Drone technology training to boost EU entrepreneurship and Industry 4.0

eduDrone

Guidelines on the use of drones in VET

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“Guidelines on the use of drones in VET”

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1. Introduction to Drones

This brochure provides guidelines on the use of Drone Technology in Vocational Education Training (VET) and outlines basic information for VET trainers and institutions who desire to incorporate Drone Technology into their curriculum and develop their professional status. It includes topics about drone technology, technical guidance for drone, applications and legislation for drones' usage. Also there are a series of case studies which indicate the common uses for drone technology in various fields. Last but not least, this brochure makes a brief reference in the potential of drone implementation in STEM disciplines and social inclusion of disabled learners, attracting students giving them an impulse toward a VET learning path.

1.1 The Drone technology

The drone can be defined as an unmanned aircraft that can navigate autonomously, without being controlled from the outside using the automatic pilot, or that can be remotely controlled by a remote-control device. Moreover, the drone can be controlled via WI-FI, smartphones or tablets equipped with Android or iOS.

Drones come in a broad of shapes and sizes. From the usability point of view, the drones are divided into the following categories:

- Unmanned Aerial Vehicle (UAV).
- Unmanned Surface Vehicle (USV).
- Unmanned Underwater Vehicle (UUV).
- Unmanned Ground Vehicle (UGV).
- High Altitude Pseudo Satellites (HAPS).

The most popular and most used ones are unmanned Aerial Vehicles (UAV). Irrespective of their usage, the unmanned Aerial Vehicle operates with battery or energy produced by their own photovoltaic cells. These types of drones are equipped with electric motors, one for each propeller. Drones equipped with internal combustion engines are less used in applications than drones with electric motors. Depending on the number of engines and their power, the drones can be classified *into tricopters, quadcopters, hexacopters, octocopters and so on*.

The *tricopter* is a drone like a helicopter, which has three rotor discs and servo propeller propulsion units[1].

The *quadcopter* is a flying machine that has four rotors / propellers. A quadcopter is stabilized using various technologies, but the main ones are gyroscopes.

The *hexacopter* are remote controlled flying devices that have six rotors / propellers. The hexacopter is a type of drone with advanced technology characterized by good maneuverability.

[1] See No.1 of Bibliography

Octocopters have eight engines and propellers. These drones have high travel speed, high safety and stability and can fly at extreme heights, even in bad weather conditions.

The first drone was designed by Nikola Tesla in 1898. Later, this model was improved by the engineer Charles F. Kettering, who attached an electronic device to the model, by which the drone hooks its propellers to fall down on the enemy positions[2]. A more similar drone model to the one used today was the AQM-34 model, created in 1948 and tested for the first time in 1951. The drone's technology develops rapidly. Motorized devices are becoming more complex, with multiple functions, but much easier to control. Regardless of the type of drones, their most important features are generally the following:

- maximum operating distance
- flight / travel duration
- flight / displacement speed
- connectivity
- the navigation system used
- type and number of sensors
- the onboard GPS system
- operating frequency
- weight

Other performance features of the drones are the following[3]:

- ✓ the availability to mount devices of various types, sizes and weights (cameras, video cameras, infrared cameras, radars, etc.);
- ✓ the ability to return independently to the take-off point (the come-home option);
- ✓ the ability to stay in a certain position (position hold);
- ✓ ability to remain at a fixed altitude (elevation hold);
- ✓ small size - they are easy to handle and can go through narrow spaces,
- ✓ data transmission methods: through radio waves, via the Internet, data coming to PCs, tablets or smartphones;
- ✓ operating autonomy at which power can be supplied from a battery that can be charged from photovoltaic panels;
- ✓ strong shock resistance so that it can operate regardless of weather conditions.

1.2 Drones applications

Unmanned Aircrafts can be used in various fields of activity: data acquisition activities in difficult-to-reach areas, transportation of objects, monitoring crops, national parks and wildlife, entertainment activities (video recordings), military applications, border control, control of aqueducts and dams and inspections of high voltage power lines etc. Depending on the field in which they are used, drones can be equipped with various devices: cameras, thermal cameras, telemetry, radar, sensors, GPS systems, remote control data acquisition boards using software, through tablets or smartphones. As new technologies emerge, new applications of drones are being developed,

[2] See the Bibliography No.2

[3] See the Bibliography No.3

especially in industrial applications, with real-time viewing of images, acquisition of data and operating control equipment based on information transmitted via the drones.

In Romania, the implementation of drone's technology in various fields of activity is constantly expanding. Professional use of the drones tends to impose new requirements of practical and theoretical knowledge of new technologies, from the operating and maintenance of the drones to the processing and use of the information obtained. Therefore, it is necessary to create appropriate structures for the development of skills in the professional use of drones.

An example of successful use of drone's technology is in forestry; it is used for studying areas affected by deforestation or fire and for tree planting. Hardly accessible areas are scanned using drones to collect information and create 3D maps. Based on the data acquired, the most appropriate ground model, called the seed plan, is generated. The used drones are equipped with specialized guidance and control software, a software that allows the distribution of seeds on the soil and the monitoring of tree growth[4]

In Romania, drone technology is used as an alternative method for inspecting the fields of photovoltaic panels, identifying potential defects or damage, or identifying low-yield solar cells detected by thermal scanning.

In recent years, research institutes and numerous companies were founded in order to develop and implement new technologies for drones. The first ITSC-SVFP Training, Studies and Research Institute (ITSC-SVFP) was founded to promote and develop research, improvement and educational models and to give advice tailored for the specifics of unmanned vehicle systems[5]. Within the Institute was developed the first online system that allows the registration of the Romanian civilian drone holders and operators, individuals or legal entities, and allows the introduction, modification and visualization of the PSPS flights on the territory of Romania.

FAE Drones is one of the Romanian companies with a great experience in the development and supply of air solutions for applications from various branches of the economy: topography, agriculture, industrial inspection, etc. FAE Drones also offers professional training services for piloting drones.

In Greece, professional use of the drones requires theoretical knowledge in basic scientific fields such as meteorology, air navigation, legislation for the use of unmanned aircraft, communication and technical knowledge even more human potential and practical education depending on the authorization category.

A successful example of drone technology is the first Unmanned Aerial Vehicle - Airplane 'HCUAV RX-1' which was constructed in 2016 in Greece. Its length reaches up to 4 meters, it takes off at a speed of 2.8 meters per second and can develop a speed of 190 km per hour. It can transmit real-time, relevant and detailed information from a 2 km height. The drone can support civil protection services and public safety by monitoring land and sea borders, protect vital infrastructure, support rescue investigations, supervision of woodland to timely extinguish fires, soil sampling, water and air pollutants, monitoring roads and provide aerial photography of areas of interest.

