

CSE 564 Project Report Number 2

Team 16

Team Member Names:

1. Aditya Pant
2. Ameya Shahu
3. Lalit Arvind Balaji
4. Pravalika Mukkiri

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1. Executive Summary

Project Name: Drone-Based Encroachment Detection System DBED

The Drone-Based Encroachment Detection System is aimed at revolutionizing the security and surveillance practices within corporations' asset portfolios. This executive summary provides a concise overview of the key aspects and objectives of the project.

1.1. Project Overview

The Drone-Based Encroachment Detection System is a cutting-edge technological solution designed to monitor, track, and report encroachments and unauthorized activities within defined property premises. It leverages modern drone technology, AI algorithms, and robust data management to enhance security practices.

1.2. Project Goals and Objectives

1. Enhanced security operations by reducing expenditure on security
2. Real-time notification and alerts, and data-driven pattern analysis are the main goals of this project.
3. Development of the System, AI model Development and Integration, Data and Surveillance Log Management, Real-time alert and notification system, Real-time alert and notification system.

1.3. Requirements

Stakeholders and reputable sources were consulted for key requirements for the Drone-Based Encroachment Detection System. Specific monitoring zones, rapid event detection, preferred alarm mechanisms, regulatory compliance, and enhanced drone capabilities are among them.

1.5. Key Features and Components

The encroachment detection system incorporates a range of critical features and components, including Aerial Surveillance Drone, Ground Control Station, Encroachment Detection Algorithm, User Interface, Data Management, and Operator of the Drone.

1.6. Modes of Operation

Encroachment detection systems operate in various modes, including Patrolling Mode, On-Demand Patrolling Mode, Event Driven Mode, Manual Mode, Training Mode, and Safe Land Mode. These modes ensure flexibility and adaptability to different security scenarios.

1.7. Summary Conclusion

The Drone-Based Encroachment Detection System is ready to raise the bar for industrial regions, ports, and commercial complexes in terms of security, compliance, and operational efficiency. The DBEDS enables enterprises to defend their precious assets and property borders while maximizing resource efficiency by using the power of cutting-edge technology and intelligent surveillance. This executive brief captures the core of a transformational initiative with the potential to alter critical sector security procedures.

2. Customer Problem

2.1. Chief Operating Officer/Management of Industry/Facility

2.1.1. Secured working environment for staff in industry

- Huge industries can have threats of encroachment of foreign entities that might intend to cause harm to the workers or steal some property

2.1.2. Efficiently Securing Large area

- Big government or private facilities cover a large portion of land
- huge organized manpower is required to secure such large areas
- efficiently monitoring the complete area with limited manpower is required

2.1.3. Reducing the cost

- the huge manpower required to secure a large area will be a costly investment
- Additional cost will be incurred on managing the increased workforce

2.2. Ground Team

2.2.1. Encroachment Patrols

- The security team needs to check the perimeter at regular intervals to ensure no encroachment

2.2.2. Smooth information transmission

- In case of encroachment, the entire team must be informed of the event and the intruder's location (GPS coordinates).

2.2.3. Ability to monitor encroachment

- Real-time information needs to be acquired about the current location of the intruder and their actions, etc.

2.2.4. Access to advanced surveillance tools

- Drone cameras give live imaging that would help the team take appropriate action

2.3. Ground Team Management

2.3.1. Access to live footage

- need footage to access threat level of encroachment

2.3.2. Provide instructions

- The management team views the footage from the drones and provides instructions to the ground team for action to be taken
- drones might be instructed to monitor a particular area

2.4. Technology providers

2.4.1. Real-time information

- Ensure that the drones can share live footage and sensor images to the system accessible by the ground team

2.4.2. drone fail-safe system

- adverse conditions might cause malfunctioning in the drone
- This needs to be taken into consideration to prevent harm to people and property

2.4.3. Storage of Data

- The real-time data/footage retrieved needs to be stored in a cloud database for a tentative period of time

