DRONES4VET

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MODULE 04

TRAINING PROGRAMME

FLIGHT SIMULATOR

Comunidad de Madrid | Dirección General de Formación | CONSEJERÍA DE ECONOMÍA, HACIENDA Y EMPLEO

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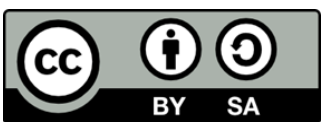

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DRONES4VET Erasmus+ project participants and writers

CMQE HEREC Occitanie France team:
Régis Lequeux - lecturer, civil engineer, Lycée Dhuoda, Nîmes - coordinator of the 10 modules
Nicolas Privat - lecturer, civil engineer, Lycée Dhuoda, Nîmes
Eric Remola - lecturer, Lycée Dhuoda, Nîmes
Nicolas Vassart - lecturer, Phd, Lycée Dhuoda, Nîmes
Valerie Poplin - CMQE HEREC Executive manager

MTU Ireland team :
Sean Carroll CEng MEng BEng (Hons) MIEI Lecturer & Researcher
Michal Otreba Inz, MScEng, PhD, Lecturer & Researcher
both coordinators of the Levelling & Follow-up sessions for educators

University of Applied Sciences Kufstein Tirol. Austria
Emanuel Stocker, Lecturer and Researcher in Facility- and Real Estate Management.
Handbook coordinator
Sarah Plank, R&D Controller

CRN Paracuellos team (Dirección General de Formación. Comunidad de Madrid). Spain
José Manuel García del Cid Summers, Director
Daniel Sanz, director of Dron-Arena
Santos Vera, technician
Jorge Gómez Sal, Leiter der Technischen Einheit
Fernando Gutierrez Justo. Erasmus Coordinator
– Project applicants

BZB Düsseldorf. Germany :
Frank Bertelmann-Angenendt, project manager
Markus Schilaski, project manager

DEX. Spain
Ainhoa Perez
Ignacio Gomez Arguelles
Diego Diaz Mori
Yvan Corbat
Erasmus management

1. Objectives of the module

Before a student or professionals fly a drone in the field for the first time, the use of a ***flight simulator*** is recommended and commonly adopted in education and training centres.

This module introduces flights simulators as a safe and realistic way for new pilots to ***learn the basic skills*** that is required ***to fly a drone***. The ***advantages of using a simulator*** and some of the types of possible learning situations that can be developed for learners are also presented. Several paid and free simulators that are currently available on the market at the time of publishing this module are identified. Finally, a more detailed example of possibilities is presented.

2. Warning

A simulation, as real as it can be, is never totally real: there is no danger, no weather interference on the pilot, no risk of injury or money loss, so the student's state of mind is not as disturbed as in reality.

Practice with simulators allows us to acquire knowledge, skills, abilities, and above all awareness without risking lives, equipment with results similar to those we would have in real life.

For a simulator to be useful and successful, we must recreate the conditions closest to reality, so that the pilot on board can experiment and make the same decisions that he would make in an extreme situation.

It is a very good introductory tool for training pilots in the fundamentals of flying and for specific situations. Many different situations or "home work" can be developed for students, but it can't replace the real flight with all its environment.

3. Why use a flight simulator?

A flight simulator runs on any common computer and allows individuals to learn and practice flying aircraft in a simulated environment. Applied to civil drones, flight simulators can help to train students.

In the case of drones, keeping in mind the conditions for flying, it is not strictly necessary for a drone operator or pilot to take practice with a simulator. However, it is recommended for several reasons:

- It is not necessary to have a Drone, therefore it will help you prepare while you get the drone you want.
- You will be able to try different types of equipment (DJI, Racers, Parrot, Fixed Wing, Multirotor, and other brands or types) to verify which is the perfect drone for your operations.
- It is the most economical way to face real situations in a simulated way, without anyone getting hurt and without spending money.
- There are applications for all tastes, there are even versions for Smartphones, which is a great advantage.

The following section outlines some of the advantages of flight simulators to learn to fly civil drones.

3.1 Realistic simulation

Flight simulators provide a highly realistic virtual representation of the flight characteristics and behaviour of different types of civil drones. They incorporate accurate physics models, aerodynamics, and control systems to simulate the drone's flight dynamics. This realism helps users gain practical experience and develop a solid understanding of how drones respond to various flight inputs.

