DELIVERABLE 3.2

AI Technology Evaluation Report

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Contents

1. INTRODUCTION

This deliverable describes the activities of ARTION for the testing of tools that were developed in the project. The tools were tested in field exercises that were organized and conducted by the emergency response end-user organizations that participate in the project, namely the Cyprus Civil Defense (CCD) in Cyprus and the Directorate-General of Civil Protection for Sardinia Region (RAS). A team of researchers and engineers from KIOS UCY participated also in all the exercises as the tools under test were developed by KIOS UCY.

In particular, two of the tools were tested in field exercises. The first is the aerial person detector that operates on videos captured by drones to detect and track individuals in real-time. Second, we tested the ARTION web-platform and mobile-app, a tool-duo that is used not only to track first responders in the field and collect data (first responders' traces), but facilitates also forms of bidirectional communication between the first responders and the control center. The web-platform supports currently an AI-powered object detection algorithm, but we envision to integrate more AI algorithms in the future.

Through the testing of the tools in the field several objectives were achieved. First, the development team had the chance to evaluate the tools under realistic conditions in order to detect errors or discover issues that could be improved. The feedback of the end users (first responders, mission commanders, etc.) after utilizing or seeing the tools in action was valuable as they pointed out points that could be improved and suggested additional features that would be useful. Moreover, the usability of the tools and the user experience were assessed. It was important to verify that the correct use of the tools by first responders is intuitive and does not require extensive training or experience. Finally, training the first responders at the usage of new technologies in their operations was also one of the project objectives.

The present deliverable is structured as follows. It describes briefly the tools that underwent testing during realistic field exercises as well as the scenarios and details of the field exercises that were conducted for this purpose. Details about the testing setup are also provided for each of the tools, followed by another section that summarizes the testing outcomes and the feedback from the end users that participated in the exercises.

2. TESTING OF TOOLS IN THE FIELD

Two of the project tools underwent testing in realistic field exercise in Cyprus and Sardinia. Specifically, the aerial person detector algorithm was tested on videos that were captured during field exercises. Also, the ARTION web-platform and mobile-app – which required the extensive participation of first responders – were tested by Cypriot and Italian first responders.

2.1. Testing of the Aerial Person Detector

The Aerial Person Detector is an AI-based algorithm for identifying individuals and consists of two main components, detection and tracking. Person detection is done by means of computer vision algorithms and a convolutional neural network whereas tracking is achieved by means of a combination of algorithms. Furthermore, upon detecting and tracking the persons, all the data collected from the entire mission is then saved in CSV files and is available for further analysis.

The algorithm has been tested with success in two of the field exercises we conducted in Cyprus. The exercises were organized by CCD with the collaboration of KIOS UCY and are briefly described in the following subsections.

2.1.1. Flood exercise scenario

A flood exercise scenario was executed at the shore of the artificial lake of Achna in Ammochostos district, in Cyprus. According to the scenario of the exercise, heavy rains in Ammochostos district resulted in an overflow of torrents. Houses flooded and people went missing. In this exercise around 50 individuals participated, including permanent staff and volunteers, who were responsible to establish a temporary hosting camp, establish a communications network, establish first aid station, pump water from flooded areas and houses and search-and-rescue missing persons. Figure 1 depicts the location where the exercise took place and Figure 2 shows some snapshots from the exercise

Figure 1: The location where the flood exercise took place.

Figure 2: Snapshots from the flood exercise

2.1.2. Search and rescue after tornado (or earthquake)

This exercise scenario assumed that in the abandoned village of Vretsia in Paphos district, after a tornado (or earthquake) seven campers who were in the village are reported as missing. Some of them are injured. In this exercise approximately 50 individuals participated, including permanent personnel and volunteers. The tasks were to establish and operate an emergency operation center, establish a first aid station, establish drone operation center and mobilise search and rescue teams with the use of K9 rescue dogs and drones. Figure 3 depicts the location where the exercise took place and Figure 4 shows some snapshots from the exercise.

Figure 3: The location where the search and rescue exercise took place.

Figure 4: Snapshots from the search and rescue after tornado (or earthquake) exercise.

2.1.3. Testing setup

The aerial person detector was tested on videos capturing the search and rescue operations in both exercises. As required by the algorithm, each time a drone was flying at a static location during the mission capturing a top-down video which was then analyzed by the aerial person detector.

