AIDERS

Deliverable 5.3 AI toolkit user manual

Coordinator Name: Christos Panayiotou

Coordinator Email: christosp@ucy.ac.cy

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Table of Contents

Executive Summary

The AIDERS AI toolkit offers new tools for collecting and analyzing emergency response data from sensors onboard UAVs. This enables incident commanders to extract knowledge about the field's operational conditions and assist them in designing evidence-based response strategies. The AI toolkit is delivered as a single software package, and this deliverable is intended to be used as the user manual illustrating all the included features and functionalities.

1. Introduction

The tools offered through the AIDERS AI toolkit enable incident commanders and first responders to collect and analyze real-time emergency response data from sensors onboard UAVs and build knowledge maps to devise effective response plans.

The AI Toolkit is an IT-based solution that includes advanced ground control data analytics and visualization applications, which are expected to facilitate and expedite disaster response. The individual tools of the AI toolkit provide standalone features for RPAS-based intelligent data collection and processing, as well as ground control-based enhanced data analytics and visualization.

Specifically, the AI toolkit consists of tools for command-and-control of UAVs and visualization, as shown in Figure 1. The command-and-control tools enable the user to manage a team of UAVs for various missions, such as aerial data collection, search and rescue (SAR), area monitoring, etc. The visualization tools provide the users with better situational awareness that helps them focus on its mission.

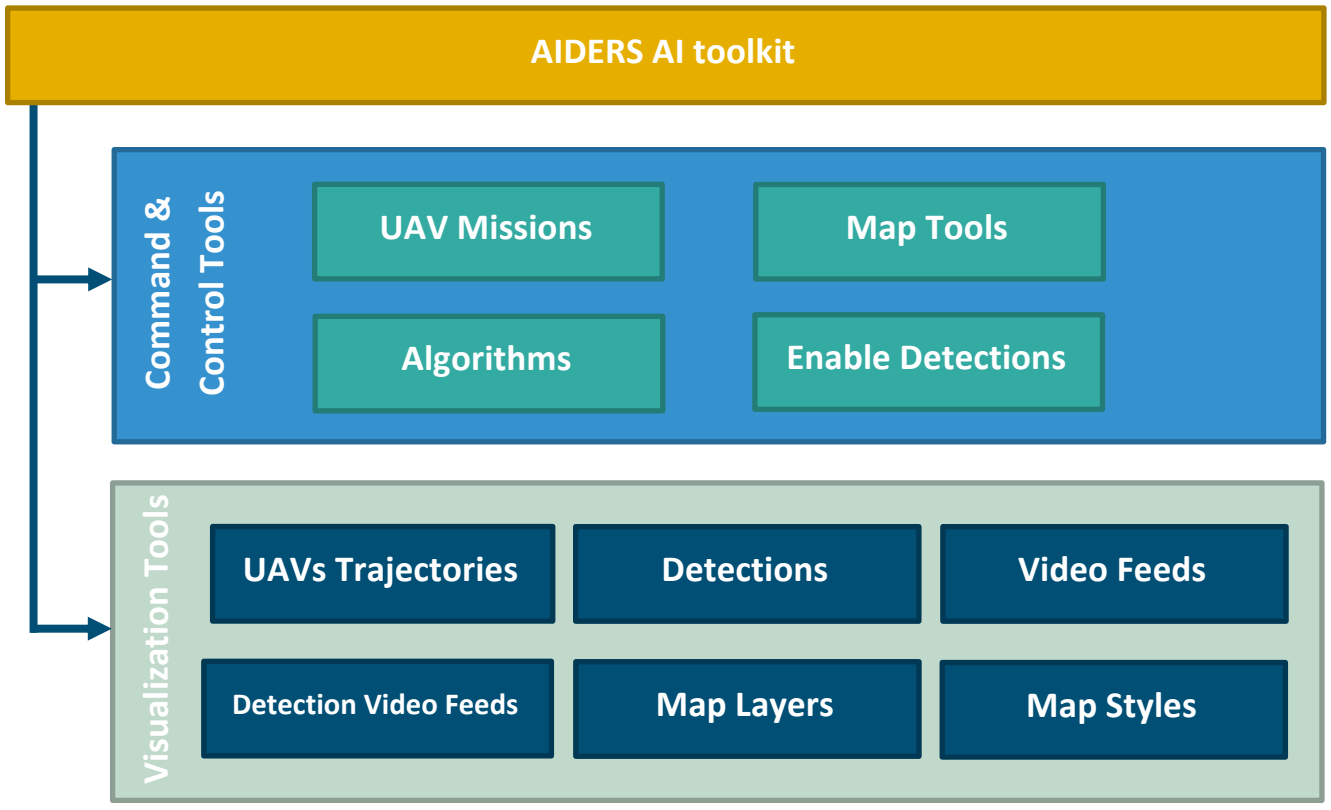

Figure 1: AIDERS AI toolkit available command-and-control and visualization tools.

In the following sections, we provide descriptions of all the tools available in the AI toolkit that help the user easily understand each one and its purpose.

2. UAV Missions

The *UAV Missions* enable the user to perform several missions with a single or a team of UAVs providing rapid control in case of emergency and real-time situational awareness for the region of interest. The UAV missions include the following two options, (a) *Monitor Points* and (b) *Build Map* after selecting available UAV(s).

2.1. Select Drones

The UAVs connected with the toolkit and assigned to this operation, appear in the *Select Drone* section. The user can select or deselect any of the available UAVs by pressing its respective toggle switch or by selecting the drone object itself on the map, as shown in Figure 2.

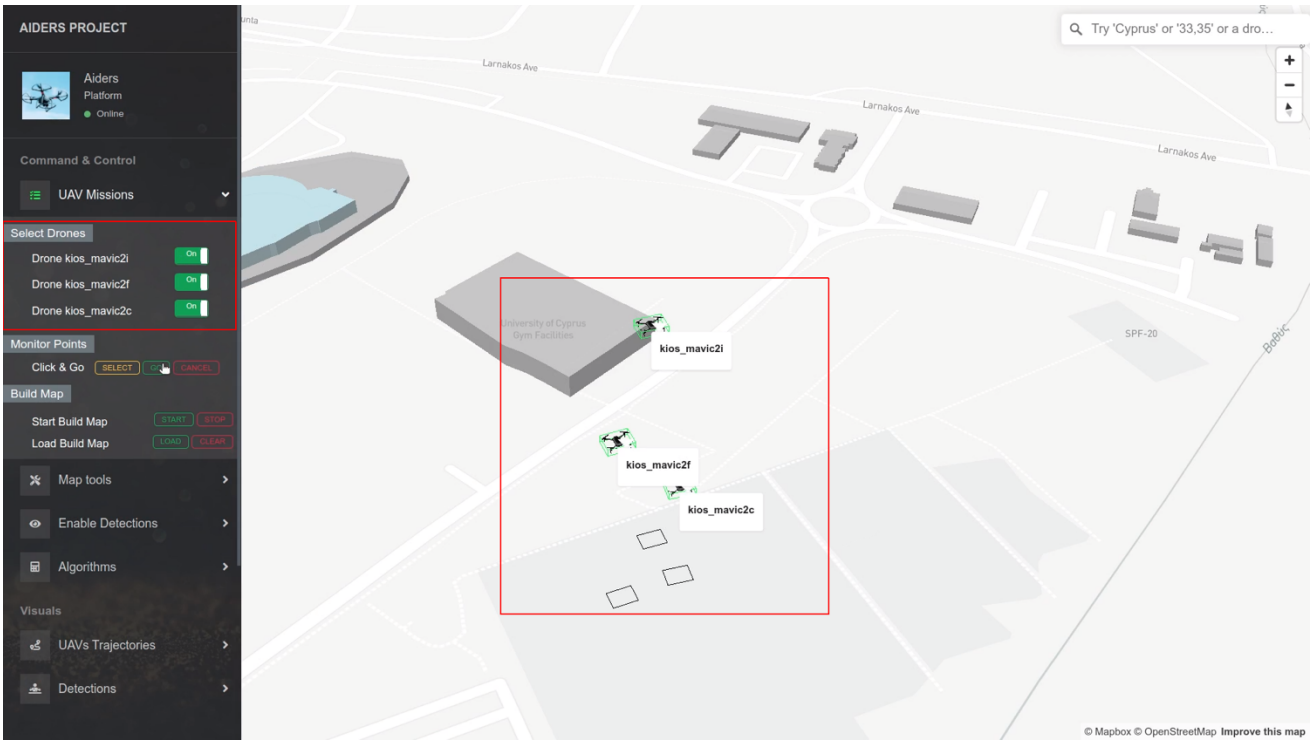

Figure 2: Quick selection of available UAVs.

2.2. Monitor Points (Click & Go)

The *Monitor Points* feature enables a single or multiple UAVs to execute a mission autonomously. The user can select through the map desired waypoints to be visited by either one or multiple UAVs, depending on the type of mission. The waypoints can be selected by pressing the "*Select*" button, as shown in Figure 3.

