AID- CIEDS
Swarm Rescue Challenge

2024-2025

1. Context

The “Centre Interdisciplinaire d'Études pour la Défense et la Sécurité” (CIEDS) of the Institut Polytechnique de Paris and the “Agence de l'Innovation de Défense” (AID) are launching a challenge on the theme of distributed intelligence. The challenge is open to students from IP Paris member schools (Polytechnique, ENSTA Paris, Telecom Paris, Telecom SudParis, ENPC and ENSAE) and schools under the supervision of the French Ministry of Armed Forces (ISAE Supaéro, ENSTA Bretagne).

2. Challenge objectives

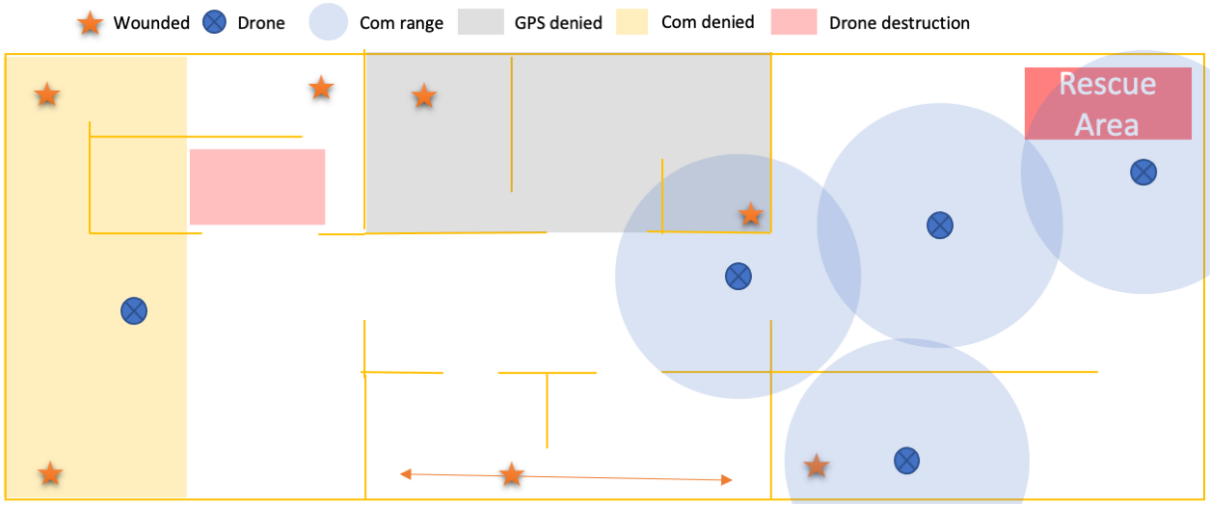
The aim of the challenge is to promote the development of artificial intelligence for multi-robot or multi-drone systems, an important topic in the fields of defense and civil security. For the organizers, this challenge is also an opportunity to assess the long-term potential of the various technical solutions proposed by the students, but the organizers have no right to the solutions developed for short-term use. All work carried out remains the property of the students.

The Challenge requires no prior specific technical skills (beyond knowledge of the Python language) and will above all mobilize creativity and scientific curiosity on the part of participants.

3. Scenario

The objective of this challenge is to explore an unknown, difficult-to-access, potentially dangerous area, search for people that can be stationary or can wander in this area and guide them out to a safe zone. A typical use case involves investigating the basement of a collapsed building in the dark or in smoke, to locate trapped people and rescue them by guiding them to the exit.

Each team will have a fleet of 10 drones. Each drone will be equipped with communication functions, a laser rangefinder (lidar, measuring distance to obstacles), a semantic sensor (enabling it to determine the nature of an object without data processing) and GPS. It is also equipped with life points that diminish with each collision with the environment or other drones, leading to its destruction when it reaches zero.



Scenario illustration

The UAVs will have to manage the limited range of communications resources, collaborate with each other to acquire and share information to optimize exploration, and be able to handle sensor and communications failures and unforeseen events such as the loss of UAVs, to conduct this mission autonomously.

The challenge therefore focuses on multi-drone exploration, navigation and coordination, and does not address issues such as person or object recognition. All scientific approaches (planning, learning, bio-inspiration, etc.) for the proposed solutions are possible.