The algorithm is effective even in videos captured from high altitudes of approximately 150 meters. In particular, during the missions the drones were flying at heights of 100-150 meters. When flying at high altitudes, the drone naturally covers a larger area. In fact, in such case the aerial person detector is at most useful as persons are of very small size and, thus, more difficult to be seen by the human eye at the video. Figure 5 shows two snapshots from the usage of the drones in our exercises in Cyprus.

Figure 5: Snapshots from the use of drones in a field exercise in Cyprus

As the employment of the aerial person detector does not require the actual involvement of first responders, its testing was neither demanding in terms of training requirements, nor prone to fail due to lack of competence. Of course, an authorized drone pilot must fly the drone. Furthermore, the execution of the algorithm is a technical task that is handled by an appropriate person. Therefore, the success depends upon the efficiency and effectiveness of the algorithm itself, and not so much upon the preparation prior to the mission.

2.2. Testing of the web-platform and mobile-app

The ARTION web-platform and mobile-app are two tools that are used together during emergency response operations. The web-platform is running on a laptop (or any PC) and is accessed by users at the command and control center (or anywhere else). The mobile app is running on the mobile phones of the first responders that operate in the field. A mission can be created at the platform. Users (i.e., first responders) who are selected for the mission can be organized in teams and they can join the mission from the mobile app that is running on their mobile phones.

The basic functionalities of the tools include: continuous tracking of the first responders (i.e., of the mobile app users) and bidirectional communication between the first responders and the command and control center and between first responders in the same team. The communication is currently facilitated in the following ways:

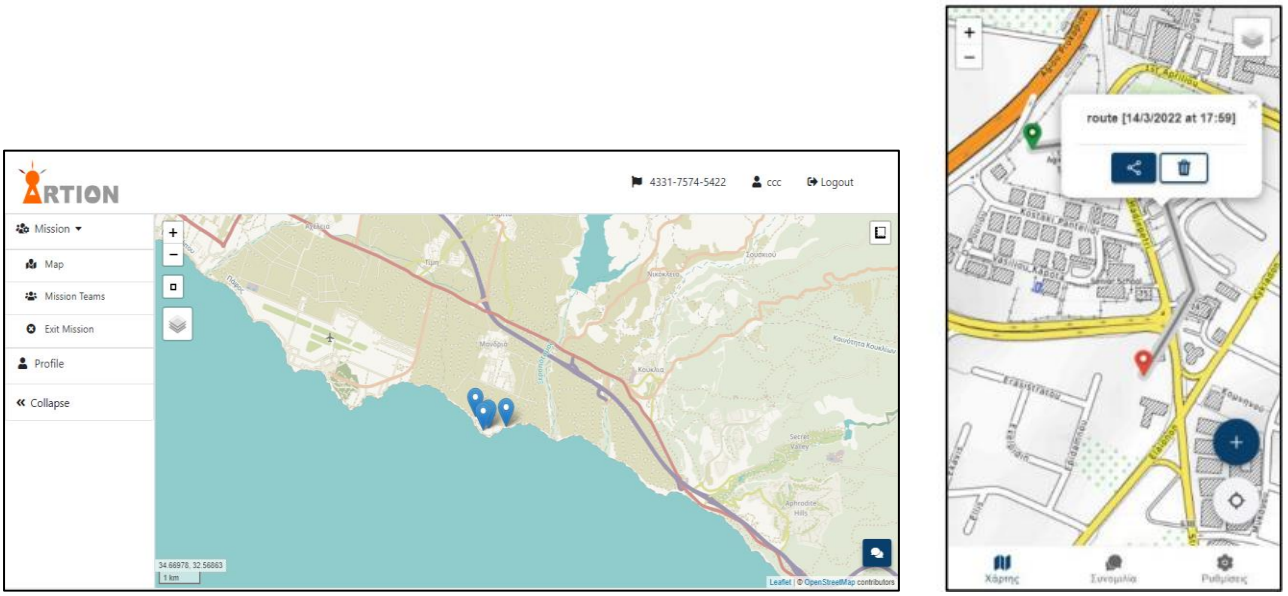
- exchange of text messages,

- sending of photos that are taken with the mobile phone, and
- sharing of points and routes of interest that are drawn on the map by the user.

Currently, an AI algorithm for persons and object recognition is integrated in the platform and runs on all photos that are captured by first responders and sent to the command and control center. In the future, we envision to develop additional AI algorithms that will be integrated in the platform with the aim to turn the platform into an AI-powered decision support tool. Figure 6 shows two screenshots; the first screenshot depicts the operational screen of a mission on the web-platform. On the map we see the current locations of the first responders. The second screenshot is from the mobile-app where the user is about to share a route that he has drawn on the map.