Figure 1 Piloting in Visual Line Of Sight (agrilaneta.com)

It is also possible to see the drone from a different point of view, for a better understanding of the drone's behaviour.

Figure 2 Close point of view (uavcoach.com DRL sim)

3.2 Flight Controls Familiarisation and security

Flight simulators allow users to interact with simulated drone flight controls, including the actual transmitter or controller used to pilot the drone. This helps beginners become familiar with the controls, buttons, switches, and joysticks, allowing them to practice manipulating the controls without the risk of crashing or damaging a real drone.

The controls are the same as on the app, so the learner can develop goods habits and learn the important information they require to fly a drone safely and competently.

Figure 3 Realistic display (Parrot Sphinx)

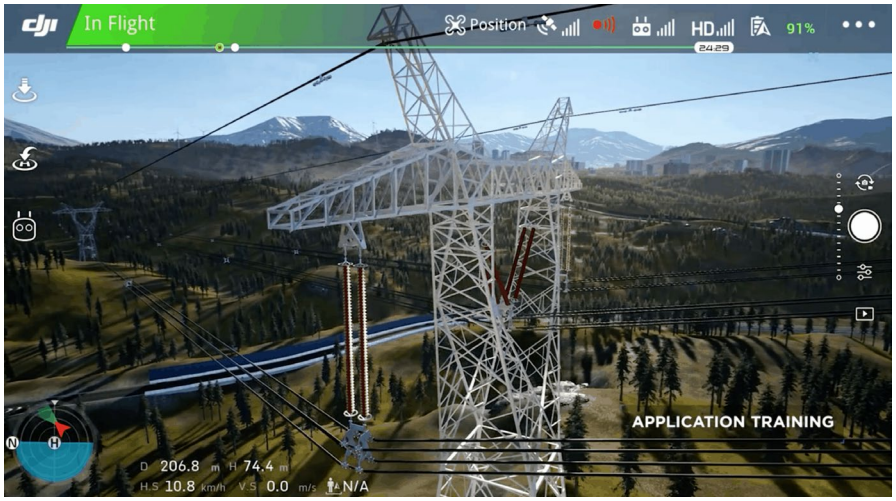


Figure 4 Approaching electric lines (DJI)

3.3 Flight Planning and Mission Training

Simulators provide tools to plan and simulate complex flight missions. Users can create virtual scenarios with waypoints, flight paths, and predefined actions such as aerial photography. This enables drone pilots to practice and refine their mission planning skills, ensuring safe and efficient operations in real-world situations to get ready for photogrammetry or expertise.

Figure 5 Photographic mission (SIMNET academy)

3.4 Environmental Training

Simulators replicate various environmental conditions, such as different weather conditions, terrain types, and lighting conditions. This enables drone pilots to train for different scenarios, including adverse weather, night flights, or flying in challenging locations. By experiencing these simulated environments, pilots can learn to adapt their flying techniques and make informed decisions in real-world conditions.

Figure 6 Backlight piloting (Parrot Sphinx)

3.5 Emergency Response Training

Flight simulators also allow users to practice responding to emergency situations without the risks involved in real-world flight. For example, simulated engine failures, control malfunctions, or adverse weather conditions can be simulated, allowing pilots to develop and hone their emergency response procedures and decision-making skills.

Figure 7 Drone malfunction at landing with wind (Zephyr sim)

3.6 Cost and Time Efficiency

Learning to fly drones through flight simulators can be a cost-effective alternative to solely relying on real-world flight training. Simulators eliminate the need for purchasing or renting expensive drones and reduce the risk of crashes and equipment damage during training. Additionally, simulator training can be easily paused, reset, and repeated, allowing learners to practice specific manoeuvres or scenarios repeatedly to improve their skills.

4. Non-exhaustive list of drone flight simulators

When deciding which simulator best suits the needs of a training programme and the trainee pilots, it is useful to consider the following:

- Will you use the simulator on a PC or Mac?
- Are you practicing for FPV (first person view) flight or Line of Sight, or both?
- Are you trying to practice your drone camera skills?
- Do you need to practice your video recording skills with your drone?
- Will you want to practice in radio-controlled helicopters and fixed-wing aircraft?
- Are you looking for a drone flight simulator just for entertainment?
- Is it for commercial or recreational use?