2.4.4. Security of data

- The data extracted from drones and stored needs to be secure and inaccessible by unauthorized people

2.5. Technical Support Team

2.5.1. Training

- Officers need training to set up and operate drones to perform required tasks
- They should respond to queries that might arise from novice users

2.5.2. Service

- Regular software updates and service are required to ensure proper operation of drones

2.5.3. Upgrades

- New sensors might be required for performing certain tasks would be added by the support team

2.6. Local Law Enforcement

2.6.1. FAA regulations^[1]

- The drone system needs to be licensed/approved by the FAA regulations

2.6.2. legal consultancy

provide guidance on additional policies that need to be implemented

¹<https://enterprise.dronerds.com/blog/enterprise-operations/how-to-determine-key-stakeholders-for-a-drone-program-implementation-project/>

²[Pros and cons of using drones for perimeter security \(asmag.com\)](https://asmag.com/pros-and-cons-of-using-drones-for-perimeter-security/)

3. Concept of Operations

3.1. Introduction

3.1.1. Project Description

- In an era of rapid growth and expansion, it is crucial to preserve the integrity of enterprises' real estate assets.
- Existing security and monitoring systems are majorly driven by human capital and often fall short of providing comprehensive and cost-effective solutions^[1].
- The Drone-Based Encroachment Detection System is a solution that facilitates seamless surveillance of various commercial complexes' boundaries.
- It employs drones to surveillance over expansive areas, offering services such as unauthorized land access detection and safeguarding critical infrastructure.
- Delivering a system that adheres to government guidelines and regulations concerning the use of drones in surveillance, data privacy laws, and aerospace-related regulations^[1].
- Drone-Based Encroachment Detection Systems remains cost-effective to benefit a wide range of organizations^[1].

3.1.2. Overview of Envisioned System

- The system's main purpose is to protect real estate assets including industrial complexes, warehouses, power generation plants, manufacturing plants and ports etc.
- The system focuses on encroachment and surveillance or the area of the facilities it is deployed in with its primary goal being to prevent unauthorized activities in the vicinity.
- The system ensures the safety of the facility it is deployed on.
- By employing drone technology, this system automates tasks & minimizes human involvement
- It aims to successfully deliver real-time tracking, monitoring, auditing, and reporting, ensuring real estate security compliance.

3.2. Description of Envisioned System

3.2.1. Needs, Goals and Objectives of Envisioned System

- Need of a robust surveillance system that cost effectively and proactively mitigate encroachments issues in commercial boundaries.
- Need to have a real time surveillance system which is essential for rapid response ensuring compliance with the regulatory requirements.

- Goal is to produce a software that has the ability to reduce security expenditure of the organization but significantly enhances the security of the assets portfolio.
- During surveillance, systems should be able to raise alerts and notify the appropriate security and implement data analysis to identify patterns and logged surveillance data.
- System aims to achieve state of the art and accurate encroachment detection algorithms and integrate with the drone^[1].
- Implement an efficient real time database and datawarehouse to store log data for future uses and data analysis.
- Developing Drone Based encroachment detection system while ensuring geofencing of the perimeter.

3.2.2. Overview of System and Key Elements

- Aerial Surveillance: Drones serve as the core of the system, equipped with cameras, various sensors, and radio communication devices. These drones are responsible for surveying the designated property.
- Ground Control Station: All the information collected during surveillance is transmitted to the ground control station. While the system is primarily automated, manual control is available in the control stations.
- Encroachment Detection: AI-driven algorithms will be optimized to analyze real-time video streams from the drones.
- User Interface: A user interface will offer features including real-time monitoring, the ability to configure alerts, and access to historical surveillance data.
- Data Management: The system will include a data management feature for storing surveillance data and generating reports in response to queries.

6. Operator of the Drone

Operators refer to human resources with expertise in manually controlling drones.