[4] See the Bibliography No.5

[5] See the Bibliography No.6

In Greece, there is a lack of training centers to promote educational material and to certify drone users. 'Hellenic Drones' and 3D A.E. are two of these few, licensed by the Civil Aviation Authority, new unmanned aircraft academies in Attica and Thessaloniki, respectively, that operate in Greece since September 2017.

1.3 How to build a drone

The minimal knowledge of electronics and IT is required to build a drone. The first step in designing a droning device is to determine the component parts and the materials they will be made of, depending on the field of use of the drones. A drone is made up of hardware and software. Some components can be purchased, but some components can be made using a 3D printer. The basic components of a droning machine are: drone frame, motors, controllers, ESCs - speed regulators for brushless motors, propellers, batteries, RC Transmitter / Receiver and other optional components (GPS modules, sensors, gyroscope, receiver, etc.).

Frame - is the structure or skeleton of the drones on which all the components of the drones are mounted. Generally, the frames are made of composite carbon fiber, aluminum, glass fiber, wood, or PLA (3D printing materials), composites that are light, robust and rigid as possible to minimize vibrations. Carbon fiber composite materials are the most used ones due to their strength, excellent stiffness and reduced weight. The drones' frame consists of two parts: the central area (plate) on which the electronic components and the arms on which engines and the propellers are mounted. The maximum dimensions of a frame are determined by the diagonal distance between two motors. The distance between the motors is determined by the dimensions of the propellers and the used hardware so that there is enough space between them.

Electric motors rotate the propellers. There are two types of electric motors for RC model multirotor: brush motors and brushless motors. Brush motors are mainly used for smaller drones with low power, while brushless motors are usually stronger and used on larger drones.

Propellers generate traction and make a drone fly. They are usually made of durable polymeric material, carbon fiber composites and even wood. In general, propellers for a drone are not actually identical, some propellers have different directions. This is because some rotors are rotating in opposite directions to each other.

Flight controller is the brain of a drone and contains at least one microprocessor (CPU) and one sensor (IMU). IMU is an electronic device that measures the speed, direction and gravity of the drones. IMU usually contains a Gyroscope (or Gyro) and an Accelerometer (Acc).

Batteries are the energy sources of the drones. The performance characteristics of the batteries are given by the nominal voltage (cell number), capacity and discharge rate.

How do I build a quadcopter (a drone with four branches and four engine)?

To build a drone, an individual must have minimal knowledge of electronics and IT. Regardless of the level of knowledge in the field of engineering, building a drone requires prior documentation for choosing the constituent elements, for combining hardware components and for programming their software.

For the construction of a quadcopter, different types of components can be used and they can be purchased from different suppliers, depending on the allocated budget.

Table 1. Example of components of a quadcopter

No.	Component	Type	Availability
1.	The frame of the drones	FPV X500 500 Quadcopter Frame 500mm	https://www.alibaba.com/product-detail/FPV-X500-500-Quadcopter-Frame
2.	Controller	DJI Naza M Lite Multi Flyer Version Flight Control Controller w/ PMU Power Module & LED &Cables & GPS & stand holder	https://www.alibaba.com/product-detail/Original-DJI-Naza-M-Lite-Multi_60735480838.html?spm=a2700.7724838.2017115.11.af1e28fLGz9bN
3.	Engines	4x 2212 920KV Brushless Motor for DJI Phantom FPV drone RC quadcopter UF330 F450 F550	https://www.alibaba.com/product-detail/4x-2212-920KV-Brushless-Motor-for_60702835898.html?spm=a2700.details.maylikehoz.6.18b9a634Iwu0iP
4.	Electronic Speed Controller	mini BLHeli_S 30A ESC OPTO Electronic Speed Controller 2-4S Brushless for FPV Multicopter Quadcopter	https://www.alibaba.com/product-detail/mini-BLHeli-S-30A-ESC-OPTO_60702758064.html?spm=a2700.details.maylikehoz.6.179a51d1yl6P3o
5.	Propellers	10x4.5" 1045 1045R CW CCW Propeller For Multi-rotor Copter Quadcopter	https://www.alibaba.com/product-detail/10x4-5-1045-1045R-CW-CCW_60181995647.html?spm=a2700.7724838.2017115.346.af1e28fLGz9bN
6.	Batterie	lipo battery 2200mAh 11.1V 30C for model airplane	https://www.alibaba.com/product-detail/Customized-lipo-battery-2200mAh-11-1V_60671330042.html?spm=a2700.7724838.2017121.93.af1e28fLGz9bN
7.	Radio receiver	2.4G FS-CT6B 6 CH Channel Radio Model RC Transmitter Receiver for rc quadcopter airplane helicopter	https://www.alibaba.com/product-detail/Drone-Radio-system-2-4G-9CH_60363462047.html?spm=a2700.details.maylikehoz.1.3968ac83IEUq8u
8.	Connectors	Female & Male Connector EC3 3.5mm Connector Bullet Plug Golden banana connector	https://www.alibaba.com/product-detail/Female-Male-Connector-EC3-3-5mm_60530527625.html?spm=a2700.7724838.2017115.96.af1e28fLGz9bN
9.	Cable	Flexible silicone rubber cable 8 10 12 14 AWG silicone wire 10CM Male to Male Servo Lead (JR) 26AWG (10pcs/set)	https://www.alibaba.com/product-detail/Flexible-silicone-rubber-cable-8-10_60101469610.html?spm=a2700.7724838.2017115.45.af1e28fLGz9bN https://hobbyking.com/en_us/10cm-male-to-male-servo-lead-jr-26awg-10pcs-set-1.html

After choosing the constituent elements, the following main steps are considered to build the drones:

- assembling the drone frame;

- mounting of electronic components on the frame;

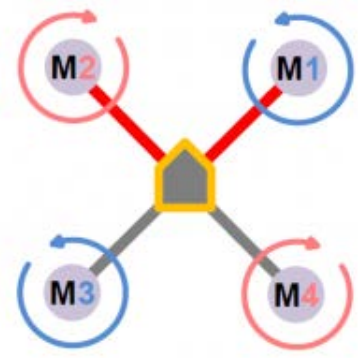
- connecting the electronic components;

- programming the controller.

Step 1. Assemble the inner frame of the drones, for the construction variant in which the frame consists of several parts (the center of the frame with the drones and the landing parts).

