

WIRELESS WORLD OF DRONES AND BEYOND

Flying Small Drones for Recreation, Education & Research

December 2, 2021

Wireless Innovation Forum 101 Technical Conference

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UAV SIG

**A BRIEF HISTORY OF DRONE SWARM
NETWORKING**

**DAVID MUROTAKI OCDS PH.D.
X4 DRONE LAB**

2013: Paparazzi Delft University

- Paparazzi drone swarm autopilot, originally developed and demonstrated by a Delft team to work for the Parrot AR Drone 2.0 with added GPS
- Remes, Hensen et al, “Paparazzi: how to make a swarm of Parrot AR Drones fly autonomously based on GPS”, International Micro Air Vehicle Conference and Flight Competition (IMAV2013), 17-20 September 2013, Toulouse, France

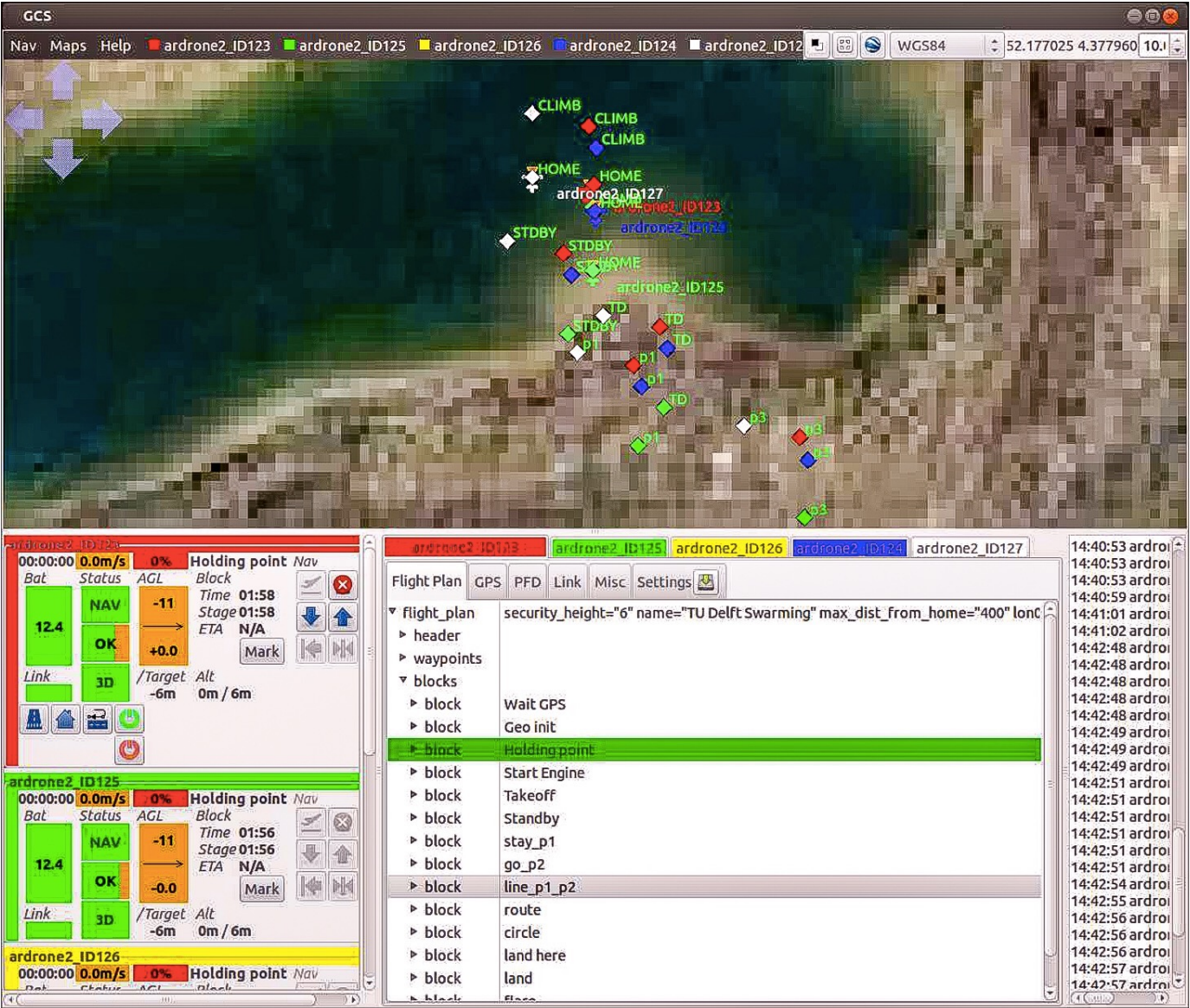
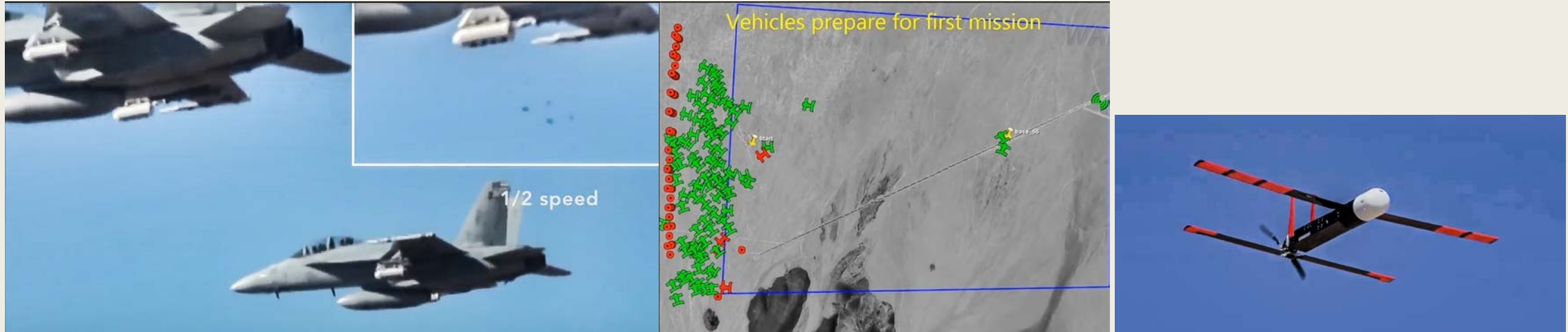


