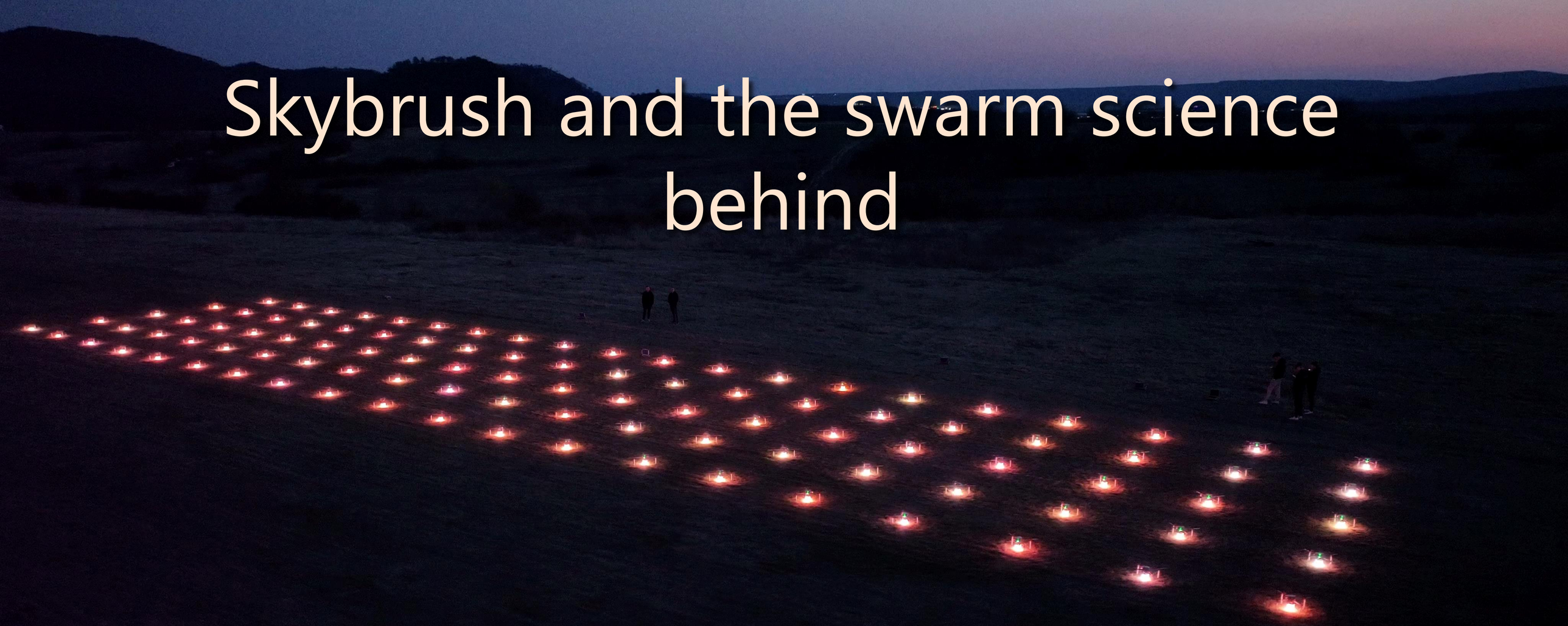
Skybrush and the swarm science behind



Gábor Vásárhelyi, PhD
CollMot Robotics Ltd. + ELTE Dep. Biol. Phys.
RSS Aerial Swarm Tools and Applications Workshop
Delft, 2024.07.19.

CollMot Robotics Ltd.