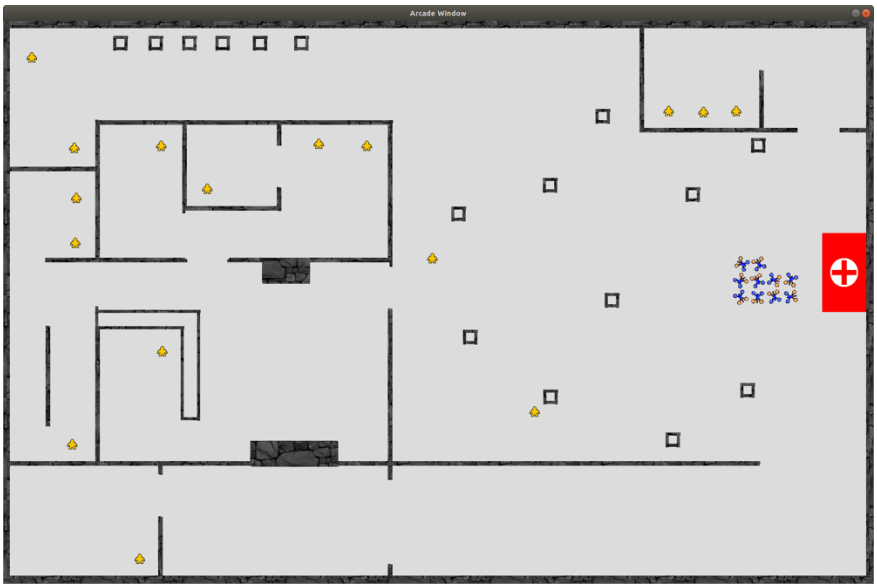
4. Simulation environment

Work on the challenge will take place exclusively in a two-dimensional simulation environment, with maps of increasing complexity. The simulator uses a physics engine to simulate drone movements and implements all sensors and communications. It also implements special zones that disable GPS, communications, or the entire drone, to which the proposed solutions should be robust. The simulator is designed to run easily on a standard consumer computer.

The controllers will be developed in Python. Participants can use any existing library, on the condition they give installation instructions to install them on the evaluation computer.

The environment is available as open source:

https://github.com/emmanuel-battesti/swarm-rescue



Example of the simulation environment for the 2023 edition of the challenge

5. Evaluation

Two intermediate evaluations will be carried out on simple maps with partial objectives:

- Evaluation of navigation functions
- Assessment of coordination and communication functions

The final evaluation will be based on unknown maps, on which the organizers will test the teams' solutions. The criteria for this evaluation will be, in limited time: the part of the explored territory, the number of people brought back to base, the time taken to bring back the last person if all are saved. The robustness of the solutions in difficult areas (loss of GPS, communication and drones) will also be assessed. Finally, the teams will have to present their solution to a jury, and the quality of the teams' presentation of their solutions will also be considered.

For each evaluation, the score will be the average on the different maps, to smooth out any random effects. Each participating team must provide its code to the organizers, so that all evaluations are carried out on the same computer, to avoid any bias due to computing power.

A website will enable candidates to enroll, follow the evolution of the competition and track their position in the team rankings : https://bit.ly/swarm-rescue

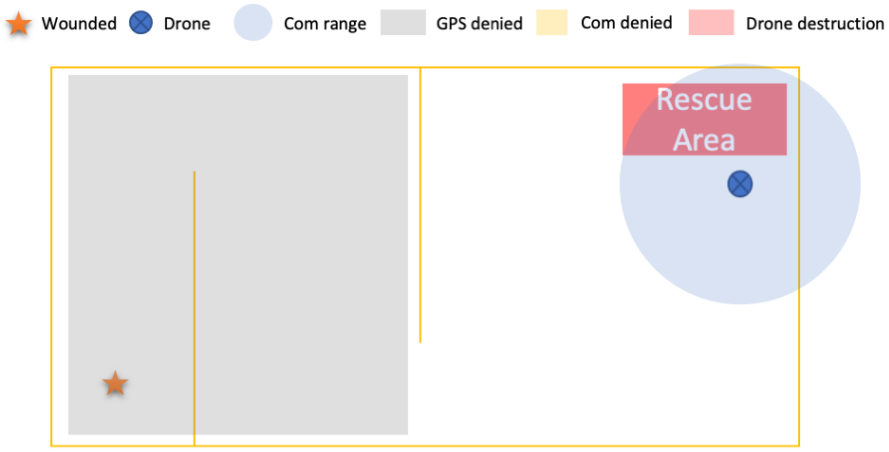
Only the final evaluation is taken into account for the awarding of prizes.

