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AEGIS: Aerial Escort Guardian Intelligence System

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Abstract

With increased concerns around personal safety and emergency preparedness in urban environments, this project proposes a novel system of low-altitude, autonomous escort drones. These drones can accompany individuals during vulnerable situations — such as walking alone in unsafe areas, being targeted by specific individuals or groups, or navigating risky environments due to age, disability, or medical conditions. They can function as a deterrent to crime while also providing real-time alerts to emergency services.

Unlike 911 calls or surveillance cameras, escort drones offer a proactive, on-site presence that can respond even when a person is unable to speak, make a call, or wait for help. The autonomous drone system integrates AI-driven decision-making, real-time vehicle-to-vehicle (V2V) communication, and autonomous rerouting to enhance public safety and emergency coordination.

While calling 911 remains the primary emergency protocol, it assumes that the individual has access to a phone and can communicate the situation. In reality, this isn't always possible — especially in low-patrol zones, college campuses, hiking trails, or during large-scale infrastructure failures. Escort drones provide a critical advantage: they are physically present, monitoring in real time, and can escalate emergencies autonomously. If someone falls while hiking, suffers a medical event, or is being followed, the drone can alert authorities with exact coordinates, visual context, and even activate lights or sirens as a deterrent. These are just a few of the many scenarios where this system fills the safety gap and provides an aviation-enabled solution that goes beyond reactive emergency response.

Introduction

Threats to safety in public spaces have always been a significant concern, yet recently, with heightened awareness and publicity of criminal activity, this problem has become increasingly prevalent. Many Americans are now confronted by a growing fear of traveling alone or in unfamiliar surroundings due to this uncertainty. Through an increase in societal awareness and environmental factors, such as crime rates, gang violence, and protests, contributing to civilians feeling concerned about their personal safety, the results are clear: there has been a decrease in the number of people visiting local parks and community area [1]. A survey conducted in 2023 found that approximately 40% of Americans feared walking alone at night, and an additional 63% believed the issue of general crime in communities was serious, meaning it significantly affects a large number of citizens [2]. At-risk populations face a further fear of navigating their neighborhoods safely [3] [4] [5]. Additionally, factors such as old age or health conditions can add additional risk when walking alone.
Currently implemented solutions are merely reactive, only responding after a threat has been identified, such as 911 or Blue Light towers. They provide an inadequate physical presence to combat potential dangers, posing the need for a faster, real-time system. The Aerial Escort Guardian Intelligence System, or AEGIS, stands as a tool to remedy this deficit, providing a proactive response to said danger. It is scalable, functions autonomously, and responds to emergencies consistently and reliably. Designed to address the shortage of direct and immediate response to danger in communities, AEGIS can protect the public in both every day and emergency scenarios.

Background

Current safety technology built to solve this issue includes mobile alerts, surveillance systems (e.g. SimpliSafe), and security apps (e.g. Citizen app, SoSecure). These have the following shortcomings:

- Require active user interfacing or ongoing attention
- Rely on a centralized infrastructure offering little redundancy
- Lack of an immediate physical presence for monitoring the current conditions of the environment and active deterrence

Systems such as 911 and computer-aided dispatch are essential in emergency and safety scenarios; however, they are reactive and require the victim to actively recognize a threat, access their phone, and successfully communicate back in an emergency. In many real-life scenarios, that simply is not possible. Response time is also extremely important; the attacker at Sandy Hook fired 154 bullets in less than four minute [5]. The average response time of the police for active shooting attacks is over 3.5 minutes [6], so reducing the response time by even a minute can save many lives. As a result, proactive policing techniques [7] have been deployed as part of creating preventive measures to protect before crime occurs. Proactive policing involves deploying personnel in statistically high crime areas to deter crimes from occurring in the first place [8]. This technique has been seen to reduce the levels of crime in an area successfully and provides deterrence to those who commit crimes, reminding them that they are more likely to be caught [9]. Although proven effective, doubling the police force is required [10] to effectively patrol and respond to crimes at the same time, which is not feasible for both urban and rural areas [11].
Escort drones are an augmentation over standard police systems and can add a proactive safety capability without the need for a significantly larger workforce. They offer a tangible, present entity capable of detecting emergencies and contacting the proper authorities, while providing an active deterrence to potential attackers. In emergencies such as assaults, shootings, or medical events, a rapid response provides a life-saving difference. A service model utilizing Unmanned

Aerial Vehicles (UAV) technology can provide an on-demand autonomous presence to personal and public safety.

Assumptions & Constraints

A necessary assumption is that current drone technologies are sufficiently advanced for use in perpetrator deterrence scenarios. This includes the capability to effectively carry and deploy deterrence tools—such as high-decibel sirens or loudspeakers—to issue audible warnings, commands, or alarms [12]. For instance, the DJI Mavic 2 Enterprise series supports an attachable loudspeaker (up to 100dB at close range) and high-intensity flashing strobe lights, which are visible over three miles and compliant with FAA regulations, specifically designed to enhance visibility and serve as visual deterrents in public safety, law enforcement, and inspection applications [13], [14], [15]. Additionally, lightweight and reliable navigation systems are essential for safe drone operation in complex urban environments [16] [17].

A primary technical constraint at present is limited mission range, which results from current battery energy densities and environmental challenges such as adverse weather conditions. One further constraint is the advancement level of onboard AI capabilities. Improvements in battery technology—specifically, in energy density—are expected to directly extend the operational range and endurance of these systems. Weatherproofing and advances in lightweight, durable materials (for example, enhanced resistance to rain, wind, and temperature extremes) can further improve reliability and safety, but the most direct pathway to longer-range missions is the ongoing development of higher-capacity, lighter batteries [18] [19].

System Description

System Overview

Users request an escort drone through a dedicated mobile application or by activating linked emergency infrastructure, such as Blue Light Towers commonly installed on college campuses [20]. Upon receiving a request, the system algorithmically selects the nearest available drone from a distributed network of assets based on various drone hub concepts (see Table 7 for typical or recommended deployment sites for drone hubs within urban and campus environments).

The selected drone autonomously navigates to the user's location and provides continuous escort by monitoring the surrounding environment through integrated sensor arrays, including high-resolution visual and auditory inputs [21]. When a potential threat is detected, the drone executes predefined deterrent protocols, ensuring immediate situational awareness and response readiness [22].

A critical component of the system is its emergency override capability, which permits authorized operators to intervene and adjust the drone’s behavior dynamically during the mission. This control layer enables escalation, mission rerouting, or abort commands in response to changing conditions or unforeseen contingencies, thus complementing the AI-driven autonomy with human-in-the-loop decision-making [23]. This combination enhances system robustness and operational safety under complex real-world circumstances.

Upon mission completion, the drone autonomously returns to its base station or diverts to the nearest charging point, decisions guided by flight parameters, remaining battery capacity, and operational task load [24]. In instances where a drone becomes incapacitated—due to battery depletion, mechanical failure, or damage—the system dispatches both a replacement drone and a retrieval drone equipped with a lightweight recovery mechanism designed to securely transport the disabled asset back to maintenance facilities for prompt repair [25] [26] (see Appendix, Table 4).

By integrating personalized safety services, institutional emergency infrastructure, autonomous fleet coordination, and manual override mechanisms, this architecture presents a scalable and resilient solution for augmenting urban safety through aerial support, enabling real-time threat deterrence and enhancing public confidence in shared environments.

System Scope

AEGIS is envisioned as a city-wide implementation, requiring substantial infrastructure and maintenance capability to ensure functionality. Built as a scalable solution that allows for deployments of all sizes, data is collected from emergency services regarding crime or dangers to civilians. This data is used to determine where to deploy drones to the highest risk areas. Additionally, maintenance procedures and facilities help to maintain the uptime of the drones and ensure that the deployed fleet has sufficient drones to cover the entire deployment area.

Description

AEGIS uses a unique combination of physical and virtual components to ensure the safety of the user, seamlessly integrating the app and drone. To start using AEGIS, the user downloads the app from their device's app store and sets up an account with their personal information. This preps the autonomous drone system for usage at their convenience. When they feel it is necessary to call a drone, they can order one directly on the app, and the request is sent into the main network. The AEGIS algorithm chooses the nearest hub and most suitable drone for the individual. As the drone proceeds to the user's location, the client and the hub operators can see the drone's progress on a map. Once the drone gets to the user's position, it accompanies the individual by following within a preset radius. If no threat is detected during the operation, the drone is released by the client using a passcode or a verbal command, and it flies back to the operating hub for recharging.

When a potential threat is identified but no immediate attack occurs, the drone activates deterrent technologies such as high-intensity strobe lights, sirens, and loudspeakers to warn and discourage the threat. In active attack scenarios, the drone employs all available deterrents, including powerful directional loudspeakers capable of broadcasting warnings or commands at high decibel levels (up to 114 dB with ranges up to 300 meters), intense multi-color LED strobe lights visible from over three miles, and sirens to create an overwhelming sensory presence that deters aggressors until either the threat subsides or emergency responders arrive [27] [28] [29].

