APPLICATION OF DRONES FOR DELIVERY OF EMERGENCY ITEMS TO VICTIMS OF DISASTERS

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This paper proposes the use of drones to deliver emergency items for victims of a natural disaster such as flooding or hurricane. Victims will be in dire need of emergency items such as food, water, medicine, and shelter; however, ground transportation means (e.g. roads, bridges, and railways) may not be readily accessible for several days after such an event. For instance, one month after Hurricane Maria swept across Puerto Rico in 2017, some towns continued to be isolated and delivery of relief supplies was hampered [1].

To address some of the issues, we propose to use drones for delivery of emergency items to victims of natural disasters. The following features of drones and the currently developed (or developing) technologies made it possible to deliver emergency items by drones:

1. Manned vehicles need road infrastructure; however, drones are able to fly directly from a location to a destination in the sky.
2. Drone's speed can reach 60 miles/hour, even for small-sized drones, which can be faster than the speed of a ground vehicle by considering the congestion or obstacles on the way. This is very important because people who are isolated may need an immediate medical care within precious lifesaving minutes. Drones can reach the victims faster than an ambulance in many situations, and they can be used to assess the condition of the patient by using remote sensors. Then they are able to send the real time data to the center and give feedback to the patient [2].
3. Drones have the ability to travel to locations where it might be hostile environment for manned systems in disaster response applications. They can fly inside the buildings to search for victims who are stuck and are unable to walk [3].
4. Drones can be economically viable alternative to manned vehicles such as trucks because operating drones may require fewer personnel labors; hence lower cost.
5. Different amount of payload can be carried by drones based on their weight capacity. Small drones are able to carry light-weight foods and medicines to victims and pickup blood and urine tests [4]. For large size packages, instead of one vehicle, a fleet of drones can be used to deliver the package.
6. It might be necessary to ship perishable items such as blood packages between the hospitals or between a patient and a hospital. Delivery of perishable products is critical because it should be done in a short time with the appropriate equipment which makes drones a good option [5].

Therefore, using drones in delivery applications, made it safer, faster, easier and cheaper in comparison to traditional mechanisms such as transportation by truck in event of disasters.

An accurate estimate of drone battery endurance during the planning stage is critical to have a safe flight return without running out of battery and losing the emergency items (which are vital for victims). The maximum battery endurance time is affected by various factors including payload amount, flight modes [6] and environmental conditions such as temperature [7] and wind [8].

In this research, we focus on lightweight parcels and investigate the impact of payload amount on drone flight time. We tested Phantom 4 pro+ to collect the flight time and the remaining charge for different amount of payloads. The data are collected in the hovering mode with the battery charge between 15% and 95%. Table 1 shows the flight time duration in minutes corresponding to different battery charge (from 15% to 95%) and payload amount (from 0 lb. to 0.882 lb.). Figure 1 also shows the data graphically.

Table 1- flight time data (in minutes) collected with Phantom 4 pro+

Battery charge (%)	Payload amount 0 lb.	0.220 lb.	0.441 lb.	0.661 lb.	0.882 lb.
95	0.00	0.00	0.00	0.00	0.00
90	1.45	1.28	1.10	1.01	0.74
85	2.65	*2.35*	2.03	1.90	1.61
80	4.06	3.61	3.11	2.96	2.60
75	5.48	4.85	4.23	4.02	3.54
70	6.84	6.05	5.23	4.97	4.42
65	8.01	7.08	6.16	5.80	5.20
60	9.39	8.26	7.30	6.80	6.11
55	10.77	9.46	8.35	7.69	7.04
50	12.07	10.62	9.33	8.59	7.84
45	13.19	11.58	10.22	9.41	8.61
40	14.54	12.75	11.30	10.35	9.50
35	15.90	13.90	12.19	11.30	10.33
30	17.15	15.03	13.16	12.18	11.15
25	18.32	16.02	14.07	13.07	11.88
20	19.62	17.18	15.12	14.03	12.69
15	20.93	18.32	16.12	15.00	13.57

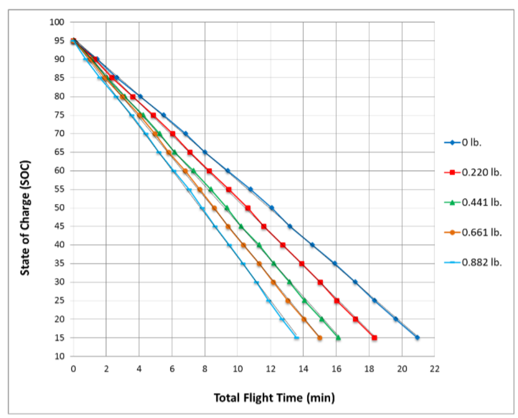

Figure 1- total travel time vs. state of charge

The collected data verifies a linear relationship between the total flight time and the payload amount according to the following equation:

$$t = \alpha \times \, payload \, + \beta$$

where α is the slope and β is the intercept of the linear relationship. Therefore, the total flight time depends on the amount of payload and has a linear relationship with the battery charge. The more payload the drone carries, the less the total flight time will be and it should be considered in assigning payloads to drones.

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