Step 2. The M1 (front-right), M2 (front – left), M3 (back-right) and M4 (back-left) motors are mounted on the drones so that they can rotate the propellers as shown in the figure below.

Figure 1. The direction of rotation of the propellers



Step 3. Attach the Speed Controllers (ESC) to the frame arms.

Step 4. The controller is glued by means of a double-sided adhesive tape (or double-glue sponge for vibration damping) to the drone frame in the central area as far as possible in the center of gravity of the drone, with the arrow on its upper surface facing towards to the front drone.

Step 5. The battery, led, receiver, voltage regulator, and GPS module are mounted on the droning frame in the available areas so that the drone is balanced. Write the X, Y and Z coordinates of the point where the GPS module was mounted, relative to the center of gravity of the drones.

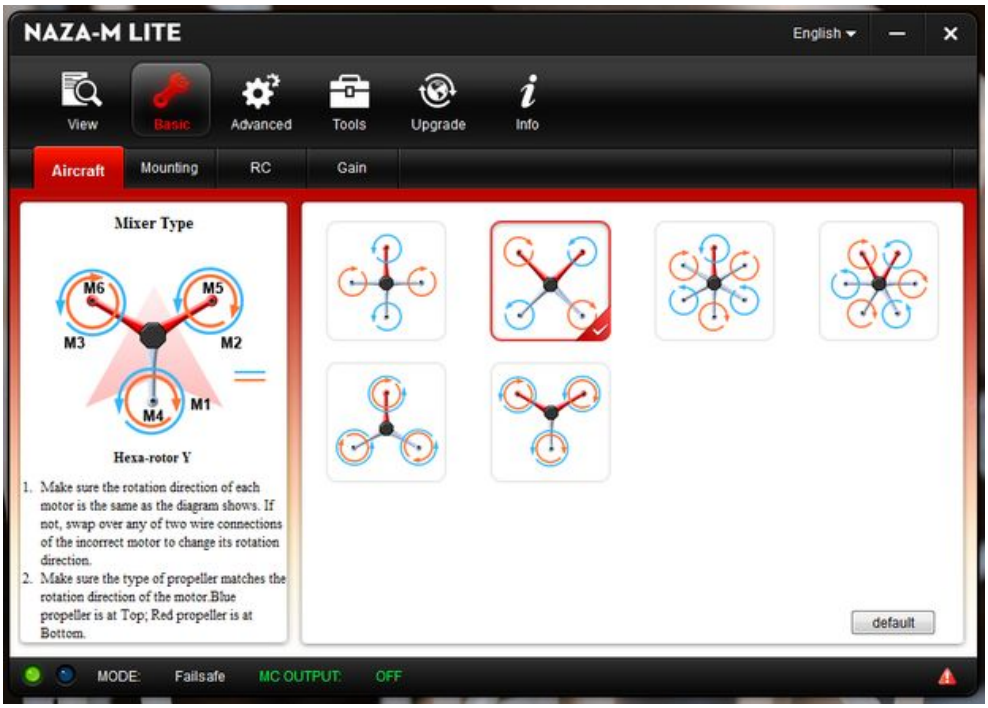
Step 6. Mount the propellers with the side on which the propeller mark is pointing up. On the fly controller the order is as follows: on the front arms, M1 - right front, M2 left front, M3 left back, M 4 right back. The propellers shall be oriented so that to allow their rotation as shown in Figure 1.

Step 7. Connect the components of the drones as follows:

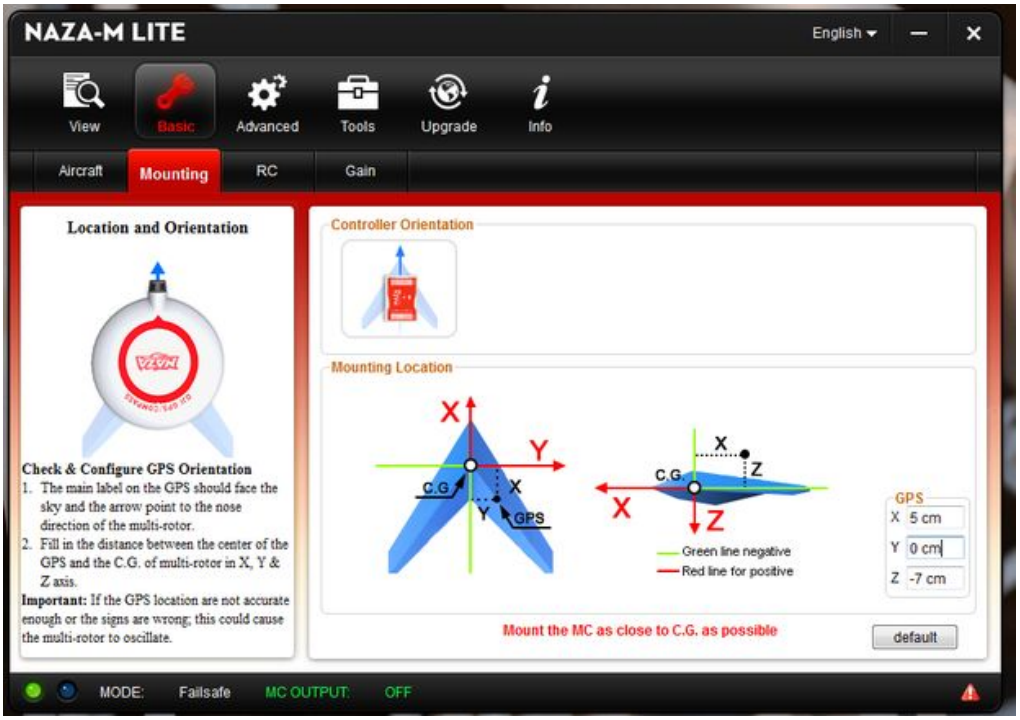
Step 8. The board software is downloaded from the Naga site and installed on the computer.

Step 9. Connect the radio first and then connect the battery to the drones. Turn on the radio and then connect the controller to the computer.