As these tools facilitate continuous tracking of the first responders in the field, they are used also for data collection, specifically to collect first responders' traces. These traces are saved in CSV format and can be accessed any time after the mission.

In total, three exercises have been conducted for the testing of the ARTION web-platform and of the mobile-app. The first two exercises were conducted in Cyprus. However, the first exercise tested an initial version of the tools, therefore many problems were identified. Furthermore, there were also Internet connectivity issues which caused delays in the testing. We want to stress, however, that this first exercise was of crucial importance as it revealed fundamental problems of the tools. It was, in fact, a necessary step in the development phase. However, at that stage it was not possible to receive actual feedback from the first responders' site, as there were still basic connectivity challenges that did not allow a completely smooth testing. Thereafter the developed tool-duo was tested in two subsequent exercises – one conducted in Cyprus and one in Sardinia – followed by the feedback obtained from the users in the following section of the present document. Both simulated search-and-rescue scenarios as the web-platform and mobile-app are very appropriate for this kind of operations.



a *b*

Figure 6: (a) A screenshot of the web-platform showing the operational screen of a mission. On the map we see the current locations of the first responders. (b) A screenshot of the mobile-app where the user is about to share a route that he has drawn on the map.

2.2.1. A search-and-rescue operation in Paphos, Cyprus

A search and rescue operation was organized in an area outside Mandria village, in Paphos, Cyprus. The exercise was organized by the CCD. The KIOS UCY participated to support with the use of the tools. However, the role of KIOS was clearly supportive as the tools were used by the first responders and the personnel of the CCD.

The tasks were to establish and operate an emergency operation center, establish a first aid station, and mobilise search and rescue teams to search for victims. 24 volunteers, moving on foot, were using the mobile-app during the mission. Specifically, 20 volunteers organized in three teams were conducting the search-and-rescue operations, whereas 4 persons formed the medic team. A single person at the command and control center was interacting with the mobile phone users via the web platform. It should be noted, however, that several persons had access to the web platform to observe the operation. Snapshots from the exercise are depicted in Figure 7.

Figure 7: Snapshots from the search and rescue exercises in Mandria, Paphos for the testing of the web platform and of the mobile app.

2.2.2. A search-and-rescue operation in Sardinia

A search-and-rescue operation was also organized in the island of Sardinia, in Italy by the Directorate-General of Civil Protection for Sardinia Region (RAS). KIOS UCY participated in the exercise with two members who traveled to Sardinia in order to support with the usage of the ARTION web platform and mobile app.

The exercise simulated the search and rescue of a missing person at the Serucci mine site, in the Municipality of Gonnesa. On the field there were 5 teams, each one consisting of 2 to 3 members equipped with smartphones running the mobile app. Each team, having the same starting point had, as target, to reach a point located some kilometers far, by car. Each team was assigned a different path to the target point. The web platform at the emergency command and control center was accessed and utilized by the KIOS UCY researchers, whereas the mobile app was used by the volunteers and by the officials of RAS. Figure 8 depicts the location where the exercise took place and Figure 9 shows some snapshots from the exercise.