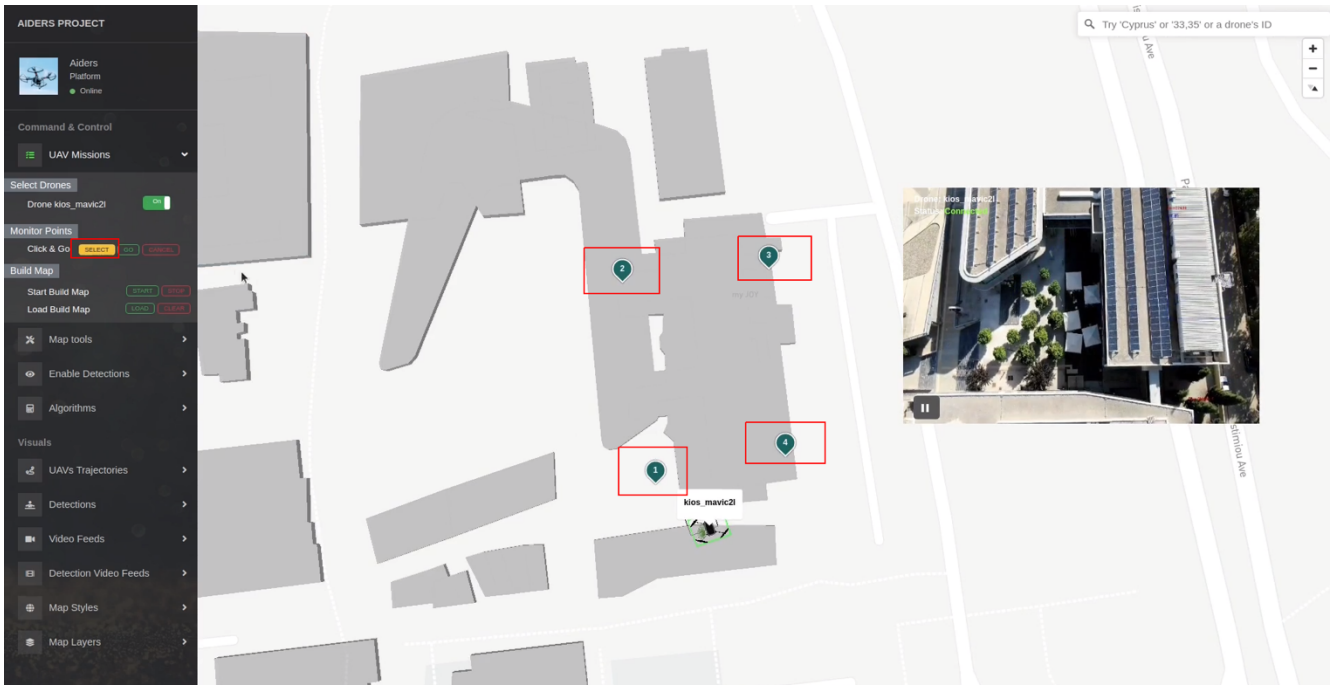

Figure 3: Setting waypoints for a mission.

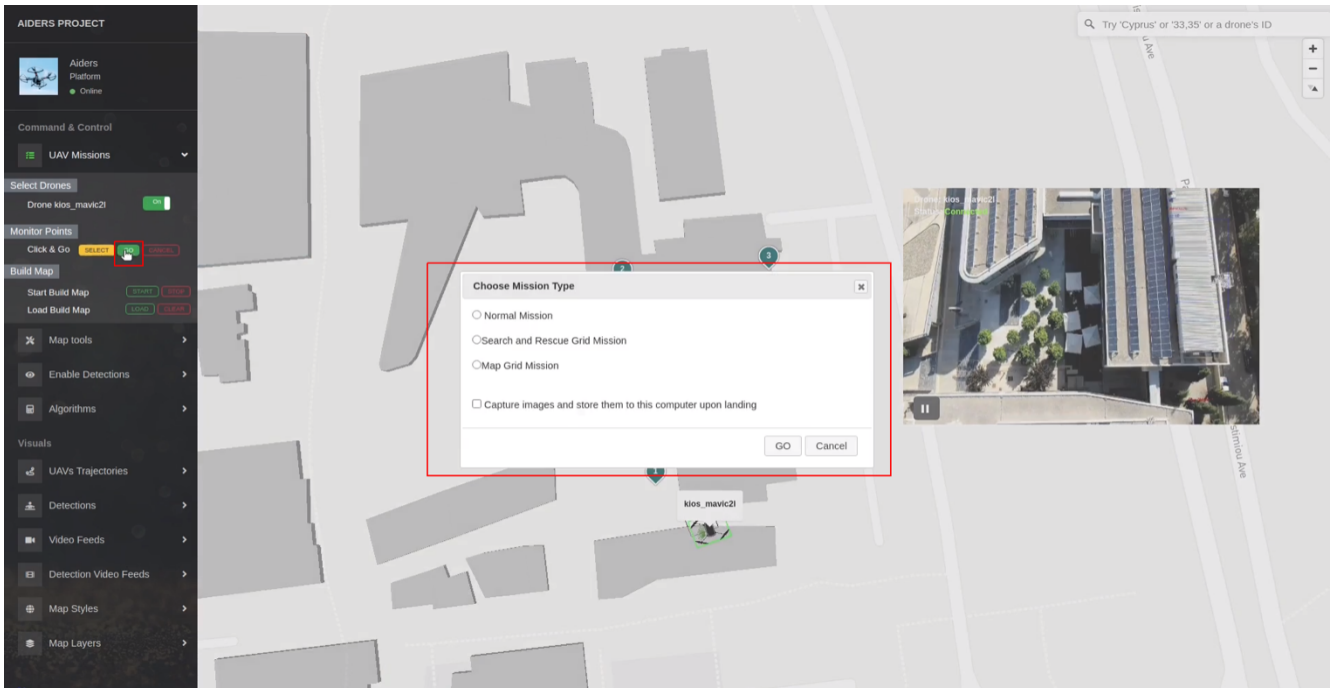

Figure 4: Pop-up window with available mission types.

Once the waypoints are selected the “Go” button can be pressed, with a pop-up window appearing to the user showing the available mission types, as shown in Figure 4.

There are three types of available missions to the user: (1) Normal Mission, (2) Search and Rescue Grid Mission, and (3) Map Grid Mission, which we explain further below. Once a type of mission is selected the user can press the GO button for the mission to start. Additionally, there is an option that can be selected so that the UAVs capture images and store them automatically upon landing.

Normal Mission

The normal mission guides the UAV to autonomously visit the selected waypoints in the sequence, one by one. Note that this mission can be executed by one UAV at a time. An example of running a normal mission is shown in Figure 5.

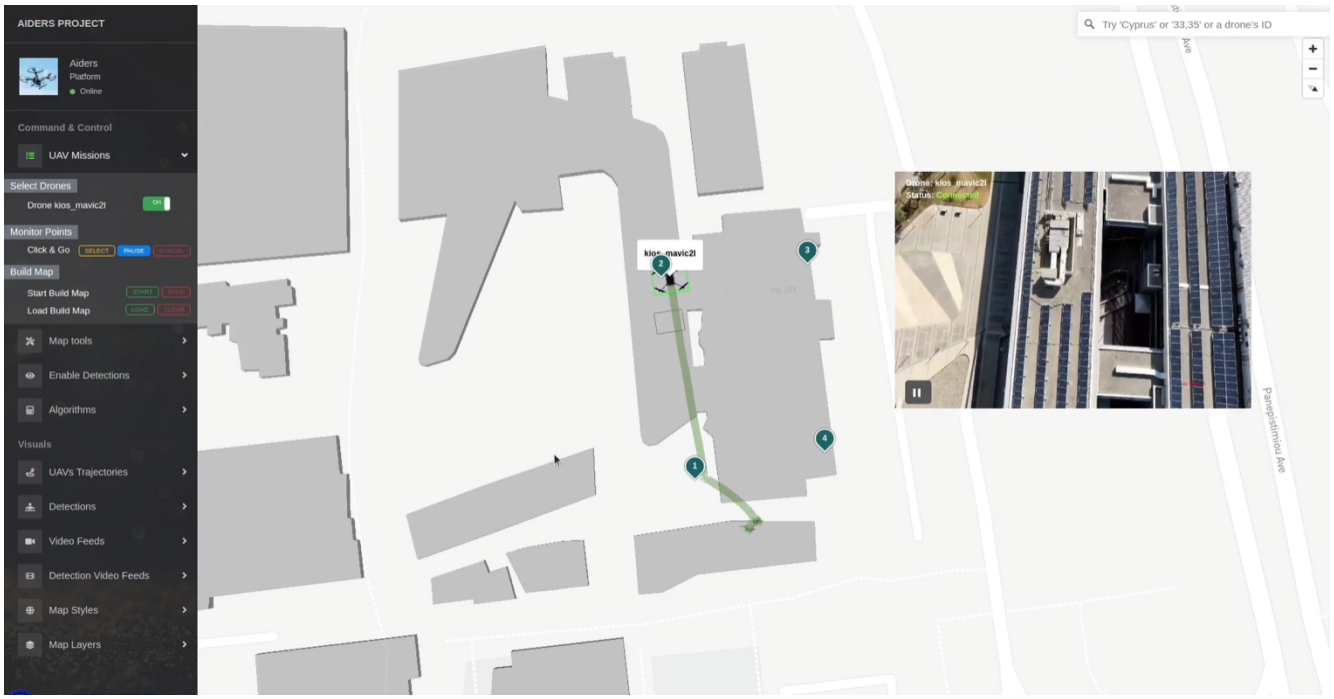

Figure 5: Normal mission example.

Search and Rescue Grid Mission

This type of mission allows the quick scanning of a selected area for search and rescue purposes. Specifically, the user creates an area on the map by selecting 4 waypoints. The area that is formed by the waypoints, is then automatically divided into smaller sub-areas. Since this mission can be run by multiple UAVs, each of the UAVs is assigned a

sub-area to search. An example of running a search and rescue grid mission is shown in Figure 6.

