Design and development of an aircraft type portable drone for surveillance and disaster management

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Abstract

Purpose – The purpose of this paper is to demonstrate the development of an aircraft-type autonomous portable drone suitable for surveillance and disaster management. The drone is capable of flying at a maximum speed of 76 km/h. This portable drone comprises five distinct parts those are easily installable within several minutes and can be fit in a small portable kit. The drone consists of a ballistic recovery system, allowing the drone landing vertically. The integrated high-definition camera sends real-time video stream of desired area to the ground control station. In addition, the drone is capable of carrying ~1.8 kg of payload.

Design/methodology/approach – In order to design and develop the portable drone, the authors sub-divided the research activities in six fundamental steps: survey of the current drone technologies, design the system architecture of the drone, simulation and modeling of various modules of the drone, development of various modules of the drone and their performance analysis, integration of various modules of the drone, and real-life performance analysis and finalization.

Findings – Experimental results: the cruise speed of the drone was in the range between 45 and 62 km/h. The drone was capable of landing vertically using the ballistic recovery system attached with it. On the contrary, the drone can transmit real-time video to the ground control station and, thus, suitable for surveillance. The audio system of the drone can be used for announcement of emergency messages. The drone can carry 1.8 kg of payload and can be used during disaster management. The drone parts are installed within 10 min and fit in a small carrying box.

Practical implications – The autonomous aircraft-type portable drone has a wide range of applications including surveillance, traffic jam monitoring and disaster management.

Social implications – The cost of the cost-effective drone is within $700 and creates opportunities for the deployment in the least developed countries.

Originality/value – The autonomous aircraft-type portable drone along with the ballistic recovery system were designed and developed by the authors using their won technology.

Keywords Portable drone, Autonomous, Ballistic recovery system, Surveillance, Disaster management

Paper type Research paper

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1. Introduction

From technological point of view, drones are considered as unmanned aircraft. Alternately, drones are also called unpiloted air system, unpiloted aerial vehicle, remote piloted aircraft systems and model aircraft. Over the last several decades, drones have been extensively utilized for diverse applications because of small size, simplicity, high reliability and low cost. At present, a large variety of application specific drones are available in the world. Typically, the drones fall into one of the following six functional categories: target and decoy—considered as a target for ground and aerial gunnery that acts as an enemy aircraft or missile, reconnaissance—suitable for battlefield intelligence, combat—suitable for attacking during high-risk military missions, logistics—suitable for cargo and logistics operation, research and development—used for further development of drone technologies to be integrated with field deployed drone, and civil and commercial—specially designed for civil and commercial applications. Beyond military applications, drones have been deployed in dynamic civil and commercial applications: crowd monitoring, surveillance, aerial surveying, delivery of products, spraying insecticides, sowing seeds, landslide measurement, detection of illegal landfill, acrobatic aerial footage in filmmaking, search and rescue operations, inspection of power lines and pipelines, counting wildlife, and detection of forest fire and illegal hunting (Crutsinger et al., 2016; Marcaccio et al., 2016; Tokekar et al., 2013; Thompson, 2013; Auat Cheein and Carelli, 2013; Springer, 2013; Tokekar et al., 2013; Hasan, 2017; Jubair et al., 2017). Typically, drones are classified as non-autonomous and autonomous depending on the controlling system. Non-autonomous drones are controlled manually by means of a remote controller requiring a highly skilled operator. In contrast, flight of the autonomous drones is precisely controlled from the remotely spaced programmable computers using the on-board autopilot and global positioning system (GPS). On the contrary, from structural point of view, the drones are classified as aircraft type and copter type. Aircraft-type drones are popular for their high-speed flying ability, which are suitable during surveillance and defense from possible attacks. On the contrary, the copter type drones are required for precise flying and vertical landing (Budiyono et al., 2011; Custers, 2016; Završnik, 2016; Unmanned Aircraft Systems, International Civil Aviation Organization, 2011). However, it is very difficult for an aircraft-type drone to takeover or land in hilly regions, forests, disaster affected rural areas or highly dense urban areas. To surmount such limitation, a ballistic recovery system can be incorporated with the drone so that the drone can land on the ground almost vertically (Wyllie, 2001; Cartwright, 2008; MARS 58 V2). However, most of the ballistic recovery systems are costly and the release mechanism is complex. As a result, a cost effective simple release mechanism is desirable in the ballistic recovery system. Most of the conventional drones use T-tail configuration where the vertical fin is joined with the horizontal tail. However, T-tail configuration resulted in higher drag compared to inverted V-tail configuration. In addition, there is a high risk of flutter occurrence at the T-tail joint. The drug reduction capacity of the inverted V-tail configuration increases the maximum range or endurance of the drone significantly. Conventional inverted V-tail drones have the propeller in pusher configuration (Muliadi, 2017). Addition of a ballistic recovery system with the inverted V-tail drones is challenging. On the contrary, due to the large size of the conventional aircraft-type surveillance drones, it is difficult to carry them without bringing the attention of the general public. A portable drone can be considered as the solution of the problem where the parts of the drone are carried in a small portable kit and can be assembled instantly.