Some flight simulators specialised in FPV-racing flight are not included in this list because they are not relevant to work in the construction sector.

The simulators have not been tested by the authors of this D4V document.

4.1 PC flight simulators

ZEPHYR DRONE SIMULATOR

Features

- Drone pilot education training program with built-in classroom management tools.
- Accurate physics to replicate real-world flight.
- FAA guidelines are incorporated into flights, and relevant warnings are included in training.
- Continual program development and updates to include new training modules and aircraft.
- Customizable weather settings to enhance training experience.
- Large selection of customizable drone models.
- FPV and VLOS flight modes available.

Pros

The Zephyr drone simulator is purpose-built to be an education tool, and is unlike any of the other simulators on this list in that it incorporates an instructor control and feedback aspect. Students enrolled in a training course will have their flight statistics sent to an instructor for review and feedback. It's not limited to classroom use, however, and professionals can use the training program individually.

The training focus is even extended to the realm of safety training, with built in FAA safety guidelines built into the program to help pilots learn to operate within the parameters of FAA rules.

The physics and customizability make the program an accurate and realistic training tool, with easy transfer to real-world flights. A huge selection of training modules and situations make Zephyr applicable to almost any commercial or even hobby drone user.

Zephyr is also quite reasonably priced as far as professional drone training simulators go. Of course you can also test out the free trial before deciding if this is the right simulator for you.

Cons

For those who just want everything in one package, the pricing structure of Zephyr (for individual professional purchase) may be a bit confusing. A number of different optional add-ons can be purchased separately, but it may be hard to know where to start. Starting with the free trial may help you determine which package you need.

Zephyr is primarily a commercial drone training simulator, and if you're just after a fun introduction to flying a drone virtually this is one of the more expensive options. And if you're wanting to get into FPV racing, Zephyr doesn't offer that style of flight training.

Compatible Controllers

- XBOX 360, XBOX One, and PlayStation controllers
- Spektrum DXe, Dx9, Dx6i
- Hobby King 6-CH RC Flight Simulator Controller
- Interlink Elite by Futaba
- FlySky FS-i6s, FS-T6
- Taranis FrSky X9D Plus
- Futaba: T6EX, T14SG, T8FG
- Iris+ FlySky FS-TH9x

REALFLIGHT

Features

- Great physics for real-world flight experience.
- Over 170 different RC and drone models.
- Over 40 different flying sites.
- Ability to add and edit aircraft and flying sites for additional customization.
- Game-like challenges, multiplayer options, and VR headset compatibility for added fun.
- Lessons to develop photography skills.

Pros

The excellent physics of the RealFlight RF9.5 simulator make for a good training tool, providing a more life-like flight experience. And the wide selection of realistic flight scenarios only adds to the training benefit of the program.

Challenges and lessons make learning and practicing intuitive and fun, keeping you engaged in learning. Flight training is not the only thing to learn on the RealFlight simulator either, as other lessons in the program help you practice photography and videography skills as well.

The compatibility with a radio controller is a good advantage here, as it gives you practice using your actual flight controller rather than a gaming controller. You can buy the Spektrum controller that comes with the program, or use one of your own, as quite a variety of radios are supported.

Cons

This flight simulator is rather expensive as they come, and this is due in large part to the fact that it's not just a drone simulator but includes such a huge selection of RC models. Unless learner is interested in these models these options are of benefit but if the priority is to practicing drone flight, cost could be excessive for what is needed.

Another big drawback is that the RealFlight RF9.5 simulator is only compatible with a PC.

Compatible Controllers

- USB 2.0 Port
- Compatible FM or FM-selectable transmitter

DRONESIMPRO

Features

- Custom-built flight engine allows the simulator to replicate the real-world physics of drone flight.
- Customizable environments with realistic lighting and terrain features.
- Two customizable drone types including Phantom 2 and Phantom 3.
- Supports USB controllers for flight control.
- Flight scenarios include obstacle courses, a house fire, and open field flight.