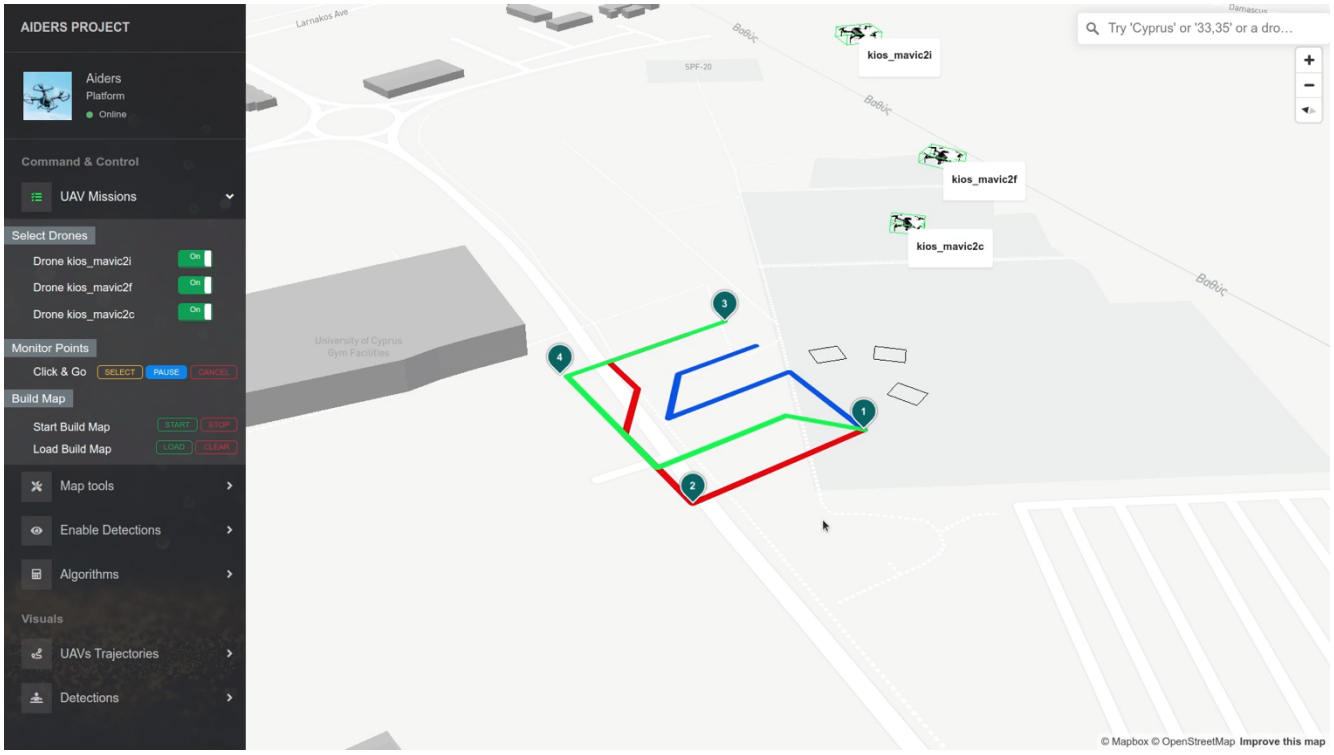

Figure 6: Search and rescue grid mission with three UAVs.

Map Grid Mission

With the map grid mission, the user can create an area on the map by selecting 2 waypoints. Then, a rectangle is formed where a selected UAV can map the area in a grid-style manner, as shown in Figure 7.

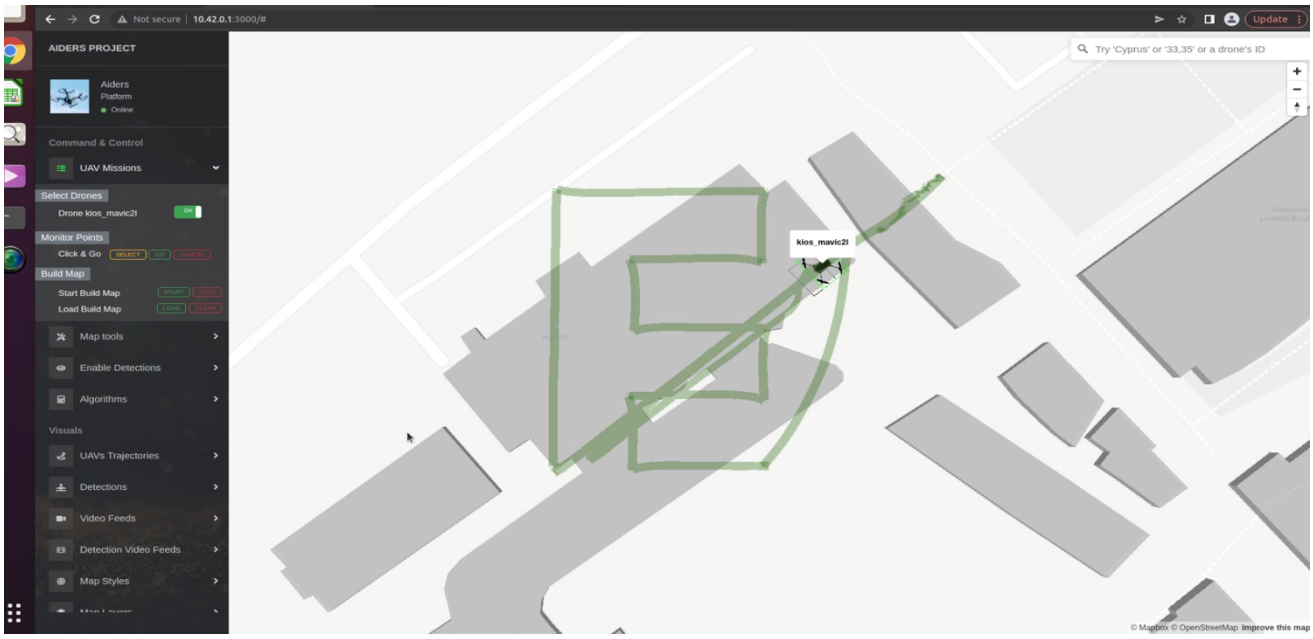

Figure 7: Map Grid Mission Example.

Any mission can be paused, resumed, or canceled at any time using the buttons next to the Click & Go feature.

2.3. Build Map

The Build Map feature allows the user to quickly build an area map in real-time using images from the available UAVs or load an already available map. Two options are available to the user: (a) Start Build Map and (b) Load / Clear Build Map, which are explained below.

Start Build Map

With this option, the selected UAV captures top-down images, which are transferred in real-time to the ground station. These images are geo-referenced and then attached to the map in real-time. An example of this feature is shown in Figure 8.

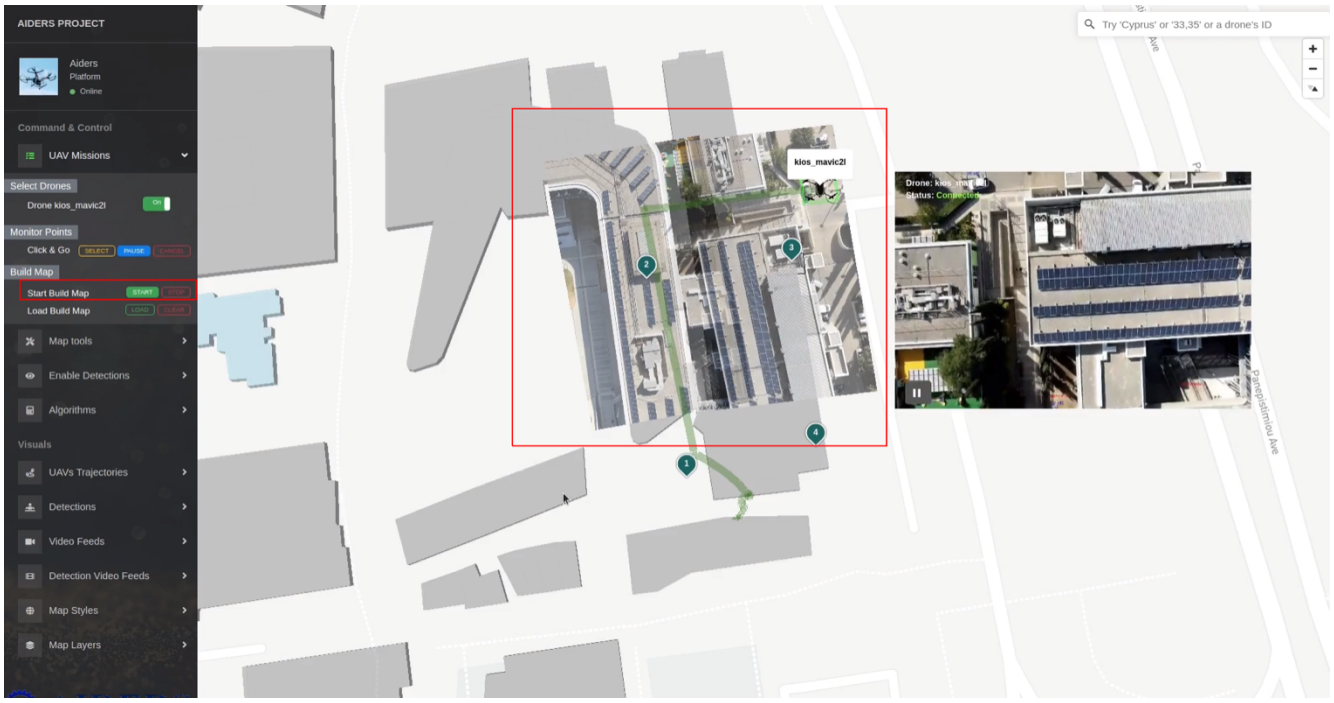

Figure 8: Start Build Map Example.

Load / Clear Build Map

The user with this option, can either load or clear from the map a Build Map session that was performed in the past. By selecting this option, a pop-up window appears that shows available Build Map sessions that the user can load or clear, as shown in Figure 9.

