Drone Human-Centered Interfaces summary

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Drone Human-Centered Interfaces

- UAV control
- Telemetry
- RF Remote Controllers
- Flight modes
- Commercial HCIs
- Tools and HRI interfaces for (intelligent) UAV cinematography
- Director Dashboard
- Flight Supervisor Dashboard

Introduction

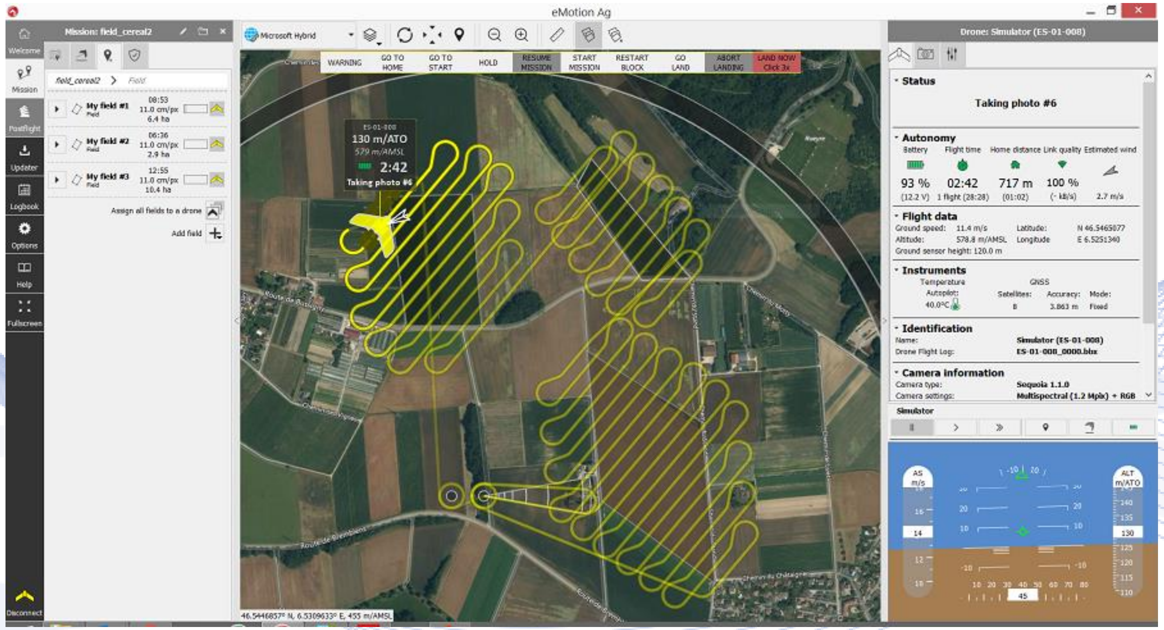
- Controlling a drone and planning a flight/mission involves Human-Robot (Drone) Interaction (HRI) through appropriate interfaces
- These interfaces shall be also capable of presenting comprehensive information regarding the status of the drone and its mission
- In this presentation we will deal with HRI issues related to drone control

Drone Human-centered Interfaces

- **Human-Drone Interaction using a Remote Control or software applications**
  - **Targeting average drone users (DJI Go), or professionals (DJI GS PRO, Pix4D Capture etc)**
- Human-Drone Interaction tools and interfaces for drone cinematography
  - Research works, products
  - MULTIDRONE project GUIs (Director's Dashboard, Supervision Station)

