BRNO UNIVERSITY OF TECHNOLOGY

VYSOKÉ UČENÍ TECHNICKÉ V BRNĚ

FACULTY OF ELECTRICAL ENGINEERING AND COMMUNICATION

FAKULTA ELEKTROTECHNIKY
A KOMUNIKAČNÍCH TECHNOLOGIÍ

DEPARTMENT OF FOREIGN LANGUAGES

ÚSTAV JAZYKŮ

SURVEY OF UAVS (DRONES) IN THE FIELD OF ELECTRONIC COMMUNICATIONS

PŘEHLED BEZPILOTNÍCH PROSTŘEDKŮ (DRONES) V OBLASTI ELEKTRONICKÝCH KOMUNIKACÍ

BACHELOR'S THESIS
BAKALÁŘSKÁ PRÁCE

AUTHOR
AUTOR PRÁCE

Vladimír Chott

SUPERVISOR
VEDOUCÍ PRÁCE

M. A. Kenneth Froehling

BRNO 2017

VYSOKÉ UČENÍ TECHNICKÉ V BRNĚ | FAKULTA ELEKTROTECHNIKY A KOMUNIKAČNÍCH TECHNOLOGIÍ

Bakalářská práce

bakalářský studijní obor **Angličtina v elektrotechnice a informatice**

Ústav jazyků

Student: Vladimír Chott ***ID:*** 168335

Ročník: 3 ***Akademický rok:*** 2016/17

NÁZEV TÉMATU:

Přehled bezpilotních prostředků (Drones) v oblasti elektronických komunikací

POKYNY PRO VYPRACOVÁNÍ:

Bezpilotní vzdušné dopravní prostředky (UAV, tj. drones) jsou stále více rozšířené ve světě. Mají různé využití, které ovlivňují mnoho aspektů globální života. Cílem tohoto semestrálního projektu je zmapovat literaturu na drones, a to s ohledem na elektronické komunikační aspekty z nich, seznámit s jejich různými použitími a prezentovat své závěry.

DOPORUČENÁ LITERATURA:

Reg Austin, Unmanned Aircraft Systems: UAVs Design, Development and Deployment. Chichester: John Wiley & Sons, Ltd., 2010. ISBN 978-0-470-05819-0 found on http://1slon.ru/book/Unmanned%20Air%20Systems%20UAV%20Design,%20Development%20and%20Deployment.pdf

Termín zadání: 6.2.2017 ***Termín odevzdání:*** 2.6.2017

Vedoucí práce: M. A. Kenneth Froehling

Konzultant:

doc. PhDr. Milena Krhutová, Ph.D.

předseda oborové rady

ABSTRAKT

Tato bakalářská práce se zaměřuje na přehled bezpilotních letadel, často označovaných jako drony, a jejich technologický pokrok a vliv v oblasti elektronických komunikací. Vysvětluje základní definici bezpilotních letounů a ukazuje příklady některých současných typů letounů. Poté práce analyzuje kulturní a sociální vzhled při jejich každodenním používání. Mimoto, práce pojednává o dalších krocích v oblasti bezpilotních letounů a jejich ustálenou pozici v životě.

KLÍČOVÁ SLOVA

Bezpilotní letouny, budoucnost, drony, předpisy, regulace

ABSTRACT

This bachelor thesis focuses on the survey of unmanned aerial vehicles, often referred as drones, and its impact and technological progress in the field of electronic communications. It explains a basic definition of unmanned aerial vehicles (UAVs) and presents some examples of current types of vehicles. Moreover, this thesis analyzes the cultural and social appearance of using UAVs in everyday life. Furthermore, it discusses future steps in the field of UAVs and its stable position in life.

KEYWORDS

Communication, drones, future, regulations, unmanned aerial vehicles.

PROHLÁŠENÍ

Prohlašuji, že svou bakalářskou práci na téma Přehled bezpilotních prostředků (Drones) v oblasti elektronických komunikací jsem vypracoval samostatně pod vedením vedoucího semestrální práce a s použitím odborné literatury a dalších informačních zdrojů, které jsou všechny citovány v práci a uvedeny v seznamu literatury na konci práce.

Jako autor uvedené semestrální práce dále prohlašuji, že v souvislosti s vytvořením této semestrální práce jsem neporušil autorská práva třetích osob, zejména jsem nezasáhl nedovoleným způsobem do cizích autorských práv osobnostních a jsem si plně vědom následků porušení ustanovení § 11 a následujících autorského zákona č. 121/2000 Sb., včetně možných trestněprávních důsledků vyplývajících z ustanovení § 152 trestního zákona č. 140/1961 Sb.

V Brně dne …………………. …………………..

Podpis

POĎEKOVÁNÍ

Chtěl bych se poděkovat vedoucímu mé práce M.A. Kennethu Froehlingovi za pedagogickou a odbornou pomoc při zpracování mé bakalářské práce.

V Brně dne …………………. …………………..

Podpis

CHOTT, V. *Přehled bezpilotních prostředků (Drones) v oblasti elektronických komunikací*. Brno: Vysoké učení technické v Brně, Fakulta elektrotechniky a komunikačních technologií, 2017. 50 s. Vedoucí bakalářské práce: M. A. Kenneth Froehling.

Contents

List of Figures **8**
List of Tables **9**
List of Symbols and Abbreviations **10**
Introduction **11**
1 Definition of UAV **12**
1.1 Payload 12
1.2 Navigation 13
1.3 Communication 14
1.4 Categories of UAVs 15
1.4.1 HALE UAVs 15
1.4.2 MALE UAVs 15
1.4.3 TUAV UAVs 15
1.4.4 Close-Range UAVs 15
1.4.5 Micro and Nano UAVs 16
2 Commercial UAVs **16**
2.1 DJI Phantom 1 17
2.2 DJI Phantom 2 18
2.3 DJI Phantom 3 4K 18
2.4 DJI Phantom 4 19
2.5 DJI Mavic Pro 20
2.6 Yuneec Q500 4K 20
2.7 3D Robotics SOLO 21
2.8 Comparison of Commercial UAVs 22
3 Non-Commercial UAVs **23**
3.1 Military UAVs Classification 23
3.1.1 Long-range UAVs 23
3.1.2 Medium-range UAVs 25
3.1.3 Close-range UAVs 27
3.1.4 Mini UAVs 29
4 Drones in Culture **30**
4.1 Photography 30
4.2 Agriculture 30
4.3 Electrical Services 30

4.5 Information Services 31
4.6 Police Forces 31
4.7 Area Inspection 32
4.8 Meteorological Purposes 32
5 Laws and Regulations 33
5.1 Australia 33
5.1.1 Remote Pilot License 34
5.1.2 Operator’s Certificate 34
5.2 Canada 34
5.2.1 Recreational Use 35
5.2.2 Nonrecreational Use 35
5.2.3 SFOC Certificate 36
5.3 China 36
5.3.1 UAS Categories 37
5.3.2 Electric Fence and UAS Cloud 37
5.4 Israel 38
5.4.1 License Requirements 38
5.4.2 Flying Restrictions 39
5.4.3 Registration and Labeling 39
5.5 New Zealand 39
5.5.1 Part 101 of Civil Aviation Rules 40
5.5.2 Part 102 of Civil Aviation Rules 40
5.6 United Kingdom 41
5.6.1 Weight Restrictions 41
5.6.2 Geographical Restriction 42
5.7 Sweden 43
5.7.1 Categories and Technical Specification 43
5.7.2 Civilian Authorization 44
5.7.3 Restrictions 44
6 Future of UAVs 45
6.1 Commercial Flights 45
6.2 Business Enhancement Tool 46
Conclusion 47
References 49