During last several decades, terrorist attacks have been extended throughout the world. Few recent attacks compelled us to rethink about our surveillance technologies and monitoring techniques. In order to ensure adequate security and safety to people, surveillance drones can be deployed. Due to global climate change over the last few decades,
we have witnessed an increasing number of natural disasters such as flood, cyclone, earth
quake and land sliding (Craft et al., 2016). During floods or cyclones, millions of people are
affected and they are in need of emergency foods, medicines and many other commodities.
Due to the lack of good communication systems, it is always difficult to send emergency
messages regarding early disaster awareness to the general public living in remote areas.
Further, sending adequate reliefs in the disaster affected areas immediate after the disaster
is challenging. Although drones cannot carry a large amount of reliefs such as foods or
blankets, but they can carry emergency medicines, water purification tablets, and light
weight commodities to the affected people where there is no other way to reach them easily.
Disaster awareness messages are also possible to spread quickly in the vulnerable areas by
drones. Another promising application of drone is road traffic monitoring. Traffic jam is a
common problem in the mega cities of the world (Megeve, 2012). During busy hours, it is
difficult to drive cars because of severe road traffic jam. Under these circumstances, drones
can be deployed to monitor road traffic or accidents so that the culprits are easily be
detected. High-speed drones having vertical landing capability can be considered as a
promising drone for such kinds of applications. Although drones have been extensively
developed and utilized in the developed countries, developing countries are well behind from
such technologies due to the lack of adequate research in the field. Because of the high price
of the current drones, they are out of reach to most of the developing countries. Thus, the
world is in need of cost-effective drones for large scale deployment. The key challenge is to
develop a low-cost inverted V-tail portable drone having ballistic recovery system for
vertical landing.

In this paper, we design and develop a low-cost aircraft-type autonomous portable
drone targeting surveillance and disaster management. The proposed drone is not only
portable but also capable of landing vertically without any requirement of runway.
To ensure portability, the structure of the drone is divided into five distinct parts, allowing
assembling within several minutes. Most importantly, the parts of the drones are fit in a
small portable kit. A ballistic recovery system is installed with the drone to achieve
vertical landing capability in an aircraft-type drone using a hemisphere parachute.
To overcome the problem of adding a ballistic recovery system in conventional pusher
configured inverted V-tail drones, we design our model using dual motor puller
configuration and place the parachute at the back side of the drone. The range of the
portable drone is several kilometers from the ground control station. The integrated
autopilot and GPS device are responsible for autonomous flight of the drone. The same
drone can be controlled non-autonomously by means of a long range remote controller.
During any emergency situation, the drone automatically returns to the ground control
station. The built-in high-definition (HD) camera and video transmitter are responsible for
real-time video streaming of the desired area to the ground control station. For audio
announcements, a high performance audio system is mounted with the drone.
Furthermore, the drone is capable of carrying ~1.8 kg of payload. The portable drone
has dynamic applications including surveillance for early detection of terrorist attacks,
road traffic and accidents monitoring, and supplying medicines and announcing
awareness messages during disaster management.

2. Research methodology
In order to design and develop the portable drone, we sub-divided our research activities in
six fundamental steps: survey of the current drone technologies, design the system
architecture of the drone, simulation and modeling of various modules of the drone,
development of various modules of the drone and their performance analysis, integration of
various modules of the drone, and real-life performance analysis and finalization. The
details of each step are discussed below.
2.1 Survey of the current drone technologies
We investigated the current drone technologies (both aircraft and copter type) and available devices required to integrate with the portable drone. Besides, before stepping into designing phase of our drone, we examined various structural and theoretical models for designing the portable structure of the drone and ballistic recovery system.