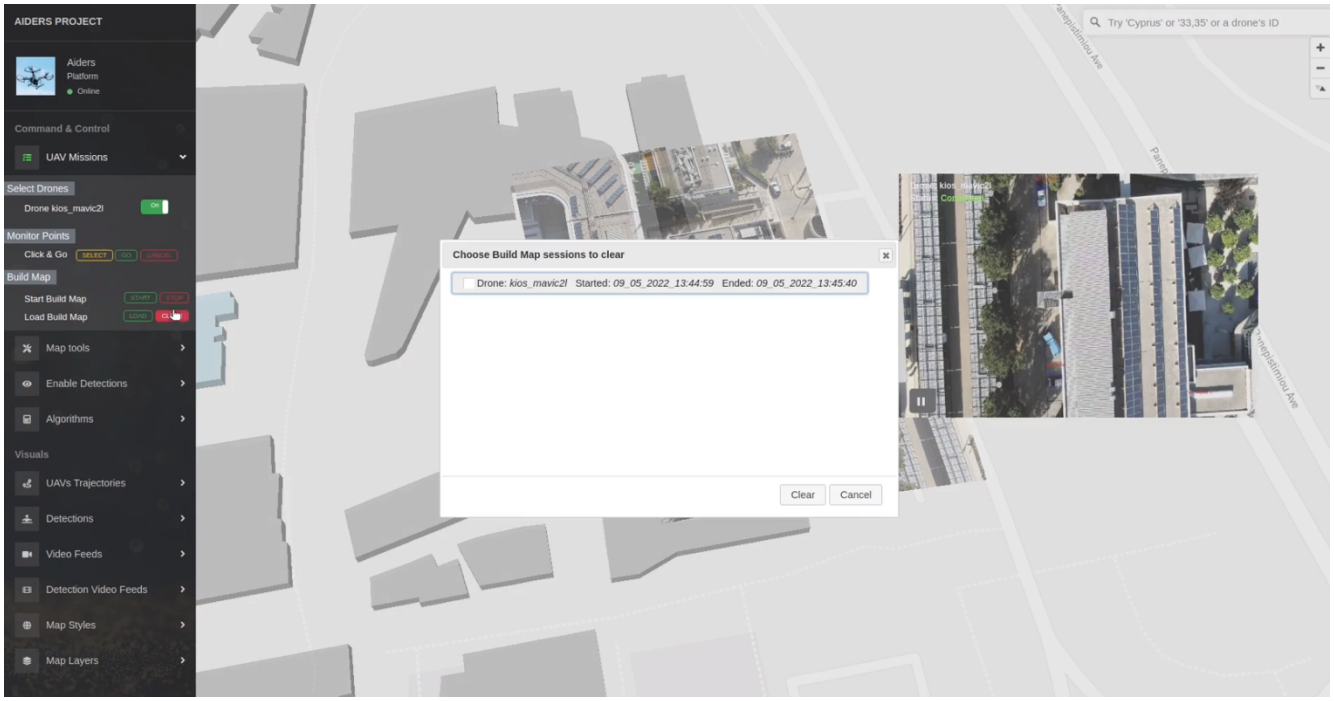

Figure 9: Load / Clear Build Maps Example.

3. Map Tools

Several Map GUI tools have been implemented to help first responders acquire information about the incident area. These tools include Measurement, Search Location, Click Area Information, Live Weather Information, and Live GPS Locations, which are explained in detail in the sequel. Each tool can be activated or deactivated by pressing its respective toggle switch.

3.1. Measurement

The user can use this tool to measure distances on the map by selecting two or more points and the area of any polygon using the tools on the right top of the screen. The calculated results are then displayed on the lower left side of the screen as shown in Figure 10.

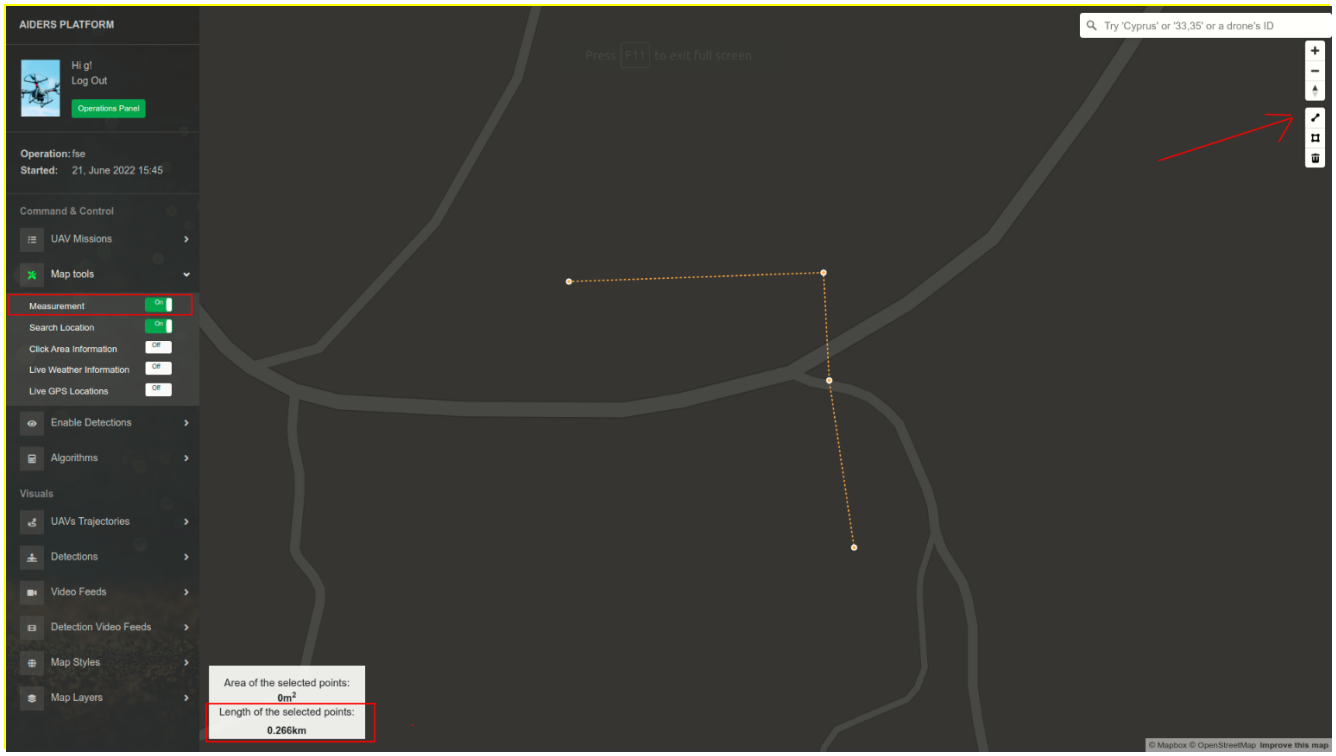

Figure 10: Measurement Tool.

3.2. Search Location

With the search tool, the user can search any place, area, or country using the search bar, as shown in Figure 11. The available UAVs can also be searched by using their name.

Figure 11: Search Tool.

3.3. Click Area Information

The Click Area Information allows the user to gather information about an area in a 1 km radius by clicking at any point on the map. The information available includes the longitude and latitude of the selected point location, the highest elevation, the radius (1 km), and the number of buildings and roads included in the radius (note that for the buildings and road information their respective layers must be first loaded on the map as discussed in Section 10). The information for the area is available on the top left side of the map as shown in Figure 12.

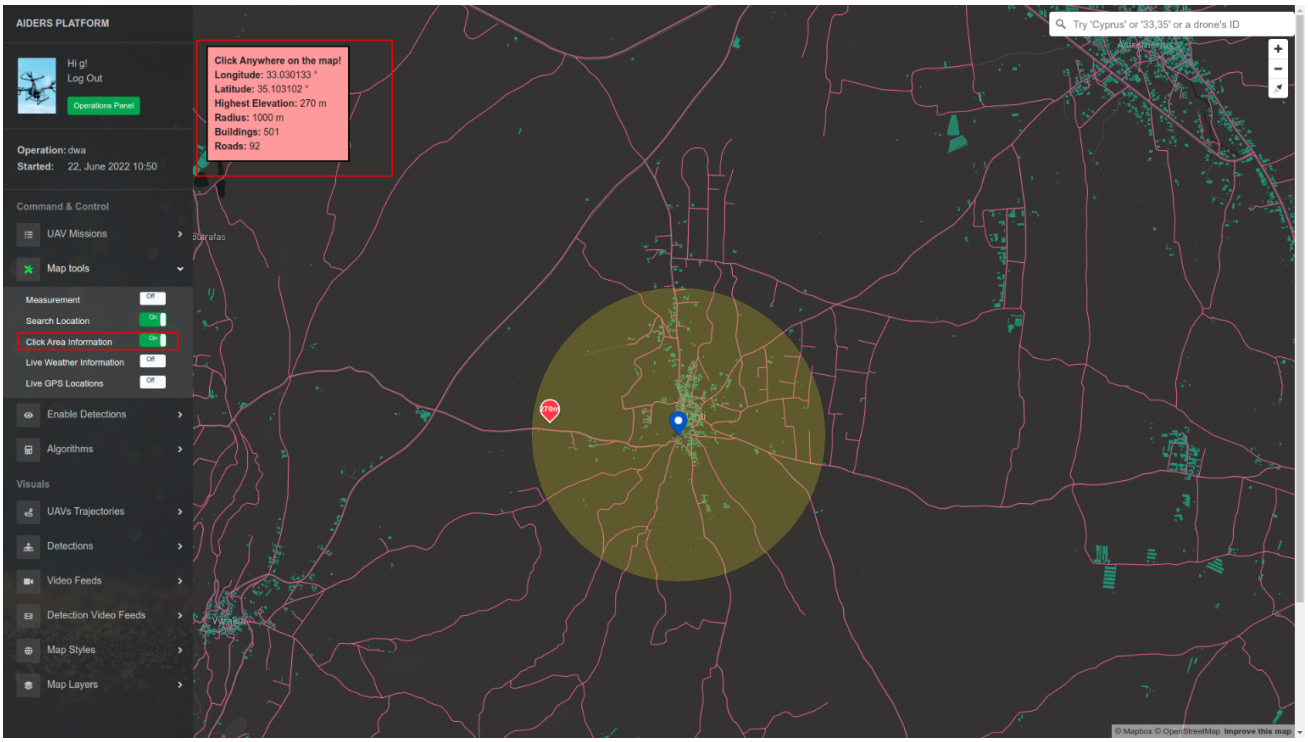

Figure 12: Click Area Information Example.