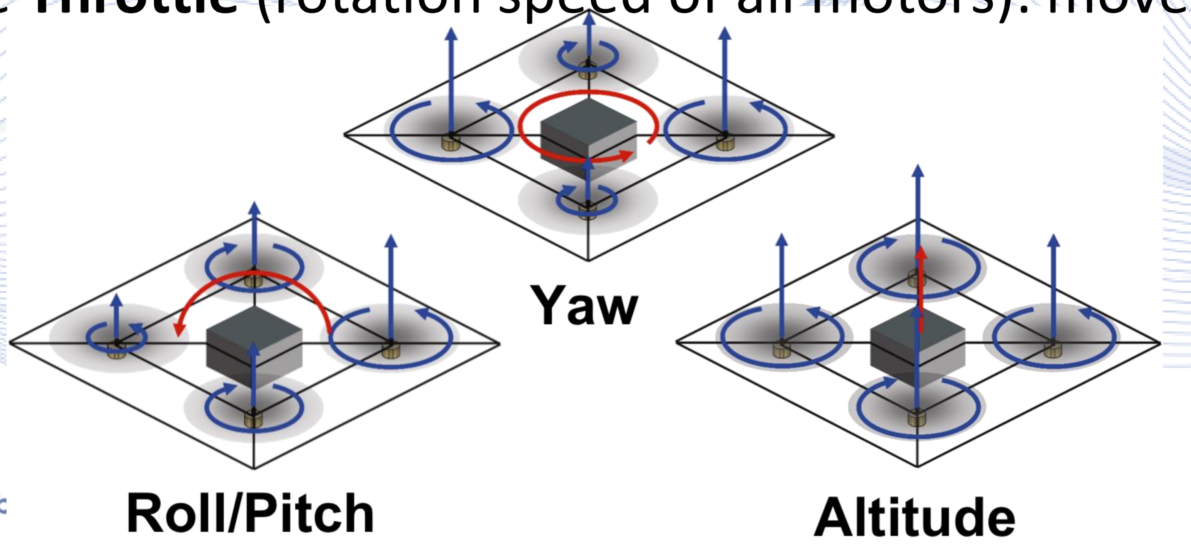
UAV control

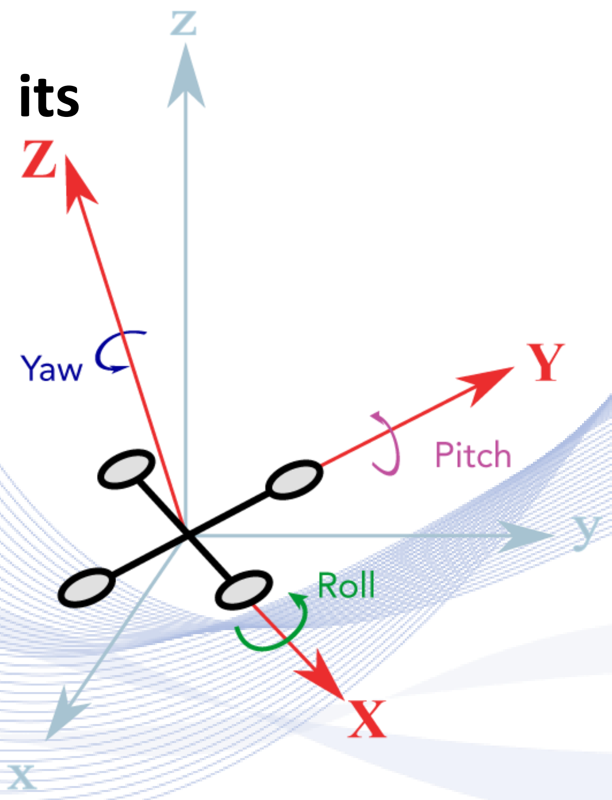
- Remote Control
- Application



Roll – Pitch – Yaw- Throttle

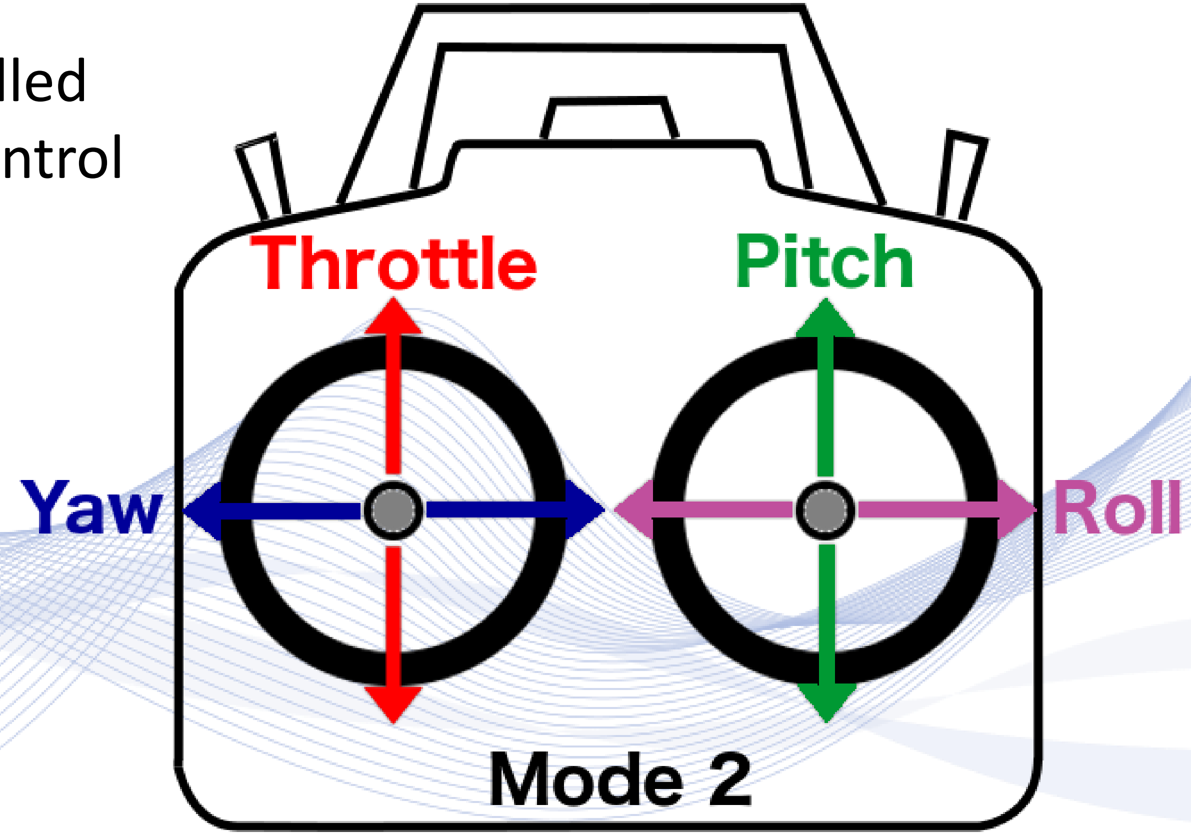
- In order for a UAV to follow a certain path, the pilot has to control three angles: **roll-pitch-yaw**.
- Changing the **yaw** angle, will result in UAV **rotating around its vertical axis**.
- Changing the **pitch** angle: move **forward or backward**
- Changing the **roll** angle: move **right or left**.
- Changing the **Throttle** (rotation speed of all motors): move up/down





Roll – Pitch – Yaw- Throttle (Remote Control)

- These angles and throttle are controlled by the movements of the remote control sticks:
  - Left stick: throttle and yaw angle
  - Right stick: pitch and roll angles



Telemetry

- During a flight it is very important for the pilot to be aware of the **flight status**
  - Battery voltage, remaining flight time
  - Position (GPS), distance from take-off point
  - Horizontal and vertical speed
  - Height (altitude)
  - Heading (compass)
  - Alerts (damaged subsystem)
- Such information is received through **telemetry**

Telemetry

- Telemetry information display options:
  - OSD Telemetry: Display on a standalone screen
  - RC telemetry: Display on remote control
  - In app telemetry: Display on smartphone/tablet screen

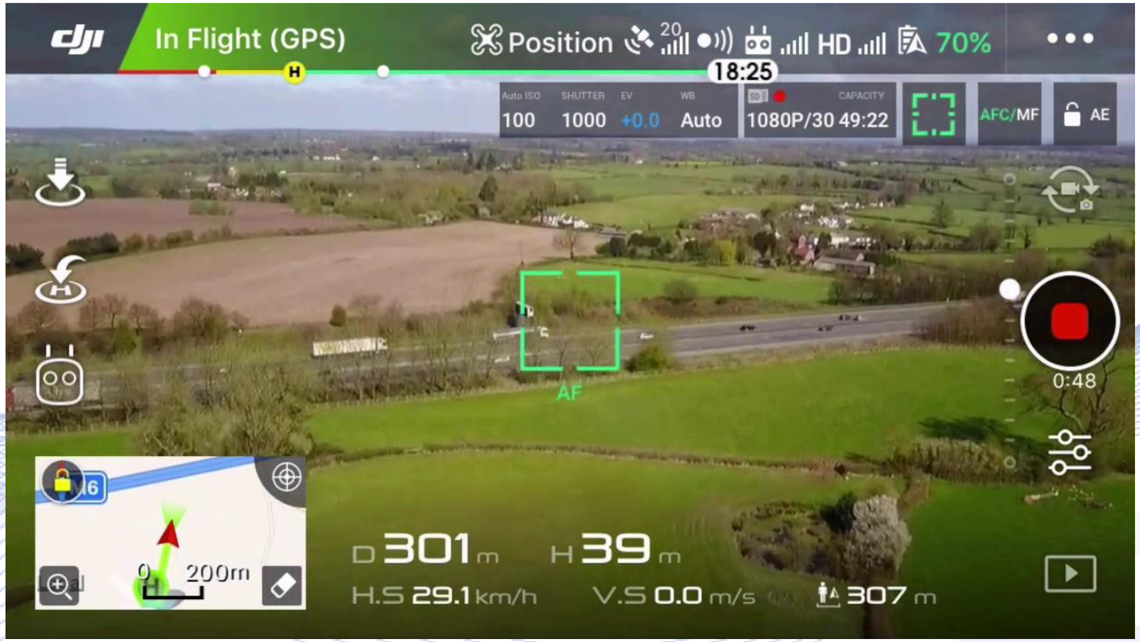
RF Remote Controllers

- Radio Frequency (traditional) Remote Controllers are still widely used in drones and other remotely controlled devices
- Drone control through apps running in smartphones / tablets / laptops is becoming more and more popular

Example: DJI Go Main Interface

- UAV status (altitude, distance from take-off, speed etc.)
- Camera settings
- UAV location on a map
- Remote control settings
- Video feed from camera

- Start recording/take photo
- Adjust gimbal
- Auto take-off/land



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DJI GO Intelligent Flight Modes

- **ActiveTrack**: mark a moving object on the mobile device screen and let the drone track it while avoiding obstacles.
  - **Trace**: track a subject from behind
  - **Profile**: track a subject from the sides.
  - **Circle**: circle the subject at a set height, radius and speed.

DJI GO Intelligent Flight Modes

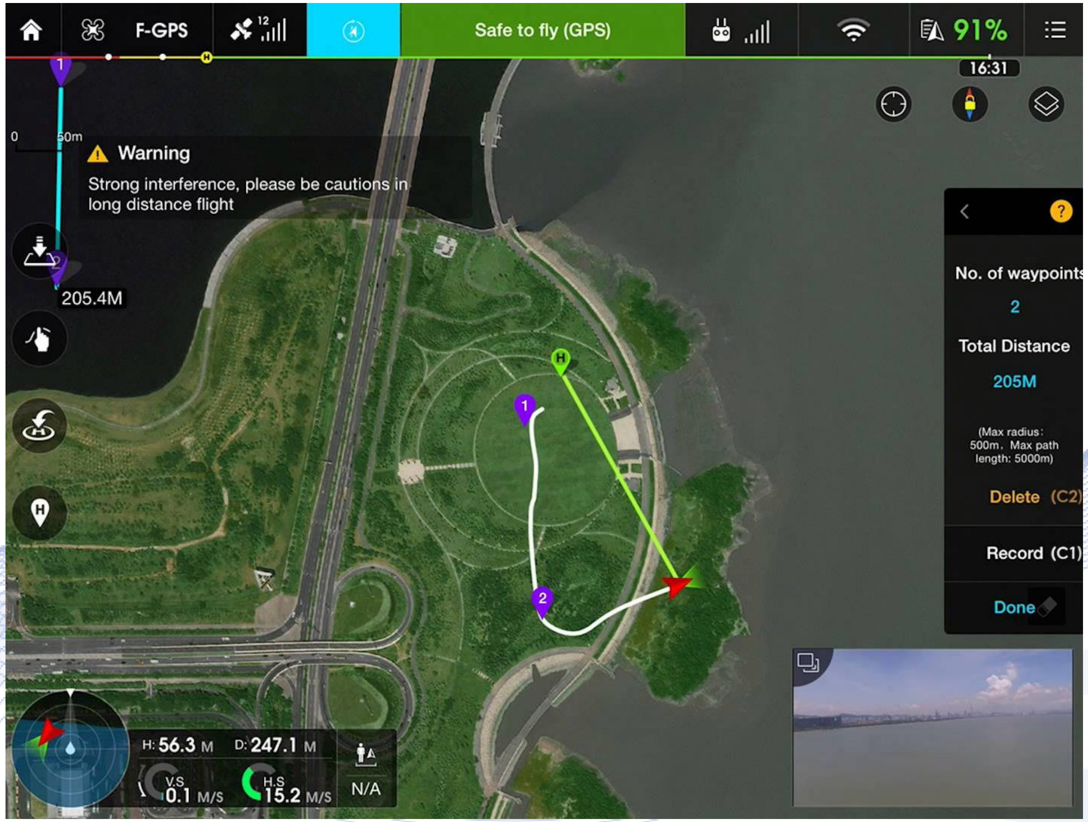
- **Gesture**: use certain gestures to control the UAV.