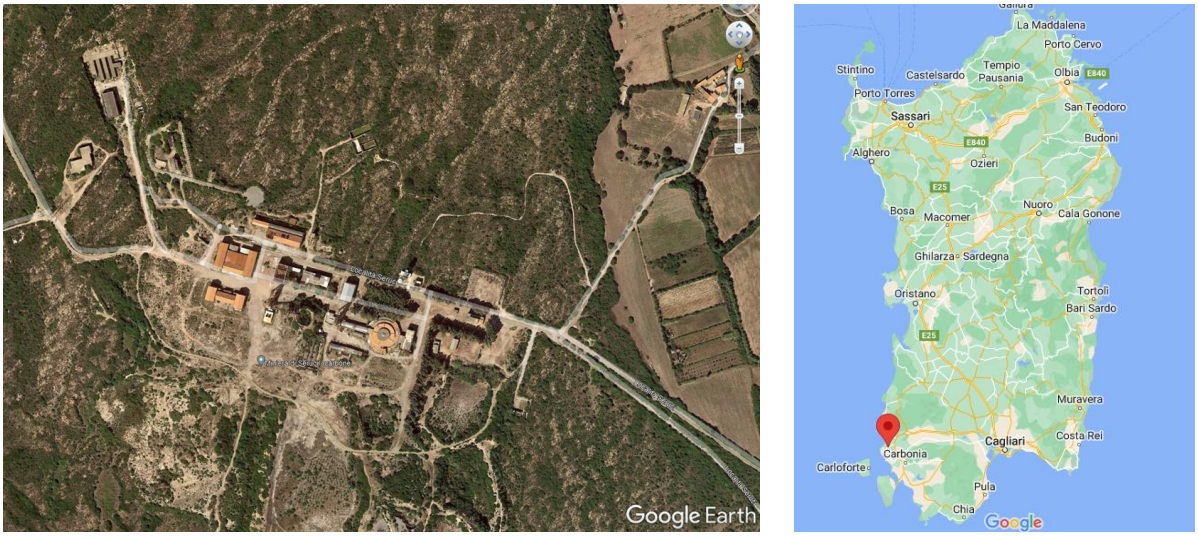


Figure 8: The location of the Seruci mine in Sardinia where a search and rescue operation took place for the testing of the web platform and of the mobile app.

Figure 9: Snapshots from the search and rescue exercise at the Seruci mine in Sardinia for the testing of the web platform and of the mobile app

2.2.3. Testing setup

As the utilization of the web platform and of the mobile app require the involvement and cooperation of the participants in the mission, training sessions were organized and took place prior to each field exercise. In Cyprus, a couple of days before the exercise one training session was conducted with the physical presence of all the participants. The session included a first part in which engineers from KIOS UCY presented the tools and was followed by a hands-on part on the usage of the mobile app during which the participants had the opportunity to ask questions and resolve all of the issues that occurred with the installation or use of the application. In addition, manuals with graphical depictions (i.e., screenshots) were distributed for the installation as well as for the use of the tools.

In Sardinia, a brief online presentation of the tools to the officials of the RAS took place a week prior to the exercise. At the morning of the exercise, an one-hour slot was reserved for going through the installation of the mobile app and showing its basic functionalities. Figure 10 shows snapshots from the two training and set-up sessions that took place in Cyprus and in Sardinia.

a ***b***

Figure 10: The training and set-up sessions that took place (a) in Cyprus (b) in Sardinia (before the field exercise)

In both cases, in Cyprus and in Sardinia, the web-platform was running at the KIOS UCY server that is situated in Cyprus, at the premises of UCY. A test mission was created and the users had the chance to play with the mobile app and the web platform the days before the actual exercise. At the day of the exercise, a new mission was created and the first responders that participated in the search and rescue operations were added in the mission (organized in teams as determined by the mission commanders). First responders were instructed to communicate with the mission commanders at the command and control center with all means available through the mobile app, namely, communicating with text, sending photos, sharing points of interest on the map. From their site, the web platform users at the command and control center responded to the communication sent by the first responders and initiated as well the exchange of messages and points or routes on the map.

Figure 11 and Figure 12 show some snapshots from the utilization of the web platform at the emergency command and control centers that were set up for the missions in Cyprus and Italy, respectively.

Figure 11: Photos documenting the utilization of the web platform in the exercise in Cyprus

Figure 12: Photos documenting the utilization of the web platform in the exercise in Sardinia

3. TESTING OUTCOMES

3.1. Testing of the Aerial Person Detector

In general, the testing of the aerial person detector was very successful. The algorithm performed as expected. Figure 13 shows two screenshots of the aerial person detector under test from the first and second exercises, respectively. It is important to note that from the two screenshots we observe that the scenery in both cases was different, however, the algorithm responded in both cases with success.

Moreover, it is evident that the drones were flying at quite high altitudes such that persons are hardly to identify with human-eye. After careful observation of the videos we verified that the algorithm was able to recognize all persons that were present in a scene. In the exercise simulating a flood scenario, the algorithm was even successful in recognizing a person found in the water (can be seen in Figure 13a).

a

b

Figure 13: Screenshots of the aerial person detector under test (a) at the flood-simulation exercise (b) at the search and rescue operation after a tornado (or earthquake)

3.1.1. Feedback from the End-User (CCD)

The following remarks were made by the end-users with regard to the aerial person detector:

i. The aerial person detector is a ***very useful tool in the field*** as it is able to detect and track persons that can be very difficult to catch when watching the video (due to being really small in the video).