List of Figures

Figure 1: DJI Phantom 1 17
Figure 2: DJI Phantom 2 18
Figure 3: DJI Phantom 3 4K 18
Figure 4: DJI Phantom 4 19
Figure 5: DJI Mavic Pro 20
Figure 6: Yuneec Q500 4K 20
Figure 7: 3D Robotics SOLO 21
Figure 8: RQ-4 Block 20 Global Hawk 24
Figure 9: MQ-9 Reaper 24
Figure 10: Hunter RQ-5C 25
Figure 11: Seeker II 26
Figure 12: Firescout 26
Figure 13: Camcopter S-100 27
Figure 14: Observer 28
Figure 15: Phoenix 28
Figure 16: Desert Hawk III 29

List of Tables

Table 1: Parameter Comparison of Commercial UAVs 22

List of Symbols and Abbreviations

UAV – Unmanned Aerial Vehicle

GPS – Global Positioning System

PPS – Precise Positioning Service

SPS – Standard Positioning System

DGPS – Differential Global Positioning System

GLONASS – Global Navigation Satellite System

HALE – High Altitude Long Endurance Vehicle

MALE – Medium Altitude Long Endurance Vehicle

TUAV - Tactical Unmanned Aerial Vehicles

EASA – European Aviation Safety Agency

VPS – Vision Positioning System

VTOL – Vertical Take Off and Launch system

MUAV – Mini Unmanned Aerial Vehicles

NAV – Nano Air Vehicles

ICAO – International Civil Aviation Organization

CASA – The Australian Civil Aviation Safety Authority

CAR – The Canadian Aviation Regulations

SFOC – Special Flight Operation Certificate

CAAC – Civil Aviation Administration of China

CAAI – Civil Aviation Authority of Israel

CAA – Civil Aviation Act

UAOC – Unmanned Aircraft Operator Certificate

UAS – Unmanned Aircraft Systems

Introduction

Human imagination is limitless. Every single person is unique and can use its creativity in any direction. Because of new and better technologies people are constantly developing new products. However, there is one institution capable of doing thing faster, better and quietly.

The military sector features some inventions that may be presented to the public, which are considered unknown and classified for the ordinary citizen. The military uses its funding for developing purposes and protecting countries. One of those products are unmanned aerial vehicles (UAVs) or drones. UAVs were transformed from only military use to civil. A pilotless aircraft able to fly in the air by itself and can be as small as a shoe box or big as a family car. Some types of army airplanes and fighters are being replaced by drones, and more people will have a chance to discover all the possibilities of using a drone.

This bachelor thesis focuses on unmanned aerial vehicles. It is divided into six chapters. The aim of the first chapter is to explain the definition of the word UAV. The role of commercial UAVs is explained in the second chapter. This chapter presents some of the most popular drones today and distinctions between them. The third chapter is dedicated to non-commercial use of UAVs. Non-commercial drones are being deployed in the combat for different types of operations. This chapter discusses different variations of army drones and their purpose. Drones in culture are explained in chapter number four. This chapter focuses on cultural influence of drones, changes in society due to drone usage in cities. Laws and regulations are the aim of the fifth chapter. With the rising usage of commercial drones, certain regulations and laws had to be established. This chapter presents different perspectives on drone legality. The final sixth chapter presents the future in the field of UAVs. With the growing popularity of drones and technology progress in electrical engineering, possibilities of drone usage are immeasurable.

1 Definition of UAV

An unmanned aircraft vehicle (UAV) is a special type of aircraft developed and designed with no human crew onboard. The crew is replaced by a computer system and a radio-link. UAVs are constructed and designed with great precision and their reliability is at a top level. [1]

An UAV system consists of the aircraft, its payload if necessary, the control station, aircraft launch and recovery, communication, support, transport and more sub-systems that are specific to the type of a drone. Each vehicle also has support equipment for maintenance work and item transporting. [1]

UAVs are often titled as “drones”. However, not every drone is able to communicate with the operator, has some type of intelligence and capable of information gathering during the fly time. An UAV, on the contrary, features some level of automatic intelligence. It is able to communicate with its controller and process some primary state information such as position, altitude and airspeed. It is also able to transmit information of some condition state, often introduced as “housekeeping data” that provides information of the amount of fuel left in the tank, temperature of the engine and its parts. UAVs are also designed to deal with faults and errors that can occur during the procedure of information gathering. It can alert the operator the operator if radio communication is broken and can change the radio frequency band. A more comprehending UAV can conduct a step procedure that enables it to deal with further problems. In case of some system failure, a more intelligent system can quickly respond and find a solution for fixing itself. [1]

1.1 Payload

A big part of a drone construction is payload. However, payload is not an essential part of a drone; thus, a drone should be able to fly with no payload on-board. Payload is often referred as an extra weight carried by drone. This weight depends on the type of a drone. Special military operations require different types of payload. Since every new development and certification is expensive, payload construction must be versatile. The military payloads might consist of different radio communication systems, surveillance cameras and sensors. [1]

Apart from the military, civilian drones use simpler payloads. Majority of civilian drones use payload only for cameras. These cameras are built-in to the body of a drone, or have a mount for an external camera. Therefore, there are two types of payload used in civilian sector:

- removable payload that offers modification
- permanent payload

1.2 Navigation

The accuracy of the controlled drone is supervised by a navigating system. Drone operator uses navigation for detecting the exact position of a drone, even if it is miles away from the operator. Currently, the best method for finding out the position is by the usage of Global Positioning System (GPS). GPS was originally created by United States Department of Defense. In the beginning, it was only accessible for the US military; however, in 1982 GPS became available worldwide. [1]

GPS uses signal transmission between the receiver and satellites that orbit the Earth. Fundamentals of the communication are based on an atomic clock installed inside the satellite and a receiver in drone. The signal contains the time travelled at the speed of light. Depending on the time and range, receiver calculates the range between the satellite and a drone. The resulted calculation determines the exact position of a drone. [1]

There are two types of GPS services available. The Standard Positioning System (SPS) is accessible for civilian use. The military uses more advanced system labeled as the Precise Positioning Service (PPS). The satellites orbiting the Earth are available for both, the military and civilian need. The difference between those systems is accuracy. SPS works with a position accuracy of 10 meters. The military uses more encrypted frequencies that enables PPS to have a position accuracy of 3 meters. [1]

GPS systems may be enhanced using the Differential Global Positioning System (DGPS). This system uses network of ground-based stations that transmit the position calculated by the satellites and the stations position. The overall accuracy is then calculated by the difference of both calculated position data. [1]

Even though GPS is the most well-known position calculating system, there exist systems, with similar position accuracy. Systems like Galileo that is generally used in Europe, Russian-made Global Navigation Satellite System (GLONASS) or Indian Regional Navigation Satellite System (IRNSS). [1]

GPS provides signals for various system, however, there are instances, when the quality of signal is reduced. If the weather conditions are inadequate, some GPS loss is possible. The most common example are geomagnetic storms or intentional signal disturbance. The presence of a stronger signal might often interfere with a lower signal and create further losses and errors. Big and dense cities often struggle with GPS failure. Transmitted signals often reflect from big glassy skyscrapers. Even a local radio frequencies may create interference of GPS signal. [1]

As a result of a signal loss, systems like TACAN and LORAN C were developed. These systems have stronger signal than GPS, however, the communication of those systems can be easily exposed. Another big negative of these systems is their insufficient availability, essentially for the military. [1]

1.3 Communication

Every communication from the UAV control station and UAV involves an up-link transmitting commands and control. The communication from UAV to the control station involves down-link commands that includes status of UAV, payload and position. This information transmission is also known as a housekeeping data. If the communication between the control station and UAV is not stable, overall functionality of UAV decreases rapidly.

