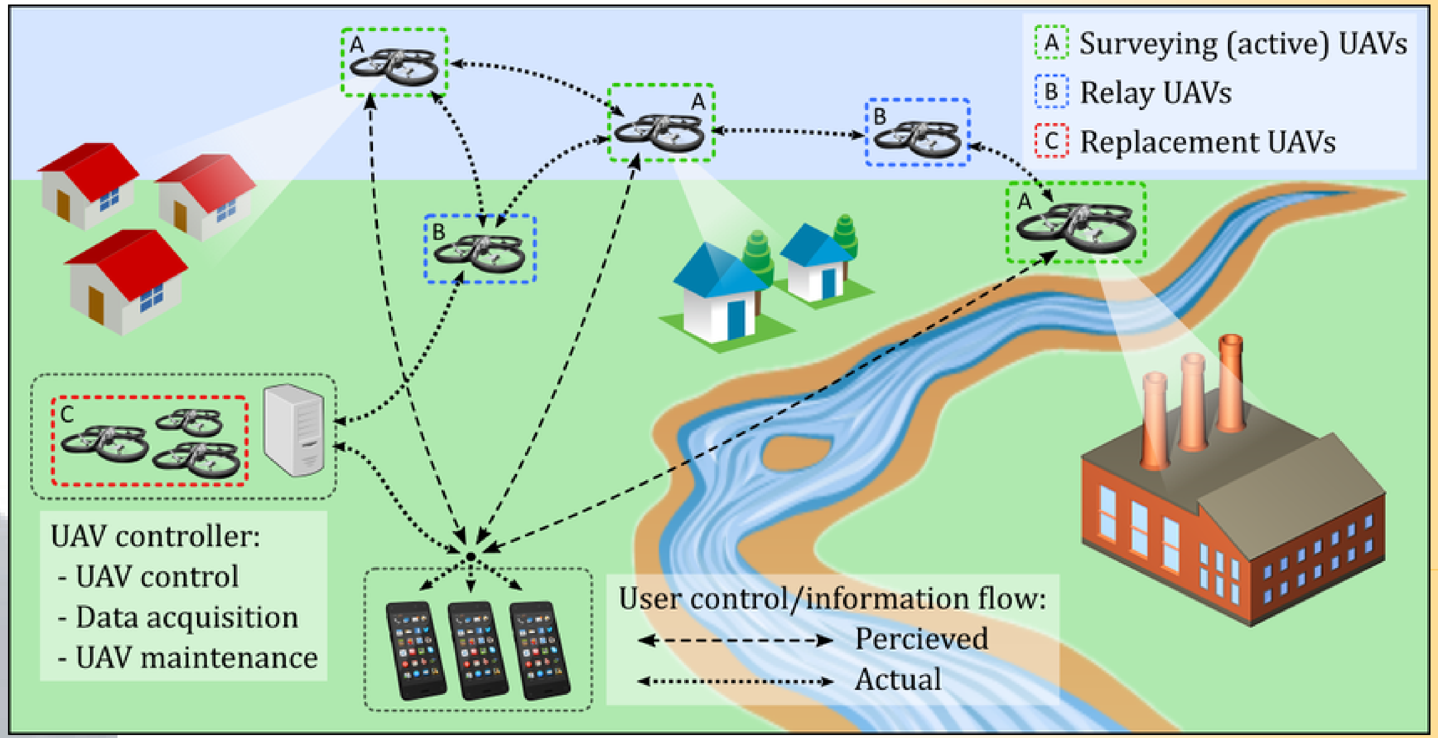


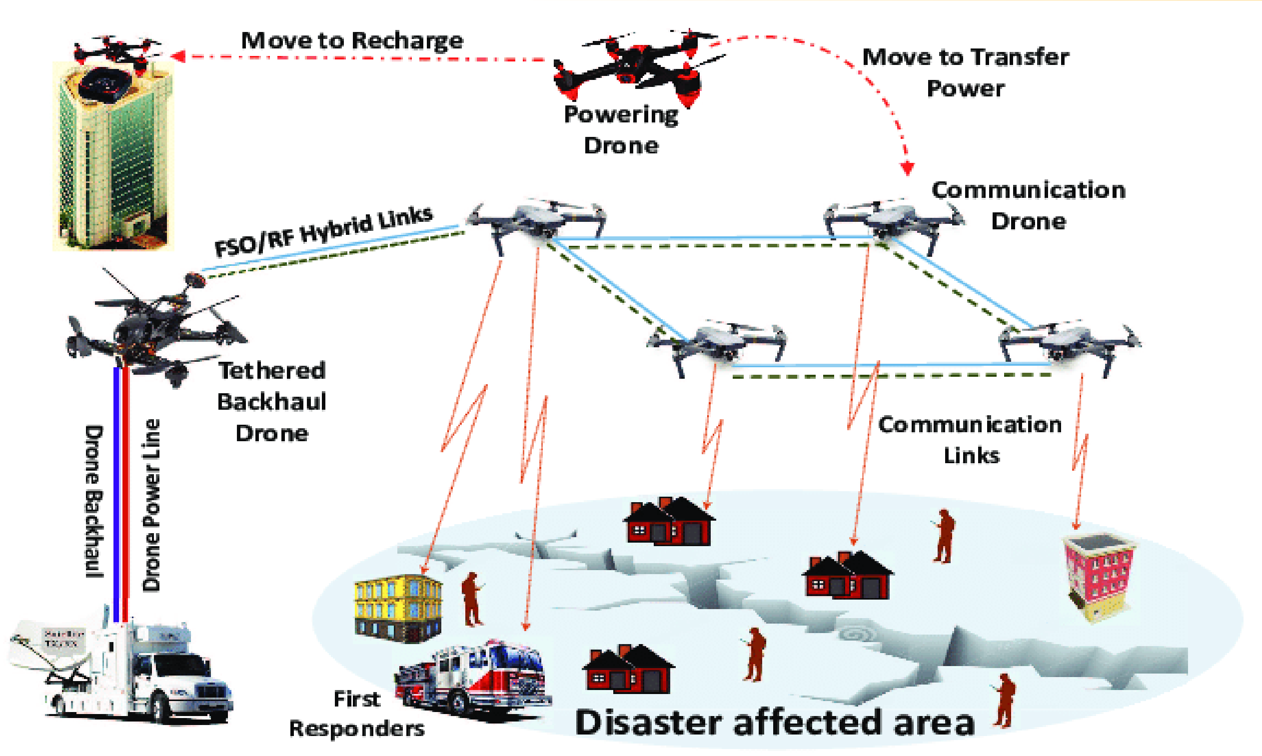
I) Robot Design vs Design

c) Delivery drone

I) Robot Design vs Design

d) Disaster and mitigation drone





1) Robot Design vs Design

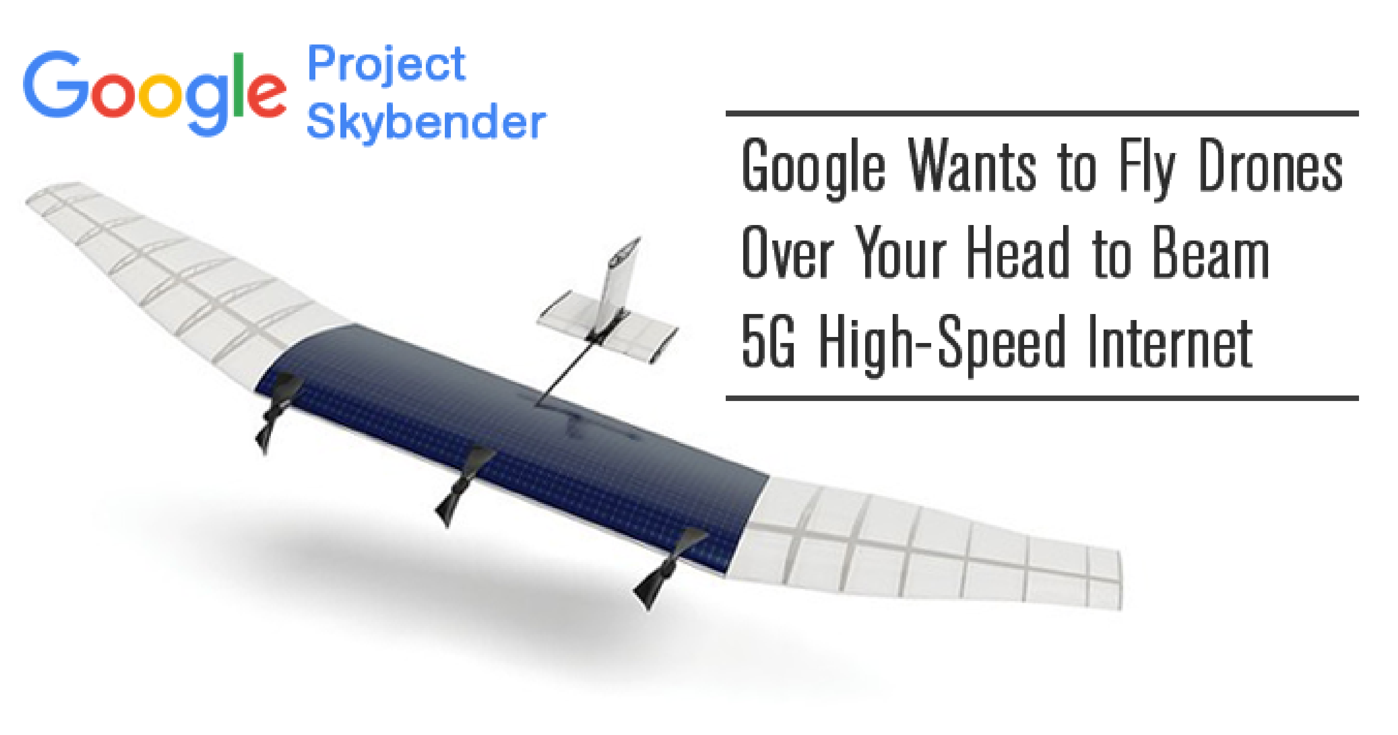
e) Logistics drone

I) Robot Design vs Design

f) Filmaking and photography drone

I) Robot Design vs Design

g) ISPs drone



1) Robot Design vs Design

1) Law enforcement drone

I) Robot Design vs Design

Type of drones

1) Multi-Rotor Drones

Drones that have multiple rotors and propellers were created for vertical takeoff and landing. If you didn't know, propellers are basically the small wings or blades on a drone that make it fly, like what you would see on a helicopter. Rotors are just the part that spins the propellers. Helicopters have just one single rotor, multi-rotor drones have many. They usually have four, six or eight rotors, four being the most common for small to regular sized drones.

The purpose of having more than one rotor is to help give you better control over the drone's position in the sky. The more rotors it has, the more ways it can maneuver itself, but the controls can be a lot more complicated to learn on an 8-rotor drone rather than a 4-rotor one.

Drones that have a lot of rotors can tend to be limited on their speed and duration of flight time because they're not nearly as efficient as other types of drones, such as a fixed-wing drone (defined later in this article), which can fly for nearly 16 hours at a time. Some multi-rotor drones can only fly for 20 minutes before needing to recharge the battery, so large-scale surveying and package delivery is out of the question.

I) Robot Design vs Design

Type of drones

2) Fixed-Wing Drones

Unlike the vertical takeoff capability of drone models that use rotors for flying, fixed-wing drones have a single long wing on either side of their body and need either a catapult or a runway to lift off the ground. They also have much more difficulty landing due to their inability to hover.
Fixed-wing drones are sometimes used for surveillance, like in the military, but they aren't generally used for other types of aerial photography and drone flying. To get stable photos and videos, a drone would need to be able to hover and stay flying at certain angles.