3.2.3. Interfaces

Encroachment Detection Systems will have following interfaces -

- User Interface : It serves as the main interface for human interaction, allowing users to visualize data, access historical data, and receive alerts, among other functions.
- Configuration Interface : Administrators of the system will utilize configuration interfaces to modify security requirements or set up new sensors on drones.
- Communication Interface: This interface will facilitate communication between drones and the ground station, enabling the logging of surveillance data by drones. Additionally, it will serve as the means for ground stations to send commands to drones.
- Alert System Interface: This interface will have the responsibility of initiating alerts based on predefined conditions and notifying the relevant authorities accordingly.

- Data Storage Interface: Various subsystems will interact with data storage facilities through this interface.

3.2.4. Modes of Operations

- Patrolling Mode - In this mode, the drone will follow a configured patrol path and surveillance area after a certain scheduled time period.
- On-Demand Patrolling Mode - On ground operators can trigger this mode to conduct a monitor on demand.
- Event Driven Mode - System can perform action particularly drone based monitoring in case of any security related events^[1].
- Manual Mode - This mode is essential for on ground operators to control drones in manual mode.
- Training Mode - For training of the operators, drones can be put in few restrictions in this mode.
- Safe Land Mode - In case of a malfunctioning drone, this mode will be activated to safely land the drone.

3.3. Support Environment

- Scheduled regular maintenance and system updates for the drone to operate with latest and accurate encroachment detection.
- In case of unfavorable weather conditions, an indoor safe location is required for drones.
- future upgrades may include using additional thermal sensors for basic detection and regular footage once detected encroachment^[1].

3.4. Operational Scenarios, Use Cases and/or Design Reference Missions

3.4.1. Nominal Conditions

- Routine Patrol [DRM: 100] - Conducting routine drone patrols over the industrial base area under normal conditions, where drones autonomously follow assigned paths, capture data, and monitor the area.
- Intrusion-Free Monitoring [DRM: 101] : Under normal conditions, the system operates without detecting any encroachments, collecting data without triggering security alarms or alerts, and maintaining surveillance data records without any incidents.
- Scheduled Maintenance [DRM: 102] : Scheduled maintenance for both the drone and the system entails a temporary suspension of all operations for system updates and checks.
- Encroachment Identification [DRM: 103]: It identifies encroachments during regular patrols and promptly alerts the security team with the relevant data.
- Data Analysis [DRM: 104] : Performing routine data analysis to recognize patterns and trends in the data.
- Scheduled Security Assessment [DRM: 105] : Conducting a scheduled security assessment that involves a comprehensive review of the surveillance data.

3.4.2. Off-Nominal Conditions

- Communication Failures [DRM: 106] - System encounters a communication failure with the drones. Drones activate failsafe methods, goes to a safe location. Keeps the recorded data safe until it gets connected to the system again.
- Adverse weather conditions [DRM: 107] - Unexpected severe weather situations such as heavy rain, storm winds, dust etc. Drones try adapting the flight pattern to ensure safe operations. In severe cases, drones activate failsafe methods, goes to a safe location.
- Data Breach Attempts [DRM: 108] - If System identifies a data breach attempt, it sends alerts, activates security measures. It blocks the intrusion attempt, notifies the cybersecurity personnel.
- Operator Error [DRM: 109] - A drone departs from its intended flying route due to operator error. System sends alerts, and lands at a safe location.
- Power Supply Interruption [DRM: 1010] - When a drone encounters an interruption in power supply, it immediately enables land safe mode.

3.5. Impact Considerations

3.5.1. Environmental Impacts

- Noise Pollution: Drones traveling between points A and B produce loud noise during takeoff and landing, which can disrupt workers and local wildlife.
- Air Pollution: The drone relies on degrading batteries, which in production and disposal, may release harmful chemicals into the environment.
- Waste Generation: Utilizing various sets of drones over time can generate waste that necessitates proper disposal measures.
- Energy Consumption: Running a multi-drone cyber-physical system can consume a lot of energy, so optimizing energy efficiency is essential.