It can assist emergency response stakeholders to detect victims, persons that are wondering in areas where they shouldn't be, as well as first responders.

ii. Although the algorithm works well, the ***markings on the resulting video could be improved***. Sometimes, especially when the display at the command and control center is not very large, it is difficult to see the outcomes of the algorithm which are displayed/marked on the video. The numbers are quite small (and maybe it is not even necessary to displayed them on the screen). Moreover, it would be useful if the colours of the markings could be changed on demand (or even automatically) in order to be able each time to select colors that stand out, depending on the scenery.

iii. The algorithm could be extended in order to ***detect and track vehicles*** as well.

iv. Some additional control functions would be useful like, for example, to be able to ***freeze*** and ***zoom*** the video.

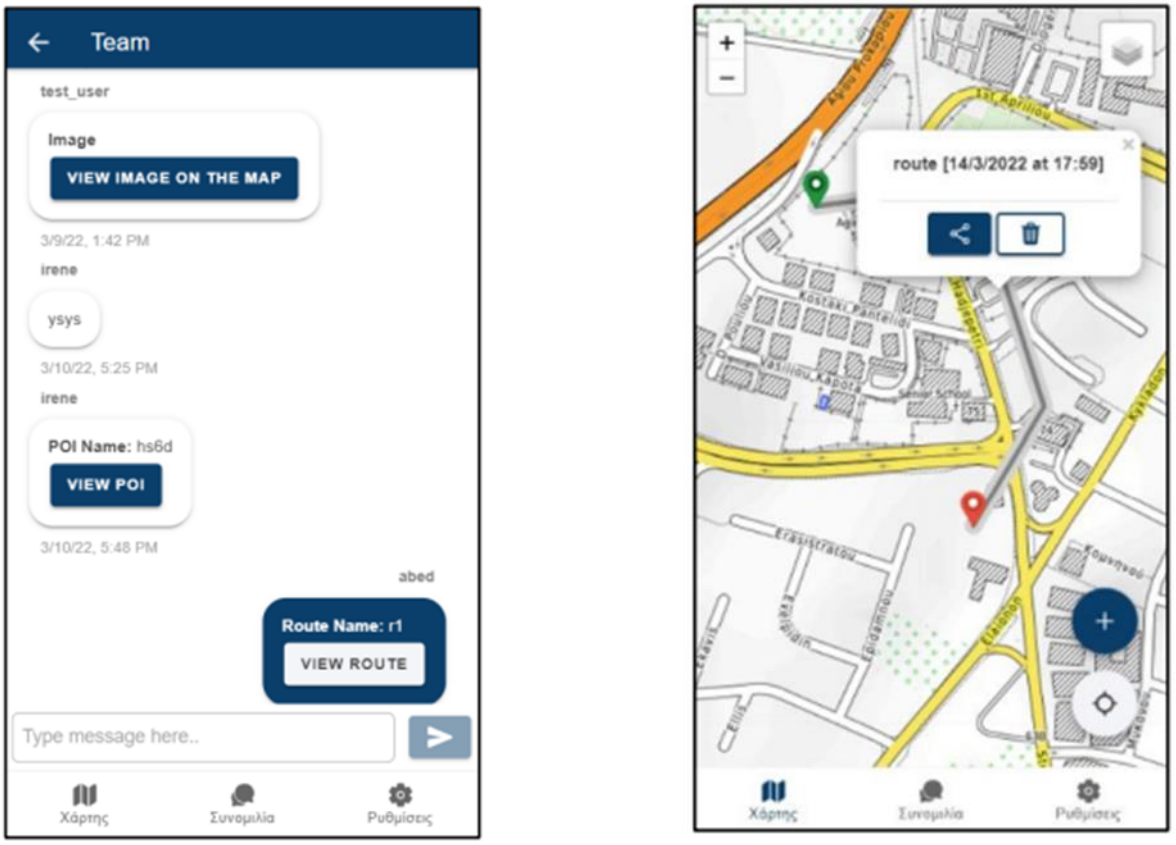
3.2. Testing of the web-platform and the mobile-app

The ARTION web-platform and the mobile-app was tested first in Cyprus and, finally, in Sardinia. In general, during the exercises the tools were used with success, however, several noteworthy points were identified and noted for further improvement of the tools. Some issues had to do with features that did not work flawlessly, others with aspects that are susceptible to improvements. In fact, after the exercise in Cyprus at the end of May a couple of improvements were made before re-testing the tools in Sardinia at the end of June.