Control System

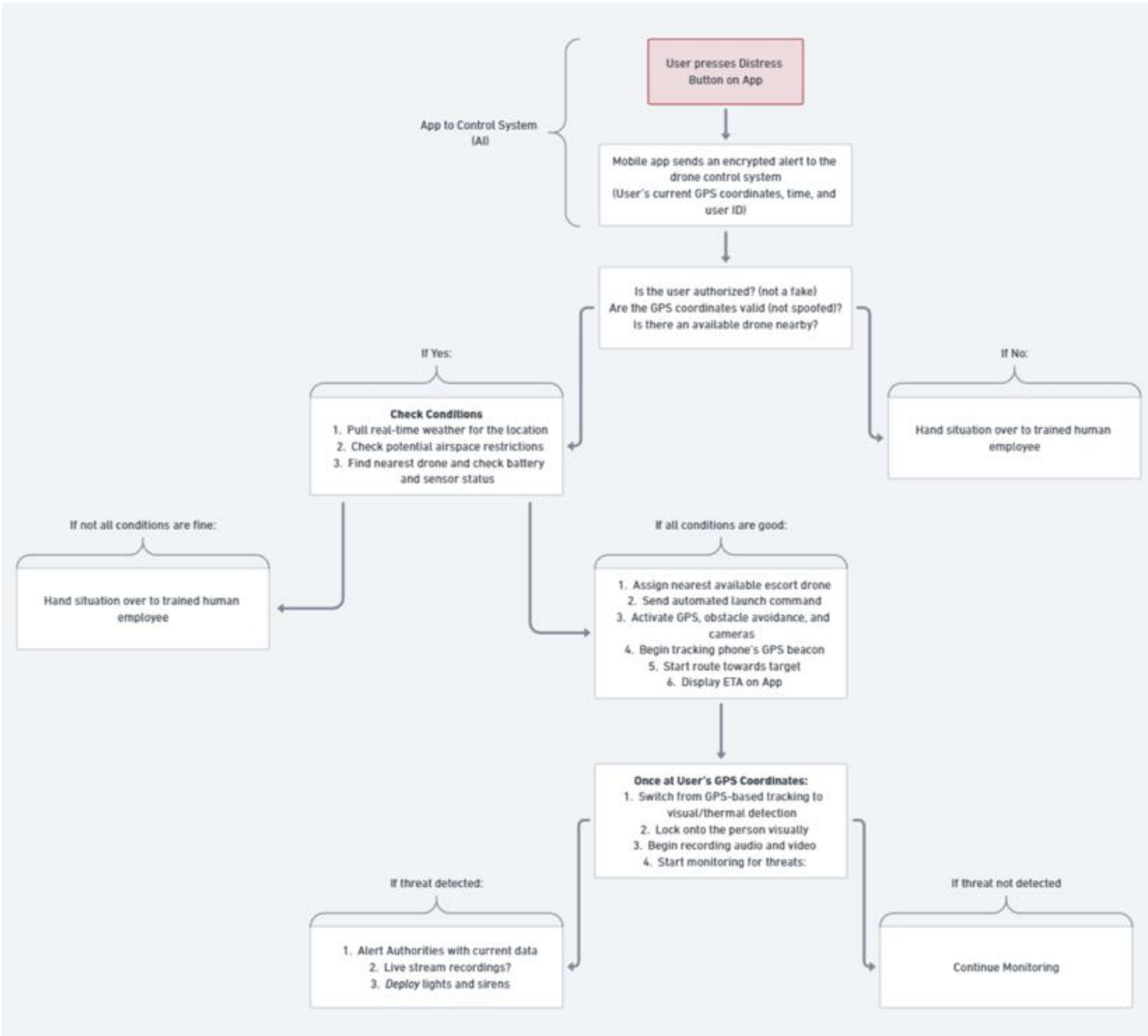


Figure 1. ***AI Decision-Making Flow Chart***

Autonomous Drone System

The central escort and response drone platform is designed as a fully autonomous, agentic system—meaning it exhibits intelligent, adaptive decision-making and independent goal pursuit, as described in recent literature on intelligent autonomous systems [30]. Leveraging onboard AI, safety protocols, and human oversight provisions, AEGIS enables real-time threat detection, contextual environmental monitoring, and autonomous incident response (Figure 1).

AEGIS was conceptualized by relying on open sources. Without accessing proprietary performance data, we pulled together insights from publicly available technical reports, case studies, reviews, and publications of real-world autonomous security drone deployments. These covered various aspects from advanced path-finding methods and privacy safeguards to different autonomy levels, data management practices, and how systems handle threats or unexpected interruptions (see Appendix, Table 1 and Appendix, Table 5; and [31]). AEGIS's agentic emergency detection integrates multi-modal sensors—including visual, auditory, and thermal arrays—and employs machine learning models to autonomously recognize emergencies such as erratic human behavior, blocked escape routes, physical threats, or environmental hazards. This approach parallels platforms like Sunflower Labs, which utilize AI-driven pattern recognition and real-time context analysis to classify threats and activate deterrent responses [32].

In emergencies, AEGIS escalates responses by deploying layered deterrent technologies—high-intensity lights, sirens, and directional loudspeakers—while issuing immediate alerts to authorities and supporting manual intervention through human-in-the-loop overrides, thereby ensuring operational safety [33]. By reviewing operational documentation and frameworks—such as FAA guidelines on UAV detection and mitigation [34] and autonomy protocols [35] —AEGIS's design aligns with best practices in agentic UAV security systems. This ensures technical feasibility, anticipated user acceptance, and important safeguards are incorporated based on existing implementations.

To optimize response time for each AEGIS drone, a path planning algorithm is required to provide safe routes for the drone to fly through, while adjusting to changes in the environment. Specifically, the A* (A-Star) pathfinding algorithm can be applied to this situation to find the shortest path the drone would follow. Rather than simply having $h(n) = 0$ and therefore utilizing Dijkstra's Algorithm, an additional heuristic function provides an estimate that aids in finding the approximate total cost of a path [36]. Being an admissible heuristic, it would not overestimate the journey costs involved. Implementation of this algorithm can be done natively on the drone with a low compute requirement, resulting in the quickest response time for the drone [37].

Real-time monitoring and threat detection is crucial to AEGIS so all escort drones will have onboard AI that can identify patterns of potential danger (e.g., erratic human behavior, pursuit scenarios, blocked paths) presented through collected visual and auditory information. Then, after rapidly processing those patterns, the autonomous control system will activate a specific level of response that corresponds to the reported severity of the threat.

When a threat is detected, the drone should initiate a tiered response, starting with deterrents like lights or sirens. Then, it must also establish a secure communication link to the appropriate authorities (police, fire, or medical responders) and escalate to transmitting live data if the danger persists. If needed, the drone is capable of physically stepping in, acting as a temporary barrier between the assailant and the user.

In the event of hardware failure, environmental interference, or loss of signal, the drone should automatically notify the system and request a replacement escort unit to continue the mission. Simultaneously, it should send its last known coordinates and operational status.

Secondary Operators

AEGIS relies on a balance between autonomous AI operations and human oversight. While AI enables real-time decision-making and efficient coordination, human operators can be involved in mission-critical oversight, response verification, and the ethical utilization of the system. By clearly defining the division of roles, with AI managing threat detection, rerouting, and networked coordination, and humans serving as secondary operators, data supervisors, and maintenance workers, we can ensure accountability, safety, and flexibility across different scenarios.

App Overview

Interface

The AEGIS app will be created with the objective of maximum ease of use to ensure anyone could understand and benefit from our service. To start, the client downloads the app onto their mobile device. Once the app is installed, the user sets up their account with necessary information such as their name, age, and general location. Their age is essential to ensure they are legally capable of consenting to recordings, and general location entails live location tracking.

They can then choose to allow or block features of the drones, such as recording video or audio. Finally, the user can link their contact list, which enables them to either automatically sync emergency contacts or manually choose people they would like to be notified if they are in danger.

