FPV drone FPV training course and FPV drone piloting

Basic UAV Piloting Course" program

Revision 17.08.2023

basic FPV flying course

1 - s y и 2 - oy days schooling

01 Introduction to the course

02 Types of UAVs by

03 design History of

UAVs

01

Introduction to the course

The training course is completely free of charge

The course consists of online lectures and materials for , for this purpose the broadcasts of each lecture and questions for consolidation of the material are posted in the group.

Ethers and questions are posted in this thread, registration is required

Knowledge base - 3rd stream

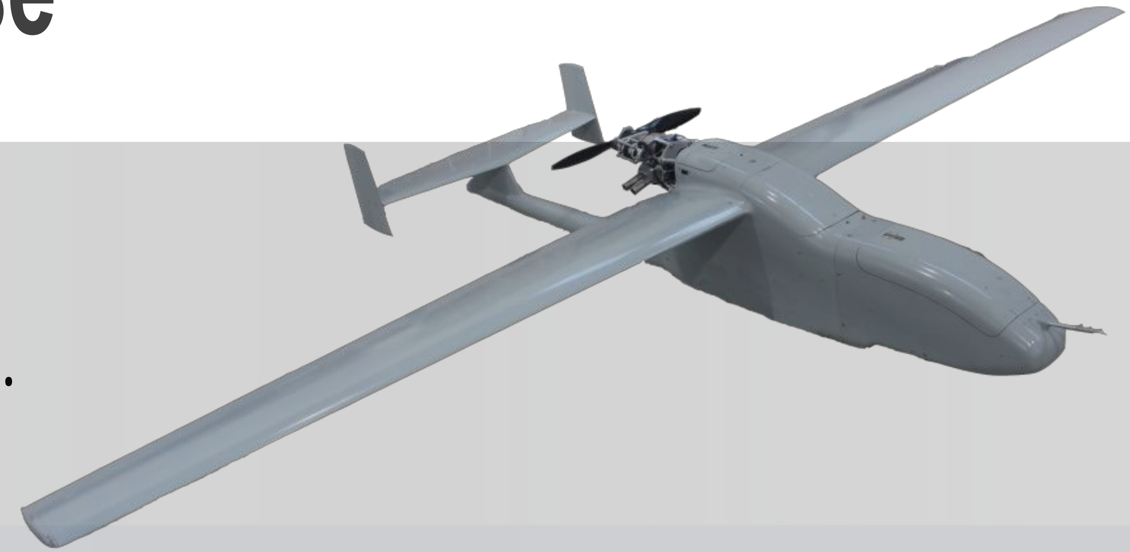
01 Introduction to the course

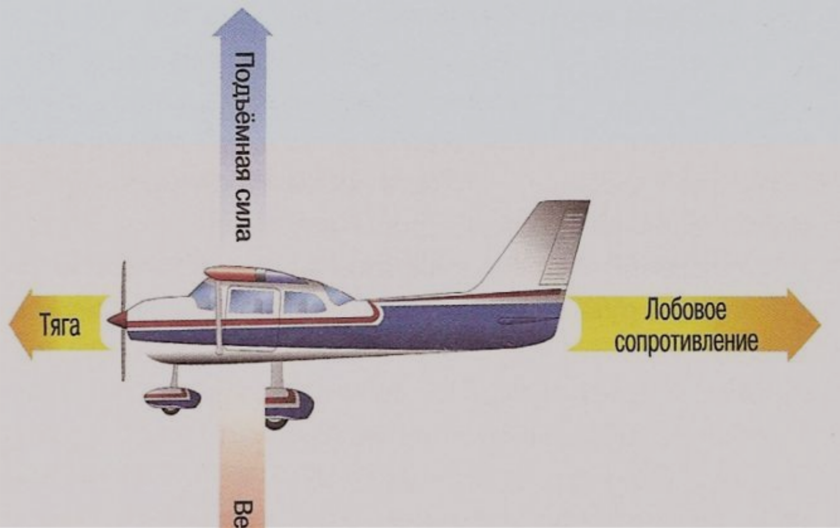
UAV - unmanned aerial vehicle

A flying machine without a pilot.

It is controlled in 3 ways:

1. By radio link from the control panel.
2. The flight controller is programmed and the machine flies itself.
3. Combined - a combination of the two.





Forces occurring in flight, using an airplane as an example:

1. Traction
2. Frontal resistance
3. Lifting force
4. Weight

01 Introduction to the course

Conditional division of UAVs by specifications into 4 groups

MICRO

The weight is less

10 kg

Airborne time up to

60 min.

Flight altitude

1km

MINI

Weight to

50 kg

Airborne time up to

5 ч

Flight altitude

3-5 km

MEDIUM

Vesdo

1т

Airborne time up to

15 ч

Flight altitude

10 km

HEAVY DRONES

The weight exceeds

1т

Airborne time more than

24 ч

Flight altitude

20 km.

02

Types of UAVs by design

Classification of UAVs by design

1. Airplane-type UAVs.
2. Multi-rotor UAVs
3. Aerostatic UAV
4. Hybrid models

Airplane-type UAV

Multi-rotor UAVs

Aerostatic UAV

Hybrid models

02

Types of UAVs by design

Airplane-type UAV

The lift force is created aerodynamically by head of air impinging on a stationary wing.

range, speed and altitude.

Usually a catapult or runway is needed, but there are small ones that can be launched by hand.

When UAVs land, catchers (nets, ropes parachutes, or landing strips) are use This type includes UAVs using the Coar effect.

VORON

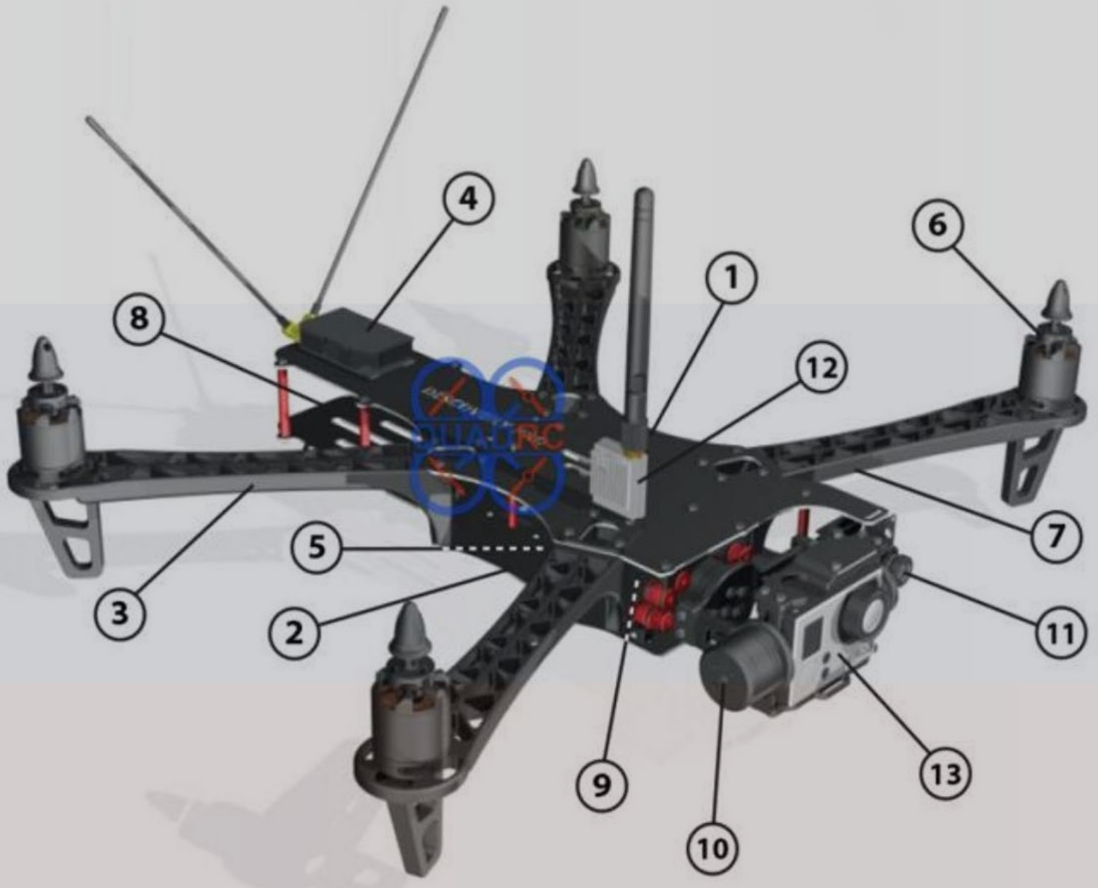
02

Types of UAVs by design

Multi-rotor UAVs

This group includes UAVs that have 2 or more propellers.

Reactive moments are balanced by rotating the propellers in pairs in different directions or tilting the thrust vector of each propeller in the desired direction.



1. Верхняя пластина
2. Нижняя пластина
3. Лучи рамы
4. RC приемник
5. Полетный контроллер
6. Бескол. моторы
7. Регуляторы скорости
8. Аккумулятор
9. Встроенный модуль CORE и контроллер подвеса
10. Бесколлекторный мотор
11. FPV камера
12. Видеопередатчик
13. HD камера

02

Types of UAVs by design

Aerostatic UAV

The lifting force is generated primarily by the Archimedean force acting on a cylinder filled with light gas.

This class is mainly represented by unmanned airships.

Advantages: large payload, range and non-stop flight.

02

Types of UAVs by design

Hybrid models

Such models have features of both airplanes and helicopters. Represented by gyroplanes and convertoplanes.

The gyroplane has an airplane-like layout with a free-rotating propeller as the wing.

Convertoplane is an aircraft with rotary propellers, which act as a lifting propeller at takeoff and landing, and as a pulling propeller in horizontal flight, while in flight the lifting force is provided by an airplane-type wing. It behaves like a helicopter on takeoff and landing and like an

airplane in flight.

03

History of UAVs

Application of unmanned aerial vehicle and design type

The history of unmanned aerial weapons goes back more than a hundred and fifty years. In 1849, the Republic of Venice rebelled against Austrian rule. **Franz von Juchatius**, a lieutenant in the Austrian artillery, came up with the idea of bombarding the city from balloons. According to his proposal, the balloons would be launched downwind towards Venice, and at a calculated moment a special device would detach the suspended explosive charge.

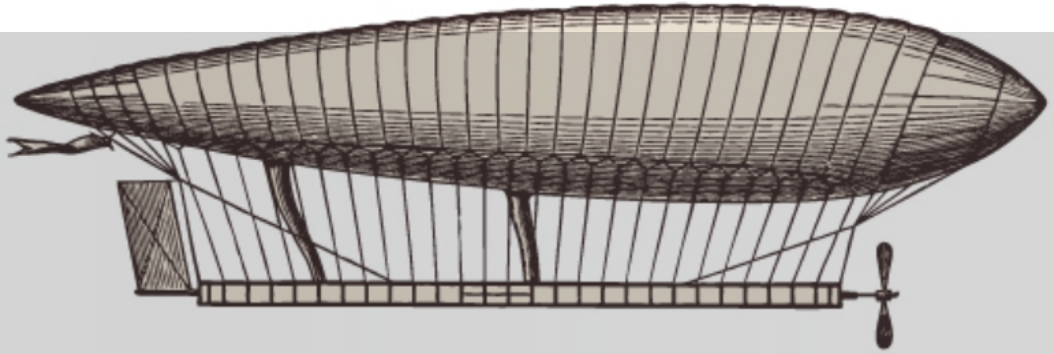
Franz von Uchatius

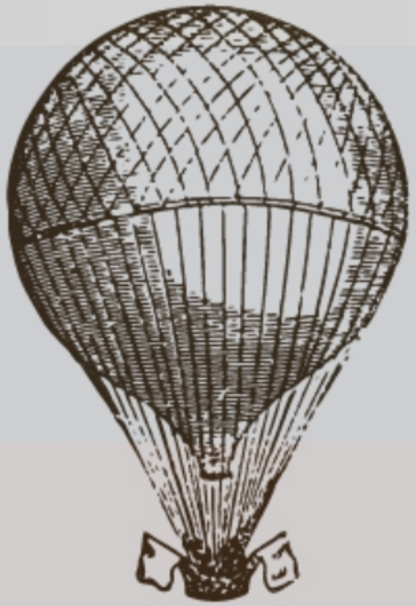
The idea interested Marshal **Joseph Radetzky**, commander of the Austrian troops, and he ordered it to be tested in practice. **They were aerostatic UAVs.** Austrians tied to the balloons bombs weighing 13 kg. At a calculated moment should have been triggered clockwork mechanisms, releasing explosive devices. However, the bombs often failed to reach their target, falling into the water or being blown away by gusts of wind.

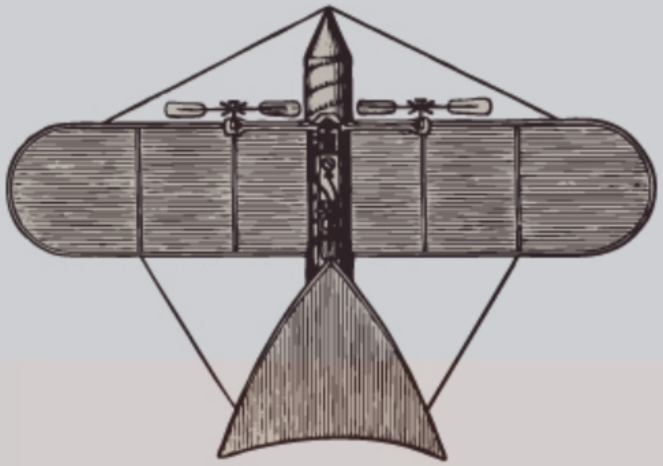
03 History of UAVs

"Victory smiles only on those who are able to foresee the coming changes in the character of warfare, not on those who wait for the changes to appear and then try to adapt to them."
Giulio Due, "Air Supremacy."

Whoever neglects historical experience is doomed to make old mistakes again and again. UAVs in modern wars in the schemes of operational construction of a massive missile-aviation strike tactical unmanned vehicles have







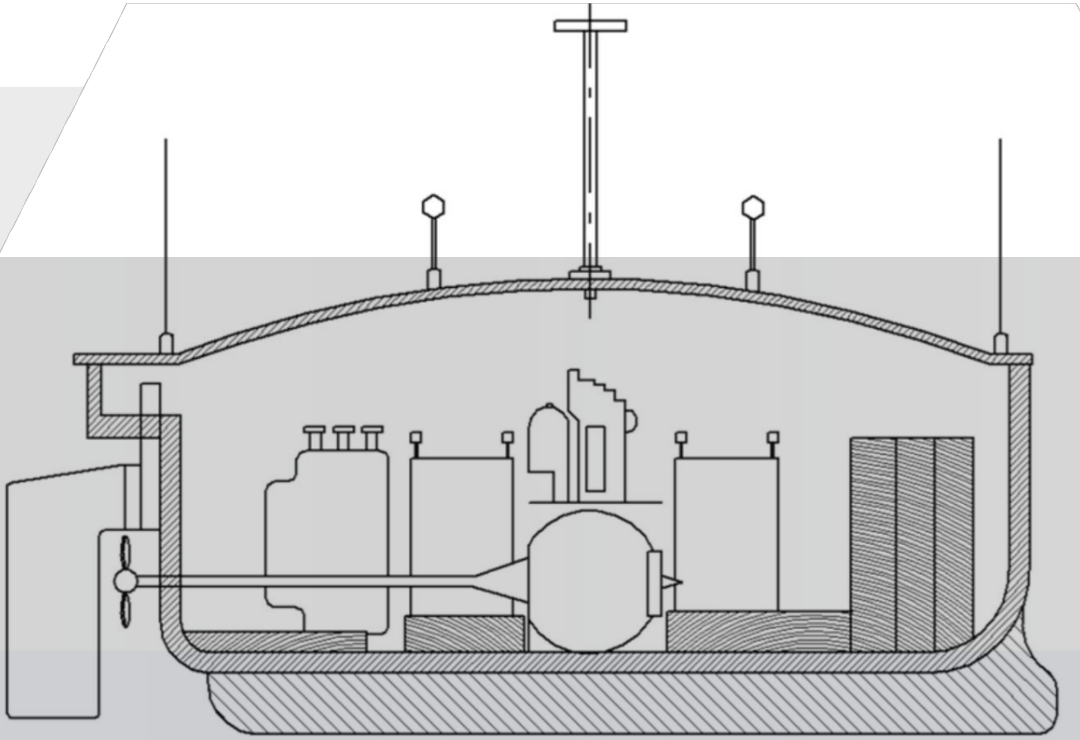
acquired a strategic character.

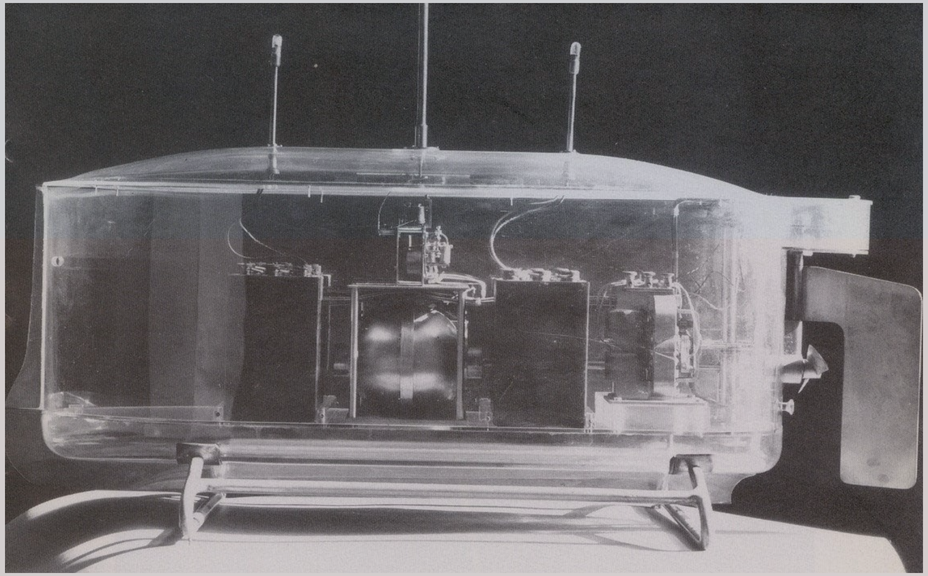
03

History of UAVs

In September 1898, the annual electric exhibition was held in Madison Square Garden (New York). At this exhibition, **Nikola Tesla** presented a remote-controlled ship.

Radio signals from the console were received by an antenna mounted on the ship,
and then transmitted inside it, where certain devices obediently carried out all the received signals. This was the first radio-controlled model.





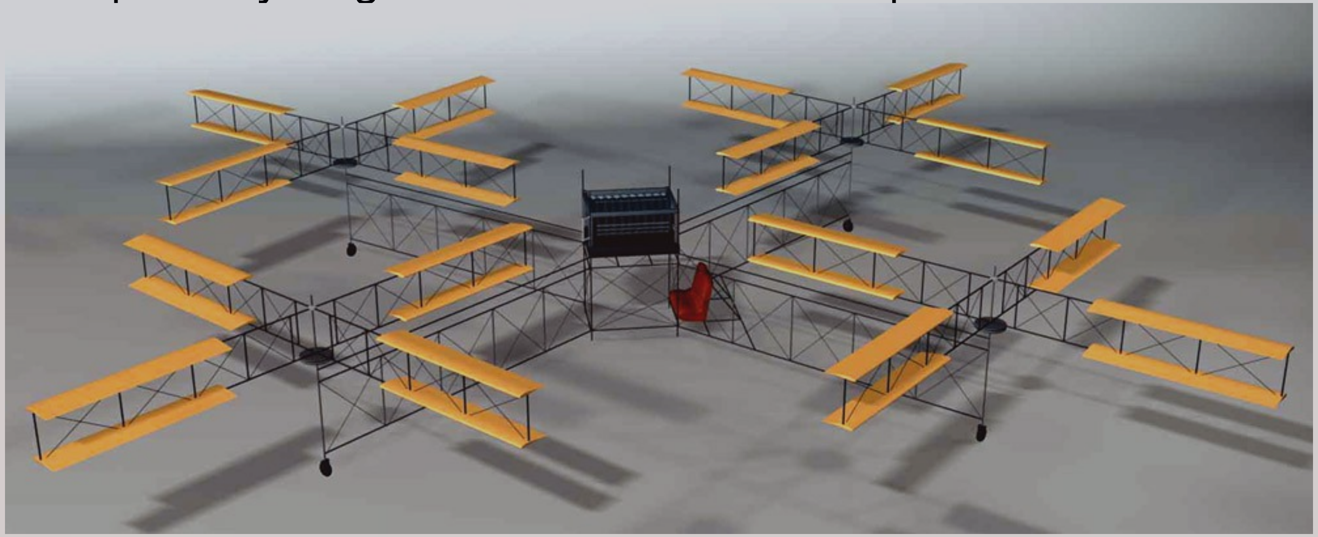
03

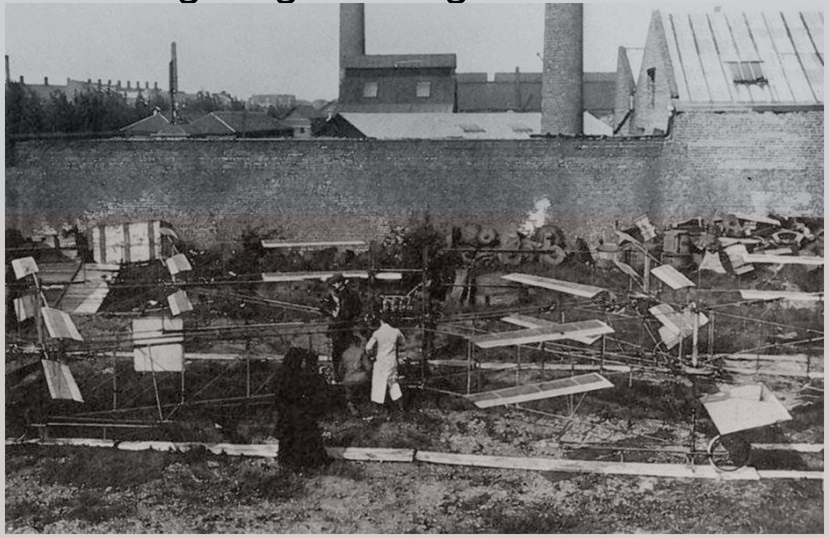
History of UAVs

Application of the multirotor type machine and its name

In September 1907, for the first time in the history of aviation, Louis Breguet' helicopter lifted a man into the air with the power of its engine. The machine was built by brothers Louis et Jacques Breguet in collaboration with Professor Charles Richet. The apparatus, named by the authors Gyroplane№ 1 (Gyroplane№ 1), had 4 rotors with biplane-type blades. The total area of 32 blades was 26 square meters.

