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ENGLISH FOR UNMANNED AERIAL VEHICLES

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для студентов I–II курсов
специальности 25.03.03
очной формы обучения

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English for Unmanned Aerial Vehicles

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Unit 1
Introduction. Defining a UAV Drone

UAV (***noun) -*** abbreviation for unmanned aerial vehicle: an aircraft that is operated from a distance, without a person being present on it:
UAVs of various types are integral parts of the United States airpower arsenal.
Synonym:
drone (AIRCRAFT)

https://www.thecoronawire.com/what-fixed-wing-drones-uavs-everything-need-know/
Figure 1. Different types of UAVs

Exercise 1. Study the Words and Word Combinations:

1. **UAV** - unmanned aerial vehicle
2. **Reconnaissance functions** - разведывательная деятельность
3. **Remotely or automatically controlled** - управляемые дистанционно или автоматически
4. **Multirotor** - мультикоптер (вертолёт с несколькими несущими винтами)
5. **High precision in positioning** - высокая точность в ориентации
6. **Environmentally friendly** - не оказывающий негативного воздействия на окружающую среду
7. **Flight endurance** - продолжительность полёта
8. **Object detection** - обнаружение объекта
9. **Traffic surveillance** - наблюдение за движущимися целями
10. **Military operations** - военные операции
11. **Exploration** - исследование
12. **Sensing** - измерение
13. **Data sharing** - обмен данными, совместное использование данных
14. **Monitoring** - оперативный контроль
15. **Global positioning system (GPS)** - система глобального позиционирования
16. **Inertial measurement units (IMU)** - инерциальный измерительный блок
17. **Configuration** - вариант компоновки и комплектации
18. **Payload** – нагрузка

Exercise 2. Read and translate the text below.

No authentic account exists that how the unmanned aerial vehicles (UAVs) got the name drones. The UAVs-drones initially performed reconnaissance functions which in the military jargons are known as “dull and dry" jobs. Male drone bees also have the similar dull and dry life, and they are stingless. So that can be one reason, the UAVs might have got the name “drones". A Drone is defined as “a land, sea, or air vehicle that is remotely or automatically controlled”. While an Unmanned Aircraft is defined as “an aircraft or balloon that does not carry a human operator and is capable of flight under remote control or autonomous programming”.

UAVs are being widely used and have gained significant attention in the last decade. Most of the studies report multirotor due to their simplicity in control mechanisms and high precision in positioning. Other types of UAVs are also reported, but their numbers are comparably low.

Unmanned aerial vehicles (UAVs) have received momentous consideration in different disciplines of military and civilian services due to their enhanced stability and endurance in several operations. UAVs have been used in a variety of applications over the last decade, including object detection and tracking, public security, traffic surveillance, military operations, exploration of hidden or hazardous areas, indoor or outdoor navigation, atmospheric sensing, post-disaster operations, healthcare, data sharing, infrastructure management, emergency and crisis management, freight transportation, wildfire monitoring and logistics.

UAVs provide more cost-efficient operations than equivalent manned systems and perform cost-efficient critical mission without risking human life. UAVs can be remotely piloted, whereby control commands are provided from a ground base station (BS) through a remote control. The UAVs are also capable of performing the control operations onboard through autopilot and different sensors, including global positioning system (GPS) and inertial measurement units (IMU).

UAVs have emerged as promising solutions with quick and innovative designs that ensure last-mile delivery while being environmentally friendly. UAVs can be deployed easily and quickly, are scalable and flexible, have the self-organization ability, are cost-efficient, and possess high maneuverability. UAVs vary widely in configuration, size, range, weight, engine type and performance characteristics in order to carry several payloads including communication gadgets, navigation equipment, sensors, and cameras. There are different classifications of UAVs according to various parameters such as configuration, engine type, weight, range and size.

Exercise 3. Give the Russian equivalents to the following Words and Word Combinations:

UAV, reconnaissance functions, air vehicle, remotely or automatically controlled, a flight under remote control, control mechanisms and high precision in positioning, flight endurance, a variety of applications, object detection and tracking, traffic surveillance, exploration of hidden or hazardous areas, atmospheric sensing, post-disaster operations, healthcare, data sharing, freight transportation, wildfire monitoring and logistics, cost-efficient operations, performance characteristics, to carry several payloads, communication gadgets, navigation equipment, configuration, weight, range.

Exercise 4. Give the English equivalents to the following Words and Word Combinations:

Беспилотный летательный аппарат, дистанционное управление, человек-оператор, компоновка, тип двигателя, вес, дальность полёта, размер, глобальная система навигации и определения местоположения, инерциальный измерительный блок, высокая точность, повышенная устойчивость, множество разнообразных устройств, обеспечение общественной безопасности, обнаружение и отслеживание объекта, транспортировка грузов, управление аварийно-кризисными ситуациями, медицинское обслуживание, военные и гражданские службы, исследование скрытых и опасных районов, не оказывающий негативного воздействия на окружающую среду.

Exercise 5. Answer the following questions:

1. What stands for the UAV?
2. What is the UAV?
3. Why are UAVs sometimes referred to as a drone?
4. What is the UAV definition?
5. What is the definition of a drone?
6. What are the UAV applications?
7. How are UAVs different from manned systems?
8. What are the specific features of UAV operation?
9. How can UAVs vary?

Exercise 6. Make up all possible types of questions:

1. A Drone is defined as a land, sea, or air vehicle that is remotely or automatically controlled.
2. Unmanned aerial vehicles (UAVs) have received momentous consideration in different disciplines of military and civilian services.

3. UAVs can be deployed easily and quickly.
4. UAVs vary widely in configuration, size, range, weight, engine type and performance characteristics.
5. There are different classifications of UAVs according to various parameters such as configuration, engine type, weight, range and size.

Unit 2

A Brief History of Drones
Part 1

Exercise 1. Study the Words and Word Combinations:

1. **To evolve over time** – развиваться с течением времени
2. **Aerial target** – воздушная цель
3. **Application** - применение
4. **To expand significantly** – существенно расширить
5. **Bug** – жук, букашка
6. **To pave the way** – прокладывать путь
7. **Military and reconnaissance applications** – военное применение и в разведывательных целях
8. **To push the boundaries of drone capabilities** – расширять границы возможностей дронов
9. **To redefine** – переопределить, найти новое определение
10. **Release** – выпуск, выход в свет
11. **Recreational use** – использование с целью активного отдыха
12. **Consumer drone** – дрон широкого потребления
13. **Array of applications** – ряд областей применения
14. **Accessibility and usefulness** – доступность и польза
15. **Growing demand** – растущий спрос
16. **Broad range of applications** – широкий диапазон применения
17. **Future advancements** – будущие достижения

Exercise 2. Read and translate the text below.

The Birth of Unmanned Aerial Vehicles (UAVs)

When it comes to the history of drones, understanding their origin is essential. Many people wonder when drones were invented and how they have evolved over time. The concept of unmanned aerial vehicles (UAVs) dates back to the mid-1800s, with the first recognized drone being the *Aerial Target* used by the British Royal Navy in 1917. Since then, drones have come a long way, and their applications have expanded significantly.

The first drone ever made was a pilotless, radio-controlled aircraft referred to as the “Kettering Bug” invented by Charles Kettering in the United States during World War I. This invention paved the way for UAV development in subsequent years.

Below is an overview of the evolution of drones:

Year	Drone Model	Notable Feature
1917	Aerial Target	First recognized drone
1918	Kettering Bug	First radio-controlled aircraft
1935	DH.82B Queen Bee	Inspired the term “drone”
1960	MQM-57 Falconer	Aerial reconnaissance
1990	Gnat 750	Advanced surveillance capabilities
2001	RQ-1 Predator	Armed for military use
2010	Parrot AR.Drone	First consumer drone

While military and reconnaissance applications dominated the early usage of drones, it wasn’t until the late 20th century that modern UAVs evolved. In the 1990s, the Gnat 750 autonomous UAV pushed the boundaries of drone capabilities, leading to the more well-known RQ-1 Predator, which redefined military and strategic operations in the 21st century.

So, when did drones become popular among the general public? The answer lies in the early 2010s with the release of the Parrot AR.Drone, which was designed for recreational use. This consumer drone quickly gained traction, and the drone industry has since expanded to include an array of applications, such as:

• Aerial photography
• Racing and sports
• Wildlife conservation
• Agriculture and environmental monitoring
• Emergency response

The evolution of drones has been rapid, and their accessibility and usefulness have only increased over time. With growing demand and a broad range of applications, it’s evident that drones are here to stay, and the potential for future advancements is limitless.

Exercise 3. Give the Russian equivalents to the following Words and Word Combinations:

Origin, have evolved over time, the concept of UAVs, the first recognized drone, used by the British Royal Navy, application, the first drone ever made, pilotless aircraft, invented by, in subsequent years, overview of the evolution, advanced surveillance capabilities, first consumer drone, reconnaissance application, early usage of drones, boundary, drone capabilities, well-known, recreational use, to gain traction, wildlife conservation, emergency response, to increase accessibility, limitless potential, future advancements, a broad range of applications.

Exercise 4. Give the English equivalents to the following Words and Word Combinations:

Существенный, происхождение, изобретать, развиваться с течением времени, вести свое начало от, первый признанный дрон, воздушная цель, пройти длинный путь, значительно расширить области применения, беспилотный самолет, проложить путь развитию БПЛА, воздушная разведка, усовершенствованные возможности по слежению, первый дрон широкого потребления, первоначальное использование дронов, расширять границы возможностей дронов, хорошо известный, быть спроектированным для активного отдыха, сохранение дикой природы, аварийное реагирование, растущий спрос, быстрое развитие, широкий диапазон применения, повысить доступность и пользу, будущие достижения.

Exercise 5. Answer the following questions:

1. When did the concept of drones first emerge, and what was one of the early examples of a drone used for military purposes?
2. What was the first drone like?
3. What role did the invention of the “Kettering bug” play?
4. What fields dominated in the usage of the early drones?
5. What are some of the diverse applications of drones today?