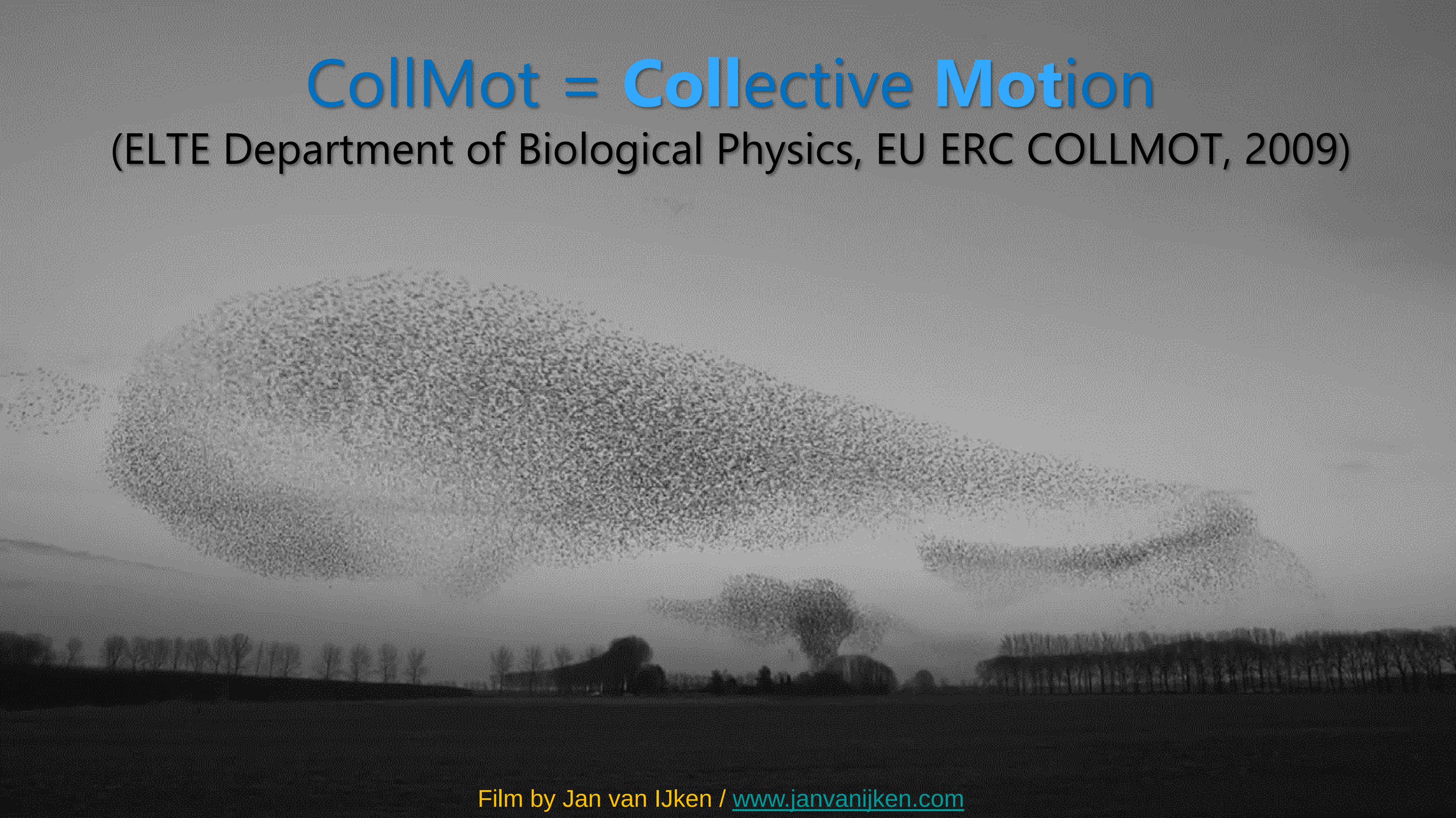
Vision: widespread industrial usage of intelligence drone swarms with high-tech, innovation-driver products and services, providing social benefits on an international scale with global impact

- Founded in 2015 at Eötvös University (ELTE), Hungary, researcher-owned
- Strong R&D (ELTE research support, R&D projects, Skybrush)
- Commercial income (drone shows, precision agriculture, dual use)
- Swarm-related SW development, SW+HW products, expert services
- Relaxed but continuous growth, no investors, open-source business model

https://collmot.com | https://skybrush.io | info@collmot.com

CollMot = Collective Motion

(ELTE Department of Biological Physics, EU ERC COLLMOT, 2009)