The eight-cylinder Antoinette piston engine developed a rated power of 44÷45 hp (maximum - 50 hp), rotors rotated at a speed of 78 rpm. During the tests the pilot's seat was occupied by engineer Volumard. On September 29, the device weighing 578 kg rose to a





03

History of UAVs

The period before and after the First World War

In the period from the inception of the idea of unmanned aerial vehicles to the end of World War I, there was a steady pattern of transfer of work on the development of unmanned rotary winged aircraft (UWA) with a propeller group from the base of cruise missiles to aircraft with a propeller group. The unifying factor was that virtually all BCLA were to be launched from ground-based . The difference was that while American engineers tried to use radio to control the gyrostabilizer-based autopilot, German and British designers tried to transmit radio control signals directly to the BKLA's actuators.

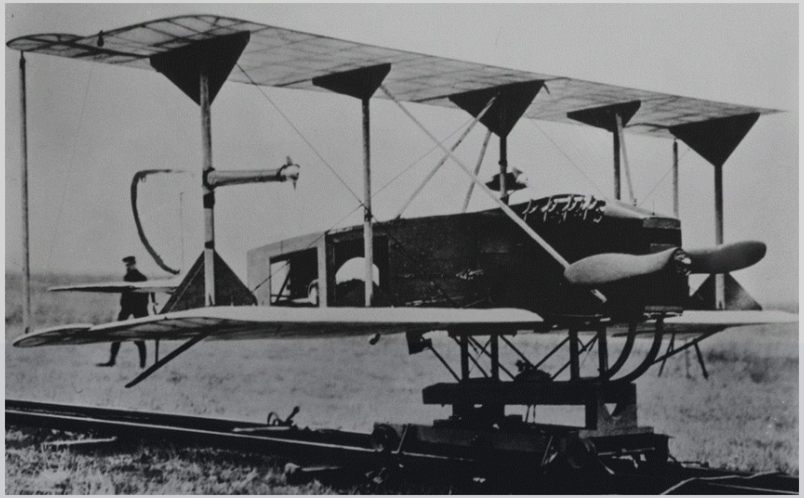
In 1916, the German military and political leadership decided to create a cheap radio-controlled unmanned airplane for long-range bombing. A. Fokker was developing such an airplane. The task had to be accomplished in a very short . Fokker had time to build only a towed glider. On its basis was proposed planning bomb. In the period between the two world wars, work in the field of creating BKLA were carried out in many countries. For example, the Entente allies converted the obsolete E-1 airplanes left after the war into flying bombs. In 1923, Germanyunder the auspices of the Ministry of Aviation, began the development of several unmanned, radio-controlled airplanes.

03

History of UAVs

1916 - 1920. Gyrocompass and smart flying bombs

In 1917, Dr. Peter Cooper and Elmer Sperry invented an automatic gyrostabilizer (gyrocompass), it allowed the aircraft to hold a given direction of flight. As a result, they succeeded in turning the Curtiss N-9 training airplane into the first unmanned flying bomb. During test flights, the aircraft flew 50 miles with a 300-pound (136-kilogram) munition on board, but it never saw combat.



On September 12, 1916, the first radio-controlled airplane-sniper "Hewitt-Sperry" was tested. In 1917 the "air torpedo" was tested - a flying machine designed by one of the pioneers of aviation - O. Wright. Wright (O. Wright) was equipped with Sperry Giroscope and General equipment.

03

History of UAVs

The working principle of the first radio-controlled airplane - Queen Bee and its impact on the development of the drone industry

A real breakthrough for drones the XX century was 1933, which is officially considered the birthplace of all further developments. It was in this year that the first UAV was developed by British engineers. The project was named DH.82B Queen Bee.
These kinds of UAVs were restored models of Fairy Queen biplanes that were remotely controlled from the ship by radio.

This drone had a speed of up to 170 kilometers per hour, maximum lift height
5000 m and was the first aircraft with the ability to be reused, including as an aerial target in training pilots for air combat. The DH.82B Queen Bee served the British Air Force

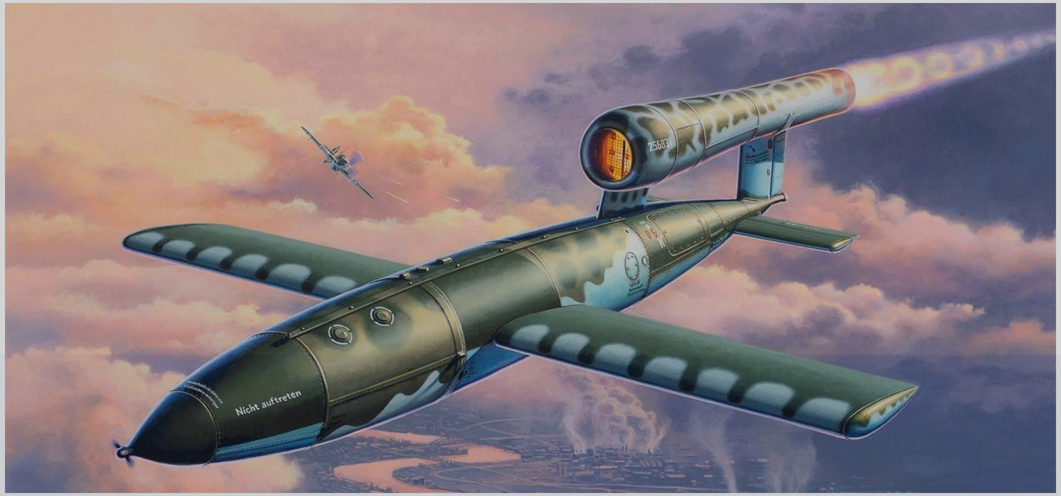
from 1934 to 1943.

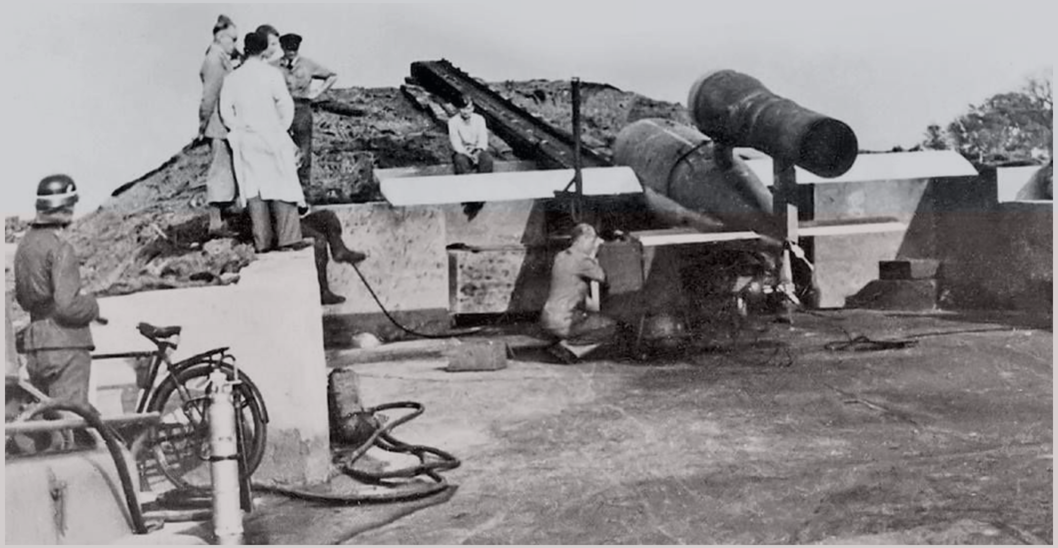
03

History of UAVs

FU-1 - Massive Use of UAVs in Combat Operations

In 1941, the design of the Fi-103 dive-bomb airplane was submitted to the Ministry of Aviation for consideration. The main engine of the vehicle was a pulsating air-jet engine created in the 1930s by German designer Paul Schmidt.
The engine was realized in metal in 1938. The idea of a pulsating air-jet engine (PREVRD) was patented back in the
1906 by Russian engineer V. V. Karavodin





Serial production of rockets began in 1942 on the island of Usedom. A concentration camp was located there, and the Nazis made extensive use of prisoner labor.

The combat deployment of Fau-1 began in 1943. In June 1944, the first use of the "Fau-1" took place, the Germans struck the British capital.

03

History of UAVs

1849 г.

Austrian troops deliver bombs to besieged Venice by balloon.

1898

Nikola Tesla designed and demonstrated a miniature radio-controlled ship.

1910

American military engineer Charles Kettering proposed, built and tested unmanned aerial vehicles.

1933

The first reusable UAV was developed in Great Britain, and the radio-controlled target created on its basis was used by the British Royal Navy until 1943.

1940

Creation of Faou-1 cruise missile as the first mass application of unmanned aerial vehicles in combat operations.

.

In the USSR, aircraft designer Nikitin developed a torpedo-bomber-planner of the following type "flying wing", and by the early 40's prepared a project of unmanned flying torpedo with a flight range of more than 100 kilometers (but the development was not launched into production).

1970-1980. The USSR was a leader in the production of UAVs for reconnaissance purposes

1991 UAVs were used by both sides during the Gulf War

2008 U.S. Air Force strike UAVs have proven highly effective in Afghanistan and Iraq

2013 UAVs are beginning to be used for peaceful and commercial purposes

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3 - й day education

04 Main legal and regulatory acts in the field of ABC

05 Flight and authorization approval

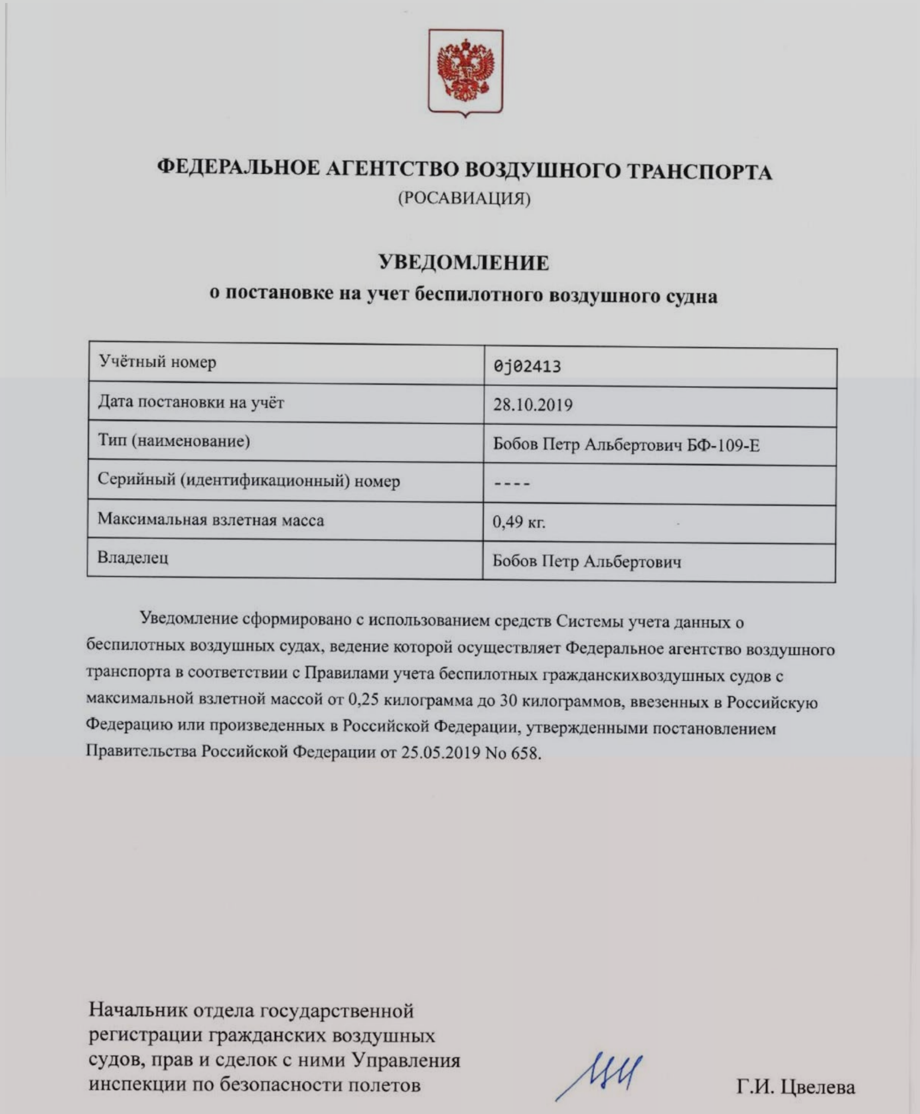
06 Sanctions for violations of the rules

Rules and regulations

Regulatory and legal regulation of the use of airspace of the Russian Federation

The two main documents we use are the Air Code of the Russian Federation (ACR) and the Federal Rules for the Use of Airspace of the Russian Federation (FAP-138). There is also a third document - the Rules of State Registration of Unmanned Civil Aircraft with a maximum takeoff weight of 0.15 kilograms to 30 kilograms, imported into the Russian Federation or manufactured in the Russian Federation. But these accounting rules are a direct consequence of some articles of the APC.

State registration of unmanned aircraft is carried out by Federal Air Transport Agency using the system of state registration of data on unmanned aircraft, which includes a database on unmanned aircraft and an information portal, which is a functional subsystem of the database published on the official website of Rosaviatsia (www.favt.ru) in the section



ФЕДЕРАЛЬНОЕ АГЕНТСТВО ВОЗДУШНОГО ТРАНСПОРТА
(РОСАВИАЦИЯ)

УВЕДОМЛЕНИЕ
о постановке на учет беспилотного воздушного судна

Учётный номер	0j02413
Дата постановки на учёт	28.10.2019
Тип (наименование)	Бобов Петр Альбертович БФ-109-Е
Серийный (идентификационный) номер	----
Максимальная взлетная масса	0,49 кг.
Владелец	Бобов Петр Альбертович

Уведомление сформировано с использованием средств Системы учета данных о беспилотных воздушных судах, ведение которой осуществляет Федеральное агентство воздушного транспорта в соответствии с Правилами учета беспилотных гражданскихвоздушных судов с максимальной взлетной массой от 0,25 килограмма до 30 килограммов, ввезенных в Российскую Федерацию или произведенных в Российской Федерации, утвержденными постановлением Правительства Российской Федерации от 25.05.2019 No 658.

Начальник отдела государственной регистрации гражданских воздушных судов, прав и сделок с ними Управления инспекции по безопасности полетов Г.И. Цвелева "registration of unmanned ".

04

Rules and regulations

Regulatory and legal regulation of the use of airspace of the Russian Federation

Use of airspace within the boundaries of populated areas and how this relates to 150/250 grams. In March 2022 amendments were made to the VZK on the basis of the Federal Law of 14.03.2022№ 56-FZ, namely: in Article 33 (VZK RF Article 33. State registration and state registration of aircraft) changed the MVM from 0.25 kg to 0.15 kg.

Please note that the changes were ONLY to ACCOUNTING, no changes were made to FAP-138, which governs IVP changes.

Article 49 of FAP-138 remained , i.e., IWP within the boundaries of populated areas is carried out with the approval of local authorities only for TWAs of 0.25 kg or more.

Regulatory framework

- AIR CODE OF THE RUSSIAN FEDERATION

Information Bulletin on the Procedure for the Use of Airspace of the Russian Federation BVS

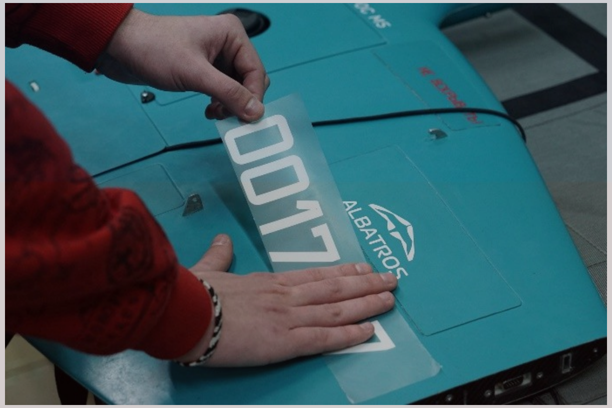
- Order of the Ministry of Transport of 27.06.2011№ 171 Instruction on the development, establishment, introduction and removal of temporary and local regimes, as well as short-term restrictions
- Report Card on the Movement of Aircraft in the Russian Federation dated 24.01.2013№ 13
- FAP Organization of planning for the use of airspace of the Russian Federation dated 16.01.2012№ 6

Federal rules of airspace use from 11.03.2010№ 138

04

Rules and regulations

Procedure for registering an unmanned aircraft



In order to register an unmanned , the owner of the unmanned aircraft shall submit an application for registration of the unmanned aircraft with a photograph of the unmanned attached. The photograph of the UAV shall be in color on a light monochrome background. The size of the unmanned aircraft depicted in the photo shall occupy at least 70% of the total size of the photo and shall contain an image of all structural elements of the unmanned aircraft. The angle of the photo shall ensure that the entire visible area of the BVS is displayed, allowing its identification.

You can apply in one of the following ways:

- through the Unmanned Aircraft Records Portal https://bvs.favt.ru/
- through the Unified Portal of State and Municipal Services (Functions) of the Russian Federation (UPGU);
- by mail, by yourself or via courier service to the Federal Air Transport Agency at the following address: 125993, Moscow, Leningradsky Prospekt, b. 37, corp. 2. 37, Bldg. 2, Moscow (mark

"Accounting for Airborne Aircraft" on the envelope). For more information on accounting of BIAs, please contact
by phone: +7(800) 200-6-555; +7(495) 601-08-43.

05

Flight and authorization approval

Registration, flight approval and permit issuance

***Simplified procedure for the use of airspace in case of visual flights of BVS with a maximum take-off weight of up to 30 kg performed within line of sight during daylight hours at altitudes of less than 150 meters from the ground or water surface in airspace (no need to obtain a flight permit):**

- outside the dispatch zones of civil aviation airfields, areas of airfields (helicopters) of state and experimental aviation, prohibited zones, flight restriction zones, special zones, airspace above the places of public events, official sports competitions, as well as security measures conducted in accordance with the Federal Law "On State Protection";
- at a distance of more than 5 km from control points of uncontrolled airfields and landing sites.

In all other cases, a permit is required, including if:

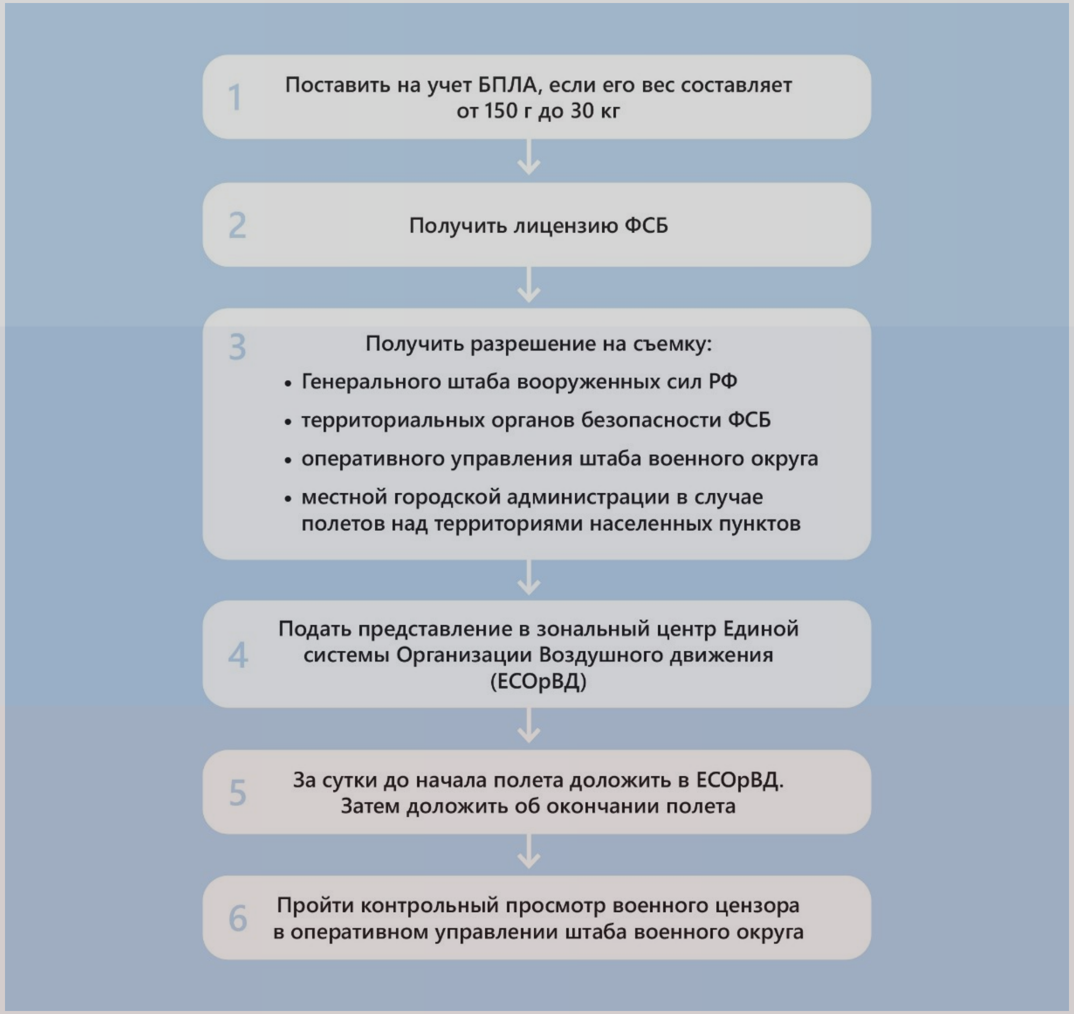
- Weight of BWS more than 30 kg
- Flight altitude more than 150 m
- Flying in the dark
- Flying over a populated area
- Flying within prohibited and protected areas

PROCEDURE FOR THE USE OF THE AIRSPACE OF THE RUSSIAN FEDERATION BY UNMANNED AERIAL VEHICLES (UAVS)

Terms and conditions of flight authorization depend on the region of the Russian Federation

Flight and authorization approval

Conducting aerial survey work



1. Register the BIA.
2. Obtain a license from the FSB.
3. Obtain filming permits :
   - of the General Staff of the Armed Forces of the Russian Federation;
   - Operations Directorate of Military District Headquarters;
   - FSS territorial bodies;
   - Local administration (if the flight is over a populated area);
4. Submit a submission to the EC Air Traffic Control Center for the establishment of a regime.
5. Submit the flight plan (also to the EC Air Traffic Control Center). Resubmit the flight plan one day before the start of the work. Report the start of the flight to the ZC two hours before the work is to be performed. Afterwards, report the completion of the flight.
6. Pass the military censor's control review in the Operations Office of Military District Headquarters.