Pros

The droneSimPro Drone Flight Simulator offers a fairly true to life flight experience, thanks to the flight engine in the software program. This makes it more accurate in the feel and response of the controls. As a training flight simulator, this is important for helping pilots transition to real-world drone flight.

Many of the higher end training simulators cost are more expensive, without improving a whole lot on the actual real-world feel of the flight experience.

The flight scenarios are realistic and satisfying as well, especially with the ability to customize the environments. You can recreate almost any type of scenario that you need to fly in real life, and practice flying it in the simulator first, whether it's a burning building or a tower inspection. This is great for drone pilot training purposes.

Cons

Only two drone types are currently replicated in the simulator, the Phantom 2 and Phantom 3. While this is great if one of these is the drone you're flying, it doesn't give quite the same feel as getting to fly your own drone model in a simulator. More drone models are promised to be coming soon.

Also a drawback is the short list of supported controllers. While gaming controllers are great, they also don't give quite the same experience as learning to fly with your real flight controller. A longer list of compatible controllers is promised to be coming soon as well.

Compatible Controllers

- Xbox One
- Xbox 360
- Xbox 360 (Gamestop brand)
- PlayStation 3

PHOENIX R/C PRO FLIGHT SIMULATOR

The Phoenix R/C Pro Flight Simulator has been on the market for some time and has become a trusted brand among drone pilots.

The Phoenix simulator provides simulations for drones but it also comes with simulations for other remote control aircraft, including planes and helicopters.

The Phoenix drone flight simulator is one of the most expensive on this list, but it's important to note that the price includes a Spektrum DX6i flight controller.

Overview

- Devices: Windows PC
- Customizable Environment: Yes
- Customizable Drone Type: Yes (over 200 drones, planes, and helicopters)

Specs & Details

- Interactive flight challenges
- Fully functional instruments in all cockpits
- Purchase comes with 2 CDs, 1 Spektrum DX6icontroller, and a 20-page instruction booklet
- Customizable wind, view, cloud cover, and heat settings
- All-new airplane physics rebuilt from the ground up and industry-leading helicopter physics for the ultimate in realism and accuracy
- Comes with a controller—fully-functional Spektrum™ DX6i 6-channel DSMX® programmable transmitter included with purchase
- Over 200 accurately modelled and detailed helicopters, planes, float planes, autogyros and more
- In-cockpit and chase camera views
- All-new tutorial videos taught by world-class champion pilots
- Realistic sounds recorded from actual model engines
- Dozens of stunning, photo-panoramic club, slope soaring and waterfront flying sites

Supported Controllers

- Comes with its own controller.

4.2 Smartphone/tablet simulators for Android or Ios

QUADCOPTER FX SIMULATOR

The Quadcopter FX drone flight simulator is the least expensive on this list. You can also try a more limited version of the app for free.

Although the Quadcopter FX simulator doesn't have the same versatility as other simulators, it has been well reviewed by users on Googe Play and could make a good beginner simulator for those just starting out with learning how to fly (or simulate flying) a drone.

Overview

- Devices: Windows PC or Mac
- Customizable Environment: No
- Customizable Drone Type: No

Specs & Details

- Simulation is based on real physics modelling of a quadcopter's flight
- Different camera types—FPV, stabilized gimbal, follow, and eye level
- Various settings—Control sensitivity, Auto stabilization, Weight, Static/Dynamic
- Thrust, Drag, PID, Dynamic Wind, and more
- Acro/Acro 3D mode
- Real-time Pitch, Roll, Heading, Altitude and Speed.
- Compatible with Google Cardboard VR

Supported Controllers

- Works with all standard drone controllers

REALFLIGHT MOBILE

The app can downloaded for free and it comes with two craft which are planes that don't require payment. It drones models are required it will cost money to unlock. It's suggested to buying the bundle rather then individual models.

The game defaults to Mode 2 controls, but it can be changed to other modes under the settings.

Unlike some other mobile RC sims, RealFlight has a fully rendered flightbox. It contains fully rendered 3D models as the environment that flights take place.

Obviously using touchscreen controls doesn't feel anything like using actual sticks, but at least the developers have made things easier by not requiring user`s fingers to be on the actual sticks. Instead each half of the screen represents a stick that can be easily used.