Communication losses may occur in these situations:

- System failure due to the lack of reliability
- Loss of signal or the line of sight due to geographic location
- Intentional or inadvertent signal interruption
- Decrease of received power due to the distance from the control station

Two specifications for the overall performance of communication between the control station and UAV are data rate and bandwidth. Data rate show the amount of data transferred per second. This data is measured in bytes per second. Bandwidth is a difference between the highest and lowest frequencies used in communication. Bandwidth is measured in MHz or GHz, depending on the control station. [1]

1.4 Categories of UAVs

UAVs can be split into two main groups, UAVs developed for civilian usage and the military UAVs. The military divides their UAVs into five categories depending on their size, altitude they fly at and overall endurance. [1]

1.4.1 HALE UAVs

High Altitude Long Endurance (HALE) vehicles are able to fly over 15 000 m altitude. HALE vehicles are capable of staying in the air for more than 24 hours. Because of its long-range endurance, these vehicles are often operated from the military bases. [1]

1.4.2 MALE UAVs

Medium altitude long endurance vehicles are capable of flight at altitude between 500 - 15 000 m. They often last less than 24 hours. MALE UAVs are similar to the ones using HALE system, however there is a slight difference in range usage. [1]

1.4.3 TUAV UAVs

Tactical Unmanned Aerial Vehicles (TUAV) sometimes referred as Medium UAV have the range of order between 100 – 300 km. Vehicles using TUAV system are often smaller in size than those using previous two systems. [1]

1.4.4 Close-Range UAVs

This group of UAVs contains both the military and civilian vehicles. They usually operate at a range of about 100 kilometers. Close-range UAVs are often used for field monitoring, inspection of power lines and crop-spraying. Vehicles with the range less than 30 kilometers are referred as Mini UAVs. [1]

1.4.5 Micro and Nano UAVs

The final group of UAVs are Micro and Nano UAVs. These vehicles are designed for radar interruptions and used in ultra-short range. As a result of small size, they are used in densely populated areas. Micro UAVs are able to fly in and out of a certain area, without causing any disturbance. The biggest disadvantage of this type of vehicles is the incapability of self-launch. Due to small wingspan used, Micro UAVs must be launched in the air by an operator. [1]

2 Commercial UAVs

Commercial UAVs popularity is on the rise. Companies are developing products that are available for a wide range of civilian customers. In order to obtain and properly use drones, some requirements must be met. Each country has its own regulations and standards that allow the user to use a drone. The most common rules concern the drone’s ability to reach a certain altitude and limit the maximum achievable altitude for a given country.

European Aviation Safety Agency (EASA) inspects all regulations in the countries that are members of European Union, however, each country can adjust these regulations for its own purpose. [1]

One of many popular companies is Da-Jiang Innovations (DJI). DJI is a Chinese technology company based in Shenzhen, Guangdong. It is mostly known for its line of Phantom drones. [2]

2.1 DJI Phantom 1

Figure 1: DJI Phantom 1

Phantom 1 (see Figure 1) is the first-generation drone from the Phantom group. It was released in August 2015. [2] With a wingspan of 350mm, weight of 840 grams and its construction based on 4 rotors, Phantom 1 came at a price of $379. The frame is made of plastic and fiber mixture. The first version could only withstand 330 grams of payload capacity; thus, the maximal flight time could be at about 15 minutes. As far as flight details goes, Phantom 1 has a maximum speed of 10 m/s and can fly up to 200 meters above sea level. Temperature-wise, maximum operating temperature is from -10°C up to 50°C. Phantom 1 can be operated by remote control connected to a tablet or smartphone. At the operating range of 1km, the controller frequency is 2.4 GHz. The first generation has a built-in battery with a capacity of 2200 mAh. Phantom 1 supports mounting of action cameras in the bottom part of drone. [3]

Since it became hugely popular among users, some regulations and flying laws has been established, depending on the location of using and application for which the drone was planned to be used. [3]

2.2 DJI Phantom 2

Figure 2: DJI Phantom 2

The second version of Phantom (see Figure 2) drones is mostly an upgraded version of the previous one. It has a bigger battery with a capacity of 5200 mAh which reflects the overall weight of 1kg. Maximum flight time has been increased from 15 to 25 minutes and its maximum speed is at 15 m/s. Phantom 2 also supports mounting of action cameras in the bottom part of drone, like previous version. [4]

2.3 DJI Phantom 3 4K

Figure 3: DJI Phantom 3 4K

Phantom 3 4K (see Figure 3) is the first of DJI drones that was capable of capturing videos 4K resolution. It was released in the beginning of 2016. The main feature of this version is its built-in 12-megapixel camera that can capture videos in 4K resolution. In order to save weight in the drone, DJI has a smaller battery with a capacity of only 4480 mAh. [5]

2.4 DJI Phantom 4

Figure 4: DJI Phantom 4

[6]

Only three months after releasing Phantom 3, DJI released its newest addition in Phantom family, Phantom 4 (see Figure 4). It is the most advanced drone from the Phantom series. It has the same wingspan as all previous models. Even though its body is made of magnesium and rotors are made of carbon fiber, Phantom 4 is the heaviest one, with 1.4kg. The flying time was increased to almost 30 minutes and can withstand a payload of 462g. Phantom 4 can fly at an altitude of 6km above the sea level. It also supports the same 12-megapixel and 4K camera. With a battery of 5350 mAh, Phantom 4 can be controlled from a distance of 5km. The latest version also comes with some new features.