The letter to the FSSB must be accompanied by: a copy of the directive of the General Staff of the Armed Forces of the Russian Federation, a scheme of the planned works, a license of the FSSB of the Russian Federation and a copy of the contract with the one for whose purposes the works will be performed. The address can be found here.
Permission for filming by the operational department of the headquarters of the military district in whose area of responsibility the object to be

filmed is located (there are four in Russia: Western, Southern, Central, Eastern+ Northern Fleet).
The letter to the military district shall already be accompanied by: a copy of the permission of the General Staff of the Armed Forces of the Russian Federation to conduct aerial survey, a copy of the license of the Department of the Federal Security Service of Russia for the city and a scheme of work execution. It is obligatory to specify the purpose of the work and which UAVs will be flown.

Sanctions and fines for violations

Fines for violation of the airspace utilization procedure

For flying any aircraft without obtaining airspace authorization:
- fine for physical persons - from 20 to 50 thousand rubles;
- for officials - from 100-150 thousand;
- for legal entities - from 250-300 thousand rubles or suspension of activities for up to three months.

For the launch of drones by persons who have no permission to use airspace at all, the fines are higher: 30-50 thousand rubles for individuals, 300-500 thousand for legal entities.

If the launch of a UAV without authorization (or other violation of the rules for the use of airspace) has caused serious harm to health or death of a person by negligence, a prison term of up to five years is envisaged, if two or more persons - up to seven years (Article 271.1 of the Criminal Code of the Russian Federation).

Violation of the law on state secrets (performing aerial photography and using its materials without observing the established rules) is subject to civil liability for compensation for material and moral damage.

basic FPV flying course

4 - your day education

07 Safety in operation

08 Safety during assembly

09 Safety in flight

07

Safety in the operation of the UAV

Pre-flight training

Before using the factory-made UAV, it is necessary to carefully study the operating manual and the set of documents received with the drone. Carefully inspect the UAV for defects and malfunctions.

- Pay attention to all warnings on the UAV body, battery, charging base, and those set forth in the owner's manual.
- Strictly follow the instructions for charging the batteries. Observe all instructions for use of the product
- Carefully inspect the launch site and the operator's location

Initial preparation

1. Drone - make sure the propeller nuts are tight.
2. Wires - place in bundles, secure with wire ties. Secure loose wires.
3. Propellers - install. Tighten the nuts.
4. Check that the propellers are correctly installed.
5. Check that there is nothing to interfere with the rotation of the propellers, if necessary

remove any interference.

07 Safety in the operation of the UAV

Pre-flight training

All works on assembly/disassembly of the aircraft, change/maintenance of the sensor, removal/insertion of memory cards are performed with the power supply of the aircraft switched off (the battery is).

It is necessary to distinguish between a factory drone and a custom (self-assembled) model.

What to bring with you (everyone has):

1. UAV.
2. Remote control with batteries.
3. Batteries.
4. Charger.
5. Multimeter or other voltage meter.

6. Spare parts.
7. Duct tape, scissors, screwdriver.

07

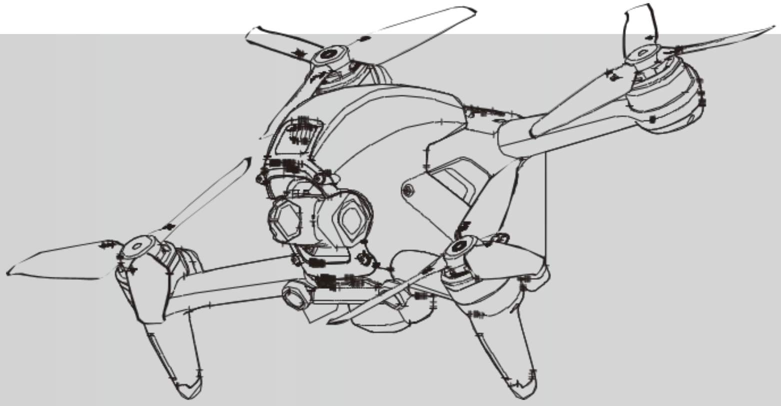
Safety in the operation of the UAV

Pre-flight training

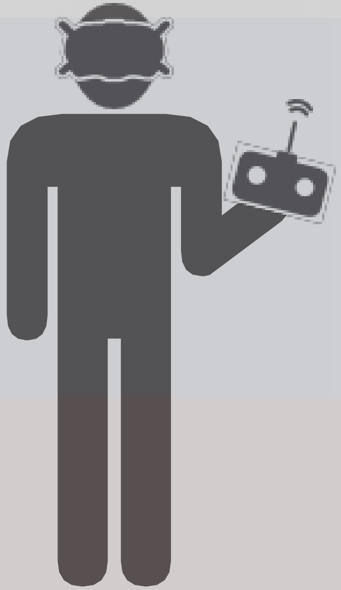
1. Charge the quadcopter battery(s) to 100% before each flight. Monitor the charge of the batteries. Charge the batteries only with original .
2. Charge the remote control battery (if built-in) to 100%. Always monitor the remote control's charge.
3. Check that the blades are installed correctly, otherwise the drone may flip over during takeoff. There are no scratches, chips or cracks on the blades, if there is damage, replace the required number of blades.
4. If you see that the horizon is off - calibrate the suspension.
5. Calibrate the compass of the quadcopter.
6. Make sure the drone has found the correct number of satellites and enters GPS mode.
7. Take off carefully, your first flights, wind the drone at a safe distance to check that it's not being pulled sideways and everything is operating normally.
8. If you have a drone without obstacle sensors or machine vision, always estimate the number of obstacles around you and set the correct altitude to return home.
9. If you are using GPS and the drone gives errors or notifications during self-diagnosis or during flight, read them carefully and comply with the drone.
10. Always monitor flight and telemetry from the drone in operational mode.

Safety in the operation of the UAV

Safety before takeoff



• All people present are behind . There are
no people at a distance of 10 meters in
front and to the side.
• Position spectators behind the pilot's
back or behind a line across both
shoulders of the pilot behind the
pilot's back.
• Do not allow spectators to enter the
hemisphere in front of the pilot's face.
• Know and remember the flight time
for which the copter and its battery
are designed.
• Stand at least 3 meters away from the copter.
• Take off from the ground from a level area,
at least 3 meters away from obstacles.
After ensuring that all items above are



completed, perform the power-up procedure
and proceed to takeoff.

08

Safety during assembly of the UAV

Safety precautions for assembly and maintenance of UAVs

1. When operating the UAV, comply with the Operating Instructions.
2. Charge batteries only in specially designated places, observing the safety requirements for the operation of batteries of this class and making sure that there are no people unrelated to this work at a distance of at least 5 meters.
3. It is forbidden to operate the batteries in case of mechanical damage of the protective film, swelling of the plates, appearance of characteristic odor of chemical reaction.
4. If a malfunction or emergency situation is detected during assembly, stop the process immediately and carry out a set of measures to eliminate it.
5. In case of uncontrolled reactions of batteries during charging (temperature rise, ballooning, open chemical), immediately shut down the process and isolate the battery by placing it in a container. the fire with a carbon dioxide fire extinguisher, earth or by covering it with a tarpaulin.
6. In case of injury, provide first aid to the victim and call a doctor. Until the doctor arrives, provide assistance based on the condition of the injured person.
7. At the end of work, roll up the set according to the operating instructions, remove the battery pack from the UAV, charge the battery pack and put it in a container. It is

forbidden to store the battery pack in free access.

Safety in flight

Safety in flight

- Follow all instructions given by the flight instructor.
- Fly only in the designated area and do not fly outside the designated area. Do not fly behind your own back.
- When learning to fly, fly at a level below your own height.
- Fly close to you at a distance at which you can see the copter's orientation in space. If in doubt about the copter's orientation, immediately land on the ground. Do not attempt to take off. Move closer to the copter and take off.
- When operating the stick, make all stick movements gently and smoothly. Do not make any sudden movements. If it is necessary to change the direction of flight, move the sticks vigorously, but not abruptly. Flying should be done carefully and only those elements that are not in doubt should be performed. It is forbidden to perform that are doubtful or risky.
- Observe the speed . Keep the speed of the copter within the speed of a walking person.

- Return the copter to the landing site by the calculated time, do not allow the battery to be completely discharged in flight. Land only on a flat, open area away from obstacles.

Safety in flight

Actions in emergency situations

In the event of an accident that did not cause injury

Disconnect the battery if possible. Monitor the battery for battery swelling and/or fire If necessary, record witness statements. Take photographs of the scene to show the position of the UAV. Ensure that all footage is retained for display as evidence. Record details of the accident and report if necessary. If heat, smoke or flames from the battery are present, do not touch it with your hands, use flame retardant gloves.

Loss of power or battery failure of the UAV

If power is lost to the flight controller or engines, the UAV may fall, or if there is no horizontal speed, it may fall vertically downward. It is important that the area under the UAV remains clear and that people in area are aware of the potential risk.

In-flight fire

If control is still possible, attempt to land the drone away from the crew on a non-combustible surface.

Fire on the ground

Allow the battery to burn out. If necessary, prevent the spread of flames by using a fire extinguisher / fire blanket. Avoid smoke inhalation as smoke is toxic. If it is safe to do so, use a fire extinguisher for Class D fires (metal fires).

09

Safety in flight

Actions in emergency situations

- When encountering meteorological conditions for which the unmanned aerial vehicle is not suited for flight, take all possible measures to extricate the unmanned aerial vehicle from them, and decide whether to continue or terminate the flight task, taking into account the air situation, meteorological conditions and remaining battery power;
- If the unmanned aerial vehicle communication systems fail, record the location of the vehicle at the time of loss of communication and the last activity of the vehicle, its speed, altitude, flight direction, remaining battery power, and the estimated remaining flight time. If communication with the vehicle is not re-established after the estimated remaining flight time, take measures to search for and rescue the vehicle;
- If other drone equipment fails, take all measures to land the drone in an emergency, avoiding free fall of the .

basic FPV flying course

5 - your day   education

10 Channels

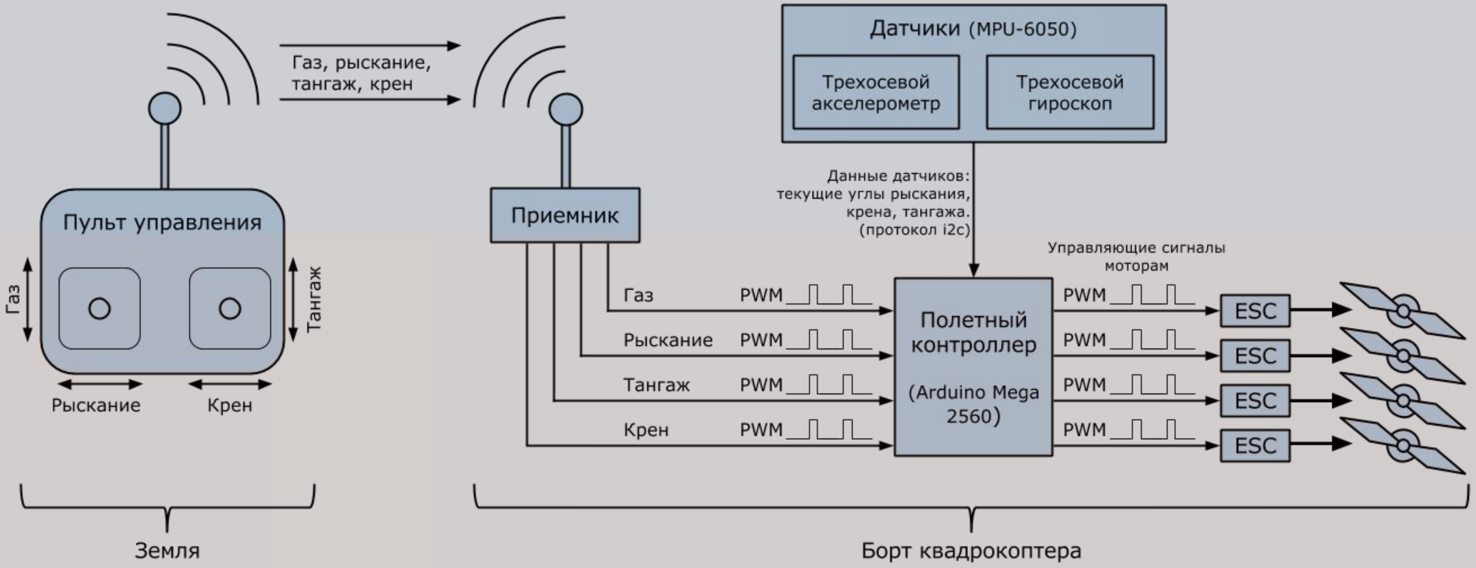
11 Frequencies

12 Repair kit

channels

Control, data and video channels

FPV is an abbreviation for First Person View and is a method of controlling a UAV using an on-board video camera that transmits real-time video data to the multicopter pilot, allowing the UAV to be flown out of human view. **Binding** is the process of establishing a permanent link (binding the receiver to the transmitter). After that, the receiver receives commands only from this transmitter, ignoring all others. This is one of the reasons why many transmitters can operate simultaneously on the 2.4 GHz frequency.



channels

Control, data and video channels

This technology allows receiving video images from the UAV via an additional video-radio channel in real time, i.e. the pilot controlling the drone sees the image received from the video camera with the help of display devices (phones, monitors, video glasses). The main purpose of FPV technology is to be able to control the drone at long distances and view the picture captured by the camera in real time.

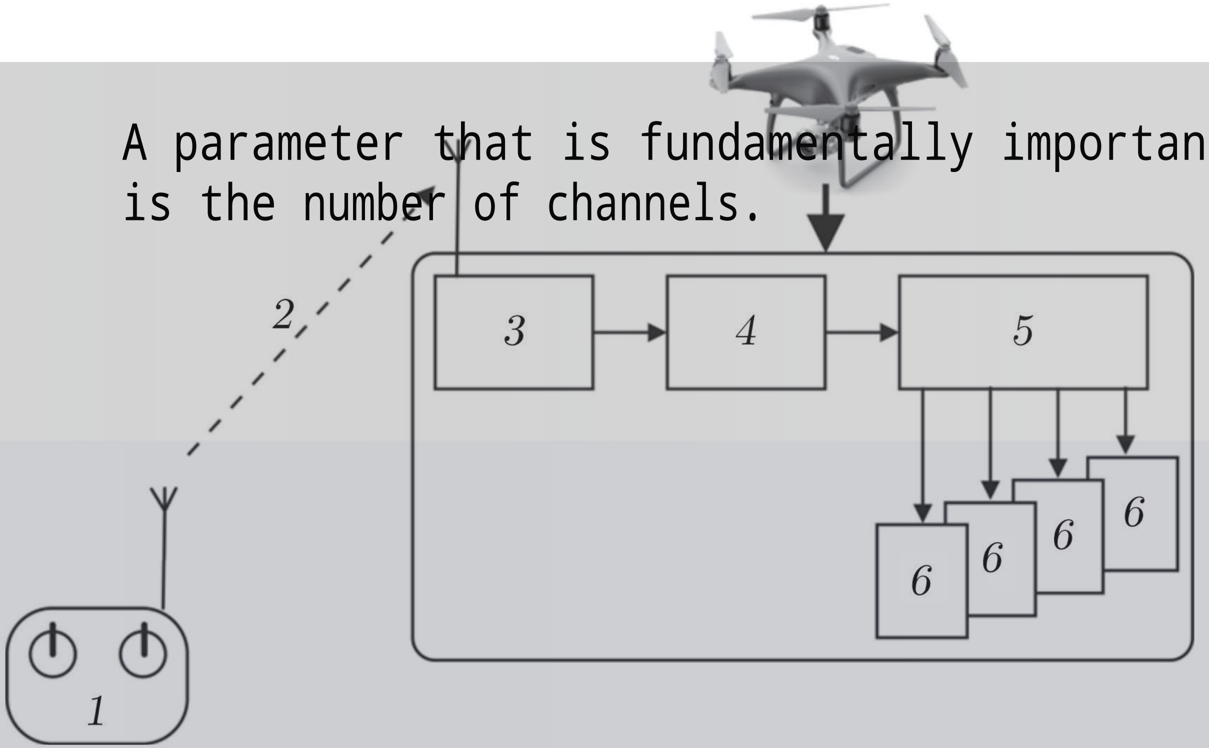
From the control panel the given commands are sent to the UAV receiver, after reception the data are transmitted to the flight controller, which includes the implementation and distribution of all the main functions of the multicopter. Based on the received command and sensor readings, which are implemented on a particular apparatus, the embedded software sends control signals to the UAV engines based on a certain algorithm. Consequently, the flight controller is a kind of the "brain" of the .

channels

Control, data and video channels

In general, radio control equipment consists of a radio control panel (transmitter) and a receiver. The main parameters are the signal coding protocol and the number of command channels.
A signal encoding protocol refers to the way in which commands received from the console controls are "packaged" into the data stream that passes through the radio channel. When designing protocols, noise immunity and density of information flow are the main considerations. The protocol of the transmitter and receiver of the radio signal should be the same.

A parameter that is fundamentally important is the number of channels.



Standard quadcopter control scheme:
1 - 13-channel remote control, 2 - radio signal, 3 - command receiver, 4 - flight controller, 5 - engine management controller, 6 - propeller groups

10

channels

Control, data and video channels

You need a minimum of four channels to control the quadcopter:

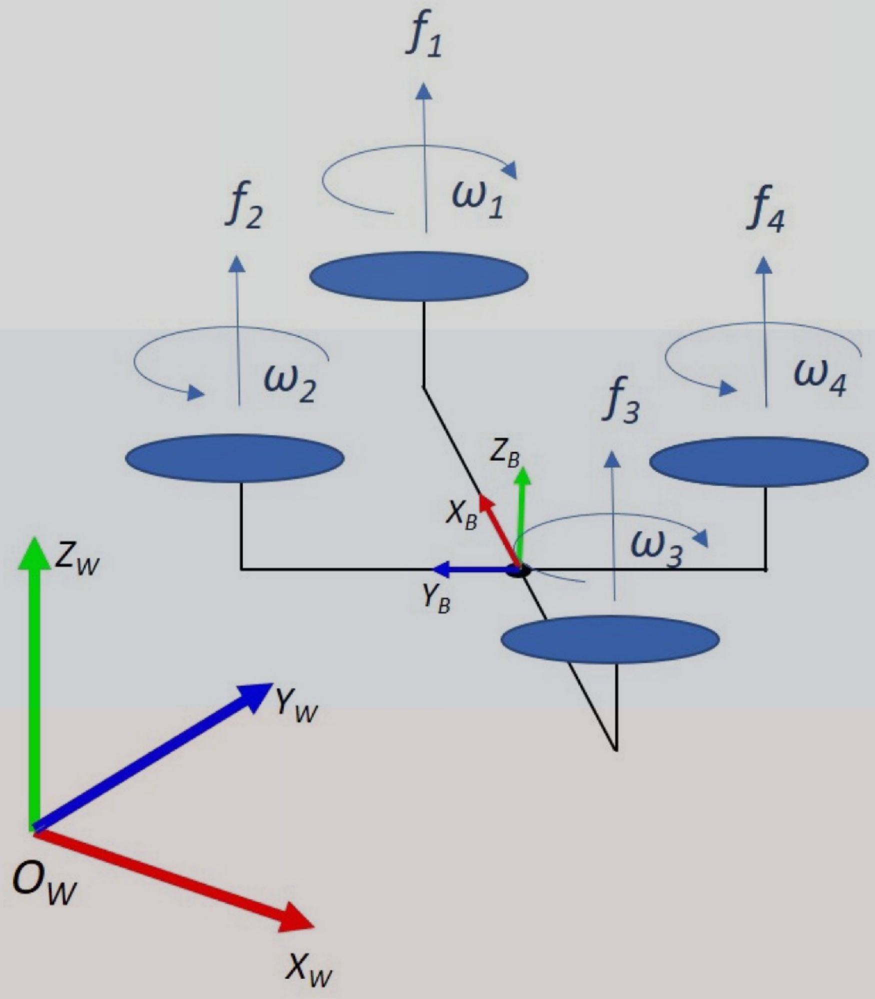
- common gas;
- pitch;
- roll;
- yawing.