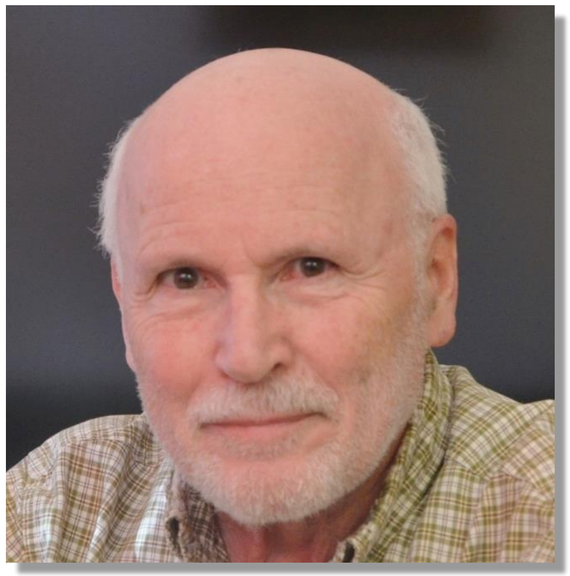


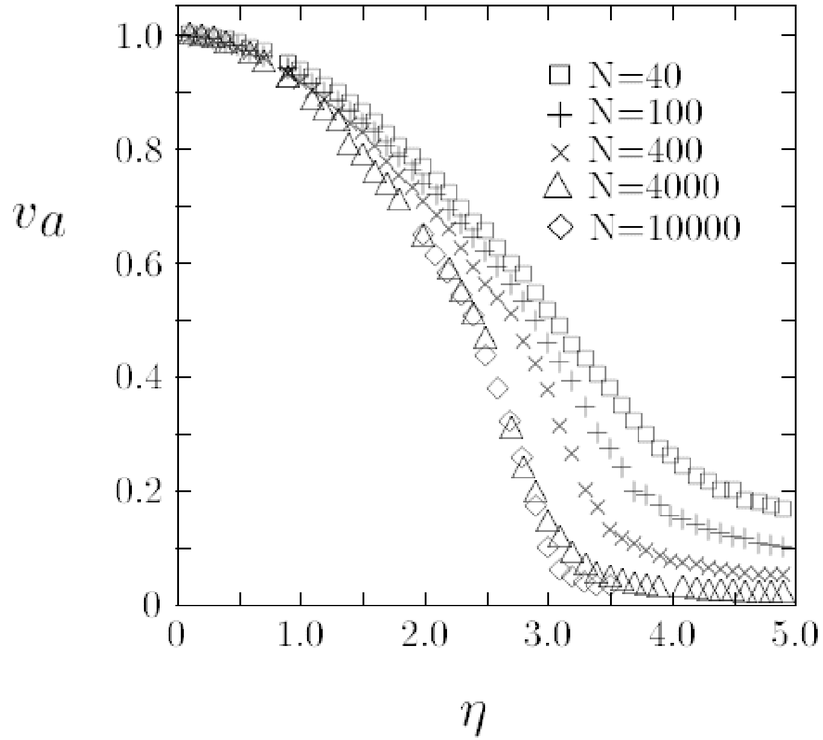
Film by Jan van IJken / www.janvanijken.com

Tamás Vicsek and the Vicsek-model

8401 citations since 1995 (Google Scholar)

- Non-eq. statistical physical description of biology
- **Self-propelled particles**, active matter
- Velocity alignment + noise