App Interface + what the drone audially tells the user

- Person downloads app and sets up account - name, age (ability to consent to recording), location (address plus allow location services), permissions (can change at any time), choose if and where they want the video/audio data to be routed to, emergency contacts
- Person calls drone (providing current location) - drone dispatches from nearest hub to person, the hub and model of drone is chosen using an algorithm which considers their location, the time of day, and other key factors, receive notification when the drone is lifting off and estimated time of arrival (see Figure 2)
- Drone flies to them - person can see where the drone is on a 2D map, hub operators can also see the drone's location
- Person has ability to share drone's progress on 2D map automatically or manually with pre-defined contacts
- Drone autonomously moves with them - uses tracking technology to stay within a certain radius of the user, minimal deterrent technology is used (lights, microphone)

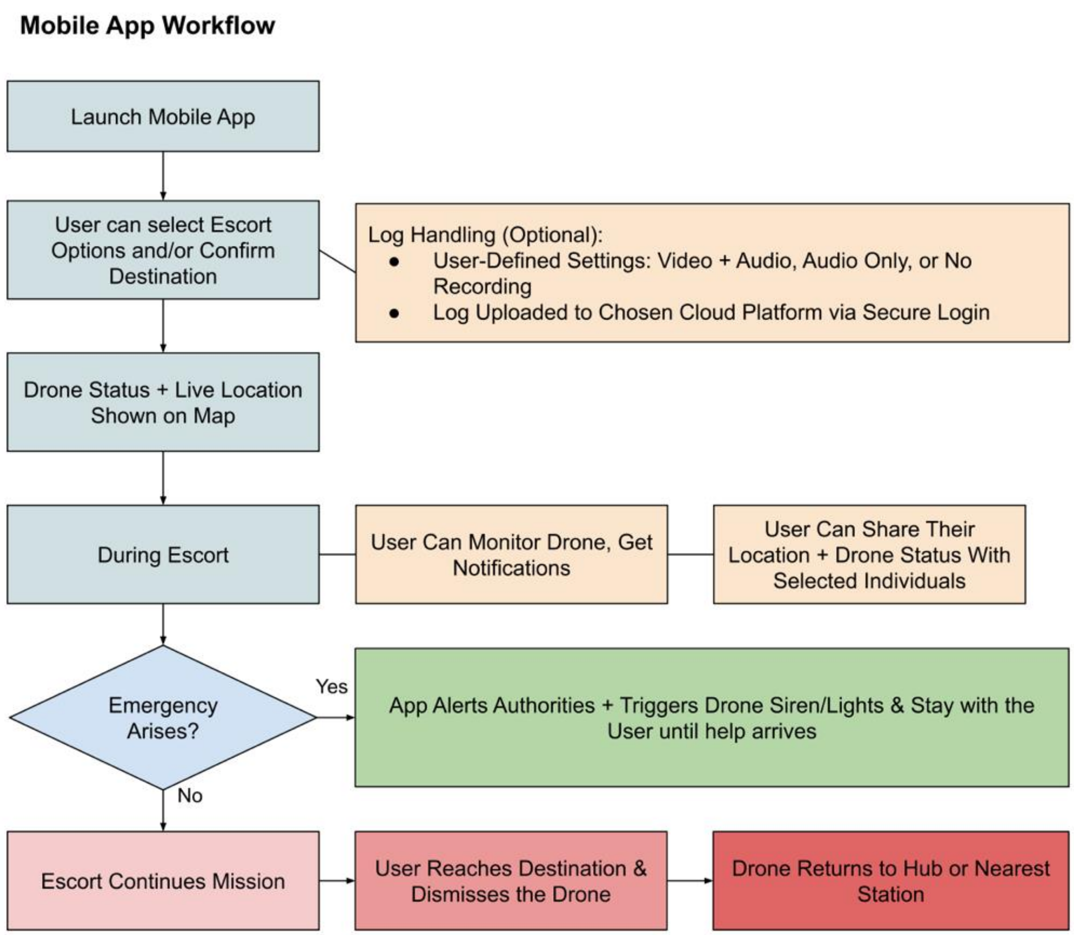


Figure 2. ***Diagram of App Workflow***

Figure 3 represents an early version of our app's interface, demonstrating the input of information necessary to call for an AEGIS drone.

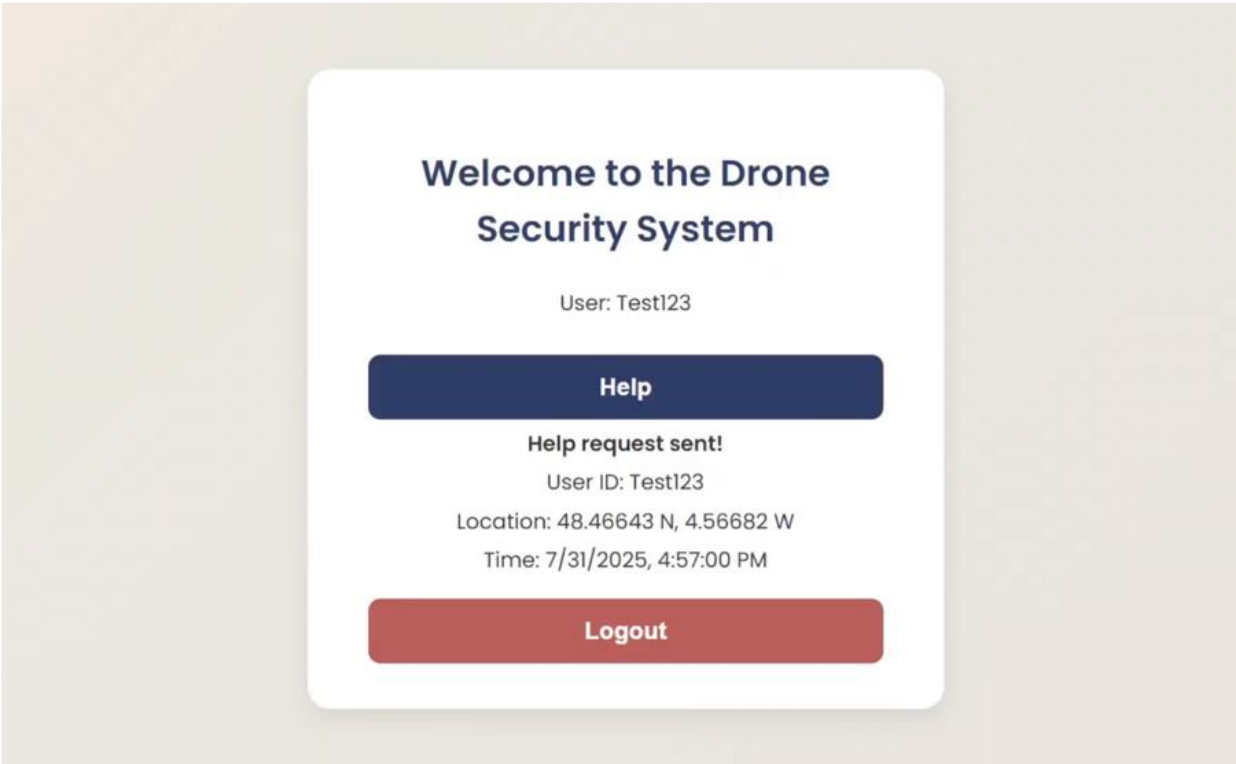


Figure 3. ***Early App Prototype***

Refer to this link to view the demonstration:
https://drive.google.com/file/d/1xDclbbPaD2Hbbwc2oPBTOKsLo6xOaixg/view?usp=sharing

Modes of Operation

Non-Emergency (Helper-for-Hire) Mode

The Non-Emergency or Helper-for-Hire Mode occurs when users request a drone's aerial presence to accompany them. Acting as both a guardian and a guide, the drone would monitor the user's well-being during the journey, while also serving as a physical deterrent to potential attackers. In this mode, the drones have limited autonomy and adhere to strict protocols to prevent their misuse. The process that these drones follow in a strictly Non-Emergency scenario, from the initial request to the end of their deployment, is illustrated in Figure 4.