Fixed-wings are more commonly flown for the purpose of long-distance tasks or just as a hobby. They can stay airborne for 16 hours or more at a time and don't require the recharging of a battery unless other electronic equipment is attached to it.
This type of drone requires quite a bit more drone flying experience and training, mainly with takeoff and landing.

1) Robot Design vs Design

Type of drones

3) Single-Rotor Helicopter Drones

Helicopters aren't just made as large, manned aircraft. They are also created as smaller, unmanned drones. These come in a multitude of different sizes, from very small kid's toys to exceedingly large drones with a built-in camera, the price goes up with the size. Some single-rotor drones are sold for as little as $20 at the store, while others go for thousands online.
Something unique to this type of professional drone is that it can run on gas instead of electric, depending on the size. They are more efficient than multi-rotor drones, but not as efficient as fixed-wing ones. The single-rotor can sometimes be nearly as hard to fly like a fixed-wing drone, and both require a balancing act.
There are not a lot of uses for single-rotor drones as there are for multi-rotors, but they can definitely carry a heavier payload. Typically, they're bought by people who are looking for a new hobby.

I) Robot Design vs Design

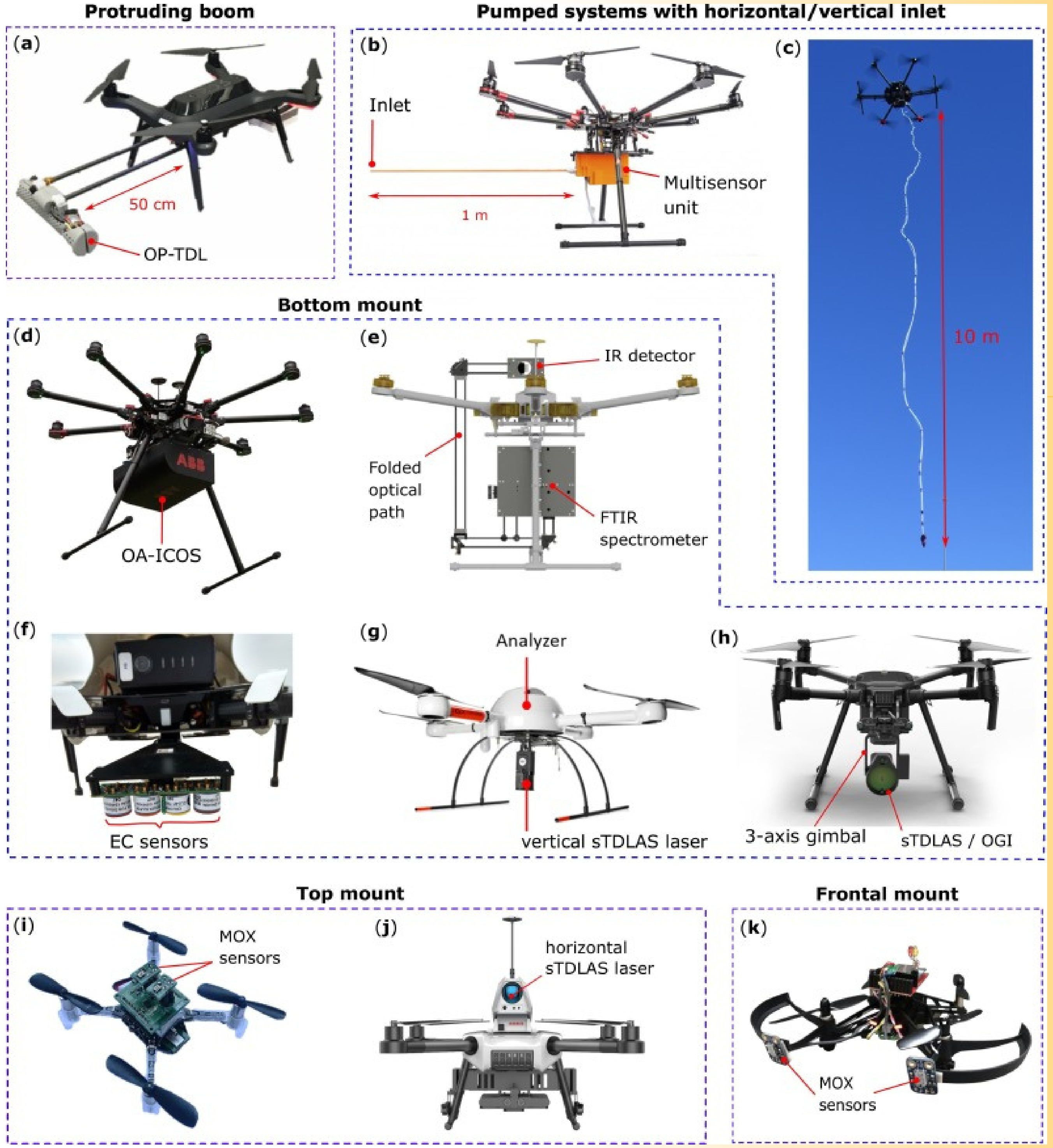
Type of drones

4) Fixed-Wing Hybrid VTOL

This newly invented type of professional drone combines the long flight duration time of a fixed-wing drone with the vertical takeoff and landing of a single-rotor or multi-rotor drone. A great example of this is the drone that was created for Prime Air.
VTOL stands for vertical takeoff and landing. This is the primary reason that this hybrid was created. Fixed-wing drones have such a big difference in flight duration compared to other drones; the only problem is that they can’t land nearly as easily. This hybrid combines the best of both. It hasn’t been a long-lived concept, but it is growing popularity and reputation very quickly.