3.4. Live Weather Information

This tool provides various real-time weather information as shown in Figure 13. This feature to be functional requires a weather station to be connected either on a UAV or on a ground station.

Figure 13: Live Weather Information Tool.

3.5. Live GPS Locations

The Live GPS Location tool enables the illustration on the map of objects with GPS transmitter devices. If for instance, first responders hold a LoRa transmitter device, their location is continuously transmitted and shown on the map in real-time. This of course requires a LoRa receiver to be connected to the ground station as well. An example of the Live GPS Locations tool is shown in Figure 14.

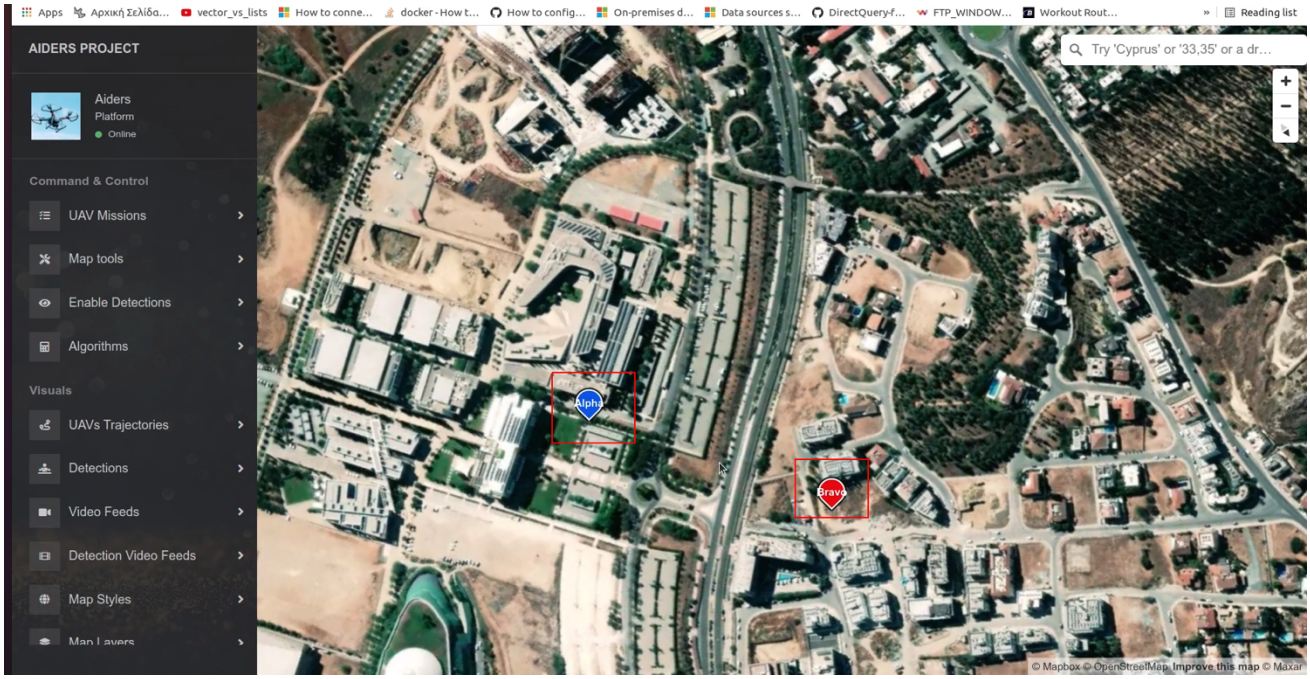

Figure 14: Live GPS Location tool.

4. Enable Detections

The Enable Detection feature allows the user to activate the detection functionality for each UAV by pressing its respective toggle switch, as shown in Figure 15. Once the detection is activated, each frame from the UAV's live stream is retrieved and then processed to detect various types of objects, as shown in Figure 16. Specifically, there are three detection algorithms implemented that the user could select from the pop-up (see Figure 15):

a) General Object Detection: Can detect 80 types of objects with good accuracy at low altitudes.
b) Vehicle Detection: Detects vehicles with high accuracy at both low and high altitudes
c) Vehicle & People Detection: Detects vehicles and people at low and high altitudes.

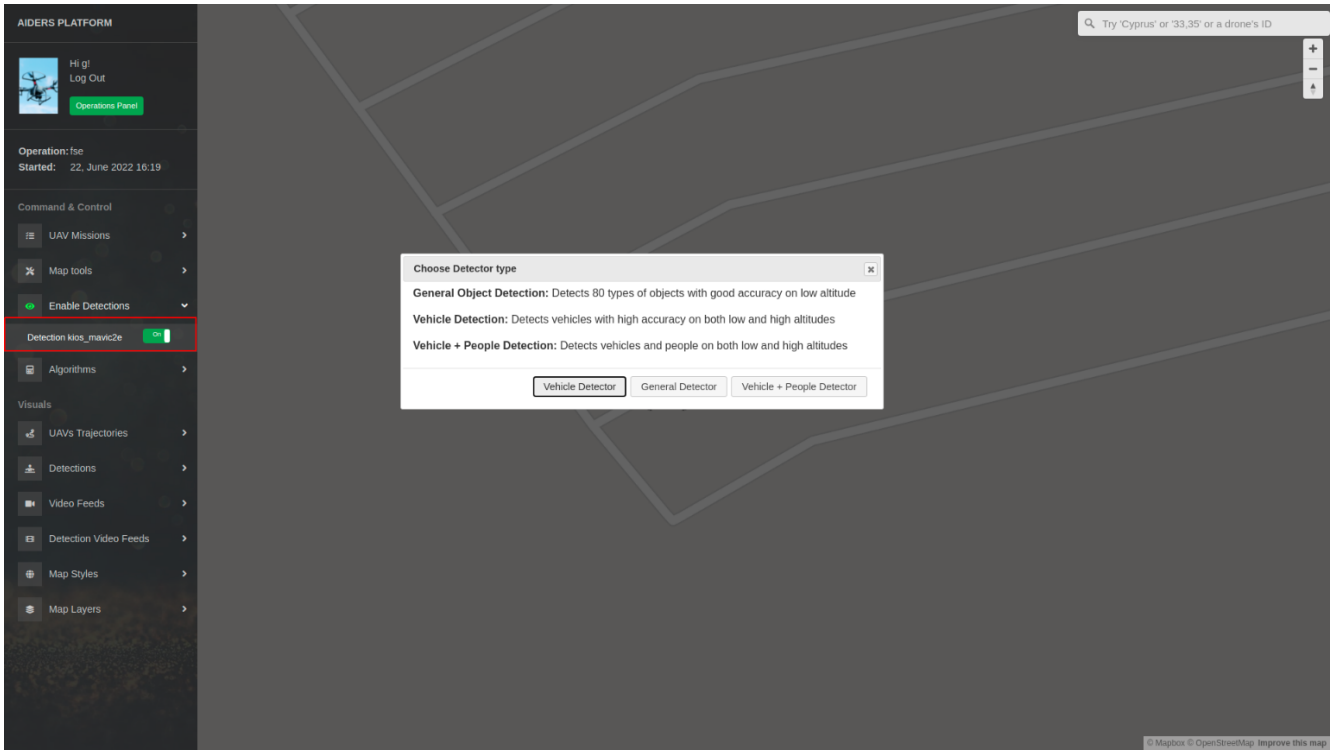

Figure 15: Activation of Detection feature.

Figure 16: Object Detection feature from UAV live stream.

5. Algorithms

The Algorithms feature allows the use of several algorithms that can help first responders in their mission. The available algorithms are explained in the following subsections.

5.1. View or Load Algorithms

The user can view a list of all the executed algorithms in the current session with their respective inputs and outputs. Moreover, the user can select from the list their desired algorithms and visualize their outputs on the map.