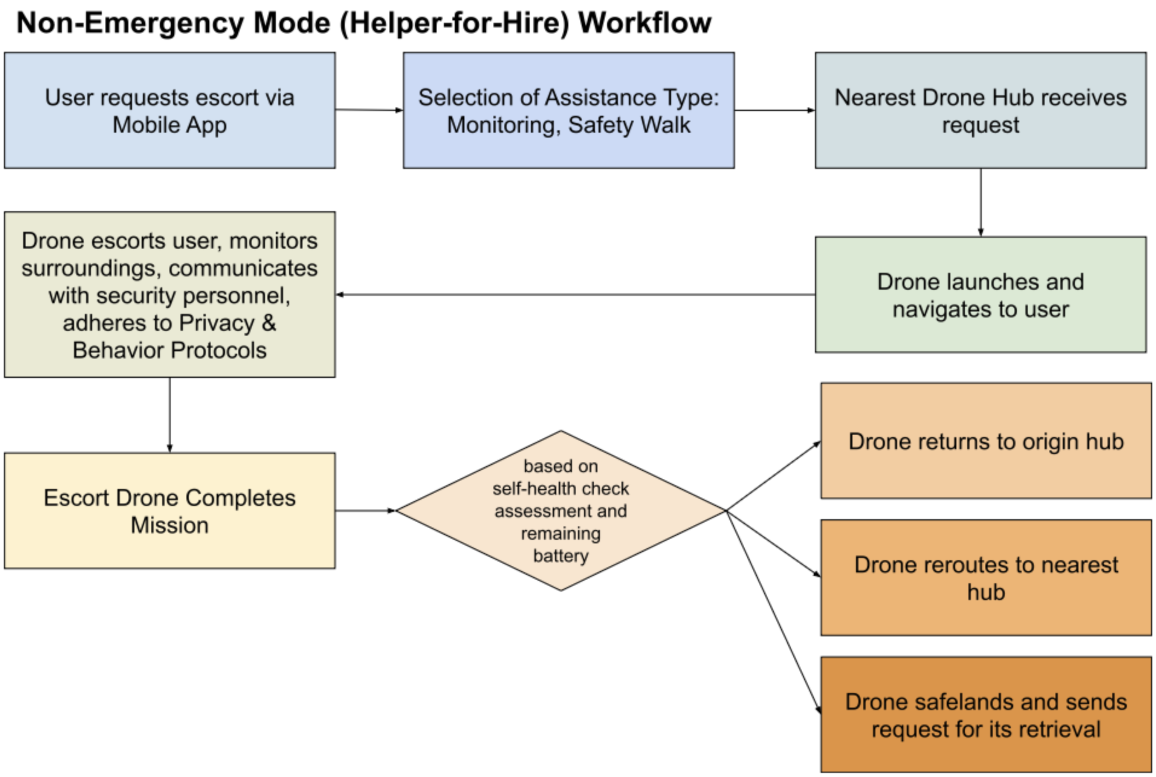


Figure 4. ***Representation of Non-Emergency Mode***

Emergency Mode

In this paper, we define “emergency” as a scenario where a person is being actively attacked by another individual or is facing imminent harm due to the threat posed by that individual’s persistent presence.

This mode can be reached through a sudden threat being detected during an existing Helper-for-Hire flight. Upon detecting the potential danger, the drone control system’s AI algorithm will assess the situation, using the gathered feed to gain a complete understanding of it. Therefore, even within the Emergency Mode, a situation will be further classified depending on the assessment conducted by the control system and allow for a unique response (see Figure 5). If it is deemed relatively “minor” -- where the user is not at risk of physical harm -- the drone will notify the user’s chosen contacts, while still offering protection until the user is safely at their destination, or additional company arrives.

On the other hand, if the alert is “major”, the drone will additionally notify the nearby emergency services, providing them with visual and auditory information and precise geolocation. Contacting emergency services through AEGIS allows for immediate response if possible, and intense lights and high decibel sirens will draw attention to the scene. The data collected and sent to the authorities through the drone’s recordings increases the likelihood of the perpetrator being apprehended. To aid in neutralizing the threat, the drones will also be capable of using information gathered from visual and thermal imaging to physically slam into the attacker, slowing them down while simultaneously buying time for the user to escape and the appropriate services to arrive. In the future, some escort drone models may also be equipped with non-lethal pepper-spray projectiles as another controlled yet effective protective mechanism. Implementing this would require collaboration with state legislatures to ensure all laws on the possession and use of pepper spray are followed (see Table 6 for FAA-related regulations).

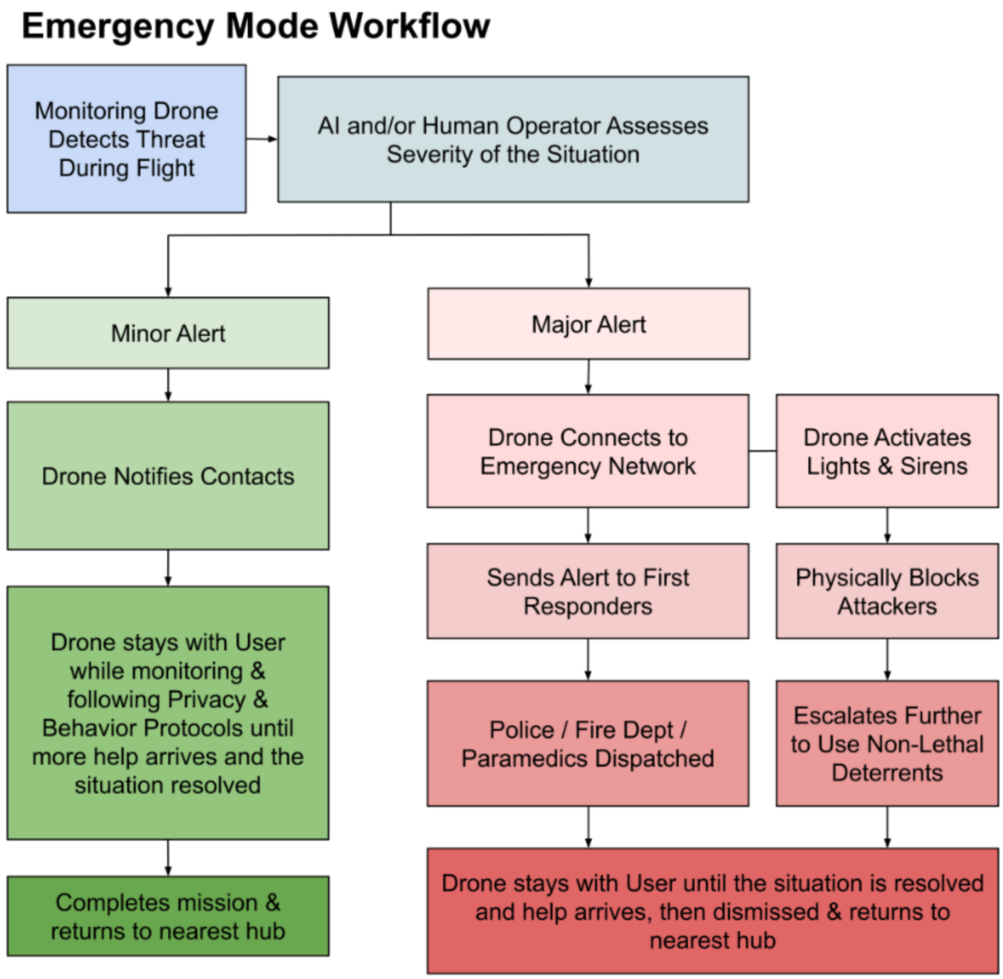


Figure 5. ***Representation of Emergency Mode***

Use Cases

The escort drone system is specifically designed for situations where traditional emergency response is delayed, unavailable, or inaccessible — including when an individual is physically unable to call for help, or where real-time deterrence or monitoring could prevent escalation. These scenarios highlight where the drone system could offer critical improvements in response time, visible deterrents, and safety.

- **Walking at Night:** It is often necessary to venture to places that an individual may not be familiar with. For example, they may be on travel and need to move between their hotel and a place to eat. Another scenario is as simple as needing to go to the grocery store at night. While this may be routine for many, the reduced visibility and situational awareness make the individual more vulnerable to attack. AEGIS is an adaptable companion for increased safety and peace of mind [38].

- **Elderly Individuals (Fall Risk, Silver Alerts):** If an individual who does not have the cognitive capacity to move around the world safely wishes to travel about in their community, AEGIS provides passive monitoring and immediate alerting when abrupt movement or stoppages are detected, or prolonged hesitancy and confusion are identified, to ensure their safety [39].

- **At-Risk Populations Who Are Targeted (Hate Crimes):** Hate crimes affect a wide range of minorities, especially in times of international tension. Innocent citizens are often targeted out of fear or hatred. AEGIS allows them peace of mind and a blanket of defense when going about their daily lives [40].

- **Campus Safety – Integration with Blue Light Towers:**
Escort drones can be triggered from Blue Light emergency systems, automatically launching from nearby hubs when a button is pressed. This would expand safety coverage and provide real-time visual deterrence, communication with campus security, and rapid response capabilities [41].

Escort Drones

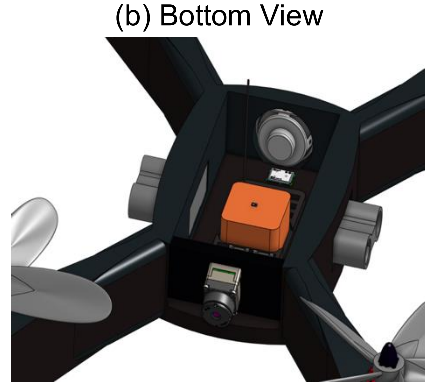
Escort drones enable civilians to walk at night safely. Utilizing a phone app, anyone walking in any area where drones are within their deployment radius can request a drone to follow them simultaneously. Features built onto the drone include speakers, strobe Lights, cameras, and wireless connectivity. Data is streamed back to the cloud with redundancy to document situations. Using autonomous systems, the drone can navigate and follow or guide the civilian on their path.
Currently, no consumer drone has all of the features necessary for AEGIS, so we have analyzed and selected several existing drones, each with capabilities that make it uniquely suited for a base model (Appendix, Table 2.a). As for specific features, which are outlined in Table 3 of the Appendix, some specialized drones and platforms have parts of them, and work in search and rescue, defense, and medical emergency contexts [42].