Exercise 6. Make up all possible types of questions:

1.The concept of drones can be traced back to the early 1900s when inventors and engineers began experimenting with remote-controlled aircraft.
2. During World War I, the U.S. military developed the Kettering Bug, an early form of a drone used for reconnaissance missions.
3. This consumer drone quickly gained traction.
4. The evolution of drones has been rapid.
5. The potential of drones for future advancements is limitless.

Unit 3

A Brief History of Drones
Part 2

Exercise 1. Study the Words and Word Combinations:

1. **To train military personnel** – обучать военнослужащих
2. **Aerial target** – воздушная цель
3. **The earliest attempt** – первая попытка
4. **To intend** – намереваться
5. **Port installations** – портовые сооружения
6. **Fast motor launch** – быстрый моторный катер
7. **Uncrewed aerial combat vehicle** – ударный беспилотник
8. **To inspire** – вдохновлять
9. **Explosive payload** – боевой заряд
10. **Bomber** – бомбардировщик
11. **Armistice** – перемирие
12. **Operational deployment** – оперативное развертывание
13. **Hostile territory** – вражеская территория
14. **To shoot down a U-2** – сбить самолет-разведчик
15. **War of Attrition** – война на истощение
16. **Israeli intelligence** – Израильская разведка
17. **Reconnaissance cameras** – разведывательный аэрофотоаппарат
18. **USAF** – United States Airforce
19. **Testament to human ingenuity** – свидетельство изобретательности человека
20. **To become more versatile** – становиться более многогранным
21. **Multitude of applications** – огромное количество применений

Exercise 2. Read and translate the text below.

Significant development of drones started in the 1900s, and originally focused on providing practice targets for training military personnel. The earliest attempt at a powered UAV was A. M. Low's "Aerial Target" in 1916. Low confirmed that Geoffrey de Havilland's monoplane was the one that flew under control on 21 March 1917 using his radio system. Following this successful demonstration in the spring of 1917 Low was transferred to develop aircraft controlled fast motor launches D.C.B.s (Defense Coastal Boats) with the Royal Navy in 1918 intended to attack shipping and port installations and he also assisted Wing Commander Brock in preparations for the Zeebrugge Raid. Other British unmanned developments followed, leading to the fleet of over 400 de Havilland 82 Queen Bee aerial targets that went into service in 1935.

Nikola Tesla described a fleet of uncrewed aerial combat vehicles in 1915. These developments also inspired the construction of the Kettering Bug by Charles Kettering from Dayton, Ohio and the Hewitt-Sperry Automatic Airplane – initially meant as an uncrewed plane that would carry an explosive payload to a predetermined target. Development continued during World War I, when the Dayton-Wright Airplane Company invented a pilotless aerial torpedo that would explode at a preset time.

The film star and model-airplane enthusiast Reginald Denny developed the first scaled remote piloted vehicle in 1935.

Soviet researchers experimented with controlling Tupolev TB-1 bombers remotely in the late 1930s.

World War II

In 1940, Denny started the Radioplane Company, and more models emerged during World War II – used both to train antiaircraft gunners and to fly attack-missions. Nazi Germany produced and used various UAV aircraft during the war, like the Argus As 292 and the V-1 flying bomb with a jet engine. Fascist Italy developed a specialized drone version of the Savoia-Marchetti SM.79 flown by remote control, although the Armistice with Italy was enacted prior to any operational deployment.

Postwar period

After World War II development continued in vehicles such as the American JB-4 (using television/radio-command guidance), the Australian GAF Jindivik and Teledyne Ryan Firebee I of 1951, while companies like Beechcraft offered their Model 1001 for the U.S. Navy in 1955. Nevertheless, they were little more than remote-controlled airplanes until the Vietnam War. In 1959, the U.S. Air Force, concerned about losing pilots over hostile territory, began planning for the use of uncrewed aircraft. Planning intensified after the Soviet Union shot down a U-2 in 1960. Within days, a highly classified UAV program started under the code name of "Red Wagon". The August 1964 clash in the Tonkin Gulf between naval units of the U.S. and the North Vietnamese Navy initiated America's highly classified UAVs (Ryan Model 147, Ryan AQM-91 Firefly, Lockheed D-21) into their first combat missions of the Vietnam War. When the Chinese government showed photographs of downed U.S. UAVs via Wide World Photos, the official U.S. response was "no comment".

During the War of Attrition (1967–1970) in the Middle East, Israeli intelligence tested the first tactical UAVs installed with reconnaissance cameras, which successfully returned photos from across the Suez Canal. This was the first time that tactical UAVs that could be launched and landed on any short runway (unlike the heavier jet-based UAVs) were developed and tested in battle.

In 1973, the U.S. military officially confirmed that they had been using UAVs in Southeast Asia (Vietnam). Over 5,000 U.S. airmen had been killed and over 1,000 more were missing or captured. The USAF 100th Strategic Reconnaissance Wing flew about 3,435 UAV missions during the war at a cost of about 554 UAVs lost to all causes. In the words of USAF General George S. Brown in 1972, "The only reason we need (UAVs) is that we don't want to needlessly expend the man in the cockpit." Later that year, General John C. Meyer, Commander in Chief, stated, "we let the drone do the high-risk flying ... the loss rate is high, but we are willing to risk more of them ...they save lives!"

During the 1980s, drone technology started to be used for civilian purposes, and they were used more and more frequently in photography, filmmaking, agriculture, search & rescue missions, and environmental monitoring.

Drones have come a long way from their rudimentary beginnings as simple, remote-controlled aircraft. Their history is a testament to human ingenuity, always striving for new ways to expand our capabilities and understanding of the world. As they continue to evolve and become more versatile, we can anticipate that drones will play an increasingly important role in a multitude of applications – benefiting us in ways we can only begin to imagine.

Exercise 3. Give the Russian equivalents to the following Words and Word Combinations:

Significant development of drones, focused on providing practice targets, a powered UAV, Defense Coastal Boats, Royal Navy, to assist Wing Commander, a fleet of uncrewed aerial combat vehicles, carry an explosive payload, a predetermined target, to develop the first scaled remote piloted vehicle, to emerge, to train antiaircraft gunners, to fly attack-missions, remote control, over hostile territory, naval units, combat mission, reconnaissance cameras, to be captured, loss rate, for civilian purposes, environmental monitoring, rudimentary, testament to human ingenuity, to expand our capabilities, to become more versatile, multitude of applications.

Exercise 4. Give the English equivalents to the following Words and Word Combinations:

Оперативное развертывание, вражеская территория, летать на боевое задание, обучать зенитчиков, свидетельство изобретательности человека, намереваться, вдохновлять, бомбардировщик, обучать военнослужащих, первая попытка, нести боевой заряд, наблюдение за окружающей средой, процент потерь, расширить наши возможности, разведывательный аэрофотоаппарат, простейшее начало, дистанционное управление, становиться более многогранным, над вражеской территорией, быть захваченным в плен, помогать командиру авиакрыла, заранее выбранная цель, боевая задача, портовые сооружения, ударный беспилотник.

Exercise 5. Answer the following questions:

1. Who developed the earliest attempt at a powered UAV in 1916, known as the "Aerial Target"?
2. What was the purpose of A. M. Low's "Aerial Target" in 1916?
3. How did Nikola Tesla describe a fleet of uncrewed aerial combat vehicles in 1915?
4. What was the significance of Reginald Denny's development of the first scaled remote piloted vehicle in 1935?
5. Which country experimented with controlling Tupolev TB-1 bombers remotely in the late 1930s?
6. What UAV aircraft were produced and used by Nazi Germany during World War II?
7. How did the U.S. Air Force's concerns about losing pilots over hostile territory lead to planning for the use of uncrewed aircraft in 1959?
8. What was the code name of the highly classified UAV program that started in response to the Soviet Union shooting down a U-2 in 1960?
9. What was the significance of the clash in the Tonkin Gulf in August 1964 in relation to UAVs?
10. How did Israeli intelligence test the first tactical UAVs during the War of Attrition in the Middle East?
11. How did the use of UAVs in Southeast Asia (Vietnam) by the U.S. military impact the outcome of the war?
12. What were some of the reasons cited by USAF General George S. Brown and General John C. Meyer for using UAVs in combat missions?
13. What are some of the diverse applications of drones in modern times, as mentioned in the text?
14. How has the evolution of drone technology reflected human innovation and our quest for expanding capabilities?

Exercise 6. Make up all possible types of questions:

1. Nikola Tesla described a fleet of uncrewed aerial combat vehicles in 1915.
2. Drones are used to deliver food, medicine, and other small packages across cities, which is known as aerial logistics.
3. Drones can be used to monitor various places such as fires or floods.
4. Over 5,000 U.S. airmen had been killed.
5. Drones have come a long way from their rudimentary beginnings as simple, remote-controlled aircraft.