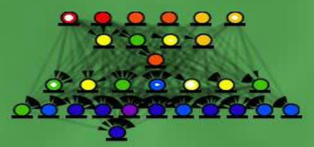


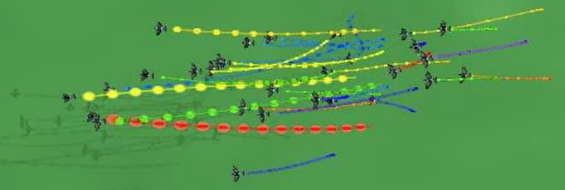


2020 Lars Onsager award: Tamás Vicsek, John Toner and Yuhai Tu; 2021 Nobel prize in physics: Giorgio Parisi

Vicsek, T.; Czirok, A.; Ben-Jacob, E.; Cohen, I.; Shochet, O. (1995). "Novel type of phase transition in a system of self-driven particles". Physical Review Letters

Collective





[1] COLLMOT Research Project, Department of Biological Physics, Eötvös University
[2] OxNav Research Group, Department of Zoology, University of Oxford

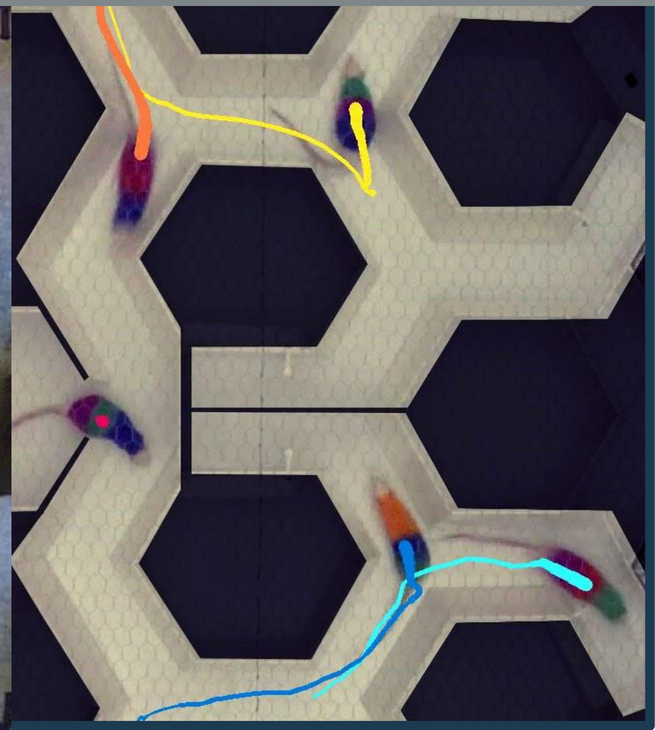
2x speed

0 1 5 10 meters
0 5 10 25 feet

intelligence

[1] COLLMOT Research Project, Department of Biological Physics, Eötvös University
[2] OxNav Research Group, Department of Zoology, University of Oxford

FQ Feeding-Queuing
Automatically identified interactions
Feeding
Queuing



Drone swarm research @ ELTE

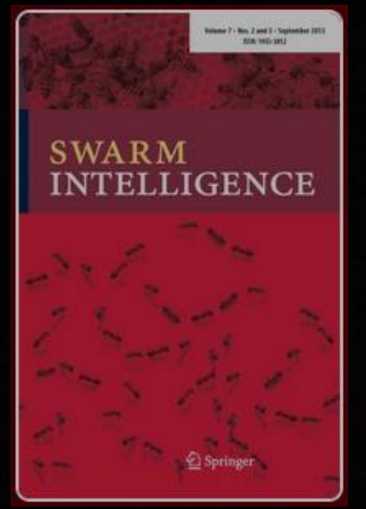
2014 IROS + Bioinsp.	2018 ICRA + Science Rob.	2020 J. R. Soc. Interface	2024 Swarm Intelligence
10 drones (100 in simulation)	30 drones (1000 in simulation)	50 drones (2500 in simulation)	100 drones (5000 in simulation)
flocking / formation flights / collective target tracking	flocking / traffic	flocking	traffic
proof-of-concept swarm autonomy realistic simulation framework	advanced dynamic model evolutionary optimization walls, obstacles	adaptive-leadership active info sharing large-scale stability heterogeneity, high speed	predictive path planning optimized interactions group interest focus

https://hal.elte.hu/drones

Flocking with 50 drones (2020)

https://hal.elte.hu/drones

Traffic with 100 drones (2024)



https://hal.elte.hu/drones

Custom drone fleet since 2016

AutoPilot: Pixhawk family
Onboard SBC: Odroid / Raspberry Pi / NVIDIA AI / Texas AI
Communication: 433/866 MHz SiK/XBee/LoRa + 2.4/5GHz Wi-Fi
Positioning: RTK GNSS