This is not enough. You need channels to control the activation of sensors and flight controller modes (barometer altitude hold, compass on/off, GPS position hold or return home). Channels may be needed to control the on-board video camera, flight lights, or turn on a fallen vehicle locator system. Comfortable quadcopter control begins with eight or more channels.

The number of receiver and transmitter channels does not have to be the same, if your receiver supports 8 channels and your transmitter supports 12 channels, then you have 8 channels at your disposal.

channels

Control, data and video channels



Flight modes are the model of quadcopter behavior. The selected flight mode determines the ease of control.

throttle, yaw, pitch, roll - 4 channels of UAV control, each stick on the remote control is responsible for one of the channels.

• Gas, Throttle - The power to operate engines. In essence, the speed along the vertical axis. If the drone is horizontal (not tilted), it determines the speed of gaining altitude, if the drone is tilted in any direction - the speed of movement.

• Yaw, Rudder - turning around its axis.

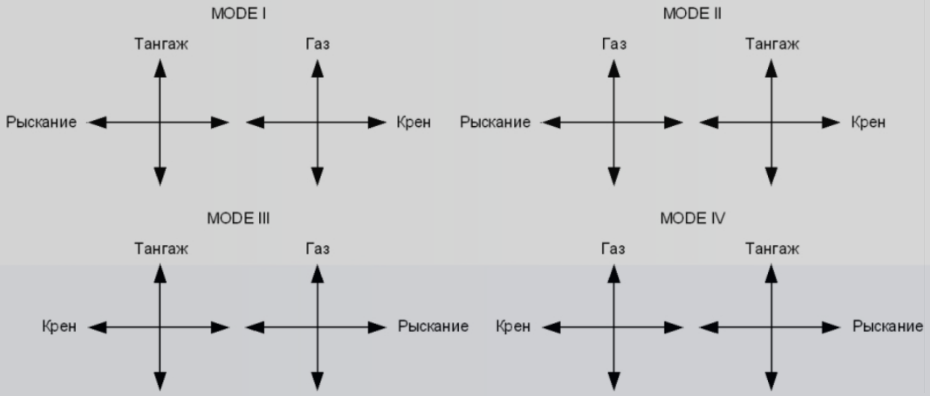
• Pitch, Elevator - tilts of the aircraft along the transverse axis ("nose" up and down).

• Roll, Aileron - tilts of the aircraft along the longitudinal axis (right/left tilts).

According to theoretical mechanics, the position of a solid body in space is given by six coordinates (degrees of freedom) - 3 translational and 3 rotational. In this paper, the *rotational coordinates are understood as Euler angles and are denoted as roll (rotation around the X axis), pitch (rotation around Y), and yaw (rotation around Z).*

channels

Control, data and video channels

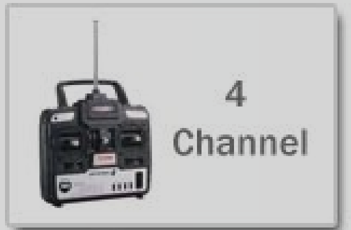


Mode 1, 2, 3, 4 (Mode I, II, III, IV) - type of control channel arrangement relative to the sticks on the control equipment.

Mode 2 is the most common and used type on the vast majority of commercially available drones.

Channels and frequencies

Control equipment (transmitter and receiver)



The control hardware (TX) is a device that allows the pilot to remotely control the copter. The signal/commands are received by the receiver, which in turn is connected to the flight controller.

Channels

The number of channels is the number of aircraft functions that can be controlled. For example: throttle, heading (yaw,), pitch (aka pitch, forward/backward tilt), roll (roll, left/right), each function requires a separate channel. As you can see, the minimum required to control the copter is 4 channels.
Additional channels are often referred to as AUX, and are represented by toggle switches and twist switches (variable resistors). You can use them to change flight modes or to activate different functions of the copter.

It is recommended to have at least 5 or 6 channels. Additional 1 or 2 channels can be used for armoring the copter (putting it into active mode) and for switching flight modes.

Most models use 2.4 GHz for control and 5.8 GHz for video transmission.

Frequencies

Operating frequency

The most popular frequency is 2.4 GHz. Lower frequencies are also used (27 MHz, 72 MHz, 433 MHz, 900 MHz and 1.3 MHz), and there are other frequencies - 1.3 GHz, 868/900 MHz, 433 MHz; these frequencies are used by long-range equipment for heavy models.

All transmitter manufacturers use algorithms with pseudo-randomization of the operating frequency, so it very easy to use the equipment. The software constantly scans the airwaves for the best frequency, monitors for interference, and automatically switches to free channels. This happens many times per second, so you won't see pauses or control failures like you used to. advantage of these algorithms is that you can fly with other pilots at the same time without fear

of jamming their equipment.

Frequencies

Video transmission and reception systems

The video stream is transmitted by means of a transmitter and a receiver. The main characteristics are the transmitter power, which directly affects the maximum range of its signals, and the carrier frequency.
Most transmitters operate in the 900 MHz (0.9 GHz), 1.2 GHz, 2.4 GHz, 5.8 GHz, and Wi-Fi data technology bands. The main types of video transmission will be discussed below.

FPV 2.4 GHz (analog)

Among the connection frequencies, 2.4 GHz is the least popular band. The main reasons for its unpopularity is the high sensitivity of the analog signal to interference, subject to blurring and noise. All because of the large number of devices that surround us and work in this range. Such as WiFi devices, Bluetooth, remote controls, etc., etc. As a consequence, the signal will be unstable and the transmitted image will be of poor quality.

The lower the frequency and longer the wavelength, the greater the penetration, but the greater the physical size of the antenna.

Wi-Fi at 2.4 GHz (digital)

Universal data transmission technology, in which FPV flights are realized. The first reason is the low cost of Wi-Fi transmitter, which is equipped with a drone camera, and the second is the lack of an additional device for video transmission, and its role is successfully performed by a smartphone or tablet. Before piloting, a special application is installed on the gadget and connected to the Wi-Fi point of the copter.

But there are some downsides:

- The signal transmission range is limited to the Wi-Fi zone;
- Image delay and the value of which increases with the distance of the copter from the remote control.

Frequencies

Video transmission and reception systems

5.8 GHz (analog)

This band is best suited for FPV flying. The frequency transmits video images with good bandwidth over long distances. The transmission delay is almost imperceptible and is optimal for high speed flights. However, various obstacles, walls, etc., have a significant impact on the range, as a consequence, the range of reliable operation of the video channel at 5.8 GHz is reduced and is used mainly on small copters.

Depending on the carrier frequency, the signal is received by a receiver whose frequency must match the frequency of the transmitter. Subsequently, the converted video signal is transmitted to the monitor screen, glasses. It is worth realizing that there are no long range receivers, as the signal range depends on

5GHz Wi-Fi (digital)

the power of the transmitter and antenna.

5GHz Wi-Fi broadcasting has come to the budget niche not so long ago, which has significantly improved the quality of the video stream and the distance of removal. Therefore, when choosing a budget FPV drone, it will be best if the model's Wi-Fi video transmitter operates at 5GHz.

Conclusion:

1. Analog FPV at 2.4GHz is an obsolete technology, hardly used at all
2. Wi-Fi FPV at 2.4GHz is a new budget technology, but the picture is broadcast with a significant delay
3. Wi-Fi FPV on 5GHz is a new budget technology, the picture is broadcast with less delay compared to Wi-Fi FPV 2.4GHz, in better quality and longer range. The best option for entry-level copters (for toys).
4. **Analog FPV at 5.8GHz is the best of the three, the choice of professionals and hobbyists.**

repair kit

Tools for small repairs in the field

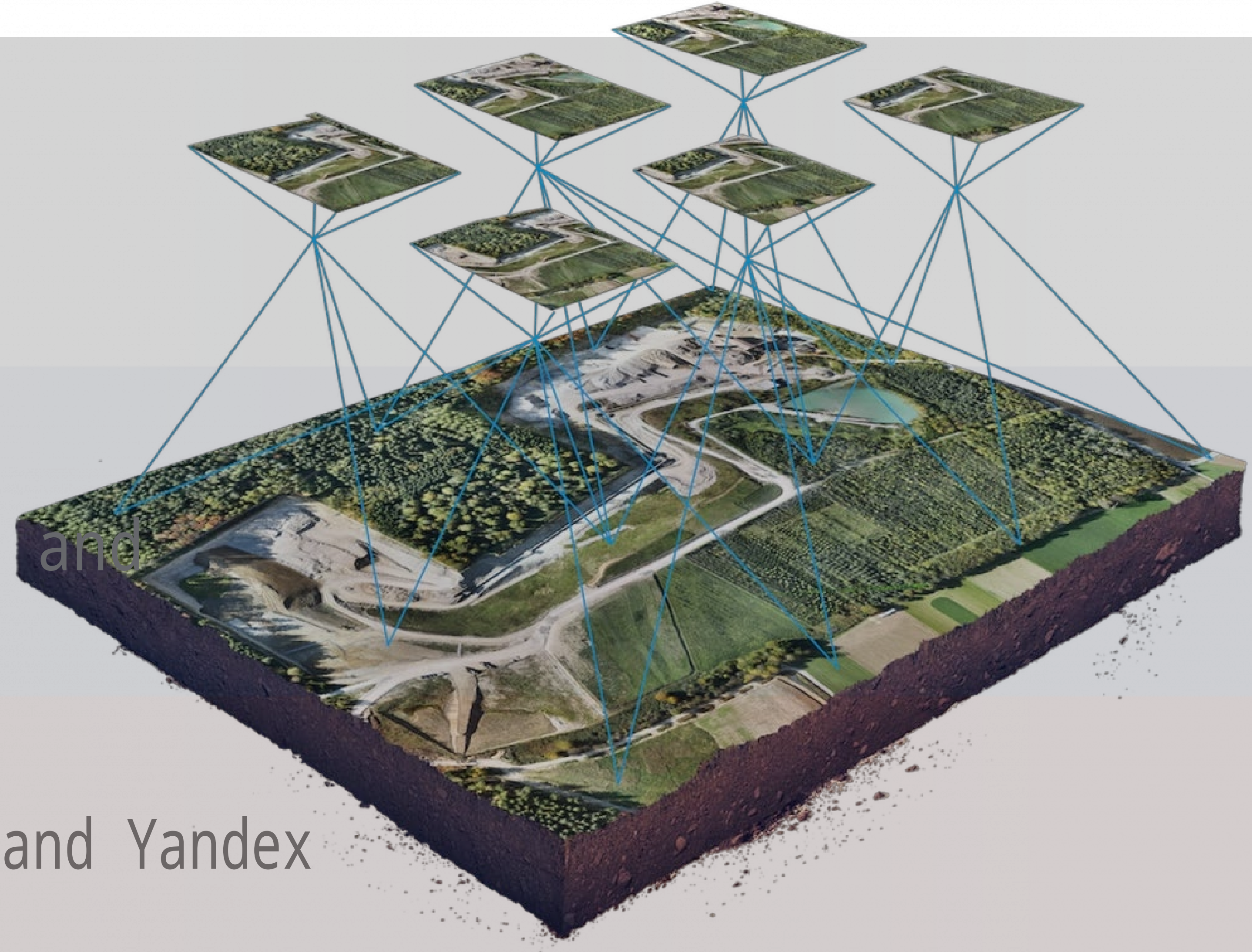
- Screwdriver and tool set
- Soldering iron and solder
- Hexagon heads - 1.5, 2, 2.5 and 3 mm
- Wire cutters
- Multimeter
- Shrink tubes
- Duct tape

Spare parts:

- Batteries
- Propellers
- Electronic components
- engines
- antenna

basic FPV flying course

6 - oy day schooling



13 Cartography

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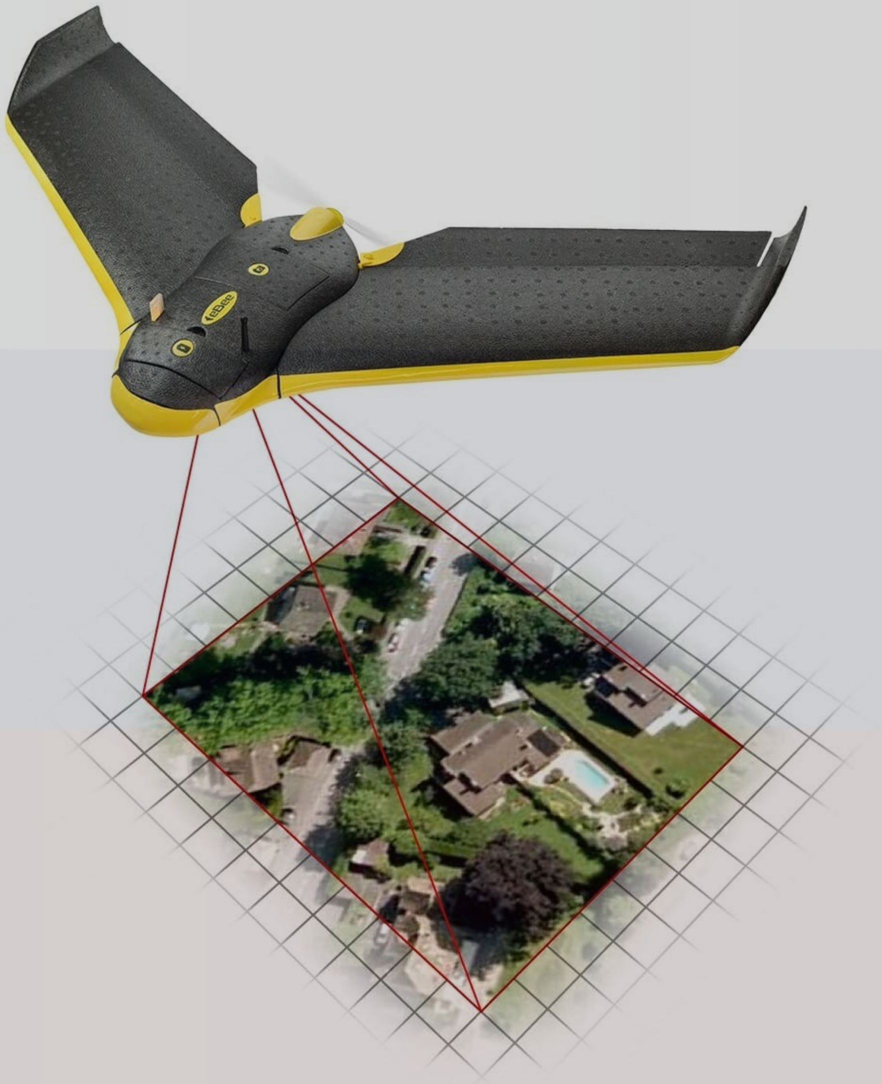
Cartography

Modern surveying methods and technologies for creating topographic plans and maps



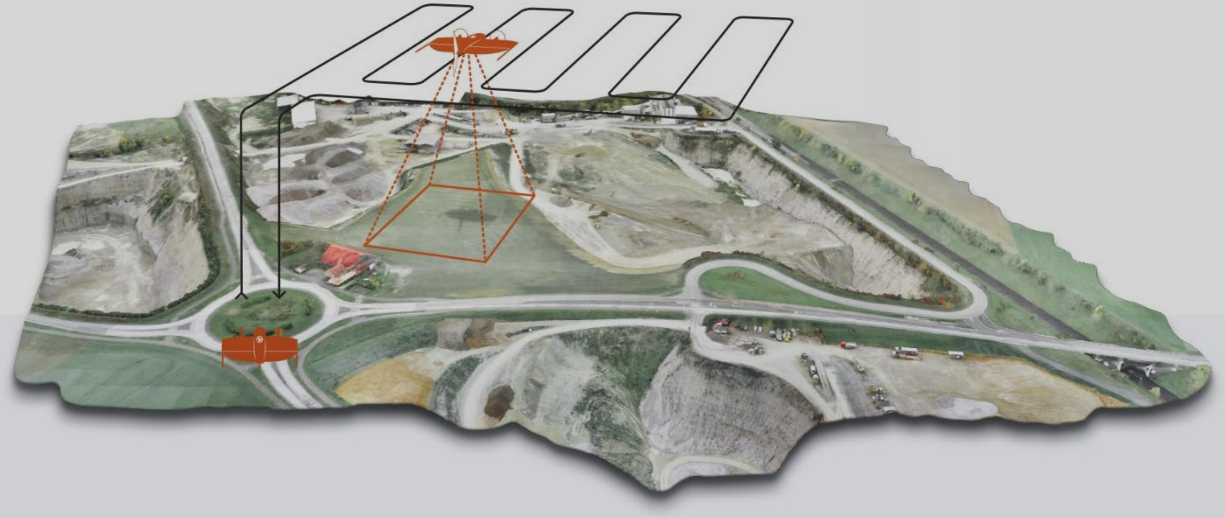
Modern methods of measurement, new equipment in geodesy and surveying make it possible to automate the process of work, which reduces the time of their implementation and provides the necessary accuracy and quality, this is facilitated by the use of unmanned aerial vehicles (UAVs) in surveying. With the development of UAVs, it became possible to install various payloads - both a digital camera and a laser scanning device (LiDAR). Today, the advanced surveying technologies for creating topographic plans and maps are airborne laser scanning (ALS) and aerial photography with UAVs (APS).

Airborne laser scanning - laser scanning that is performed from the air using aircraft.

UAV aerial photography is the photographing of the surface of a certain territory with georeferencing to coordinate data and creation of a series of relief images, which are formed with a small overlap.

Aerial photography and photogrammetry

Modern applications of aerial photography

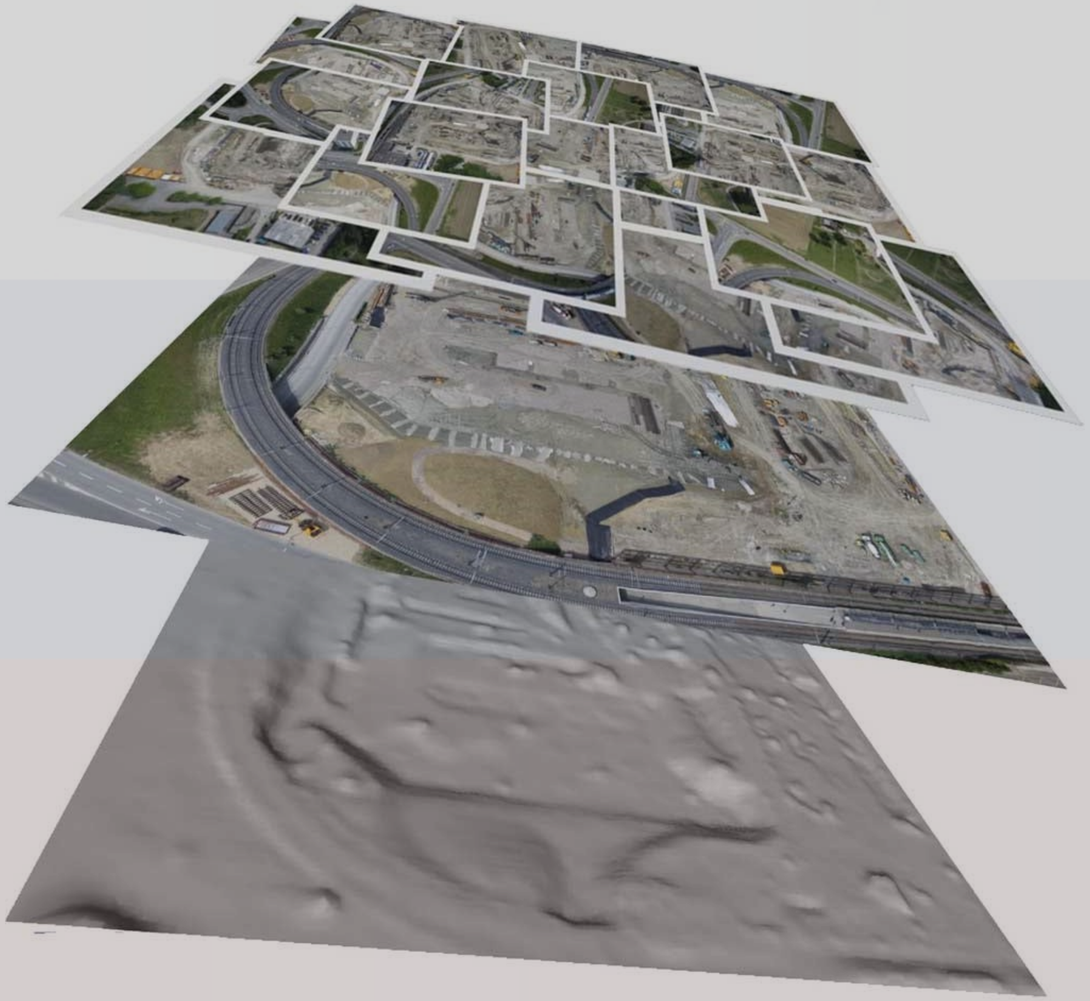


1. Creation of terrain maps, including depiction of relief and objects in 3D projection.
2. Plotting boundary markings and existing properties on a location map.
3. Control of land use, construction and surveillance process in .
4. Photography of natural landscapes, architectural objects, terrain, archaeological research.
5. Site planning and design, preparation of photographic site plans.
6. Traffic flow control.
7. Shooting for media and movies.

8. Advertising of hotels, resorts, land and real estate.

Aerial photography and photogrammetry

Modern applications of aerial photography



Aerial photography from UAVs with the installation of appropriate survey equipment allows to obtain digital images of ultra-high spatial resolution up to several centimeters (2-4 cm) in various spectral ranges.