Exercise 7. Translate these word combinations paying attention to the adjectives:

Capable of flight, momentous consideration, hazardous areas, indoor or outdoor navigation, atmospheric sensing, cost-efficient operations, equivalent manned systems, global positioning system, inertial measurement units, cost-efficient, high maneuverability, different classifications, a broad range of applications, significant development, environmental monitoring, the earliest attempt, successful demonstration, various forces, special training, vertical landing, **conventional wing,** high speed, heavy payload, various forces, aerodynamic shape, smooth surfaces, lateral movement, circular motions, **horizontal flight.**

Exercise 8. Complete the following table using suitable forms:

Noun	Adjective	Verb
		install
	special	
sensor		
		demonstrate
evolution		
		assist
	trained	
		recognize
performance		
success		
	significant	
		innovate

Unit 4

Classification of the UAV types

Exercise 1. Study the Words and Word Combinations:

1. **Specifications (Specs)** - технические характеристики
2. **A fixed-wing UAV** - беспилотный летательный аппарат (БПЛА) с фиксированным крылом
3. **A single rotor UAV** - БПЛА вертолетного типа с одним винтом
4. **A fixed-wing hybrid** - БПЛА-гибрид
5. **A multirotor** - БПЛА вертолетного типа с несколькими винтами
6. **Aerial mapping** - топографическая аэросъёмка
7. **Power line inspection** - осмотр ЛЭП
8. **To hover** - зависать в воздухе
9. **Video surveillance** - видеоконтроль
10. **To utilize UAV** - использовать БПЛА
11. **Inspection** - осмотр
12. **Rescue groups** - спасательные команды
13. **Vertical take-off and landing (VTOL)** - вертикальный взлёт и посадка
14. **Capability** - функциональная возможность
15. **Search and rescue (SAR)** missions- поисково-спасательные операции

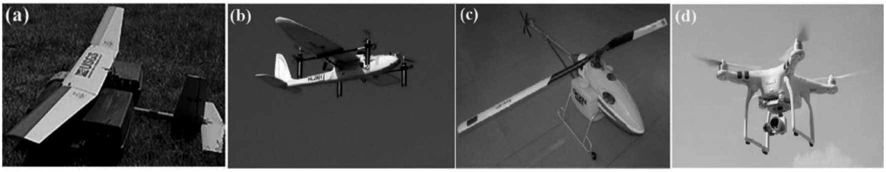
Exercise 2. Read and translate the article below.

UAVs come in a variety of specs, equipment, sizes, ranges, and forms.
Different types of UAVs can be found in the literature:

1. Fixed-wing
2. Single rotor
3. Fixed-wing hybrid
4. Multirotor

Fixed-wing UAVs contain a main body, wings, propeller and motor. These UAVs need special training to control, and they remain useless for aerial surveillance.
A fixed-wing UAV is depicted in *Fig. 4a*. These unmanned aerial vehicles are often used for surveillance, dropping supplies, explosives. Such UAVs are not capable of hovering or forward flight.
Figure 4b. depicts a hybrid fixed-wing UAV.
Figure 4c. depicts a single-rotor UAV. However, single-rotor UAVs are costly to produce and need skill training.
Furthermore, multirotor UAVs are the most affordable and simple to build. These unmanned aerial vehicles are often employed for image and video surveillance.

Quadcopters are the most often utilized UAVs, as seen in *Fig. 4d.* Quadcopters have gained popularity for their vertical landing, or quick maneuverability, low cost, and compact size.



a fixed-wing, **b** fixed- wing hybrid, **c** single rotor, and **d** multirotor UAVs
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9841964/

Exercise 3. Answer the following questions:

1. What are the basic types of UAVs?
2. What elements does a fixed-wing UAV consist of?
3. What requirements should be fulfilled to utilize a fixed-wing UAV?
4. For what purpose are fixed-wing UAVs used?
5. What are their disadvantages?
6. What are the single-rotor UAV features?
7. What drawbacks are typical for a single-rotor UAV?
8. What are the most applicable UAVs?
9. What is the purpose of a multirotor?
10. Why have multirotors become popular?

Exercise 4. Read and translate the articles below.

1. Fixed- wing UAVs

There are many types of fixed-wing UAVs such as unmanned gliders, seaplanes, conventional wing, and flying wing drones among others. They have gained popularity in military and defense applications. A fixed-wing UAV has high speed and heavy payload. The fixed-wing drone can cover larger areas as well as the longest range over any of the other categories. This category can spend up to 16 h time in the sky because a fixed-wing UAV drone uses a gas engine rather than an electric engine. These models use a wing to lift themselves in the sky. The fixed-wing design is one of the most popular and used drone designs today alongside rotary-wing UAVs.

But they are not suitable for stationary applications, because fixed-wing UAVs can't do a close inspection. Another downside is the requirement for a runway during landing or take-off.

Exercise 5. Fill in the table.

Advantages of a fixed-wing UAV	Disadvantages of a fixed-wing UAV

Exercise 6. Study the Words and Word Combinations:

1. **Control surfaces**- поверхности управления
2. **Forces of flight: lift, thrust, weight (gravity), drag**- силы, воздействующие на полёт: подъёмная сила, тяга, вес (воздействие гравитации), лобовое сопротивление
3. **Shape and span of wings -** форма и размах крыла
4. Powerplant - силовая установка
5. **To glide -** планировать
6. **Airfoil -** профиль (аэродинамическая поверхность)
7. **Ailerons -** элероны
8. **Elevator -** руль высоты
9. **Rudder -** руль направления
10. **Pitch -** тангаж
11. **Roll -** крен
12. Yaw – рысканье

How do fixed-wing drones/UAVs fly?

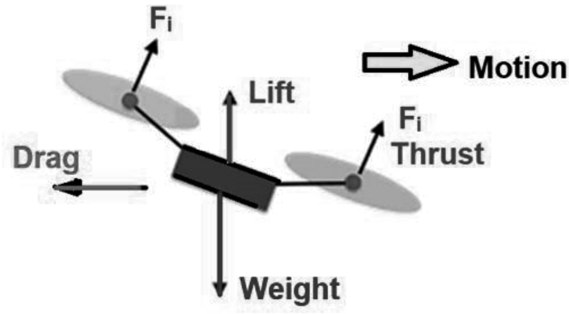
Fixed-wing drones/UAVs are unmanned aircraft that use the reaction of air flowing against their lifting surfaces (wings, fuselage etc.) to generate lift which is possible due to the aircraft's airspeed, shape and span of its wings. Fixed-wing drones/UAVs have the ability to generate lift through the use of their lifting surfaces, and powerplant among other devices such as propellers for propulsion. Many fixed-wing drones can also glide for certain lengths of time. Some are built to glide for long periods of time using rising air to stay aloft (unmanned gliders).

The wing/airfoil is sized and shaped in a way that captures the flow of air as the aircraft's airspeed increases which thus produces lift.

The lift is gained using ailerons, elevators and a rudder which control the UAV's roll, pitch and yaw.

Major forces acting on a Drone.

When a drone moves in the air, various forces act on it. The resultant force will affect its movement. There are four major forces acting on a drone:



Weight

- Due to the mass of the drone, the body mass force always acts in the direction of gravity.
- The higher the weight of the drone is, the more power is required to lift and move the drone.
- Weight of drone = mass of drone × acceleration due to gravity.

Lift

- To overcome the weight force, aircraft generate an opposing force, called lift.
- Lift is the upward force that keeps the UAV in the air.
- Lift depends on the shape, size, and angle of the UAV and its components, as well as the speed and density of the air.
- To fly efficiently, a UAV needs to maximize lift and minimize drag.
- This force is generated by the motion of the aircraft through the air and is an aerodynamic force. Lift is directed perpendicularly to the flight direction.
- The speed, size, and shape of the propeller blade impact the amount of the lift force.
- To create this force, all four propellers run at high speed to lift the drone.

Thrust

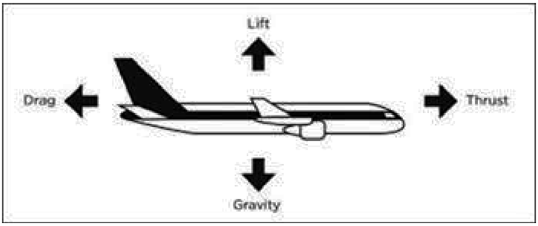
- The force acting on the drone in the direction of motion is called thrust.
- However, for drone dynamics, it is normal to the rotor plane.
- Thrust is the forward force that propels the drone through the air.
- In fixed-wing drones, thrust is typically generated by a propulsion system, such as a motor-driven propeller or a jet engine.
- This force is essential to move the drone in the desired direction at equal speed.

• To get desired motion, propellers have been given high speed.

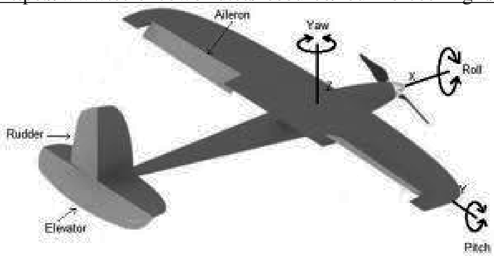
Drag

• The force acting on the drone in the opposite direction of motion due to air resistance is called drag.
• Drag slows the aircraft down.
• This may occur because of pressure difference and viscosity of air.
• Wind, blowing at high speeds, will make it difficult for the drone to hold its position or maneuver as desired.
• To reduce the drag, the aerodynamic shape of the drone is selected, i.e., streamlined designs and smooth surfaces, which help reduce drag.

Exercise 7. Describe the pictures.



https://www.scienceworld.ca/resource/four-forces-flight/



https://www.researchgate.net/figure/Control-surfaces-and-angular-motions-of-a-typical-fixed-wing-UAV

Exercise 8. Read and translate the text.

Three major aerodynamic motions.

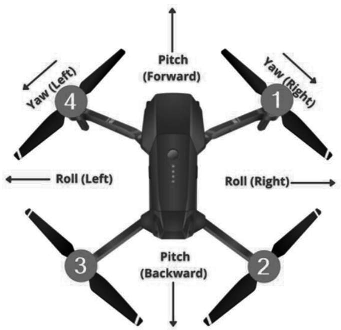
The **roll** (φ angle) represents the drone's rotation on the X-axis. It identifies the drone's lateral movement in left directions (called **negative roll**) and right directions (called **positive roll**).

The **pitch** (θ angle) represents the drone's rotation on the Y-axis and describes the drone's lateral movement with the drone's nose (front side) tilting downward to move forward (called the **positive pitch**) and the nose tilting upwards to move backwards (called the **negative pitch**).

The **yaw** (ψ angle) represents the drone's rotation on the Z-axis. It describes the rotational motion that moves the drone in clockwise and counterclockwise directions. It produces the drone's circular motions. A **positive yaw** turns the drone to the right and a **negative yaw** turns the drone to the left.

The **throttle** is the vertical movement that moves the drone up (called the **positive throttle**) or down (called the **negative throttle**). It determines the drone's speed. The drone's angled propellers spin and push air down to push the drone up to fly.