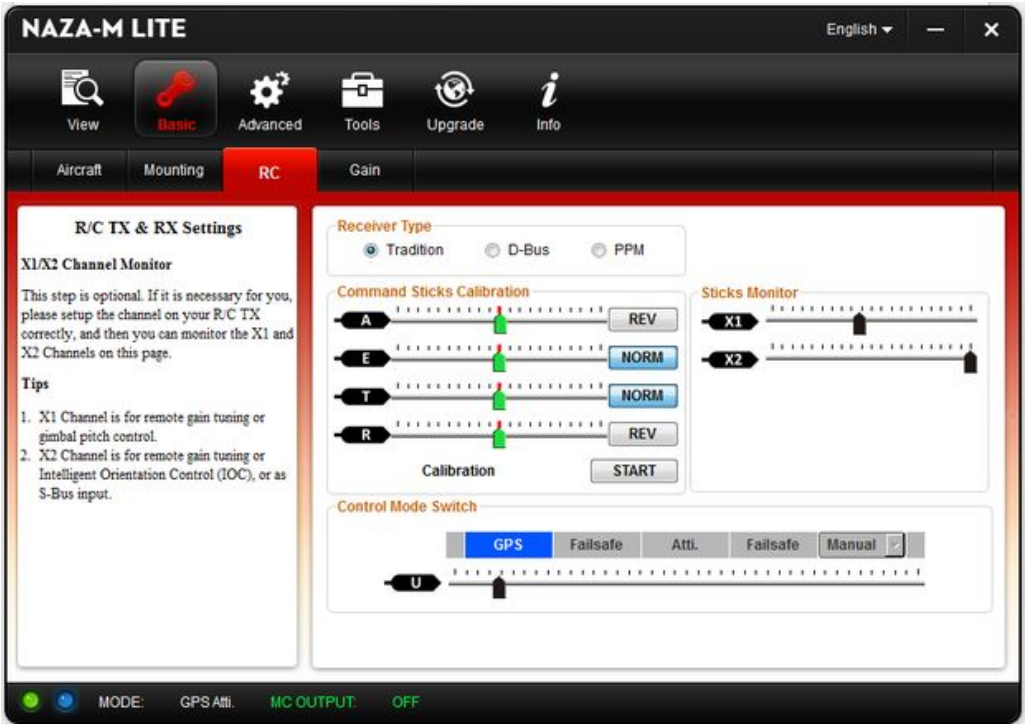
Step 10. Select the type of droning from the Basic menu, the Aircraft submenu.



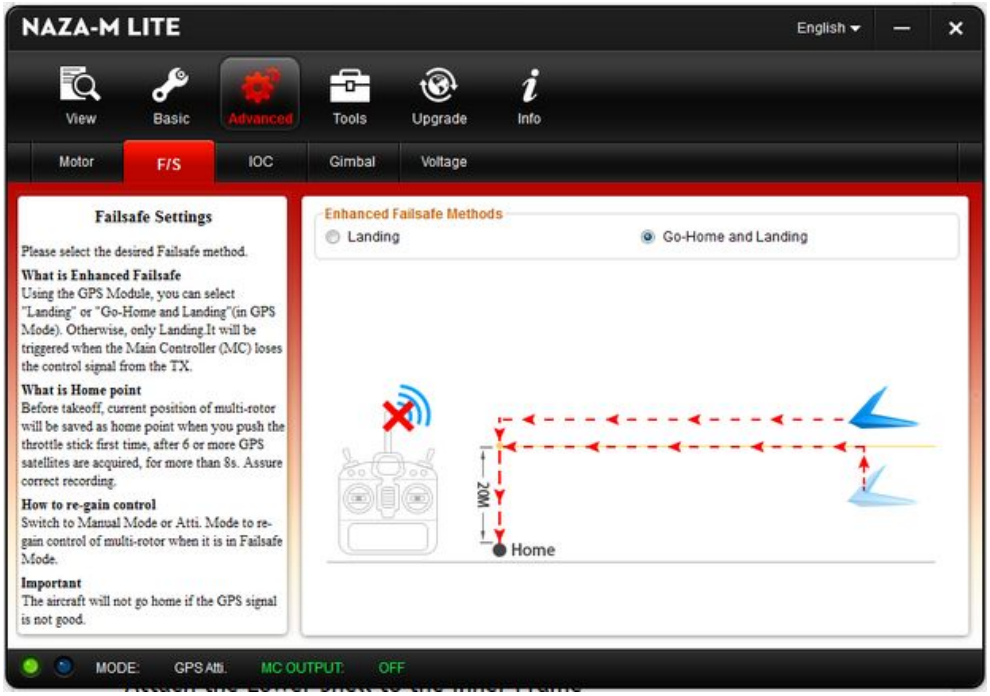
Specify the coordinates of the GPS mode relative to the center of gravity of the drones on the *Basic* menu, the *Mounting* submenu.



We will setup the flight control endpoints.



Set the droning safety behavior.



2. Legislation for the use of drones

This chapter concludes information about the legal framework regulating the use of drones in four European countries in order to inform trainers about the basic rules and law directions of using drones.

2.1 Romanian Legislation

In Romania, the term "*drone*" was not found in any of the normative acts in force until now. According to the national legislation in force, the drones are unmanned motorized aircrafts and their use together with other devices is regulated by law, regardless of their size, weight or field of activity. Currently, the legal framework regulating the use of drones, according to http://www.caa.ro/reglementare/legislatie-generala, includes the following normative acts:

Table 2. Legislative framework for the use of unmanned aircraft[6]

Type and Code of the Normative Act	Site
Civil Air Code, **republished and consolidated at 19.02.2016**	http://www.caa.ro/media/docs/Codul_Aerian_2001.pdf
Government Decision no. 912 **of 25 August 2010 "for the approval of the procedure for the authorization of flights in the national airspace as well as the conditions under which the take-off and landing of civil aircraft may also be performed on / on other land or water surfaces than certified aerodromes"**	http://www.caa.ro/media/docs/A.3.6_a_HG_912-2010.pdf
Law no. 257 **of 22 May 2001 "on the action against aircraft using unauthorized airspace of Romania"**	http://www.caa.ro/media/docs/A.3.2._L257-2001.pdf
RACR-OPS LAAG, edition 01/2009 **for the approval of the Romanian Civil Aviation Regulation, Air Operations and General Aviation**	http://www.caa.ro/media/docs/OMT_nr._301_din_2009_-_Anexa_-_RACR-OPS-LAAG.pdf
RACR-IA, Edition 1/2016 **Romanian Civil Aeronautical Regulation "Registration of Civil Aircraft"**	http://www.caa.ro/media/docs/RACR-IA_Ed-1_2016.pdf
RACR-AZAC**, Edition 1/2010 "Flight Admissibility of Certain Civil Aircraft Categories"**	http://www.caa.ro/media/docs/C.2.2.b_RACR-AZAC_Ed_1.pdf
DN 14-02-001 **"Issuing of Identification Certificates for Unmanned Civil Aircraft (UAV)" Edition 2**	http://www.caa.ro/media/docs/DN_14_02_001_2.pdf