This equipment allows you to solve the following tasks:

- Automated acquisition of orthophotos with spatial resolution up to several cm
- Creation of photorealistic digital 3D terrain models
- Monitoring of emergencies and their consequences, control of the progress of emergency recovery operations, search for victims
- Analysis and assessment of the dynamics of terrain changes
- Production and environmental monitoring
- Remote monitoring of oil and gas pipelines, power lines, railroads, roads, forests and agricultural lands

- Thermal imaging

Aerial photography and photogrammetry

Advantages and disadvantages of UAV aerial photography

Advantages	Disadvantages
Unprecedented spatial resolution from 2 cm.	Limited survey area per flight.
High frequency of surveying, possibility of continuous monitoring, short time of preparation for flight. No need for a large team to carry out the work, 1-2 people are enough. Possibility of fully automated flight.	Incompleteness of legislation in the field of UAV flight regulation and the laboriousness of obtaining the necessary permits for flight activities.
Weather conditions have little influence on the work, but data obtained during precipitation/fog are often unsuitable for processing. Digital photogrammetry relies in its algorithms on connecting points on the images, if they are of poor quality, the result will be incorrect.	It is not possible to obtain historical data for monitoring an area if the area has not been previously surveyed.
The first results of the flight are already an hour after landing: orthophotos, 3D digital terrain models, but it depends on the number of images and their resolution, as well as on the capacity of the processing system. Average processing time on a laptop of 500 images to obtain an orthomosaic can take about 4 hours.	High cost of the aircrafts themselves and the order of shooting, long payback (cost-effective in case of permanent shooting).
Monitoring of long objects (oil, gas pipelines, power lines), high flight range	Small size.
Target tracking, hovering over an object (helicopter-type UAVs), perspective , creation of 3D models of objects based on primary images (e.g., buildings under construction).	The frequency of flights is limited by the speed of the operator (human factor).
Spot shooting in hard-to-reach places.	Unable to control the flight if the ground control station loses communication with the UAV
The possibility of installing environmental monitoring equipment (sensors for temperature, humidity, radiation background, chemical pollution, etc.), this is an advantage for UAVs, without being attributed to aerial photography.	

Conducting multispectral survey and obtaining vegetation indices required for monitoring of agricultural lands.	

Aerial photography and photogrammetry

Building a three-dimensional surface model

Photogrammetry is a technical science of methods of determining shape, size, position of objects from their photographic images and a method of obtaining three-dimensional data from multiple images taken from different points. This is the method of construction used, for example, in the PhotoScan package (Agisoft PhotoScan is renamed Agisoft Metashape since version 1.5). **There are also analogs, for example:**

- Pix4Dmapper
- DroneDeploy
- Autodesk ReCap 360
- RealityCapture

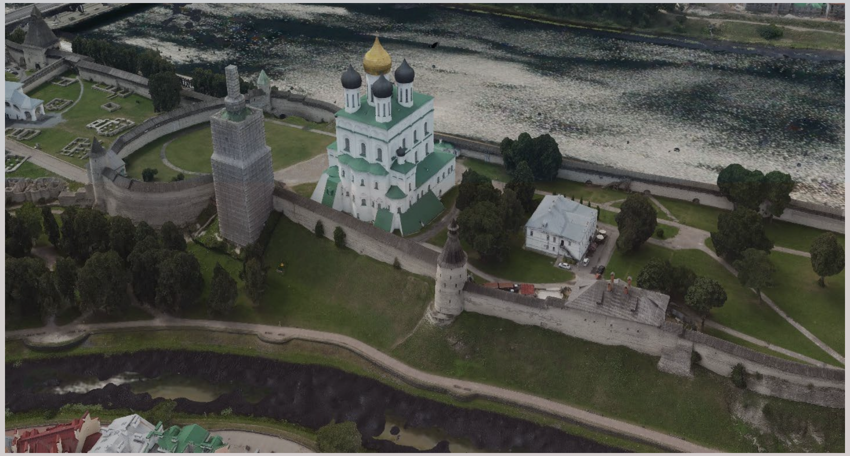


Image processing to support topographic works includes a number of sequentially performed operations, some of which are realized by modern methods of machine vision and are based on the use of projective geometry, homogeneous coordinates and photometric image processing:

- Selection and identification of corresponding points on images
- Building photogrammetric models
- Equalization of coordinates of network points

- Construction of digital elevation models and textured terrain models

Aerial photography and photogrammetry

Building a three-dimensional surface model

The general process of photogrammetric processing can be described as follows:

The first stage is a block phototriangulation by independent mappings method. At this stage common points of images are searched and identified and all camera parameters are determined using them: position, orientation, internal geometry (focal length, distortion parameters, etc.). The results are a cloud of connecting points in 3D model space and data on camera position and orientation.

The second stage involves building a point cloud or three-dimensional surface: a polygonal 3D model and/or a Digital Terrain Model (DTM) 2.5D. The polygonal model can be textured for photorealistic representation of the survey object.

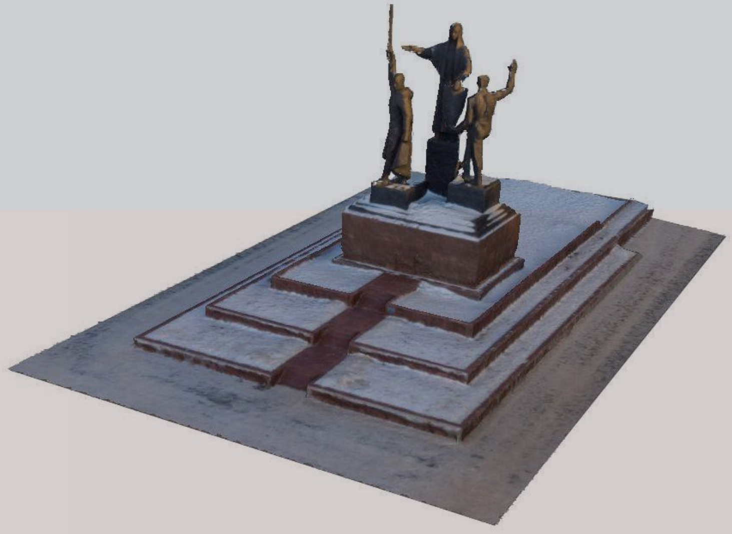
At the third stage, an orthophoto can be constructed based on the obtained surface.

Aerial photography and photogrammetry

Building a three-dimensional surface model

Point cloud with isolines, Northern Baseg mountain survey, Ural Mountains.

All calculations are performed in automatic mode, according to the preset parameters and settings. In exceptional cases, operator intervention is allowed and some actions are performed in non-automated (manual) mode.



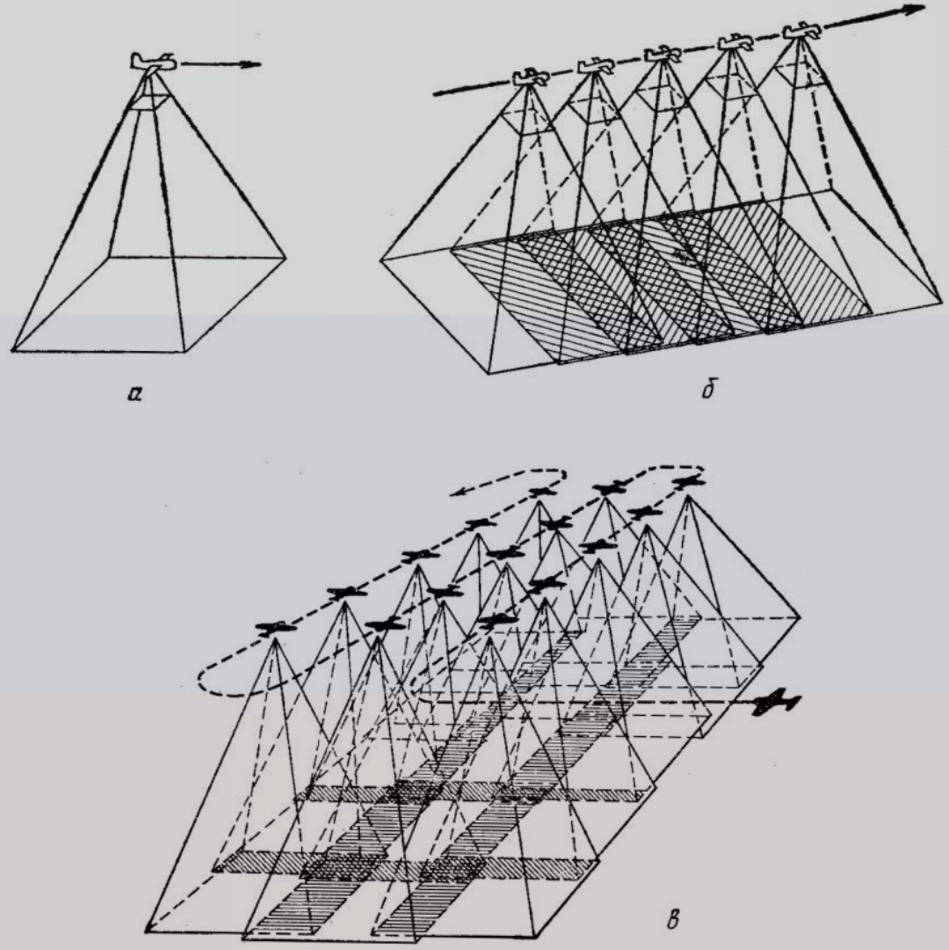
Example of a complete digital model of an object

The input data for photogrammetric processing of UAV aerial imagery materials are aerial images in one of the formats accepted by the system, geodetic data about the terrain and survey camera parameters, as well as elements of external orientation of images (coordinates of image centers and angles: heading pitch roll/omega phi kappa).

Geodetic data about terrain can be represented either by distances between points recognized on aerial images or their spatial positions in the terrain coordinate system. In the first case the program will limit itself to bringing the constructed photogrammetric model to the specified scale, and in the second case - to its geodetic orientation, construction of orthophotomaps, digital and textured terrain models.

Aerial photography and photogrammetry

Building routes for aerial photography



Single (selective) aerial photography means selective photography of small areas of terrain covered by single images. **Single-route aerial photography** is usually used for photographing linear terrain objects - river valleys, glaciers, highways, etc. In the case of area (multi-route) aerial photography, an area of terrain is covered with images belonging to a series of rectilinear survey routes laid parallel to each other.

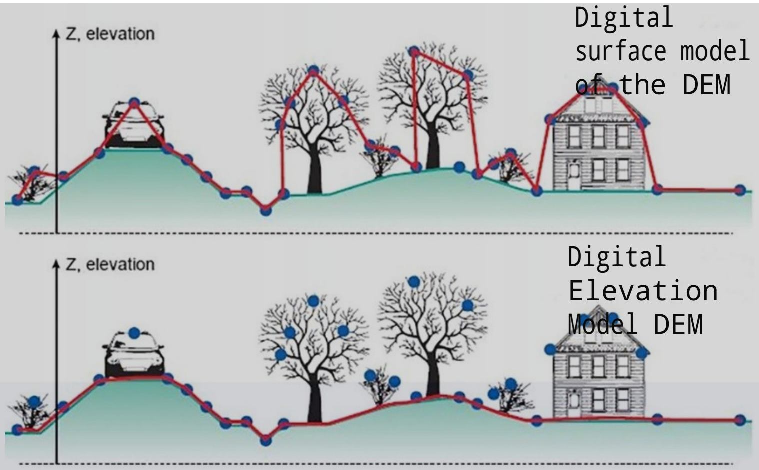
Single (a), single-route (b) and area (c) aerial photography schemes In a route the images are overlapped by a specified amount of longitudinal overlap. The distance between routes shall be such that the images of adjacent routes also overlap each other, forming a transverse overlap zone. In multi-route aerial photography of flat areas, usually 60% and 35-40% longitudinal and transversal overlap are sought, respectively. For aerial photography from UAV cameras (often cameras) it is recommended to design longitudinal overlap of at least 60%, longitudinal overlap of at least 50%. This is due to large distortions in camera images relative to aerial survey systems.

It is also recommended to use a fixed value of the camera parameters all the time of the flight, it is especially recommended to fix the focal length and shutter speed.

Aerial photography and photogrammetry

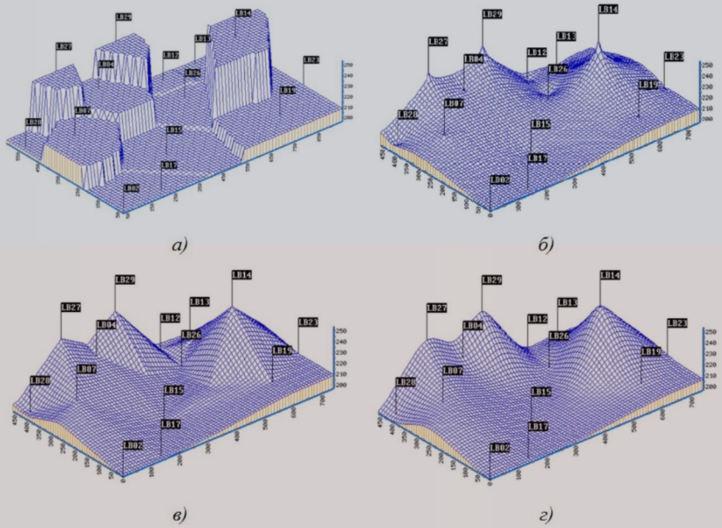
Digital models

A digital terrain model (DTM) is a set of information about all its elements, such as situation, relief and individual topographic objects. All objects included in the DEM are similar to real objects. Construction of DEM is performed in the course of digital mapping of terrain during topographic works. **Digital terrain model (DTM) includes digital surface model (DSM), digital elevation model (DEM) and digital situation model (DSM).**



Digital Surface Model (DSM) - contains information about the height of the earth's surface, natural (e.g. vegetation) and man-made objects (e.g. buildings and structures).

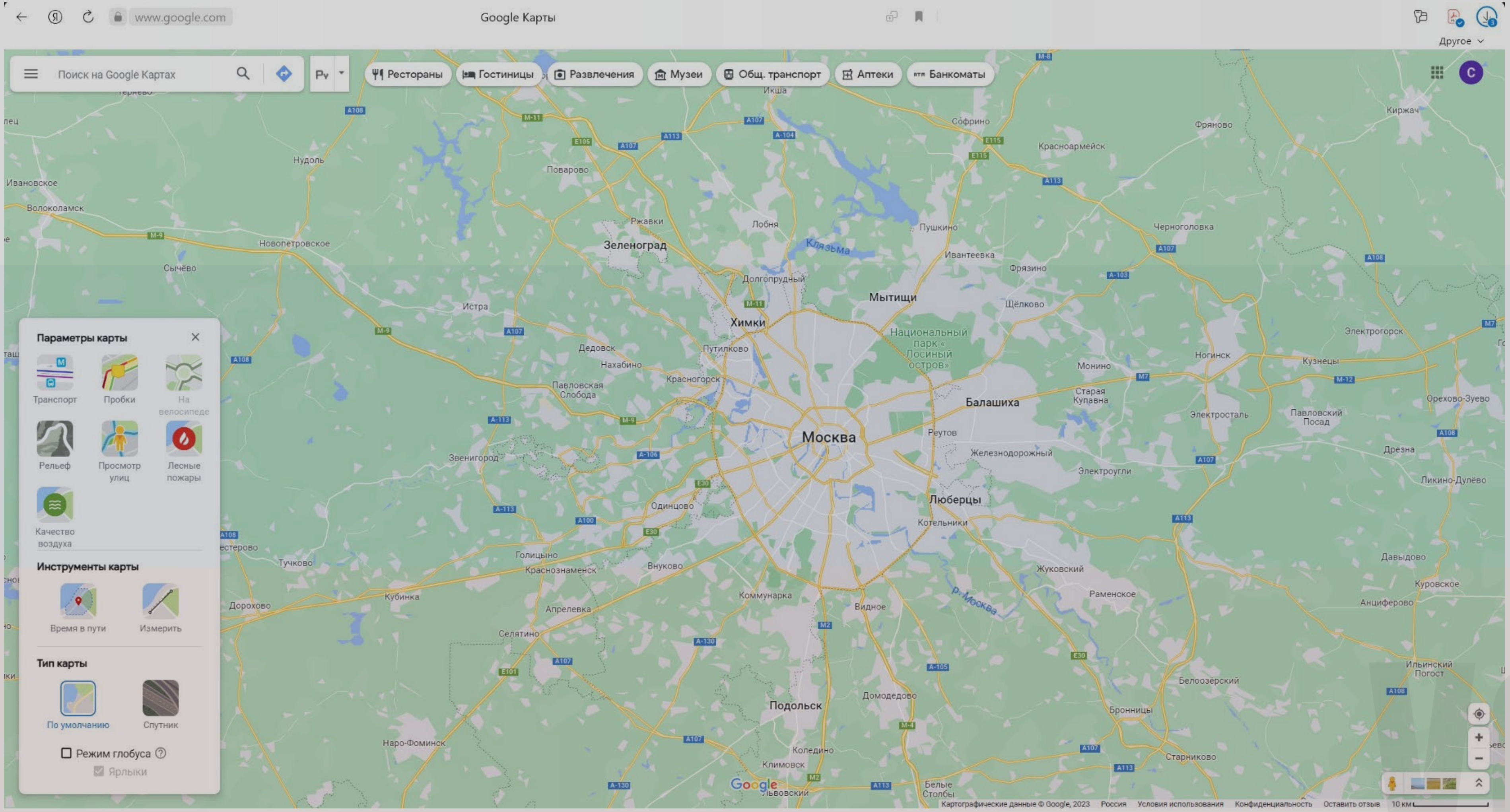
Digital Elevation Model (DEM) is a mathematical representation of the earth surface area obtained by processing topographic survey materials. The term digital elevation model (DEM) means a means of digital representation of three-dimensional spatial objects (surfaces or reliefs) in the form of three-dimensional data forming a set of height marks (depth marks) and other values.



Digital situation model (DSM) - digital representation of topographic objects of terrain, including their geometric description by means of vector data model in the form of a set of points and polylines with spline or spatial coordinates defining their boundaries.

Working with google and yandex

Features and functionality



Google Maps

It can be used to:

- View a map of the world or a ;
- Plot a route in real time;
- Find out the schedule of public transportation;
- Call navigation (for mobile version);
- View street panoramas and more.

Tools on the left:

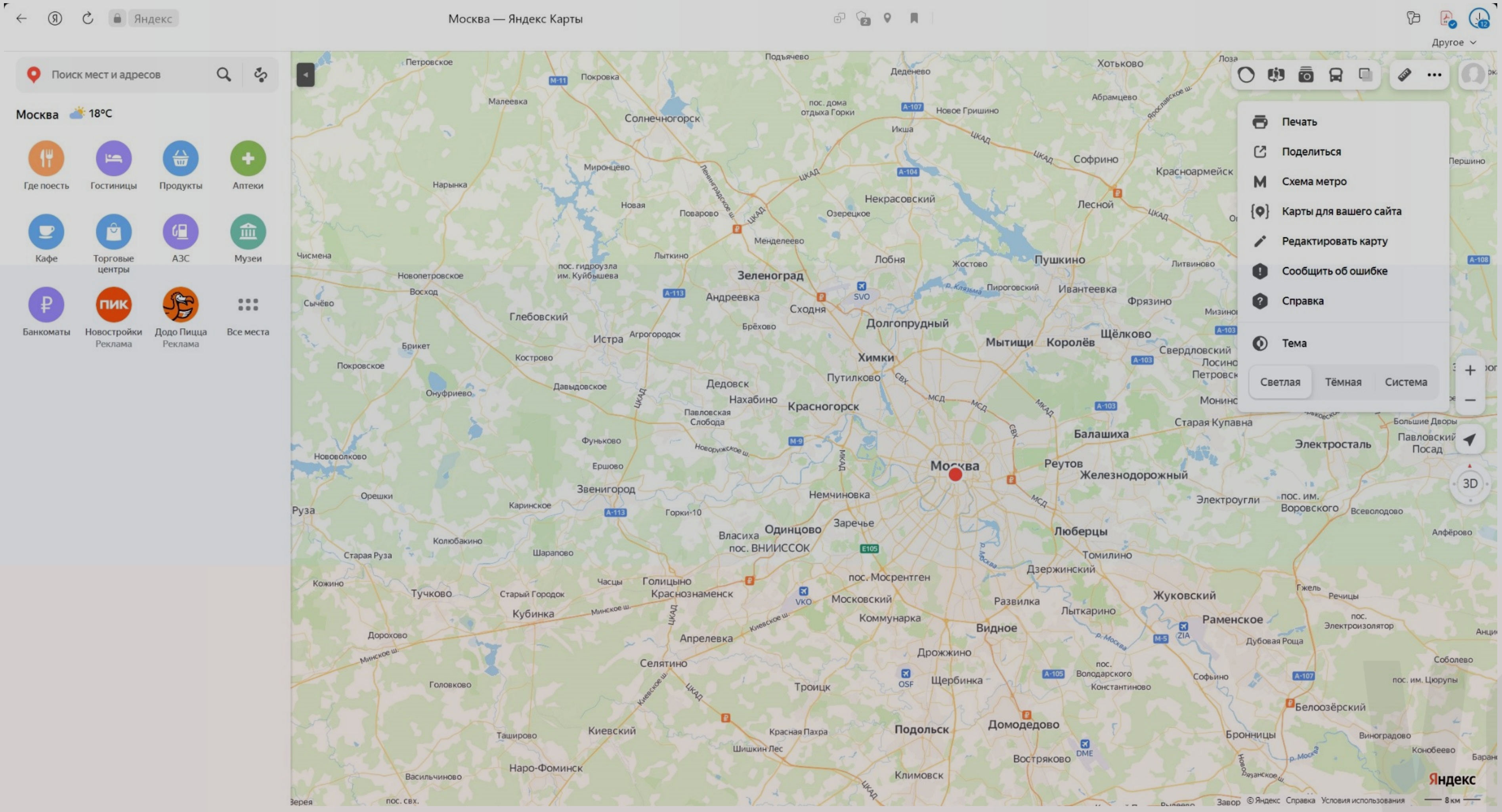
- Map parameters
- Map tools
- Card type

Tools on the right:

- Panoramas and photos

Working with google and yandex

Features and functionality



Yandex.Maps

Yandex.Maps is no less popular than Google Maps.

It is functionally identical to its American competitor.

Opportunities:

- View building schematic
- Displaying public transportation on the map
- Search for detailed information about the object
- Route Builder (manual creation of a convenient

navigation route),
etc.