Exercise 9. Describe the picture.



https://discuss.px4.io/t/how-to-fly-a-quadcopter/35099

Exercise 10. Answer the following questions:

1. What are the basic forces acting on the aircraft operation?
2. What are positive and negative forces acting on an aircraft in-flight?
3. What generates the lift force?
4. How to reduce the drag force?
5. What do you know about the flight controls of a fixed-wing UAV? Where are they located?
6. What are the axes of rotation of the aircraft?
7. What are aerodynamic motions of a drone?
8. What does the roll represent?
9. What is the pitch?
10. What is the throttle?

2. Fixed-wing hybrid UAVs

https://www.jouav.com/blog/drone-types.html

Fixed-wing UAVs and rotary-wing UAVs are two of the most popular drone designs. They both have incredible benefits and fewer drawbacks compared to other types of drones.

The hybrid fixed-wing/vertical takeoff and landing (VTOL) design uses features found in both of these designs and attempts to blend them together in an efficient and effective way that theoretically eliminates the drawbacks found in each of the individual designs. **This category represents drones that can operate in both vertical flight for takeoff and landing and horizontal flight once in the air. They are hybrids between fixed-wing UAVs and rotary-wing UAVs, incorporating both fixed wings and propellers in their designs.**

As the latest drone technology to be introduced, fixed-wing hybrid VTOL drones refer to fixed-wing aircraft that have been modified to take off and land vertically. They combine the long-range and flight time of fixed-wing UAVs with the vertical takeoff capability of rotary-wing devices, eliminating the drawbacks of fixed-wing UAVs that require large spaces for takeoff and landing. They are designed for mapping, power line inspection, surveillance, agriculture, and rescue operations.

Exercise 11. Translate from Russian into English using different rules of grammar.

1. Дроны с неподвижным крылом характеризуются одним жестким крылом и напоминают самолет.
2. Этот дрон имеет большую дальность полета, фиксированное крыло, превосходное качество и производительность.
3. Эти модели отличаются большой выносливостью, большой площадью покрытия и более высокими скоростями полета.
4. Также они способны летать на больших высотах, нести более тяжелую полезную нагрузку

5. В отличие от мультикоптеров, дронам с неподвижным крылом не требуется постоянная энергия, чтобы оставаться в воздухе, что делает их более энергоэффективными.
6. Дроны с неподвижным крылом превосходно справляются с такими задачами, как аэрофотосъемка, съемка с помощью дронов в целях лесного хозяйства и охраны окружающей среды, проверка трубопроводов и линий электропередач, сельское хозяйство, строительство и безопасность.
7. Взлет и посадка - пожалуй, самые сложные моменты в использовании дронов с неподвижным крылом.
8. Взлет и посадка требуют хороших навыков и сложной подготовки пилота. В зависимости от размера дрона для запуска может потребоваться взлетно-посадочная полоса, какая-то катапульта или запуск вручную.
9. Дроны с неподвижным крылом не могут зависать на месте, что снижает их универсальность.
10. БПЛА с неподвижным крылом имеют улучшенные аэродинамические характеристики, чем дроны с несколькими роторами, поэтому выдерживают сильный ветер.
11. Дроны с неподвижным крылом актуальны для задач, требующих охвата огромных территорий, таких как инспекции трубопроводов или сельскохозяйственные исследования.
12. Программное обеспечение для полетов совместимо с операционными системами Windows, iOS, Android и Mac и разработано для легкого понимания и гибкости, обеспечивая плавную интеграцию в работу.

3. Single-rotor UAVs

https://www.researchgate.net/figure/Single-rotor-helicopter-style-drone-used-for-surveillance-37_fig4_368535797

Powerful and durable, single-rotor drones look similar in construction and design to actual helicopters, with only one rotor to provide power, plus a tail to control direction and stability. Combining the advantages of tiny multi-rotor drones and single-rotor drones, they are better suited to carry larger payloads and fly more efficiently than multi-rotors. Single-rotor devices typically use gas engines rather than batteries, which greatly increases their flight time.

However, these drones tend to be larger and more complex than other types of UAVs. This means they are more expensive and more difficult to operate, and their larger blades can make them more dangerous.

Single-rotor unmanned aerial vehicles (UAVs), often called unicopters, are drones with one large main spinning rotor along with an anti-torque device (often a tail rotor) that produces lift and aids in controlling the UAV in flight.

Single-rotor drones are unmanned helicopters that have been around for a very long time. These types of unmanned aerial vehicles (UAVs) rival the fixed-wing UAV configuration. **Single-rotor drones/unmanned aerial vehicles (UAVs) are types of rotary-wing UAVs that have a single main rotor and an anti-torque device.**

Exercise 12. Make up all possible types of questions:

1.Powerful and durable, single-rotor drones look similar in construction and design to actual helicopters.
2.Their larger blades can make them more dangerous.
3.Single-rotor drones are better suited to carry larger payloads.
4.**This category represents drones that can operate in both vertical flight for takeoff and landing and horizontal flight once in the air.**
5. This may occur because of pressure difference and viscosity of air.

4. Multirotor UAVs

https://www.jouav.com/blog/drone-types.html

Rotary-wing unmanned aerial vehicles (UAVs) are some of the most popular types of drones alongside fixed-wing UAVs. They are also commonly referred to as rotary-blade UAVs and unmanned helicopters.

These types of UAVs enable unmanned systems to accomplish otherwise impossible tasks because of their unique capabilities. Multi-rotor UAVs typically do not have these complex systems instead varying the speed that each rotor rotates in a controlled manner that can change the direction of the UAV in flight. Depending on the number of rotors the multi-rotor drone has, they may also configure the direction the rotor rotates differently.

Some props may rotate clockwise, and the opposing props may rotate anti-clockwise to cancel torque generated by each rotor which is why both twin-rotor and multi-rotor UAVs don't need a tail rotor. They also incorporate other devices such as propellers that are powered by electric motors.

Rotatory-wing UAVs are known as quadcopters, hexacopter, tricopter, and helicopter are the kinds of rotatory wing UAV. A rotatory wing UAV drone is designed for monitoring the ground situation from the air, for instance, detecting and tracking border state, surveillance of military equipment, and so on. It has been specially created for remote surveillance. Rotatory-wing UAV drones have limited speed and payload rather to fixed-wing. They can stay in a stationary position in the sky. This UAV can do a close inspection.

Offering great versatility, they allow the installation of all types of cameras to perform different tasks. They are drones that can hover easily and take off vertically, adding more flexibility as well.

However, the biggest drawback of multi-rotor drones is usually related to the flight autonomy they offer. Adding more rotors makes the drone more difficult to control. All those moving parts also consume extra energy, draining the battery faster. Most multi-rotor drones have a flight time of less than an hour. If we want to perform certain tasks that take a long time, we have to have several batteries to replace them. This also means extra costs.

Exercise 13. Give the Russian equivalents to the following Words and Word Combinations:

Powerful and durable, construction and design, a tail to control direction and stability, payload, flight time, difficult to operate, blades, **one large main spinning rotor, an anti-torque device,** the fixed-wing UAV configuration, **a single main rotor, an anti-torque device,** to accomplish otherwise impossible tasks, unique capabilities, complex systems, to incorporate other devices, to rotate anti-clockwise, to rotate clockwise, twin-rotor, a tail rotor, powered by electric motors, quadcopters, hexacopter, tricopter, A rotatory wing UAV drone is designed for monitoring the ground situation from the air, remote surveillance, stay in a stationary position.

Exercise 14. Give the English equivalents to the following Words and Word Combinations:

Разработка и проектирование, винты, стационарное положение, потреблять дополнительную энергию, затраты, движущиеся части, самый большой недостаток, раскручивающийся ротор, нести большую коммерческую нагрузку, дистанционное наблюдение, время в полёте, трудно управлять, зависать в воздухе, лопасти, устройство парирования крутящего момента, уникальные технические возможности, приводимые в движение электрическими моторами, установка камер, выполнять определённые задачи, выполнять осмотр с близкого расстояния, расходовать аккумулятор, взлетать вертикально, заменять батареи, объединять (включать) устройства, отслеживать наземную обстановку с воздуха.

Exercise 15. Fill in the table.

Advantages of a rotary wing UAVs	**Disadvantages of a rotary wing UAVs**

Exercise 16. Compare different types of UAVs and write down sentences of your own using: but, however, whereas, by contrast, in comparison, unlike.

Here are the differences between single, twin &multirotor UAVs

	Single-rotor UAV	Twin-rotor UAV	Multirotor UAV
Payload capacity	Typically higher payload capacity than twin+multi-rotor UAVs	Typically moderate payload capacity	Typically low payload capacity
Speed	Moderate speed	Moderate speed	Generally very high speeds
Weight	Average weight	Much heavier in general	Can be made very light
Operation difficulty	Moderate operation difficulty	Very challenging operation difficulty	Generally very easy to operate
Stability	Moderate stability	Moderate stability	Very stable
Flight time	Very high flight time	Moderate flight time	Typically very low flight time

Exercise 17. Compare the classification and characteristics of different UAVs.

Based on the weight, UAVs can be divided into:
- **micro** (< 1 kg),
-**miniature** (1–25 kg),
- **heavier** (> 25 kg) UAV.

According to the flight endurance/range, UAVs can be divided into:
- **short** (< 5 h, < 100 km),
- **medium** (5–24 h, 100–400 km),
- **long/range** (> 24 h, > 1500 km).

Also, UAVs can be classified as:
- **low altitude** (< 1 km),
- **medium altitude** (1–10 km),

- **high altitude UAV** (> 10 km) UAV regarding the maximum flying height of the UAV.

In addition, UAVs can not only fly in the air but also move on water surfaces or underwater. They are divided into:

- **seaplane UAV**,
- **submarine-launched UAV**,
- **underwater UAV**.