2) Actuators and Locomotions

- **Remote Sensing**
- **Agriculture**
- **LightShow**
- **Transporter**



2) Actuators and Locomotions

Sugiura, Noguchi et al. [6] used an unmanned helicopter equipped with an INS (inertial sensor) and a GDS (geomagnetic direction sensor) to obtain data with the pitch angle and rotation angle of the flight platform. Moreover, GPS (Global Positioning System) receiver also installed IMU (Inertial measurement unit) to measure roll and yaw data. Based on the above hardware basis, the authors propose a method that uses rotation conversion to convert the coordinate data on the image to the geodetic coordinates, thereby correcting the error reduction error in measurement. This method compensates for the error of acquiring data from the bottom layer and is more accurate than a single image mosaic method. Now, for different applications, the benchmark for RS image processing is generally divided into pixel-based and object-based.

2) Actuators and Locomotions

Low-weight full-polarimetric SAR in Drone

Airborne Synthetic Aperture Radar (SAR) sensors have been commonly used during the last decades to monitor different phenomena in medium-scale areas of observation, such as object detection and characterization or topographic mapping. The use of Unmanned Aerial Vehicles (UAVs) is a cost-effective solution that offers higher operational flexibility than airborne systems to monitor these type of scenarios. The Universitat Politècnica de Catalunya (UPC) has developed the first fully polarimetric SAR system at X-band integrated into a small UAV Multicopter Platform (UAV MP). The sensor, called AiRBased REmote Sensing (ARBRES), has been integrated into the platform overcoming restrictions of weight, space, robustness and power consumption. The ARBRES-X SAR system represents an evolution of a previous version developed by the Remote Sensing Laboratory of the UPC [4] [5]. It is a SAR sensor operating at 9.65 GHz that works with a Stepped Linear Frequency Modulated Continuous Wave (SLFM-CW) signal. The complete system has been designed to be fitted in small UAVs, as is the case of the UAV MP. This has imposed strong constraints in its design in terms of weight, power consumption, compactness and robustness.

3) Navigation system and controller

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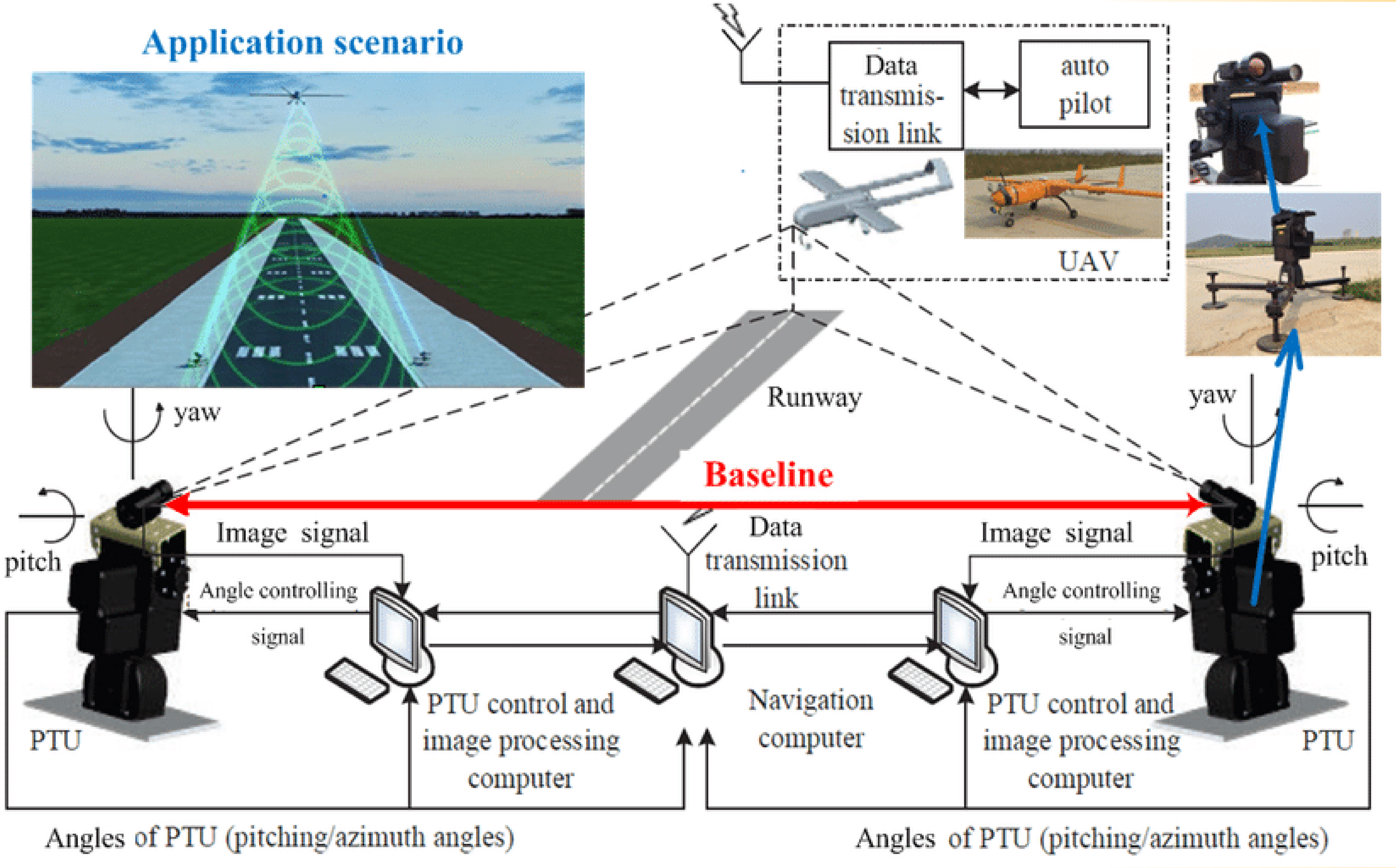


