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The Integration of Unmanned Aircraft Systems (UASs) and the Next Generation Combat Vehicle (NGCV)

by LaKaiya DeJarnette-Crumsey, Jared Savage, Deon Shaffer, Lavoris Marshall-Leverette, Bryce Stephens, Heshmat Aglan, Firas Akasheh, Munshi Basit, Pablo Guzmán, Vascar Harris, Curtis Kelly, Robert W Kubiak II, Adriane Ludwick, Mandoye Ndoye, and Keith Roberts

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14. ABSTRACT
The design, fabrication, and characterization of a platform intended to house, deploy, and capture unmanned aircraft systems and adhere to ground vehicles is described. This report details preliminary findings and future work to finalize the prototype.

15. SUBJECT TERMS
unmanned aircraft system, UAS, unmanned aerial vehicle, UAV, Next Generation Combat Vehicle, NGCV, Military Information Sciences

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1. Introduction

The focus of the integration of unmanned aircraft systems and the Next Generation Combat Vehicle (NGCV) was motivated by our US Department of Defense Aerospace Education, Research, and Innovation Center team to collaborate on a project to support US Army Soldiers. We collaborated with the US Army Combat Capabilities Development Center Army Research Laboratory through our bi-weekly interactions with Chris Kroninger and Pablo Guzmán. We developed the idea of creating a box that acts as a storage and platform for a drone to land, take off, and be protected during travel. The initial goal of this effort was to develop an efficient and effective prototype of a mobile drone platform for eventual use by Soldiers in the field. Our plan was to perform multiple tests on ways for the drone to stay on the lid (platform) of the box, providing extra protection while it was inside of the box.

2. Background

The evolution of safety and security while using commercial drones and transportable boxes has had a huge impact on the world. In a 2018 publication, Hasan et al. described a drone design that would provide safety and surveillance for traffic jam monitoring.[1] An additional goal of their drone design was to provide access to the drone so that objects could be moved to different locations quickly when disasters occur. In a 2017 publication, a drone designed to carry a mounted custom cooler box to hold chemistry and hematology samples long distances was described.[2] Extensive testing was required to address the drone networking issue and the ability for the samples to maintain their temperature during travel.[2] The authors concluded that the ability for a drone to travel long distances with chemistry and hematology samples is feasible, but environment control is mandatory for consistent results.[2]

3. Unmanned Aerial Vehicle (UAV)

3.1 Specifications and Design

The Anafi Parrot UAV (Fig. 1) is a lightweight, maneuverable, and controllable UAV. All specifications are provided by the Parrot Company.[3] The UAV weighs 320 g (0.7 lb). The structure of the UAV is carbon-fiber-reinforced polyamide, part of the carbon-fiber-reinforced polymer family. It can operate in temperatures between –20 to +50 °C. The integrated camera with a Sony IMX320 sensor, which has a 180° tilt, is heavily used during the landing process when placed at a 90°

down angle from the horizon. It is equipped with a three-axis gyroscope and three-axis accelerometer, an AKM AK8963 magnetometer, an STMicroelectronics Barometer, a U-blox GPS, and an Ultrasonar for height measurement.

Fig. 1 Anafi Parrot UAV

3.2 Flight Performance

This UAV has a maximum speed of 15 m/s (33 mph), a flight time of 25 min, a maximum climb and descent speed of 4 m/s (787.4 ft/min), and a maximum service ceiling of 4800 m (15,748.3 ft).

3.3 Flight Modes

The UAV is equipped with a Return Home Function, which uses the camera to figure the camera's location and guide the autopilot to the initial location. For takeoff, the UAV hovers at 1 m above the platform after takeoff and will hover as low as 50 cm (19.685 inches) above any surface during flight.

4. Platform

4.1 Setup and Design

The initial box was constructed from wood, with an electric actuator used to open and close the platform, as shown in Fig. 2. Foam was placed in the center of the box to hold the drone in place while vertical. It is also light enough to not damage the drone.

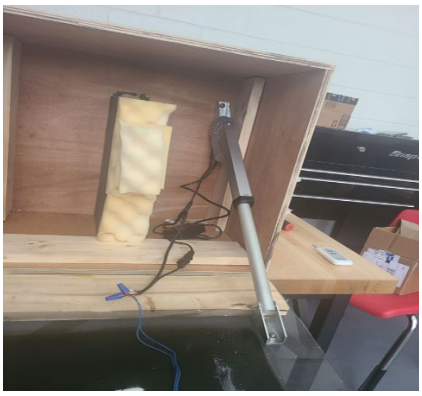

Fig. 2 Box with actuator

4.2 Electromagnet

The electromagnet chosen (Fig. 3) was an ultra-thin mini circular holding electromagnet (250 N) purchased from a YJ electric store. The electromagnet has an operating voltage of 12 V and a power rating of 8 W. Wired in conjunction with the actuator, the electromagnet is active when the actuator is powered on and inactive when the actuator is off.