Onboard software: Linux, C / Python
Low-level flight controller: ArduCopter + MAVLink
High level swarm control: FlockCtrl (onboard) + Skybrush (ground)

Drone light shows

https://collmot.com

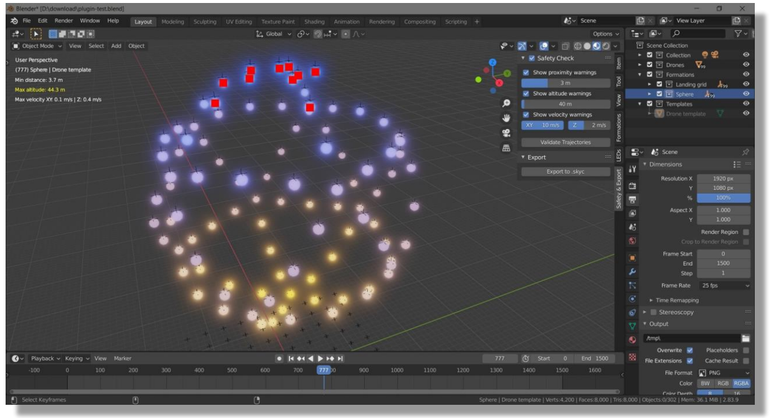
Photo: CollMot / Zsolt Bézsenyi

Photo: MTI / Zoltán Máthé

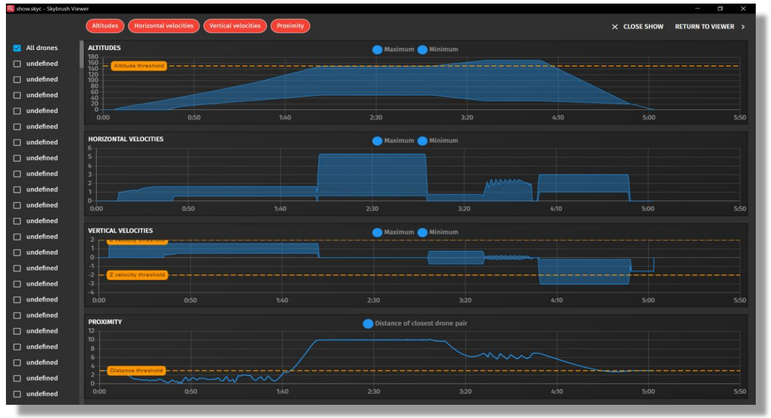
SKYBRUSH®

PROFESSIONAL DRONE FLEET & DRONE SHOW MANAGEMENT

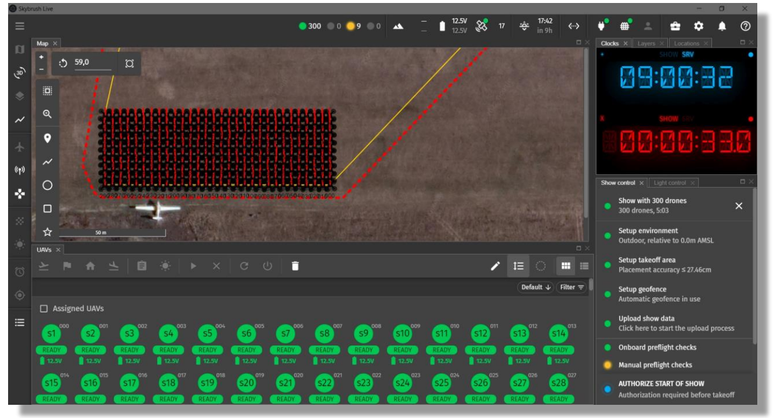
Studio



Viewer

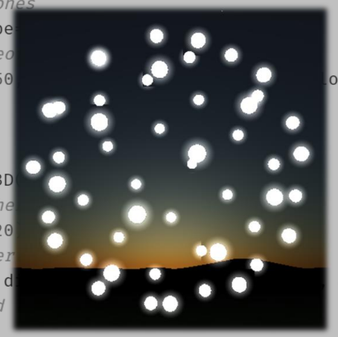


Live



SkyScript

```
# create a takeoff grid for 50 drones
takeoff_grid = create_2d_grid(shape
# create a drone swarm at the takeo
drones = create_drone_swarm(size=50
# make the drones take off
drones.takeoff()
# create a sphere formation
sphere = create_sphere(center=Pos3D
# make the drones morph to the sphe
drones.morph_to(sphere, duration=20
# make the sphere rotate around ver
drones.rotate(center=Pos3D(z=30), d
# drones should return to home and
drones.return_to_home()
```



Server

```
PS C:\Users\ubi\git\skybrush-server> poetry run skybrushd
[12:40:08]    server                  Starting Skybrush serv
          √   skybrush                Loaded configuration f
[12:40:09]    logging                 Storing logs in 'C:\Us
              logging                 Logging started
              gps                     Listening for incoming
          ▲   hotplug                 No suitable backend fo
              http_server             Starting HTTP server o
              flockctrl   wireless    Connection at 10.1.43.
          ▲   mavlink                 Move the 'connections'
              mavlink     mav         Routing primary traffi
              mavlink     mav         Routing RTK correctior
              mavlink     mav         Routing RC overrides t
