Blog Post 2: How Do Drones Fly Together? A Look at PANTHEON's Swarm Navigation Framework

In our last post, we introduced the PANTHEON project's goal of using drone swarms for disaster management. But how do you get a group of autonomous drones to fly together, cover an area efficiently, and not crash into each other?

This is the focus of our **Swarm Navigation** framework. We developed a system that enables coordinated UAV movement between specific Points of Interest (POIs) while ensuring real-time collision avoidance.

Our system is built on four key components:

1. **Waypoint Definition & Prioritization** In a disaster, not all locations are equal. We identify critical POIs, such as damaged infrastructure or survivor sites. Each POI is assigned a "priority-based prize value". This allows the algorithm to prioritize the most critical information, especially if it's impossible to visit every point. We also define "Time Windows" (TW) for each POI to ensure the area is a safe flight zone when the drone arrives.
2. **Swarm Composition** A swarm is often heterogeneous, meaning the drones have different capabilities. Based on the mission, we select UAVs with specialized onboard sensors like thermal cameras, gas sensors, or LiDAR from a capabilities database.
3. **Swarm Formation** To ensure maximum sensor coverage, the swarm is organized into a specific spatial formation, like a 2D or 3D polygon. A designated UAV at the geometric center serves as a reference for the formation and as a central communication hub. This "Swarm Bridge Broadcaster" maintains strong signal links and ensures reliable data transmission between all agents and the ground station.
4. **Route Generation & Collision Avoidance** To find the most efficient route that visits the high-priority "prize" POIs, we implement a priority-based variant of the "Traveling Salesman Problem" (TSP).
   But the most critical part is avoiding obstacles. Each UAV agent builds a local submap of its immediate surroundings using a "Euclidean Signed Distance Field" (ESDF). This map allows the drone to instantly compute its distance from any obstacle. This information is fed into an optimization-based replanning algorithm, which generates a smooth, safe B-Spline trajectory that avoids obstacles *and* other drones in the swarm.

Up next: Drones have limited battery life. We'll explore our "Energy Aware Coverage Path Planning" method designed to get the most out of every flight.