

A Survey of UAV-Based Emergency Medical Supply Delivery and Communication Support for Disaster Response

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Abstract: Natural disasters can damage roads, bridges, power supplies, and communication networks, delaying assistance until conventional rescue teams can reach victims. Unmanned Aerial Vehicles (UAVs) can cross damaged infrastructure, carry light emergency supplies, and collect information. This paper surveys UAV-assisted disaster communication, search and rescue, first-aid delivery, medical-supply logistics, packet dropping, and aerial monitoring. Most reviewed systems focus on one function; field studies also report practical barriers involving payload, weather, approvals, transport, and coordination. A capability comparison identifies a need for a compact, low-cost platform integrating medical-kit delivery, daytime monitoring, GPS waypoint navigation, telemetry, and fail-safe operation. We describe a quadcopter design using an APM 2.8 flight controller, A2212 motors, a 3S Li-Po battery, camera video link, and servo-operated release, with methods for estimating thrust, payload, energy, and response time. The prototype remains at the design stage; estimates are planning values, not measured performance, and flight testing remains future work

Keywords: UAV, Quadcopter, Disaster Response, Emergency Medical Delivery, First-aid Kit, Live Monitoring, GPS Navigation, Telemetry, Drone

I. INTRODUCTION

Floods, earthquakes, landslides and cyclones can destroy the very infrastructure that a normal emergency response relies on. Roads get blocked, bridges can collapse, power can go out and communication networks can fail. The delay this causes is especially serious when victims need first-aid supplies right away, or when rescue teams need information about an area that is unsafe or hard to reach. For this reason, this paper looks at UAVs as an extra layer of response and not as a substitute for human rescue work.

Existing studies already point in several useful directions. UAVs have been used as communication relays when cellular infrastructure is damaged [1], as cooperative search-and-rescue platforms [3], and as carriers of first-aid or medical supplies [5], [8]. Field deployments in North-East India show that drone-based medical delivery works in difficult terrain [6].

Those deployments also bring out problems with drone selection, payload capacity, permissions, transport, weather and coordination [6]. The engineering challenge is therefore not only to get a drone into the air; the whole response chain has to be reliable.



1.1 Background and Motivation

This survey is motivated by the way capabilities are split across the literature. A delivery UAV can carry a kit but may offer little situational awareness. A monitoring platform can watch an area but may not be able to carry a useful payload. A communication-oriented UAV can restore a link but does not necessarily handle medical logistics. We therefore propose bringing delivery and live monitoring together in one practical quadcopter.

1.2 Contributions

Reviews the UAV applications that matter for disaster response, namely medical delivery, search and rescue, communication support and aerial monitoring.

Compares existing system classes on common operational capabilities and combines the research gap and the challenges in one section.

Describes a hardware architecture and mission workflow for medical-kit delivery with live monitoring, GPS waypoint navigation, telemetry, servo release and fail-safe operation, built from off-the-shelf parts.

Sets out the basic design relations for take-off mass, thrust, payload, battery energy and flight time, and response time, kept separate from facts taken from the literature.

II. LITERATURE REVIEW

2.1 Functional Classification of Existing Research

The reviewed work can be grouped into four categories. Communication-oriented research deals with the loss of connectivity after disasters, using aerial relays or adaptive communication [1], [2]. Search-and-rescue research relies on UAV sensing and coordinated flight to collect information about affected areas [3], [4]. Medical-delivery research focuses on moving first-aid kits, medicines or samples to places that are hard to reach by road [5], [6], [7], [8], [9], [10]. Newer monitoring systems add onboard imaging and processing to improve situational awareness [9]. The four categories complement each other, but they are seldom combined in a single low-cost platform.

2.2 Key Findings from the Reviewed Papers

Shamsoshoara et al. [1] showed that UAVs can provide communication support when cellular infrastructure is damaged, and Erdelj and Natalizio [2] reviewed the applications and open issues of drone-assisted disaster management. Cui et al. [3] studied cooperative UAVs for post-disaster search and rescue, and Verma et al. [4] argued for wider use of aerial platforms in inaccessible environments.