              sidekick                Listening for Skybrush
              mavlink     mav         Connection at :14550 u
[12:40:13]    clients     sio5:PI2tv  Client connected
```

https://skybrush.io

design, validation ⇨ visualisation, sharing ⇨ execution, monitoring

Opened in May, 2022

1500+ Discord users
150+ GitHub forks

Extendible server for swarm applications

Onboard swarm-level control

VIP support, custom solutions

SKYBRUSH® ecosystem is **open-core**

https://github.com/skybrush-io

Open-source drone firmware

Community support on Discord

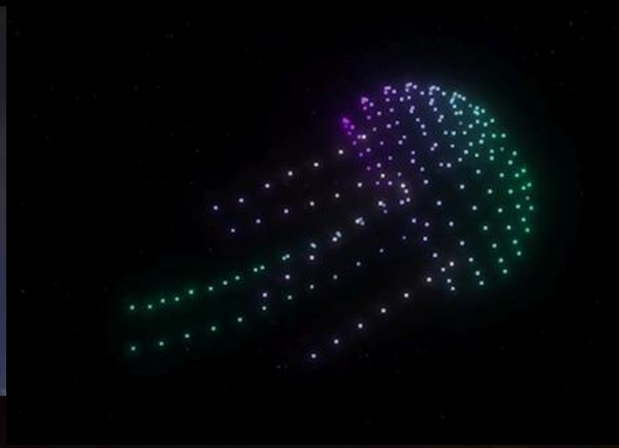
Open-source GCS backend and frontend

High quality code, transparent documentation

Open-source comm. protocols, file formats

Shows from SKYBRUSH users

https://skybrush.io/r/discord/



WohnderDrone A10

powered by

SKYBRUSH®

CollMot robotics

MouldTech Systems

https://www.wohnderdrone.hu/a10

Back

The National Laboratory for Cooperative Technologies

NATIONAL LABORATORY FOR COOPERATIVE TECHNOLOGIES

Field of Operation

Software-in-the-loop (SITL) drone **swarm** simulator

CollMot robotics

- **SITL**: running on real code, small (but never zero!) reality-gap
  - Skybrush base station backend and user interface
  - Multiplied onboard SITL environment (many ArduCopter + FlockCtrl instances)
  - RC transmitter integration
- External **Flight Simulator** integration
  - AirSim/AutonomySim/Gazebo/…, virtual 3D environment and flight simulation
  - Rendered 3D visuals → virtual computer vision, environment perception…
- Safe and efficient **swarm development** with quick testing iterations
- **User feedback** for future swarms, ideas, inspiration
- Realistic and safe test environment, optimal user **learning phase**