  - Take off
  - Move a closely flying drone by moving the palm

  - Increase/decrease the user-to-drone distance
  - Take selfies

DJI GO Intelligent Flight Modes

- **Draw**: fly along a flight path drawn on-screen on a map. As it flies, UAV will automatically brake and hover when it detects obstacles



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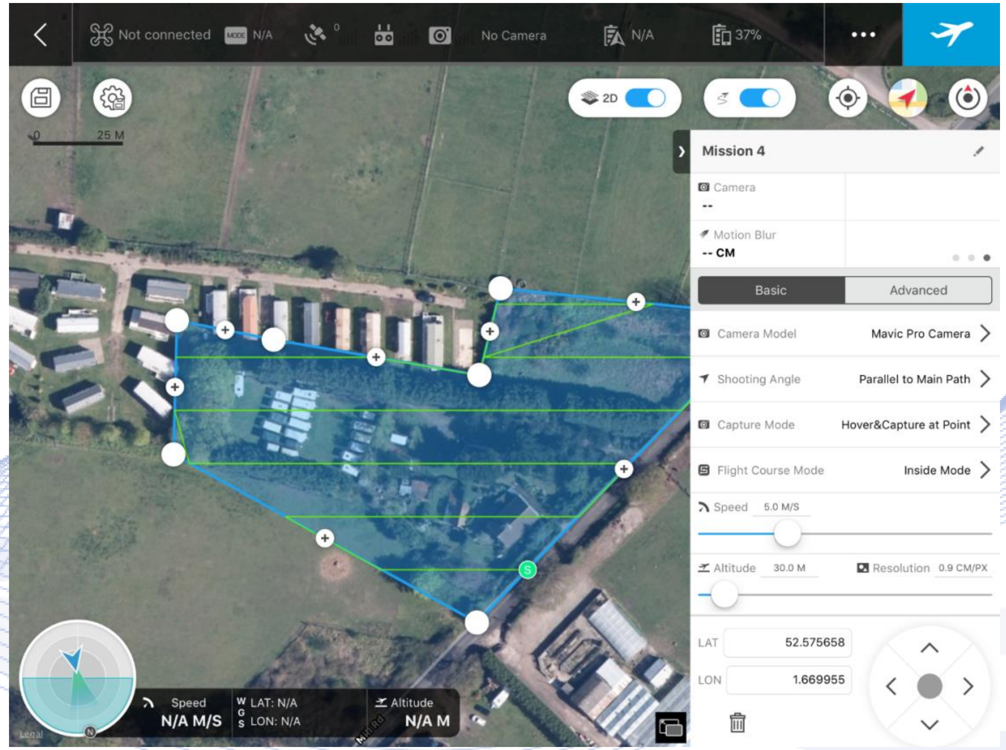
DJI GS Pro

- **More advanced** application, targeting professionals
- The pilot creates **Flight Missions** and sets the parameters of the flight
    - Virtual Fence Mission
    - 3D Map Area Mission
    - 3D Map POI Mission
    - Waypoint Flight Mission
- Drone flies **autonomously** in order to complete the desired task

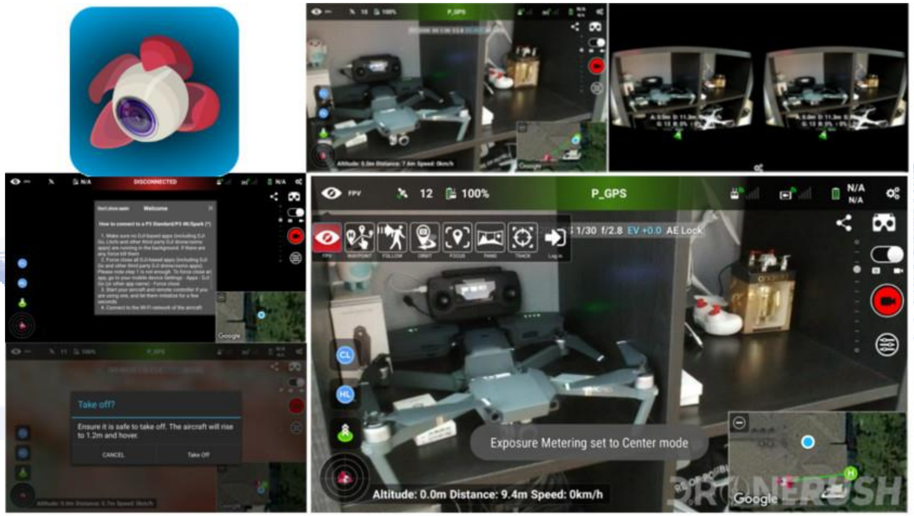
DJI GS Pro

- 3D Map Area Mission/3D Map Point of Interest Mission
  - GS Pro automatically generates efficient flight paths to “scan” an area set by the user on a map.
  - The recorded image data can be used to e.g. generate 3D maps.



Other applications

- There are many other smartphone/tablet applications that are designed for UAV control
- Usually they offer similar features with apps like DJI Go or used for more specific tasks (e.g. Pix4D Capture – 3D models)



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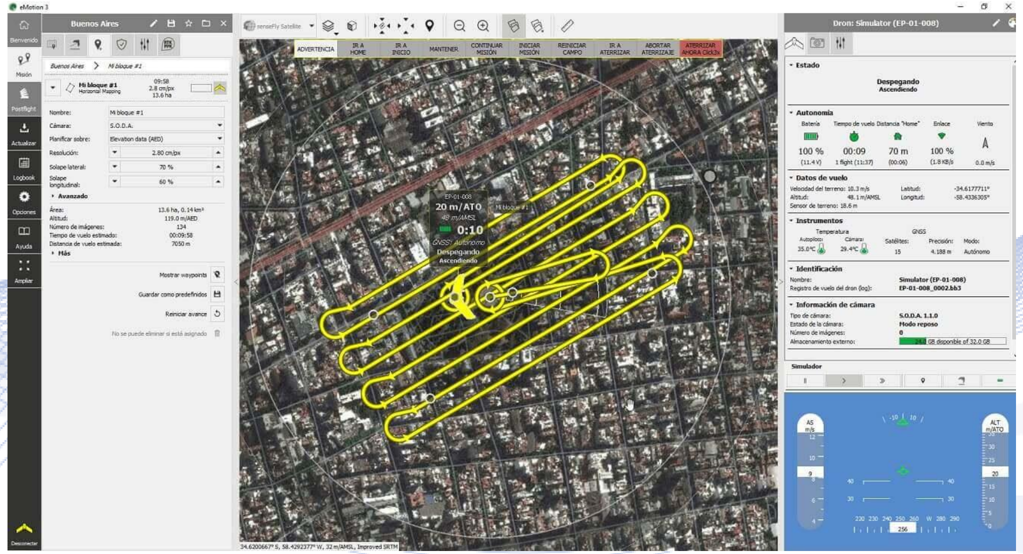
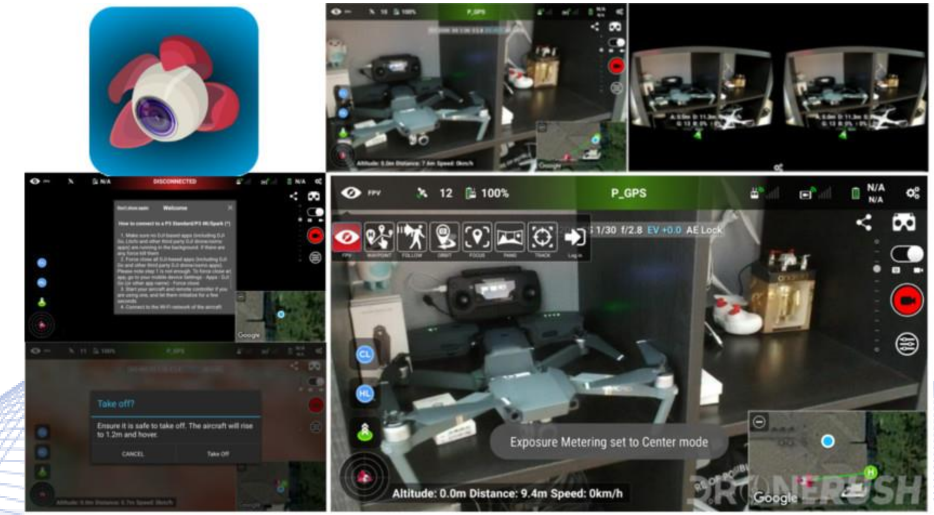
SenseFly eMotion

- Pilot can set a polygonal area on the map and the software automatically determines the path in this area
- The flight can be simulated by the software with e.g., certain wind speed, before the actual execution
- Pilot monitors the flight and can pause or abort the mission
- Used for mapping large areas, photogrammetry etc.