2.2 Greek Legislation

In Greece, the legal framework regulating the use of drones, according to http://www.ypa.gr/press-releases/kanonismos-ekpaideytikwn-kentrwn-kai-adeiodothshs-xeiristwn-systhmatwn, includes the following normative acts:

Table 3. Legislative framework for the use of unmanned aircraft in Greece

Normative Act	Site
Flight rules – General flight Schedule of Unmanned Aircraft Systems, published and consolidated at 30.09.2016	http://www.opengov.gr/yme/wp-content/uploads/downloads/2016/05/2016_05_23_Kanonismos_UAS_V.1.1.pdf
Government Gazette Decision no. 3152 **of 9 September of 2016 Flight rules – General flight Schedule of Unmanned Aircraft Systems**	https://uas.hcaa.gr/Content/Documents
Government Gazette Decision no. 4527 **of 30 December of 2016 Educational Centers Regulation and Licensing donor operators of Non-Aircraft - Unmanned Aircraft Systems-UAS).**	https://uas.hcaa.gr/Content/Documents

[6] See the Bibliography No.4

2.3 Italian Legislation

Table 4. Legislative framework for the use of unmanned aircraft in Italy

Normative Act	Site
Information note NI-2017-007 of 17 May 2017 - **Implementation of the standard scenarios for the critical operations of remote piloted aircraft**	https://www.enac.gov.it/La_Regolazione_per_la_Sicurezza/Note_Informative/info-22158831.html
LG 2017/001-NAV - Ed. 1 of 16 January 2017 - **Risk assessment methodology in RPAS operations for authorizations and non-geographical flight permits - Application guide**	https://www.enac.gov.it/La_Normativa/Normativa_Enac/Linee_Guida/info-1796580782.html
LG 2016/004 - Ed. N.1 of 13 October 2016 - **Project certification**	https://www.enac.gov.it/La_Normativa/Normativa_Enac/Linee_Guida/info-1415913786.html
Information Note 2016-007: **Regulation on "Remote Piloted Air Vehicles" APR pilot attestations**	https://www.enac.gov.it/La_Regolazione_per_la_Sicurezza/Note_Informative/info1839829792.html
Circular LIC-15 of June 9, 2016 - **Remote Piloted Air Vehicles - Training Centers and Pilot Certificates**	https://www.enac.gov.it/La_Normativa/Normativa_Enac/Circolari/Serie_LIC/info730824716.html
LG 2016/003-NAV - Ed. No. 1 of 1 June 2016 - **Remote piloted aircraft with harmless characteristics**	https://www.enac.gov.it/La_Normativa/Normativa_Enac/Linee_Guida/info148190721.html
Regulation (EC) 216/2008 **of the European Parliament and of the Council of 20 February 2008 on common rules in the field of civil aviation and establishing a European Aviation Safety Agency, and repealing Council Directive 91/670 / EEC , Regulation (EC) 1592/2002 and Directive 2004/36 / EC**	https://www.enac.gov.it/La_Normativa/Normativa_internazionale/Normativa_europea/Regolamenti/info-303191980.html
Regulation (EC) 785/2004 **of the European Parliament and of the Council of 21 April 2004 concerning insurance requirements for air carriers and aircraft operators**	https://www.enac.gov.it/La_Normativa/Normativa_internazionale/Normativa_europea/Regolamenti/info417264093.html
“Remote Piloted Air Vehicles" Regulation	https://www.enac.gov.it/La_Normativa/Normativa_Enac/Regolamenti/Regolamenti_ad_hoc/info-122671512.html
ENAC Technical Regulation	https://www.enac.gov.it/La_Normativa/Normativa_Enac/Regolamenti/Regolamento_Tecnico/index.html
ENAC Regulation "Rules of the Air"	https://www.enac.gov.it/La_Normativa/Normativa_Enac/Regolamenti/Regolamenti_ad_hoc/Archivio/info-1311144678.html
ENAC Regulation "Air Traffic Services"	https://www.enac.gov.it/La_Normativa/Normativa_Enac/Regolamenti/Regolamenti_ad_hoc/info151376896.ht

	ml
ENAC Regulation "Health Organization and Medical Certifications of Suitability for Licenses and Aeronautical Certificates"	https://www.enac.gov.it/La_Normativa/Normativa_Enac/Regolamenti/Regolamenti_ad_hoc/info1745280969.html
Regarding the rates, please refer to the ENAC Tariffs Regulation.	https://www.enac.gov.it/La_Normativa/Normativa_Enac/Regolamenti/Regolamenti_amministrativo_contabili/info-1372911780.html

2.4 Polish Legislation

In Poland, the unmanned aerial vehicles can fly only within the line of sight of the operator. For safety reasons, flying drones in the line of sight is limited in some areas of airspace. For example, no one can fly in the airport controlled zone unless the permission from the Polish Air Navigation Services Agency is obtained 7 days ahead. To carry out drone flights in a manner other than leisure and sports, the operator must hold a certificate, or a document confirming that the he can safely operate such a device, aero-medical certificate and insurance. All flights related to the provision of services, such as photography, video making require a certificate of competency issued by the President of the Civil Aviation Authority after passing the state theoretical and practical exam. The principles of use of drones in the Polish airspace are set out in the Act of 3 July 2002 - Aviation Law and its implementing regulations. Detailed rules of operations of the unmanned aerial vehicles in Poland are described in three regulations of the Minister of Transport, Construction and Maritime Economy. More information concerning legal status UAV can be found in the Report on the current legal status relating to unmanned aerial vehicles „Remotely Piloted Aircraft Systems (RPAS) in Poland" http://jarus-rpas.org/sites/jarus-rpas.org/files/rpas_poland.pdf.

Table 5. Legislative framework for the use of unmanned aircraft in Poland

Normative Act	Site
The Act of 3rd July 2002 – Aviation Law (OJ 2016.605 as amended), sets out the principles of use of drones in the Polish airspace.	http://www.ulc.gov.pl/en/law/2556-aviation-law-act-and-implementing-regulations
• Regulation of 26 March 2013 on the exclusion of some provisions of the Aviation law act for certain types of aircraft and determine the conditions and requirements relating to the use of these aircraft (it partly determines the rules of conduct of flights)	http://dziennikustaw.gov.pl/DU/2013/440/
Regulation of the Minister of Transport, Construction and Maritime Economy of June 3, 2013 on certificates of competency, which sets out the rules of licensing of drone operators	http://www.dziennikustaw.gov.pl/DU/2013/664/1
Regulation of April 26, 2013, on the Technical and Operational Rules on Aircraft of Special Category, Not Subject to the Supervision of the European Aviation Safety Agency, which mostly applies to UAS weighing more than 25 kg.	http://www.dziennikustaw.gov.pl/DU/2013/524/1

3. Case studies

In this chapter, some case studies of using drones are represented. The diversity of the following case studies, illustrates the complex and challenging nature of drone technology in various sectors.