Figure 3: GCS with five AR drones.

2016: US DARPA SCO

100+ Perdix drones launched from F-16/F-18



- **DARPA SCO** successfully launched a swarm of over 100 Perdix Drones from F-16, F-18 (Prototypes - MIT Lincoln Labs, October 2016)
- **Washington Post:** “Veil of secrecy lifted on Pentagon office planning ‘Avatar’ fighters and drone swarms” 8 March 2016
- <https://www.washingtonpost.com/news/checkpoint/wp/2016/03/08/inside-the-secretive-pentagon-office-planning-skyborg-fighters-and-drone-swarms/>

2018 Olympics: Intel

Flew over 1K drones in a drone swarm “dance”



- Intel successfully demonstrates drone swarms with over 1,000 drones in precision flight (2018 Olympics)
- By now drone swarms have replaced many fireworks displays around the world



Intel® Insight Platform

THE INTEL® INSIGHT PLATFORM

The Intel® Insight Platform helps you store, organize, process, and harness the growing amounts of visual data associated with large assets and sites spread around the world, in a collaborative environment designed to enable geographically dispersed teams in complex multi-party projects. With its open cloud infrastructure you can develop and deploy analytics and applications at scale with the help of Intel and other ecosystem players.



Drone swarm network platforms by a major player like INTEL® brought drone swarms into “prime time” over 3 years ago...



INTEL® DRONES LIGHT UP THE SKY

Our light shows take the wonders of drone technology and transform them into an entirely new form of entertainment. Intel enables clients to brighten up the night sky with a choreographed light show featuring hundreds of Intel® Drones - creating a stunning way to communicate to audiences large and small.¹

The Intel drone logo was not part of the Opening Ceremony.