CAD Model

(a) Top View

(b) Bottom View

(c) Isometric View



(d) Detailed Zoom-In

Figure 6. ***AEGIS Escort Drone***

To demonstrate the general structure of the drones AEGIS will use, a CAD (Computer-Aided Design) model was created, providing perspective on the positioning of sensors and computer hardware on the drone. A symmetrical design with space for a large array of navigation, communication and deterrence devices was used. In this model, two LIDAR-Lite modules are placed on either side, along with a FLIR thermal camera, and an Orange Cube+ Flight controller.

Collector Drones

In the event of system failure or emergency landings in particularly inaccessible locations, such as rooftops, construction zones, dense vegetation, or even over water, the system will send a specialized collector drone to locate and retrieve the disabled escort unit using onboard object recognition, GPS tracking, and visual alignment.

Each escort drone will feature a standardized pickup appendage, such as a reinforced, lightweight loop or docking ring on its top surface. The collector drone will utilize a hook-and-dock mechanism, guided by optical aids such as LED markers (Appendix, Table 4). In addition to the many possible retrieval designs, these models will need to be weather-resistant and able to safely transport large payloads (Appendix, Table 2.b). To minimize weight and power consumption, the design avoids heavy magnetic or robotic gripping systems in favor of passive, lightweight solutions. Once secured, the incapacitated drone is taken to a maintenance hub for inspection and repair.

Hub Infrastructure

Hub Overview

Drones will be supported through a network of vertiports and charging hubs [43] placed throughout operational zones (see Appendix, Table 7). These hubs will consist of public safety facilities (e.g., police and fire stations) where infrastructure already exists for emergency response integration, dedicated rooftop drone stations in high-traffic urban areas, and solar-powered recharging pads to support sustainability and off-grid operation during power outages or disasters.

Each hub will also function as a data offloading and diagnostics center, performing health checks, software updates, and readiness assessments for each drone before deployment. The central system would track the status of all drones in operation, which would include, but not be limited to, mission logs for each unit, health information, battery life, and current geographic location.

With this distribution, a network of bases and charging vertiports is created, allowing escort and collector drones to return to either a base for a comprehensive check and charge, or to land on a vertiport station for quick diagnostics and recharging. For energy efficiency, each of these locations will be integrated with solar-charging pads.

Due to regional differences, hub placement in urban or rural settings would reflect the individual needs of each location, necessitating variants in drone models and features. As such, the drones assigned to each hub would take factors like distances and weather into consideration.

Inspiration for hub design can be taken from the Skyscape Drone Ports, which are currently on track to being built in Japan. Designed to house, charge, and deploy drones, the site analysis and design choices that Skyscape has taken is analogous to the process required for AEGIS drone hubs [44].

Drone Maintenance

Maintenance for the drone is carried out proactively as well. Drones are removed while at charging hubs for maintenance and the points of focus include the frame, motors, camera, and battery systems. Batteries are replaced after a particular lifetime, dependent on their chemistry, to prolong battery life and increase drone deployment time.

Fail-Safe Drone-to-Drone Handoff

In cases where the original escort drone cannot complete its mission (e.g. due to low battery, damaged sensors, or flight constraints) but remains operable long enough to issue a transfer request, a fail-safe drone-to-drone handoff protocol will be initiated. The system will automatically dispatch a replacement drone to the user's location, ensuring mission continuity. This handoff should be managed by the system's central command algorithm, which would evaluate drone availability, proximity, and battery levels in real time.

The drone waiting for its replacement can either remain on standby until the replacement arrives or navigate to the nearest safe recovery zone if it's unable to maintain hover/escort safely. Via the app or an audio cue, the original drone will notify the user that another drone is en route: "Escort drone is powering down. Please stay alert – backup is being arranged."

The user can then choose to briefly wait if a replacement is on the way, request emergency support if they continue to feel unsafe, or end the flight altogether if they have reached a safe location.

If no backup drone is available, the system should escalate to a human secondary operator or the user's chosen emergency contact. They will receive the user's location, the current journey status, and information about the failed drone in the form of live feed and/or alerts.

If the drone is landing due to failure, it should do so in an accessible manner, so that it can be retrieved by a collector drone or maintenance team. The landing should not alarm the user; instead, it will be explained clearly in the app and/or audio message. The goal is to guarantee that if the system fails, it will do so gracefully – never leaving the user without complete awareness or support.

Case Study – San Bernardino vs. Redlands

To simulate the placement of AEGIS hubs in different geographical locations that vary in safety levels, we examined the cities of San Bernardino, CA and Redlands, CA (see Figure 8).

With an urban setting, San Bernardino was chosen for its high crime rates, as evidenced by the FBI's Uniform Crime Reporting (UCR) program. According to UCR's raw crime data from 2023, San Bernardino has a total crime index of 4, making it only safer than 4% of cities in the United States [45] [46]. Furthermore, the city's violent crime rate of 1,071.15 per 100,000 residents more than doubled the statewide average of 508.2 per 100,000 people, leading to the launch of the California Highway Patrol – a government-led operation to assist the San Bernardino Police Department and other local law enforcement [47] [48]. In the same year, San Bernardino had an aggravated assault rate of 11.90 per 1,000 residents, which is also significantly greater than California's rate of 345.3 per 100,000 residents.

Located nearby in the San Bernardino Valley, Redlands was selected to represent a more suburban area that offers a different feel compared to the city of San Bernardino. The aggravated assault rate there is 2.148 per 1,000 residents, which is much lower than that of San Bernardino [49]. Being only approximately 36.4 square miles, as opposed to San Bernardino, which, according to the U.S. Census Bureau is 62.1 square miles [50], the Redlands Police Department has both less area to cover and fewer stations where AEGIS drone hubs could be housed.

Maps Data: ©2025 Google Imagery

(a) San Bernardino, CA

Maps Data: ©2025 Google Imagery

(b) Redlands, CA

Figure 8. ***Aerial Maps***

Based on the information collected about the cities' criminal activity, we then decided to model the implementation of AEGIS in each area (see Figure 9). To simulate the selection algorithm involved in choosing drone hub locations, we began by assessing the locations of existing emergency services (e.g. police stations, fire departments). To maximize the effectiveness of AEGIS and strengthen the response network with public safety centers, hubs would be integrated into these existing facilities.

Then, in correlation with the above violent crime data, the locations of the additional hubs were decided to suit the individual circumstances of each city. In an urban setting like San Bernardino, where the crime rate was exceptionally high, having more hubs located on dedicated rooftop stations allows for a faster response time. By considering accessibility and power availability, this placement allows for a steady aerial presence, with enough coverage overlap to account for unexpected drone shortage or failure.

Maps Data: ©2025 Google Imagery, ©2025 Airbus, Maxar Technologies

(a) San Bernardino, CA

Maps Data: Imagery ©2025 Google Imagery, ©2025 Airbus, Maxar Technologies

(b) Redlands, CA

Figure 9. ***Maps with Theoretical Hub Placements***

Having more hubs in larger cities also means that each drone can cover shorter distances during its flight, before being directed back to the closest hub. In the case of Redlands, relatively fewer drones are necessary, with most hubs just being located in local public safety facilities. The drones present in these suburban or rural areas would also be equipped differently, with greater battery lives and louder sirens to cover and be heard across the larger distances between locations and hubs. For the placement of additional hubs, AEGIS would take into account the experiences presented by city council members and other local leaders who can provide insight into foot traffic trends. This ensures that hubs are always in the most frequently used spots that would best serve the community.

Implementation Roadmap

To realistically deploy and scale the escort drone system, we propose a phased approach as described in Figure 10.

