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DEVELOPMENT OF SPECIALZED DRONE SYSTEMS FOR DISASTER MANAGEMENT

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ABSTRACT
Natural disasters such as earthquakes, floods, and large-scale fires continue to create significant challenges for emergency response teams, especially in densely populated urban areas. Effective disaster management requires rapid intervention and reliable communication infrastructure, both of which are often compromised in the aftermath of a major event. This study focuses on the development and practical implementation of customized unmanned aerial vehicles (UAVs) designed specifically for post-disaster scenarios. Proposed drone systems include a mobile base station drone with ground-based power supply for establishing emergency communication networks, a lighting drone to support nighttime search and rescue operations, and specialized models for rapid delivery of medical aid and real-time mapping of affected zones

The research combines engineering design, technical feasibility analysis, and simulation-based testing to address operational challenges such as energy management, coverage optimization, and environmental resilience. In addition, the study discusses regulatory and ethical aspects of UAV deployment in disaster areas within the context of Turkish legislation. Results indicate that integrating drone technologies into disaster response strategies can significantly shorten response times, improve situational awareness, and facilitate lifesaving interventions. The findings also highlight the potential for local manufacturing and cost-effective solutions, emphasizing the importance of tailored engineering approaches in real-world disaster management.
Keywords: Disaster management, drone, mobile base station, search and rescue, communication infrastructure, energy management,

1. INTRODUCTION
Earthquakes, floods, and fires continue to affect human life and daily living deeply in many parts of the world. Disruptions in communication, transportation difficulties, and problems accessing critical information during and after disasters can severely hinder crisis management [1]. Therefore, modern disaster management does not only focus on emergency intervention; it also includes preparation beforehand, rapid organization during the event, and recovery processes afterward [3].

In practice, it is well known that the first 72 hours after a disaster are critical. During this period, rapid, organized, and data-driven action by search and rescue teams is the key to minimizing casualties. However, classical methods often fall short, especially when roads are blocked, GSM networks are down, or there is no night vision capability [1] [2].

In recent years, unmanned aerial vehicles (UAVs, or drone systems) have provided a significant advantage for accessing disaster areas, gathering real-time information, and establishing communication infrastructure [3] [4]. Thanks to their lightweight structures, autonomous operation capabilities, and adaptability with various sensors, drones fill an important gap in areas where conventional methods cannot reach or are delayed. In this study, the technical and operational features of custom-designed drone systems developed to meet the critical tasks required for disaster management are examined.

2. UNIQUE DISASTER DRONE DESIGNS AND TECHNICAL FEATURES

2.1 Mobile Base Station Drone
This system is designed to provide fast LTE/5G coverage in the field, especially when communication infrastructure is completely down after major disasters such as earthquakes [2]. During the 2023 Kahramanmaraş Earthquake, it is known that many rural areas could not establish communication for days [1]. The mobile base station drone, powered by an industrial ground battery, can hover for hours at an altitude of 60 meters and provides communication within a radius of approximately 500 meters.
Technical Specifications:
- Motor: T-Motor MN4014-400KV (4 units)
- Propeller: 15×5.2 inch carbon fiber

- Flight Control System: Cube Orange
- Navigation System: GPS + IMU
- Communication Module: SIM7600E-H / Quectel EC25 LTE/5G
- Battery (Ground): 48V 100Ah LiFePO4 (4.8 kWh)
- Tether Cable: 2×6 mm², 70 m
- Power Consumption: ~250 W
- Endurance: ~15–18 hours

Communication in the first hours is life-saving [3]. In an environment where GSM networks do not exist, this system rapidly enables coordination between teams and connection with disaster victims.

2.2 Night Lighting Drone
Disasters that occur at night severely affect both search and rescue operations and overall safety. During the Maraş earthquake, rescue teams' operations slowed down at night due to damage to the electricity infrastructure [1].
Technical Specifications:
- Motor and Propeller: T-Motor MN4014-400KV, 15-inch carbon fiber (4 units)
- Flight Control System: PX4
- Lighting: 2×10,000 lumen LED projectors
- Battery (Ground): 48V 100Ah LiFePO4 (4.8 kWh)
- Tether Cable: 2×6 mm², 70 m
- Power Consumption: 325 W
- Endurance: ~14.8 hours

When the electricity is down or there is no lighting in the area, this drone provides illumination throughout the night, increasing the efficiency of teams and playing a critical role in search and rescue [1] [3].

2.3 First Aid Delivery Drone
Delivering medical supplies to rural and isolated areas when roads are blocked or temporarily inaccessible is a major challenge. During the Van earthquake, some villages were unreachable for more than 24 hours [2].
Technical Specifications:
- Motor: 900–1200KV brushless motor (4 units)
- Propeller: 13–15 inch carbon fiber
- Navigation: GPS, IMU, barometer
- Payload Capacity: 2–5 kg
- Battery: 14.8V 16Ah Li-Po (236.8 Wh)
- Power Consumption: 200 W
- Endurance: ~35–40 minutes

In scenarios where every minute counts, it delivers medicine, serum, insulin, and other critical materials to the target area quickly, saving lives [3].

2.4 Sub-Rubble Sound and Heat Detection Drone
During live search operations under rubble, classical methods are often slow and risky [4]. Thanks to its thermal camera and sensitive microphones, this drone can detect signs of life under rubble within minutes [6] [7].
Technical Specifications:
- Motor: Silent mode brushless motor (4 units)
- Flight Control System: GPS, IMU, barometer
- Sensors: 320×256 px thermal camera, multi-directional microphone array
- AI: Sound and heat analysis software
- Battery: 6S 10,000 mAh Li-Po (222 Wh)
- Power Consumption: 220 W
- Endurance: ~25 minutes

Compared to traditional search and rescue methods, it provides much faster and safer life detection—even in areas inaccessible to humans or dogs—day or night [6] [7].

2.5 Mapping and Structural Analysis Drone
After a disaster, rapid and detailed mapping is needed for damage assessment, evacuation planning, and identifying safe passage routes. In Germany's 2021 flood disaster, access to hundreds of villages was re-established through such mapping systems [5].

Technical Specifications:

- Motor: T-Motor MN3510 700KV (4 units)
- Propeller: 15-inch carbon fiber
- Flight Control System: Cube Orange / Pixhawk
- Lidar Sensor: 16 channels, 120 m range
- Camera: 20 MP RGB, global shutter
- Positioning: RTK GNSS
- Battery: 6S 10,000 mAh Li-Po (222 Wh)
- Power Consumption: 180 W
- Endurance: ~24 minutes

It quickly identifies safe routes, risky areas, and building stability in disaster zones, greatly accelerating planning and intervention [5].

3. CONCLUSION

The developed drone systems make a significant difference in speed, accuracy, and access to information in disaster management. They directly address critical needs such as reaching areas inaccessible by traditional means, maintaining communication, night illumination, medical supply transfer, detecting survivors under rubble, and precise mapping. Thanks to energy efficiency and long operational endurance, they can provide uninterrupted service in the field. Widespread adoption of these systems, developed as a solution to global problems, will play a key role in strengthening disaster management strategies.

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