• **View aerial panoramas**

basic FPV flying course

7 - o y day schooling

16 Commercial drone operation frequencies and minimum kit

17 Commercial drone kit for SWO operations

18 Civilian applications of commercial drones

Commercial UAVs

Mini UAV (quadcopter type)

DJI mini 1, 2, 3, SE.
Features and functionality of the DJI Mini 3 Pro:

- Weight of the Mini 3 Pro: 249g.
- Camera used with 1/3 CMOS sensor with dual ISO and viewing angle 82.1°. Video shooting is available in 4K at 60 fps, photos are 48MP in JPEG/RAW formats.

Autonomy: with a regular battery can fly up to 34 minutes, with an advanced battery - as much as 47 minutes.

- Range is up to 18 km or up to 25 km with an advanced battery.

Fimi X8 Mini

Autel Evo Nano+ (Plus)

- Weight: 249 grams
- A camera on board with a 1/1.28" CMOS sensor that captures 4K video at 30 fps and photos up to 50MP vs. a camera with a 1/2-inch sensor and 48MP photo resolution on the regular version of the Nano.

Autonomy: 28 minutes, and video transmission range up to 10 km.

- Weight: 258g with standard battery and 245g with "Pro" battery
- Video camera with 1/2.6-inch CMOS sensor based on Hisilicon ISP chipset. Video shooting is available in 4K at 30 fps, photos are 12MP. **Autonomy:** 30/31 minutes. The Fimi X8 Mini can be controlled by a smartphone or remote control, in which case the maximum flight range will be 8 km

Commercial UAVs

Medium UAVs (quadrocopter type)

- Average range: up to 15 km.
- Weight: up to 1000 g.
- Availability of a thermal imaging camera on some models
- It is possible to install a reset system

Large UAVs (quadcopter type)

- Average range: up to 15 km.
- Weight: more than 3 kg.
- It is possible to install a reset system and relay devices

Commercial UAVs

Commercial drone operation frequencies

Название	Камера	Время полёта	Заявленная дальность полёта	FPV
 DJI Inspire 2	6K (24Мп APS-C Super-35)	до 27 минут	до 7 км	LightBridge 2.4ГГц/5.8ГГц
 Autel Robotics EVO	4K	до 30 минут	до 7 км	2.4ГГц
 FIMI X8 SE 2020	4K	до 35 минут	до 8 км	5.8ГГц (TDMA HD 2.0)
 DJI Mavic Pro (Platinum)	4K	27/30 минут (Pro/Pro Platinum)	до 7 км	2.4/5.8ГГц (OcuSync)
 Autel EVO Lite+	5K	40 минут	до 12 км	2.4ГГц/5.1-5.8 ГГц (Autel SkyLink)
 DJI Mavic Air 2	4K	до 34 минут	до 10 км	2.4/5.8ГГц (OcuSync 2.0)
 DJI AIR 2S	5K	до 31 минут	до 12 км	2.4/5.8ГГц (OcuSync 3.0)
 DJI Phantom 4 Pro V2.0	4K	30 минут	до 10 км	2.4/5.8ГГц (OcuSync)
 DJI Mavic 2	4K	до 31 минут	до 10 км	2.4/5.8ГГц (OcuSync 2.0)
 XDynamics Evolve 2	4K	до 33 минут	до 11 км	2.4ГГц/5.1-5.8ГГц
 Autel EVO II	8K	до 40 минут	до 9 км	2.4ГГц
 DJI Mavic 3 (Cine)	5K	до 46 минут	до 15 км	2.4/5.8ГГц (DJI O3+)

The main characteristics of commercial drones:

- X-shaped frame
- Its own protocol in which both control and video are transmitted (O3, O4 - DJI)
- Control frequencies (2.4 GHz, 5.2 GHz, 5.8 GHz)

Commercial UAVs

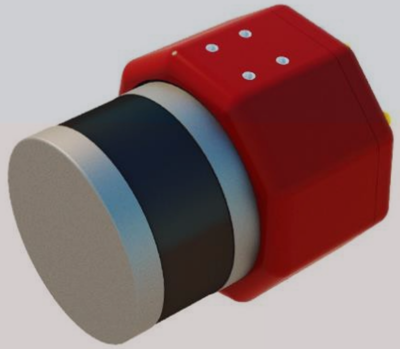
Medium-sized UAVs (quadrocopter type)

Camera

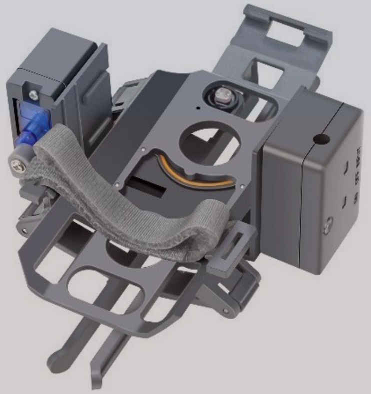
Thermal imager

Video camera

Thermal imager+ camera



Laser scanner



Load dumping systems

Commercial UAVs

Pros and cons of commercial drones

ADVANTAGES

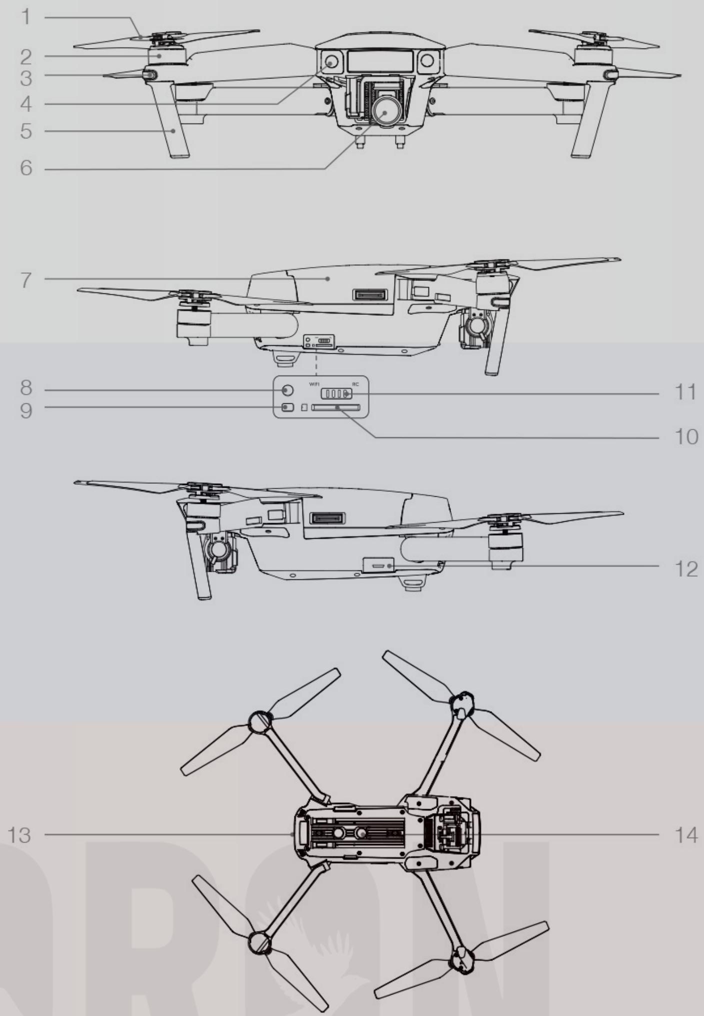
- Ready-made solution
- Ease of operation
- Kit weight
- Mobility
- Small size and low visibility;
- There are no losses;
- Ability to carry payloads (repeaters, jettisoners)
- Possibility of finalization

DISADVANTAGES

- Difficulty of repair
- There is no possibility to change the video camera, in some models it is purchased separately.
- High acoustic noise level
- Flight range
- Vulnerability in the sky
- Subject to tampering
- Meteorological dependence

Commercial UAVs

Drone schematic



1. Пропеллер
2. Электродвигатель
3. Передние огни
4. Система переднего обзора
5. Посадочное шасси
   (со встроенными антеннами)
6. Стабилизатор и камера
7. Аккумулятор Intelligent Flight Battery
8. Кнопка подключения
9. Индикатор статуса подключения
10. Слот для карты памяти Micro SD в
    камере
11. Переключатель режимов управления
12. Порт Micro USB
13. Индикатор состояния дрона
14. Система нижнего обзора

In combat applications, the backlight should be turned off or the indicators should be taped off so as not to demask the drone

Commercial UAVs

Apps for drone control

DJI Fly, GO, GO 4 - synchronize with the drone via a mobile device and also give full control to the user. The main difference between each app from each other is the purpose for different models of quadcopters. **Litchi** is a popular drone app. The fundamental advantage of Litchi is the ability to plan flights on a computer by transferring the plans to a smartphone. For people who don't like to look at the small display of a mobile device, this feature is essential.

FIMI NAVY allows you to customize the parameters of FIMI drones:

- Manage flight modes.
- Receive an image from the on-board camera.
- Display telemetry.
- Track the drone's position on the map.

Autel Explorer is the name of the app you can download to your smartphone to control the Autel Evo I and II series of drones. The Autel ExplorerTM app enables live streaming, advanced flight and camera control features from your mobile device

Commercial UAVs

Commercial drone control panels

RC Pro

DJI RC

RC-N1

Smart Controller

Commercial UAVs

Improving the performance of UAVs

There are 2 ways to improve performance - hardware and software.

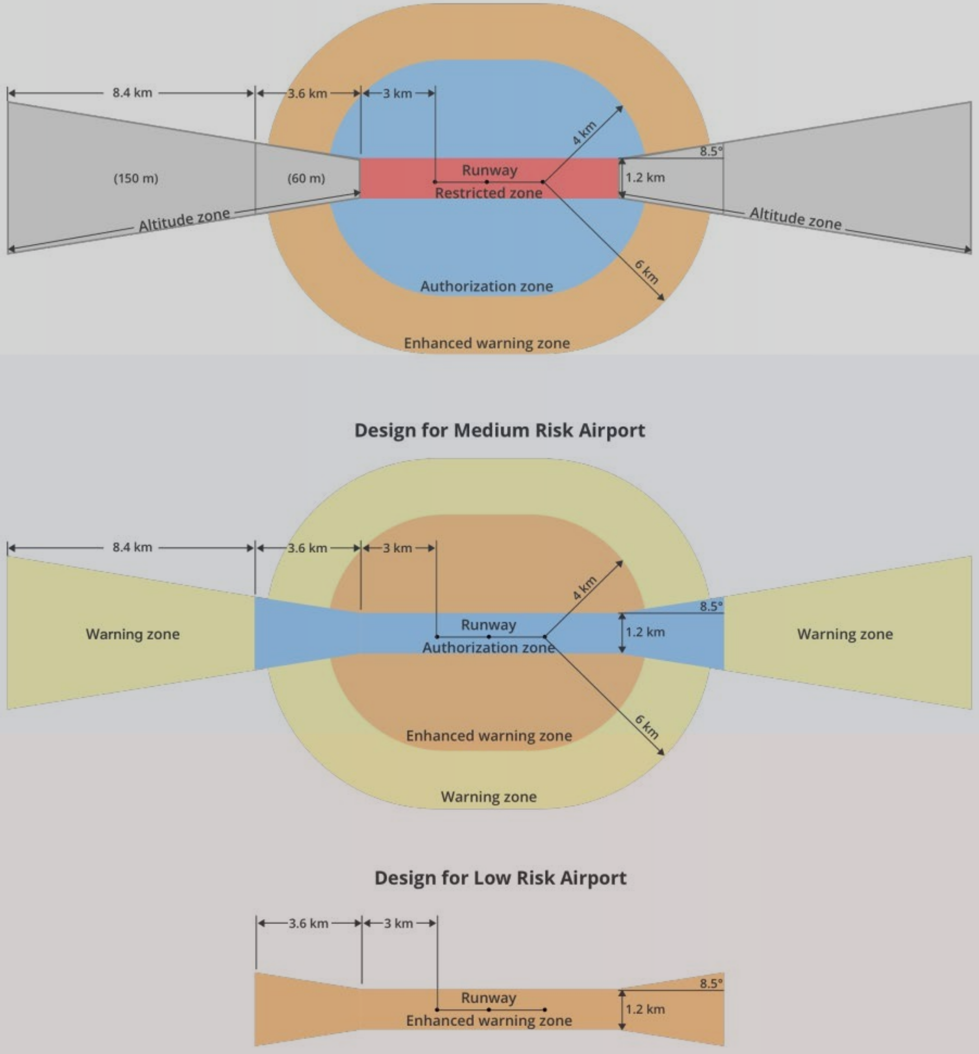
Hardware:
Changing flight characteristics - just install more efficient propellers
Increasing power - installing powerful alternative motors
Improved drivability - use of alternative firmware or control units
Safety - install blade guards
The range of the quadrocopter depends on the power of the transmitter installed on the remote control. The usual control panel has a transmitter power of 10 mW, if you put an intermediate amplifier of 1-2 watts between the RF part and the antenna, the range of flight from 900 meters will increase to 10 kilometers.
Increasing power with a booster (Neobooster, xq-02a)
Increased battery capacity

When making changes to the characteristics of the UAV it is important to keep in mind:
- Each model has limitations that should not be exceeded;
- Before a long-range launch, you should set up drone tracking so you don't lose the drone;
- You will have to replace or upgrade the remote to transmit control signals;

Commercial UAVs

Improving the performance of UAVs

Structure of the NFZ



Programmatic modification of UAV characteristics:

- Removing Flight Restrictions - No Flight Zones (NFZ) (legal and not so legal). (NFZs) are areas designated by DJI as places where drones either can't fly at all or can fly with restrictions. DJI itself calls them "GEO zones." The no-fly zones at the time of writing exist only for DJI drones. NFZ is not a point with coordinates, it is several nested shapes, marked on the map with different colors, and where restrictions of different order apply.
- Disabling the altitude limit
- Increased power (FCC)
- Enabling additional operating frequencies (5.8 GHz)
- Fine-tuning the quadcopter

Commercial BPAs and SWOs

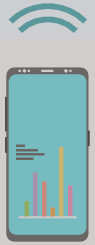
Marking of configured UAVs

1. Removed restrictions on the maximum power of the drone remote control signal (maximum power)
2. Flight restrictions are removed, you can fly above 500 meters and in prohibited places (airports, administrations, etc.)

3. Stealth mode
4. Fine-tuning with the example of switching off the lights
5. Hardware amplifier (specific board physically sewn into the remote control)

Main rules when using UAVs of the copter type on the territory of the NWO:

Don't connect your smartphone to the drone! Don't give it to a



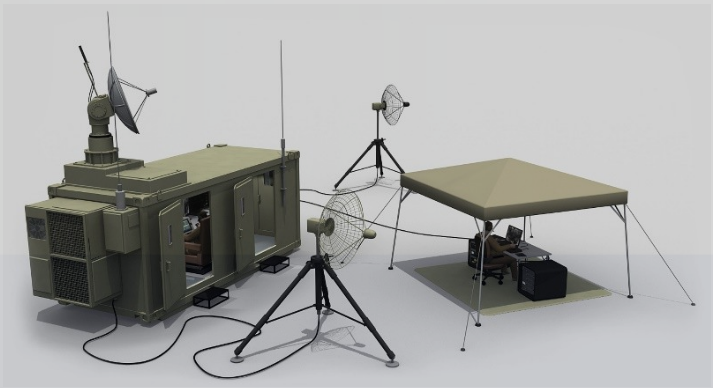
friend!
Don't insert a sim card or connect to wi-fi
Don't update anything!

The only way to break invisibility mode is to break the rules yourself

The correct DJI FLY program will be given to you with your phone

Commercial BPAs and SWOs

A set of additional equipment for use with UAVs



POWERBANKS AND CHARGING STATIONS

PROPELLERS

RETRANSLATORS

RESET SYSTEMS

GAIN ANTENNAS

CAS
E

REB SYSTEMS

Commercial BPAs and SWOs

DJI Mavic 3 Quadcopter (not Classic)

One of the best consumer drones out there.

Some characteristics of the Mavic 3:

- Takeoff weight - 895 g (DJI Mavic 3E and 3T - 1050 g).
- Folded dimensions - (DxWxH mm) 221 x 96.3 x 90.3
- Flight speed max. - 16 m/s (57.6 km/h)
- Ceiling max. - 6 000 м
- Flight time max. - 46 min.
- Flight distance max. - 30 000 м
- Permissible wind speed max. - 12 m/sec.
- Geopositioning systems - GPS+ Galileo+ BeiDou
- Mavic 3 has a wide-angle camera Hasselblad, telephoto lens 28x hybrid zoom, image stabilizer, there is an option to install additional equipment.

Effective application:

- Reset 2 BOGs, F1.
- Point reconnaissance, targeting, correction, objective

control

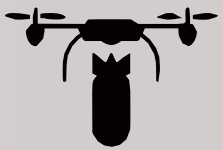
Commercial BPAs and SWOs

DJI Mavic 3 Classic Quadcopter

DJI Mavic 3 Classic is the third-generation Mavic drone.

Key features of the Mavic 3 Classic:

- 20 MP, 3/4 CMOS sensor;
- EFFR: 24mm, Aperture: f/2.8 - f/11;
- 3x digital zoom in movie mode;
- Video in 5.1K/50p, DCI or UHD 4K/120p and 1080/200p;
- Record H.264 at 200 Mbps and H.265 at 140 Mbps;
- OcuSync 3.0 (O3) - transmitting video up to 15 kilometers;
- All-way obstacle avoidance system; APAS and ActiveTrack 5.0;
- The flight time is 46 minutes;
- Maintaining a constant speed during flight;
- Weight - 895 g.



Effective application:

- BOG reset, F1
- General reconnaissance, flank tracking, working in a convoy of vehicles

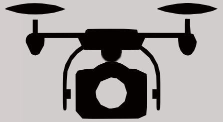
- Objective control

Commercial BPAs and SWOs

DJI Mavic AIR 2S Quadcopter

The DJI AIR 2S quadcopter is a high-tech and multifunctional device combines compact size and light weight for portability and convenience in the . Its advanced camera has a high resolution to record high quality video and capture crystal clear photos. This functionality allows the operator to capture important data and information in real time.

- 4K at 30 frames per second;
- 4K at 60 fps and 150 Mbps bitrate;
- Full HD at 120 fps;
- Full HD in Slow Mo (slow) at 240 fps.



Effective application:

- General reconnaissance, flank tracking, working in a convoy of vehicles
- Objective control

Commercial BPAs and SWOs

DJI Mavic Mini Quadcopter

The ultra-light and compact DJI Mavic Mini quadcopter weighs 249 grams and has a maximum flight time of 30 minutes.
Equipped with a camera capable of recording 2.7K video, as well as a 3-axis mechanical stabilizer and GPS module. In first-person flight mode, the maximum flight distance is 2 km.

Another characteristic of the Mavic Mini is its powerful camera for such dimensions, whose work is corrected by a mechanical 3-axis stabilizer with DJI's proprietary technology. The 12-megapixel resolution, 1/2.3-inch sensor and 83-degree FOV allow you to shoot 2.7K video and get excellent quality photos.

Effective application:

- General reconnaissance, flank

tracking, working in a convoy of vehicles

- Objective control

Commercial BPAs and SWOs

DJI Enterprise family of quadcopters

DJI Mavic 2 Enterprise Advanced is a next-generation industrial drone and a versatile solution for a wide range of different tasks.

Features:

- Dual camera sensor: RGB and thermal imager;
- RTK module for data acquisition with centimeter accuracy;
- Build up to 240 waypoints for automated inspections;
- Mode of separate and simultaneous viewing of visual and thermal images;

DJI Mavic 3 Enterprise Thermal is equipped with a thermal imaging camera. The main advantages of this drone are its exceptional imaging performance:

- Wide-angle camera: 24mm focal length, 48 MP;
- Zoom: 162mm focal length, 12 MP, 56x hybrid zoom;
- Thermal imaging camera: DFOV 61°, focal length 40 mm, resolution 640x512.