3.5.2. Organizational Impacts

- Enhanced Security: Our system offers real-time monitoring across the expansive facility, enhancing threat detection and preventing unauthorized access.
- Cost Savings: Our objective is to deploy drones and reduce the need for security personnel. Deploying drones proves to be a more cost-effective approach, as corroborated by ²asmag.com.
- Efficiency: Unlike security personnel who need breaks, drones can be quickly replaced when their batteries run out, either by changing the battery or using another drone.
- Data Analysis: Our system facilitates live monitoring, providing access to data in the event of a security breach. This data can be utilized to enhance security measures.

4. Initial Received Requirements

4.1. Source: Customer Stakeholder

4.1.1. Requirement 1: Real-time monitoring and alerts

4.1.1.1 Monitoring in real-time and rapid alerts for any encroachments or unauthorized activity.

- The system must monitor the defined property premises in real time.
- Any encroachment or unlawful activity should be detected and reported immediately by the system.

4.1.1.2. System should have an alerting mechanism

- Real-time alerts should be provided to specified personnel.
- Alerts should be on time, clear and informative.

4.1.2. Requirement 2: Easy to use Interface

4.1.2.1 An intuitive and user-friendly interface that allows for simple system interaction.

- Users should be able to navigate and retrieve essential information with ease.
- To be effective, the interface should require little training.

4.2. Source: Government Regulations

4.2.1. Requirement 1: Regulatory compliance

4.2.1.1 Observance of government norms and legislation governing drone use

- The system must function within the legal parameters established for drone surveillance.
- The system must follow government standards and restrictions concerning drone use.

4.2.1.2. Compliance with data privacy laws and aerospace rules is required.

- The system must function within the legal parameters established for drone surveillance.

4.2.2. Requirement 2: Environment Responsibility

4.2.2.1 The system should minimize its negative impact on the environment

- Reduce the amount of noise pollution caused by drone operations.
- Implement eco-friendly drone technology and methods

4.2.2.2. Optimize Battery usage for better performance.

- Optimizing battery utilization increases flying time and operating efficiency.
- Longer surveillance durations and broader coverage are ensured by effective tactics.

4.3. Source: Industry Best Practices

Using best practices from the industry ensures that the incursion detection system satisfies high-quality standards and is operationally efficient.

4.3.1. Requirement 1: Best Practice Integration

4.3.1.1. Encroachment detection methods in the system should be robust and accurate.

- Accuracy is essential for reliable detection and low false positives/negatives.

4.3.1.2. Machine learning techniques should be used to continuously enhance the algorithm.

- Adhering to the industry's best standards for algorithm development promotes long-term performance.

4.3.2. Requirement 2: Best Practice Training

4.3.2.1. The system should contain thorough operator training sessions.

- Training improves system use and efficiency.

4.3.2.2. Provide training materials and regular updates to keep operators up to date on system updates and improvements.

- Keeping operators informed improves their capacity to operate the system efficiently.

4.4. Source: Drone Technology Manuals

Source: Drone Technology Manuals

The use of drone technological breakthroughs is critical for an effective and efficient intrusion detection system.

4.4.1. Requirement 1: Utilization of Advanced Drone Features

4.4.1.1. The drone must have high-resolution imaging capabilities.

- Obtaining detailed and clear images for accurate surveillance and detection.

4.4.1.2. For excellent imaging during surveillance operations, use zoom and stabilization features.

- Improving image quality and stability for better monitoring.

4.4.2. GPS and Location Accuracy

4.4.2.1. During surveillance, the GPS on the drone should provide correct location data.

- Ensuring accurate tracking and monitoring of designated regions.

4.4.2.2. Install redundant GPS devices for backup and improved location data accuracy.

- Improving the dependability and quality of location data for efficient surveillance.