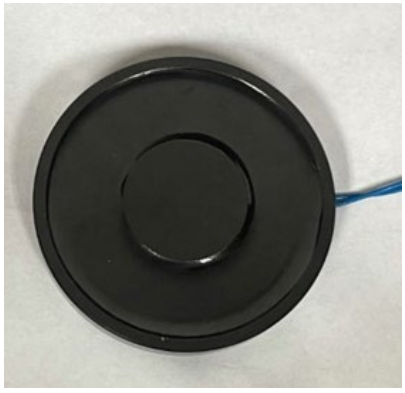

Fig. 3 Electromagnet used in platform design

5. Experimentation

Initial testing was conducted with permanent magnets attached to all four UAV "legs" by means of duct tape with a sheet of metal placed on the platform and attached under the body of the UAV, as shown in Fig. 4. To increase the stability of the drone in the air, the magnets were placed on two of the UAV legs. We then introduced the electromagnet (Fig. 4) and placed it in the center of the platform with the polyurethane foam inside the box (Fig. 4). This electromagnet was meant to connect with a circular steel plate attached to the UAV. For all tests, foam was placed inside the box, as shown in Fig. 4.

Fig. 4 Steel plate and electromagnet incorporated into platform design

6. Results

For the first experiment using permanent magnets, the UAV failed to detach from the platform, leading to a forced manual shutdown of the UAV. It is hypothesized that an imbalance in the center of gravity of the UAV occurred. During the second magnet experiment, on takeoff the UAV immediately flew into the box with no foam inside, damaging five propeller blades, as shown in Fig. 5. After the replacement blades were installed, the UAV remained attached to the platform as the box opened and closed softly, aligning itself onto the polyurethane foam. We then flew the UAV and observed that the UAV moved toward the right without user input. This was most likely due to the metal causing the UAV to be slightly imbalanced. The team transitioned to a circular steel plate placed on the underside of the UAV balanced around the center of gravity of the UAV. This plate attached to the electromagnet located in the platform. This improved the UAVs controllability. This was tested with the actuator, and the UAV remained attached to the platform when the box opened and closed. A final experiment was run to simulate the box being taken onto a bumpy road by shaking the box very hard. This experiment was run to test electromagnet durability and the polyurethane foam security provided to the drone. These UAV and electromagnet results are summarized in Table 1.

Fig. 5 Damaged propeller blades

Table 1 Experiments and results

Date	Experiment	Result
4/7/21	Magnets on all four drone legs	Drone did not lift from platform; attempted twice; had to manually disconnect battery to shut off
4/7/21	Magnets on two drone legs	Drone flew into platform; five propeller blades damaged; all replaced
4/14/21	Tested drone flight characteristics, installed new propeller blades	Drone flew balanced without steel attached
4/22/21	Tested electromagnet, steel plate attached underneath drone	Drone remained attached to platform for box opening and closing
4/22/21	Tested drone flight characteristics with steel plate	Drone flew off balance
4/28/21	Tested electromagnet, circular steel plate	Drone remained attached to platform for box opening and closing
4/28/21	Tested drone flight characteristics with steel plate, balanced	Drone flew balanced; landed on target one of three times

7. Conclusion and Future Work

The results showed that a prototype for a drone platform has been constructed successfully. The need for the finalization of the components is to provide a deadline where we can continue the process of giving the Army a product that will help Soldiers use simple technology to complete a task. To achieve this plan, the team must make a more durable and redundant box, platform, and linear actuator. There will be a box made from sturdier material as well as precisely cut polyurethane foam and a measured metal plate on the platform. The plan is to begin to finalize the box structure and the components to be used making the final box. By improving the resources and technology used on the prototype, the final box will be faster at opening and closing while preventing harm to the drone.

8. References

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3. Parrot Company. Anafi. https://www.parrot.com/us/drones/anafi.

List of Symbols, Abbreviations, and Acronyms

GPS	Global Positioning System
NGCV	Next Generation Combat Vehicle
UAS	Unmanned Aircraft System
UAV	Unmanned Aerial Vehicle

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