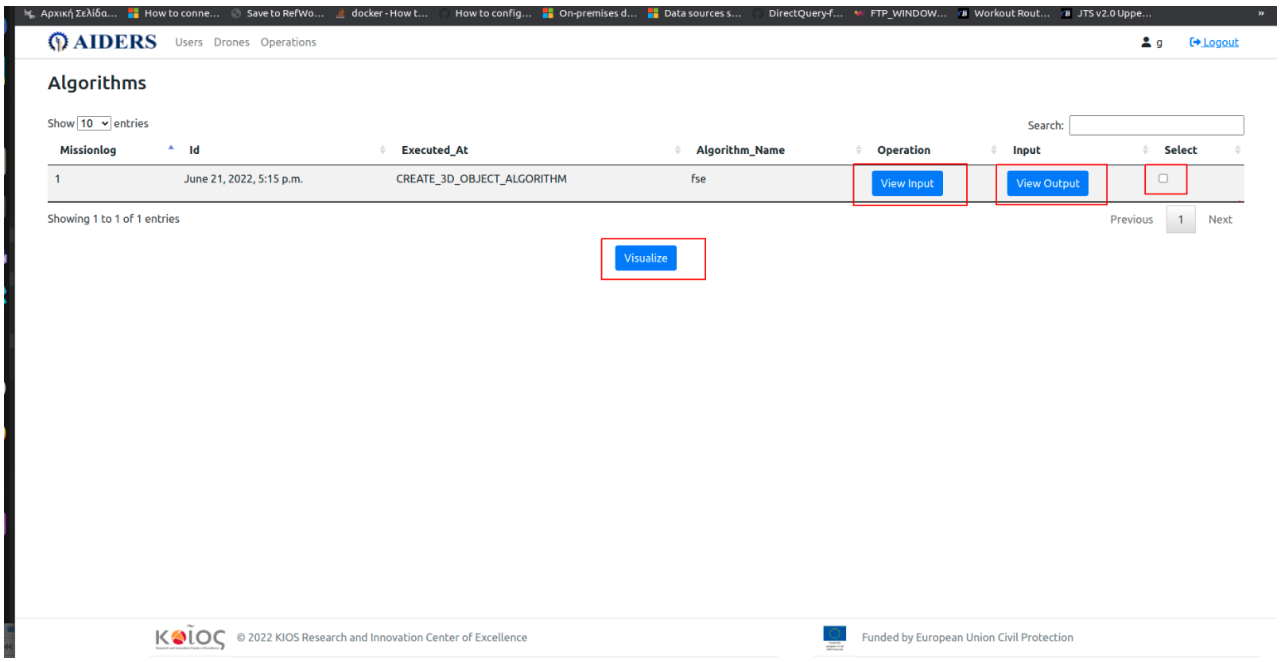

Figure 17: View or Load algorithms feature.

5.2. Fire Spread

The Fire Spread algorithm calculates and visualizes how a fire will propagate after a specified time. It requires input information about the weather, such as wind speed and wind direction, the fire spread rate, and duration. The input information can be inserted into the pop-up window that appears when the algorithm is activated, as shown in Figure 18. After that, the user can press the submit button to see the fire spread estimation result as shown in Figure 19.

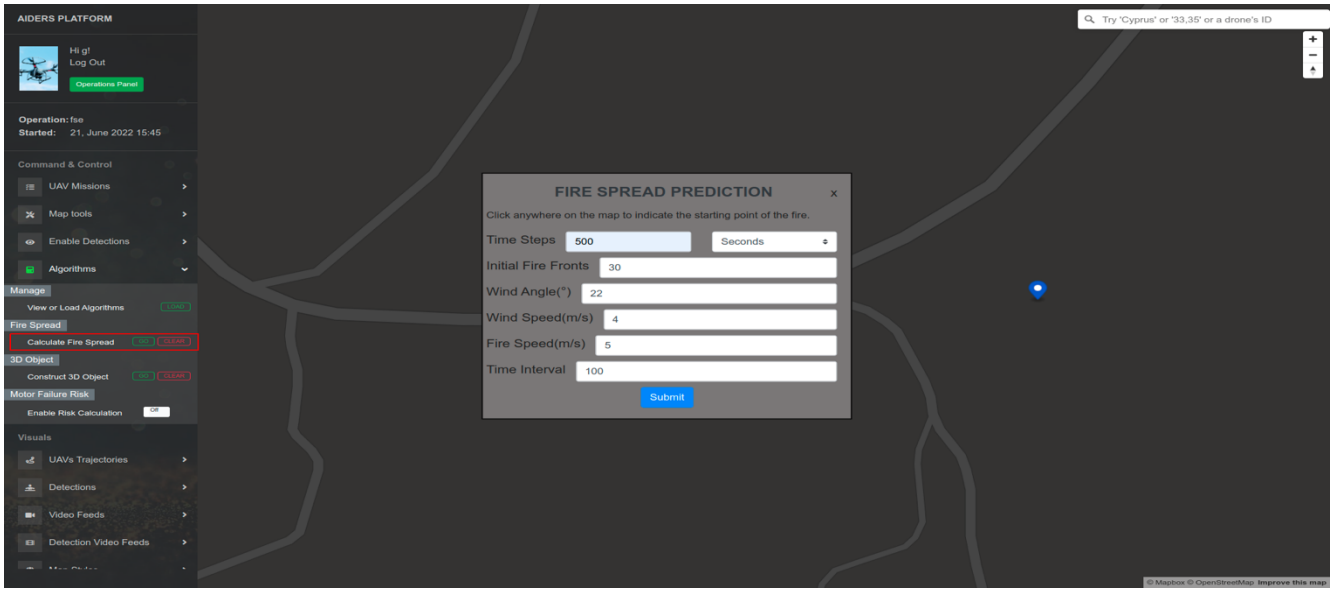

Figure 18: Fire Spread algorithm input information

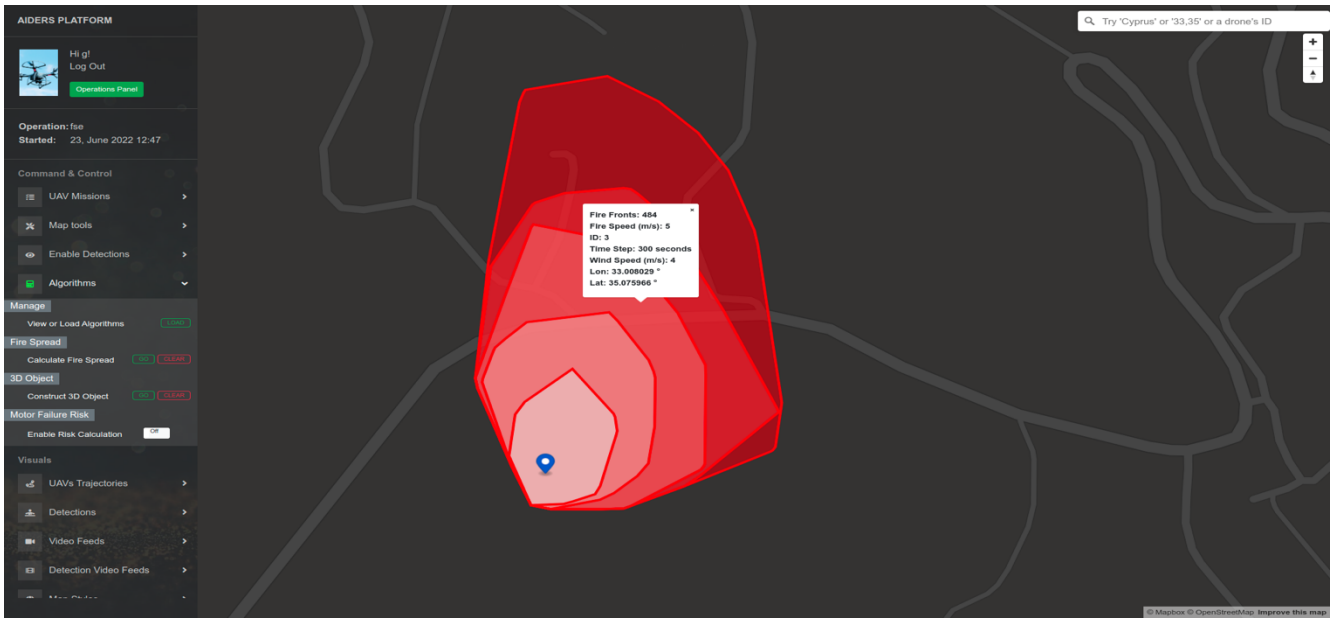

Figure 19: Fire Spread estimation result.

5.3. 3-D Object

The 3-D Object algorithm allows the user to construct a 3-D object from the aerial UAV data. Specifically, the algorithm converts 2-Dimensional images to 3-Dimensional objects, as shown in Figure 20. Then the 3-D objects are georeferenced and placed on the map, as shown in Figure 21. The user can then inspect the 3-D object quickly through the map.