2.2 Design the system architecture of the drone
Based on the surveyed information regarding the types of drones and their built-in devices, we designed the system architecture of all the modules of the portable drone including ground control system, communication system, power unit, autopilot unit, GPS unit, camera and video transmission unit, audio unit and ballistic recovery system. We also designed the structure of the drone, circuit diagrams for electrical and electronic modules and their interfacing to develop the autonomous portable drone.

2.3 Simulation and modeling of various modules of the drone
The portable drone is functional due to the coordination of electrical, electronics, communication, mechanical and software modules. Before finalization of the design and development, each module of the portable drone was designed and simulated using various commercial computer aided design (CAD) software. The electrical and electronics modules were designed and simulated using PSpice and PROTEUS simulators. Depending on the simulation results, we made the necessary changes in our design before finalization. The flying path was programed using the Mission–Planner software installed in the ground control station.

2.4 Development of various modules of the drone and their performance analysis
After we are convinced with the simulation results for each of the required components/circuits, we developed various modules of the portable drone. Although the portable drone consists of five separate parts, the system architecture of the drone is divided into fundamental four sections: mechanical, electrical and electronic, communication, and ballistic recovery system. The performance of all these sections was analyzed using various measurement tools.

2.5 Integration of various modules of the drone
After the performance of all the modules passed the desired value, all modules/sections were integrated to develop the complete portable drone and the corresponding ground control station. The power unit, autopilot unit and transmitter/receiver unit were located inside the body of the drone. The GPS unit was placed just on top of the portable drone. The HD camera, camera gimbal and the audio unit were mounted at the bottom part of the drone. The ballistic recovery system was placed at the back side of the drone. After installation of all the modules, we calculated the motor thrust in the laboratory. After laboratory test, necessary modifications were made where required. Although our initial design was to place the ballistic recovery system at the upper part of the drone, after measurements and testing in the laboratory we moved the ballistic recovery system at the back side of the drone.

2.6 Real-life performance analysis and finalization
After satisfactory results in the laboratory, we went for real-life performance analysis. We checked the flying capability and speed of the drone, altitude, coverage area, maximum flying duration and performance of the ballistic recovery system. The performance of various components such as autopilot, telemetry, GPS, video transmitter, audio system,
ground control station, HD camera and remote controller was analyzed as well. Furthermore, we investigated the video quality and response time during real-time video transmission/reception. Most importantly, we checked the vertical landing capability of the drone and found convincing results. Our portable drone was capable of flying autonomously where the flying path was programmed from the ground control station. In addition, we were successful in real-time handover from autonomous flight to non-autonomous flight using a long range remote controller.

3. Architecture of the drone system
We designed and developed a low-cost aircraft-type autonomous portable drone, suitable for surveillance and disaster management. The system architecture of the drone is depicted in Figure 1(a). Although the primary purpose of the drone is surveillance, the same drone can be utilized during disaster management and supply of emergency commodities

![Diagram of drone system](image)

**Notes:** (a) Architecture of the drone system; (b) functional diagram of the drone system

**Figure 1.** Architecture and functional diagram of the drone system
The ballistic recovery system, integrated with the drone, enables the vertical landing capability of the drone. The drone system has primarily two modules: ground control station and the drone itself.

### 3.1 Ground control station

The drone is controlled from the ground control station, connected to a control computer. The control computer is equipped with open source software, namely, Mission-Planner (http://ardupilot.org/planner/docs/mission-planner-overview.html) to support local signal processing operations and to control the flying path and direction of the drone. For autonomous flight, a firmware (ArduPlane; Version: 3.7.1), developed by ArduPilot Community, was installed to the autopilot device of the drone (ArduPilot Mega 2.8: an Arduino mega microcontroller). The flying path of the drone is transferred from the ground control station to the built-in autopilot of the drone. A high power long range transmitter antenna ($T_x$) of the ground control station communicates with the integrated high-speed receiver ($R_x$) of the drone through wireless communication. The movement of the camera gimbal and operation of the audio system were also controlled by the Mission-Planner software of the ground control station. The video output coming out from the HD camera is transmitted to the ground control station by means of the video transmitter. The functional block diagram of the drone is shown in Figure 1(b).

### 3.2 Drone architecture

The multi-purpose portable drone consists of the following sections: GPS, autopilot, telemetry, HD camera, video transmitter, audio unit and ballistic recovery system. Figure 2 delineates the schematic diagram of various parts of the portable drone and carrying box.