R&D: *Where are we headed tomorrow?*

- Spectrum allocations
- Drone taxis & deliveries
- Heavily encrypted mesh networks
- LPI/LPD “Stealthy” Airborne Networks
- AI & Embedded propagation managers
- Blockchain for 4D navigation matrices
- Cybersecurity!!!





UAV SIG

**FLYING SMALL DRONES FOR
EDUCATION AND RESEARCH**

**DAVID MUROTAKI OCDS PH.D.
X4 DRONE LAB**

Rationale

- 1) It's easy and inexpensive to register as a *Recreational Flyer* in the USA. (Defined by USC 44809 under Part 107 rules).
 - *Especially if the drone is less than 0.55 lbs*
- 2) There is a legal “exception “ (PL115-254. Section 350) under Part 107 that distinguishes some forms of educational and research drone use as “recreational”.
- 3) **Teaching**: Some drones, like the Tello EDU quadcopter, can be programmed in Python for both individual and swarm flight.
- 4) **Research**: Small drones can carry a useful array of optical sensors (cameras, EO/IR) and RF sensor (RF signal detection and DF) up to the legal 400-foot AGL altitude limit.
 - *In 2017, our first RF/DF sensor payload was a WIFI Pineapple*



Unmanned Aircraft Systems

UAS en Espanol

Getting Started

Recreational Flyers & Modeler Community-Based Organizations

Where Can I Fly?

The Recreational UAS Safety Test (TRUST) →

TRUST For Industry

Certificated Remote Pilots including Commercial Operators

Public Safety and Government

Educational Users

Critical Infrastructure & Public Venues

Advanced Operations

Programs, Partnerships & Opportunities

Research & Development

Resources & Other Topics

Contact Us

FAA Home ▶ Unmanned Aircraft Systems ▶ Recreational Flyers & Modeler Community-Based Organizations ▶ The Recreational UAS Safety Test (TRUST)

The Recreational UAS Safety Test (TRUST)



All recreational flyers must pass an aeronautical knowledge and safety test and provide proof of test passage (the TRUST completion certificate) to the FAA or law enforcement upon request. The [FAA's 2018 Reauthorization Bill](#) (PDF) introduced new requirements for recreational pilots (see P.L. 115-254, [Section 349](#) (PDF) – exception for limited recreational operations of unmanned aircraft).

Top Tasks

- Register your drone
- Download the B4UFLY Mobile App
- UAS en Espanol
- [Keep your Remote Pilot Certificate Current](#)
- Check out Hot Topics in UAS

What is a recreational flyer?

A recreational flyer is someone who operates their drone for fun or personal enjoyment purposes only.

How to fly a drone recreationally:

1. Pass TRUST
2. If your drone weighs more than .55 lbs, register your drone through the FAA's DroneZone
3. Follow safety guidelines on the FAA [website](#) or of an existing aeromodelling organization



In June 2021, the FAA announced the following entities as FAA Approved Test Administrators of TRUST (FAA approved TRUST TA):

Flying for Education

Drones (including model aircraft) are great tools for use in education. If you're a teacher or a student looking to bring drones into your curriculum, here are a few resources to help you get started.

Flying drone: Know the rules

The rules for flying drones are based on the purpose of the operation. There are a few options for flying for educational purposes. Learn more about which rules apply to your operation.

– **Part 107** is the primary law for flying small drones (less than 55 lbs.) in the United States. You can fly under part 107 rules for many reasons, including work or business, recreation, education, or for public safety missions.

- [Learn more about flying under part 107](#)

– **Exception for Recreational Flyers and Community-Based Organizations.**

There is an exception (USC 44809) that allows flying drones for recreational purposes (under certain conditions) without complying with Part 107. In order to fly under the statutory exception, you must comply with all portions of Section 44809, including flying your drone for purely recreational purposes.

- [Learn more about flying under the Exception for Recreational Flyers](#)

– **Institutions of Higher Education.** There is also a statutory provision (PL 115-254, Section 350) that distinguishes some educational and research uses of drones by institutions of higher education as recreational in nature. The FAA intends to publish specific implementation guidance for Section 350 later this year.