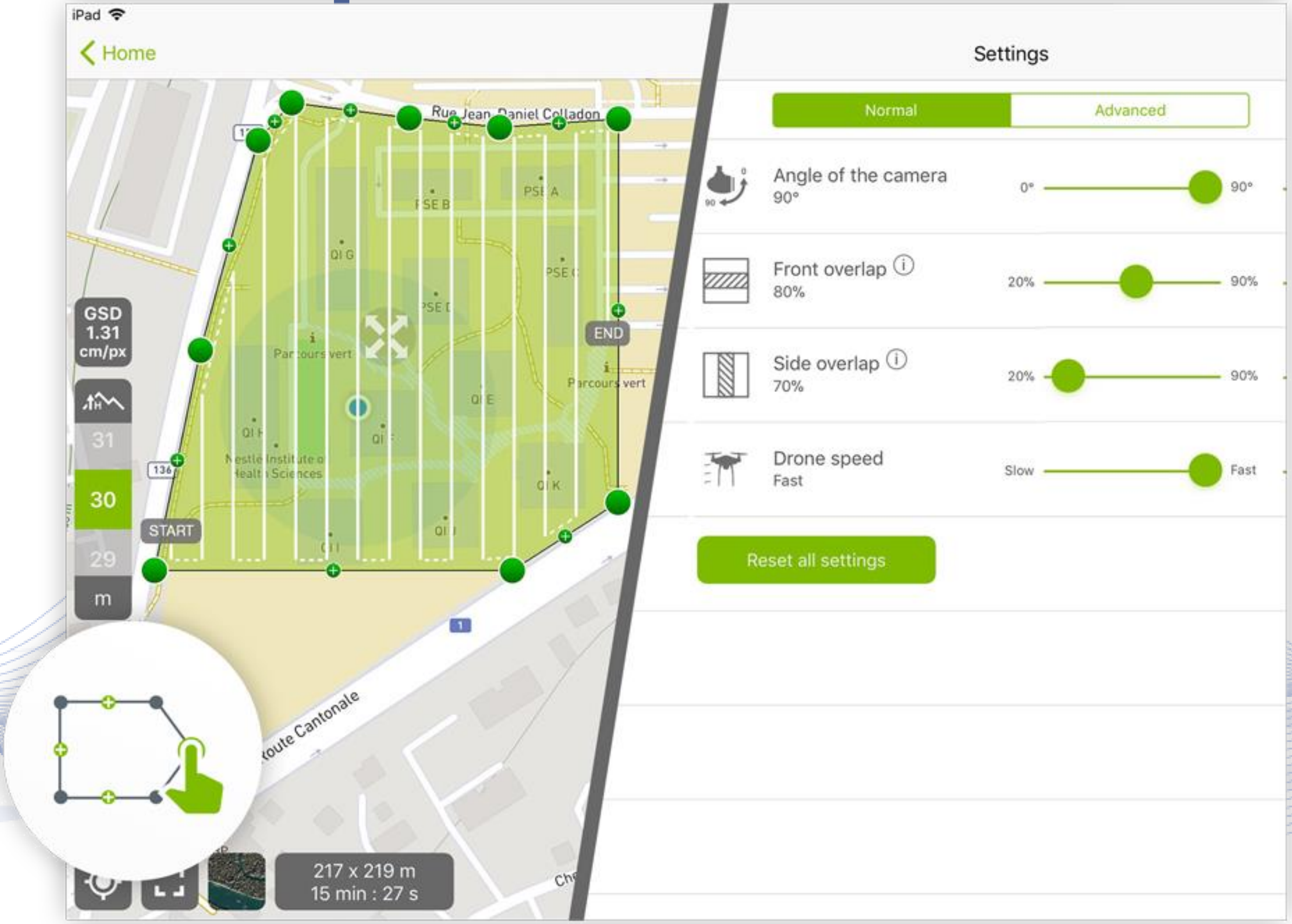


Litchi

- A more advanced alternative to DJI Go
- More options for camera settings
- Waypoint flights
- Panorama mode
- Focus assist mode
- Target tracking mode
- Better and more informative flight logs than DJI Go

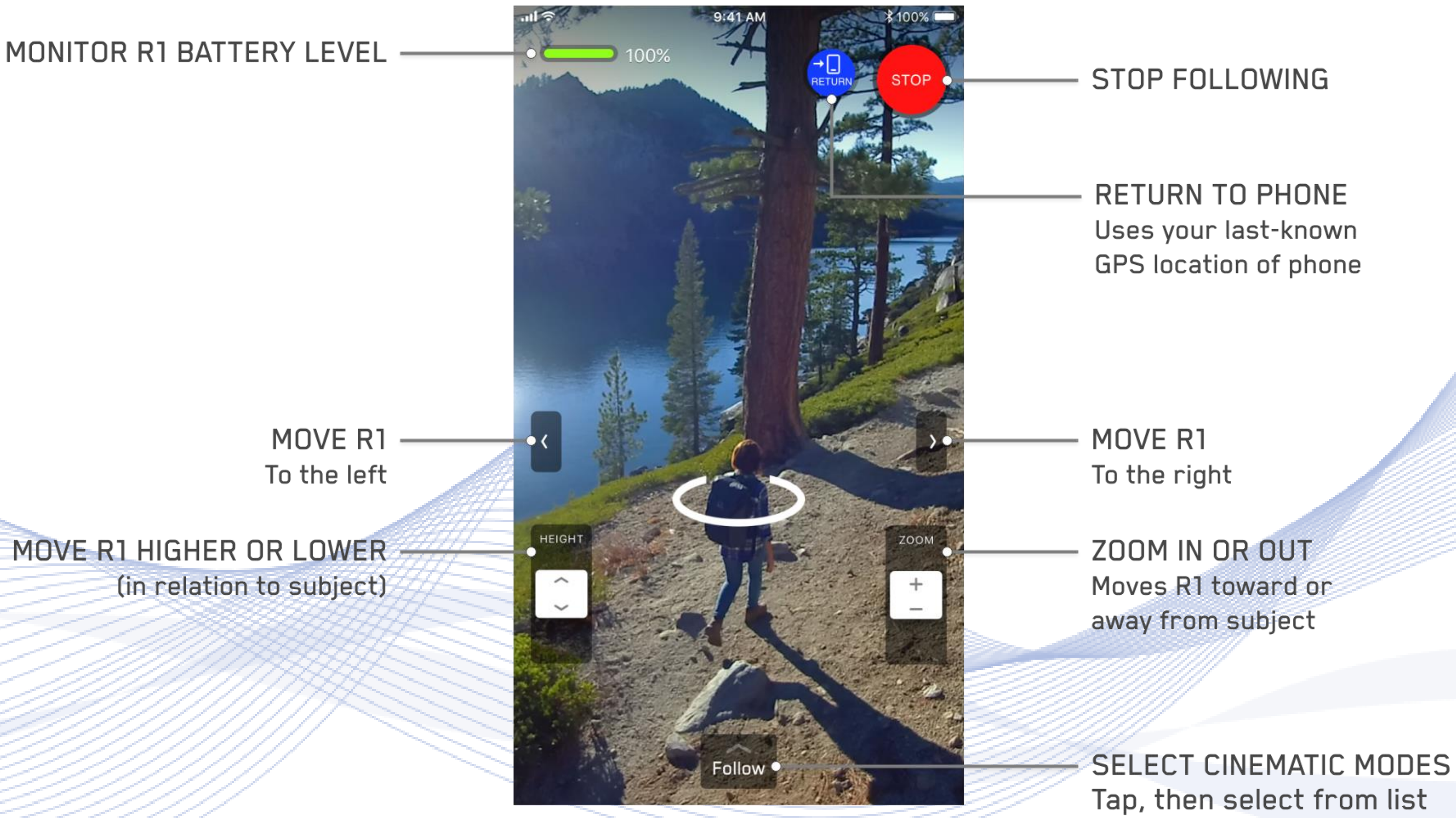


Pix4D Capture - Interface



Skydio mobile application

- Due to its autonomy R1 is very easy to control
- No RC needed, just a mobile with the app
- Gestures for take-off/land
- Easy selection of cinematic modes