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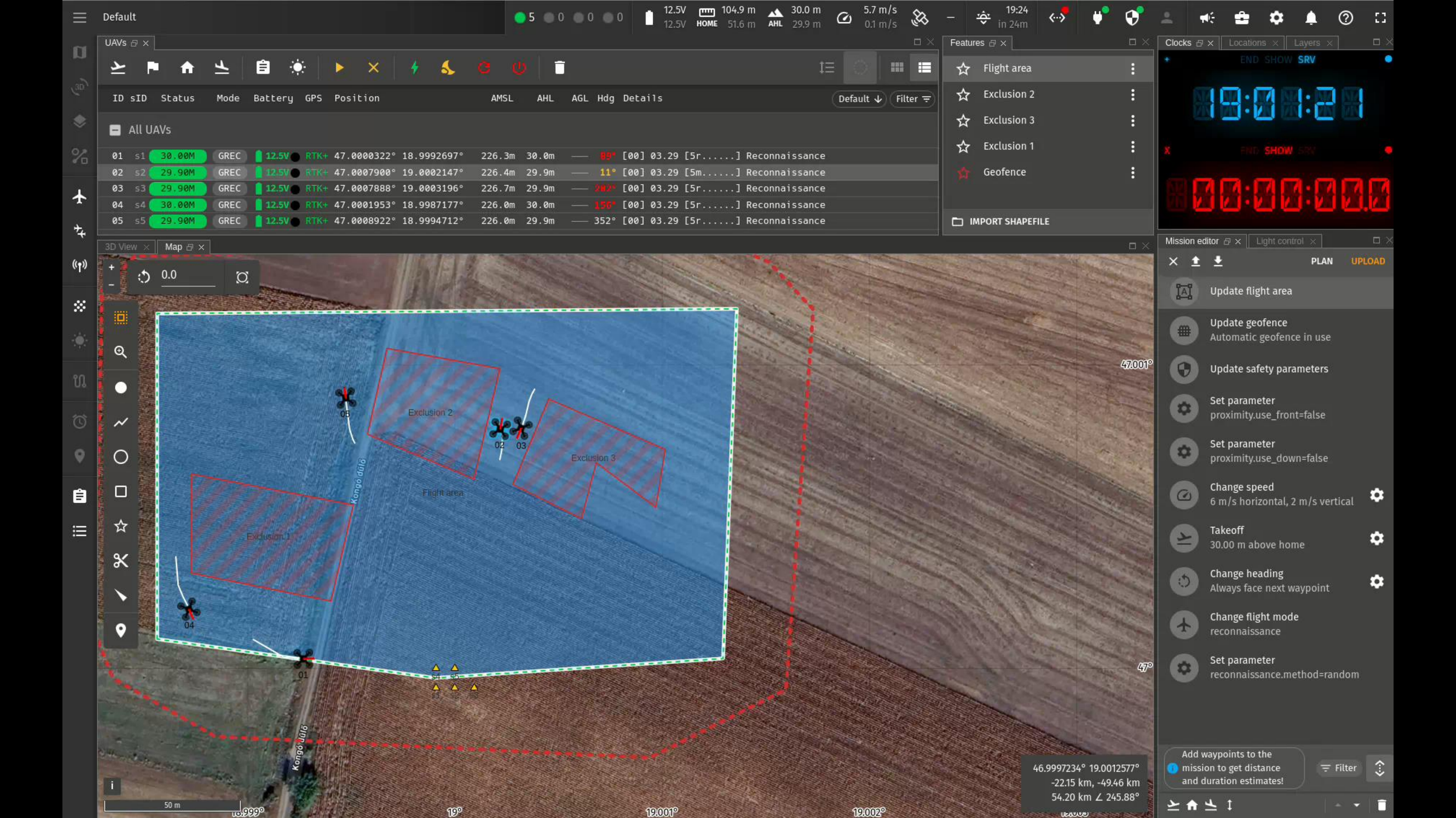
Default
5 0 0 0
12.5V 12.5V
HOME 104.9 m 51.6 m
AHL 30.0 m 29.9 m
5.7 m/s 0.1 m/s
19:24 in 24m
UAVs
ID sID Status Mode Battery GPS Position AMSL AHL AGL Hdg Details
Default
Filter
All UAVs
01 s1 30.00M GREC 12.5V RTK+ 47.0000322° 18.9992697° 226.3m 30.0m — 89° [00] 03.29 [5r.....] Reconnaissance
02 s2 29.90M GREC 12.5V RTK+ 47.0007900° 19.0002147° 226.4m 29.9m — 11° [00] 03.29 [5m.....] Reconnaissance
03 s3 29.90M GREC 12.5V RTK+ 47.0007888° 19.0003196° 226.7m 29.9m — 282° [00] 03.29 [5r.....] Reconnaissance
04 s4 30.00M GREC 12.5V RTK+ 47.0001953° 18.9987177° 226.0m 30.0m — 156° [00] 03.29 [5r.....] Reconnaissance
05 s5 29.90M GREC 12.5V RTK+ 47.0008922° 18.9994712° 226.0m 29.9m — 352° [00] 03.29 [5r.....] Reconnaissance
Features
Flight area
Exclusion 2
Exclusion 3
Exclusion 1
Geofence
IMPORT SHAPEFILE
Clocks
Locations
Layers
END SHOW SRV
19:01:21
FNT SHOW SRV
00:00:00.0
3D View
Map
0.0
Exclusion 2
Exclusion 3
Exclusion 1
Flight area
Kongó útló
05
02
03
04
01
S1
S5
47.001°
47°
19°
19.001°
19.002°
50 m
46.9997234° 19.0012577°
-22.15 km, -49.46 km
54.20 km ∠ 245.88°
Mission editor
Light control
PLAN
UPLOAD
Update flight area
Update geofence
Automatic geofence in use
Update safety parameters
Set parameter
proximity.use_front=false
Set parameter
proximity.use_down=false