First evaluation

In this first scenario, a simple environment will be used to evaluate navigation capabilities. The environment will feature a few obstacles, a single fixed wounded person, a single drone and a GPS loss zone.

The score will be the time taken to return the wounded person to the rescue zone, evaluated with and without the GPS loss zone.

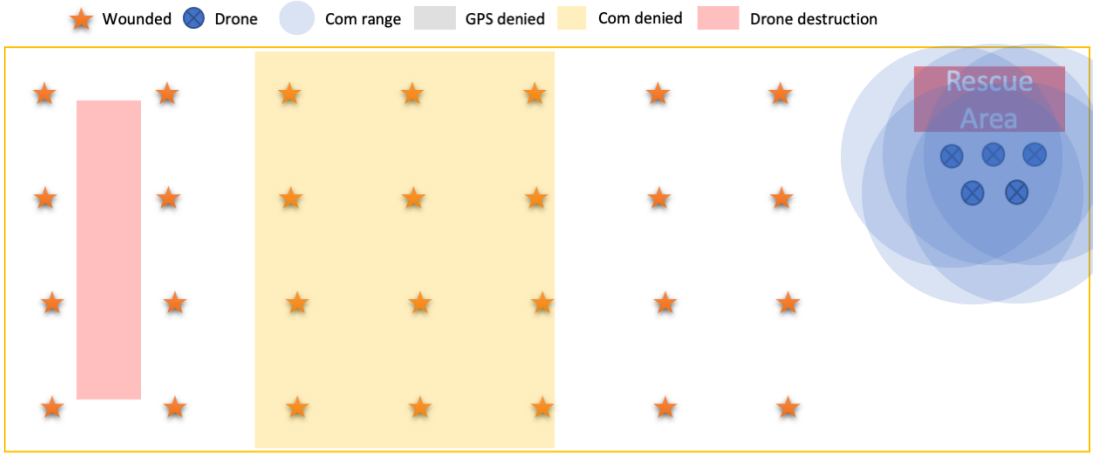
Possible solutions for this evaluation range from very simple solutions exploiting random displacements, to much more complex solutions using GPS loss compensation, mapping and planned exploration methods. All these solutions are accepted. The aim is to enable participants to assess the quality and need for improvement of their navigation functions.



Conceptual illustration of the first environment

Second evaluation

In this second scenario, a simple environment will be used to evaluate coordination and communication capabilities with 10 drones, a large number of wounded people (fixed of moving) on a large, unobstructed map with areas of communication loss and drone loss.



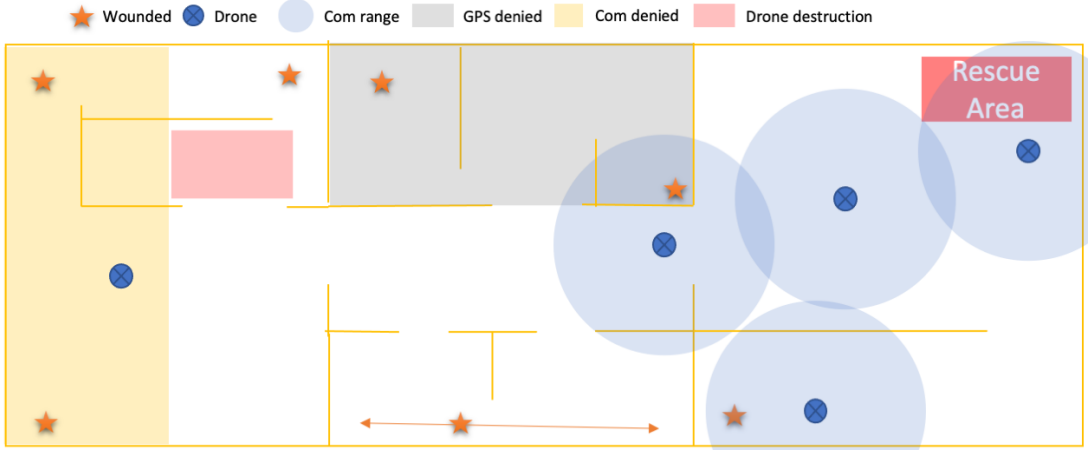
Conceptual illustration of the second environment

The score will be the time taken to bring all wounded people back to the rescue zone, assessed with and without the areas of lost communication and drones.