As soon as first responders sign-in at the application and join the mission, their locations are continuously tracked using the built-in GPS receiver of the smart phone. The instantaneous location of each first responder is shown on the map at the web-platform and at the same time they are saved at the server. In both cases, in Cyprus and in Sardinia, there were times (i.e., locations) during which first responders were losing the 4G connectivity, thus their tracking was lost. Field exercises are typically held in less-developed areas far from cities and villages, therefore it is actually expected that the 4G connectivity is limited. In fact, during real missions this would be even more frequent or probable either because of the lack of 4G network either because the network is damaged due to the disaster. The dependency of the mobile-app on Internet connectivity was actually the greater source of a potential dysfunctioning.

First responders were instructed to use the features of the mobile-app in order to communicate with the command and control center during the mission. The exchange of text messages was working flawlessly. Also, the exchange of points of interest was tested. A point of interest is drawn on the map by the user, either on the mobile-app, or at the web-platform, and it can be shared with others. Similar function is available with a route of interest that is drawn on the map. The exchange of points of interest was tested successfully in Cyprus, however in Sardinia some problems were reported as some times the point was shared successfully, but other times it was not reaching the recipient. This is most probably due to some settings at the back-end related to the fact that the mobile phones were operating in the cellular network of an Italian operator, whereas the web-platform was running on a server in Cyprus. The problem is currently investigated by the team of developers. Figure 14a shows a screenshot of the mobile app demonstrating the exchange of messages. In the conversation, the sharing of an image, a point of interest, and a

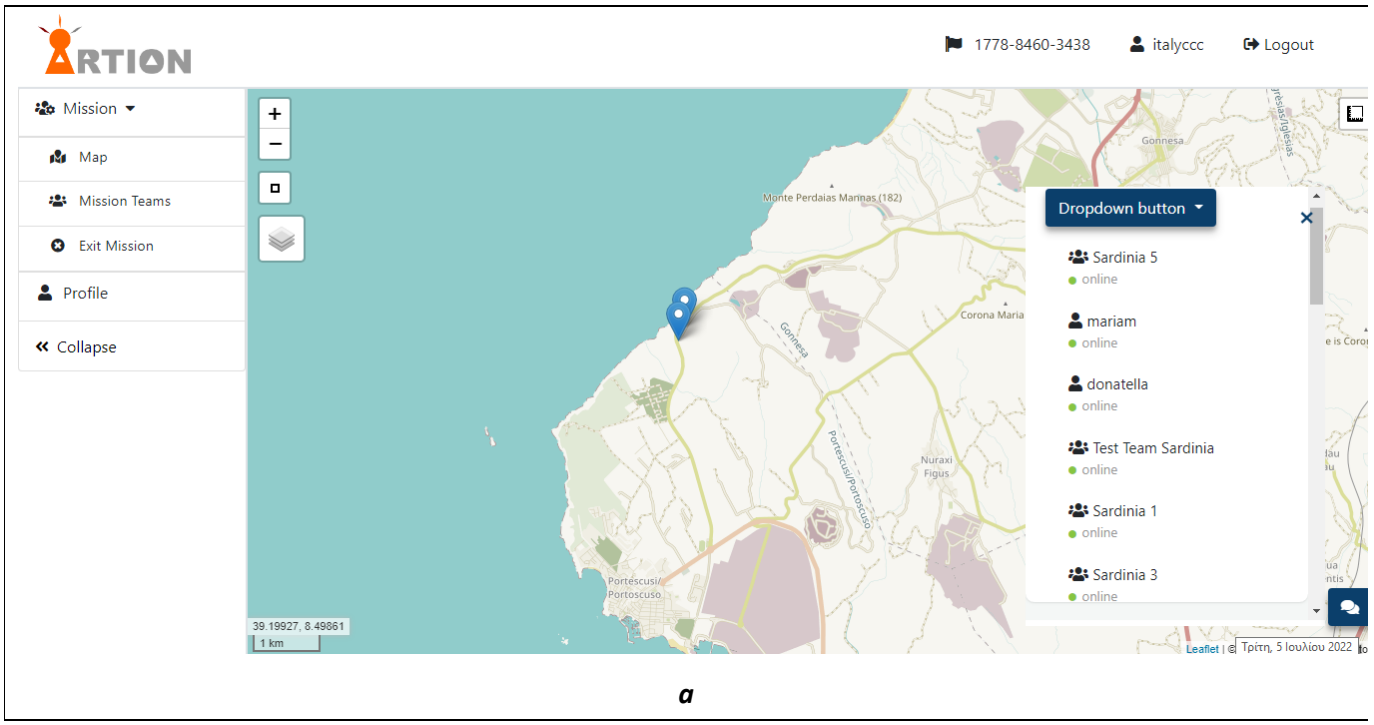
route is depicted. In Figure 14b we see a route that the user has drawn on the map and is about to share with others. We need to note, however, that the screenshots of Figure 14 are not taken from one of the field exercises as first responders did not make any screenshots of their mobile phone displays during the operation. These particular screenshots are from a testing performed by the KIOS UCY team.