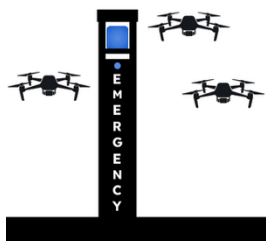
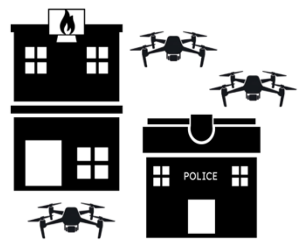
Phase 1 Concept Validation & Alpha Testing	**Phase 2** Integration with Existing Infrastructure	**Phase 3** Expanded Capabilities & Real-World Scenarios	**Phase 4** Advanced Public Safety Integration
			
Build or simulate basic drone escort functionality Test in controlled environments (e.g., school campus or retirement community) Manual override and supervision of all drone behavior Data collection on performance, user comfort, and emergency escalation timing	Pilot integration with Blue Light Emergency Towers on college campuses Test automated drone deployment when tower button is pressed Build secure two-way communication channel with campus security Assess wireless network reliability and line-of-sight limitations	Add disaster-response routing, thermal search features, and accessibility upgrades Include collector drones for failed unit retrieval Test in simulation or partnership with first responder agencies (e.g. fire dept.) Begin regulatory certification process for deployment in public zones	Collaborate with city-level authorities for deployment near parks, trails, or underserved areas Develop app for public requests (e.g., helper-for-hire, safety escort) Refine autonomous handoff, multi-drone coordination, and ethical oversight

Figure 10. Development and Deployment Phases

Ethical Considerations

Data Compartmentalization & Storage

Local + cloud data handling
o On-Device Storage: Each drone will include encrypted onboard memory to temporarily store mission-related data (video, audio, flight logs). The storage capacity will be defined based on typical mission length and resolution settings, but it must be secure and tamper resistant.
o Cloud-Based Redundancy: Simultaneously, the drone will upload video/audio streams and critical metadata in real-time to a secure cloud-based server for redundancy and potential real-time access. The prompt upload ensures that data is preserved even if a drone is damaged, stolen, or incapacitated during a mission.

Mission-based data compartmentalization - to balance functionality with user rights, the system enforces data compartmentalization rules based on the type of mission.
o Emergency Missions: In cases of active threat or distress (e.g., medical emergencies, criminal activity, natural disasters), video and audio recordings must be immediately accessible to verified emergency personnel (e.g. police, fire, and medical responders). These authorities will have limited-time access through secure credentials, and all retrievals will be logged for transparency.
o Non-Emergency / Helper-for-Hire Missions: For general safety escorts or monitoring tasks, the user can control the amount of data collected. Users may choose to:

- Enable full video/audio logging
- Record audio-only
- Disable recording entirely
- The user can set their preferences in the mobile app before the mission.

Privacy Regulations

Unlike the EU's General Data Protection Regulation (GDPR), there is no national privacy law applying to the United States that apply. Instead, individual state laws, such as California's Consumer Privacy Act (CCPA), have been implemented, though, except for California, most other state privacy laws are similar to each other. Due to the CCPA being both the first and most comprehensive of such data privacy acts, the framework for AEGIS's privacy protections is centered around this act.
With the passage of Proposition 24, or the California Privacy Rights Act of 2020, the CCPA was amended to allow residents to determine how much businesses can use their sensitive personal information (SPI) [51]. More specifically, they can opt out of sharing SPI such as Social Security numbers, specific genetic data, and financial information, or limit its disclosure [52] [53].
To protect and uphold the rights of users, all data collection done by AEGIS follows a clearly defined process that users are made aware of before opting to use the provided service. In the Non-Emergency mode, users are given the option to consent to video and/or audio collection either manually on the app or verbally using the drones' auditory recognition capabilities. When users set their preferences, consent can be given for both features, only one of them, or for the recording of an upcoming flight to be disabled altogether. Biometrics such as facial recognition and demographic information can be obtained through visual recordings. To ensure the security of the user's SPI, all data collected will be stored securely in an encrypted third-party cloud infrastructure that is inaccessible to the general public. Such platforms include Google Cloud Platform with Confidential Compute, Microsoft Azure Government Cloud, and AWS GovCloud. Depending on the type of mission, the level of access to this secure data also varies. In the Non-Emergency mode, only the user and authorized system operators will be able to access the

collected data. However, if a situation shifts to Emergency mode where verified public service authorities such as the Police or Fire Department are contacted, video and audio recordings will have to be made available and sent immediately to them to ensure the safest and most proactive outcome.
Although precise geolocation is also considered SPI, AEGIS involves monitoring the flight path of each drone as it conducts its missions. All information collected regarding location is strictly encrypted and inaccessible to any third-party sites, complying with state privacy legislation. Users do have the option on the app to share their drone's flight status with chosen others, such as friends and family, for further peace of mind. If this is selected, both their drone's location and the current mode of operation (Emergency vs. Non-Emergency) will be accessible to said others.

Federal Aviation Administration (FAA) & Further Considerations

Deploying a civilian-facing aerial safety system like AEGIS introduces a new class of aviation-enabled public services, one that parallels the transformative impact of ridesharing on ground transportation. Just as platforms like Uber and Lyft modernized mobility through regulatory evolution and infrastructure alignment, AEGIS will require deliberate integration with current FAA guidelines and strategic engagement with airspace regulators [54] [55].
Currently, civilian drone operations in the U.S. are governed primarily under FAA Part 107, which applies to commercial unmanned aircraft systems (UAS). This includes limitations on flight altitude (max 400 ft.), operations only within visual line of sight (VLOS), restrictions on flying over people, and requirements for daylight-only operations unless special waivers are obtained. These core rules, along with requirements for remote pilot certification and aircraft registration, form the backbone of FAA's efforts to ensure airspace safety, privacy, and accountability [56] [57].
Table 6 in the Appendix summarizes the most relevant FAA restrictions that will apply to AEGIS deployment, including conditions for recreational use, commercial operations, and more advanced missions such as BVLOS (Beyond Visual Line of Sight), night operations, and operations over people or moving vehicles. While AEGIS may initially function within Part 107 boundaries—especially for campus or controlled-area deployments—future scalability will require regulatory flexibility.

- *Early Coordination with FAA:* We will initiate formal discussions and partnership opportunities with the FAA to explore Part 107 waivers for BVLOS, night-time operations, and flights over populated areas. Early engagement can help shape AEGIS's technical development in alignment with evolving UAS safety frameworks.
- *Pursue Operational Waivers for Advanced Missions:* Some AEGIS mission profiles—such as escorting users after dark, navigating inaccessible terrain, or launching autonomous emergency responses—will require waivers or new classifications under FAA experimental or public use exemptions. A waiver package should include robust documentation of safety systems (e.g., obstacle avoidance, geo-fencing, V2V communication), fail-safes, and operator training protocols.
- *Geo-fencing & Airspace Compliance:* AEGIS drones must be equipped with automated geo-fencing capabilities to avoid restricted airspace (e.g., near airports, national parks) and comply with Temporary Flight Restrictions (TFRs) that may occur during emergencies or special events.
- *Digital Remote ID Integration:* In compliance with Remote ID mandates, all drones must broadcast identifying information during flight. AEGIS must incorporate Remote ID modules to ensure airspace accountability and lawful operation, especially in public safety scenarios.
- *Coordination with Local Authorities:* Beyond federal regulations, AEGIS must also comply with local and state UAS ordinances, which can vary by jurisdiction. Engaging local

governments, campus security, and emergency responders will streamline safe integration into community safety infrastructure.

o *Data, Privacy, and Ethics:* Regulatory frameworks should also account for ethical considerations around aerial surveillance, data access, and user consent. Working with policymakers to establish tiered data access models and mission-specific privacy protocols will be essential in building public trust.

In summary, the success of AEGIS depends not only on technical innovation but on thoughtful navigation of the regulatory environment. By engaging early with FAA partners, building a transparent operational framework, and aligning with airspace safety best practices, AEGIS can lead the way in defining a new generation of aviation-enabled public safety services [58] [59] [60] [61] [62] [63].

Recommendations

Implementing AEGIS in its current form would offer communities an innovative aerial solution to support personal safety, particularly in environments where traditional emergency infrastructure may be delayed, inaccessible, or overwhelmed. However, further refinements are necessary to expand the system's operational range, improve response time, and optimize deterrence behavior based on situational context.

One direct way to enhance AEGIS's effectiveness is by extending the operational range of escort and collector drones. This is especially valuable for rural or low-patrol areas where coverage gaps are wider, and fewer drones must serve larger geographic regions. Increasing the range would reduce the number of required units per area, lowering both capital and operational costs. However, this is constrained by current lithium-based battery limitations. Exploring alternative energy sources—such as hydrogen fuel cells or integrating regenerative elements like solar panels—could extend flight duration and ensure system availability during prolonged or remote missions.

Response time is another critical component of system performance. While onboard autonomy and AI decision-making are central to AEGIS, they also demand significant processing power and sensor input, potentially increasing latency in emergencies. Mapping high-frequency deployment zones and commonly traveled areas can improve navigational efficiency by allowing drones to operate in familiar terrain with reduced sensor load and simplified route planning. This would reduce computational demands and shorten time-to-response.

Behavioral optimization is essential for real-time deterrence. Drones must react not only to threats but also to the environment in which those threats occur. For example, visual deterrents like strobing lights may be more effective in loud urban areas, while audible alarms may be preferable in quieter spaces. Tailoring the drone's deterrence behavior to ambient noise, light conditions, and historical incident data could reduce escalation and improve user protection. Future deployments of AEGIS should include environmental sensing and contextual profiling to enable such targeted responses.