Effective application:

- BOG reset, F1
- Point reconnaissance, targeting, correction, objective control
- Tracking enemy movements at night, preventing

DRG sorties

FPV bpla and SWO

FPV drones in the special operation zone

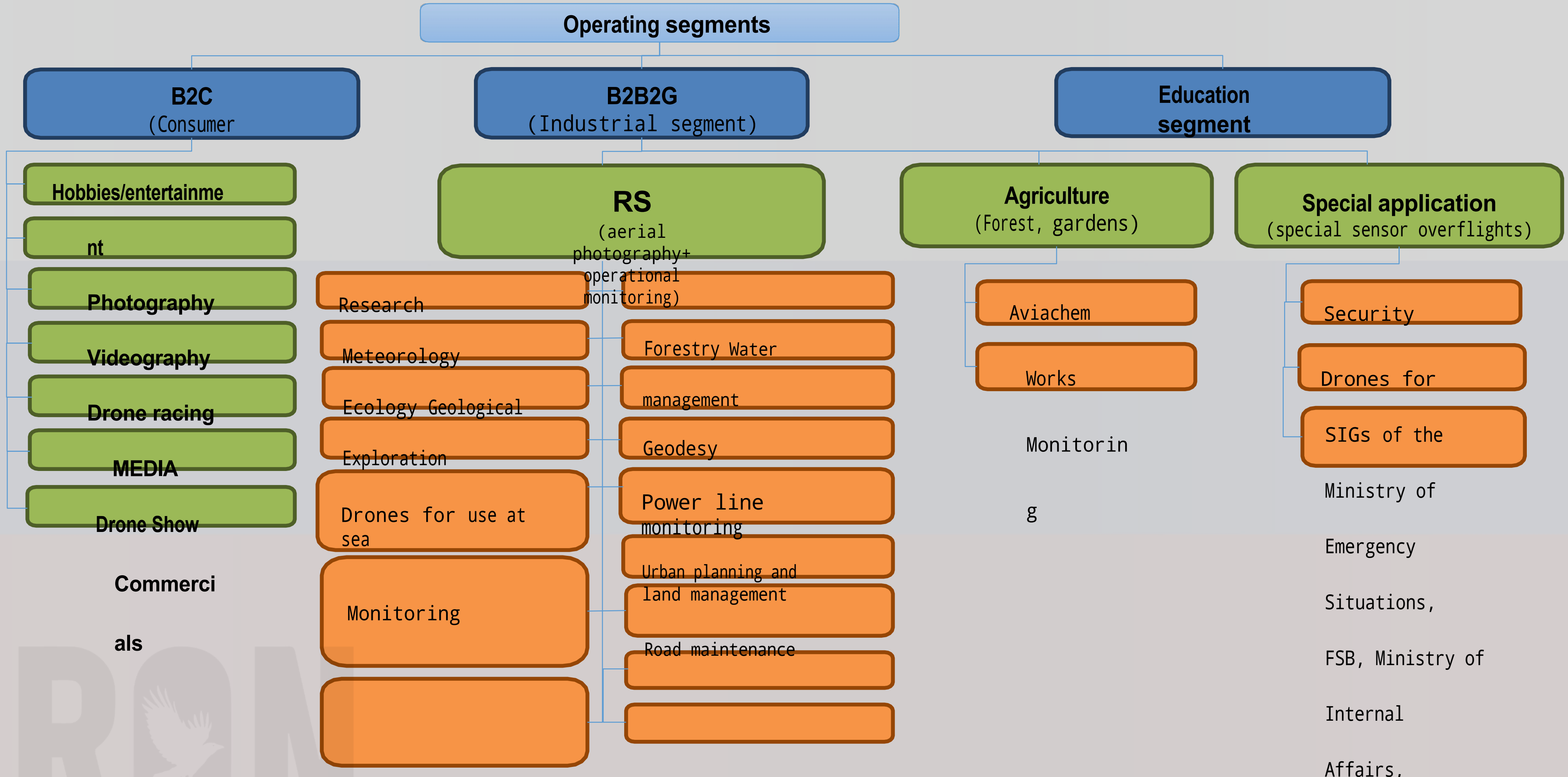
FPV drones are designed for strikes deep in the frontline - varying range and flight speed. These drones can carry RPG-7 grenades such as PG-7VL, RKG-3M hand-held anti-tank grenades, and fragmentation charges.

Flight range and payload capacity depend on the selection of components to meet the requirements of the drone, but on average the range depending on the purpose of the drone from 2 km to 5-6 km, and payload capacity is enough to deliver the same combat parts PG-7VL/VM/VS.

The advantage of an FPV drone over conventional quadcopters is the operator-friendly orientation in space and the ability to easily follow a route or chase a moving target at speeds of up to 170 km/h. Therefore, they are difficult to detect and intercept, are highly maneuverable and give the maximum level of control to the operator. This allows them to be used with maximum effectiveness to destroy moving targets, as well as to destroy manpower in dugouts and special shelters.

Commercial UAVs

Civilian applications of UAVs



Rosguard	industrial facilities (bridges, pipes)	Eco monitoring
		Oil and gas sector
	Insurance (real estate, road accidents, agro-insurance)	Oil and gas sector
		Hunting farms

basic FPV flying course

8 - o y day schooling

19 Main types of batteries used in UAVs

20 Operation and service life of th

21 UAV battery design

Batteries for UAVs

Main types of batteries used in UAVs

el-cadmium)

3. NiMh (nickel-metal hydride)

One of the most important parts of any quadcopter is the battery. The capacity of the battery will also determine the time drone can spend in flight.
There are specialized batteries for radio-controlled models, so you need to know how to select, operate them
and charge. This will ensure safe and long-lasting operation.

4. LiPo (lithium polymer)

5. LiFePO4 (lithium ferrophosphate)

There are 5 main types of batteries in use today:

1. Pb (lead-acid or lead-acid);
2. NiCd (nickel-cadmium);
3. NiMh (nickel metal hydride);
4. LiPo (lithium polymer);
5. LiFePO4 (lithium ferrophosphate, also known as A123, LiFe, LiFo, lithium phosphate).

Batteries for UAVs

Main types of batteries used in UAVs

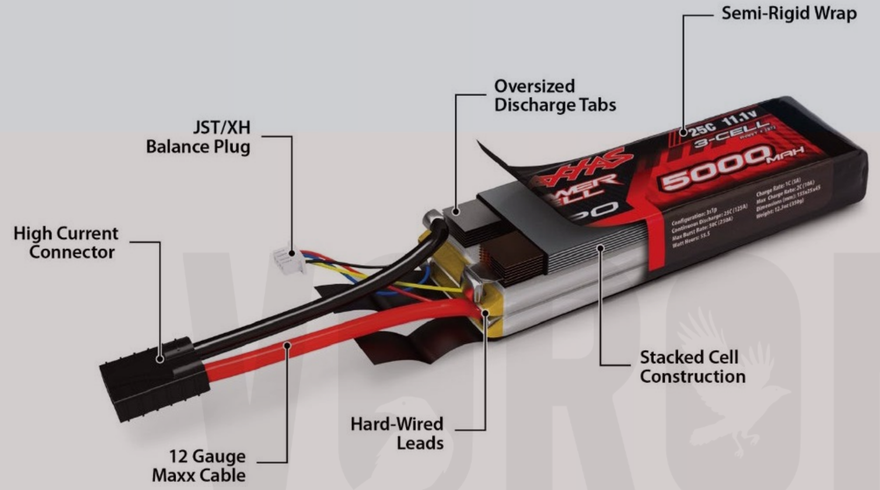
Lead-acid (Pb) batteries in relation to UAVs are used practically only as a source of energy for recharging in the field of other types of batteries and as a power source for the starter and starter panel for propulsion systems with internal combustion engines.
Nickel-Cadmium (NiCd) batteries are often used to power transmitters and as power **batteries** in applications where recoil currents and long life are important.
Nickel-metal hydride (NiMh) batteries replaced NiCd. All of the above mentioned about NiCd generally applies to NiMh as well. The difference with NiMh is that they usually have a noticeably higher capacity at the same weight as similar NiCd. Their "memory effect" is less pronounced. The shelf life of NiMh is usually shorter than NiCd.
Lithium-iron-phosphate (LiFePO4, LiFe, LFP, IFR), commonly known as "Lifer"was discovered in 1996 by John Goodenough as a cathode for Li-ion cells. The cells entered mass production thanks to A 123 Systems and its investors Motorola, Qualcomm and Sequoia Capital. The disadvantages are a limited range of capacities (only 2300 mAh output), greater weight compared to LiPo, low voltage on the bank and its rather large sag under load.

Batteries for UAVs

Main types of batteries used in UAVs

Lithium Polymer (LiPo): LiPo batteries have high energy density and can provide high power, making them suitable for high-performance drones. They are lightweight, have very high capacity relative to their weight and size, high recoil currents, and fast charge capability. LiPo batteries are critical to the modes of operation. In case of discharging such a battery below the permissible level, it irrevocably fails, and excessive voltage on the battery can lead to its explosive spontaneous combustion. , the advantages of LiPo batteries outweigh their disadvantages, and therefore they are used by following certain rules of operation.

There are two main groups of lithium polymer batteriesHi Discharge and conventional. They differ in the maximum discharge current, is specified either in amperes or in units of battery capacity, denoted by the letter "C".



Batteries for UAVs

Operation and service life of the battery

LiPo operating temperature range.

• For mini-squads, the maximum output of LiPo batteries is achieved at temperatures between 25°C and 55°C.

• Cold weather noticeably degrades the performance of LiPo batteries: discharge rate and effective capacity are reduced (up to 40%). Common symptoms when using LiPo in temperatures are: shorter flight times, loss of power/gain and severe voltage sagging

• For optimal performance, it is best if the battery is preheated to 30°C ... 35°C before the flight. For this purpose, it is sufficient to put the batteries in a warm place (e.g. pocket) or you can use the so-called "Heated LiPo Protective Bag", the best offers of which have the possibility to adjust the temperature modes

• LiPo also doesn't like it when it gets too hot. Once the battery reaches 60°C, it can swell and even

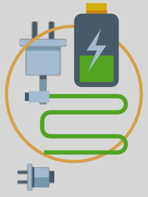
At what voltage to terminate the flight

Professionals recommend to end the flight when the voltage for each battery bank reaches between 3.5V and 3.6V. Li-Polymer batteries must not be discharged to zero, it must always have an acceptable level of charge!

The graph below explains why. The point is that the voltage in LiPo does not decrease linearly as the consumed, but drops sharply when it reaches about 3.5V -3.6V for each LiPo cell. And if you haven't landed by this time, you run the risk of over-discharging the battery, and over-discharging a LiPo battery can in turn cause permanent damage to the battery and shorten its .

Batteries for UAVs

Operation and service life of the battery



Lithium polymer batteries require strict adherence to the rules of use:

- Do not overcharge - above 4.2 V per cell;
- avoid short circuits;
- Do not allow overheating above 60 °C, also when charging or discharging with high currents;
- Do not leave the batteries in direct sunlight, near heaters or
- open flames;
- do not compromise the tightness of the shell;
- Do not discharge below 3 V per cell;
- Do not subject to impact, piercing and other mechanical effects;
- do not store in a discharged state;
- Charge without waiting for a full discharge;
- after use in the cold - keep it at room temperature for a couple of hours and then charge it;
- Store in a semi-charged state in a cool, dry place away from .

If the operating rules are not followed, the batteries lose their capacity quickly. If overheated to 70 °C, a spontaneous reaction occurs, converting energy into heat. As a result, the battery can ignite. But if the rules of use of Lo-Po elements are observed, they are absolutely safe, effectively cope their tasks and enjoy a long service life. A bloated battery should not be used as it may cause the case to burst.

Batteries for UAVs

Operation and service life of the battery

Battery life depends on several factors.
Battery size. Larger batteries are more powerful because there is more surface area for current transfer. Their discharge capacity, however, is significantly less. LiPo are best for drones because they are lightweight. However, they are also smaller, giving them less electricity. Capacity refers to how much energy a battery can store.
It is stated in mAh.

LiPo battery capacity is measured in mAh/mAh (milli-amp hours/milli-amp). "mAh" is basically a measure of how much current you can get from the battery for an hour until it runs out of power (1000 mAh = 1Ah.).
Battery capacity decreases with each charge/discharge. Storage at too high or too low temperatures can also lead to a gradual decrease in capacity. In the model design, battery packs still provide 50 to 80% of the capacity of a new battery after 50 cycles if the charging and discharging regulations are followed, which is achieved by high discharge currents and motor induction currents. Battery packs must not be connected either in series or in parallel, as the capacities of the battery cells may be too different.

Your drone's battery will last 300 to 500 recharges before needing to be replaced. That's approximately 12,500 minutes of flight time on a single battery, or over 200 hours of flight time.

Batteries for UAVs

Operation and service life of the battery

LiPo batteries designed to power drones have in their specification such an important parameter as C-Rating/Discharge Rate. Knowing the nominal "C" value and the capacity of the battery, we can calculate the theoretical safe constant maximum discharge current of a LiPo battery: Max. discharge current= C-Rating× Capacity/1000.

For example: A battery with the specifications: 2000 mAh 65C has an estimated continuous max discharge current of 130A.

Charge Rate is another equally important parameter that can be displayed on a battery pack. Often, most batteries are designed for a charge rate of 1C. This value determines the maximum allowable current with which the battery can be safely charged. To calculate the max. possible charging current for a particular battery, use the formula: Capacity (mAh)/1000× "Charge Rate=XX amperes.

The charging current value is one of several preset settings of the charger before charging the battery. A C-rating that is too low will prevent the drone from developing its maximum flight potential and it will be less dynamic. And if the current exceeds the rated value, you can even damage the battery as a result. When the C-rating is higher than required, you won't get a significant improvement in performance. Instead, the battery will be heavier, which will affect flight time.

For example: If you have a 2200 mAh LiPo battery with a 2C charge rating, the maximum allowable charging current for it is 4.4A.

Batteries for UAVs

Operation and service life of the bat

Charger Selection.
There are many different chargers on the market and so, as with the choice of battery, the best and most reliable solutions are offered exclusively by time-tested brands such as: ProLead RC, SKYRC, EV- PEAK, Tenergy, Toolkit RC, HOBBYMATE, ISDT.

Improper handling of LiPo batteries may result in fire.

Batteries for UAVs

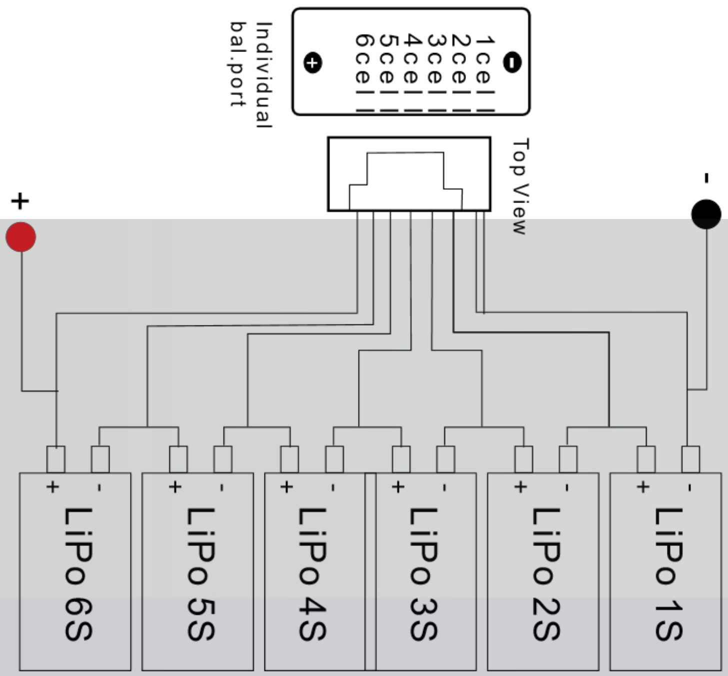
Operation and service life of the battery

Please take your time, familiarize yourself with these safety guidelines before using/charging batteries.

- Never leave charged batteries unattended, as a rule all fires caused by LiPo ignition were caused by the user's carelessness!
- During charging, check regularly if the battery heats up or starts to swell, and if it does, stop charging immediately!
- A good LiPo battery will never heat up during the charging process. If this , stop the process immediately and find out the cause of the heat.
- It is recommended to charge the battery with a current of 1C or less.
- Check that the charger settings match the battery being charged (e.g. : number of "S" cans). Never use or charge a damaged battery - do not charge it if it is swollen or has other visible signs of damage.
- Make sure that the battery is not overcharged. Although the charger monitors and prevents overcharging, it is recommended to check the current battery voltage regularly with a voltmeter.
- Do not leave the battery in .

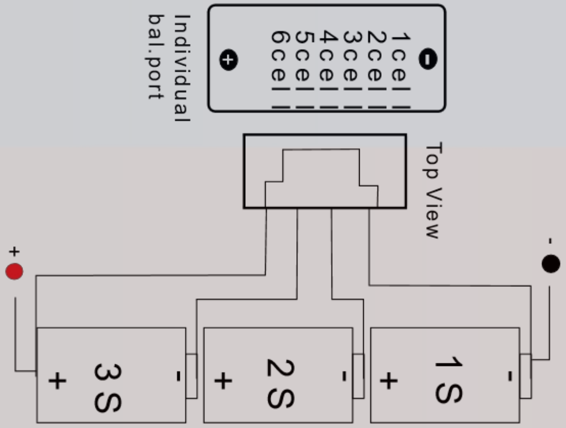
Batteries for UAVs

UAV battery design



Battery voltage and number of cells (S)
LiPo batteries are made up of individual cells/cells/cell(s) (also referred to as "S"; in the hobby they are called "banks").
Each LiPo cell/can has a voltage rating of 3.7B. If higher voltages are required, these cells can be connected in series to form a single battery.

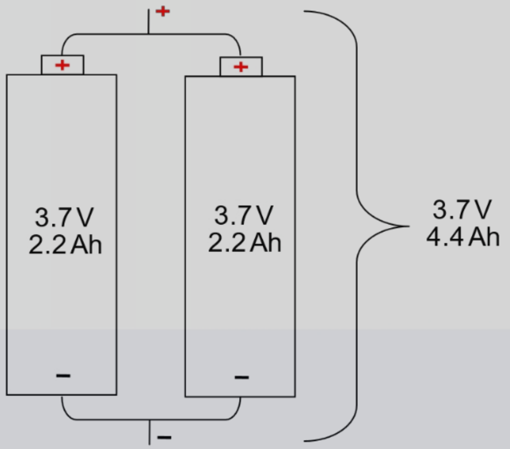
Usually when referring to a lithium polymer battery, they do not refer to the voltage of the battery, but to the number of cells (cans) in the battery or the number of "S's":
1S= 1 cell (1-cell battery)= 3.7V 2S= 2 cells (2-cell battery)= 7.4V 3S= 3 cells (3-cell battery)= 11.1V 4S= 4 cells (4-cell battery)= 14.8V 5S= 5 cells (5-cell



battery)= 18.5V 6S= 6 cells (6-cell
battery)= 22.2V

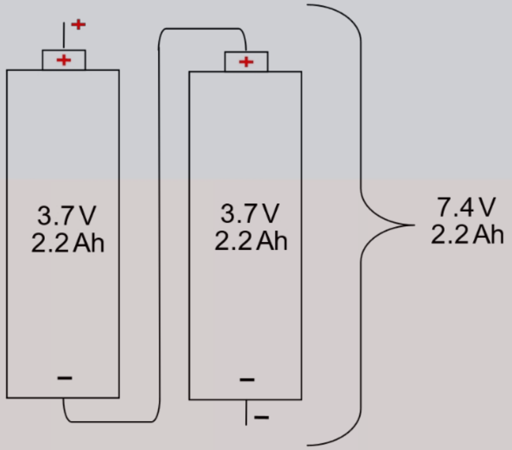
Batteries for UAVs

Battery connection methods



Serial connection

Parallel connection



Parallel connection

The amount of discharge current that a single can can withstand depends on many factors, but primarily on the design, materials used, and size of the can. The larger the plate area of the electrodes, the more current they can . This principle is used for parallel connection of the same type of batteries when it is necessary to increase the current to the load. But to charge such a design it will be necessary to raise the power of the source. This method is rarely used for ready-made designs, because now it is much easier to immediately purchase the necessary battery. But it is used by manufacturers of acid batteries, connecting different plates into single blocks.

Serial connection

Depending on the materials used, a voltage of 1.2/1.5 or 2.0 volts can be generated between the two electrode plates of common household batteries. (This range is actually much wider.) For many electrical appliances, this is clearly not sufficient. This is why batteries of the same type are connected in series, often in a single case.

basic FPV flying course

9 - Yi day education

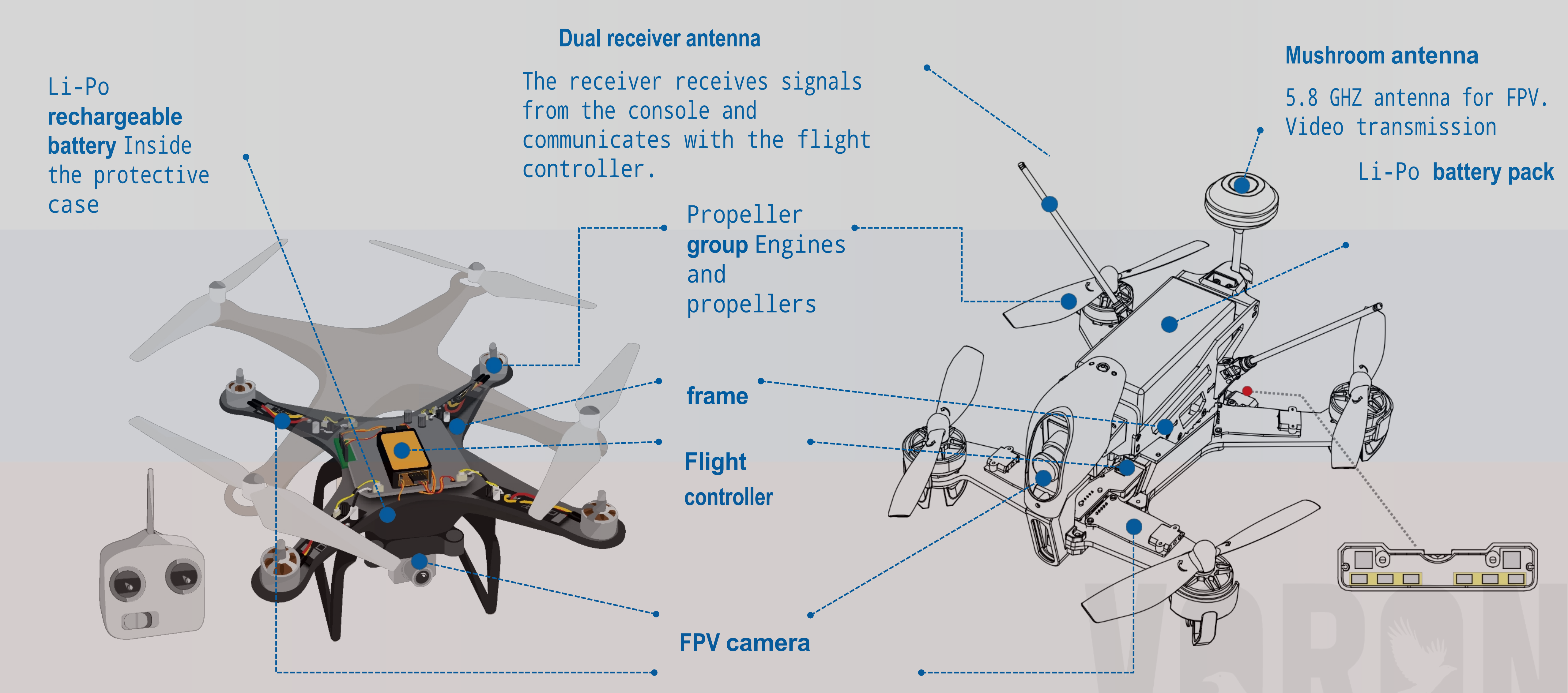
22 FPV drone main elements and frame materials