The altitude of the drone was measured using the barometric pressure sensor of the autopilot device. The drone is capable of flying autonomously from the ground control station due to the autopilot section of the drone. The integrated HD camera along with the video transmitter device is responsible for real-time video transmission of any area, thereby allowing real-time monitoring of any region and disaster management (e.g. rescue operation). The audio system can be used for announcements of audio messages. The brushless motors connected with the propellers produce adequate thrust for smooth flying of the drone. Because of the ballistic recovery system, the drone is capable of landing vertically in a small area using a parachute and, thus, suitable for landing in hilly or forest regions. The drone can be divided into five different parts those are easily installable within several minutes. Figure 2(a) shows various parts of the multi-functional autonomous portable drone. Figure 2(b) illustrates the appearance of the drone after all modules are assembled. The vertical landing technique of the portable drone using the ballistic recovery system is depicted in Figure 2(c). Figure 2(d) represents the placement of various parts of the drone inside the carrying box. The architecture of the drone is divided into fundamental four sections: mechanical section, electrical and electronic section, communication section and ballistic recovery system.

#### 3.2.1 Mechanical section

The airframe of the portable drone was constructed using glass fiber on top of lightweight plywood and foam so that it can carry the built-in power unit, GPS unit, autopilot unit, telemetry unit, HD camera and video transmission unit, audio unit and receiver unit. As mentioned before, the whole body of the drone was divided into five parts to make the drone portable. The portable drone can be assembled just within several minutes. The total weight of the drone including the power unit, control unit, camera unit and ballistic recovery system is approximately 2.2 kg. The payload capacity of the drone is approximately 1.8 kg.
3.2.2 Electrical and electronic section. We used two 88 percent efficient brushless motors along with propellers to drive the portable drone. For proper coordination of the motors and controlling the motor speed, we connected two electronic speed controllers with the motors. We incorporated lithium polymer battery having 8000 mAh current rating as power unit of our drone. We considered a laptop as our ground control station. One HD camera along with three-axis camera gimbal was installed with the drone whose pan and tilt are pre-programmed in autonomous flight using the Mission–Planner software installed in the ground control station. The autopilot unit accepts the flying path from the ground control station and converts the incoming signals to appropriate commands for autonomous flight of the drone.

3.2.3 Communication section. Primarily, the drone is guided autonomously from the ground control station. Using the Mission–Planner software, the flying path of the drone was programmed from the ground control station for autonomous flight. The flying path was transferred through the antenna of the ground control station to the receiver of the autopilot installed in the drone. Figure 3 shows the flying path of the drone programmed from the ground control station for autonomous control of the drone during our test flight. In parallel with autonomous flight, the drone can be controlled manually by long range remote controllers. The operating frequency of the drone for sending the control command is 2.4 GHz. The real-time video captured by the camera unit was transmitted by the video transmitter to the ground control station using the frequency band of 5.2 GHz.
For autonomous flight control, a high precision GPS (ground evaluated tolerance: ~1 m, refresh rate: 5 Hz) unit was installed with the drone. The telemetry unit, operating at 900 MHz, is a two-way digital system, which is responsible for transmitting the necessary data regarding the flight controller (battery voltage, traveled distance, current power consumption of the system, heading, altitude, drone’s orientation, airspeed, waypoint and bearing) down to the ground control station and receiving control commands and flying path from the ground control station. Frequency Hopping Spread Spectrum modulation technique was used for two-way communication of the telemetry unit. The transmitter power of the telemetry was ~20 dBm, whereas the receiver sensitivity of the telemetry was down to –121 dBm. The maximum air data rate between the ground control station and the telemetry was ~250 kbps where MAVLink (Micro Air Vehicle Link) protocol was considered for framing the packets. The signals were multiplexed using adaptive time division multiplexing technique.

3.2.4 Ballistic recovery system. A parachute was located inside the ballistic recovery system, which was remotely opened from the ground control station. To achieve the gore pattern, the hemisphere is divided into eight vertical and eight horizontal lines, as shown in Figure 4(a). The gore pattern of a hemispheric parachute is illustrated in Figure 4(b). Consider $D$ be the diameter of the parachute. The equations for calculating the radius and heights of the gores are summarized in Table I (Hemisphere Parachute Design).