Seaplane UAVs are used to collect useful information without disturbing the surrounding environment. It is important that these vehicles are light, easily disassembled and can be used in remote and harsh marine environments such as arctic poles.

Exercise 18. Complete the following table using suitable forms:

Noun	Adjective	Verb
		fly
	responsible	
division		
classification		
	stable	
		differ
power		
		construct
		develop
		operate
launch		
control		

Exercise 19. Summarize all the information about the UAV types and give the respective definitions:

- A fixed-wing UAV
- A single rotor UAV
- A fixed-wing hybrid UAV
- A multirotor UAV

Unit 5

UAVs applications

Exercise 1. Study the Words and Word Combinations:

1. **Military application** - военное применение
2. **Weapons delivery** - доставка вооружения
3. **Guided missile support** - обеспечение управляемых боевых ракет
4. **Directing artillery** - наведение артиллерии
5. **Spotting enemy positions** - выявление расположения противника
6. **Security awareness** - понимание важности безопасности
7. **Critical infrastructure monitoring and inspection** - осмотр и контроль критической инфраструктуры
8. **Disaster response** - ликвидация чрезвычайных ситуаций
9. **News/sporting event coverage** - освещение спортивных событий и новостей
10. **Power facilities** - энергетические объекты
11. **Aerial photography/aerial mapping** - аэрофотосъёмка/топографическая аэрофотосъёмка
12. **Digital terrain modeling** - цифровое моделирование ландшафта
13. **UAS** (**Unmanned aircraft system) –** БАС (беспилотная авиационнай система)

Exercise 2. Read, translate the text below and study the fields of UAV applications.

Naming the different missions for UAVs is a difficult task, as there are so many possibilities and there have never been enough systems in use to explore all the possibilities. However, the two main classifications for UAS missions are the following:

1. **The military mission**: Military applications focus on weapons delivery and guided missile support, as well as directing artillery and spotting enemy positions.
2. **The civilian mission:** Civilian applications of UAS are open to the imagination, and only time will tell us of the future missions of UAVs for civilian applications:

- security awareness;
- disaster response, including search and support to rescuers;
- communications and broadcast, including news/sporting event coverage;
- cargo transport;
- spectral and thermal analysis;

- critical infrastructure monitoring and inspection, including power facilities, ports, bridges, and pipelines;
- commercial photography, aerial mapping and charting, and advertising.

On the geospatial and mapping applications side, the UAS can be used for the following activities:

- aerial photography/ survey
- LIDAR
- digital mapping
- contour mapping
- topographic mapping
- digital terrain modeling
- geophysical survey.

Military and civilian missions of UAS overlap in many areas. They both use UAS for reconnaissance and surveillance. In addition, they both use UAS as a stationary platform over a point on the ground from which to perform many of the communications or remote sensing satellite functionalities with a fraction of the cost.
Note-LIDAR, which stands for Light Detection and Ranging, is a technology used for precise data collection in the form of 3D models. It achieves this by emitting high-powered laser beams and other forms of light energy to measure distant targets. Think of it as a sophisticated tool for creating detailed 3D maps from a distance.

Exercise 3. Match the words forming collocations.

Stationary	mapping
Data	response
Digital	surveys
Power	tool
Disaster	applications
Aerial	facilities
Civilian	platform
Sophisticated	collection

Exercise 4. Study the Words and Word Combinations:

1. **Maritime sector** - морской сектор
2. **Precision agriculture** - точное сельское хозяйство
3. **Crop monitoring** - мониторинг сельскохозяйственных культур
4. **Plant health analysis** - анализ состояния растений
5. **To collect data** - собирать данные

6. **Pests, nutrient deficiencies, and diseases** - сельскохозяйственные вредители, недостаточность питательных средств и болезни
7. **To target their resources more efficiently** - планировать ресурсы более эффективно
8. **Pesticides and fertilizers** - пестициды и удобрения
9. **Cost savings and environmental benefits** - сокращение затрат и экологические выгоды
10. **Infrastructure maintenance and inspection** - ТО и осмотр инфраструктуры
11. **To access hard-to-reach areas** - иметь доступ к труднодоступным районам
12. **To inspect bridges** - осматривать мосты

Exercise 5. Read and translate the texts below.

Uses of UAVs at Industry Level

Drones have found applications in a wide range of industries, from agriculture to infrastructure, and from maritime to energy sectors. Let's find out how UAVs are used in each of these industries:

- **Precision Agriculture**

Agriculture is one of the most promising fields where UAVs have made a significant impact. UAVs are used in agriculture for crop monitoring, plant health analysis, and precision agriculture. Farmers can use drones to collect data about their crops and detect problems such as pests, nutrient deficiencies, and diseases. The data collected by the drones are used to create maps and identify areas that need attention, allowing farmers to target their resources more efficiently. UAVs also help farmers reduce the use of pesticides and fertilizers, resulting in cost savings and environmental benefits.

- **Infrastructure**

Infrastructure maintenance and inspection are essential for ensuring public safety. However, it can be challenging and dangerous for human inspectors to access hard-to-reach areas. UAVs equipped with cameras and sensors can help inspect bridges, tunnels, and buildings more efficiently and safely. Drones can also be used for construction monitoring and to create 3D models of structures, enabling engineers to identify potential problems before they become severe.

Exercise 6. Give the Russian equivalents to the following Words and Word Combinations:

Precision agriculture, crop monitoring, plant health analysis, to collect data, to detect problems such as pests, nutrient deficiencies, and diseases, to create maps and identify areas, to target their resources more efficiently, to reduce the use of pesticides and fertilizers, cost savings and environmental benefits, infrastructure maintenance and inspection, challenging and dangerous, to access hard-to-reach areas, and sensors can help inspect, to identify potential problems.

Exercise 7. Give the English equivalents to the following Words and Word Combinations:

Точное земледелие, мониторинг сельскохозяйственных культур, анализ состояния растений, собирать данные, одна из самых перспективных областей, оказывать значительное влияние, обнаруживать проблемы, болезни, составлять карты, сокращение затрат, экологические выгоды, позволять фермерам планировать ресурсы более эффективно, уменьшить использование пестицидов и удобрений, создавать 3D модели строений, контроль за проведением строительных работ, обеспечить безопасность населения.

Exercise 8. Match the words forming collocations.

To target	problems
Crop	public safety
Infrastructure	monitoring
To identify	analysis
Cost	hard-to-reach areas
Plant health	resources
To access	monitoring and inspection
To ensure	savings

Exercise 9. Study the Words and Word Combinations:

1. **Ocean research, search and rescue, marine monitoring** - исследование океана, поиск и спасение, мониторинг морского сектора
2. **To identify environmental issues** - определить проблемы, связанные с окружающей средой
3. **To rescue people lost at sea** - спасать людей, потерявшихся в море
4. **Risk of flooding** - риск затоплений
5. **To mitigate the effects of sea level rise** - уменьшить воздействия повышения уровня моря
6. **To assess the impact of natural disasters on ecosystems** - оценить воздействие природных бедствий на экосистемы
7. **To detect wildlife poaching** - обнаруживать случаи браконьерства
8. **Mapping deforestation** - составление карт по вырубке лесов
9. **Conservationists** - специалист по охране природы

• **Maritime and Coastal Monitoring**

UAVs are also useful in maritime applications, including ocean research, search and rescue, and marine monitoring. UAVs equipped with cameras and sensors can collect data on water quality, temperature, and currents. This information is used to monitor marine ecosystems, identify environmental issues, and protect marine life. Drones can also help search and rescue teams locate and rescue people lost at sea.

UAVs can be used to monitor coastal erosion, sea level rise, and changes in beach morphology. The data collected can be used rescue people lost at sea, identify areas at risk of flooding, and develop strategies to mitigate the effects of sea level rise

• **Environmental Monitoring**

UAVs equipped with sensors and cameras can be used to monitor water quality in lakes and rivers, track changes in vegetation health, and assess the impact of natural disasters on ecosystems. Additionally, they can also help detect wildlife poaching and aid in forest management by mapping deforestation and tracking forest fires. UAVs have become a valuable tool for environmental scientists, government agencies, and conservationists in the effort to monitor and protect the environment.

Exercise 10. Study the Words and Word Combinations:

1. **Inspecting power lines, wind turbines, and oil rigs** - осмотр линий электропередач, ветряных мельниц и нефтяных вышек
2. **To collect data** - собирать данные
3. **To reduce their environmental footprint** - уменьшить экологические последствия
4. **Monitoring emissions and identifying potential leaks** - осуществлять контроль за выбросами и определять потенциальные утечки
5. **To collect high-resolution data** - собирать высокоразрешающие данные
6. **Natural Disaster Response** - реагирование на природные бедствия (меры в случае природного катаклизма)
7. **Damage assessment** - оценка ущерба
8. **To survey affected areas** - исследовать пострадавшие районы
9. **To provide detailed information on the extent of the damage** - обеспечить детальной информацией по степени ущерба
10. **To allocate resources** - выделять ресурсы
11. **Missing persons** - люди, пропавшие без вести
12. **Hurricane and earthquake response efforts** - работы по ликвидации аварий в случае урагана и землетрясения

- **Energy**

The energy industry is another area where UAVs have found applications. Drones can be used for inspecting power lines, wind turbines, and oil rigs, which can be difficult and dangerous for human inspectors. UAVs can collect data on the condition of equipment and identify areas that need maintenance or repair. Drones can also help companies reduce their environmental footprint by monitoring emissions and identifying potential leaks.

- **Forestry Management**

UAVs are useful in forestry for monitoring forest health, detecting wildfires, and mapping deforestation. With advanced sensors and cameras, UAVs can collect high-resolution data on tree cover, forest structure, and vegetation health. This data can be used to assess the impact of climate change, identify areas at risk of deforestation, and plan reforestation efforts. UAVs can also detect forest fires in their early stages, which can aid in early detection and prevention.