Flight Controls

Drone Human-centered Interfaces

- Human-Drone Interaction using a Remote Control or software applications
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- **Human-Drone Interaction tools and interfaces for drone cinematography**
  - **Research works, products**
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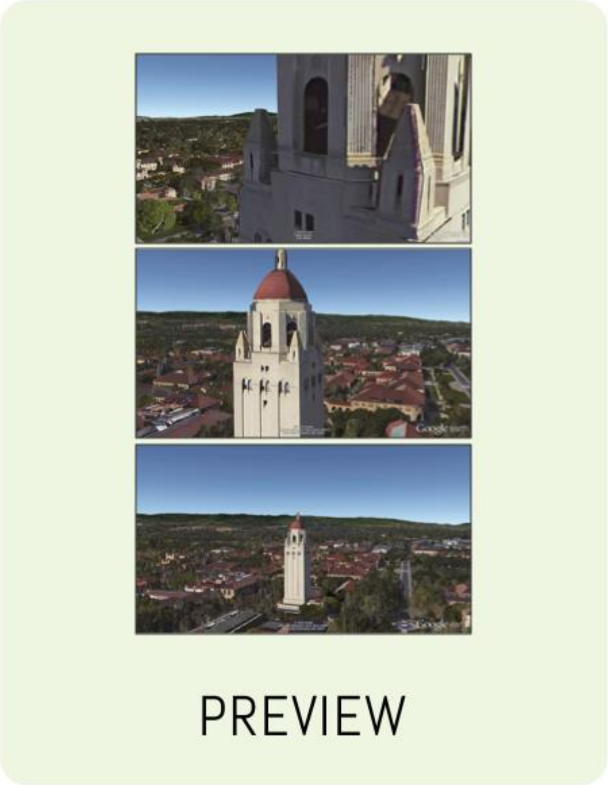
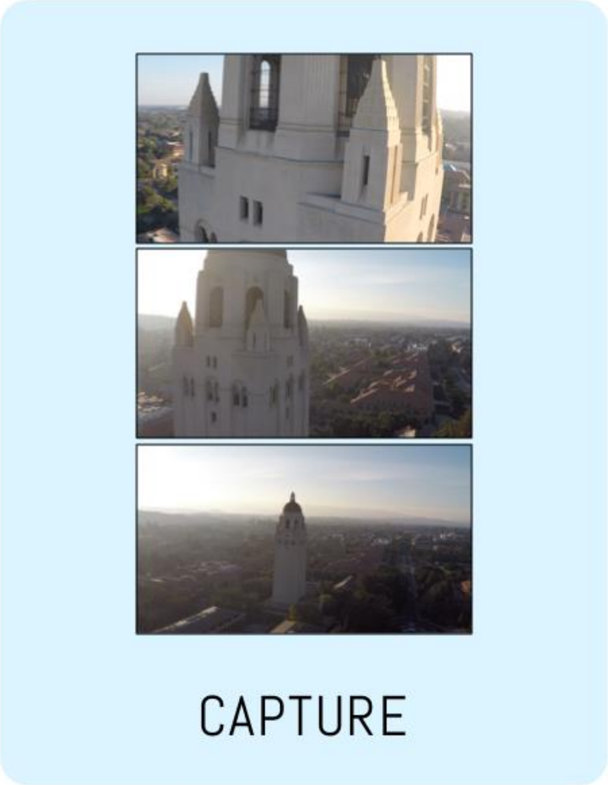
Tools and HRI interfaces for (intelligent) UAV cinematography

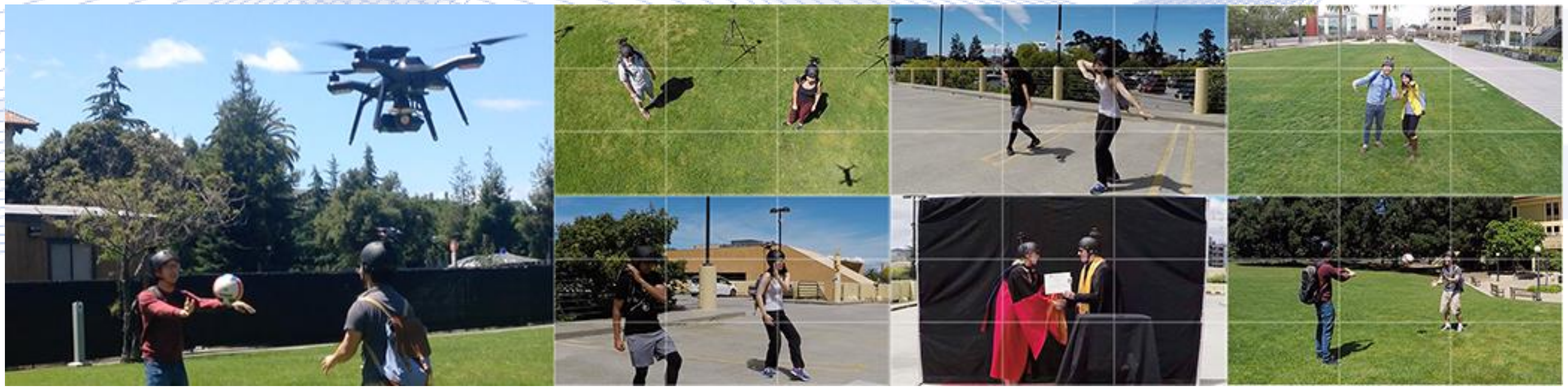
- **Preview** the resulting shots in a 3D environment.
- **Capture** the resulting shots in the real world using a UAV.





Tools and HRI interfaces for (intelligent) UAV cinematography

- Joubert et al (2016) present a system to capture drone video footage of human subjects performing rather limited movements:
  - Subjects are **tracked** using wearable **RTK GPS** and **IMU** sensors.
  - The system **automatically captures static (framing) shots** that respect visual composition principles (rule of 3rds).
  - It also automatically calculates **transitions** (drone trajectories and camera parameter configurations) between these shots.
  - Evaluated transitions are **feasible, safe** (e.g., not too close to humans), and **visually pleasing.**



N. Joubert, D. B. Goldman, F. Berthouzoz, M. Roberts, J. A. Landay, and P. Hanrahan, *"Towards a drone cinematographer: Guiding quadrotor cameras using visual composition principles"*, arXiv:1610.01691, 2016.

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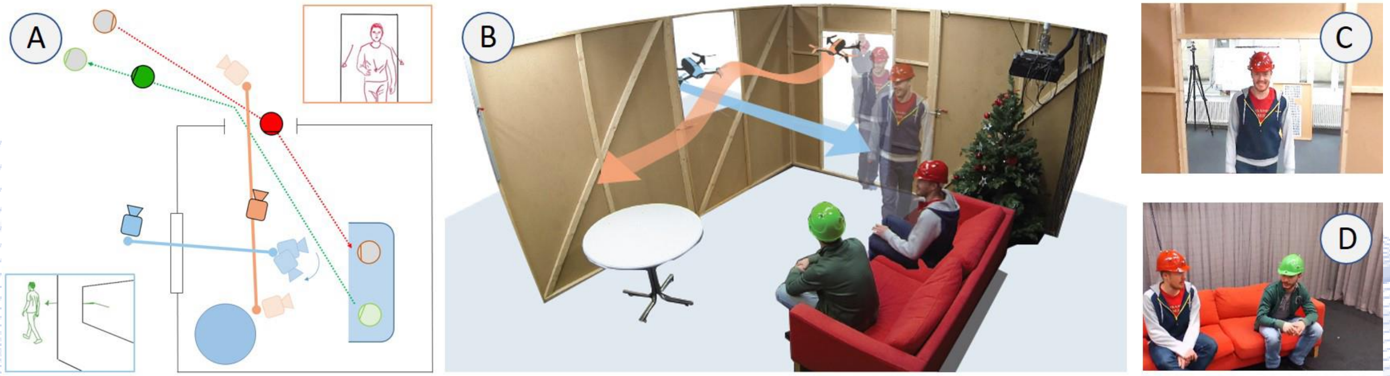
Tools and HRI interfaces for (intelligent) UAV cinematography

- Nageli et al (2017) propose a method for aerial videography planning in cluttered and dynamic environments.
- The method takes as input user specified, **high-level plans** (paths) and **framing objectives** (position and size of filmed person in the frame).
- The algorithm **adapts** the high-level plans in **real-time** to produce feasible drones trajectories, while also taking the **motion of the subjects** into account, e.g., to avoid collisions.



[Nageli2017b]: T. Nageli, L. Meier, A. Domahidi, J. Alonso-Mora, O. Hilliges, *"Real-time Planning for Automated Multi-view Drone Cinematography"*, ACM Transactions on Graphics, vol. 36, no. 4, pp. 132:1-132:10, SIGGRAPH 2017.

[Nageli2017a]: T. Nageli, J. Alonso-Mora, A. Domahidi, D. Rus, O. Hilliges, *"Real-Time Motion Planning for Aerial Videography With Dynamic Obstacle Avoidance and Viewpoint Optimization"*, IEEE Robotics and Automation Letters, vol. 2, no. 3, pp. 1696-1703, 2017.

Tools and HRI interfaces for (intelligent) UAV cinematography

- The algorithm can also handle **multiple drones:**
  - Drone to drone **collision avoidance**.
  - Drone path modification to prevent a drone from entering the field of view of other drones.

Tools and HRI interfaces for (intelligent) UAV cinematography

- **Skywand**:
  - A system utilizing **VR hardware (HMD, motion controllers)**
  - The user explores a 3D model of the scene and place desired, example key-frames in the environment.
  - The system computes the **UAV trajectory** and the sequence of **camera motions**, so as to capture **smooth footage** containing the key-frames.
  - Previsualization of the trajectory and the video is available.