On the medical-delivery side, Sanjana and Prathilothamai [5] proposed delivering a first-aid kit by drone while ambulance access is delayed, and Das et al. [7] reinforced the idea of UAVs as an alternative logistics layer. Aggarwal et al. [6] documented real medical-supply deliveries in North-East India and reported practical, operational challenges instead of purely theoretical ones. Their later Himalayan study [10] found that delivery is feasible at high altitude and in cold conditions, although the environment adds further constraints. A 2024 study [8] proposed a drone-based medical delivery algorithm for emergencies, and a 2024 packet-dropping system [9] combined GPS, wireless communication, image processing and OpenCV-based drop-zone detection. More recent humanitarian-logistics research [11] uses optimization models that consider supply priority, payload, battery use, round-trip feasibility and drone-base placement together, which shows that logistics and vehicle limits should be handled jointly.

III. COMPARATIVE ANALYSIS, RESEARCH GAP AND CHALLENGES

3.1 Existing Systems vs. Proposed Solution

Table I compares the system classes by capability. A check mark means the function is a central or explicitly described part of the system, while “Part.” means it supports the mission but is not the main contribution.



System class	Medical kit	Live video	GPS nav.	Comm. link	Auto-detect
Communication-focused UAVs [1], [2]	–	Part.	✓	✓	–
Search-and-rescue UAVs [3], [4]	–	✓	✓	Part.	Part.
First-aid delivery systems [5], [8], [9]	✓	Part.	✓	Part.	–
Medical field deployment [6], [10]	✓	Part.	✓	✓	–
Proposed framework	✓	✓ (day)	✓	✓	Future

TABLE I. Capability comparison of existing system classes and the proposed framework.

This comparison does not claim that the proposed framework performs better than image-processing packet-drop systems [9]. The goal is a lower-cost, modular baseline made from commercial off-the-shelf parts, in which delivery and live monitoring are treated as simultaneous mission functions and automatic detection is added later.

3.2 Research Gap and Engineering Challenges

The literature shows a gap between individual technical capabilities and a complete, field-ready response workflow. Table II links each gap to a design response.

Observed gap	Design response
Delivery and monitoring treated as separate functions	Combine live camera view with payload release
Payload, battery and range are strongly coupled	Size motors and battery from calculations (Sect. 5)
Barriers beyond hardware: weather, permissions, transport, coordination	Include operational constraints in mission planning
Night and poor-visibility operation is difficult	Daytime-only operation; low-light sensing is future work
GPS or communication loss is realistic in disasters	Telemetry monitoring, return-to-home, emergency landing
Automatic detection is emerging but not universal	Operator identifies drop zone now; vision added later

TABLE II. Observed gaps and the corresponding design response.

Some other practical challenges also matter: wind and bad weather, which affect stability, energy use and route safety; the lack of a flat, obstacle-free landing area at disaster sites, limited battery endurance once payload, distance and hover time are counted.

IV. PROPOSED SYSTEM ARCHITECTURE

The proposed concept is a quadcopter platform with two outputs at the same time: delivery of a lightweight medical or first-aid kit, and live aerial information for the rescue team. The design is modular, so basic GPS and telemetry operation can be built first and more sensing can be added later.

4.1 Hardware Architecture

Subsystem	Candidate element	Role in the mission	Related paper
Flight control	APM 2.8 flight controller	Processes pilot commands and navigation inputs; supports waypoint-based flight when configured and validated.	[5], [9]
Propulsion	Four A2212 brushless motors, ESCs and propellers	Generate lift and control; the selected motor–propeller pair must provide the required thrust with reserve.	[5], [9]
Energy	3S Li-Po battery	Supplies propulsion and onboard electronics; usable capacity and discharge limits determine mission endurance.	[5], [9]
Navigation and control link	GPS receiver, radio receiver and telemetry	Provide position and command/status information to the operator; link-loss behavior must be configured.	[1], [5], [9]
Monitoring	Camera, video transmitter and phone-connected OTG	Send a live view to the ground display for daylight observation and operator assessment.	[3], [4], [9]



	receiver		
Payload release	Servo-operated mechanism	Releases the kit at a selected location without requiring the aircraft to land.	[5], [9]
Airframe	Quadcopter frame and landing gear	Supports the equipment and protects clearance for the propellers and release mechanism.	[5], [9]