Top Tasks

- Register your drone
- Download the B4UFLY Mobile App
- UAS en Español
- Keep your Remote Pilot Certificate Current
- Check out Hot Topics in UAS



Teaching computer programming, e.g. Python
Carrying sensors aloft up to 400-ft AGL

Drone consortia, e.g. Flight Test Ranges (VT)

USEFUL TIPS FOR BEGINNER DRONE PILOTS





The Recreational UAS Safety Test (TRUST) Completion Certificate

Name:

David Murotake

Authentication Token:

IAMA49435735001

Issued by:

Academy of Model Aeronautics on 7/27/2021

Obtain your TRUST
Certificate ASAP.
They're inexpensive
(free). Keep it with
you whenever you fly.



Your Registered Inventory

[Export Inventory](#)

SEARCH

Register at least one active drone with FAA Drone Zone.

SHOWING ITEMS 1 - 3 OF 3 TOTAL ITEMS.

FILTER BY [All Inventory](#)

NICKNAME	UAS MANUFACTURER	UAS MODEL	SERIAL NUMBER	REMOTE ID	DEVICE TYPE	REGISTRATION	ISSUED	EXPIRES	STATUS	ACTIONS
Mavic...	DJI	Mavic ...	1SZD...		Purch...	FA3PE9NHF7	11/27/...	11/27/...	Active	⋮
Bebop...	Parrot	Bebop...	PS722...		Purch...	FA3P7MCLFT	11/25/...	11/25/...	Active	⋮
Spark2	DJI	Spark	OASU...		Purch...	FA3MKN47NF	11/16/...	11/16/...	Active	⋮

Label your registered drone on the outside



U.S. Department of Transportation
Federal Aviation Administration
800 Independence Avenue, SW

Washington, DC 20591
(866) TELL-FAA ((866) 835-5322)

Web Policies

[Web Policies & Notices](#)
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[Accessibility](#)

Government Sites

[USA.gov](#)
[Plainlanguage.gov](#)
[Regulations.gov](#)
[Data.gov](#)

Contact Us

[Contact FAA](#)
[Office of Inspector General \(OIG\) Hotline](#)
[Freedom of Information Act \(FOIA\)](#)