Personnel and Roles

- The following people are involved in the MULTIDRONE system:
- **Director**. Person in charge of the media production. Specifies the shots to be taken by the drone team. He **interfaces** with the system through the **Director Dashboard**.
- **Supervisor Operator**. Person in charge of the security of the system. Through the **Supervision Station** he/she validates plans as safe, and gives a green light to the Director.
- **Drone Pilots.** For security & legal reasons, each drone has a human pilot, to take over in case of emergency.
- **Cameramen**. In charge of the drone camera, to take manual control if required by Director.

Dashboard & MULTIDRONE ecosystem interaction

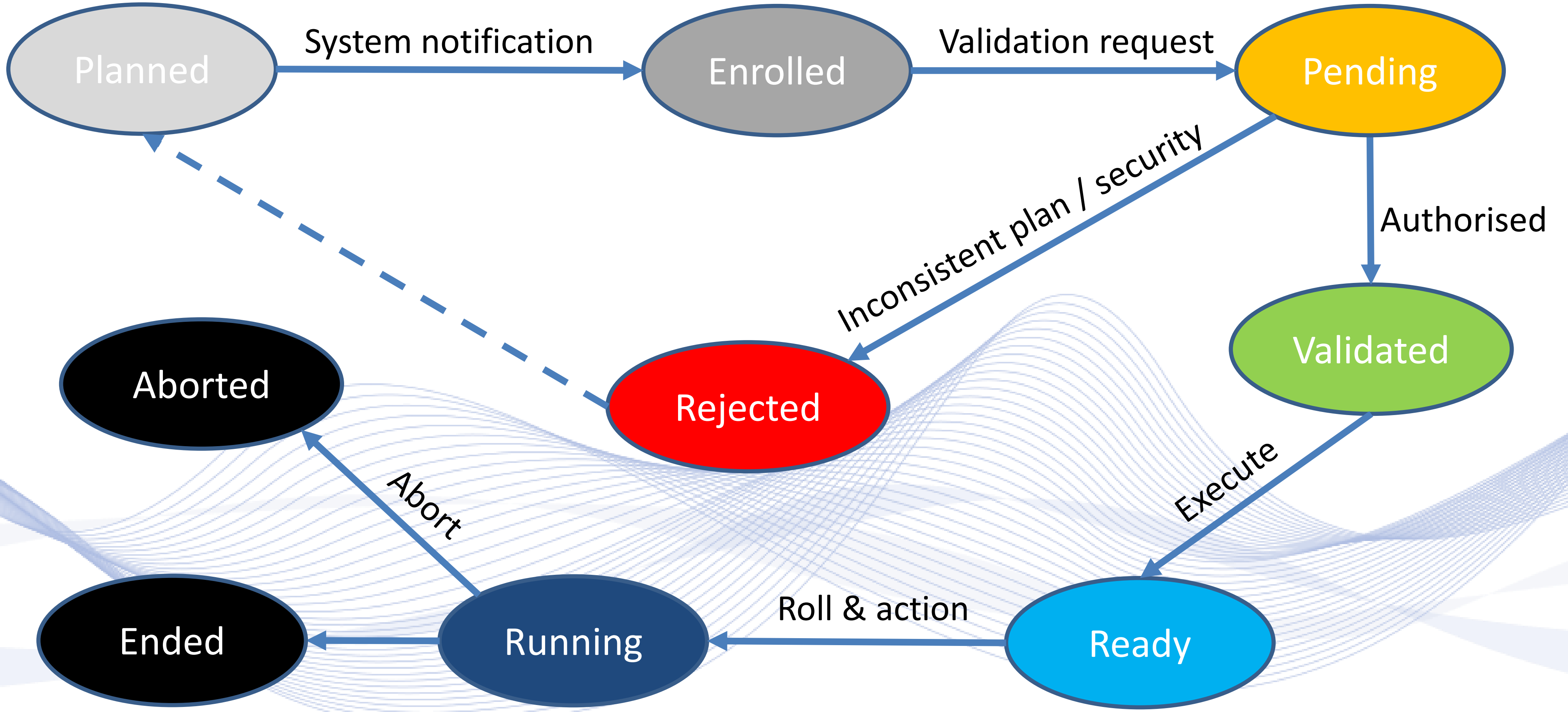
The Director Dashboard

- REST services:
  - GET *Mission & drone status*
  - POST *Send event & mission, select role, director events*

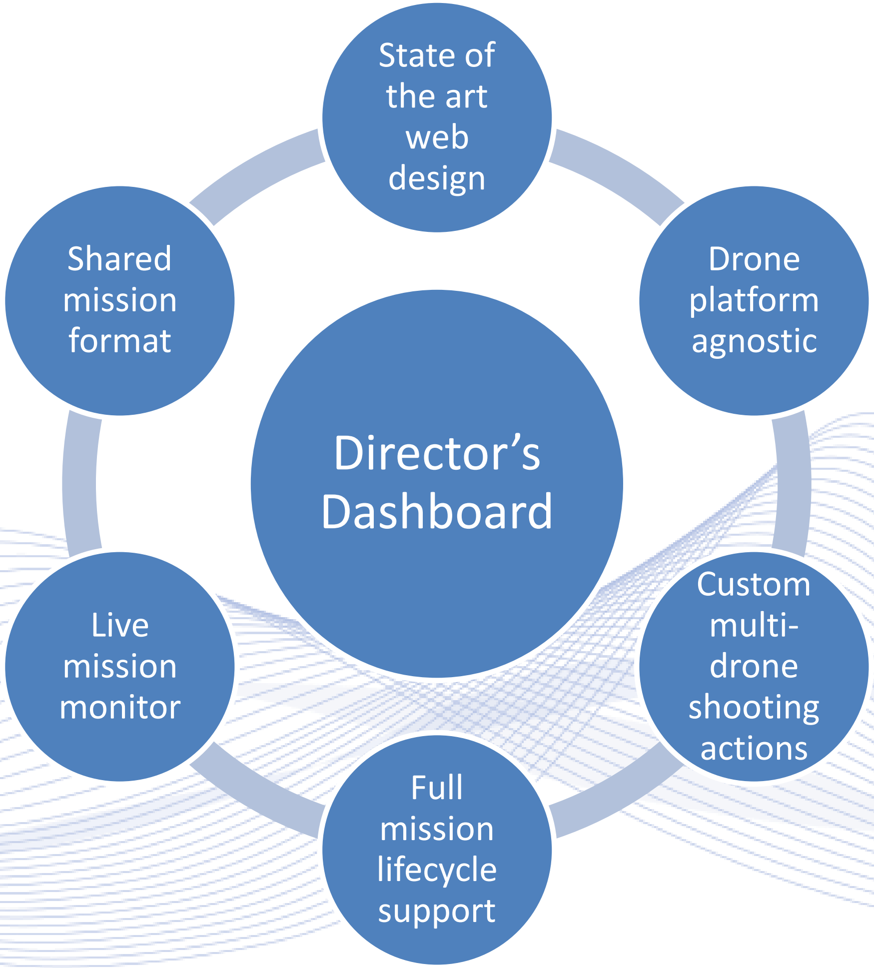
The MULTIDRONE ecosystem (e.g. Mission Controller, Event Manager)

- ROS topics (*Mission status*) and services (*Send event / mission, Select role, Director events*)