5. Requirements Elicitation

5.1. Chief Operating Officer/Management of Facility

5.1.1. What is the duration for which the drone data needs to be tentatively stored?

5.1.1.1. Rationale

- The footage from drones would consume huge amounts of storage
- Similar to CCTV camera footage, this footage needs to be erased after some fixed interval to effectively utilize fixed storage

5.1.2. What are your data security and privacy requirements when using drones for surveillance purposes?

5.1.2.1. Rationale

- To understand and implement data security policies appropriate to requirement

5.1.3. What integrations do you require to adopt and use with existing system technology?

5.1.3.1. Rationale

- The industry might want to integrate drone interface with existing security infrastructure

5.2. Ground Team

5.2.1. Apart from live footage, what are other kinds of data you might need the drone to share?

5.2.1.1. Rationale

- Ground team might need information regarding the exact location of encroachment (eg. GPS/ Maps location)
- To understand their requirements to take action

5.2.2. How would you want the drones to operate to assist in monitoring the Perimeter?

5.2.2.1. Rationale

- To understand the needs of the ground team

5.3. Ground Team Management

5.3.1. Could you please specify the parts of the property that require continual surveillance for security reasons?

5.3.1.1. Rationale

- To comprehend the exact areas of concern for continual monitoring.
- To verify that our system is in accordance with the customer's security priorities and expectations.

5.3.2. In addition to Scheduled patrol, what are the other functions that you would need in the system?

5.3.2.1. Rationale

- To learn about the additional features that the stakeholders expect
- To accommodate the needs and develop features

5.4. Legal enforcement

5.4.1. What regulations and guidelines do you recommend for the safe and responsible use of drones in encroachment detection and security applications?

5.4.1.1. Rationale

- to understand the legal considerations in the state and develop the system accordingly

5.4.2. Are there best practices or legal frameworks that you recommend for using drones responsibly in these applications?

5.4.2.1. Rationale

- To use recommended frameworks and avoid legal problems in the future

6. Conclusion

6.1. Potential Outcomes of the System

6.1.1. The Power of Surveillance Evolution

- harnesses cutting-edge drone technology, advanced AI algorithms, and robust data management transcending traditional security measures.
- Takes a proactive stance against encroachments and unauthorized activities, ensuring property boundaries remain sacrosanct.

6.1.2. Scalability and Adaptability

- DBEDS is designed to be flexible, offering a range of operational modes to suit different security scenarios.
- Its scalability architecture ensures that it can grow with an organization's changing needs, making it a long-term investment.

6.1.3. Harness Data for Informed Decisions

- Through data analysis and trend identification, understands the broader security landscape.
- Foresee potential threats and take preventive measures.

6.1.4. Enhancing Security, Compliance, and Efficiency

- Primary goal is to enhance security manifold by providing real-time monitoring and rapid response capabilities.
- By automating encroachment detection, DBEDS optimized resource allocation and streamlined operations.

6.2. Elicited Requirements from stakeholders and sources

6.2.1. Comprehensive monitoring parameters, Detection, and Alerting

- The requirements include specific locations and characteristics for continuous monitoring, ensuring a comprehensive surveillance strategy.
- real-time detection and alerting are crucial methods for monitoring.

6.2.2. Regulatory Compliance and Advanced Technology Integration

- Compliance with rules were addressed, emphasizing the need to follow legal frameworks.
- utilizing modern cutting-edge technology for successful intrusion detection.

6.3. Items for future consideration

- Addition of authentication methods such as Multi-level authentication to ensure security of data/footage from drones

Conclusion

- Integration with existing systems of the facility/ utilizing legacy software or popular software in the industry
- Adopting legal framework recommended for drone usage.

7. Appendix A: Credit Sheet

Team Member Name	Contributions
Aditya Pant	Updated version of Executive Summary, ConOps & Conclusion.
Ameya Shahu	Updated CoOps, Executive Summary and Conclusion Involve in requirements discussion and elicitation
Lalit Arvind Balaji	1. Customer problem 5. Requirements elicitation 6. conclusion
Pravalika Mukkiri	4. Initial Received Requirements 1. Executive Summary 6. conclusion