3) Navigation system and controller

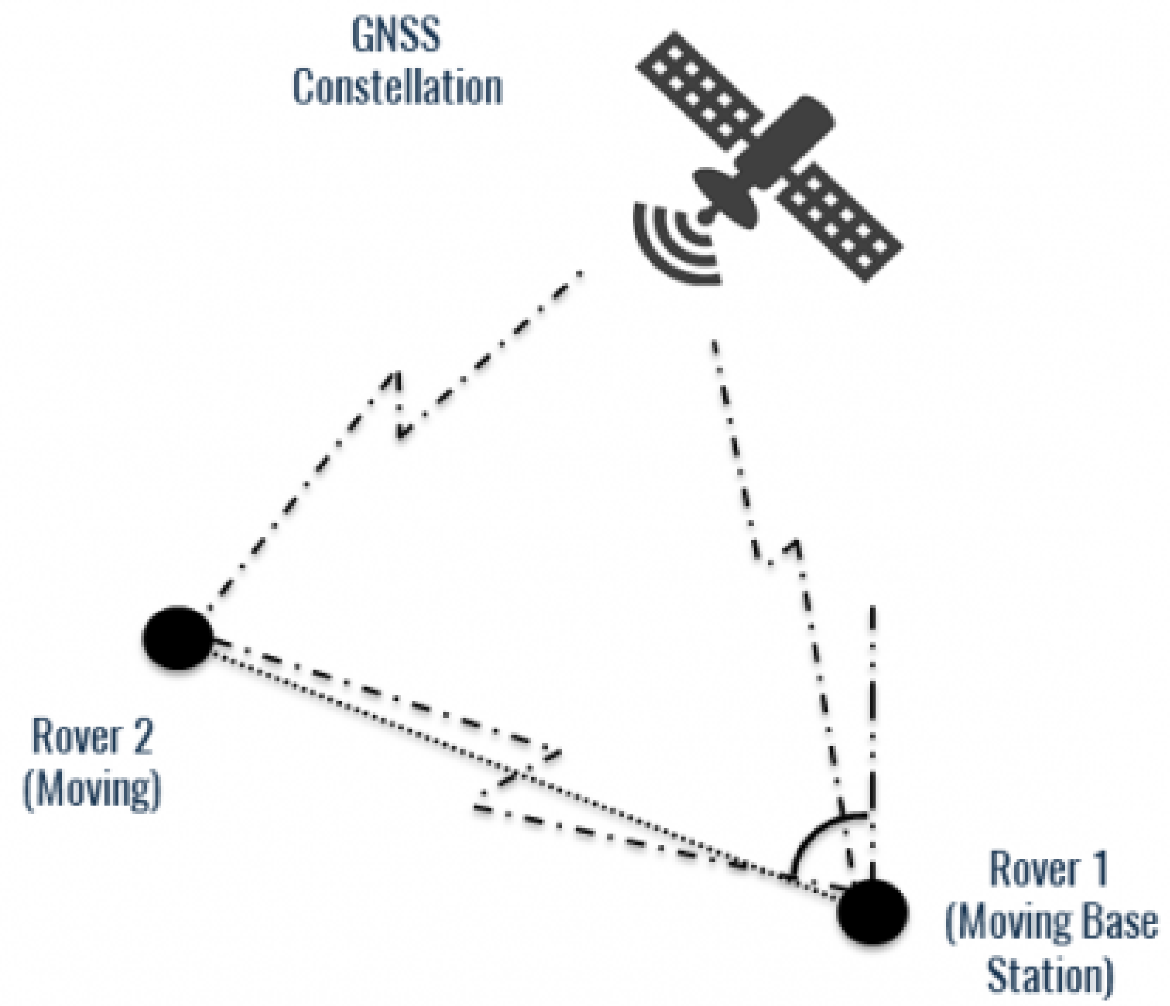
•RTK. One of the methods used to improve accuracy is a Real-Time Kinematic (RTK) system, which can reduce errors to as little as a couple of centimeters, as opposed to traditional GNSS precision where error is measured in meters.

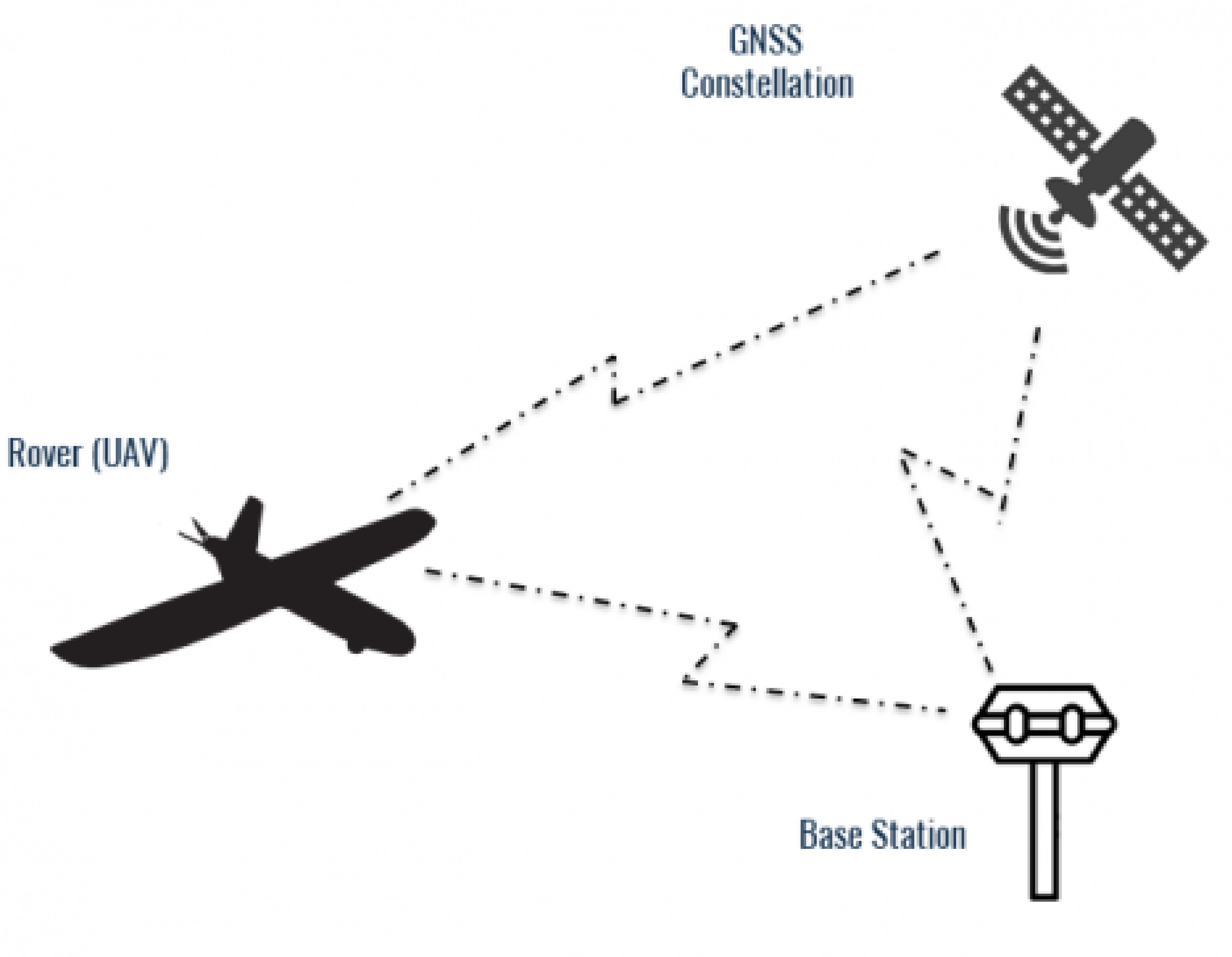
RTK consists of a 'base station' and one or more 'rover' units which communicate directly between themselves. The known location of the base station helps the system to reduce errors. The base station broadcasts its position together with a code; the receivers are then able to fix phase ambiguities from satellite signals in order to determine their relative position to the base with a very high degree of precision. For this reason, when using RTK excellent radio coverage is always required and means that the system is not generally suitable for Beyond Line Of Sight (BLOS) flights. RTK technology is widely used in the UAV industry to enable precision landing. Some landing techniques, such as net recovery of a UAV on a moving vessel at sea developed by UAV Navigation, require very high positional accuracy as even the smallest error may clearly lead to an accident.