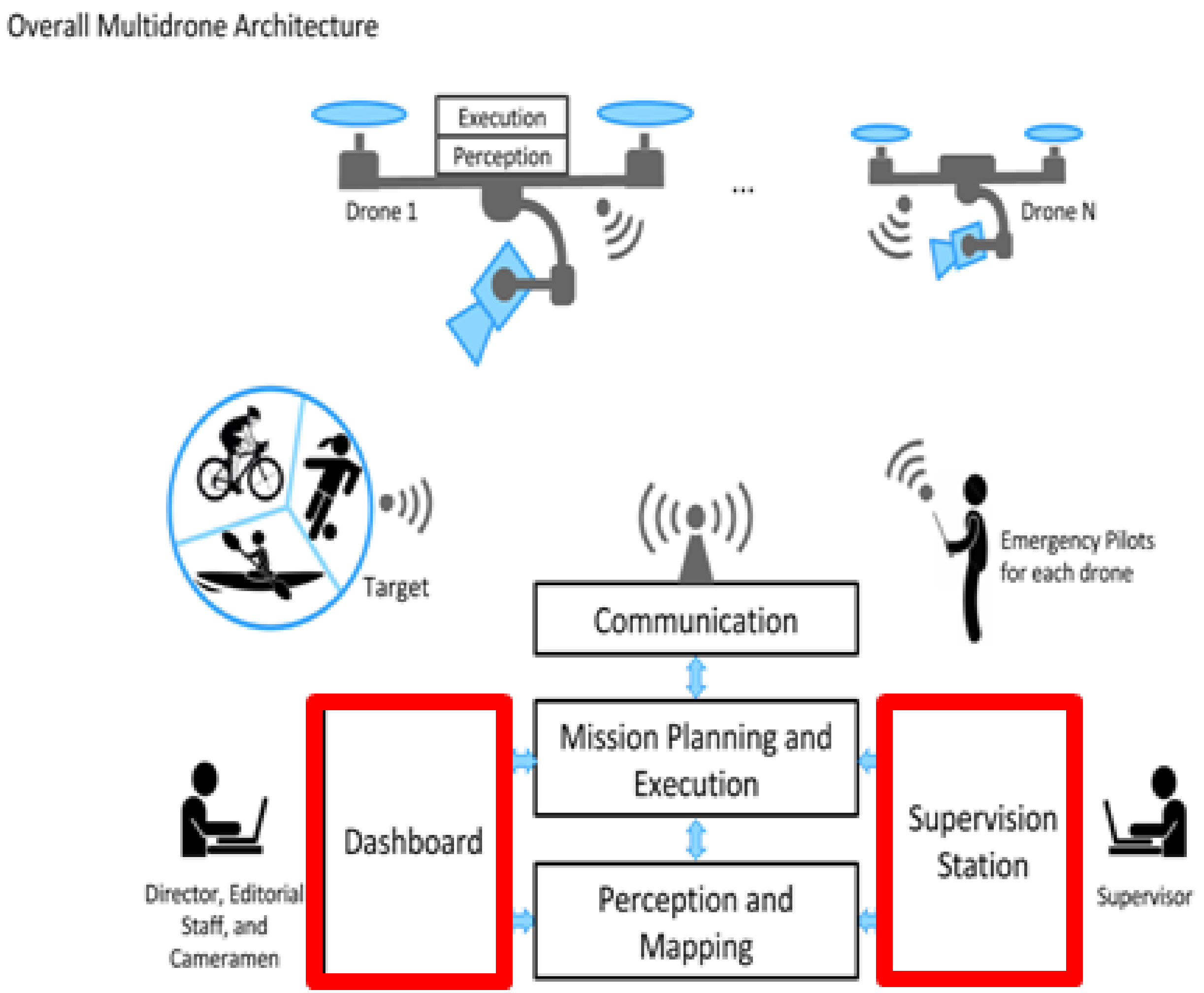
Mission lifecycle



Key concepts



Overall Multidrone Architecture



- Director’s Dashboard
- Supervision Station

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Director’s Dashboard

- Main concept: “**Event of Interest” (EOI)** i.e., a real world event that is associated with a certain time & location, a characterising action and a set of actors playing different roles in the action

Example: a goal, a race start

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- A Shooting Action is characterised by its type (e.g. orbit) and parameters (e.g. radius, height and speed of orbit).
- In each Shooting Action a set of Shooting Roles can be identified

A Shooting Role is a role acted by one or more drones

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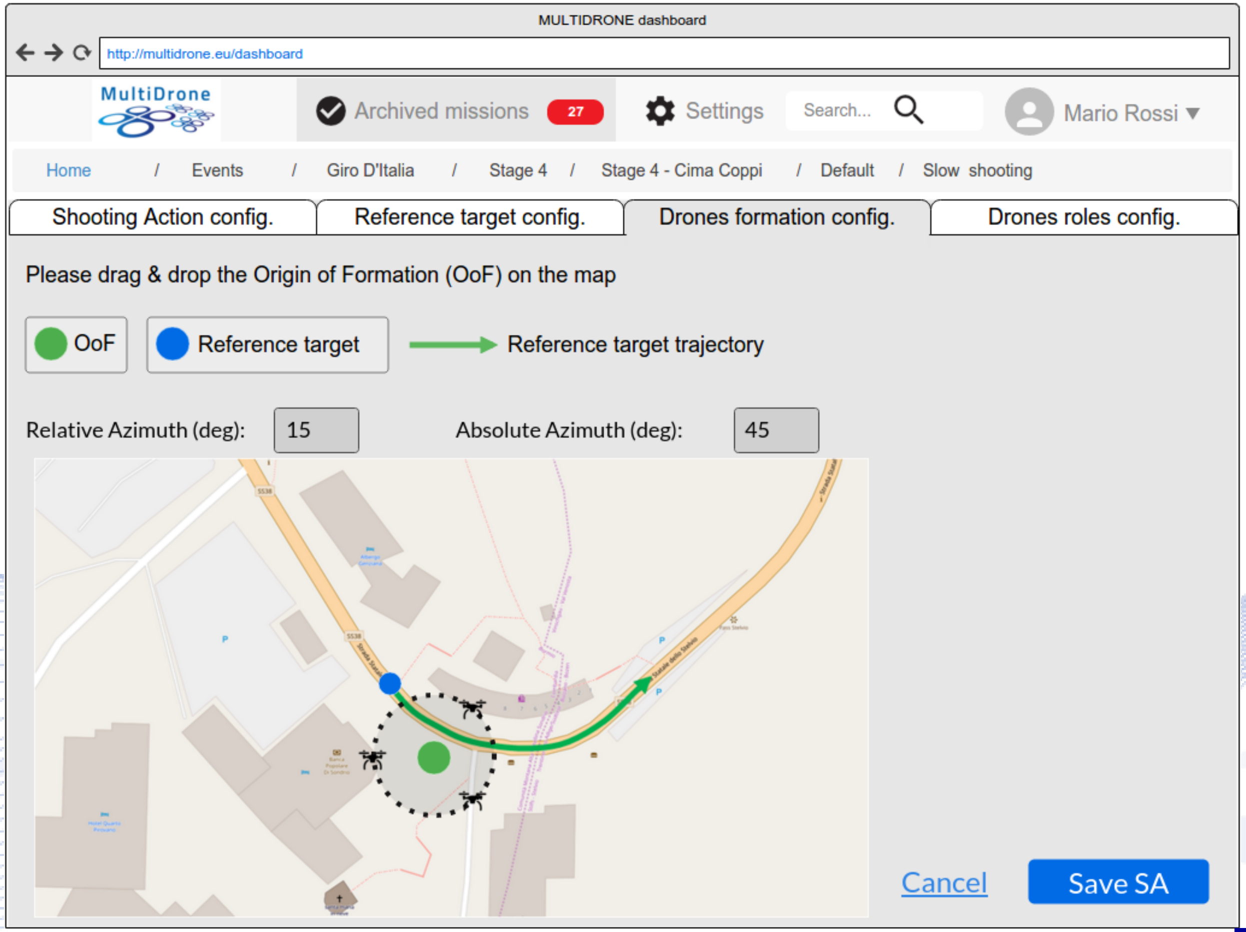
* The **Shooting Action** is normally associated with a reference target (RT) around which the formation and the shooting will take place.