a ***b***

Figure 14: Screenshots of the mobile-app demonstrating (a) the exchange of text messages (in the conversation the exchange of an image, point and route is shown) (b) the sharing capability of a route drawn on the map by the user.

Figure 15 shows two screenshots of the web-platform that were captured during the exercise in Sardinia. The top image (a) shows the window with all active chats (right bottom of the screen) and the bottom image (b) shows an open window with a discussion with the team 'Sardinia 5'.



a

b

Figure 15: Screenshots of the web-platform that were captured during the exercise in Sardinia showing (a) the window with all active chats (right bottom of the screen) and (b) an open window with a discussion with the team 'Sardinia 5'.

Finally, the tool features also the capability to take a photo with the mobile phone (through the app) and send it to the web-platform. An AI algorithm for person and object recognition is integrated in the platform and runs on all photos that are captured by first responders and sent to the command and control center. As the photos are taken by first responders in the field under not optimal conditions they might be of compromised quality. They might be, for example, dark, shaken, or taken from a large distance

from the scene of interest. To this end, the detection of the objects on the image is useful and helps to identify persons and items which could be missed by a human eye who sees the photo due to a combination of factors, such as the bad quality of the photo and the rush that characterizes all actions during emergency events. Figure 1Figure 16 shows a message-exchange box appearing at the platform in which a photo sent by one of the first responders out in the field is shown. This is a screenshot taken during our field exercise in Cyprus, captured by a first responder the moment one of the teams found one of the victims. The photo is located and shown also on the map, at the location where it was sent by the first responder. In fact, two photos appear on the map; the left photo is the original one, and the right photo is after the person and object recognition algorithm is executed. A detail of the right photo is depicted in Figure 17 where two persons are detected. Although the AI algorithm works well and persons and objects are indeed detected, during the testing we identified that the marking of those on the photos could be bolder and this is one of the points that are should undergo a minor improvement.

Unfortunately, the feature with the photos could not be demonstrated in Sardinia due to an error caused by the mismatch between the time zone at which the mobile app was running (in Italy) and the time zone of the web-platform server (in Cyprus). The KIOS UCY team could not find out the error during the field exercise, however the problem was discovered the following day. Although we were not able to try out this feature in Sardinia, it is important that the exercise revealed and led to resolving one bug in the back-end of the web platform (which is, actually, one of the key reasons these testing exercises are conducted).

