Brigham Young University

AUVSI Capstone Team (Team 45)

# Unmanned Ground Vehicle Initial Concept Development

| ID | Rev. | Date | Description | Author | Checked By |
|---|---|---|---|---|---|
| GV-001 | 0.1 | 2018-10-23 | Initial Draft | John Akagi | Jacob Willis |
| GV-001 | 1.0 | 2018-10-31 | Added introduction | Jacob Willis | Andrew Torgesen |
| GV-001 | 1.1 | 2018-11-8 | Added conclusion and reference key success measures | Jacob Willis | John Akagi |

# 1 Introduction

This document describes the initial concept generation of the Unmanned Ground Vehicle system.

# 2 System Objective

In the 2019 AUVSI SUAS competion, points are awarded for successfully delivering an Unmanned Ground Vehicle (UGV) to a target location; additional points are awarded if the vehicle drives to another target location. The UGV must be capable of carrying an 8oz water bottle, and the impact must subjectively be "soft." During the delivery the airframe cannot drop below 100ft ASL, so a system or mechanism for landing the UGV without damage is required.

Because points can be received for just delivering the UGV without it driving, and because the payload drop problem is the most challenging part of the UGV design, the key success measure related to this subsystem is airdrop accuracy. With this in mind, determining how to accomplish the payload drop is the subject of this concept development. The UGV is assumed to be a 700 gram "black box" capable of driving to its target once it is on the ground.

# 3 UGV Delivery Initial Concepts

The UGV delivery concepts were generated individually by team members and then discussed as a team to combine similar ideas. After all ideas were discussed, a subset were selected as being most promising and advanced to the testing stage. The concepts generated and initial decisions are listed in Table 1. Additionally, the concepts are shown as a concept classification tree in Figure 1 to highlight the variety of ideas generated.

*Table 1: Description of initial ideas and decisions made. "Discarded" indicates the idea was considered unfeasible, "Investigate" indicates the idea was studied further, "Modify" indicates the idea was considered usable in conjunction with another idea or ideas.*

| Idea | Description | Decision | Rationale |
|---|---|---|---|
| Skycrane | UGV is lowered on a rope from the UAV | Investigate | Would eliminate the need for most cushioning and control surfaces on the UGV |
| Fins | Fins are used to give minimal control to a fast falling UGV | Investigate | Would be smaller than full glider wings but still allow decent control |

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|---|---|---|---|
| Glider | Unpowered aircraft is used to control the falling UGV | Investigate | Would likely provide the greatest amount to control |
| Parasail | A controllable parachute is used to steer the UGV | Discarded | Difficult and unknown controls |
| Control Grids | Similar to SpaceX, grids are used to steer the descent of the UGV | Discarded | Too complex for this application |
| Magnus Effect | Spin the wheels of the UGV in the air to generate lift and control UGV attitude | Modify | Could be used in conjunction with other methods but unlikely to have much effect by itself |
| Autogyro | Unpowered helicopter rotors are used to slow descent and blades can be tilted to control the drop | Discarded | Mechanism was considered too complex |
| Bounce | UGV uses some elastic material under it to decrease the time of impact | Discarded | Bouncing would likely not reduce the impact forces to survivable levels |
| Airbag | An airbag is inflated just before lading to cushion the drop | Discarded | Needs precise measurements to determine when to inflate airbag, Airbag inflation mechanism is likely to require dangerous materials |
| Springs | Springs are placed under the UGV to absorb the energy from the drop | Modify | Could be used to reduce impact energy but unlikely to be able to dissipate all by itself |
| Counterweight | A large mass is ejected downwards just before impact in order to slow UGV descent | Discarded | Requires ejecting a large mass at high acceleration which is likely to be dangerous and impractical |
| Crumple Zone | Use a deformable material to break and absorb energy when UGV impacts ground | Modify | Could be used to reduce impact energy but unlikely to be able to dissipate all by itself |
| Balloons | Use balloons to increase drag and provide some lift | Discarded | Would be large and impractical to carry on board the UAV |
| Parachute | Use a parachute to slow the descent of the UGV | Investigate | Simplest idea and almost guaranteed to work |

| | | | |
|---|---|---|---|
| Seedpod | Attach a single propeller blade to the UGV which would cause the UGV to spin and slow its descent similar to how maple seeds work | Discarded | The UGV is likely too heavy to implement this properly |
| Nothing | Make the UGV as rugged as possible and drop it from the UAV with no slowing mechanism | Discarded | Any UGV that is rugged enough to survive a 100 ft drop would be too heavy and bulky to carry on the UAV |
| Low Drop | Drop below the minimum allowable flight level and drop the UGV from a lower altitude for increased survivability | Discarded | Would violate rules that state we must remain above a certain altitude |