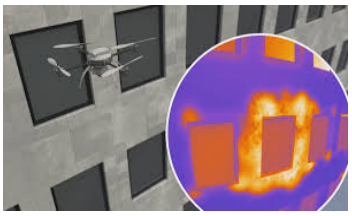
3.1 Case Study: Using drone technology in industrial inspection

Traditional inspection and control methods of massive bridges and buildings require complicated equipment and important and strict security measures. The climbing inspection techniques involve very high risks and costs. Drones can be specially designed to inspect this kind of constructions in a very fast manner, without exposing the staff to the dangers.

Source: https://www.uab.edu

The bridge construction requires a regular inspection, which involves the use of many equipment. Regular inspections are essential to detect warning signs before disasters occur. First step is the collection of sensor data and the next step is scanning data and inform the engineers when a bridge is failing.

An engineer can use an unmanned aerial vehicle to identify difficult to reach and fragile structures which will require human inspection, and consequently significantly reduce time, risk, and cost of facade inspection. Besides, drone technology can be used to identify specific technical problems and to detect thermal bridging faults.



Source: https://www.expouav.com

Source: http://kilmanjaro.ca/

Using drone technology, it is possible to identify liquid levels or leaks in large storage tanks and silos, to map long-distance buried pipelines and localize leaks found within the system and to locate thermal hot spots on boiler tubes before they become critical failures.

Solar panels must be regularly inspected and diagnosed in order to efficiently generate electricity. Drone technology can be used to carry out thermographic surveys and defect analysis of solar panels and wind turbines. Using an IR camera as part of drones, the inspection of the solar panels is performed in a non-contact, non-destructive manner at a safe distance from the target

Source: http://www.unmannedsystemstechnology.com

3.2 Case Study: Using drone technology in Security Industry

Drones are already widely used in the security industry. Drones have the potential to play a significant role in the safety.

- Security guards can be found from protecting homes up to large facilities. But as humans, they have limited performance capabilities, so drones could be a precious tool for them.

- For owners of small business or large corporation, security and surveillance measures are of primary importance and the use of drones can add another layer of security measures offering the ability to move around and capture images.

In security sector drones could be operated:

- In case of routine monitoring, drone is a simple and fast way to control and provide surveillance in industrial and domestic areas.
- In case of sudden situation including theft, strange noise, lack of visibility and other problems, drone technology can receive the signs and provide evidence referring the time and the cause of facts.

'Europa security' is a private company, well known in the region of Thessaly, which provides security services for the private and public sector. Few months ago, company decided to implement a pilot testing program in which the security guards would patrol a local industrial area with the use of Drone. Using the Drone Technology, the security guards could identify the problem from a distance, without sending the patrol vehicle to check if everything is fine. As a consequence, company reduced the number of vehicles and its expenses. Moreover, with the use of drone, the security guards can have instant access to the industries at night, which gives them the opportunity to evaluate a situation much better. These new high quality services that Europa Security can provide to the customers, urged the board of the company to decide on a training program for the security guards in order for them to learn the use of drone and enhance their skills.

Source: https://venturebeat.com/2018/01/13/drone-trends-to-watch-in-2018-big-data-flying-taxis-and-home-security/

3.3 Case Study: Using drone technology to improve environmental monitoring

Through the drone technology, it's possible to evaluate the melting of glaciers, the temporal dynamics of the glaciers, the debris flow and the water resources. The use of drone technology will allow human to do researches in places and conditions where there is no other access.

- Drones will create maps that recreate the morphology of the glaciers.
- Air pollution can be detected by installing a specific payload on the drone, which will overfly industrial complexes and collect data concerning the quality of the air.

- Underwater drone “Robotic Explorer (UX-1)” will be able to produced 3D surveys of completely flooded mines. The drones will also collect information about the geological state of different European sites, in order to be able to analyze more carefully the morphological variations in the Earth’s crust.
- Drones can monitor the hillsides in real time with mapping accuracy and through photographs and algorithms it’s possible to foresee landslides and debris flow.

3.4 Case Study: Using drone technology to monitor air quality

SoftBlue, young SME from Poland, came with the idea to use drones to analyze the composition of smoke coming out of chimneys because Polish cities face problem with the quality of air. Many people use rubbish, containing many chemical substances and burn this waste in a furnace to heat their houses. At the same time, various research show that the number of people affected by lung diseases is on the increase.

An engineering company, FlyTronic, in cooperation with Katowice City Council, City Guard and the Institute for Chemical Processing of Coal started the initiative anti-smog drone. The first reconnaissance flight took place on January 23, 2018 and lasted about 120 minutes. First fine was given within the first hour of testing. SoftBlue, FlyTronic, and few other innovative companies from Poland are working in cooperation with research centers and public institutions on solving the problem of air pollution.

Source: https://www.riseabove.com.au/industrial-agriculture-drones/cameras-sensors-modules/

The drones used to analyze the quality of air and its chemical components are equipped with relevant components (onboard sensors) for air quality measuring. Data collected from the system is transmitted to storing and monitoring devices. In case of SoftBlue, they want to avoid frequent visits in laboratories, so the sensors are going to be certified intoximeters.

3.5 Case Study: Using drone technology in Agriculture

Among the most promising fields for commercial drone use is the agriculture sector, where drones offer the potential for addressing several challenges. Farmers, constantly face problems regarding irrigation, phenomena of pest or disease, issues that have to be solved quickly in order to protect their crop and their income. Drones fly over the field and take high resolution pictures. The data gathered, is directly sent to the software and after that is available to the customer. Thanks to this data, the user can select from the pictures all the information that are necessary, with

Source: http://www.zdnet.com/article/data-driven-farming-with-agricultural-drones/

the aim to make different prescription maps, depending on the operation that a farmer wants to perform on the field.

The maps can then be uploaded on the farm equipment which will adjust the amount of inputs (seeds, fertilizers, pesticides) in order to be applied in the field accordingly.