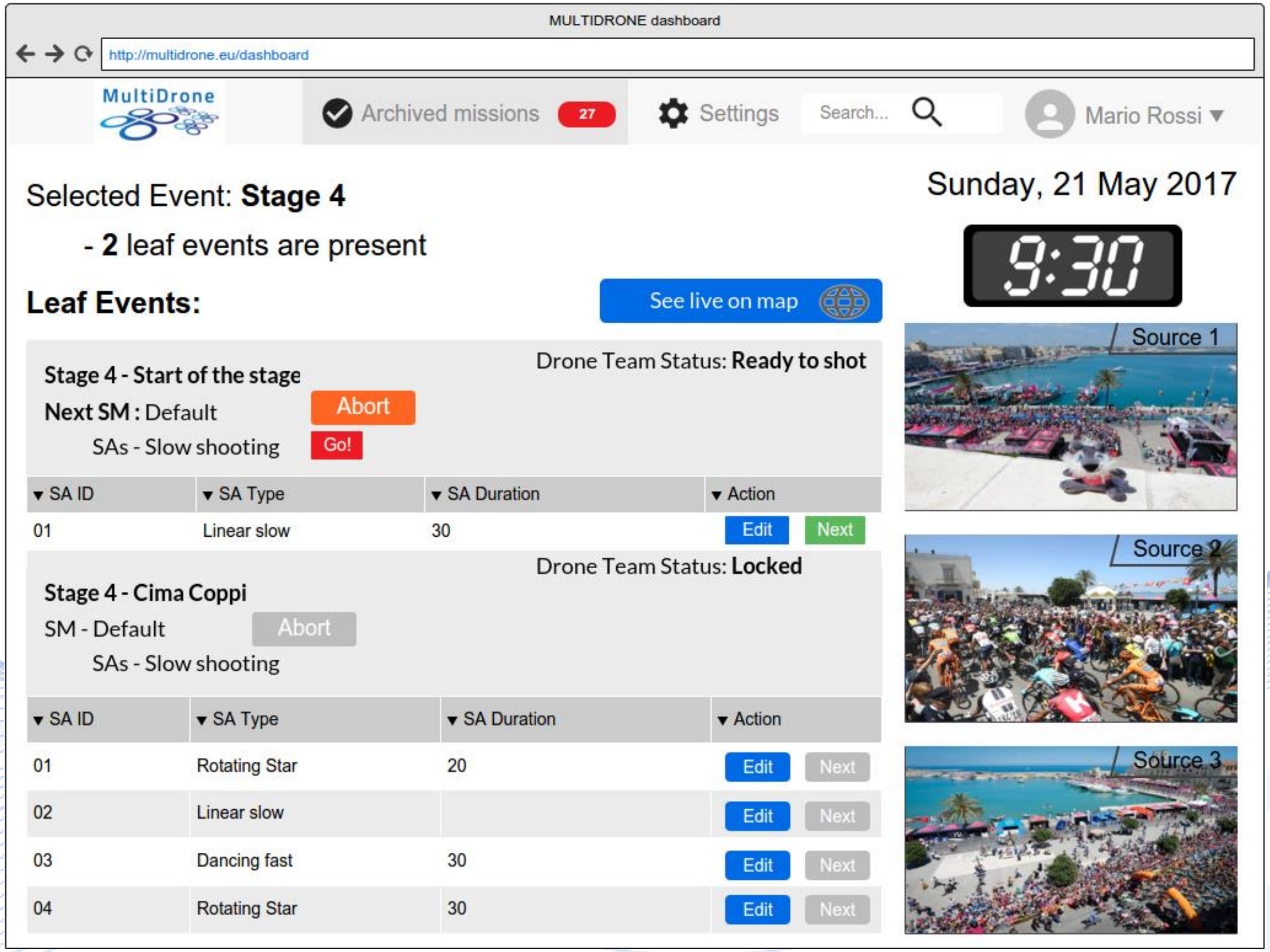
Reference target configuration

- Reference target start position and expected trajectory can be set in the Dashboard



Execution Timeline

- The interface shows the **timeline of Events** as well as **video feeds** from drones
- The Director is then able to **launch** the corresponding **Shooting Action Sequence** by clicking on the “Go!” button.



Flight Supervision station

- Supervising several drones with one operator is challenging:

Operator needs a good situational awareness to take informed, timely and appropriate decisions.

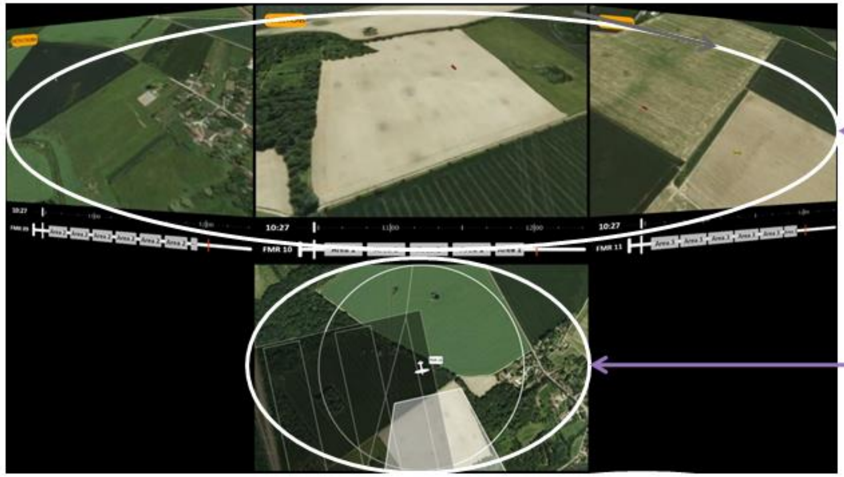
Operator has to simultaneously:

- Handle the mission.
- Ensure security.
- Re-plan drone mission in real-time when necessa
- Monitor and manage events (obstacles), alarms (battery) etc

⇒ **Need for a well adapted cognitive system that allows the supervision of several UAVs by one/few operator(s).**

Flight Supervision station

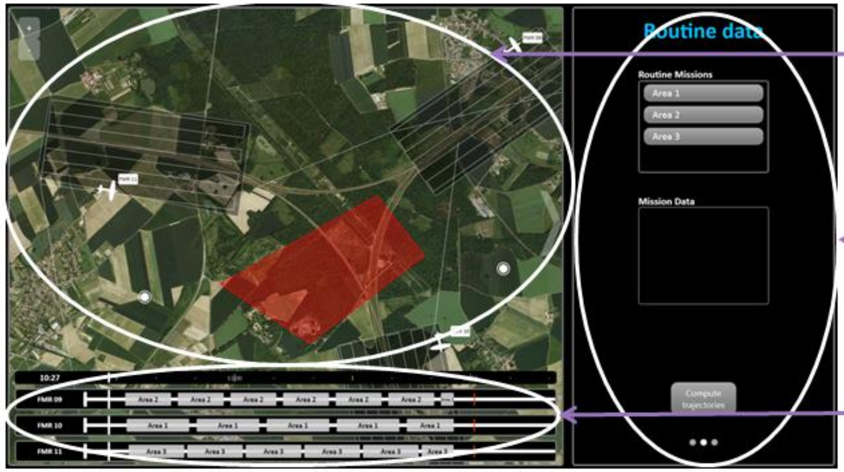
Head up display for sensor information



Display of sensor data and processing results (for example Object tracking)

Neighborhood situation around a specific drone (zoom of the map around the drone)

Head down display for mission monitoring



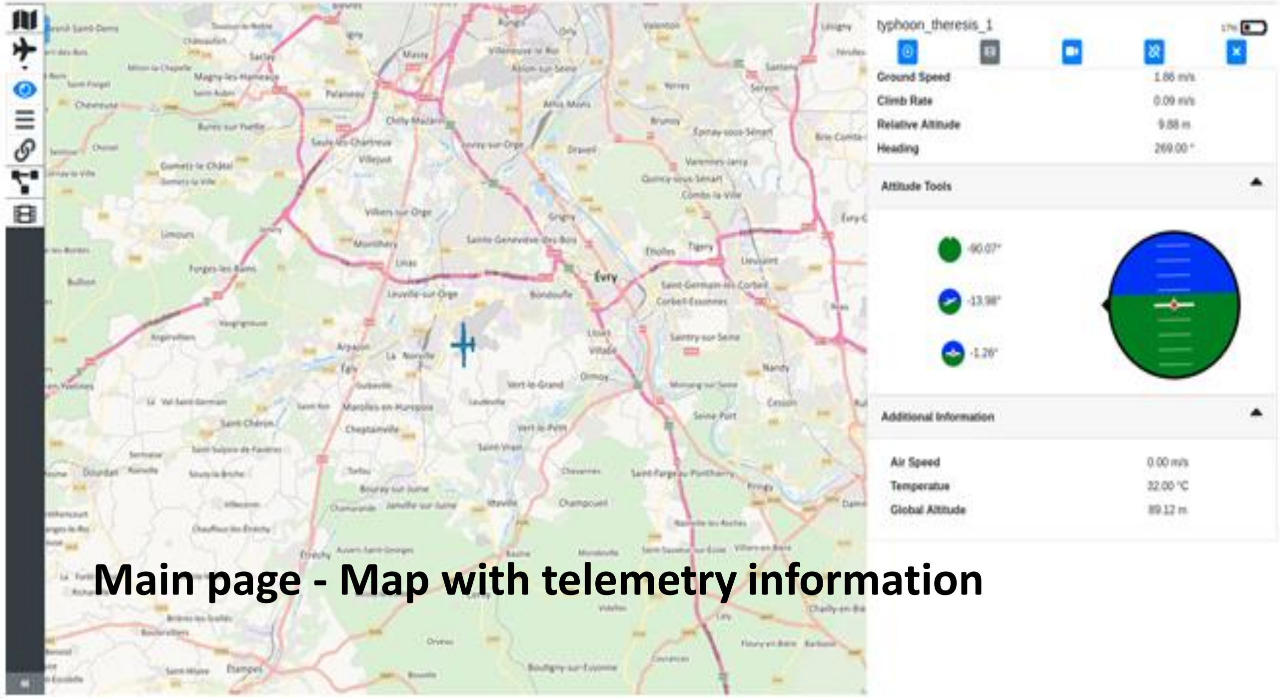
Situation overview (Map with planned trajectories, forbidden areas...)

Mission data, navigation data, ...

Mission status – Timeline

Flight Supervision station

- **Map wireframe**
  Display drones’ positions on the map
  Display annotations



Main page - Map with telemetry information

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Q & A

Thank you very much for your attention!

More material/lectures in
http://icarus.csd.auth.gr/cvml-web-lecture-series/

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