3) Navigation system and controller

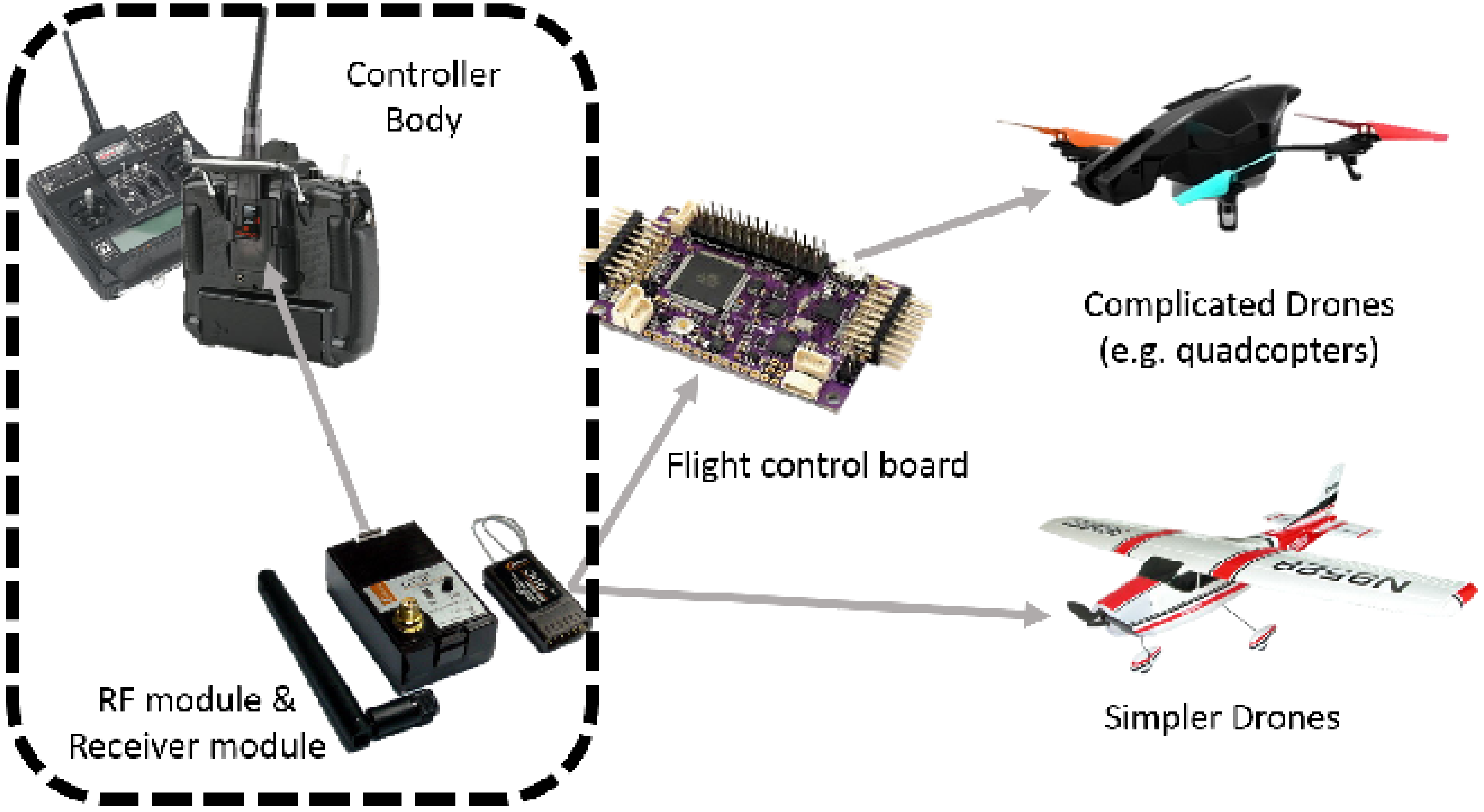
Dual GNSS Compass. A similar technique is used in another technology: the Dual GNSS Compass. By utilizing GNSS interferometry techniques, the course of a vehicle or platform may be calculated. The baseline signal from the base station is received for two separate GNSS rovers on a platform; these separate receivers then calculate the phase variation of the signal, meaning that it is therefore possible to determine the orientation of the system. An added benefit of this method is that the effect of magnetic interference, such as electromagnetic noise (cabling, moving mechanical parts etc.), is minimized. Dual GNSS Compass navigation enables accurate heading estimation under both static and dynamic conditions without any reliance on magnetic sensors.

3) Navigation system and controller





3) Navigation system and controller



3) Navigation system and controller

Common Control Modes

Semiautomatic and manual control modes sometimes have the function of training safety pilots about the UAV control. This is advantageous since they are obligatory modes for some operations, depending on the responsible aviation authority. The automatic control mode would be the usual control mode with Veronte Autopilot, which can be deactivated at any time during the flight in order to allow the pilot to control the UAV.

Manual Mode

In this control mode the pilot fully controls the drone, commanding directly the control surfaces through the joystick, which permits to directly manage the servos movement. In this mode the pilot has to be skilled enough when managing the aircraft, since he/she is not assisted by Veronte Autopilot.

Semiautomatic or Arcade Mode

The semiautomatic or arcade mode is equivalent to the manual mode but assisted by the Veronte Autopilot. In this case, the pilot commands through Veronte Autopilot, which receives the joystick signal as well as it manages the servos through an automatically stabilized control. In essence, a person without advanced knowledge of piloting could manually control the UAV through this control mode: for instance, the Veronte Autopilot could control the attitude while the pilot, manually, could control the altitude, speed and/or other variables.

Automatic Mode

This control mode permits the UAV to perform operations in a way fully autonomous with no need of a pilot, as well as it makes possible to a single pilot to control many UAVs simultaneously. In this case, Veronte Autopilot together with Veronte Pipe software, allows different flight phases that permit the pilot to monitor the operation. These phases consist of following a waypoints route and following a predetermined direction, to perform takeoffs and landings, hover and loiter maneuvers, among many other possibilities.

3) Navigation system and controller

Advanced Control Modes

In addition to what has been said, there are advanced control modes that become essential for the development of a wide variety of operations. Nevertheless, these control modes are only available in some control systems such as Veronte Autopilot. Down below some of them are described.

Fly-by-Camera Mode

Sometimes during an operation with a preconfigured route, it may appear a focus of interest for the sake of that operation; in that moment the system may alert us about that eventuality and suggest to take the control through the fly-by-camera mode. Through this mode, the control of the UAV is taken intuitively, aiming with the camera to the focus of interest and permitting the Autopilot Veronte to adjust the flight, keeping it stabilized and controlling it directly to the direction indicated by the camera. This control mode is especially useful for applications such as tracking vehicles, borders surveillance and other similar situations

Followme Mode

The "Follow Me" advanced control usually keeps the UAV following the target at a fixed distance, but in case of UAVs that use Veronte Autopilot, this mode goes beyond: The "Follow Me" of Veronte Autopilot permits to create any kind of operation and maneuvers regarding to an objective, to perform takeoffs, landings, climbing, loiter, hover, mapping…

Follow My Path Mode

One of the most recent incorporations to the advanced control modes of Veronte Autopilot is the "Follow My Path". With this new control mode, instead of following a moving target, the UAV follows the route performed by that target, so if it made a path avoiding collisions with fixed obstacles, the UAV with Veronte Autopilot will perform the same manoeuver avoiding collisions with the environment.