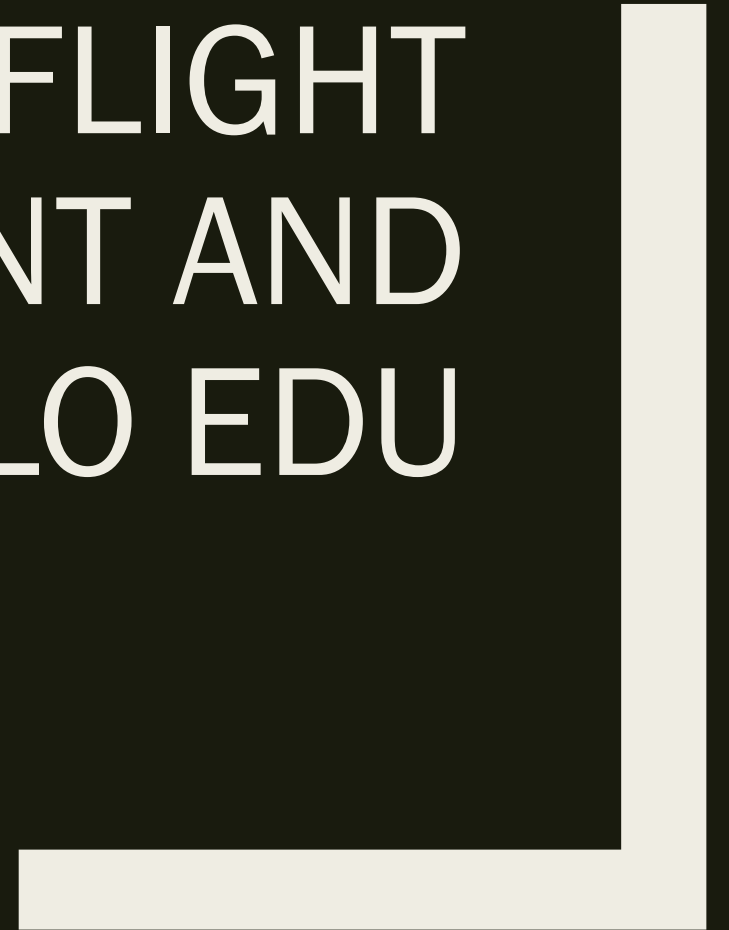
First Steps: Getting your first drone

- Watch how-to-fly tutorial videos on YouTube
 - *"Drone Flying Tips: 7 Tips for Beginner Pilots"*
 - Link:
https://www.youtube.com/watch?v=3qd4bbssmKc&list=PLUmMI_n4NvqGYRT_I23Ods0kgtko5_EF1&index=15&t=29s
- Obtain a crashworthy, easy-to-fly drone
 - *Refurbished! (You can spend less than \$100)*
 - *Simple to fly in basic mode (ability to fly indoors is also useful)*
 - *GPS equipped and Includes, or can add, flight management capability*
- Example: Parrot Bebop (refurbished) is very sturdy
 - *Very stable, comes with LARGE propeller guards*
 - *Streamlined gimbaled HD camera in nose*
 - *Altitude sensing and collision avoidance*
 - *Can upgrade with Parrot Flight Management SW*
 - *Excellent trainer for Parrot ANAFI – and DJI Spark/Mavic Mini/Mavic*