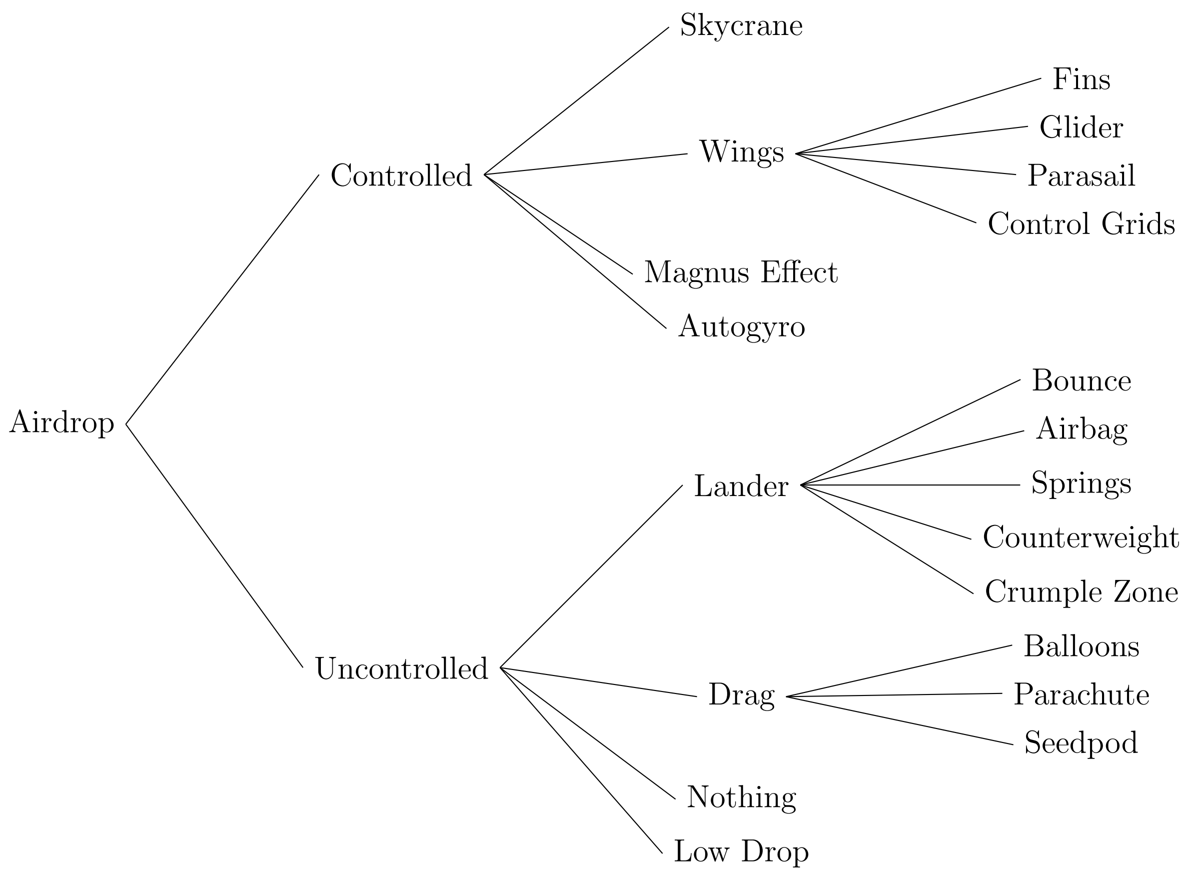


*Figure 1: Concept development tree of the initial ideas generated for the payload delivery system.*

# 4 Conclusion

Through our concept generation efforts, seventeen distinct concepts were created. After considering novelty and feasibility, four concepts were selected for additional investigation. These concepts are the skycrane, glider, and parachute, along with combining the parachute and fins concept to create a controlled parachute.