- Precision Hovering which uses Vision Positioning System (VPS) for making it easier and safer to fly. VPS also allows it to brake instantly and hover when the joystick controls were not used.
- Tap to Fly function enables a user to put a Phantom in the air by just tapping the remote control. Obstacle Sensing System used in the Phantom 4 keeps the device away from near objects.
- Visual Tracking enables it to lock onto an object and copy its moves.
- Sport Mode benefits from its lightweight magnesium body and enables an increase of speed by 25%, while all systems are safe and stable. [6]

2.5 DJI Mavic Pro

Figure 5: DJI Mavic Pro

DJI released Mavic Pro (see Figure 5) in September 2016. Mavic Pro's weight is only the half of weight of Phantom series drones. With the weight of only 743 grams, Mavic is the lightest produced DJI drone yet. Since Mavic Pro has 4 foldable rotor legs, it has a very compact body construction. However, due to the small size, internal battery has capacity of only 3830 mAh. That limits Mavic's flight time to only about 20 minutes, depending on the weight of payload used. Like Phantom 4, Mavic Pro supports 12 Megapixel camera with 4K resolution. Lightweight construction and high-quality camera makes Mavic Pro a perfect choice for shooting professional videos. [7]

2.6 Yuneec Q500 4K

Figure 6: Yuneec Q500 4K

Chinese aircraft manufacturer Yuneec International became popular in 2009 when its first drones were produced. One of the most popular types of this company is Yuneec Q500 4K (see Figure 6) released in June 2015. [8] It is a smaller size drone, compared to DJI production. It has built-in battery with capacity of 5400, which enables Q500 4K to be in air for about 25 minutes. Given its name, this drone can capture 4K videos with 12 Megapixel camera resolution. Yuneec Q500 4K has an operation range of 800 meters, however, it only can fly at an altitude of 122 meters above the sea level which is a low altitude, compared to DJI. [9]

2.7 3D Robotics SOLO

Figure 7: 3D Robotics SOLO

3D Robotics is an American company that designs and manufactures unmanned aerial vehicles. It specifies mainly on consumer drones. Their most famous drone is SOLO Drone (see Figure 7). It was released in 2015 and marked as the smartest drone ever. [9] SOLO weights 1.5 kg and given its big battery with a capacity of 5200 mAh, SOLO is one of the fastest consumer drones. With its maximum speed of 24.6 m/s, SOLO has a flight time of 25 minutes. The construction has no built-in camera, but it is compatible with many of action cameras. [10]

2.8 Comparison of Commercial UAVs

Name	Weight [g]	Wingspan [mm]	Battery [mAh]	Payload [g]	Camera [MP]	Altitude [m]	Speed [m/s]	Flight time [min]
Phantom1	840	350	2200	330	-	200	10	15
Phantom2	1000	350	5200	300	-	500	15	25
Phantom3	1280	590	4480	-	12/ 4K	120	16	25
Phantom4	1380	350	5350	462	12 / 4K	6000	20	28
MavicPro	743	-	3830	-	12 / 4K	-	18	27
Q500 4K	1100	565	5400	600	12 / 4K	122	8	25
3D Solo	1500	460	5200	420	-	122	24.6	25

Table 1: Parameter Comparison of Commercial UAVs

3 Non-Commercial UAVs

3.1 Military UAVs Classification

Military UAVs are divided into four categories depending on the range of the flight, size of an aircraft and overall endurance of the aircraft. [1]

3.1.1 Long-range UAVs

Long-range UAVs are characterized as vehicles used for long-endurance purposes. Surveillance missions which are time-demanding require usage of this type of UAV. The onboard fuel tank capacity is dictates the overall size of a vehicle. For the sake of achieving an excellent mission results, long-range UAVs are designed with great precision and aerodynamics on a high level. This ability saves fuel and time spent in air. [1]

In order to design a vehicle which is working perfectly at every level, three important requirements must be executed:

a) Aerodynamic drag of the aircraft must be minimized
b) For the sake of reducing the overall weight, latest technological procedures and advanced materials must be present
c) Stable, lightweight and fuel-efficient construction

There are two most recognized UAVs in the category of long-range UAVs. The first one, RQ-4 Block 20 Global Hawk (see Figure 8) constructed by Northrop-Grumman, belongs to the category of high altitude long endurance vehicles (HALE). The second is MQ-9 Reaper (see Figure 9). It is made by General Atomics and is a part of medium altitude long endurance (MALE) category of UAVs. [1]

Figure 8: RQ-4 Block 20 Global Hawk

RQ-4 Block 20 Global Hawk is a UAV used in long-range operations. This UAV flies over 15 km altitude, and falls into the category of high altitude long endurance UAVs. The total endurance of Block 20 is about 35 hours in the air. With a wingspan of almost 40 meters, the overall length of the aircraft is 14.5 meters. Due to its big size, payload carried by this UAV can weight up to 1.4 kilograms. This enables Block 20 to carry more advanced communication systems and synthetic aperture radars. [1]

Figure 9: MQ-9 Reaper

For the reason that MQ-9 Reaper is able to fly at a maximum altitude of 12 km, it belongs to the category of medium altitude long endurance UAVs. In comparison with Block 20, the overall endurance and construction of this UAV is slightly smaller. The biggest advantage of MQ – Reaper is the payload capacity. It is able to carry more than 200 kilograms of mass and fly in the air for about 30 hours. [1]

3.1.2 Medium-range UAVs

Both long-range and medium-range categories use only HALE and MALE systems. As a result of operating at high altitude, long-range UAVs are only able to use technology of fixed wings. However, Medium-range UAVs are able to use both fixed-wing technology and rotary-wing technology. Therefore, they are divided into two categories depending on the type of wings used. [1]

The structure of medium-range UAVs with fixed-wing is very simple. The front part of the aircraft is used for carrying payload, the center part carries the fuel tank and behind the fuel tank. Tail part contains the power-plant and propeller that pushes the whole aircraft down. The most common types of these type of UAVs are Hunter RQ-5A (see Figure 10) made by collaboration of Malat and Northrop-Grumman, and Seeker II (see Figure 11) made by Denel Aerospace Systems. [1]

Figure 10: Hunter RQ-5C

A collaboration of companies Northrop-Grumman and Malat constructed Hunter RQ-5A. There are currently three version of Hunter model available. The first version RQ-5A is only able to fly in the air for 12 hours fly at the altitude of 4600 meters. The overall weight of the first version was 727 kilograms. The second version RQ-5B is just an updated version of the previous one, with extended wingspan and prolonged air time. The biggest difference comes with the third and latest version, RQ-5C. It offers 30 hours of time spend in air. The latest model gained some additional weight due to fuel tank expansion and almost doubled the wingspan compared to the first model. With the increase of wingspan and endurance, RQ-5C is able to fly at the altitude of 7600 meters. [1]

Figure 11: Seeker II

The second example of medium-range UAV is Seeker II developed by Denel Aerospace Systems. Compared to Hunter, Seeker II is a smaller type of UAV. The overall weight of the aircraft only about 275 kilograms and it is able to fly in the air for up to 10 hours. However, the maximum speed of Seeker II is 220 km/hr, thus, it is a great choice for quick surveilling missions that require payloads up to 50 kilograms. [1]

Rotary-winged UAVs are less popular then the aircrafts using fixed-wing construction, due to short endurance and lack of experience and development in the rotary-winged sector. Nonetheless, these types of UAVs are very powerful and useful in the combat situations. Two of the most popular examples are Firescout developed by Northrop-Grumman (see Figure 12) and Camcopter S-100 constructed by Schliebel company (see Figure 13). [1]

Figure 12: Firescout

Figure 13: Camcopter S-100

This type of medium-range UAVs is mostly used for short surveilling missions that last no more than six hours. The light construction enables fast infiltration of the enemy territory. The majority of payload contains high-quality cameras, mine detection systems and radars. [1]

3.1.3 Close-range UAVs

The category of close-range UAVs consists of aircrafts used both for the military and for civilians. Due to the low altitude flight they have, the response time used in these aircraft is very fast. Close-range UAVs depend fully on being mobile. These aircrafts might or might not use the Vertical Take Off and Launch system (VTOL) that enables the operator to launch the aircraft in a place where is no possible use of a runway. The construction of some close-range UAVs does not allow the aircraft to be self-launched. The example system that does not use VTOL is Observer (see Figure 14) and Phoenix (see Figure 15). These close-range UAVs are able to fly in the air for up to four hours in radius of 25-50 kilometers. [1]