![Figure 3. Flying path of the drone programmed from the ground control station for autonomous flight](image)

![Figure 4. Design of the hemispherical parachute used in the ballistic recovery system](image)

Notes: (a) A hemisphere is divided in eight vertical and horizontal lines to achieve gore pattern parachute; (b) gore pattern of a hemispheric parachute
Eight similar separate parachute cloths are sewed to get a nearly perfect hemispherical parachute. The length $L$ of shroud lines is obtained using the following equation (Hemisphere Parachute Design):

$$L = 2.25 \times (D + S)$$

(1)

where $S$ is stitching length. The descend velocity of the parachute during vertical landing can be calculated using the following equation (Benson):

$$V = \sqrt{\frac{8mg}{\pi \rho C_d D^2}}$$

(2)

where $m$ is the mass of the aircraft, $g$ is the acceleration of gravity, $D$ is the chute diameter, $\rho$ is the density of air and $C_d$ is the drag co-efficient of the chute.

4. Results and discussion

The portable drone was constructed using durable materials so that the drone can fly for hundreds of hours uninterruptedly. The production cost of the drone was within $\$700$. Figure 5 illustrates the architecture of the developed portable drone. The autonomous portable drone is shown in Figure 5(a), whereas image of the HD camera is depicted in Figure 5(b). The portable drone is capable of landing vertically because of the ballistic recovery system. Figure 5(c) shows the vertical landing capability of the drone by means of the ballistic recovery system during real-life performance analysis. The portable drone is hand launched, the speed of which was controlled by means of two brushless motors and corresponding electronic speed controllers.

The average cruise speed of the drone was in the range of 45–62 km/h, whereas the maximum loiter velocity and stall speed were 62 and 32 km/h. The maximum and minimum altitudes of the drone were approximately 500 and 20 m when operating in the autonomous mode. During manual operation, the altitude of the drone can be reduced down to ~5 m by means of a remote controller. The thrust of the motors was ~2 kg/motor. The total weight of the portable drone including the power unit, control unit, camera unit and ballistic recovery system was ~2.2 kg and maximum payload was ~1.8 kg. The maximum duration of a single flight varies from 20–30 min, depending on the altitude and payload. The flight time decreased with the altitude and amount of payload. Furthermore, we were able to place various sections of the portable drone in a carrying kit. We successfully integrated various sections of the portable drone within 10 min. The details of the autonomous portable drone are summarized in Table II.

<table>
<thead>
<tr>
<th>Source: Hemisphere Parachute Design</th>
<th>Aircraft type portable drone</th>
<th>155</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Radius</th>
<th>Height</th>
<th>Gore pattern equations for hemispheric parachute</th>
</tr>
</thead>
<tbody>
<tr>
<td>r1</td>
<td>0.093 × D</td>
<td>0.2222 × D</td>
</tr>
<tr>
<td>r2</td>
<td>0.1297 × D</td>
<td>0.1083 × D</td>
</tr>
<tr>
<td>r3</td>
<td>0.1541 × D</td>
<td>0.0888 × D</td>
</tr>
<tr>
<td>r4</td>
<td>0.17 × D</td>
<td>0.0722 × D</td>
</tr>
<tr>
<td>r5</td>
<td>0.1819 × D</td>
<td>0.0666 × D</td>
</tr>
<tr>
<td>r6</td>
<td>0.19 × D</td>
<td>0.0638 × D</td>
</tr>
<tr>
<td>r7</td>
<td>0.1947 × D</td>
<td>0.0625 × D</td>
</tr>
<tr>
<td>r8</td>
<td>0.1966 × D</td>
<td>0.0583 × D</td>
</tr>
</tbody>
</table>

Table I
In order to reduce the complexity, we considered a simple gravity assisted free fall technique for the ballistic recovery system. The release mechanism of the parachute is also simple to save weight and cost. When the parachute was released, the velocity of the drone guaranteed its inflation. For our portable drone, the mass of the aircraft \( m = 4 \) kg, chute diameter \( D = 1.524 \) m, acceleration of gravity \( g = 9.81 \) m/s\(^2\), drag co-efficient of the chute \( C_D = 1.75 \) (typical value for hemispherical parachute), \( \pi = 3.1459 \), and density of air \( \rho = 1.229 \) kg/m\(^3\) (Benson). The value of descend velocity of the parachute, calculated using
Equation (2), was 4.47 m/s. We also tested the performance of the ballistic recovery system under different altitude on a sunny day at a temperature of 24°C with a wind speed of 4 m/s. The weight of the drone including the payload was ~4 kg. The dependence of parachute opening time and descend velocity on the altitude and velocity of the drone are summarized in Table III. There are significant differences between the practical and theoretical descend velocity of the drone during vertical landing by ballistic recovery system. The wind speed and direction during real-life performance analysis might be responsible for such difference. The minimum parachute opening time of 1.09 s was measured at an altitude of 34 m when the drone velocity was 20.22 m/s.