4) Data collections

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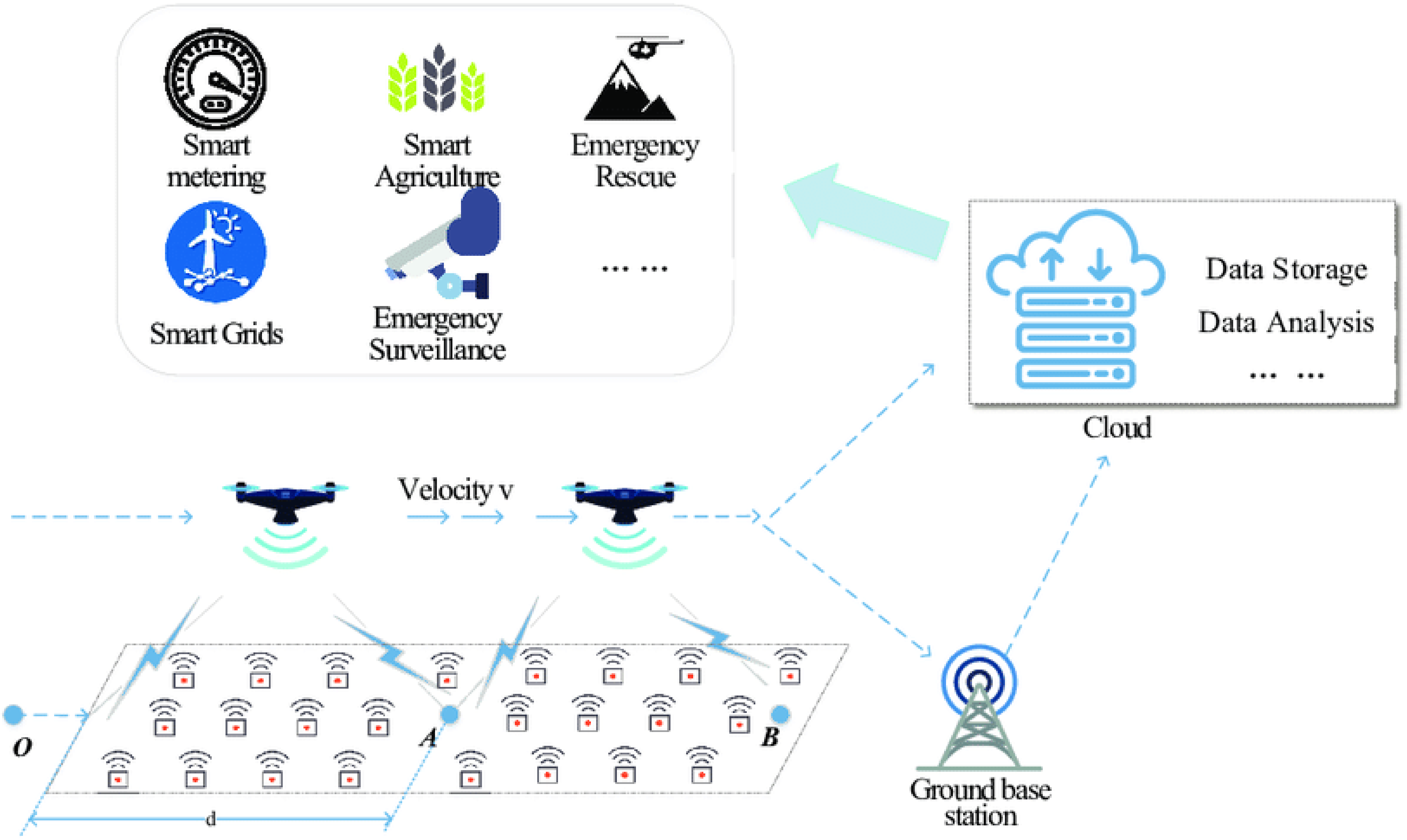
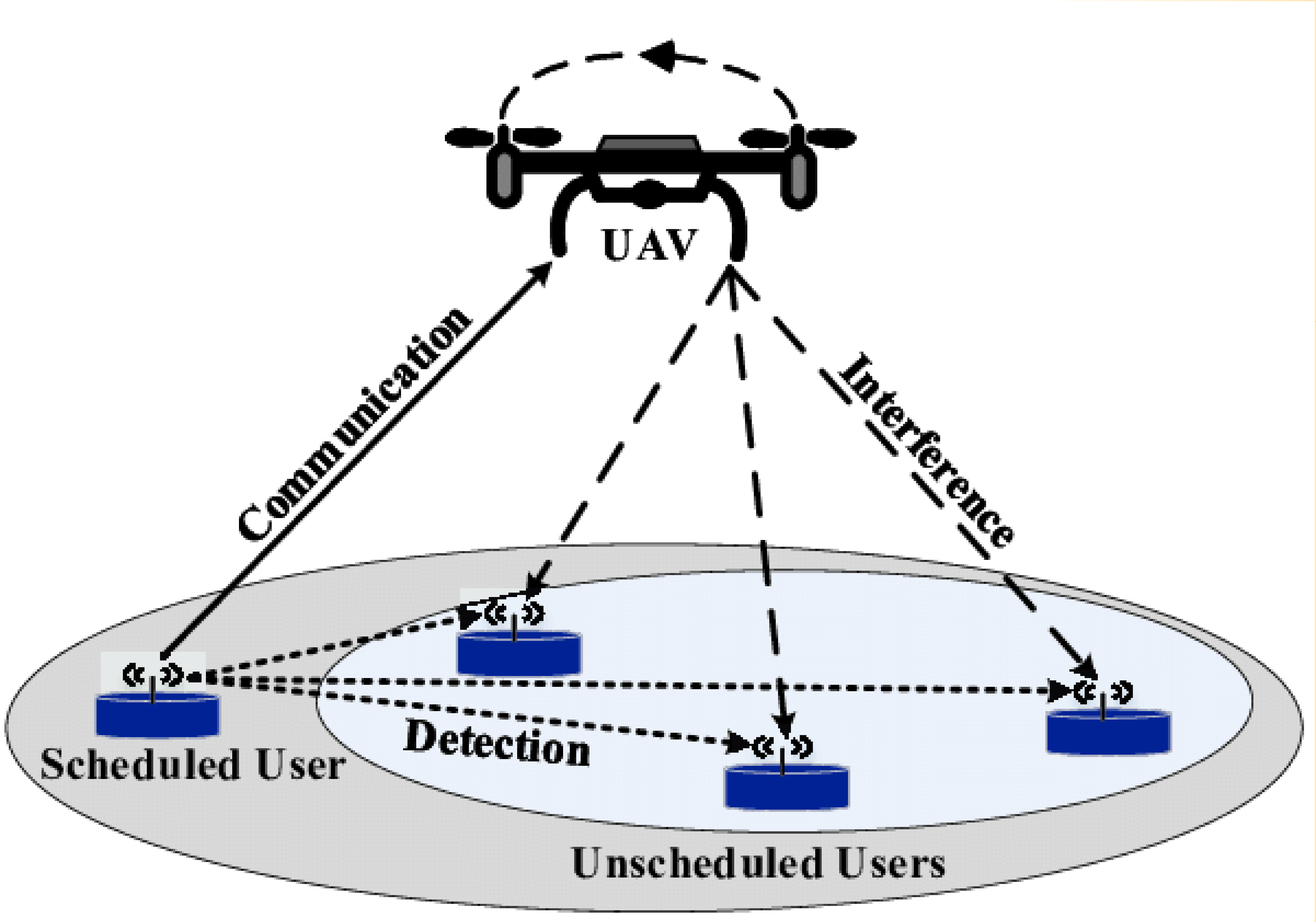


4) Data collections



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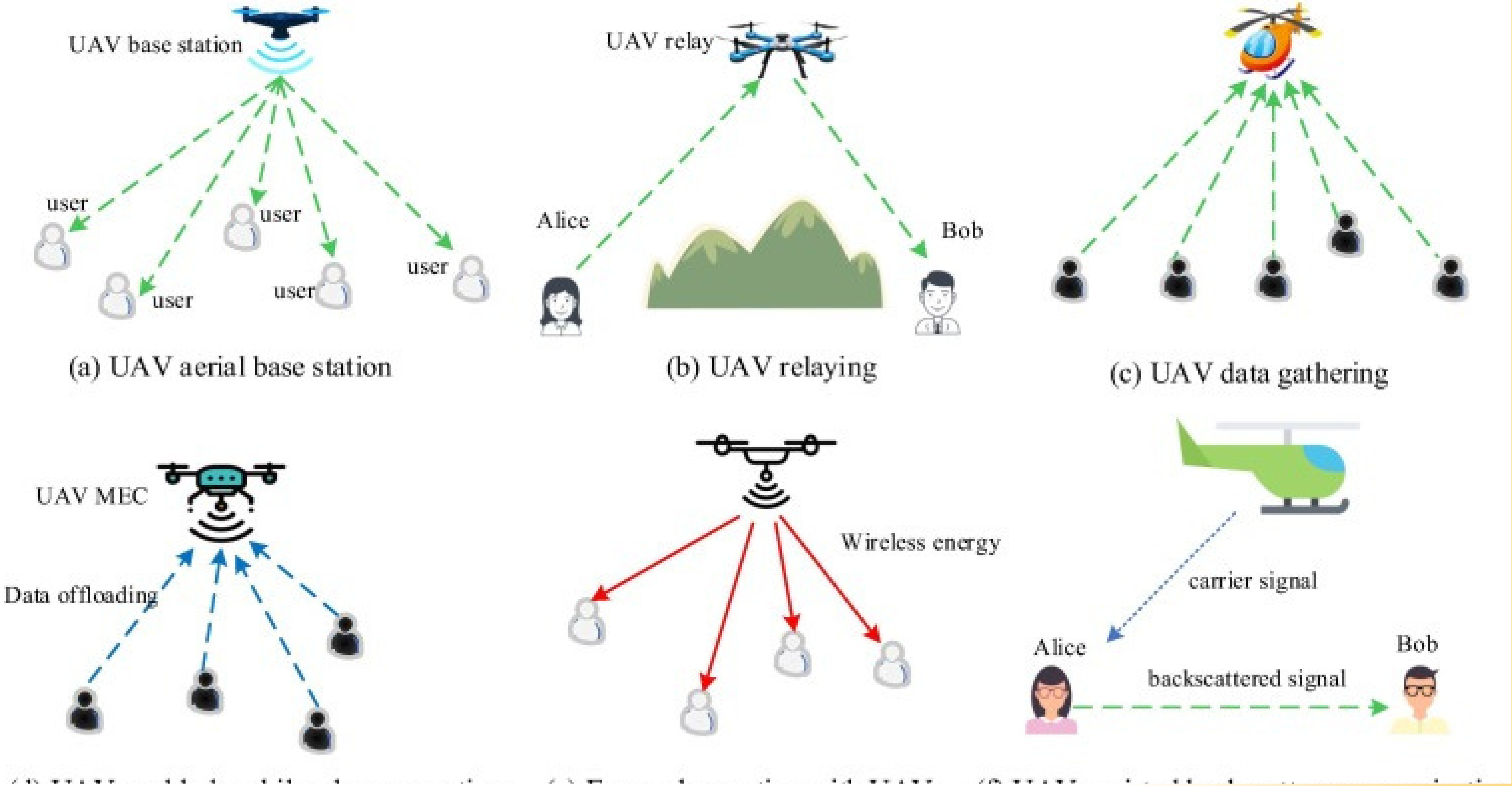