TABLE III. Proposed System Hardware Components

The camera video path is independent of the flight-control path in the proposed arrangement. This separation means that a video interruption should not be treated as proof that the aircraft has lost control, and a working video feed should not be treated as proof that telemetry is healthy. The described camera has no night-vision capability, so monitoring is limited to daylight.

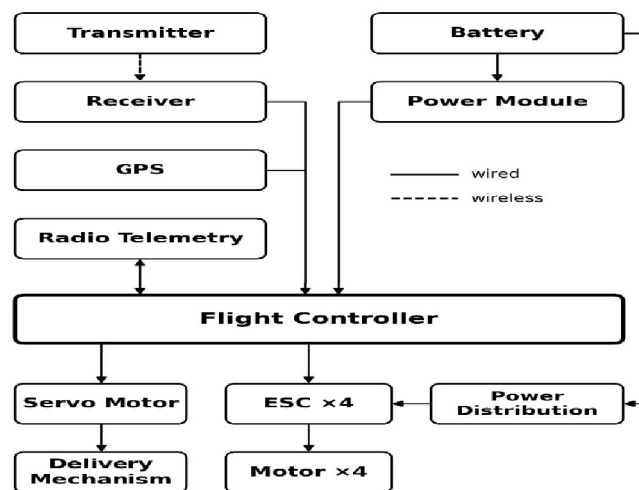


Fig. 1. Block diagram of the proposed drone: power, control, propulsion and payload release.

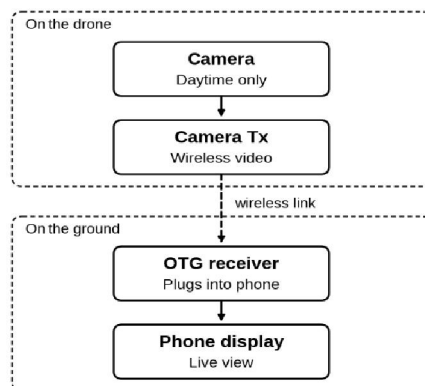


Fig. 2. Video link from the drone camera to the ground display (daytime only).

4.2 Software and Mission Logic

Mission planning, navigation, payload control and fail-safe functions can be managed with Mission Planner [5], [9].



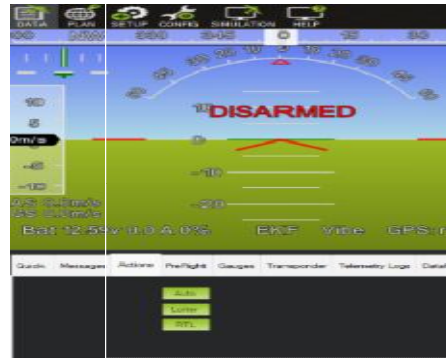


Fig. 3. Mission Planner software interface.

V. MATHEMATICAL DESIGN CONSIDERATIONS

The relations below show how the proposed drone is sized step by step, from total mass to flight time. They are standard design relations and not measured results. The mass, thrust and battery values are to be filled in from manufacturer data and prototype measurements once the prototype exists.

5.1 Total Take-off Mass

The total take-off mass is the empty mass plus the payload. The empty mass is itself the sum of the structure, propulsion, battery and electronics masses:

$$m_{\text{empty}} = m_{\text{str}} + m_{\text{prop}} + m_{\text{batt}} + m_{\text{elec}}(1)$$

$$m_T = m_{\text{empty}} + m_p(2)$$

Here m_{str} is the frame and landing gear, m_{prop} covers the motors, ESCs and propellers, m_{batt} is the battery, m_{elec} covers the flight controller, receiver, GPS, telemetry, camera link, release mechanism and wiring, and m_p is the payload.