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SMALL DRONE FLIGHT MANAGEMENT AND SWARMING WITH TELLO EDU

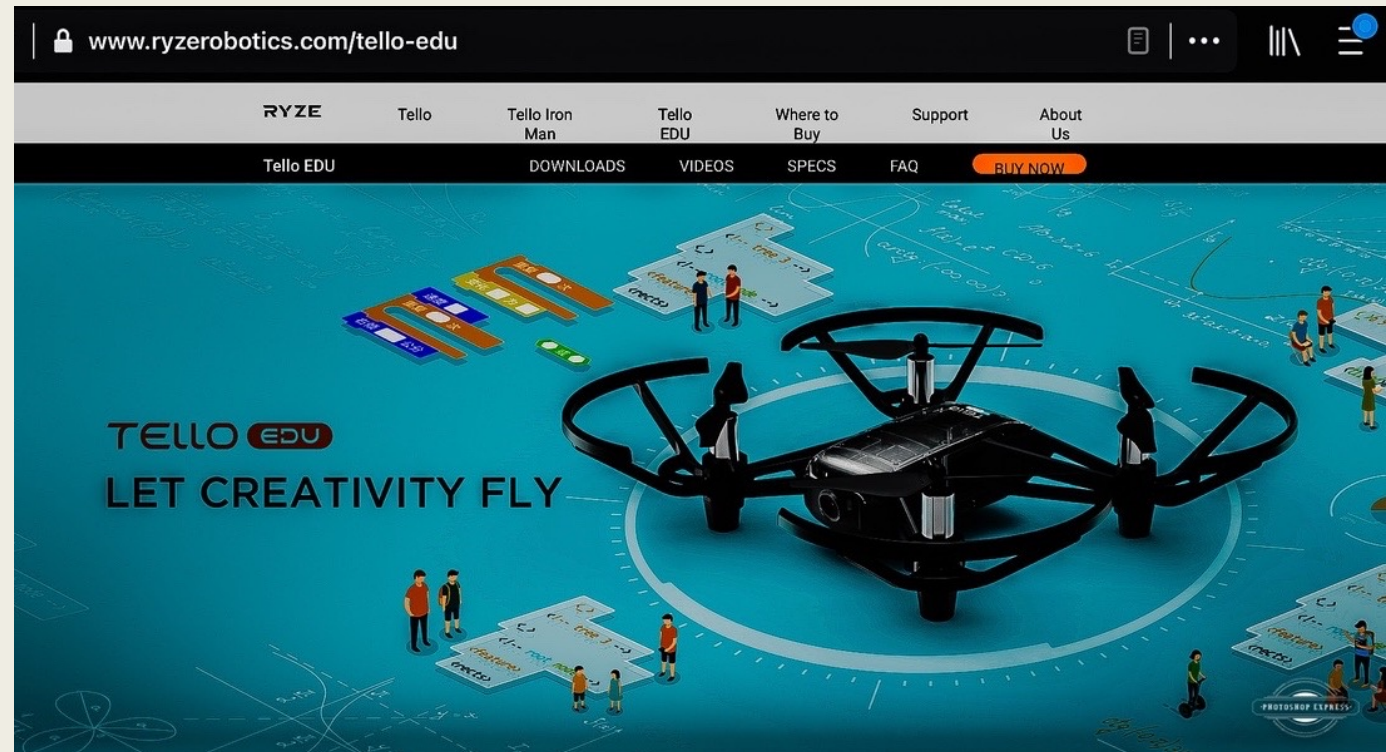


Tello EDU Drone Swarming Tutorial with Packet Sender and Python

- A new ~ \$100 drone called “Tello EDU, using DJI technology, is being used for experimentation and computer science education
- YouTube video 13:49
- Author: Dennis Baldwin
 - *This is a detailed overview of how to configure Tello EDU to swarm using Packet Sender and Python. You'll need an access point for to achieve this functionality. Here is the one I used in the video:*
- <https://youtu.be/clsddY4SKgA>

Thinking of Getting a Tello EDU Drone? Watch These Videos First!

- Tello EDU Drone 2020 Review
 - *Link*
<https://www.youtube.com/watch?v=6yWEUdLRs40>
- Ryze Tello vs Tello EDU – Best Beginner Drone? Learn to Fly, Learn to Code
 - *Link*
<https://www.youtube.com/watch?v=zEnQ91KTPeA>
- DJI Tello Drone Full Review – Should You Buy It?
 - *Link:*
<https://www.youtube.com/watch?v=IOWY2NNj3tE>
- Ryze Robotics Tello EDU website
 - *Link:* <https://www.ryzerobotics.com/tello-edu>
 - *Recommended source: DJI Store*



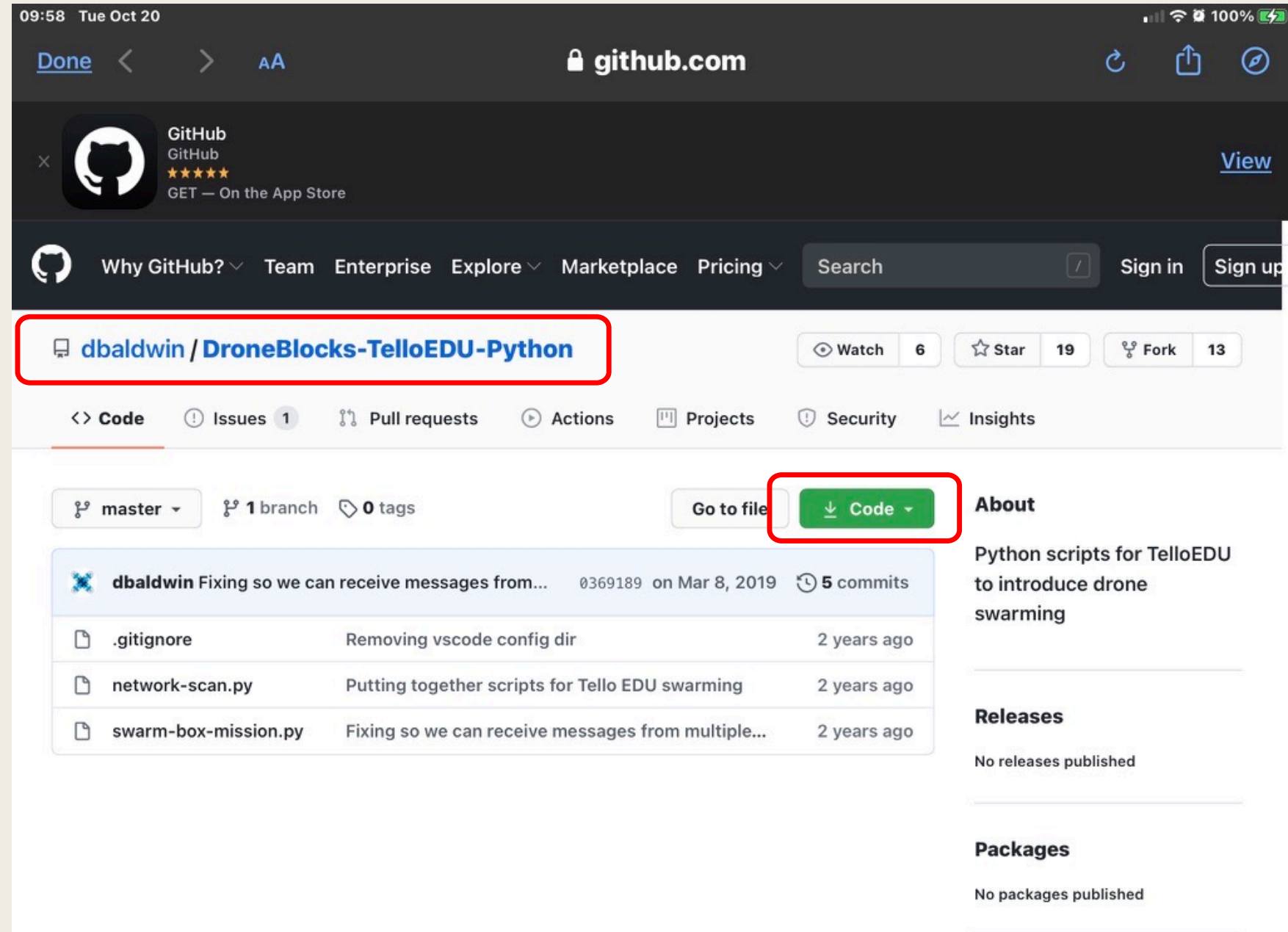
How to Download the Tello EDU Python Code

