University of Colorado

Department of Aerospace Engineering Sciences

Preliminary Test Considerations

29 October 2014

Drones Versus Zombies (DVZ)

Change Summary

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| Revision | Description of Changes | Date Released |
| - | Initial Release | 29 September 2014 |
| Rev A | Revisions | 1 October 2014 |
| Rev B | Dr. Frew Edits, project purpose | 2 October 2014 |
| Rev C | Revisions | 8 October 2014 |
| Rev D | Added Electrical basement | 15 October 2014 |
| Rev E | Changed Quad to multi-rotor | 29 October 2014 |

**Team Contact Information**

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# Project Description

The Drones Versus Zombies (DVZ) project centers on the design and implementation of a cooperative system of unmanned multi-rotor vehicles with the goal of environment navigation and target identification. The system being designed by the DVZ team will consist of a minimum of two multi-rotors coupled with a ground station and will nominally be capable of navigating a map and identifying and differentiating targets. The concept for this project came from elements of search and rescue operations and target search problems similar to the Humans-versus-Zombies game. In the case of this project the targets that will be identified will be stationary inanimate objects. The ultimate goal at the end of the academic year is to be able to showcase the functionality of the DVZ system capability in a large public space such as either the Engineering Center or the Fleming Law Building.

# Potential Test Locations

Testing and demonstration of Fall 2014 Semester milestones will nominally be accomplished in either the Engineering Center or the Fleming Law Building at the University of Colorado, Boulder, and specifically in less travelled spaces therein. Testing of the DVZ system requires an environment which can be easily configured and controlled, but which allows for sufficient reflection of useable building space. The current candidate locations for the two buildings are:

* Engineering Center: Basement hallway of the Aerospace Engineering Wing directly indoors from the North-East facing loading dock.
* Fleming Law: The lobby directly inside the building from the main North entrance OR the main study room of the Idea Forge directly outside of the machine shop.
* Engineering Center: Basement hallway of the Electrical Engineering Wing

# Safety Concerns and Mitigation

## Safety Concerns

Due to the common use of both test locations, there are several safety and environmental concerns which will need to be mitigated before testing can be carried out, namely:

* Test locations will need to be controlled to prevent and mitigate danger to bystanders.
* Team personnel will need to be protected from off-nominal flight behavior.
* The environment (e.g. windows, fire sprinklers, walls) will need to be protected from off-nominal flight behavior

## Mitigations for Safety Concerns

The following measures will be implemented to mitigate the safety concerns detailed in Section 3.1:

* Protection of Bystanders
  + Tests will be conducted at times when the building locations are not typically used, i.e. in the early mornings or late at night.
  + Notice will be given in advance of the test to ensure the community at large is informed about when the test will be performed and what space the test will cover.
  + During the test, team members will be stationed at entry points to the test space to prevent bystanders from entering the test space and provide the ability to suspend the test as necessary.
  + The system will be designed with failsafe measures including the potential to immediately stop flight and the potential to tether the multi-rotor during flight.
* Protection of Team Members
  + Only necessary team members will be directly involved in the test to limit the potential for interaction with the multi-rotor.
  + The system will be designed with failsafe measures including the potential to immediately stop flight and the potential to tether the multi-rotor during flight.
* Protection of the Environment
  + The environment will be thoroughly evaluated for durability prior to testing.
  + Test locations will be chosen with as few fire sprinklers and other infrastructural features (e.g. lights) as possible.
  + Environmental features with damage potential will be protected as much as possible via covers in accordance with building safety codes.
  + The system will be designed with failsafe measures including the potential to immediately stop flight and the potential to tether the multi-rotor during flight.

The Fall 2014 Semester milestones will only include flight operation of a single multi-rotor robot at one time. A full safety review will be conducted prior to flight tests. The safety review board will include CU faculty and staff Eric Frew, Nisar Ahmed, Joe Tanner, James Mack, and Matt Rhodes.

# Project Rationale

The DVZ project represents the first major step by the Research and Engineering Center for Unmanned Vehicles (RECUV) outside of a controlled environment with a motion capture system for multi-rotor operations. Multi-rotor drones are growing rapidly in popularity, attracting the interest of many current and potential CU students. Future applications, such as search and rescue or disaster response, require operation in unstructured environments. The only way to create realistic test conditions is to operate in actual building hallways.

The Drones Vs Zombies theme was selected by the project customer and advisor to purposefully echo the popular Humans Vs Zombies game occasionally played in the Engineering Center. By crafting a robot challenge around this game, the expectation is that the engineering student population at large can appreciate the difficulty of the tasks. Further, once the DVZ system is in place it can be used in course settings to connect student experience to advanced research material. Furthermore, there are immediate related applications for the DVZ output. The DVZ team has already been in contact with the Idea Forge leadership discussing the concept of an aerial robot “tour guide” through the Idea Forge space.

Capabilities enabled by the DVZ project support various education and research initiatives within RECUV. For example, Prof. Eric Frew (AES) studies communication aware planning and autonomy, Prof. Jason Marden (ECEE) studies distributed decision-making especially in adversarial settings (“game theory”), Prof. Nisar Ahmed’s (AES) research focuses on human-robot interaction with emphasis on search and rescue, and Prof. Gabe Sibley (CS) creates advanced perception algorithms for unstructured environments that have been developed for self-driving cars but can be leveraged by aerial robots.