Given the fact that aircrafts like Observer use no runway, the recovery system must be present. Close-range UAVs construction must include parachute deployment and some padded materials that inflate just before the landing occurs. [1]

Figure 14: Observer

Figure 15: Phoenix

3.1.4 Mini UAVs

The basic idea for Mini Unmanned Aerial Vehicles (MAUV) is to create an aircraft that is able to be fit into a small case or bag, where it is easily transported. Due to the small size and weight, MUAVs are very popular. The small size enables MUAVs to fly under the rules that are based for aircraft plastic models. Another positive of MAUVs is the cheap manufacturing and availability. The best-known types of MAUVs are Desert Hawk III (see Figure 16) developed by Lockheed-Martin and Bluebird (see Figure 17) created by company Skylite. The average flight time of MUAV is about 90 minutes with the maximum speed of 100 km/h. [1]

Figure 16: Desert Hawk III

Mini UAVs are not the smallest UAVs produced. The concept of Micro Air Vehicles (MAVs) is not to exceed the overall diameter of a vehicle that is 150mm. The role of MAVs is to conduct surveillance missions that are located indoor. MAVs are usually operated by a smartphone or a tablet. [1]

Nano Air Vehicles (NAV) were originally financed by Defense Advanced Research Projects Agency (DARPA). The basic idea of NAV is to create a vehicle that is made out of parts built by nanotechnology. NAVs are the future of UAV systems which may include vehicles that are able to fly inside the buildings and gather valid information about the size of the searched rooms and floors. [1]

4 Drones in Culture

Once sole military product, now fully established in commercial sphere, drones present an alluring tool for the industry. Therefore, many businesses can use drone’s potential to optimize their production and overall performance. [1]

4.1 Photography

Modern drones have equipped high-quality cameras that can take pictures or record videos high definition. The materials can be used for documentary and educational purposes. Given the small-scale size, drones are able to get into poorly accessible areas without any disturbance of the surrounding. [1]

4.2 Agriculture

Different types of payload can offer farmers the option to monitor and control large farmland areas. Drones with payloads containing chemicals can be used for spraying pesticides and preserving crops. This method can be less costly and more efficient than traditional agricultural machinery. In some instances, large animal herds can be monitored and guided by drones. [1]

4.3 Electrical Services

In order to have a stable supply of electricity, powerlines must be maintained. Powerlines are mounted on tall pillars that are anchored in the ground. In case of blackout, a service technician must be able to climb to the top by ladder or by excavation platform to fix the issue. This process is highly dangerous, due to the high-voltage that flows through the lines. Any contact with the conductive parts can be fatal. Drones present a safer alternative that lowers the risk of injuries. A drone operator can be standing on the ground in safe distance and detect any damage or insulation breakdown with a high-quality camera. However, a drone construction must be able to resist any electromagnetic field that can influence the control of drone. Usage of a drone also lowers the environmental disturbance. Some powerlines pass through forests. Considering that drones produce less noise than any manned aircraft, animals are less likely to be stampeded during the process of inspection. [1]

4.4 Fire Services

When a big forest fire occurs, drones can use the heat sensors and cameras mounted onto the body, to identify possible origin of fire. Bigger size enables the drone to be even used as an extinguishing tool against forest fires. During the drought season, drones provide an aerial view for places that are conducive to the outbreak of fire. [1]

4.5 Information Services

Organizations such as TV companies, news agencies and publishers can improve and enrich their production with drones. Equipped with high-resolution cameras, drones display a possible replacement for TV helicopters, that are used during famous events and occasions. Sport matches can use drones and provide a different viewing angle to the game. Hover capability of a drone provides quality images and offers a less expensive alternative than traditional helicopters. [1]

4.6 Police Forces

Police forces are in charge of security and peace in cities. Police departments can use drones during street riots for faster identification of the offenders, or even used payloads that can entice people from additional vandalism. In case of missing person, drones can fasten up the process of searching mostly in remote areas. However, city regulations often limit police options of drone usage. Another negative aspect is that majority of drones operate well only in favorable weather conditions. [1]

4.7 Area Inspection

Drones can be used for inspection purposes of areas that can be transformed into new roads, housing neighborhoods and industrial parks. In time of natural disaster, drones can determine the extent of the damage. Places that are known for having great volcanic activity can be able to monitor the area and alert people in case of an eruption. [1]

4.8 Meteorological Purposes

Given the fact that some drones are capable of flying at a high altitude, meteorological stations might be able to modify drone payloads with sensors for determining the composition of atmosphere and detect any abnormalities. However, meteoritical drones would require to be weatherproof and windproof. [1]

5 Laws and Regulations

Due to the increasing drone usage for civilian purposes, many countries have introduced drone regulations. These regulations are based to oversee safety of drone operating in places where public and national security can be jeopardized. In addition to the security, certain laws are established to monitor areas that have natural or historical importance, in which the presence of an inexperienced drone operator can disrupt the environment. [11]

However, drone regulations vary from country to country. In order to unify certain standards for drone operating, the International Civil Aviation Organization (ICAO) issued a brochure in 2011, that requests the countries to provide a commentary on drone regulations, in order to create background for unified international regulatory framework. [11]

5.1 Australia

The Australian Civil Aviation Safety Authority (CASA) started regulating civilian drone activity in 2002. These regulations were reexamined and modified in 2016, including new set of rules related to drone usage. According to new rules, the operation of very small drones (with the overall weight under 2 kilograms) and small drones (with the overall weight under 25 kilograms) can be done without any pilot license or certificate. Although, drones with the overall weight exceeding 25 kilograms must be operated only by a person with a valid pilot's license. Operation of large drones (with the overall weight over 150 kilograms), as well as smaller drones for nonrecreational purposes, must be conducted by a person with pilot's license and operator's certificate. Large drones must also have airworthiness certification. [11]

In order to be eligible for a remote pilot license, operator must obtain a specific qualification. This can be achieved by completing a certain training and having a minimum of hours of experience. Additionally, for the sake of safe drone operating, some requirements must be met:

- Drones may not be operated in areas with restricted or prohibited access, unless the authorities have granted a permission to operator.
- Drones may be operated at an altitude greater than 100 meters above the ground only if they are not violating any air traffic control clearance.