Types of information farmers can get from the drone images:

- Plant counting: plant size, plot statistics, stand number, compromised plots, planter skips
- Plant height: crop height and density
- Vegetation indices: leaf area, anomaly detection, treatment efficacy, infestations, phenology
- Water needs: Drones ensure a permanent monitoring of the crop regarding the period and the quantities of water that the field needs
- To categorize field zones: a) without intervention, b) little intervention, c) great intervention. The spatial data of each zone will guide the producer to implement its strategy for each zone

The 'Geosense' company in Thessaloniki city, tried to improve the quality of the cotton. The implementation of Drone Technology helped the farmers of Sophiada in Fthiotida region to reduce the inputs during the cotton cultivation. At the same time, farmers improved the quality of their final product and they were able to sell it in a higher price to the cotton industries.

4. Using drones to improve teaching

For the VET providers and participating organizations with educational profile, the main advantage of the inclusion of guidelines on the use of Drone Technology in training, is the reinforcement of their structure as they broaden their curriculum with innovative courses, adopting new teaching tools indissolubly linked with cutting edge technology and the needs of labor market and attracting a great number of trainees by providing new learning opportunities to them and better educational services.

4.1 Using drones to increase the attractiveness of STEM disciplines

Most countries across Europe are facing a low number of students interested in studying or pursuing a career in the STEM (Science, Technology, Engineering and Mathematics) field while the demand for STEM resources is growing rapidly. Consequently, VET institutions need to increase the attractiveness of STEM in order to reduce early school leaving and to enhance employability and entrepreneurship. Considering the rapid evolution of the new technologies, the use of drones in education is highly impactful, specifically in science, technology, engineering and math. Using these small devices in teaching activities can be an opportunity to make courses more appealing and useful for the students. Working with a real practical tool, in an academic environment, will help the students achieve new competences for jobs in STEM fields.

In the field of engineering, drone technology can be successfully implemented especially for disciplines involving the choice of materials from which certain parts of the drones are made (Material Science and Materials Technology, Rapid prototyping technologies). The use of new composite materials with the smallest specific weight and the greatest possible strength for the manufacture of drones and propellers implies the design of certain technologies for the development of these components. The manufacturing technology adopted and the design of the technological parameters depend on the properties of a composite material. Furthermore, the design of the composite materials needs the determination of: the type of constituent elements, the geometry and orientation of the reinforcement element (determines the degree of anisotropy of the final properties), the distribution of the reinforcement elements (resulting in the homogeneity of the system).

To increase the attractiveness of certain disciplines, the design of the propellers can be a topic in the courses for assisted design of products using specialized software: AutoCAD, CATIA, etc. Designed beams can be developed in 3D Rapid Prototyping Labs and then modeled and tested using the ANSYS software to simulate their behavior in real-life conditions.

Moreover, drone technology can be implemented within Data Acquisition disciplines where a user needs to know the technical specifications of sensors that could be used to measure temperature, humidity or impurities in the atmosphere or in areas that are hardly accessible or dangerous for humans. Data acquired through the drones is processed using a specialized software and transmitted in an accessible form for making decisions regarding the area or operating hardware in the data acquisition system. The data collected using the drones that are equipped with thermal imaging cameras can be analyzed using a specialized software, used for concrete applications, particularly attractive for future engineers.

In the electronics field, some laboratory activities could be developed in such a way that students can measure the electrical quantities from the circuits encountered in different construction versions of the drones or design and make sensors that can be used to acquire data using the drones. Developing applications for tablets or smartphones to detect and locate drones can be a challenge for any person studying computer programming.

Drone technology helps students to retain Math concepts better by allowing them to apply the information in the real world. Real world application to mathematical problems and equations are helping students not only realize the great power of Math, but also to see the actual result of their work. In the mathematical discipline, exercises can be formulated to calculate the distance traveled by a drone from point A to point B, for calculating the speed of movement and then performing practical exercises using the drones to verify the results obtained using mathematical formulas.

Also, drone technology is used to teach Science. The students understand better when drones are used to demonstrate abstract notions. For example, when teaching the laws of physics, students calculate the time needed by the drone to cross a certain distance or the influences of wind on drone's path.

At the Natural Sciences discipline, plant drones, plant development requirements, school histograms, and analysis can be used. Also, for the practical activities assigned to these disciplines, the drones can be equipped with devices for distributing seeds on the soil or for uniformly spreading

the substances used to treat plants, which may sometimes have an unpleasant odor or be toxic to the human body.

Good practice - DELTA

As a good practice of increase the attractiveness of STEM disciplines, the 5 schools involved in the ERASMUS+ project DRONES: EXPERIENTIAL LEARNING AND NEW TRAINING ASSETS (DELTA) are making use of Drone Technology.

Two main approaches are employed to implement Drone Technology in classroom:

- As a complement to the existing VET curricula
- As extra-curricular activities

The Computer High school from Iasi, Romania, employed Drone Technology in some extra-curricular activities in order to attract the students to Engineering. The students have been involved in the following activities:

- designing of drone parts using open source CAD software (TinkerCad)
- 3D printing of designed parts
- assembling of the parts with other required components (motors, electronics, etc.) to build a functional drone

The students developed an application for wall crack detection based on data collected by drones, using open source software. This application allows students to acquire knowledge and abilities in IT. and develop other skills: problem solving, team working, etc. Drone technology was used to better illustrate some concepts in Electronics. Electronic components used by drones have been presented by teachers in class and the drone built was used as teaching material.

Good practice - eDrone

According to European Commission, by 2050, drone industry, could create some 150 000 jobs in the EU, spread across manufacturers, operators and other actors providing drone-enabling technologies (such as flight control, sensors and energy). However, educational institutions need to adjust their offer in order to equip their students in competences in demand. Developing new curricula and programmes is expensive, as well as the purchase of necessary equipment. The solution may be applying for funds through various EU or national programmes.

Another example of how EU programmes like Erasmus+ promote new technologies and support the development of related skills is project, eDrone – EDUCATIONAL FOR DRONE" co-funded by the Erasmus+ Programme. The aim of eDrone proposal is to define a learning environment to deliver more opportunities to access new competences related to the use of drone technologies in professional activities. The use of drones by professionals will open new scenarios requiring practical and theoretical knowledge that are beyond the simple driving and maintenance of drones:

- drone mechanical characteristics

- sensing equipment
- processing and use of the acquired information
- national and local laws regulating drone use

The main objective of the eDrone project is to provide higher education institutions in the Partner Countries with effective and efficient instruments to setup Offices for Education for Drones (OED), for the transferring the knowledge to professionals of each Partner Country during Vocational and Educational Training (VET) course.