Beyond these technical recommendations, advancing the broader ecosystem around AEGIS will be crucial for scalable deployment:

o *Launch Controlled Pilot Programs:* AEGIS will begin with small-scale deployments in university campuses or urban testbeds integrated with existing emergency systems like Blue Light towers. Collect real-world data to improve AI threat detection, user interaction, and system performance.

o *Enhance V2V Mesh Network Capabilities:* We will develop and simulate drone-to-drone communication models that allow for coordinated coverage, adaptive handoff, and redundancy in fleet operations—especially during system failure or high-load periods.

o *Accelerate Retrieval System Prototyping:* Building and testing physical collector drone mechanisms (e.g., lightweight hook-and-loop, winch systems) to autonomously recover non-functional units and reduce equipment loss will increase system cohesion.

- *Engage in Early FAA Coordination:* It is necessary to pursue FAA Part 107 compliance and apply for BVLOS (Beyond Visual Line of Sight) waivers where appropriate. Early coordination will also help guide drone safety, privacy policies, and geofencing practices necessary for public deployment.
- *Foster Public-Private Partnerships:* Collaboration with local governments, academic institutions, emergency responders, and private firms can reduce implementation costs and increase trust. Shared drone fleets and joint infrastructure—like vertiports or recharge hubs—will support broader scalability.
- *Incorporate Community Feedback Loops:* Community acceptance will be a key enabler of AEGIS. Establish public forums, surveys, or stakeholder panels to understand privacy concerns, gather feature suggestions, and build long-term user trust.

By addressing both the technical and human dimensions of deployment, these recommendations position AEGIS not only as a promising innovation but also as a socially responsible and operationally viable solution to modern safety challenges.

Conclusion

As fears about personal safety continue to rise, leading to people feeling unsafe in their own neighborhoods and local communities, it is evident that this issue needs to be addressed nationally. With AEGIS, we have designed a system that both integrates existing emergency services and ensures a steady presence and rapid response time that is currently not available. By providing for the widespread use of drones by the general public, AEGIS offers an easily accessible companion meant to help regain confidence when traversing uncomfortable or unfamiliar environments. Connecting to the mobile app, all users are made aware of and can choose to consent to the amount of information being actively logged by the drones. There, they can request a drone whenever one is needed, providing their current location.

Being an autonomous system, AEGIS is centered around an AI algorithm that considers factors such as proximity to drone hubs, the number of currently deployed drones, weather conditions, distance being traveled, and time of day, before it decides on which drone is dispatched. In this Non-Emergency mode, the drones would operate under a set of restrictions to collect only the minimum data necessary, while still adhering to all privacy protocols. In the case of emergencies, the AI algorithm will rapidly assess the threat, deploy the nearest drone to the location, and contact the appropriate emergency services for an efficient joint response.

Although with AEGIS we have concentrated on developing the system rather than the actual drones, we have identified what features each drone needs to increase its effectiveness. With advanced autonomous AI tracking, the drones can accompany users over long distances and through crowded landscapes without losing their way. A combination of visual and thermal imaging additionally ensures that said navigation is seamless, regardless of any obstacles encountered. Each drone is designed to have noticeable speakers and lights, allowing them to be operable at any time of day and draw attention to their aerial presence. This combination of features ensures that the drones serve as deterrents to future harm, with their presence being viewed as a significant disincentive by potential attackers, while also allowing users to feel protected.

To handle the distinctive features of different living environments, such as population density and infrastructure concentration, the spacing of drone hubs is calculated considering those factors, as well as the crime rate and areas that are highly frequented. Further collaboration with local and state offices will enable hub distribution to be controlled.

The AEGIS concept currently faces some technical limitations, operational risks, and regulatory concerns that will continuously be tackled. Poor weather conditions, such as extreme precipitation or high winds, can pose challenges during drone flights, and signal loss can occur entirely. Compliance with current FAA regulations and state privacy laws can put limits on the capabilities of the drones, and a balance must always be established in AEGIS's data collection interactions with the public. The transition to public acceptance of this system may also take some time due to the drastic change in airspace usage and the noise concerns that could also arise. Still, as AEGIS continues to evolve with further development, these limitations can be addressed.

Ultimately, this system isn't just about technology – it's about filling the real-world gaps between danger and help. Adding a layer of proactive visibility, speed, and support that existing services cannot always provide, AEGIS will work to create a world that feels safer to walk through.

Appendix

Table 1 - Key Systems for Evaluation

Feature	Autonomy Level	Description	Privacy
Sunflower Labs Home Drone [64]	Semi-Autonomous	Residential drone-based security system that patrols private properties. Integrated with ground sensors ("Sunflowers") to detect motion and trigger drone surveillance. Operates within pre-defined geofenced area.	Video feed is streamed to a secure app and privacy handling focuses on both homeowner control and encrypted video. Still, it is limited to within personal property zones.
Airobotics "Drone-in-a-Box" System [65]	Advanced Autonomy	System that operates from automated docking and charging station. Designed for industrial and urban infrastructure monitoring. Deployed on ports, factories, and large cities.	Being often used for scheduled patrols, perimeter breaches, and infrastructure inspection, due to its focus on anomaly detection, real-time data streaming is involved. There is encrypted storage and integration with control centers.
Fortem SkyDome System [66]	Advanced Autonomy	Military-grade aerial security system used for critical infrastructure protection. Includes radar sensors and autonomous drones equipped with "Drone Hunters" to intercept rogue drones. Uses AI for threat classification and decision-making.	Lesser emphasis on privacy due to it being developed for national security and other large-scale use cases.

Table 2.a - Escort Drone Candidate Models

Model	Flight Time	Camera	Sensors	Payload Capacity	AI Autonomy Level	Weather Resistance	SDK Access	Approx. Cost	Notes

DJI Mavic 3 [67]	~45 min	4/3 CMOS, 4K video	360° obstacle avoidance	< 0.5 kg	Basic tracking	Limited (clear weather only)	Yes	~$2,500	Lightweight, good optical quality, compatible with DJI Enterprise solutions
Skydio X2d [68]	~35 min	4K HD + thermal imaging	720° obstacle avoidance	< 0.2 kg	Advanced AI autonomy	Moderate (no heavy rain)	Limited	~$10,000	Excellent autonomy in complex urban environments, thermal capability for night operations
Autel EVO Max 4T [69]	~42 min	Wide-angle/zoom, thermal, laser rangefinder	360° obstacle avoidance	< 0.35 kg	Autonomous tracking	IP43 rated (splash resistant)	Yes	~$10,000	Robust sensor suite, thermal imaging for emergency response
Teal 2 [70]	~30 min	FLIR Hadron 640R thermal	Multi-vehicle coordination	< 0.35 kg	Athena AI (voice control)	Moderate (light rain OK)	Partial	~$16,000	Voice command recognition, modular payload configurations
Jouav | Dji (T40 or similar) [71]	~40-50 min	High-res RGB + thermal combo	RTK GPS, obstacle avoidance	< 1.0 kg	Semi-autonomous	IP54 (dust & water resistant)	Yes	~$15,000	Industrial-grade, good endurance, supports extended missions
BRINC LEMUR 2 [72]	~20-25 min	Infrared, thermal, low-light cameras	Obstacle avoidance, audio comms	< 0.25 kg	AI-assisted (human in loop)	Unknown	Limited	~$25,000	Tactical indoor/outdoor drone, used in law enforcement and SAR

Table 2.b - Collector Drone Models

Model	Flight Time	Camera	Sensors	Payload Capacity	AI Navigation Level	Weather Resistance	SDK Access	Approx. Cost	Notes
DJI Matrice 350 [73]	~55 min	Customizable (RGB/thermal)	RTK GPS, obstacle avoidance	< 2.7 kg	Semi-autonomous	IP55 (all-weather capable)	Yes	~$12,500	Popular enterprise drone with flexible payloads, widely used for inspections and SAR
Doosan DS30 [74]	~120 min	Customizable	GPS, barometer, optional sensors	< 3.0 kg	Ground-controlled	Military-grade (likely high)	Unknown	~$30,000	Hydrogen fuel cell, extended endurance, requires pilot, good for long-range retrieval
Jouav (T40 variant) [71]	~50 min	RGB + thermal combo	RTK GPS, obstacle avoidance	< 1.0 kg	Semi-autonomous	IP54 resistant	Yes	~$15,000	Versatile for both escort and retrieval tasks