- **Natural Disaster Response**

UAVs are useful in natural disaster response for search and rescue operations, damage assessment, and mapping affected areas. In the aftermath of a disaster, UAVs equipped with cameras and sensors can quickly survey the affected area and provide detailed information on the extent of the damage. This data can be used to prioritize rescue efforts and allocate resources more efficiently. Additionally, UAVs can help locate missing persons and assess the stability of buildings and infrastructure. Examples of UAVs in natural disaster response include their use in hurricane and earthquake response efforts, where they have proven to be valuable tools in the effort to save lives and mitigate the impact of natural disasters.

These are just a few examples of the many ways UAVs are being used for earth observation. As technology continues to advance, we can expect to see even more innovative applications of UAVs in environmental monitoring and other areas of earth observation.

Exercise 11. Answer the following questions:

1. In what fields are the UAVs applicable?
2. How are UAVs used in agriculture?
3. How is data collected by UAVs utilized in the precision agriculture?
4. What is essential for ensuring public safety in terms of infrastructure?
5. Where do UAVs replace human inspectors?
6. What is the major mission of drones in infrastructure?
7. What types of missions can they be engaged in?
8. How can drones be used in marital and environment monitoring?

9. What type of equipment is installed on UAVs?
10. Why have drones become a valuable tool?
11. How do drones serve in the energetic sector and forestry management?
12. What is the purpose of UAVs in the event of natural disaster?
13. For what purpose can data be used when a natural disaster occurs?

Exercise 12. Match the words forming collocations.

Maritime	resources
To collect	data
To allocate	the impact of climate change
Disaster	persons
High-resolution	applications
To assess	areas
Missing	data
The affected	response

Exercise 13. Translate from Russian into English using different rules of grammar.

1. Дроны или беспилотные летательные аппараты (БПЛА) изготавливаются из различных легких композитных материалов для улучшения маневренности и снижения веса во время полета.
2. Для изготовления рамы обычно используются полимеры или прочные, но легкие сплавы. Помимо этого, активно применяется карбон, стекловолокно и другие материалы, которые смогут обеспечить максимальную жесткость конструкции, улучшить маневренность и снизить вес во время полета.
3. БПЛА могут быть оснащены различным дополнительным оборудованием, включая камеры, системы глобального позиционирования (GPS), навигационные системы, датчики и различные другие программные и аппаратные средства.
4. В каждом дроне можно выделить следующие части: Двигатели, Регуляторы оборотов, Пропеллеры, Полетный контроллер, Рама.
5. Полетный контроллер — это «мозг» дрона.
6. К полетному контролеру подключается набор различных датчиков (GPS, гироскопы, барометр, акселерометр и т.д.), которые передают ему свои показания.
7. Он запрограммирован на обработку различных сигналов, поступающих с дистанционного пульта оператора и установленных на нем датчиков.
8. Полетный контроллер соединен с каждым из четырех двигателей, что позволяет подавать на них управляющие сигналы (запрограммированные команды).

9. Пропеллеры нужны для того, чтобы создать подъемную силу с помощью двигателя, они непосредственно влияют на то, как себя будет вести квадрокоптер в воздухе.
10. Пропеллеры бывают:2-лопастные;3-лопастные;4-лопастные;5-лопастные.
11. Полетный контроллер — (он же: мозги, полетная плата, компьютер, контроллер) это устройство, которое обеспечивает полет коптера, управляя газом, креном, тангажом и рысканьем (throttle, pitch, roll, yaw).
12. Полетный контроллер выполняет следующие функции:

- Собирает информацию с датчиков (установленных на нем или внешних: компас, GPS, гироскопы и т.п.);
- Устанавливает/рассчитывает свое положение в пространстве, согласно датчикам;
- Собирает информацию о внешних управляющих воздействиях (отклонения стика пилотом или следующий шаг алгоритма программы/автопилотирования);
- Рассчитывает неувязки и Пропорционально-Интегрально-Дифференциальные (PID) коэффициенты, в соответствие с прошивкой/программой автопилотирования или ручного управления;
- Отправляет управляющие/корректирующие сигналы на исполнительные механизмы (на регуляторы оборотов).

Exercise 14. Make up all possible types of questions:

1. Drones have found applications in a wide range of industries.
2. Farmers can use drones to collect data about their crops and detect problems.
3. Examples of UAVs in natural disaster response include their use in hurricane and earthquake response efforts.
4. UAVs are useful in natural disaster response for search and rescue operations, damage assessment, and mapping affected areas.

Exercise 15. Complete the following table using suitable forms:

Noun	Adjective	Verb
		apply
	useful	
inspector		
assessment		
		collect
		respond
	equipped	
		prevent
performance		
		detect
emittance		
	additional	

Exercise 16. Write and translate the Present and Past Participle of the following verbs:

Incorporate, monitor, rotate, control, provide, develop, apply, use, prevent, map, track, locate, manufacture, depend, protect, replace, damage, identify, perform, transmit, receive, carry, determine, consider, save, require, design, create, communicate, limit, inspect, monitor, steer, reduce, increase, serve, affect, install, replace, include, search, rescue, find, target, direct, allow, offer, perform.

Exercise 17. Retell the text.

Disaster management.

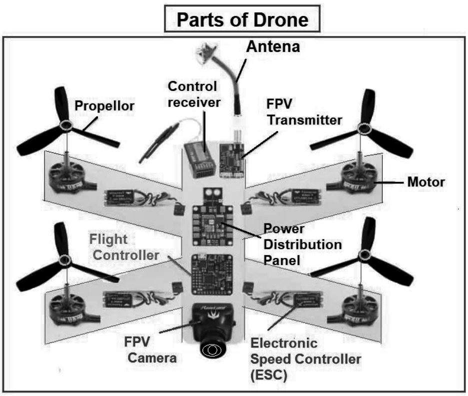
UAVs can visit disaster regions that are unsafe for manned action in the event of a man-made or environmental catastrophe, such as terrorist strikes, tsunamis, and flooding. Power, telecommunications infrastructure, water utilities, and transportation are all vulnerable to these calamities. UAVs can assist in the collection of data, the need for quick answers, and the navigation of debris. UAVs equipped with sensors, radars, and high-resolution cameras can aid rescue teams in identifying damage, launching urgent recovery efforts, and dispatching supplies including first-aid manned helicopters and medical kits. UAVs can aid with catastrophe assessment, disaster alarms, and discovering preventative measures in real-time. A swarm of drones equipped with firefighting equipment can watch, analyze, and track any region in the event of a wildfire without jeopardizing human life. As a result, UAVs may help with real-time surveillance of a vast region without jeopardizing the safety and security of anyone involved. Unmanned aerial vehicles (UAVs) can help to find people and animals in danger so they can be saved.

Unit 6
Major Components of Drones

Exercise 1. Study the Words and Word Combinations:

1. **Carbon fiber** – углеродное волокно
2. **Impaired flight** – нарушенный полет
3. **Pusher propeller** – толкающий воздушный винт
4. **Motor torque** – крутящий момент двигателя
5. **Guard** – защитное устройство, кожух
6. **To determine** – определять
7. **Brushless motor** – бесщёточный мотор
8. **Maintenance costs** – затраты на техническое обслуживание
9. **To contribute** – способствовать
10. **To launch** – запускать
11. **Mainframe** – корпус, центральный процессор
12. **Motherboard** – материнская плата
13. **Alterations** – изменения
14. **Available** – доступный
15. **Requirements** – требования
16. **Capacity** – емкость, вместимость
17. **Inbuilt** – встроенный
18. **Detachable** – отделяемый, съемный

Exercise 2. Read and translate the article below.



https://cfdflowengineering.com/working-principle-and-components-of-drone/

• **Propellers:**

1. Standard Propellers.
The propellers are usually located at the front of the drone/quadcopter. There are very many variations in terms of size and material used in the manufacture of propellers. Most of them are made of plastic especially for the smaller drones but the more expensive ones are made of carbon fiber. Propellers are still being developed and technological research is still ongoing to create more efficient propellers for both small and big drones. Propellers are responsible for the direction and motion of the drone. It is therefore important to ensure that each of the propellers is in good condition before taking your drone out for flight. A faulty propeller means impaired flight for the drone and hence an accident. You can also carry an extra set of propellers just in case you notice some damage that was not there before.

2. Pusher Propellers.
Pusher propellers are the ones responsible for the forward and backward thrust of the drone during flight. As the name suggest, the pusher propellers will determine the direction the drone takes either forward or backward. They are normally located at the back of the drone. They work by cancelling out the motor torques of the drone during stationary flight leading to forward or backward thrust. Just like the standard propellers, the pusher propellers can also be made of plastic or carbon fiber depending on the quality. The more expensive ones are usually made of carbon fiber. There are different sizes depending on the size of the drone. Some drones provide for pusher prop guards that will help protect your propellers in the event of an unplanned crash. Always ensure you inspect your pusher propellers before flight as this will determine the efficiency of the flight.

The speed and load lifting ability of a drone depends on shape, size, and number of propellers. The long propellers create huge thrust to carry heavy loads at a low speed and less sensitive to change the speed of rotation. Short propellers carry fewer loads. They change rotation speeds quickly and require a high speed for more thrust.

• **Motor.**
All drones being manufactured lately use the brushless motors that are considered to be more efficient in terms of performance and operation as opposed to the brushed motors. The design of the motor is as important as the drone itself. This is because an efficient motor means you will be able to save on costs of purchase and maintenance costs. In addition to that, you will also save on battery life which contributes to longer flight time when flying your drone. Currently, the drone motor design market is pretty exciting as companies try to outdo each other in coming up with the most efficient and best developed motors. The latest in the market is the DJI Inspire 1 which was launched recently. This offers more efficient performance and saves on battery life. It is also relatively quiet and does not produce a lot of unnecessary noises. A brushed motor is less expensive and useful for small-sized

drones. Brushless type motors are powerful and energy very efficient. But they need Electronic Speed Controller (ESC) to control their speed. These brushless motors are widely used for racing freestyle drones, traffic surveys and aerial photography drones.