4.2 Using drones to enhance the social inclusion

Drone technology education could be an important mean to improve social inclusion. In the place where educational resources and learners with disabilities intersect, technology has a vital role to play. It could operate as the great equalizer and help move all learners towards a level playing field. The characteristics of adult trainees with disabilities are low self-esteem, lack of motivation, lack of time due to accumulated problems, physical disabilities and absence of learning culture.

At the same time, the adult trainee, belonging to a vulnerable group, may experience the following negative emotional responses while participating in training programme:

• Fear of critical attitude from team members

• Anxiety and depression

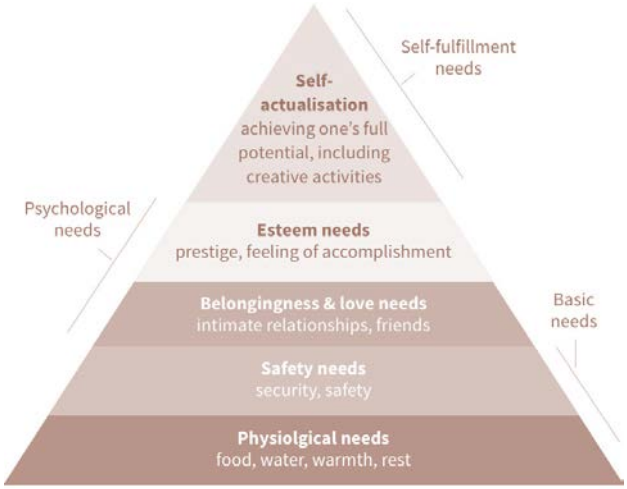
• Alienation and marginalization

• Negative self-image, low self-esteem

• Passive or aggressive attitude resulting from previous experience in the education system

• Disappointment

An adult trainee faces additional obstacles in learning and education. Maslow supports that human behavior is guided by our motivation to meet specific needs. According to his pyramid of hierarchy of needs, it is obvious that the fulfillment of a current need, demands the fulfillment of need in previous level. In the inferior levels of pyramid there are the most basic needs, while the more complex needs are located at the top of the pyramid.



We, therefore, understand that the difficulty of satisfying the basic needs of a trainee prevents him from satisfying other needs and therefore to invest emotionally in learning process. In this case, people interest to cover his/her basic needs, without being able to meet the needs in higher level as determined by Maslow.

According to Maslow theory, the need of trainees for learning and the participation in educational programme, comes from different factors, such as coverage of security needs (finding work), developing social relationships and strengthening his/her self-image or need for self-fulfillment.

Disable Trainee needs self-actualization. In other words trainees need to feel that achieve their targets, including creative activities. In this way, trainees may have positive feelings, such as hope for the prospects that education may offer, as well as optimism and self-esteem and faith in their abilities. There are types of disabilities that enable acquisition of knowledge on drone technology that could be used it in professional life, which includes people with mobility problems, persons suffering from hearing and speech disability or people with invisible disabilities, for example people who suffer from cystic fibrosis.

In addition, there are many cases where people with disabilities are willing to master mathematics, science and technology disciplines, but they do not have the opportunity, or the courage to do that because of their differences. The invasion of drones in the educational procedure will help them not only to get interested in technological sector but also to regain their strength to acquire professional skills, where the drones will be a useful tool in their future jobs.

Source: https://www.springwise.com/training-people-disabilities-become-drone-pilots/

As an example of strong act to bring closely drone technology and disabled community, is 'HandiDrone', collaboration between a digital Agency and French association for social and professional involvement of people with disabilities. 'HandiDrone' is an initiative that enables those with mobility issues and disabilities to experience drones, while give them the opportunity to start a new career, setting them up to become drone pilots. The first test of this act incurred June of 2016.

In addition, many researches and experiments-testing incurred use of drones by disabled people. The aim is to give people with impaired motor abilities a new avenue for interaction. For instance, using the drone to take a close-up look at objects which are out of reach. This is an interesting way to give hope and introduce people with reduced mobility to an emerging field, which can help improve their lives.

Taking into consideration that the acts of familiarization have already started between disabled community as regards the drone technology and its implementation in several areas of world, we are witnesses of a new era in educational system and provinces for people with fewer opportunities increasing their participation in entrepreneurship and business sector.

Trainers can foster learner's collaboration, problem solving and learning and give to all of them a sense of participation. All learners need the opportunity to become self-motivated and perceiving themselves as capable learners. This includes the ability to assess and manage themselves with independence. Trainees with disabilities may need additional support to manage themselves with independence, achieve personal goals, make plans, manage projects and take the risks connected with learning new skills.

There is a common admission about the teaching approaches that consistently have a positive impact on learning. This admission highlights that all students need trainers-teachers who:

- create supportive learning environments
- encourage reflective thought and action

- enhance the relevance of new learning
- facilitate shared learning
- make connections to prior learning and experience
- provide sufficient opportunities to learn
- inquire into the teaching-learning relationship

Depending on the learners and their characteristics, trainers have to plan and coordinate their teaching tools and their appropriate intervention in classroom. This will help to:

- combine theory and practice
- exploit trainees' previous experience, knowledge and communication
- develop comfortable climate regarding the right to freedom of expression, communication, mutual respect, meaning that participants are entitled to their opinion
- encourage and empower trainees to overcome the specific obstacles they face in learning, like phobias, anxiety, defense mechanisms and their stereotypes, that prevent them from thinking critically or renegotiating their values and goals
- ensure the right circumstances for the trainees in order to participate in learning

A basic, commonly used educational method, which is implemented with disabled learners, is the participatory-energetic method. This category supports trainees in retaining easily, the lesson, via the combination of lecture and practice. This helps them to give solutions to problems. The abovementioned, can be achieved through the use of the energetic method and techniques which develop the interaction not only between the trainer and trainee but also between trainees.

Under these circumstances, trainees with disabilities need to participate in the training process, tackling the discrimination and marginalization and facing their own fears. Drone technology is an alternative issue, which can contribute to the social inclusion of people with disabilities. Accessible educational content and guidelines on drone technology can have a lasting impact on students/learners to pursue careers that they may have never considered. In fact, it is an opportunity for the drone community, educational community and disabled community to be connected providing advantages such as:

- enhancement of disabled students' interest to STEM subjects, following a career in these sectors
- enhancement of social inclusion giving opportunities to disabled people to become acquainted with technological achievements, which can be helpful in creating their business ideas
- enhancement of the educational materials with alternative and innovative thematic fields, that could be attractive to learners and students
- development of a certified team of people that use drone technology and enhancement of the labour market with new job opportunities in various occupational sectors.

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