23 Flight controller and propeller group

24 Control panel

Design of fpv drone

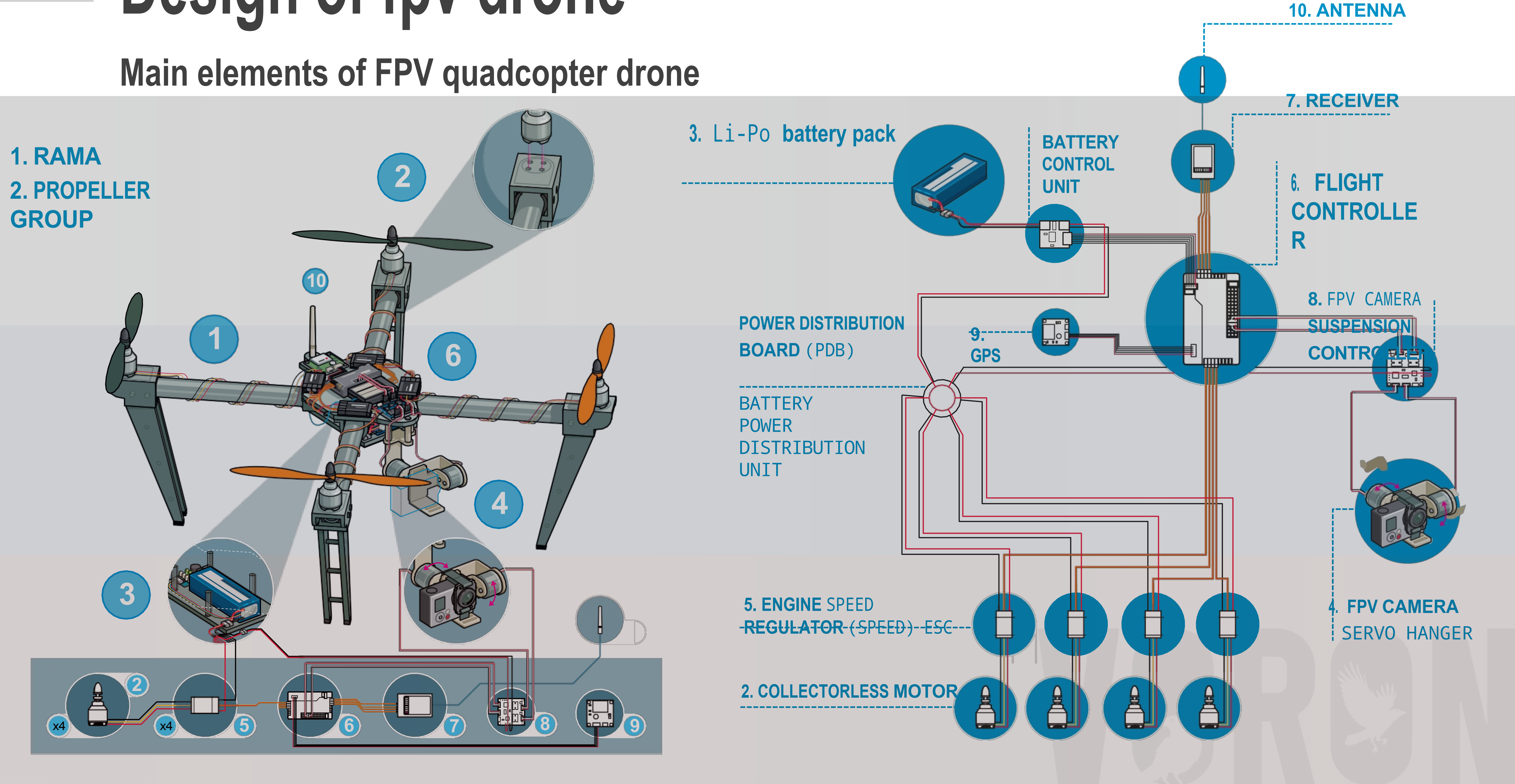
Main elements of commercial and FPV quadcopter drone



Motor speed controller (speed)

Design of fpv drone

Main elements of FPV quadcopter drone



Design of fpv drone

Main elements of FPV quadcopter drone

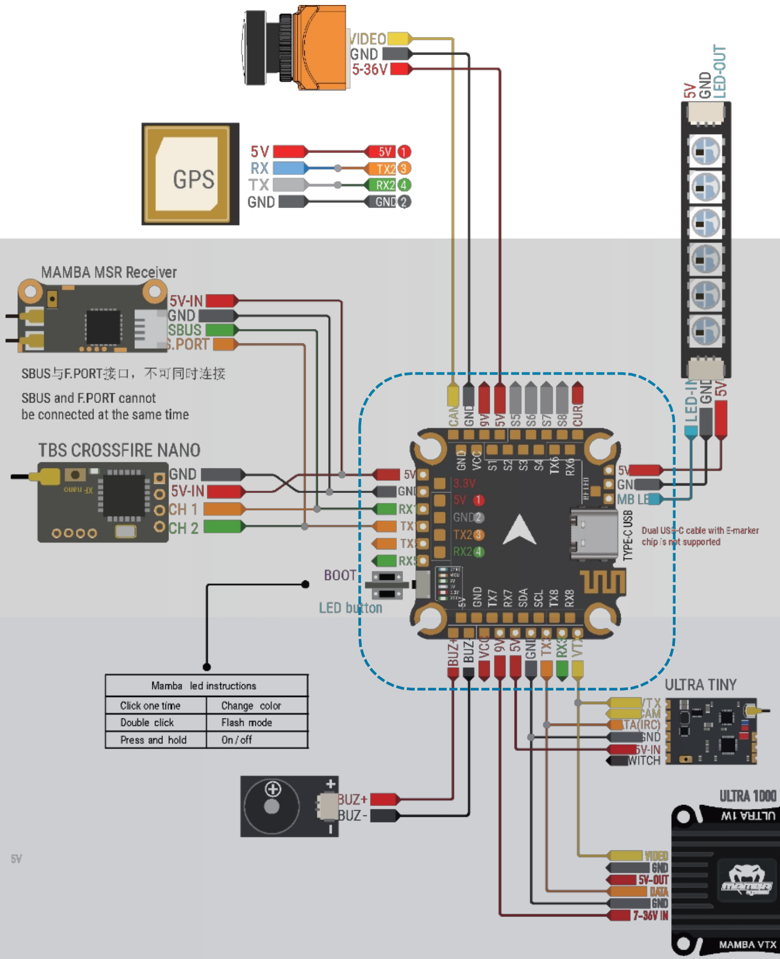
FRAME. The frame, which is the base of the drone and to which all other elements are attached; it is made of polymers or light metal alloys, carbon fiber. The frame is responsible for important functions of the drone: it provides reliability and rigidity of the structure with its low weight. The rigidity of the structure increases control stability by reducing unwanted vibrations, and the light weight increases flight time.

Size - "Size" is usually specified in millimeters (e.g. 450mm) and represents the largest distance between the two motors on the UAV. Size can also define the "class" of the UAV (micro, mini, etc.).

Design of fpv drone

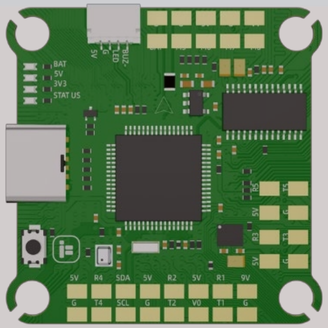
Flight controller and propeller group

The **flight controller** is the most important part. Ninety percent of flight stability and controllability depends on the ability of the flight controller. The task of the flight controller is to translate the commands from the control panel into signals that set the engine speed. It also has inertial measurement sensors to monitor the current position of the platform and make automatic adjustments.



Mamba led instructions	
Click one time	Change color
Double click	Flash mode
Press and hold	On / off

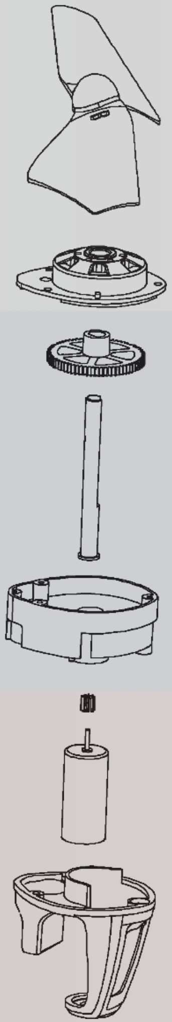
It determines the condition of your aircraft apparatus, polling the sensor array hundreds of times per second, and then making microscopic instantaneous changes to the operation of each motor to ensure the drone remains stable in the

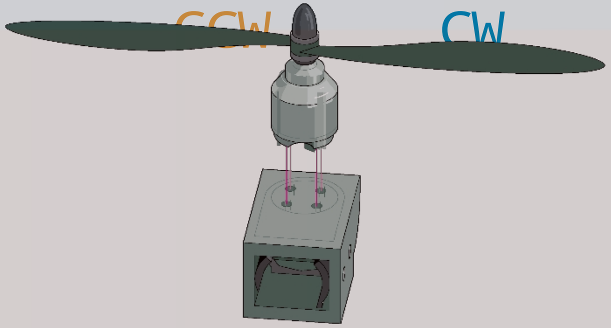


air.

Design of fpv drone

Flight controller and propeller group





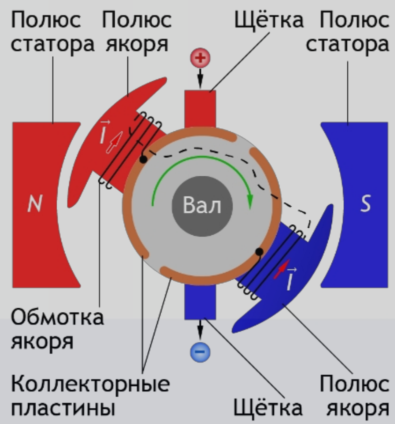
PROPELLER GROUP. A propeller motor group (PMG) is an installation that generates thrust, under the influence of which a rotorcraft moves in the required direction (or tends to move, for example, hovering, when the force generated by the PMG is compensated by the force of gravity).

The VMG includes the engine, propeller, components (e.g., propeller blade collective pitch controls), systems, and assemblies necessary ensure reliable and efficient operation. The VMG may also include a motor controller that determines motor performance.

A propeller motor group (PMG) is a combination of an electric motor and an air propeller attached to its shaft. **CW** - . **CCW** - .

Design of fpv drone

Propeller group



Collector motor schematic

Collectorless motor

MOTOR MOTOR) - collector (brush) or collectorless (brushless). **Collector motor** - the simplest electric motor in terms of realization, which has a rotor with windings, a stator with permanent magnets, positive one side and negative on the other, a collector (two metal plates connected to the stator) and in contact with the collector.

The collectorless motor is characterized by high efficiency and a long service life if the operating conditions are met; it has no collector and , so that only ball bearings remain as rubbing parts, with minimal friction. Unlike a collector motor, a collectorless motor has a rotor with magnets rotating, while the stator with windings is stationary. A distinction is made between inrunners (with internal rotor) and outrunners (with external rotor). The latter are usually used for multicopters due to their higher torque and, as a consequence, no need for a reduction gearbox.

Kv - revolutions per volt KV is simply a parameter that shows how many revolutions per minute the motor will make, it will not be an indication of power, thrust or efficiency.

KV 8000 means that if you apply 1 volt to the motor, it will spin at 8,000 rpm.

Design of fpv drone

Propeller group

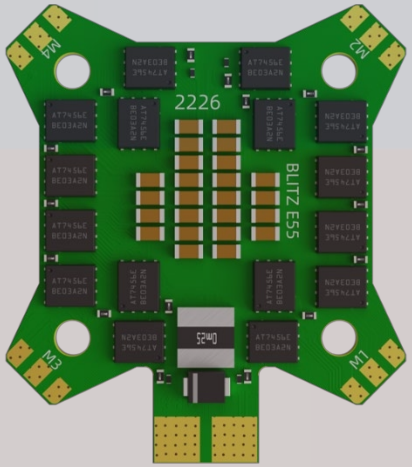
ENGINE SPEED CONTROLLER (ESC). ESC or Electronic Speed Controller is a stroke or speed controller. It is designed to regulate the rotation speed of motors (for example, in quadcopters of racing type). The ESC receives a signal from the flight controller and controls the collectorless motor by changing its rotation speed through power control. When choosing an ESC, it is important to consider its size and weight, maximum current, supply voltage, firmware, processor, protocols used, active braking and hardware PWM.

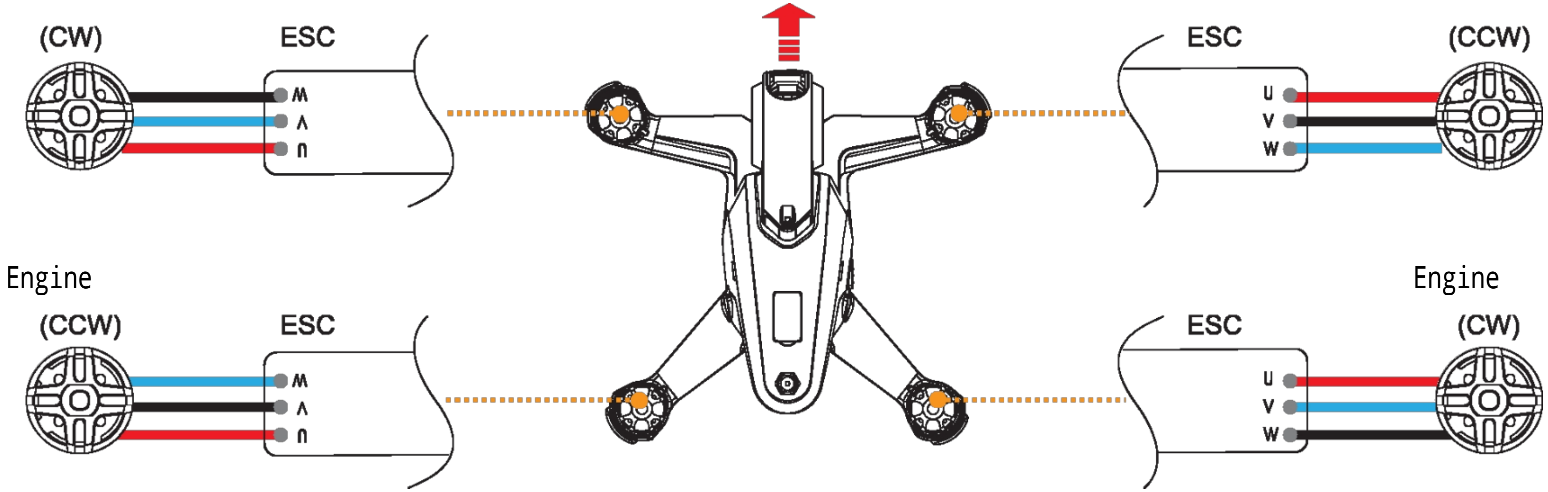
The regulator has a couple of important characteristics:

1) Maximum battery voltage (in banks), for example from 2S to 3S, on the second one from 2S to 6S. If you put more than necessary, it will burn out.
2) The maximum current that the regulator can handle.

Engine

Engine





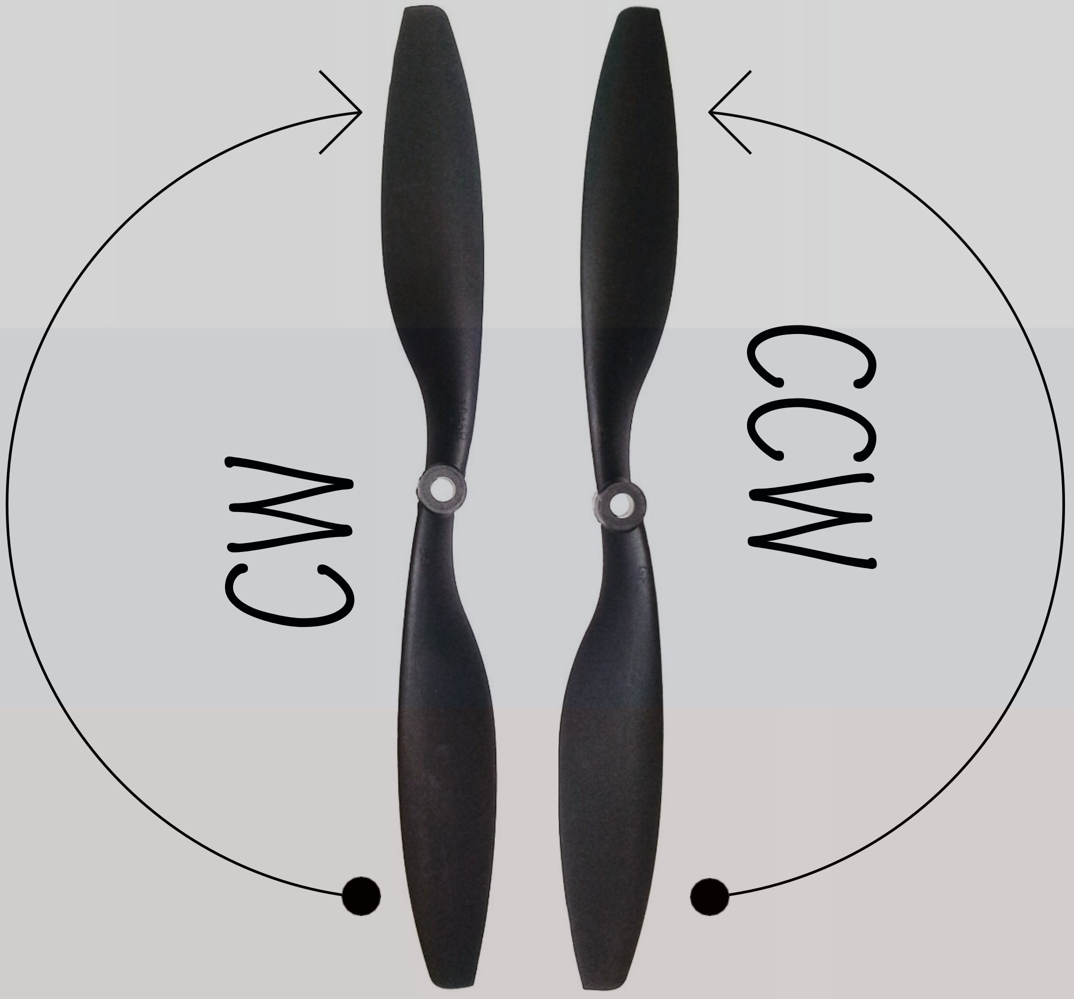
(CW)
ESC
W
V
U
ESC
(CCW)
U
V
W
Engine
(CCW)
ESC
W
V
U
Engine
ESC
(CW)
U
V
W

Design of fpv drone

Propeller group

PROPELLERS (PROPELLERS). By increasing the diameter of the propeller, we increase its static thrust, and by increasing the pitch - the flow velocity, respectively, increasing the efficiency of the propeller at high flight speed. simply increase both values is impossible - in this case, the load on the engine will increase and the efficiency of the VMG will decrease sharply. Propeller configuration is how many blades the propeller has. The most efficient would be a single-blade propeller, but it is physically impossible to use due to unbalance.

The defining parameters are the diameter and pitch of the screw. The propeller pitch corresponds to the imaginary distance the propeller travels in an incompressible medium per revolution. The size of the propellers depends on the size of the frame. All propellers start with a marking such as



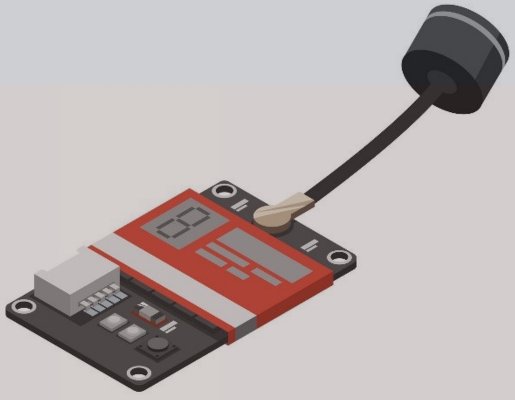
5045, these are 5-inch propellers with a pitch of 4.5. The size of acceptable propellers should be specified in the frame description.

Design of fpv drone

Radio control equipment, video signal transmission

RADIO CONTROL HARDWARE. Radio control hardware is essential for controlling your drone in flight. The frequency of the radio transmitter is an important factor to consider when choosing a transmitter for your FPV drone. Different controller models use different protocols to communicate with the receivers (the tiny chip that is put on the drone). No firmware can make the ELRS receiver on the drone work with the Crossfire module on your remote control. Therefore, when buying a controller, you should realize that you are choosing not only the controller, but also the receiver on the drone.

Frequency of use for video signal transmission. Typically, video transmitters operate at 900 MHz, 1.2 GHz, 2.4 GHz, or 5.8 GHz. The 2.4 GHz and 5.8 GHz bands have the least amount of interference to on-board equipment. They absolutely not overlap with cellular networks or aviation bands, and you can buy the best antennas for them.



The Video Transmitter (VTX) is a critical component of an FPV system, wirelessly transmitting the camera image to the FPV goggles. When selecting a 5.8 GHz VTX, consider the compact size, features, channel support and precise transmission frequency, in addition to the long range and high power output to ensure optimal flight performance and minimal interference to fellow pilots.

Special thanks

For creating, correcting, finalizing this methodological material:

VORON🇷🇺FPV,® Soyuz-2.1, @Murmansk01

Telegram channels that cover FPV drone use in today's realities as correctly and honestly as possible:

@ncbs18 @uavural @aucpustelga @xronikabpla @Lunay14 @BOBRMORF @BPLAROSTOV @sudoplatov_official @razvedosaa

@dva_majors @Mestb_Dobroj_Voli @labppsh @zloy_dron @vladlentatarsky @MishaDonbass @FPV_vyZOV @voenacher @z4lpr @DroneCenterDNR

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