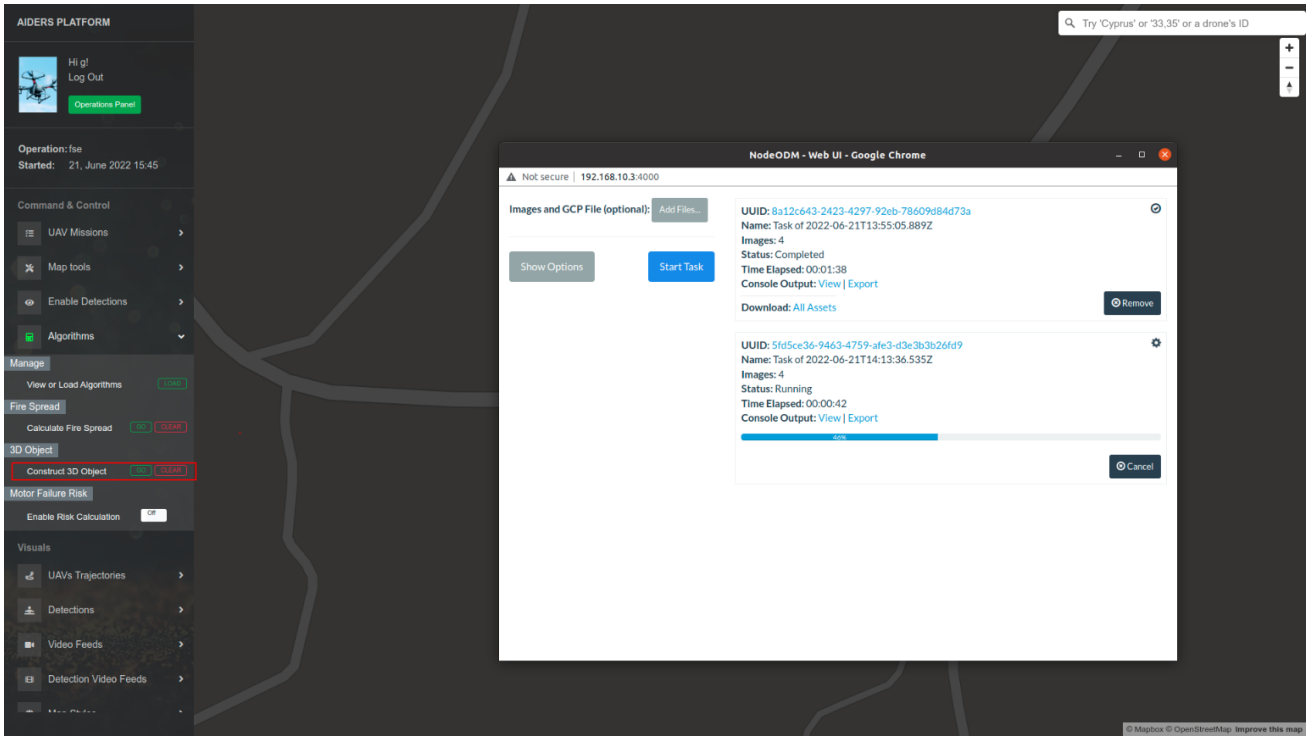

Figure 20: Conversion of 2D images to 3D objects.

Figure 21: 3D object construction.

5.4. Motor Failure Risk

Lastly, the Motor Failure Risk algorithm can calculate both the probability of failure and the MTTF (Mean Time to Failure) of the connected UAV motors, battery and chip in real-time. The results are shown on the top left side of the map, as shown in Figure 22.

Figure 22: Motor Failure Risk algorithm.

6. UAVs Trajectories

This feature activates the visualization of UAVs trajectories. Each UAV trajectory is saved on its own layer, and the user can make each of these layers visible or invincible by pressing their respective toggle switch. An option is also given to clear all the UAV trajectories from the map, as shown in Figure 23.

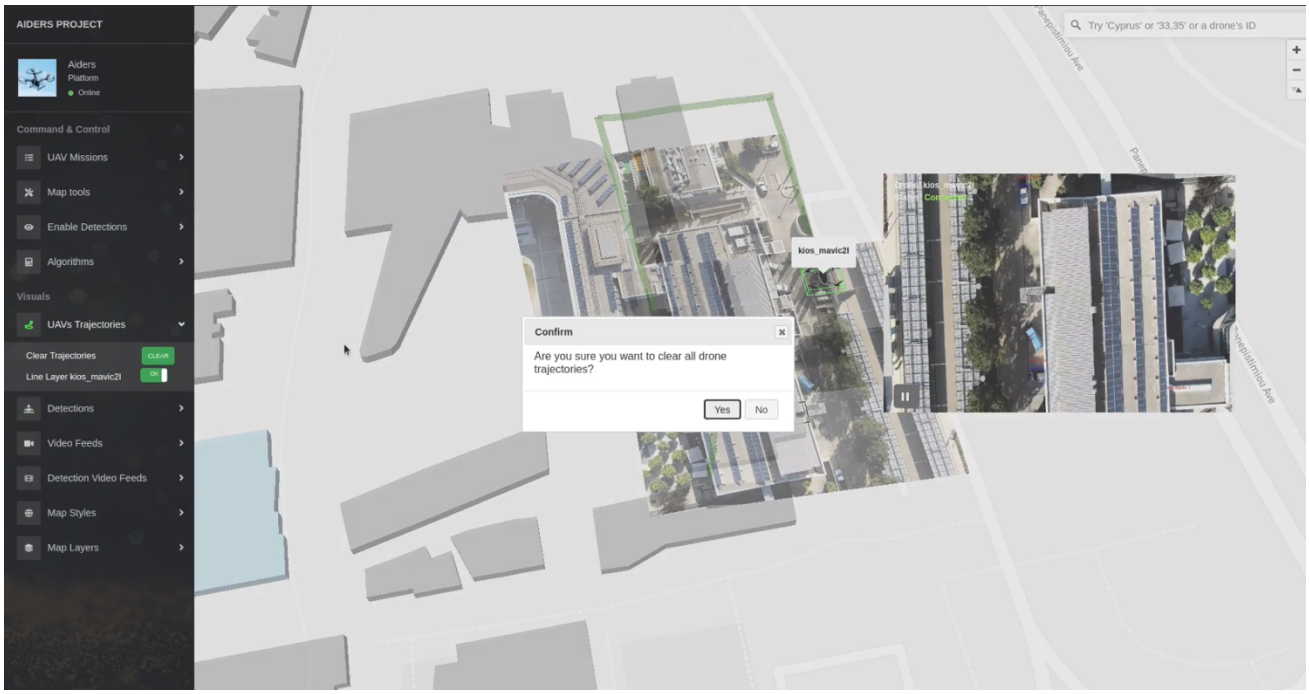

Figure 23: UAV trajectories visualization.

7. Detections

The Detection visualization enables the objects detected from the UAV live feed to be visualized in real-time on the map. The user can select which available object types will be visible on the map, as shown in Figure 24.

Figure 24: Visualization of detected objects on the map.

8. Video Feeds

The Video Feeds feature allows the user to see the live stream from each UAV camera. Each video feed panel can be toggled on or off and is available on the map, as shown in Figure 25.

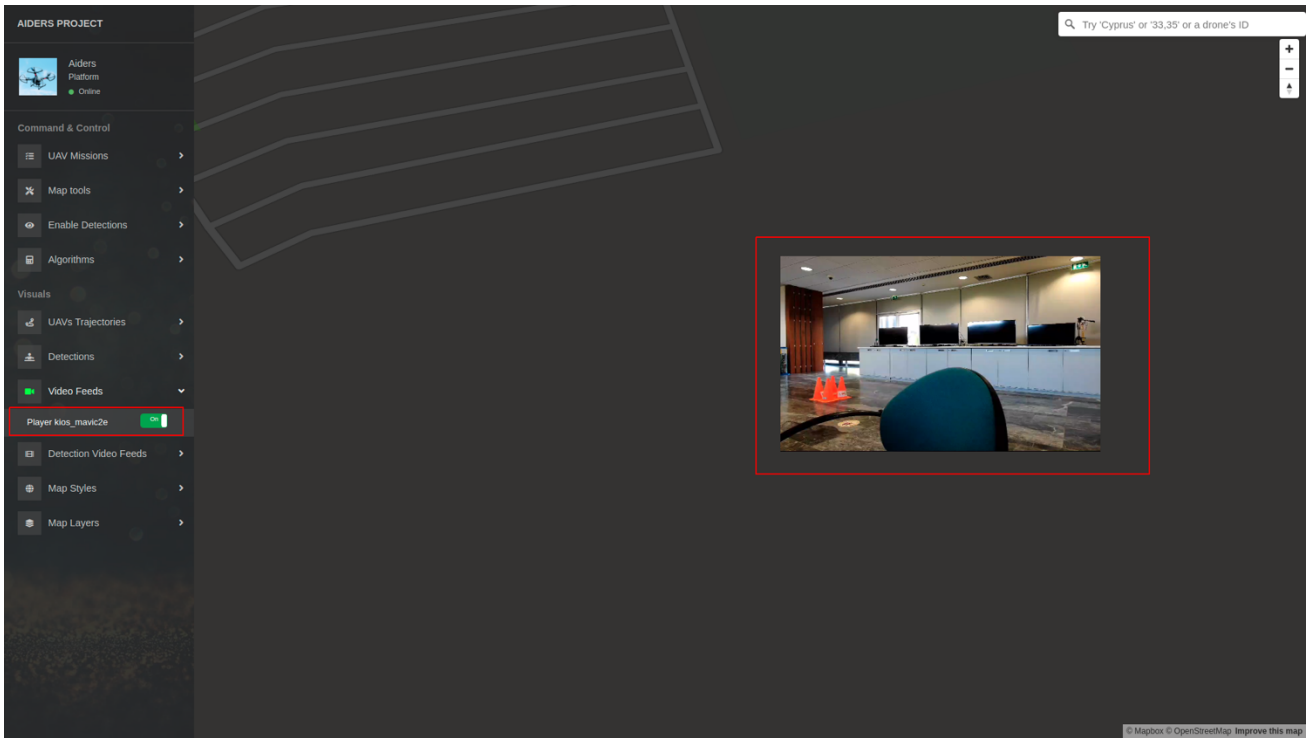

Figure 25: Live Video Feed from UAVs.

9. Detection Video Feeds

The Detection Video Feeds feature is the same as the live stream video feed, but the detection data are also visible on each frame. Specifically, bounding boxes appear on the frame and around the detected objects. The user can toggle the detection video feed for each available UAV, as shown in Figure 26.