(a) UAV aerial base station
(b) UAV relaying
(c) UAV data gathering

5) Data Transmissions

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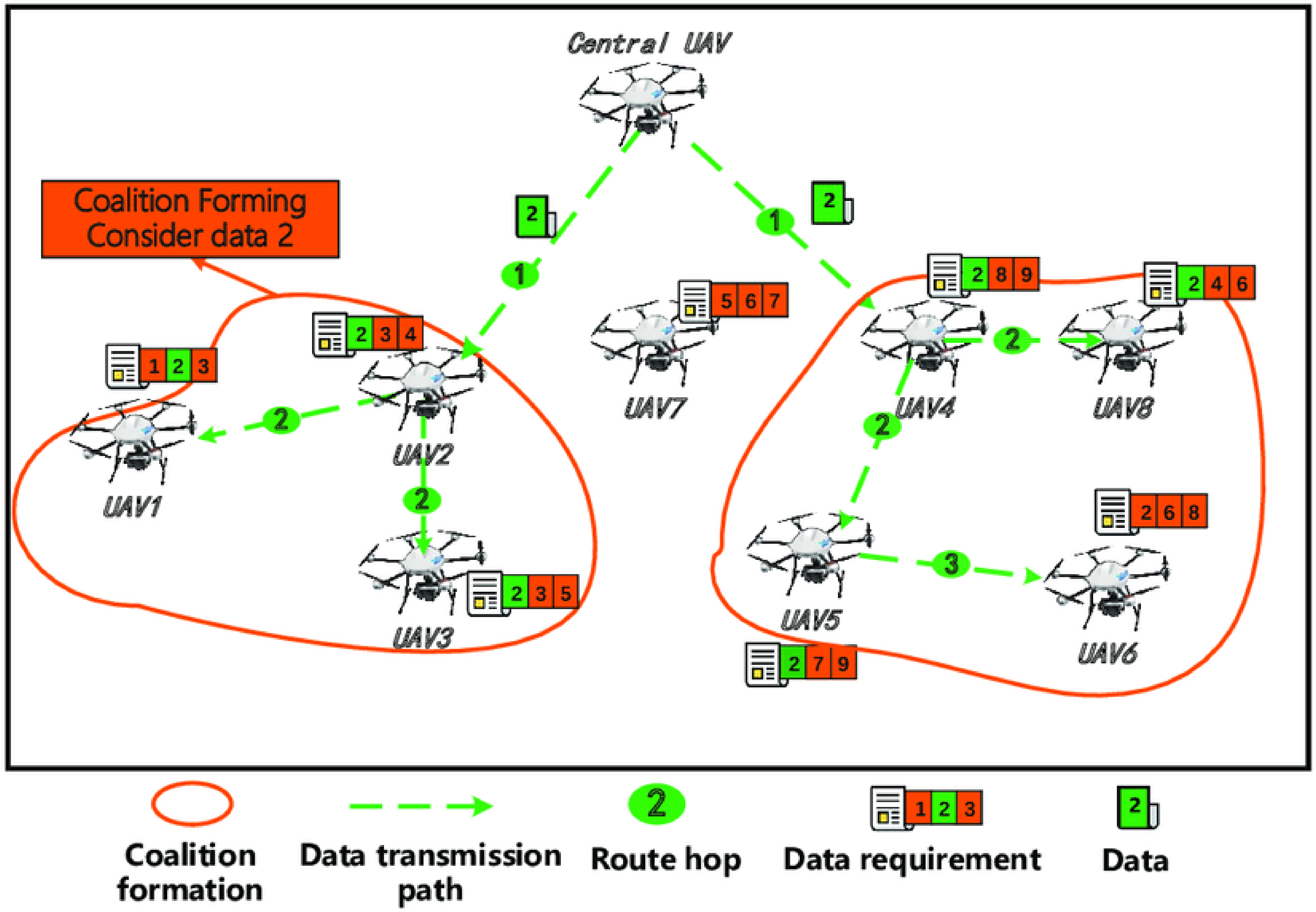

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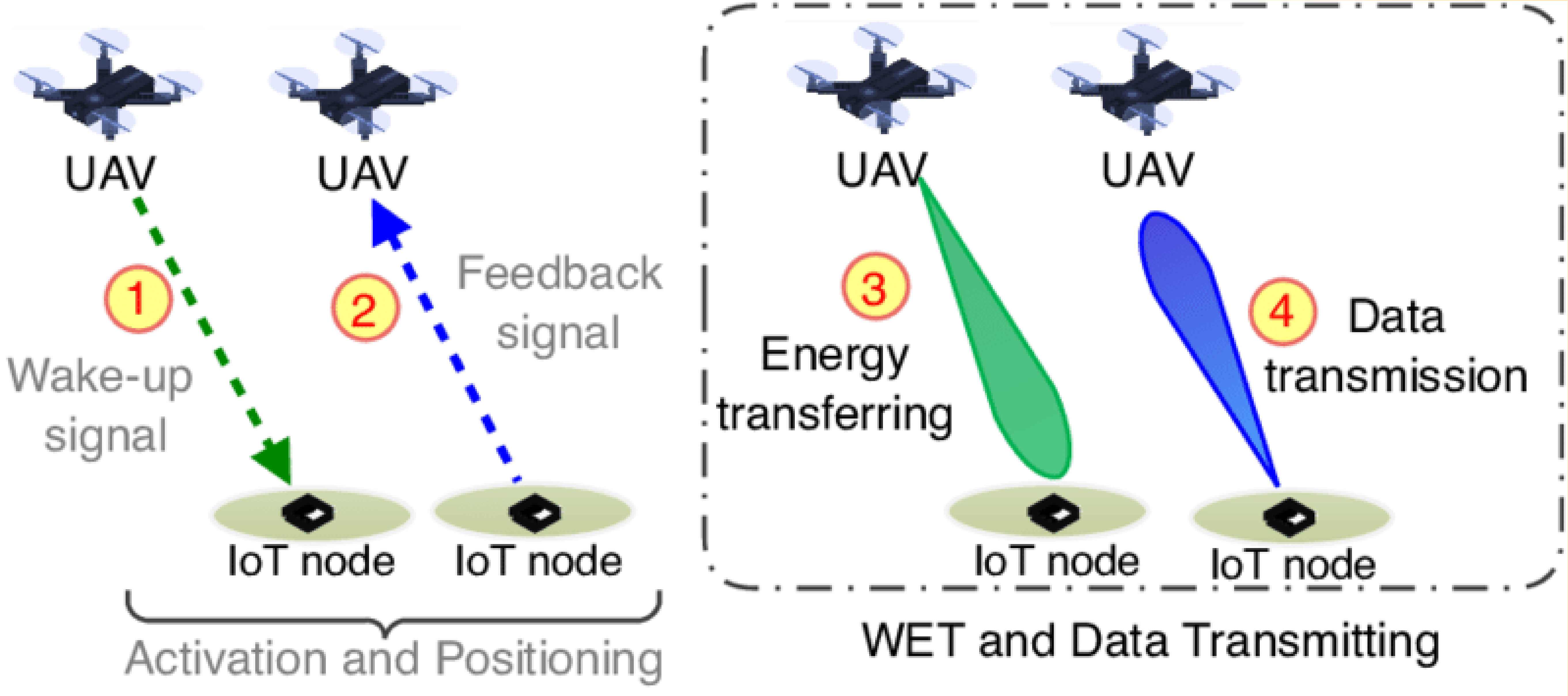
- 