- Drones must be operated within the operator's visual line of site.
- Drones may be operated at an altitude greater than 100 meters in permitted areas.
- Drones may be operated at an altitude greater than 100 meters within 5.5 kilometers of an airfield if permitted by the regulations or by the CASA.
- Drone operators must ensure that dropped or discharged parts of a drone will not cause any danger to another aircraft, person, or property.
- Drones must be operated in visual meteoritical conditions, or in in conditions that require specific approval. [11]

5.1.1 Remote Pilot License

Remote pilot license can be provided to a person that passed an examination or a training course related to theory of aviation and presented a satisfactory aeronautical knowledge. The range of license depends on the overall qualification of the licensed person and type of drone usage. [11]

5.1.2 Operator's Certificate

In order to be able to get operator's certificate, the operator must satisfy these conditions:

- Provide a background for safe drone operation
- Have a person with sufficient qualification and experience in drone operation
- Have an appropriate equipment necessary for drone operation
- Have suitable documentation of procedures including maintenance of the drone [11]

5.2 Canada

Regulation of drones in Canada falls under the jurisdiction of the federal government. Drones are primarily regulated by the Canadian Aviation Regulations (CAR) and standards issued by Transport Canada. Depending on the type of usage and weight, CARs determines the operator's obligation to have a special flight operations certificate (SFOC). Drones with the overall weight under 35 kilograms and used only for recreational purposes do not require SFOC. Every drone that weights more than 35 kilograms or is used for nonrecreational purposes is required to have valid SFOC. [11]

5.2.1 Recreational Use

CAR defines drones as model aircrafts with the overall weight under 35 kilograms. These drones are manually operated for recreational purposes and designed not to have any person on board. If a drone weights more than 35 kilograms, it is considered as an UAV and operator must apply for the SFOC. Recreational drone operators must follow these Transport Canada's safety guidelines:

- Operator must inspect the drone before the flight.
- Operator must have a valid permission from the property owner.
- Operator must know the classification of the present airspace.
- Operator must confirm no radio frequency interference.
- Operator must have an emergency plan in case of loss of control.

Recreational operators are recommended to fly their drones during daylight hours and in acceptable weather conditions. Operators also should be able to keep drones in sight and respect the privacy of other people. [11]

5.2.2 Nonrecreational Use

Every nonrecreational use of drones with the overall weight exceeding 35 kilograms requires special flight operation certificate. However, there are some exceptions for operating a nonrecreational drones without valid SFOC. If a drone has the overall weight between 2.1 kilograms and 25 kilograms, operator is not required to have SFOC. Likewise, in order to fly a drone without SFOC, the operator must be educated to understand airspace classification and structure, weather reporting services, aeronautical charts and relevant sections of CAR. [11]

5.2.3 SFOC Certificate

Special flight operations certificate (SFOC) contains set of rules and requirements that defines conditions such as maximum flying altitude, maximum distance from any property on persons, and air traffic service coordination. In order to obtain SFOC, the applicant must provide following information:

- The name, address and the telephone number of the applicant.
- The name, address, and telephone number of the person entitled to have operational control over the drone.
- Method by which the operator can be contacted during the operation.
- Type and purpose of the operation.
- Date of the proposed operation.
- Full description of the flight area that includes altitude, location and boundaries of the flight area.
- Security and emergency plan in case of any disaster occurs.
- Any additional information requested by the CAR. [11]

5.3 China

The provisions issued by the Civil Aviation Administration of China (CAAC) regulate the operation of unmanned aircraft systems (UAS) with a maximum weight of 116 kilograms or less, or a maximum take-off weight of 150 kilograms or less, and with the maximum speed of no greater than 100 kilometers per hours. [11]

These provisions require an aircraft to have real-time supervision system that consists of “Electric Fence” system, a combination of hardware and software that is able to stop an aircraft from entering specific location, and “UAS Cloud”, a database management system that monitors flight data. [11]

Any UAS flying within visual line of sight must be operated during daytime and must give way to manned aircraft. [11]

5.3.1 UAS Categories

The provisions divide UAS and unmanned airships into seven categories, based on weight and use:

- Category I: UAS with the overall weight less than 1.5 kilograms.
- Category II: UAS with the overall weight between 1.5 kilograms and 4 kilograms, or with a take-off overall weight between 1.5 kilograms and 4 kilograms.
- Category III: UAS with the overall weight between 4 kilograms and 15 kilograms, or with a take-off overall weight between 4 kilograms and 15 kilograms.
- Category IV: UAS with the overall weight between 15 kilograms and 116 kilograms, or with a take-off overall weight between 15 kilograms and 116 kilograms.
- Category V: UAS used for plant protection.
- Category VI: Unmanned airships.
- Category VII: Category I and II UAS that can operate 100 meters beyond visual line of sight. [11]

5.3.2 Electric Fence and UAS Cloud

The Electric Fence system is a system that consists of hardware and software. This prevents the drone from entering certain areas. [11]

The UAS Cloud is a database management system that monitors all flight data. This includes the location, altitude and speed information in real time. The UAS Cloud has a built-in alarm that can be activated in case of collusion with the Electric Fence. [11]

Categories III, IV, VI and VII of UAS must have installed both the Electronic Fence and the UAS Cloud. Operators must be able to report at least every second when drone is flying in populated areas and every thirty seconds when drone is flying in non-populated areas. [11]

Categories II and V must have installed both Electric Fence and UAS Cloud. Operators must be able to report at least every second if they are flying a drone above the airspace of key areas and in airport clear zones. Key areas are places near military sites, nuclear power plants, and places with higher population, such as administrative centers and neighborhoods. [11]

5.4 Israel

Israel Aviation Law regulates and monitors the operation and manufacturing of all aircrafts and unmanned aircrafts in Israel. Israel Civil Aviation Authority (CAAI) regulates the licensing and supervision of civilian drones. CAAI has issued various directives to regulate aspects of drone activity, including altitude of a drone, transmission devices and procedures for the preapproval of flights. CAAI has also issued a proposal for registration of unmanned aircraft. This register would include drones owned by Israeli citizens or Israeli corporations, which have received necessary authorization to work with drones in Israel. The proposal would also require proper drone labeling that would include the name of manufacturer and registration number. Furthermore, the proposal would require a drone to have fire-resistant license plate that would include identifying information such as type and model of a drone, serial number, and authorization status. [11]

5.4.1 License Requirements

The Aviation Law regulates the operation of all aircrafts, including unmanned aircrafts. According to the Aviation Law, any person who is involved in an aviation profession, including flying an aircraft, managing aircraft inspections, providing aviation or air control services is required to be properly licensed. In order to receive a license, operator must meet specific conditions, such as having Israeli citizenship or residence in Israel. In case of a corporation, a license can be given only if the corporation is incorporated in Israel. Further requirements include having proper aircraft with sufficient equipment and authorization for flying and landing in specific areas in Israel. [11]

5.4.2 Flying Restrictions

According to CAAI, drones can be operated over a populated are only at the altitude of 1.5 kilometers or higher. Additional approving for experimental flights is required. Simultaneous remote operation of more than one drone by the same operator is prohibited. Further, the operator must ensure that drone will not interfere with any manned aircraft during the flight. [11]

5.4.3 Registration and Labeling

In order to prevent any criminal or terrorist activity, CAAI has published a proposal for registration and labeling of drones. This would maintain a register of all drones based on ownership. Registration would be available only for Israeli citizens or corporations that have required authorization. Furthermore, every drone would need a proper labeling, including fire-proof license plate. This license place must contain information of the type of drone, manufacture identification and other required information. [11]

5.5 New Zealand

New Zealand started regulation of unmanned aerial vehicles (UAVs) in August of 2015. The rules applied both for commercial and noncommercial use and do not categorize UAVs by the type of use. However, in order to by able to operate any UAV freely, the overall weight of the UAV must be lower than 25 kilograms. Any UAV with the weight higher must be operated by a certified person. Additional requirements include the maximum altitude that an UAV can fly at and location of the area used for operating an UAV. [11]

The Civil Aviation Rules, which are a part of Civil Aviation Act (CAA) are divided into two groups of rules called Part 101 and Part 102. Part 101 defines the operating rules for gyrogliders and parasails, unmanned aircrafts, kites, and rockets. Part 102 describes certification for unmanned aircraft vehicles. [11]

5.5.1 Part 101 of Civil Aviation Rules

Part 101 of Civil Aviation Rules is only applicable to UAVs that have the maximum weight of 25 kilograms or less. In order to fulfill the operating limits in Part 101, the operator must meet these requirements:

- Ensure the safety of the aircraft.
- Minimize the hazards to person, property or other aircraft.
- Operate the aircraft only in daylight hours.
- Maintain a visual line of sight with the aircraft.
- Ensure that the aircraft does not create an obstacle for manned aircrafts.
- Operate the aircraft at the altitude lower than 120 meters above the ground.
- Have proper knowledge of airspace restrictions and classifications.
- Have a permission from the property owner or person supervising the flight area.
- Avoid any airfields that are closer than 4 kilometers.