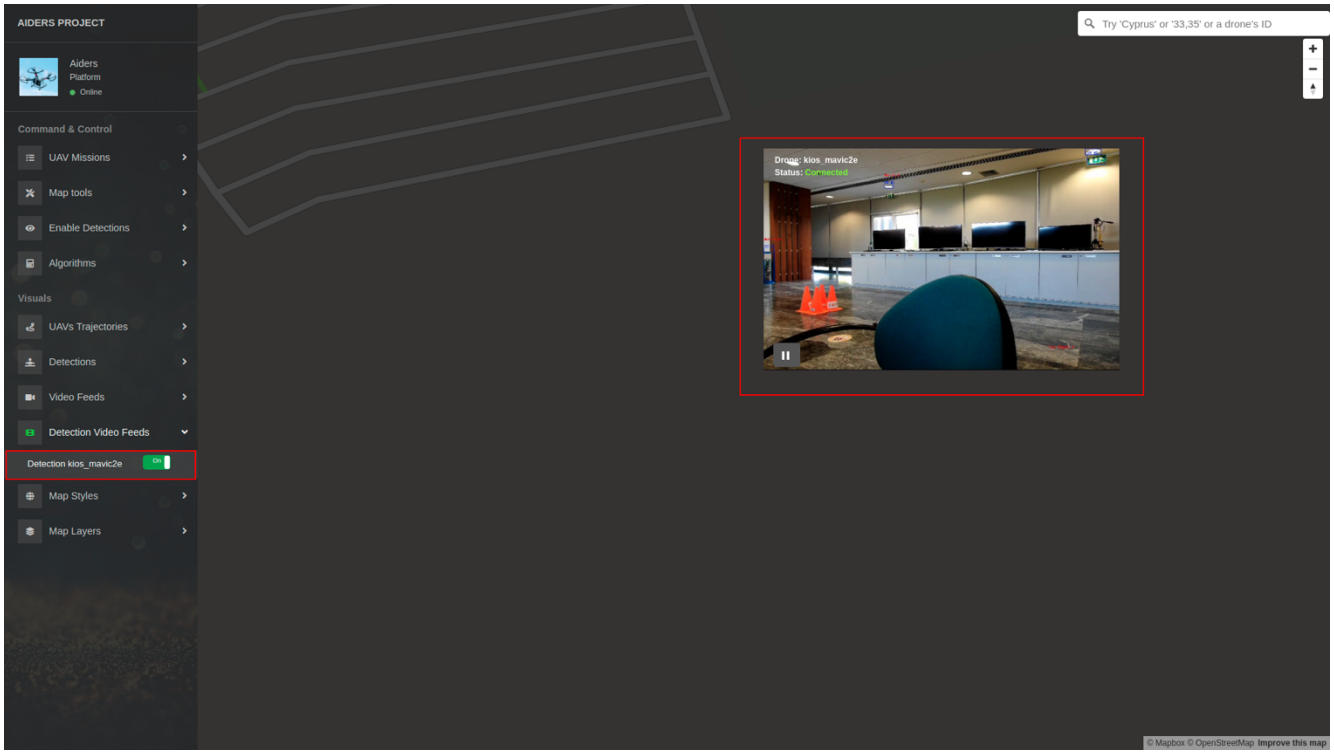

Figure 26: Detection Video Feed.

10. Map Layers

The Map Layers feature allows the user to load and visualize offline data on the map as layers. For instance, data regarding critical infrastructures (hospitals, utility pole lines, and others) can be loaded and provide the first responders with valuable information during their mission.

The user can visualize each of the available layers on the map by pressing the respective toggle switch of each layer, as shown in Figure 27. Further information for each item in each layer can be retrieved by clicking on it, as seen in Figure 28.

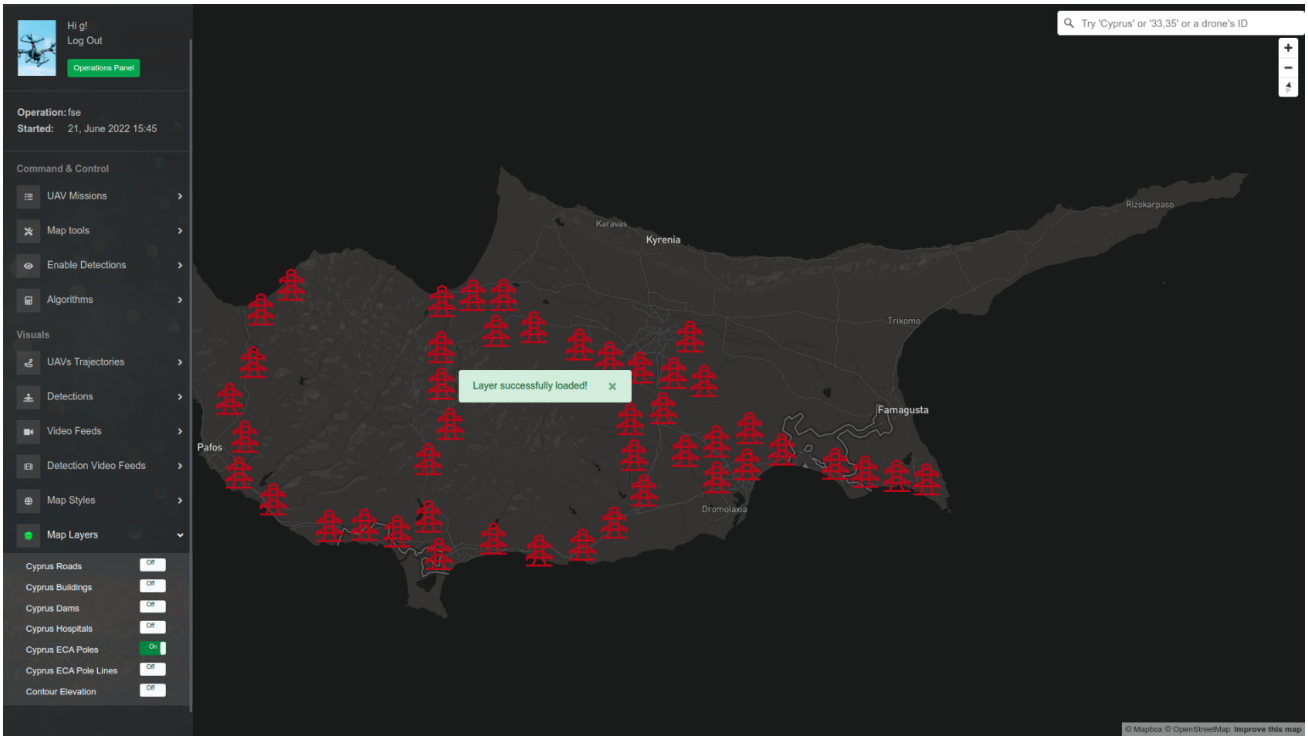

Figure 27: Map Layer load of critical infrastructure.

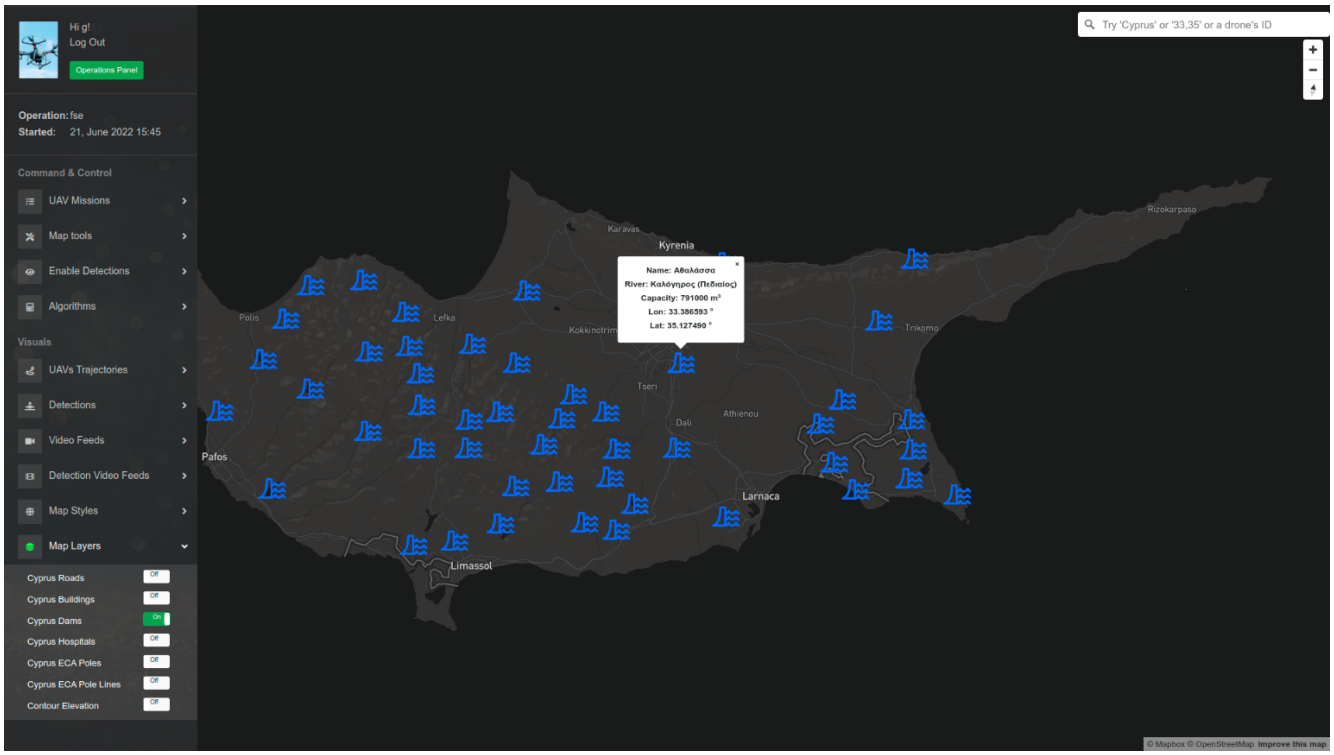

Figure 28: Information details for each item in the loaded layer.

11. Conclusion

The deliverable details all the tools and features offered by the AIDERS AI toolkit, including command and control tools for the simultaneous management of a UAV fleet and visualization tools for helping first responders in their missions. It is indented to be used as a user manual for the operators before using the AI toolkit to familiarize themselves with all available tools and features.