5.2 Weight and Hover Thrust

The weight is the total mass multiplied by gravitational acceleration. In steady hover the total thrust must equal the weight, and each of the N motors carries an equal share:

$$W = m_T(3) \quad g$$

$$T_{\text{hover}}(4) = W / N$$

with $g = 9.81 \text{ m/s}^2$ and $N = 4$ for a quadcopter.

5.3 Thrust-to-Weight Ratio and Motor Selection

The thrust-to-weight ratio (TWR) compares the maximum thrust available with the weight of the drone and shows how much reserve is left for manoeuvring and wind. With T_{max} the maximum static thrust of one motor-propeller pair,

$$\text{TWR} = N T_{\text{max}}(5) / W$$

A target TWR is chosen (about 1.5 to 2 is a common design range).

5.4 Payload Capacity

The airframe has a maximum take-off mass m_{max} , which follows from the motor thrust and the lowest acceptable ratio TWR_{min} as $m_{\text{max}} = N T_{\text{max}} / (\text{TWR}_{\text{min}} g)$. The usable payload is what is left after the empty mass:

$$m_{p,\text{max}} = m_{\text{max}} - m_{\text{empty}}(6)$$

Payload therefore cannot be chosen independently of the battery and frame: more payload needs more thrust and also raises energy consumption.



5.5 Motor Speed

For a brushless motor with speed constant KV and applied voltage V, the first-order no-load speed is

$$(7) \text{ RPM} \approx \text{KV} \times V$$

which gives about $1000 \times 11.1 = 11,100$ rpm for the A2212 1000KV on a 3S battery.

5.6 Response-Time Model

Emergency response time is the sum of the dispatch, flight, delivery and return times:

$$T_{\text{resp}} = T_{\text{disp}} + T_{\text{fl}} + T_{\text{del}} + T_{\text{ret}} (8)$$

VI. APPLICATIONS

Remote and hilly areas: Gives a faster first response where ground transport takes hours, until an ambulance or rescue team can arrive.

Daytime aerial monitoring: The live camera shows the extent of damage, blocked routes and the places where people are gathered.

Situational awareness for rescue teams: Operators and rescuers see the affected area in real time, so they can plan safer ground routes and decide where to send help first.

Support for ambulances: Sends basic supplies when an ambulance is delayed by traffic or damaged roads

VII. FUTURE ENHANCEMENTS

Night-vision or thermal sensing, together with controlled lighting, for low-light operation.

Computer vision to detect victims and drop zones.

LiDAR or depth sensing for obstacle avoidance.

Weather-aware route planning and better battery technology.

Redundant positioning and communication methods for when GPS or telemetry degrades.

Prototype flight tests and field validation in flood, landslide, earthquake and remote-terrain scenarios, with a human-in-the-loop operating model.

VIII. CONCLUSION

The existing literature highlights the growing importance of Unmanned Aerial Vehicles (UAVs) in disaster response, particularly in medical supply delivery, aerial monitoring, search and rescue, and communication support when conventional infrastructure is disrupted. This paper presents a survey of disaster-response drone systems, reviewing their applications, navigation techniques, communication systems, payload capabilities, power requirements, and safety mechanisms. It also examines the major challenges associated with UAV deployment, including limited battery endurance, payload capacity, adverse weather conditions, landing constraints, communication failures, regulatory requirements, and operational reliability. The survey identifies a significant research gap in the integration of delivery, real-time monitoring, GPS-based navigation, telemetry, and fail-safe mechanisms into a unified, low-cost system. Based on the findings of the reviewed literature, the paper discusses the potential design of a modular quadcopter capable of supporting medical-kit delivery and daytime aerial monitoring. The study also highlights the importance of component selection, power estimation, flight endurance, payload capacity, and communication reliability in designing an effective disaster-response drone.

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