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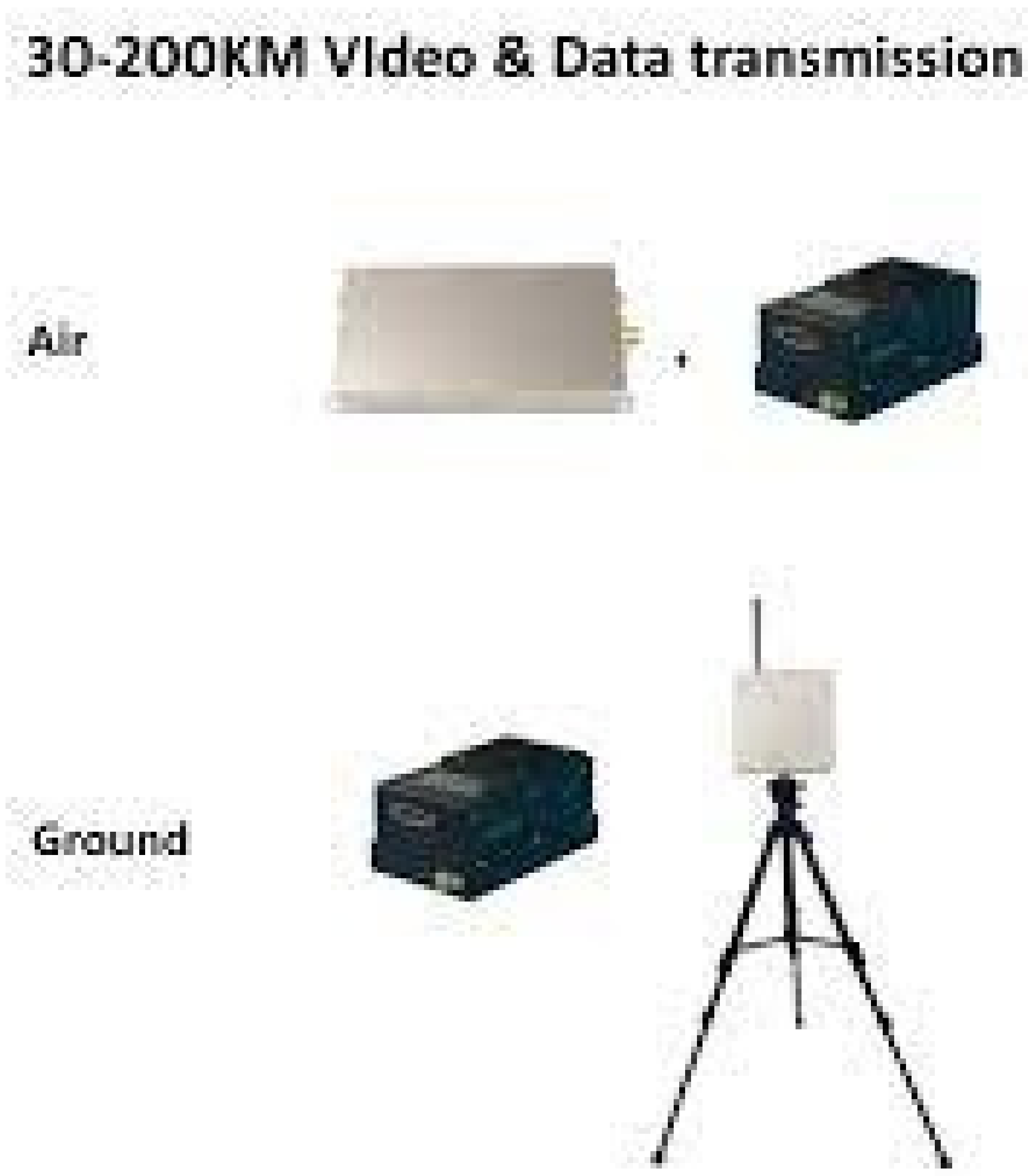
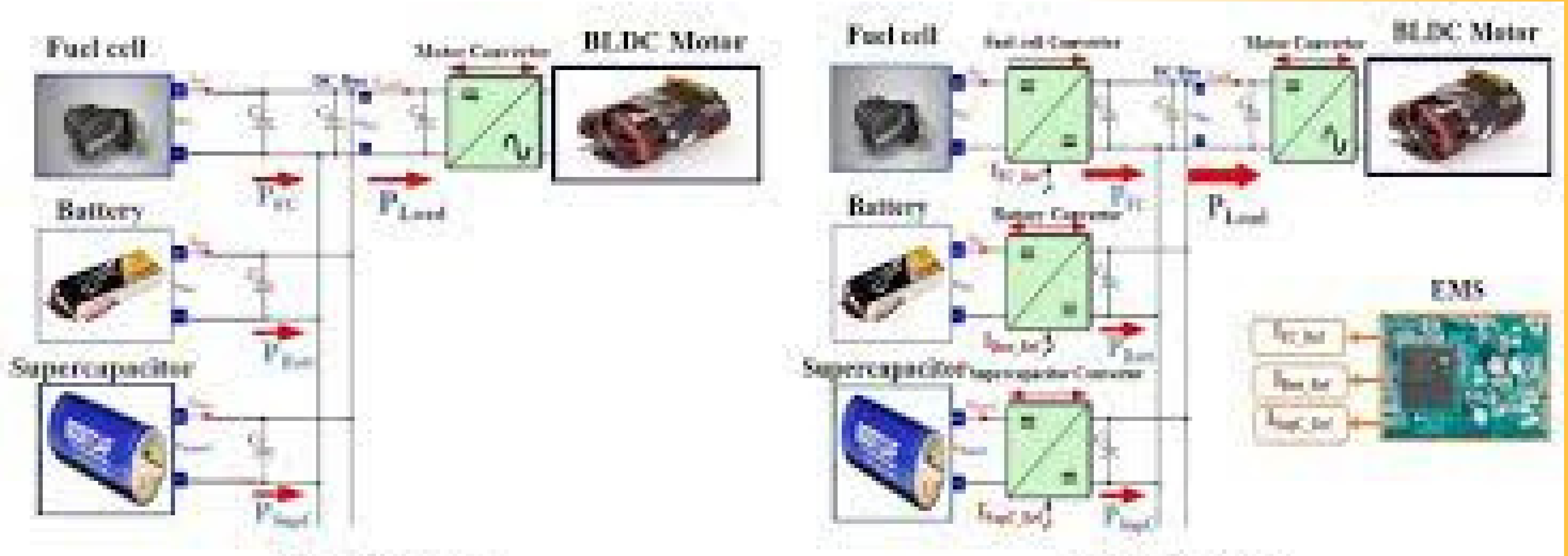


6) Power System Management

- 

(a) Passive PMS. (b) Active PMS.

LIST OF UAV Company (Service / Manufacture/ Components) Locally

- **AERODYNE**
- **POLADRONE**
- **DEFTECH**