Part 101 also defines Shielded Operations. Shielded Operation can be described as an operation of an aircraft within 100 meters of, and below the top of any natural or manmade object. This operation can be conducted at night, and within 4 kilometers of any nearby airfield, without the authorization. [11]

5.5.2 Part 102 of Civil Aviation Rules

Part 102 of Civil Aviation Rules is applied to every unmanned aircraft with the overall weight higher than 25 kilograms. In order to be legally authorized to fly this type of UAV, the operator must acquire Unmanned Aircraft Operator Certificate (UAOC) from the CAA. [11]

An applicant for UAOC must be able to demonstrate, that the operation of an aircraft will be save and without the cause of any risk. Besides the application form that necessary to be submitted to the CAA, an applicant must provide these information to the CAA:

- Name of the person responsible for the operation.
- Name of any person who has a control over the operation.
- Location used for the operation.
- Register of any hazards to people, property or other aircraft.
- Detailed information of the aircraft used for the operation.
- Detailed information of the aircraft's control system.
- Information about the minimum distance from any person or property
- Construction and designed of the aircraft

Validity of the given certificate is set for two years for first-time applicants; further certification may be issued up to five years. [11]

5.6 United Kingdom

Regulation of drones in the United Kingdom is based on air navigation laws. Some of the laws that are based on regulating those type of drones that are carrying a camera onboard require more strict regulations. Civil Aviation Authority (CAA) is responsible for the air navigation laws. According to CAA, every drone must meet the safety and operatory standards as manned aircraft, in order to not cause any hazard to person, property or other aircrafts. [11]

5.6.1 Weight Restrictions

Articles 166 and 167 of the Air Navigation Order define restriction for drones with the overall weight less than 20 kilograms. These articles present safety rules such as:

- Prevention of drones from dropping any items that might harm animals, persons, or property.
- Constant visual contact with the aircraft during the flight is required.

- The maximum altitude of the aircraft must not exceed 400 meters and 500 meters horizontally away from the operator without the permission given by CAA.
- The operator must ensure that the drone operation is realized only in good conditions.

Any drone that has a camera attached to the body must not be flown within 150 meters of a populated are or 50 meters of a person, vehicle or building. [11]

Drones with the overall weight higher than 20 kilograms and less than 150 kilograms are allowed to be operated only by the person that has obtained a certificate of airworthiness, have a valid permit to fly and has a knowledge of rules of the air. Previously mentioned safety rules for drones with the overall weight less than 20 kilograms are applied to this group of drones as well. [11]

5.6.2 Geographical Restriction

According to The Air Navigation Order, drones may not be operated in these areas without a special permission given by the CAA:

- Within 150 meters of, or over, a populated area
- Within 150 meters of, or over, an organized open-air event of 1000 or more people
- Within 50 meters of any car, building or ship that is not directly controlled by the operator
- Within 50 meters of any person that is not under the control of the operator

Restricted areas such as prisons, powerplants, airports and airfields are specified as no-fly zones, and drone operating in these areas is prohibited. Zones with high-intensity radio transmission and military areas are specified as no-fly zones as well. [11]

In order to fly a drone for commercial purpose, the operator must retrieve a license from CAA. The operator must display proper knowledge and skills in order to get a license. Drone operators of the aircrafts with the overall weight over 20 kilograms are required to get an insurance, in order to cover their liability, mostly in case of an accident or damage to property. [11]

5.7 Sweden

Drone regulation in Sweden highly depends on the type of drone. Drones that are lighter, more compact are less regulated then the bigger ones. Drones in Sweden can be only operated during daylight and within visible range from the operator. Further, drones must be operated at the maximum altitude of 120 meters off the ground and 50 meters away from any person or object. Operation of drones near prisons and airports is prohibited. Additionally, some areas require special permission for drone use. [11]

Civilian drones with the overall weight exceeding 150 kilograms are regulated by European Union Law and monitored by the European Aviation Service Agency (EASA). Drones with the overall weight under 150 kilograms are not regulated at the EU level. [11]

5.7.1 Categories and Technical Specification

Sweden divides drones into three main categories:

Category 1:

- Drones lighter than 1.5 kilograms, generating less than 150 joules of energy
- Drones with the weight between 1.5 kilograms and 7 kilograms, generating less than 1000 joules of energy.

Category 2:

- Drones with the overall weight more than 7 kilograms
- Drones that are operated within the view of the operator

Category 3:

- Drones that are operated outside the view of the operator

Every drone is required to be equipped with an emergency tool, that can deactivate the drone in case of an emergency. The construction of drones from category 2 and 3 must be precise, in order to prevent any damage in case of an accident. Category 3 drones must have incorporated a technology that will prevent unauthorized drone control. Additionally, category 3 drones must have anti-collision and weather condition systems built in. [11]

5.7.2 Civilian Authorization

Drones that belong to the category 1 may be only operated during daylight. Any drone operation in the dark requires a special permit for flight. In addition, operator must make ensure no radio and frequency interruption during the flight, and provide all safety precautions, such as plan of the flight and area inspection. Any incident happened during the flight must be reported to the Swedish Transport Agency. [11]

Category 2 drones must satisfy all the requirements of category 1 drones. In order to be able to receive a permit for flying category 2 drones, a person must be at least eighteen years old, and have successfully passed Unmanned Aerial System program certified by the Swedish Transport Agency. Likewise, category 2 operators should have a sufficient knowledge of the flight standards established by the European Aviation Safety Agency (EASA). Additional requirements include technical maintenance of the operated drone, provide a book of flight records, and ability to form a flight map. [11]

Category 3 drones must satisfy all the requirements of category 1 and 2 drones. Given that the category 3 drones may be operated outside the view of the operator, authorized person must be fully acquainted with the control system, and must take proper action in emergency situations. [11]

5.7.3 Restrictions

Some areas in Sweden are classified as restricted airspace, any drone operation in these areas is prohibited. However, the Swedish Transport Agency may give a temporary exception in some cases. Any drone activity near prisons, national park and power plants is prohibited in Sweden. [11]