• **ESC (Electronic Speed Controller).**

An electronic speed controller (ESC) is an electric circuit whose main responsibility is to monitor and vary the speed of the drone during flight. It is also responsible for the direction of flight and variations in brakes of the drone. The ESC is also responsible for the conversion of DC battery power to AC power to propel the brushless motors. Modern drones depend entirely on the ESC for all their flight needs and for performance. More and more companies are coming up with better performing ESC that reduce power needs and increase performance, the latest one being the DJI Inspire 1 ESC. The ESC is mainly located inside the mainframe of the drone. It is unlikely that you will need to do anything or make any change on the ESC but in case you need to make any changes, you can locate it inside the mainframe of the drone.

• **Flight Controller (FC).**

The flight controller is basically the motherboard of the drone. It is responsible for all the commands that are issued to the drone by the pilot. It interprets input from the receiver, the GPS Module, the battery monitor and the onboard sensors. The flight controller is also responsible for the regulation of the motor speeds through the ESC and for the steering of the drone. Any commands such as triggering of the camera, controlling the autopilot mode and other autonomous functions are controlled by the flight controller. Users will most likely not be required to make any alterations to the flight controller as this may often affect the performance of the drone.

• **Radio Receiver.**

The receiver is the unit responsible for the reception of the radio signals sent to the drone through the controller. The minimum number of channels that are needed to control a drone are usually 4. However, it is recommended that a provision of 5 channels be made available. There are very many different types of receivers in the market and all of them can be used when making a drone.

• **Radio Transmitter.**

The transmitter is the unit responsible for the transmission of the radio signals from the controller to the drone to issue commands of flight and directions. Just like the receiver, the transmitter needs to have 4 channels for a drone but 5 is usually recommended. Different types of receivers are available in the market for drone manufacturers to choose from. The receiver and the transmitter must use a single radio signal in order to communicate to the drone during flight. Each radio signal has a standard code that helps in differentiating the signal from other radio signals in the air.

• **Battery.**
The battery is the part of the drone that makes all actions and reactions possible. Without the battery, the drone would have no power and would therefore not be able to fly. Different drones have different battery requirements. Smaller drones may need smaller batteries due to the limited power needs. Bigger drones, on the other hand, may require a bigger battery with a larger capacity to allow it to power all the functions of the drone. There is a battery monitor on the drone that helps in providing battery information to the pilot to monitor the performance of the battery.
• **Camera.**
Some drones come with an inbuilt camera while others have a detachable camera. The camera helps in taking photos and images from above which forms an important use of drones. There are different camera types and qualities in the market and a variety to choose.

These are basically the main components of a drone. If you ever need to make a drone, you will need to have all of these in order to have a working drone.

Exercise 3. Give the Russian equivalents to the following Words and Word Combinations:

To be made of carbon fiber, technological research, to create more efficient propellers, to ensure, a faulty propeller, impaired flight, to carry an extra set of propellers, forward and backward thrust of the drone, to determine the direction of the drone, to cancel out the motor torques of the drone, during stationary flight, to provide guards, load lifting ability, brushless motor, brushed motor, to save on costs of purchase, maintenance costs, battery life, to contribute to longer flight time, to outdo each other, more efficient performance, traffic surveys, relatively quiet, Electronic Speed Controller(ESC), to be responsible for the direction of the flight, conversion, to be located inside the mainframe, Flight Controller(FC), motherboard, onboard sensors, steering of the drone, to make alterations, to affect the performance of the drone, in order to communicate, different battery requirements, inbuilt camera, detachable camera, variety.

Exercise 4. Give the English equivalents to the following Words and Word Combinations:

Изготовлены из углеродного волокна, создание более эффективных винтов, неисправный винт, нарушение полета дрона, дополнительный набор винтов, толкающий воздушный винт, во время стационарного полета, защитный кожух для толкающего воздушного винта, неожиданная авария, определяет эффективность полета, способность подъема нагрузки дрона, щеточные моторы, бесщеточные моторы, экономить на затратах на покупку и обслуживание, сэкономить заряд батареи, превзойти друг друга, экономить заряд батареи, энергоэффективный, изучение транспортных потоков, электронный регулятор скорости, преобразование постоянного тока батареи в переменный ток, снижать потребность в энергии, располагаться внутри корпуса дрона, полетный контроллер, материнская плата дрона, прием радиосигналов, передача радиосигналов, иметь разные требования к батарее, потребовать более крупную батарею с большей емкостью, встроенная камера, съемная камера, делать фотографии и изображения сверху.

Exercise 5. Answer the following questions:

1. What are the major components of a drone?
2. What types of drone propellers are known?
3. Where are standard propellers mounted?
4. What is the location of pusher propellers?
5. What material is used to manufacture propellers of a drone?
6. Why is it essential to make sure that each propeller is serviceable?
7. What does the speed and load lifting ability of a drone depend on?
8. What is the difference between long and short propellers?
9. What types of drone motors are you familiar with?
10. Could you compare brushless motors with brushed ones?
11. What is the purpose of an electronic speed controller?
12. What are the capabilities of a radio receiver?
13. How does a radio transmitter operate?
14. Why is a battery required?
15. How does a camera help?

Exercise 6. Make up all possible types of questions:

1. The receiver and the transmitter must use a single radio signal in order to communicate to the drone during flight.
2. The speed and load lifting ability of a drone depends on shape, size, and number of propellers.
3. Propellers are responsible for the direction and motion of the drone.
4. Short propellers carry fewer loads.
5. The growing use of unregulated UAVs has raised questions about privacy and physical safety.

6. In 1980s drone developers began to focus their attention on alternative power sources for drones.

Exercise 7. Find in the text the sentences with the verbs in the Passive voice, explain their usage.

Exercise 8. Complete the following table using suitable forms:

Noun	Adjective	Verb
		create
	responsible	
motion		
variation		
		determine
		depend
		inspect
		protect
performance		
		reduce
reception		
	detachable	

Exercise 9. Translate the following sentences into English:

1. Винты отвечают за направление и движение дрона.
2. Неисправный винт означает нарушение полета дрона и, следовательно, аварию.
3. Как и обычные винты, толкающие воздушные винты могут быть изготовлены из пластика или углеродного волокна в зависимости от качества.
4. Скорость и способность подъема нагрузки дрона зависят от формы, размера и количества винтов.
5. Щеточный мотор менее дорогой и подходит для маленьких дронов.
6. Контроллер полета — это, по сути, материнская плата дрона. Он отвечает за все команды, которые отправляет пилот дрона.
7. На дроне есть монитор батареи, который помогает предоставить

информацию о батарее пилоту для контроля производительности батареи.
8. Некоторые дроны поставляются с встроенной камерой, в то время как у других камера съемная.

Exercise10. Think of your own sentences using the structures:

- Either …...or
- Neither…nor
- Both…and

Exercise 11. Give the definitions of the phrases and words:

- an electronic speed controller
- a radio receiver
- a radio transmitter
- a battery
- a flight controller

Reader

Future Trends

Text 1

Design

Study the Words and Word Combinations:

1. **Environmental robustness** – устойчивость к воздействию окружающей среды
2. **Variables** – переменные факторы
3. **Detriment** – вред
4. **UAV endurance** – продолжительность полета БПЛА
5. **Adverse weather** – неблагоприятная погода
6. **Autonomous capability** – автономные функциональные возможности
7. **UAV swarm** – рой БПЛА
8. **Smart dust** – интеллектуальная пыль
9. **Ally** – союзник
10. **Battery storage capacity** – емкость аккумулятора
11. **Design constraint** – конструктивное ограничение
12. **Equation of motion** – уравнение движения

13. **Battery energy density** – плотность энергии батареи (удельная энергоемкость
14. **Additive manufacturing** – аддитивное производство (3D-печать)
15. **Ratio** – соотношение
16. **Perturbations of the** wind – ветровые возмущения
17. **Flapping wing** – машущее крыло (насекомоподобное)
18. **Bio-inspired** – на основе биотехнологий
19. **Payload** – коммерческая загрузка
20. **Feasible** – возможный, обоснованный

Read and translate the text below:

Despite significant advances over the last decade, there remain some strong limitations for UAV use. These limitations present broad technical challenges to engineers and scientists, and they could shape future research trends. At present time, the primary engineering limitations presented by UAVs lie in limits on flight time, flight range, and structural mechanics.

The limitations result from a combination of weight, power, compactness, environmental robustness, and communication requirements. These different variables are interrelated because improvement in one can come at the detriment of another. Environmental robustness refers to UAV endurance to adverse weather and environmental conditions.

Communication requirements affect the maximum distance a UAV can fly from a ground controller before requiring an autonomous capability. In this section, current technical challenges and possible solutions under active research are presented. In particular, current trends in artificial intelligence for autonomous systems are described for so-called possible future "UAV swarms," "internet of drones," and "smart dust."

1. Components, Materials, and Manufacture

Propulsion technologies are the primary limit related to weight, compactness, and power requirement of rotary-wing UAVs. More specific ally, battery storage capacity is the main limit for most UAVs. One suggested idea is that battery life could be extended through the use of solar energy in fixed-wing UAVs, but the charging rate is not fast enough for the geometries and power requirements of typical rotary-wing UAVs.

The maximum technical takeoff weight is a design constraint determined by the UAV equations of motion. There is also a weight limit. The heaviest components present in rotary-wing UAVs are the batteries, which can account for almost half of the total weight. Consequently, a reduction in battery weight and the ability to miniaturize batteries are both highly desirable. For this reason, improving battery energy density and not just battery storage capacity is an ongoing technological challenge for the UAV community. Although weight can also be reduced in other ways, such as replacing body materials with carbon fiber and minimizing payload weight, these gains are marginal in comparison to improvements in battery technology. Improved battery energy density is also desirable for increasing the compactness of UAVs.