Change speed
6 m/s horizontal, 2 m/s vertical
Takeoff
30.00 m above home
Change heading
Always face next waypoint
Change flight mode
reconnaissance
Set parameter
reconnaissance.method=random
Add waypoints to the mission to get distance and duration estimates!
Filter

Cooperation possibilities

CollMot robotics

1. Skybrush is open-core, do what you want first ☺ … and let's cooperate on advanced projects and ideas
2. R&D project+grant partnership involving applications of drone swarms
3. Application-driven swarm HW+SW product development for commercial use
4. Full-stack swarm simulator usage (brain-storming, testing, education, training, experimentation)
5. Strategic partnership with soft-XOR competences for accelerating growth

https://collmot.com | https://skybrush.io | info@collmot.com

Thank you for your attention!

Tamás Nepusz

Founder/Head of IT

Our senior code guru and benevolent IT dictator.

Gergő Somorjai

Founder/Co-CEO

Senior hardware engineer who also runs day to day operations of CollMot.

Gábor Vásárhelyi

Founder/CEO

Senior physicist, engineer, programmer and thinker.

Csilla Vitályos

Head of Sales

Sales, marketing and business development expert.

SW+HW: István Donkó, Marcell Zahorán, Gergely Vadász
K+F: Pedro Lacerda, András Zábó
admin: Helga Kucsera, Szilvia Szalai

info@collmot.com

Check out the Skybrush SITL simulator!