You can adjust the realism and assists up and down depending on your level of skill and resetting after a crash is instant. Finally, Realflight Mobile is a great little simulator for good price.

5. Main functionalities of flight simulators

5.1 Connect the Remote Controller

A Flight Simulator is compatible with many remote controllers (R/C). **It is also available to operate in the software with the keyboard.** It is possible to connect the remote controller to the computer using a USB cable. Power on the remote controller and it will be ready for use in the Flight Simulator. In case of USB connection missing it is possible to use the keyboard to control the drone, but it won't be a real flight training.

Some simulators need their own R/C.

Login Screen

This is the page that the Launcher leads to. Log in/out, configure settings, and view FAQ and instructions on this page with a mouse.

Select START

Click to enter the Main Screen of the Flight Simulator.

Main Screen

Only the remote controller and keyboard can be used in the Main Screen and its sub-screens. A mouse can be used only in some specific scenarios.

Figure 8 DJI FS main screen

Aircraft Models

Here select an aircraft to use in training modules.

Use the remote controller or keyboard to switch between different sections and POVs.

- basic features of the aircraft,
- specifications,
- available commands.

Use the remote controller or keyboard to operate the aircraft or change settings in the modules. See detailed instructions below. These instructions can also be viewed in the Login Screen (Option > Instruction) or the Main Screen (Settings > Remote Controller and Keyboard).

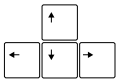
Action	Remote Controller Commands	Keyboard Commands
Switch between aircraft	Push the left stick left/right	A/D
View features	Push the left stick up/down	W/S
Adjust POV	Push the right stick in any direction	
Switch between accessories*	Video Recording button	Space

Figure 9 Keyboard commands example explained.

5.2 Basic training Modules

This section introduces all the modules and their corresponding modes and levels. More actions are available in some scenarios or with specific aircraft.

Select Skills Training in the Main Screen, and then select an aircraft to select a training. Skills Training includes Tutorials, pilot courses and several tests.

TUTORIALS – THE MAIN COURSE

Learn the basics of piloting a drone.

There are several levels of difficulty to get trained. Try the lowest one first and raise the level progressively.

There are several levels:

- Basic flying skills
- Shooting skills
- Free flight mode

TESTS – FOR SELF-ASSESSMENT AND PROGRESS

HOVERING TEST

The hovering test provides a series of virtual testing conditions to assist in testing and improving the hovering skills.

There are several levels:

- Single Target, Multiple Targets
- Fixed Orientation Hovering, Four Directions Hovering
- Single Target with Wind, Multiple Targets with Wind
- Four Directions Hovering with Wind

The difficulty gradually increases with each level, also incorporating the effect of wind.

FLY TRACK TEST

This test is to check pilot`s control skills over the aircraft. User will be required to fly along the designated route.

There are different tracks:

- Square Track
- Rectangle Track
- Ring Track
- Double Ring Track
- random...

The difficulty gradually increases with each level.

The system will display the aircraft's actual flight route and compare it with the pre-set, standard flight route to calculate a score. In this exercise, users have to overcome parallax, which also exists in real flight.

FREE FLIGHT MODULE

Select Free Flight in the Main Screen, and then select an aircraft to select a scenario. Free Flight includes different situations: City, land, hangar, mountain, forest, tunnel...

5.3 Application Training Module

An Application Training module allows to practice a professional approach. Select a training scenario and learn without risk the basics of a professional work with the drone.

Power Line Inspection

Simulate a power line inspection.

There are 2 levels: Getting to know the pylon, and practice Inspection.

Search and Rescue

Understand and practice searching process, and get prepared for the real SAR mission.

Image Capture and Video Recording

In Drone FPV (First Person View) or Remote Control View, use the remote controller or keyboard to take photos and record videos. View the photos and videos in Gallery in the Main Screen or Pause View.

Action	Remote Controller Commands	Keyboard Commands
Take photograph	Shutter button	H
Start/stop recording video	Video Recording button	L

Figure 10 Example of key table for camera

Signal Interference

In some scenarios, there will be random interferences that may impact the imaging or the controls. This is designed to help users train their emergency response abilities. The image display might be blurred or go dark completely. There might also be a latency in the control latency or signal interruption.