Additive manufacturing (i.e., "3D printing") is another possibility for weight reduction. Several studies have explored the potential of additive manufacturing for customized UAVs that have strong structures. The strength-to-weight ratio is an essential characteristic for the UAV to ensure structural integrity. Additive manufacturing seeks to maximize the strength-to-weight ratio, thereby minimizing overall UAV weight, for a UAV that is targeted to a particular purpose. In addition, additive manufacturing can allow the production of more compact structures that have similar strength to existing structures, resulting in increasingly compact UAV designs. Technological advances in additive manufacturing, as well as cost reductions and the ability to process increasingly lightweight and strong materials, might lead to greater usage of this technique for the production of UAVs in the future.

2. Miniaturization

There is currently an increasing trend toward UAV miniaturization. Reduced power consumption, improved transportability, and greater maneuverability are all possible through miniaturization. A challenge, however, is that the miniaturization of both rotary-wing and fixed-wing aircraft is fundamentally limited by the laws of physics. Shrinking the size of propellers is only possible up to a point, beyond which friction overtakes the lift force. For rotary-wing aircraft, in this limit motors overheat in an attempt to maintain lift. For fixed-wing aircraft, at smaller scales lift drops on miniaturized airfoils, and there is increased sensitivity of flight stability to small scale perturbations in the wind. Some researchers study insects for inspiration on how to achieve flight for a lightweight aircraft while maintaining high levels of control and in the presence of atmospheric turbulence.

The development of a bio-inspired "flapping wing" UAV presents significant aerodynamic and control challenges. Some UAVs, like the eBee and AR.Drone 2.0, are bio-inspired yet still based on rotary-wing or fixed-wing design (i.e., not flapping wing). Flapping-wing UAVs that closely mimic insect flight are still in the developmental stage. Two notable examples of existing flapping-wing designs are the Nano Hummingbird and the RoboBee. Floreano and Wood suggest that bio-inspired UAVs might be increasingly important in future markets because of their potential simplicity. Even so, their applications can be expected to be limited to those that do not require a substantial payload.

Bio-inspired UAVs have several additional possible advantages. The wings of bio-inspired UAVs can produce less noise than rotary-wing UAVs. Flapping wings also allow for sharp turns and abrupt flight arrest without loss of stability. These capabilities coupled with miniaturization could make the use of UAVs in indoor environments increasingly feasible. Such UAVs might also be less invasive in applications such as wildlife monitoring, photography, and surveillance.

"Smart dust" is an aspirational goal that represents the limit of the miniaturization trend. Smart dust refers to micrometer-sized UAVs. Recent advances in microelectromechanical (MEMS)-based sensors and systems are enabling the development of UAVs on this length scale. The possibility of visually undetectable UAVs that are the size of dust particles and equipped with cameras and other sensors could find many applications and benefits. Still, many social and political dilemmas related to privacy and health can be expected to complicate widespread use and early adoption of smart dusts.

Text 2
Communication

Study the Words and Word Combinations:

1. **Malicious actor** – злоумышленник
2. **Vulnerable** – уязвимый
3. **Covertly** – кулуарно, скрытно
4. **Overtly** – публично, в открытую
5. **Override** – блокировать автоматическую систему управления, действовать вручную
6. **To be encrypted** – быть зашифрованными
7. **Jammer** – средство радиоэлектронного подавления
8. **Geofencing** – геозонирование
9. **Custom-built UAV** – БПЛА, выполненный по заказу (несерийный)
10. **GPS spoofing** – постановка ложных сигналов
11. **UAV capture** – перехват БПЛА
12. **Countermeasures** – меры противодействия
13. **Substantial impact** – значительное влияние
14. **Data-sharing effort** – борьба за коллективное использование данных
15. **Encroach** – вторгаться

Read and translate the text below:

Identification and Control

Since UAV systems are operated remotely, there is the possibility for compromise by malicious actors. The data link portion of the UAV communication system is the most vulnerable part of the UAV control system. Attacks by bad actors may be done covertly, such as stealing onboard data, or overtly whereby control of the UAV is overridden. To help prevent this scenario, devices use a unique identification code to identify the origin of a transmission. Transmitters and receivers are paired using a radio frequency identifier (RFID). This receiver identifies the origin of the information. To prevent the malicious actor from copying this RFID, signals between the transmitter and receiver can be encrypted. The Advanced Encryption Standard (AES)-256 is used for information exchange between the UAV and its controller. Some UAVs may also feature password protection for UAV activation, linking to a new controller, or providing access to onboard data.

UAV jammers present an additional challenge. Radio jammers are able to generate high-power signals that block or interfere other radio communications through decreasing the signal-to-noise ratio of existing signals or by mimicking these signals. The frequencies targeted by UAV jammers typically focus around the 2.4 GHz and 5.8 GHz bands due to their high usage for UAV communication. Civilian use of jammers is illegal in most countries. Jammers are being increasingly used by authorities in response to criminal use of UAVs such as near airports and prisons.

Jammers are able to halt communication between the controller and UAV. Although jammers are intended for public safety, bad actors can also use them to hijack UAVs, track a UAV back to its pilot, force the UAV to land, or merely block communication between the UAV and pilot. UAVs can themselves be used as jammers. Geofencing by UAV manufacturers adds software-level functionality that prevents flight near sensitive airspace such as airports, prisons, and nuclear power plants. Geofencing is not foolproof, however. It can be bypassed by using aluminum foil to block GPS signals or by using a custom-built UAV without built-in geofencing. Another potential attack on UAVs is through GPS spoofing. A radio transmitter interferes with the GPS signals by feeding false GPS coordinates. Autonomous UAVs, which often navigate directly using this GPS information, are especially susceptible to this kind of attack. Waveforms used by the military are designed to be unpredictable and are resistant to spoofing. For consumer applications, however, waveforms are unencrypted and unauthenticated. UAV capture is also possible using GPS spoofing, whereby the bad actor is able to specify the position and velocity estimates to manipulate the state of the UAV, effectively taking control of UAV flight. GPS spoofing is difficult to prevent, but it can be efficiently detected. The best-known countermeasures are using encrypted GPS information and using machine learning to detect spoofing attacks.

The FAA has proposed to integrate RFID identifiers on UAVs. This change may also have substantial impacts on UAV communication and navigation. The proposal suggests the creation of a UAS Data Exchange, which would be a collaborative data-sharing effort between government and private agencies for airspace information. The UAS Data Exchange aims to cover multiple partnerships, the first of which is named the Low Altitude Authorization and Notification Capability (LAANC). LAANC would provide a simpler framework than currently exists for the integration of UAVs into the NAS by providing information to air traffic control on where current UAV flights are taking place. This information can also be used by UAV pilots to know where they may and may not fly. The information could further enhance geofencing capabilities by vendors to ensure that pilots do not encroach upon controlled airspace. The integrated nature of this FAA proposal could provide UAV users with real-time authorization for flights. At the same time, law enforcement and airspace authorities can monitor controlled airspace and identify any unusual activity to facilitate public safety. As such, according to the proposal, this system would simultaneously provide increased freedom to business and recreational UAV users while aiding authorities to prevent UAV-related security threats, such as those that have occurred in recent years.

Text 3
Autonomous UAVs

Study the Words and Word Combinations:

1. **Flight path** – траектория полета
2. **High-resolution onboard measurements** – бортовые измерения с высокой разрешающей способностью
3. **Accurate and reliable** – точный и надежный
4. **Data-or compute-intensive algorithm** – алгоритм, предполагающий большой объем данных и вычислений
5. **Built-in machine learning algorithm** – встроенный алгоритм машинного обучения
6. **Constraint** - ограничение
7. **UAV swarm** – беспилотный рой
8. **To avoid collisions** – избегать столкновений
9. **Shannon capacity** – шенноновская (предельная) пропускная способность
10. **To monitor pollution level** – следить за степенью загрязнения

Read and translate the text below:

Fully autonomous UAVs are under development. Many commercial UAVs allow the user to program flight paths using GPS coordinates. This capability can be described as “automated” or “semi-autonomous.” By comparison, an “autonomous” UAV (i.e., “self-driving”) must be capable of following and updating its flight path based on real-time data without human input. Fully autonomous UAVs are expected to be useful for many applications, such as package delivery, policing, or environmental monitoring.

At present time, machine learning algorithms are focusing on data extracted from UAV flights. The goal of these efforts is to develop UAV systems that can respond in real-time to high-resolution onboard measurements. More data continue to become available as sensors become smaller, more accurate, and more reliable. The use of built-in machine learning algorithms on UAVs, however, presents new processing and storage challenges because many such algorithms can be data- or compute-intensive. Optimization under this constraint is sometimes called “tiny machine learning.” Decisions must be made whether data are stored and processed onboard, data are communicated to a ground station, cloud, or other computing platform, or a combination of both.

UAV Swarms

Orchestrating the coordinated movements of tens of UAVs or more in a simultaneous fashion is considerably more complicated than direction of a single system. Such orchestration, which is a research topic of multi-agent systems, has led to the term “UAV swarms.” These swarms can require rapid communication and coordination to avoid collisions among UAVs. Even when more widely spaced, communication and coordination can still be important for sharing data and coordinating flight paths. Communication among too many devices can quickly cause a network to reach the Shannon capacity, becoming saturated and halting all communications.

UAV swarms have been demonstrated at several public events. In the opening ceremony of the 2018 Winter Olympics, 1,218 UAVs were used in a single display. In the future, an array of coordinated UAVs could be equipped with gas sensors to monitor pollution levels across an entire city or equivalently in a large warehouse to assess indoor air quality. A similar approach could be used to form an airborne surveillance system for security of buildings and public events. UAV swarms might be able to use artificial intelligence for autonomous operations. Recent interest from industry, military, and academic bodies suggests that UAV swarms may become more prevalent in the coming years.

Study the abbreviations:

Unmanned aircraft system (UAS) – беспилотный авиационный комплекс

National Aircraft Standard (NAS) – национальный авиационный стандарт

Radio Frequency Identifier (RFID)

Advanced Encryption Standard (AES)

Low Altitude Authorization and Notification Capability (LAANC)

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