Performance comparison of our ballistic recovery system with some of the commercial ballistic recovery systems are summarized in Table IV. The cost of the ballistic recovery system of our drone was reduced significantly due to the use of free fall technique.

We captured video of the desired trajectory using the HD camera and transmitted the video to the ground control station from a maximum altitude of 100 m and distance of ~300 m from the ground control station; the altitude and range of the drone can further be increased for video transmission whenever required. Plate 1 depicts the image captured from an altitude of ~100 m and distance of ~300 m from the ground control station. Using the audio system, we announced audio messages from a maximum altitude of 23.6 m.

5. Conclusion
In summary, we designed and developed an aircraft-type autonomous portable drone suitable for surveillance and disaster management. For autonomous flight, the flying path was programmed from the ground control station and transferred to the autopilot of the drone. The same drone can also be controlled non-autonomously by means of a long range remote controller. The drone can fly in different altitudes with a cruise speed ranging

<table>
<thead>
<tr>
<th>Test altitude (m)</th>
<th>Airplane velocity ( m/s)</th>
<th>Inflation time after Triggering (s)</th>
<th>Descend velocity (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>13.1</td>
<td>1.37</td>
<td>3.12</td>
</tr>
<tr>
<td>15</td>
<td>13.9</td>
<td>1.33</td>
<td>3.10</td>
</tr>
<tr>
<td>23</td>
<td>14.88</td>
<td>1.27</td>
<td>2.88</td>
</tr>
<tr>
<td>27</td>
<td>15.27</td>
<td>1.25</td>
<td>2.95</td>
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<tr>
<td>32</td>
<td>16.66</td>
<td>1.22</td>
<td>3.22</td>
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<tr>
<td>36</td>
<td>17.22</td>
<td>1.13</td>
<td>2.98</td>
</tr>
<tr>
<td>34</td>
<td>20.22</td>
<td>1.09</td>
<td>2.98</td>
</tr>
</tbody>
</table>

Table III. Dependence of inflation time and descend velocity on altitude and velocity of the drone

<table>
<thead>
<tr>
<th>Parameter</th>
<th>MARS 58 V2 (MARS 58 V2)</th>
<th>Galaxy GBS 10/50 (Galaxy GBS 10/50)</th>
<th>Our system</th>
</tr>
</thead>
<tbody>
<tr>
<td>System weight (kg)</td>
<td>0.35</td>
<td>0.36</td>
<td>0.32</td>
</tr>
<tr>
<td>Release mechanism</td>
<td>Compression spring system</td>
<td>Pyrogenerator</td>
<td>Free fall</td>
</tr>
<tr>
<td>Deployment mode</td>
<td>Automatic</td>
<td>Manual and automatic</td>
<td>Manual and automatic</td>
</tr>
<tr>
<td>Triggering device</td>
<td>Servo</td>
<td>Servo</td>
<td>Servo</td>
</tr>
<tr>
<td>Minimum deployment height (m)</td>
<td>15</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>Minimum inflation time (s)</td>
<td>~1.4</td>
<td>~1</td>
<td>~1.09</td>
</tr>
<tr>
<td>Cost ($)</td>
<td>389</td>
<td>930</td>
<td>50</td>
</tr>
</tbody>
</table>

Table IV. Comparison of the proposed ballistic recovery system with other commercial ballistic recovery systems
between 45 and 62 km/h. The maximum duration of a single flight was ~30 min. The five distinct parts of the drone were fit in a small portable kit, where the parts were reinstalled just within 10 min. The ballistic recovery system of the drone allowed us to land vertically. The HD camera integrated with the drone was capable of real-time video streaming to the ground control station from an altitude of 100 m and distance of 300 m. The altitude and distance can be increased up to 500 m and 2 km, depending on the requirement. The pre-recorded audio messages announced from the audio system were hearable from a maximum altitude of 23.6 m. Most importantly, the drone can carry ~1.8 kg of payload with it. The capability of the autonomous portable drone exemplifies the applicability of the drone in a wide range of application areas including surveillance, disaster management, monitoring and counting wild life, and road traffic monitoring.

References


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