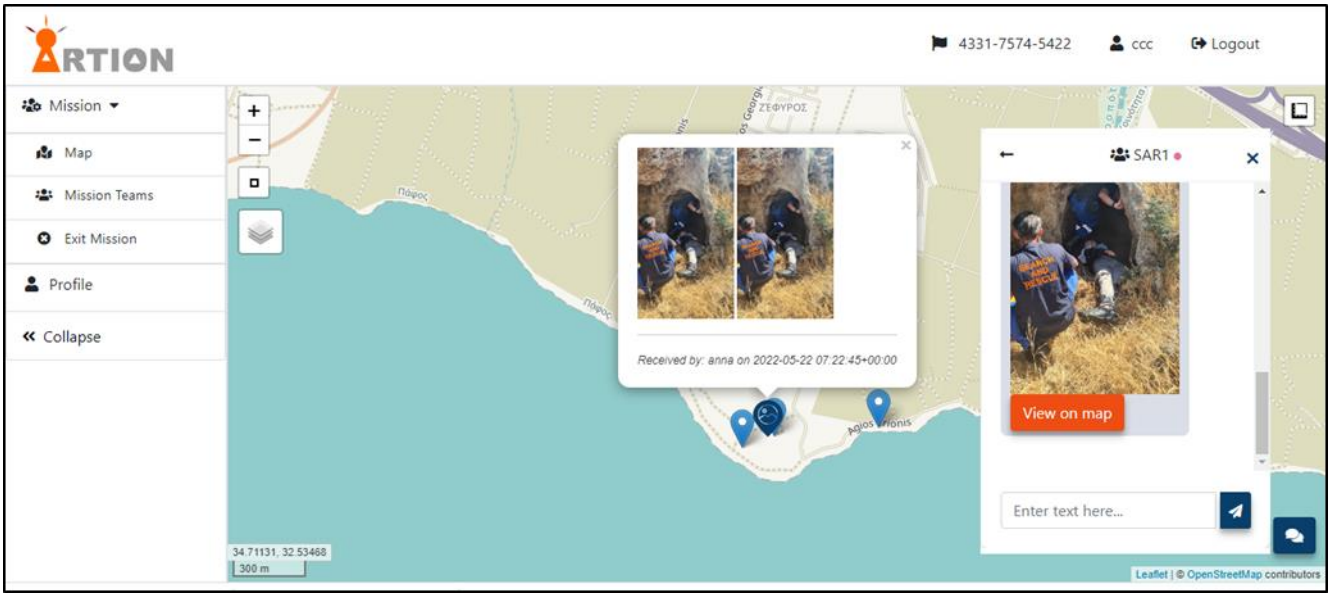


Figure 16: A message-exchange box appears at the platform showing a photo sent by one of the first responders in the field. The photo is located also on the map (left photo is the original one, right photo is after the person and object recognition algorithm is executed).

Figure 17: A detailed of the photo sent by a first responder, in which two persons are detected by means of an AI algorithm.

3.2.1. Feedback from the End-Users (CCD and RAS)

The following remarks were made by the end-users with regard to the web-platform and the mobile app:

i. It was recognized that ***the ARTION web-platform and mobile-app are very useful tools***. Both, the CCD and the RAS, stated that they would be interested in using these tools as soon as they reach a production release stage.

ii. The web-platform and the mobile app are both ***intuitive and easy to use*** provided that the users are familiar with the use of Internet and simple software tools (for the web-platform) and with the use of smart phones and typical, widely used mobile apps (for the mobile-app).

iii. The dependency on Internet connectivity is probably the weaker point of the mobile-app at present.

iv. The ***maximum zoom*** of the map at the web-platform is not sufficient.

v. The ***marks on the map*** that indicate the locations of the first responders often ***fall on each other*** when the corresponding persons are close to each other and ***cannot be easily identified***. A larger zoom would probably fix the problem, but maybe also the location marks on the map should be of smaller size.

vi. The location marks on the map of the web-platform could be ***colour-coded according to their teams***, i.e., each team should have a different colour.

vii. The feature of ***recording and sharing voice messages*** would be especially useful as writing text messages can be inconvenient during emergency operations.

viii. In the photos that are sent to the web-platform by the mobile users, the AI algorithm that performs person and object recognition is very useful. However, the marking on the photos is not bold enough.

ix. Initially, the specifications for these tools were determined in collaboration with the CCD. After the exercise in Sardinia, officials from RAS pointed out that some ***features of the application could be configurable*** as the needs are different with different types of operations (e.g., search and rescue operations, fire response operations, water contamination events, etc.). For example, it should be an option whether the locations of all first responders or only of the team leaders will appear on the map. Also, at the mobile app, whether first responders will be able to see on the map and communicate with only members of their teams, with other teams leaders, or with all others could be provided as an option at the stage of a mission creation at the web-platform.

x. It will be useful if the commander that uses the web platform can not only see on the map the instantaneous locations of the first responders, but if ***the route of each first responder could be displayed on the map*** upon request. This information is stored at the server, however, it would be useful if it could be displayed on the map even during the mission.

4. CONCLUDING REMARKS

Within the framework of ARTION, realistic field exercises were conducted in order to test two of the tools that were developed during the project, namely the aerial person detector, and the ARTION web-platform and mobile-app.

These exercises gave the opportunity to test the tools under realistic conditions and identify bugs that need to be corrected as well as issues that could be improved. Also, the use of tools in the field provided a usability testing and yielded a valuable feedback from the end users with regard to possible improvements and desired new features. Finally, training the first responders at the usage of new technologies in their operations was also one of the project objectives that was achieved through these exercises.

In general, the end users from Cyprus and Sardinia rated positively the tested tools. More importantly, they both agreed that the two tools are useful for emergency response operations and easy to use.