Table 3 - Key Functional Features for Escort Drones

Feature	Available Platforms/Systems	Notes
Voice Command Control [75] [76]	Most mainstream commercial drones do not come with native voice control capabilities. However, select systems—such as the U.S. military's Black Hornet and various academic or public safety R&D projects—have integrated third-party voice command software (e.g., Primordial Labs, Onvego Voice AI, Skydio 2, DJI SDK-enabled systems). This demonstrates that voice control can be feasibly added to escort drones through custom development or modular integration.	Enables hands-free operation, critical if user is incapacitated
Distress/Voice Detection [77] [78]	Fraunhofer FKIE experimental modules [79] with addition of AI-Based Noise Suppression Systems and/or Optimized microphone arrays (Crow's Nest Array and MEMS microphone configurations – beamforming - [80]	Emerging tech for cry detection and threat escalation
Night Vision / Thermal [81]	Skydio X10, DJI Mavic 3, Autel EVO Max	Essential for 24/7 operation and SAR in low light

Software platform for health/vital detection (Draganfly Vital Intelligence) [82]	Extracts heart rate, respiratory, SpO2, temp from RGB video AI-driven detection of medical distress (e.g., falls, abnormal health) Cloud dashboard for data live sharing • Can run on most drones with RGB/thermal cameras • Supports integration with other sensors/platforms	Provides the best health/fall/medical event detection for escort drone missions. Needs suitable drone integration with camera and platform.
Modular Payloads	Skydio, DJI Matrice, Teal	Allows sensor customization depending on mission needs

Table 4 - Drone Retrieval System Mechanisms

Mechanism	**Description**	**Pros**	**Cons**	**Notes**
Hook & Loop [83],	Mechanical hook docks onto loop/ring on the drone	Lightweight, low/no power use, simple & low-cost to fabricate and integrate	Requires precise alignment, hooks and loops can slip or fail to attach due to the wind	Suitable for urban retrieval but not reliable and might fail in bad weather or if dirty or worn out
Magnetic Coupling [84]	Collector drone uses electromagnet to attach metal plate	Fast, secure grip, electromagnets (or strong permanent magnets) require little or no power to maintain a grasp during flight	only suitable if escort has metallic (ferrous) plate asnon-magnetic payloads not supported; dust, debris, or rain on magnets can compromise holding strength and reliability	Less preferred due to power
Mechanical Gripper [85]	Robotic claw grasps drone frame	Precise control, versatile, high security even for non-magnetic or irregular objects	Complex, high power consumption, mechanisms add moving parts, increasing weight and the likelihood of mechanical failure	Used for heavy payload retrieval
Tension-Controlled Winch + Hook [86]	Cable lowers hook to grab grounded drone	Reaches difficult locations by remaining on higher altitude	Slow operation, added weight/drag, and winches + hooks are more mechanically and electronically complex, increasing risk of malfunction	Suitable for rooftops, trees, hard-to-reach or hazardous locations

Table 5 - Distress Detection Drone Platforms & Features

Drone/Platform	Features	Limitations	Use Cases / Notes
DJI M30T (Enterprise) [87]	-Triple payload: 48MP wide, 12MP tele, 640x512 thermal, laser rangefinder (1,200m) -IP55 weather resistant, -20°C to 50°C -41min flight, hot-swappable batteries -OcuSync 3 Enterprise, 6-directional collision sensors -Advanced mapping (ActiveTrack, autonomous modes)	-No built-in two-way audio -No native voice command recognition or AI for complex behavior detection -Modularity limited to payload options, not fully open	Search and rescue, fallen person detection, customizable, remote mission management. Strong for surveillance, search and rescue. Modular payload but might not be open hardware/software for further customization
DJI Mavic 3 Thermal [88]	-Lightweight (920g), 45min flight -High-res 48MP cam, 56x zoom, 640x512 thermal -Excellent for night ops, SAR, inspections -Advanced obstacle detection, spot metering, split-screen zoom	-No two-way audio or voice commands -Modularity limited, not an open platform -No true AI for autonomous abnormal behavior/medical events detection	SAR operations, manual interpretation, good for rapid deployment, small scale monitoring, search missions. Lacks escort-specific modularity/AI.
BRINC LEMUR 2 [72]	-IR sensors -4K day/night cam, FLIR thermal, LiDAR for floor mapping -Powerful autonomy engine, indoor+outdoor nav -Two-way audio (mic + loudspeaker), live streaming -Mesh networking for drone-to-drone comms -Modularity: payload dropper, glass breaker -Obstacle awareness, "turtle mode", strobe, floodlight	Requires human-in-the-loop distress ID, and ~20min typical flight (longer perched) Not designed for extended outdoor escort Not voice controlled - AI limited to environmental awareness, not deep behavior analysis	Indoor/outdoor tactical SAR. Leading for close-in monitoring in complex/denied environments, de-escalation, 2-way comms, user-initiated modules, and rugged design. Not optimized for persistent outdoor patrol (but might be a candidate)
Skydio Dock + Remote Ops [89]	-Fully autonomous docked drone solution 360° obstacle avoidance, advanced autonomy -Remote 24/7/365 control, scheduled or triggered flights -Real-time livestream, full remote management -Cloud API for data and integration -Up to 24/7 operation, weather robust (-4°F/+122°F)	-No two-way audio -No native voice/AI abnormal behavior analysis (but API allows integration) -Limited info on modular sensor expansion	Ideal for 24/7 patrol, on-demand deployment, and scalable remote ops. API allows third-party AI, so can be built out for analytics and voice, and more

Aerones Heavy-Duty Rescue [90]	-Life-saving payload delivery, thermal sweep -Lifts 100–200kg for rescue, firefighting -UHD and thermal cameras; radar obstacle avoidance 30min endurance, truck-powered for unlimited ops -Parachute fail-safes -Modular mount for tools	-No autonomous distress detection -Not suitable for escort/follow missions (bulk, size) -No voice/AI/2-way audio -Niche for rescue (not continuous monitoring or day-to-day escort)	Used in Europe for rescue missions. Excellent for emergency rescue, heavy lifting, and firefighting but not practical for escorting a person walking/running in public settings

Table 6 - Current FAA Restrictions [34]

Restriction Area / Requirement	**Description (as of July 2025)**
Registration ,	All drones >250 grams (0.55 pounds) must be registered with the FAA through FAADroneZone; registration number must be displayed on the drone.
Remote ID	Mandatory for all drones in unrestricted airspace; drones must broadcast identification and location. Compliance via built-in tech or external modules. Drones without Remote ID may only fly in FAA-Recognized Identification Areas (FRIAs). Full enforcement since March 16, 2024.
Maximum Altitude	Maximum altitude is 400 feet above ground level, unless drone stays within 400 feet of a structure.
Visual Line of Sight (VLOS)	Drone pilots must keep drone in direct, unaided visual line of sight at all times; exceptions require specific waivers.
Part 107 Certification	All non-recreational (commercial/public safety) pilots must have a Part 107 certificate; includes recurrent training, and knowledge of updated rules (e.g., night ops, Remote ID, airspace access).
Night Operations	Permitted if drones have anti-collision lights visible for at least 3 statute miles; waivers no longer needed if criteria are met.
Operations Over People / Vehicles	Now allowed under certain conditions if drone fits in operational categories 1-4; otherwise requires demonstration and FAA waiver.
Operations in Controlled Airspace	Requires LAANC (Low Altitude Authorization and Notification Capability) or specific FAA airspace authorization for operations in controlled airspace (Class B, C, D, or E).
Geofencing and No-Fly Zones	Strict no-fly zones over certain areas (e.g., airports, national security sites, government facilities); check B4UFLY and NOTAMs for temporary restrictions.
Waivers for Advanced Operations	Waivers are required for flights BVLOS, multiple drones, flights over people/vehicles (outside specified categories), and other operations beyond standard Part 107 restrictions; FAA processing time is typically under 90 days.
Weight Limit	Drones operated under Part 107 must weigh less than 55 pounds including payload at takeoff.
Airspace Awareness	Must understand and avoid restricted airspace, review NOTAMs, use apps like B4UFLY to confirm permitted airspace, and comply with Temporary Flight Restrictions (TFRs).
Armed Capabilities	Drones are prohibited from carrying weapons by Section 363 of the FAA 2018 Reorganization Act, unless special authorization is received on a mission-by-mission basis. Dangerous weapons are classified by their risk of causing serious body harm or death.

Table 7: Potential Drone Hub Deployment Sites in Urban and Campus Environments

Deployment Site Type	**Description / Role**	**Example Locations**
Police Stations	Strategic locations for law enforcement drone assets	City police precincts
Fire Stations	Emergency response bases equipped for rapid drone deployment	Urban and suburban fire departments
University Security Offices	Campus safety hubs integrated with Blue Light Towers	Campus public safety buildings
Municipal Drone Centers	Dedicated facilities for city-operated drone fleets	Urban municipality drone operations centers
Hospital or Medical Facilities	Locations near hospitals for emergency escort capabilities	Trauma centers, medical emergency dispatches
Public Transportation Hubs	Busy transit centers for rapid area coverage and response	Major bus/train stations
Commercial Drone Ports	Licensed drone ports providing infrastructure and maintenance	Developed urban drone hubs like SkyScape

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