Possible solutions for this evaluation range from very simple solutions exploiting random displacements, to much more complex solutions using drone coordination mechanisms, task allocation and robustness to communication loss. All solutions are accepted. The aim is to enable participants to assess the quality and need for improvement of their communication and coordination functions.

Final evaluation

The final assessment will be an average of several qualitative and quantitative criteria defined below. The evaluation will be carried out on maps unknown to the participants, grouping together all the difficulties in a complete scenario.



Conceptual illustration of the final environment

Quantitative evaluation

A set of scores out of 100 points will be calculated by the challenge organizers using the evaluation script provided to participants, on new maps unknown to the participants.

The score calculated by the script uses the following formula:

$$S = w_r * R + w_e * E + w_b * B + w_t * T$$

Where:

- **R** is the percentage of people brought back to the rescue zone,
- **E** is the percentage of the map explored when all people are rescued or the time limit is reached,
- **B** is the percentage of life points of the drones that come back to the rescue zone at the end of the mission compared to the life points of drones at the beginning,
- **T** is the percentage of time remaining relative to the time limit when all people are rescued.

Weights are set at $w_r = 0.5$, $w_e = 0.2$, $w_b = 0.2$ and $w_t = 0.1$.

Based on this formula, 6 scores will be calculated using 6 evaluation maps which may or may not include the different difficulty zones:

- 3 maps without difficulty zones
- 1 map with a communication loss zone
- 1 map with GPS loss zone
- 1 map with a drone destruction zone

The final S_M score will be the average of these 6 scores.

Jury's grading

This grade is awarded by the jury following the teams' presentation of their work. It will take into account the following criteria:

- Quality of presentation
- Quality of answers to questions
- Operational credibility of the solution
- Respecting the spirit of the challenge

This score, hereinafter referred to as **J**, is out of 100 points.

Final score

The final score out of 100 points will be calculated by aggregating the scores according to the formula:

$$N = (J + S_M) / 2$$

6. Organization

Registration

The challenge is open only to students enrolled at IP Paris schools and schools under the supervision of the French Ministry of the Armed Forces (ENSTA Bretagne, ISAE Supaero).

Student recruitment will run until October 31, 2024. The aim is to form teams of 2 to 5 students.

You can register individually or by team at: https://bit.ly/swarm-rescue

Individual registrants will be put in touch with each other to form teams.

Calendar

The Challenge will be officially launched on October 15, 2024, 6pm, at the X-Novation Center building of the Institut Polytechnique de Paris, in the presence of students and Challenge organizers. The presentation will be visible online at: https://ecolepolytechnique.zoom.us/j/99115028427?pwd=e3AjuXvYeaXPGmHgURlfQJYB1ZqaxJ.1

The agenda of the challenge will be (subject to potential changes):

- 15/10/2024: Challenge presentation, V0 environment made available
- 03/12/2024: Intermediate point (videoconference) and first evaluation
- 28/01/2025: Second intermediate point (videoconference) and second evaluation
- 14/03/2025: Final evaluation and public presentation of projects

NB: intermediate checkpoints will be organized by the organizers between these dates to monitor the teams' work and answer any technical or rules-related questions.

Jury

The jury is made up of representatives from AID, CIEDS and the French Ministry of Defense.

Intellectual property

The organizers are not asking for any intellectual property rights. Participants are encouraged to publish their solutions as scientific papers and open-source code.

7. Prizes

The following prizes will be awarded to the top three teams, shared equally between the team members:

- 8,000 € for the winning team,
- 4,000 € for the second-placed team,
- 3,000 € for the third-placed team.