5.4 Switch POVs

Drone Follow View:

The video camera of the Flight Simulator is behind the aircraft to follow its movements. Users cannot adjust the heading of the video camera.

Drone FPV:

Drone FPV is what the aircraft camera sees. Real-time footage from the aircraft camera is displayed along with the app screen. The app screen is a copy of the view in virtual reality goggles. Users can view the status display on the screen, the only adjustable settings are camera settings. Refer to the corresponding aircraft user manual for app display descriptions. Some simulators are compatible with VR googles.

Pilot FPV:

Pilot FPV is the pilot's perspective on the ground looking at the aircraft. It is similar to the perspective when operating the aircraft in the real world, without 3D: there is only one screen, but in the reality you have two eyes to capture distance between your drone and obstacles.

Remote Control View:

Remote Control View is the view looking at the handheld remote controller from the pilot's perspective.

In this POV, the display is the mobile device with the app screen on it. The app screen is a near- duplicate of your remote control. Users can view the status display on the screen, the only adjustable settings are camera`s. Refer to the corresponding aircraft user manual for app display descriptions.

3rd Person View:

3rd Person View looks at the pilot from the 3rd person's perspective.

In this POV, the pilot is being controlled. Users can control his position to simulate a change in the pilot's movement in real life.

Action	Remote Controller Commands	Keyboard Commands
Forward	Push left stick up	W
Backward	Push left stick down	S
Left	Push left stick left	A
Right	Push left stick right	D
Jump	Video Recording button	Space

Figure 11 Keyboard navigation commands

5.5 Aircraft Functions

Flight Modes

There are three flight modes in some flight simulators, often called Position mode, Attitude mode, and Sport mode (names can vary).

Position-mode (GPS): The aircraft uses GNSS or Vision Positioning System for positioning. It allows the aircraft to hover precisely and brake automatically.

Attitude - mode (no GPS): Neither the GNSS nor Vision Positioning System is used for positioning. The aircraft can only maintain attitude. It is significantly more difficult to control the aircraft in this mode.

Sport -mode (high speed): The aircraft uses GNSS or Vision Positioning System for positioning. It allows the aircraft to hover precisely and brake automatically. The aircraft flies at a high speed. Operate with caution.

Collision Feedback

The aircraft will crash in the simulation when it collides with objects such as buildings and trees. Two kinds of feedback will be given: the aircraft location will be reset or the mission fails. Users can continue the mission after the reset or restart after failing.

Return to Home (RTH)

There three types of RTH option: Smart RTH, Low Battery RTH, and Failsafe RTH.

Smart RTH

Enter RTH: Press and hold the RTH button on the remote controller or press a key on the keyboard and then confirm to enter RTH. The aircraft will automatically return to the take-off point. Aircraft control is unavailable during RTH.

Cancel RTH: Press the RTH button on the remote controller or the key on the keyboard and then confirm to cancel RTH. The aircraft will hover in place, and the user will regain control.

Low Battery RTH

Enter RTH: Low Battery RTH is triggered when the battery is depleted to a point that may affect the safe return of the aircraft. The aircraft will automatically return to the take-off point. Aircraft control is unavailable during RTH.

Cancel RTH: Press the RTH button on the remote controller or the key on the keyboard and then confirm to cancel RTH. The aircraft will hover in place, and the user will regain control.

After cancelling Low Battery RTH, the aircraft will land automatically when the battery level drops to 10%.

Failsafe RTH

Enter RTH: Failsafe RTH will be automatically activated if the remote controller signal is lost. The aircraft will automatically return to the take-off point.

Cancel RTH: During Failsafe RTH, if the lost remote controller signal is found, press the RTH button on the remote controller or the key on the keyboard and then confirm to cancel RTH. The aircraft will hover in place, and the user will regain control.

5.6 Display

Mini map

In the Drone Follow View or Pilot FPV, the thumbnail of the location of the drone will show up as a Mini map at the lower right corner of the screen.

It is possible to open or close the Mini map display. The take-off point and flight path will be shown in the Mini map.

Flight Route

This function lets users to see the flight route in the air.

Press and hold the specific button on the remote controller or the specific key on the keyboard to show or hide the flight route.

List of figures