6 Future of UAVs

6.1 Commercial Flights

In the past few years, the U.S. military changed the way of training its pilots. Nowadays, more than half of these pilots are ground operators who operate UAVs. In the beginning, UAVs were only used for surveillance missions. But very soon they managed to replace manned aircraft, handle air battles and evacuate wounded soldiers from the battlefields. This approach can be clearly seen in commercial aviation too. In the past, plane cockpits consisted of more than four crew members and took more space in plane, thus less passengers could be transported. Automatization in the field of aviation resulted in the reduction the crew members to only two members, one as a pilot, and the other one as a co-pilot. But they still cannot be completely replaced by a computer. Due to the lack of a free frequency bandwidth, planes piloted remotely and without crew cannot communicate with the ground stations and identify planes flying nearby. Because of this, commercial aviation still uses a human crew. [12]

Each pilot is required to be able to look out of his window and see if there is a possibility of getting into contact with another plane. Planes that are fully automated have to monitor the area around them and avoid having any collisions by themselves. This is still difficult to achieve in automated planes. Even UAVs cannot freely monitor its surroundings. Only military UAVs are capable of doing this due to military network latency that is less than a half a second. This is achieved by having satellite systems working on greater channels and by the support of hidden high-speed cables under the sea. [12]

In order to achieve perfect manageability while controlling the plane from the ground, each plane would have to be equipped with some additional software that would gather the information from onboard cameras, radars and further sensors. Furthermore, automated planes would have to cooperate with the whole airspace, including planes that are piloted by a human crew. [12]

With the advent of a new era of commercial flights, there is one factor that significantly affects the whole situation. The sense of security is still highly presented in the minds of people and so far, only human pilots can achieve this difficult task. [12]

In order to overwhelm the fear of flying with an automated plane, the software used in this plane will have to develop more in the way that will be safer and also sufficient for society. But, it will cost money. Software development is very expensive when combined with people's security. Likewise, airlines would have to invest significant amounts of capital. These planes will still use fuel that is getting more and more expensive. [12]

6.2 Business Enhancement Tool

Another way to utilize UAVs in our lives is to make them do tasks which are demanding in terms of time. They can be used as a delivery tool in places that are remote and far from major cities. Civilian usage of UAVs in agriculture, entertainment industry and wildlife monitoring is on the rise due to a combination of electronic advancing, prices and higher demand. However, regulations have to be established. Regulators will have to find a way to keep UAVs businesslike and effective. When an accident or some technical failure occurs, regulators will have to solve it quickly. A more dangerous scenario is that these devices could be hacked and used for vicious purposes. Additionally, with the advance of built-in cameras, regulators will also have to deal with privacy violations. [13]

Conclusion

The reason for creating an unmanned aerial vehicle was to enable the military to conduct operations and surveillance missions without taking the risk of losing any member of the military. With the continuous development of UAVs, the military established a new way of approaching to the surveillance and protection of areas, constructions and people. Different types of UAVs are now able to conduct more complex tasks, and at the same time, save a lot of time and expenses related to the military operations.

After getting noticed by public, UAVs slowly developed its way to lives of ordinary people. Companies that were previously focusing on manufacturing small replicas of real airplanes, were introduced to drones. Current drone market offers a variety of models, suited for different customers and purposes. Equipped with high-definition cameras and stabilization systems, drones are able to produce high-quality video in high speed and create beautiful aerial scenes. However, drones can offer far more than just taking videos and pictures. Different types of industry all over the world adjusted the functionality of drones to their own requirements. Law enforcement is now able to use drones in cases of missing person and maintain public control. Informational, intelligence and electrical services are able to improve their performance and offer safer environment for people.

But, with the rise of drones in cities, one big part of people's lives is threatened, privacy. Some drones can fly unnoticed to private areas, capture photos and videos that might violate the law, or even cause an accident. That is why countries have developed a set of rules and regulations, in order to preserve a healthy approach to drones. Some of the countries do not differ an unmanned aerial vehicle from the traditional aircraft, and the same rules are applied for both. However, some countries have created extensive rules for drone regulations. In some countries, drone operation is available only if the authorized person has a license for operating a drone, or has passed a process of certification that enables the operator to fly drone freely. Further restrictions are related to the flight area. Some cities have established places that are banned from drone usage, in order to limit drone collusion with historical constructions and people. Drone manufacturers must also ensure, that their product will not be used as a tool for committing crimes. Systems must be able to resist potential breach from third parties, such as hackers and frequency jammers.

The aim of this work was to do a survey on unmanned aerial vehicles used both by the military sector and civilians. From solely a part of military, to be used as a device in everyday life, unmanned aerial vehicles present a different perspective to the use of airspace. Although, in order to maintain healthy boundaries, future drone regulations and new types of drones must ensure safe environment for people and nature.

References

[1] AUSTIN, Reg. *Unmanned Aircraft Systems: UAVs Design*. [online]. Chichester: John Wiley & Sons, Ltd, 2010, pp. 4-172, [cit. 2017-5.20]. ISBN 978-0-470-05819-0.

[2] *Wikipedia: DJI (company)* [online]. [cit. 2017-5.20]. Available at: https://en.wikipedia.org/wiki/DJI_(company)

[3] *Specout: DJI Phantom 1* [online]. Specout, © Copyright 2017 [cit. 2017-5.20]. Available: http://drones.specout.com/l/20/DJI-Phantom-1

[4] *Specout: DJI Phantom 2* [online]. Specout, © Copyright 2017 [cit. 2017-5.20]. Available at: http://drones.specout.com/l/16/DJI-Phantom-2

[5] *Specout: DJI Phantom 3 Standard* [online]. Specout, © Copyright 2017 [cit. 2017-5.20]. Available at: http://drones.specout.com/l/44/DJI-Phantom-3-Standard

[6] *Specout: DJI Phantom 4* [online]. Specout, © Copyright 2017 [cit. 2017-5.20]. Available at: http://drones.specout.com/l/452/DJI-Phantom-4

[7] *Specout: DJI Mavic Pro* [online]. Specout, © Copyright 2017 [cit. 2017-5.20]. Available at: http://drones.specout.com/l/16/DJI-Mavic-Pro

[8] *Wikipedia: Yuneec International* [online]. [cit. 2017-5.20]. Available at: https://en.wikipedia.org/wiki/Yuneec_International

[9] *Specout: Yuneec Q500 4K* [online]. Specout, © Copyright 2017 [cit. 2017-5.20]. Available at: http://drones.specout.com/l/45/Yuneec-Q500-Typhoon-4K

[10] *Specout: 3D Robotics SOLO* [online]. Specout, © Copyright 2017 [cit. 2017-5.20]. Available at: https://en.wikipedia.org/wiki/3D_Robotics

[11] BUCHANAN, Kelly et al. *Regulation of Drones*. [online]. The Law Library of Congress, Global Legal Research Center, 2016, pp. 15-100, [cit. 2017-5.20]. Available at: https://www.loc.gov/law/help/regulation-of-drones/regulation-of-drones.pdf

[12] ROSS, Philip E. *When Will We Have Unmanned Commercial Airlines?* [online]. IEEE, 2011, [cit. 2017-5.20]. Available at: http://spectrum.ieee.org/aerospace/aviation/when-will-we-have-unmanned-commercial-airliners

[13] BERGER, Ivan. *Drone control* [online]. IEEE, 2012, [cit. 2017-5.20]. Available at: http://theinstitute.ieee.org/technology-focus/technology-topic/drone-controlhttp://www.strategic-culture.org/news/2012/11/02/uavs-human-and-legal-aspects.html