Download the drone swarming code from GitHub.

Use the **GREEN** Code downlink button.

Link:

<https://github.com/dbaldwin/DroneBlocks-TelloEDU-Python>



09:58 Tue Oct 20

Done < > AA github.com

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dbaldwin / DroneBlocks-TelloEDU-Python Watch 6 Star 19 Fork 13

<> Code Issues 1 Pull requests Actions Projects Security Insights

master 1 branch 0 tags Go to file Code

dbaldwin Fixing so we can receive messages from... 0369189 on Mar 8, 2019 5 commits

.gitignore	Removing vscode config dir	2 years ago
network-scan.py	Putting together scripts for Tello EDU swarming	2 years ago
swarm-box-mission.py	Fixing so we can receive messages from multiple...	2 years ago

About
Python scripts for TelloEDU to introduce drone swarming

Releases
No releases published

Packages
No packages published

FLIGHT PLANNER TUTORIALS



Parrot Anafi Flight Plan Tutorial

- Parrot Anafi Flight Plan Tutorial
 - *YouTube Video 9:53*
 - *Author Shawn Williams*
 - *Gives a good “feel” for programming the Parrot Flight Planner, which is remarkably like the DJI Flight Planner in actual both user interface and flight operation. (They use the same API)*
 - <https://www.youtube.com/watch?v=XS14u9A68B4>
- Parrot Anafi is typically available for \$450 or less, complete with stabilized gimballed cameras, GPS, controller and batteries. It is popular for use by commercial operators, like realtors, landscapers, and power line survey companies. It is approved for purchase by US DOD operators. Versions with Infrared cameras, UV sensors, etc. are available at added cost.

DJI Flight Planner Tutorial

- DJI Flight Planner Tutorial
 - *YouTube video 6:24*
 - *Useful tutorial showing how to program the DJI Flight Planner, an automated flight management system used with an entire range of DJI drones ranging in price from about \$400 (DJI Spark, DJI Mavic Mini) to much more expensive units. DJI drone come with stabilized, gimbaled cameras and GPS costing several thousand dollars. Most of the recent DJI models also feature collision avoidance, which is not offered by the inexpensive Tello EDU Drone.*
 - https://www.youtube.com/watch?v=cC_XVms9JMw
- DJI drones are NOT allowed to be used by US DOD operators due to a concern for cyber hacking.

THANK YOU!

