RECEIVING STATION FOR DRONE DELIVERY

Team D4S-2: Design for Sustainability
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Receiving Station for Drone Delivery: *But Why?*

On December 1, 2013. Amazon, the undisputed king of E-commerce and Internet retail made a statement. Jeff Bezos, CEO of Amazon, looks to the future. On CBS *60 Minutes*, Bezo introduces to the world the concept of utilizing drones to deliver packages, or *Amazon Air Prime*; instead of a courier, a fleet of drones would fly to a customer's residence, and deliver a package within the hour with certain restrictions.

With Bezo's announcement, the entire market for logistics changed. Many other companies such as USPS, FedEx, UPS, and even 7-Eleven are trying to enter the drone delivery market in the near future.

Tackling the Problem

A typical drone delivery requires it to land in an open area. This is because most homes have trees, light posts, power lines and other obstacles that can restrict the maneuverability of the drone and can also potentially be hazardous to it. To expedite this process, we tackle the problem of delivering and receiving.

Our solution: the drone hovers at a higher elevation relative to the system to avoid obstacles and drops the package so it doesn't have to land.

The potential design must be able to:

1. Safely catch/receive a package dropped from a hovering drone.

2. Protect the package from theft and the environment

3. Transport the package to an area for the consumer where he/she can easily retrieve it.

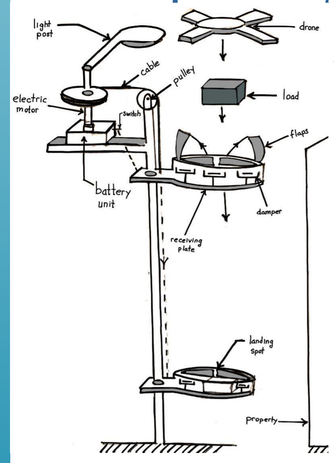
Design Requirements:

To apply for *Amazon Air Prime*, Amazon specifies the package must weigh no more than 5 lbs (2.25 kg), and be small enough to fit into a cargo box that the drone can carry. To not limit our design to just Amazon's specifications, we broaden our requirements to fill a broader range of possible package sizes and weight.

More specifically, the potential design solution must be able to:

- Catch the package with a maximum weight of 50 lbs without any damage.
- Catch the package within a drone horizontal velocity of 2 mph.
- Catch the package from a 5 foot drop to the 18 foot system.
- Withstand environment factors such as a 20 mph wind.

Conceptual Design and Selection

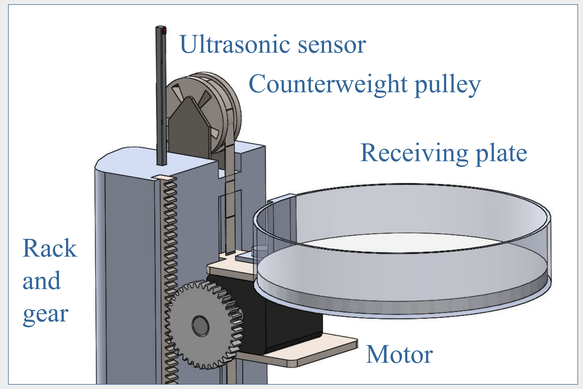


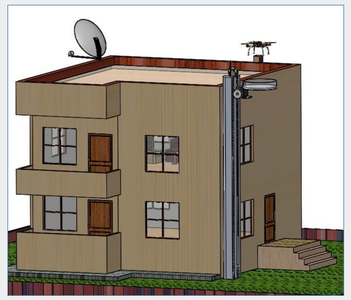
Top-down approach to break down the main functions into subfunctions.

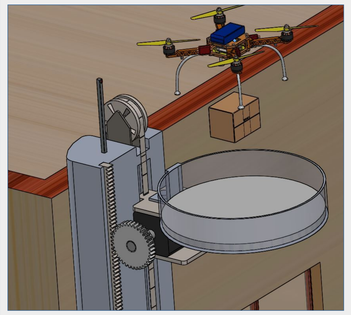
- Use of morphological chart to produce several viable designs using different mechanisms to catch the package.
- Decision matrices used to assign each criteria a score of 1-10 and then tabulating each design for total points.

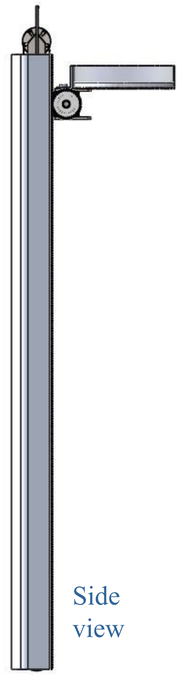
- **The receiving plate is accelerated downward to nearly match the velocity of the falling package. The small difference in velocities result in a minimal average force of impact upon contact by impulse momentum theorem.** Designed to protect and minimize the damage on the package
- Use of an **ultrasonic sensor** to detect when the package is dropping, triggering the motor to accelerate the receiving plate downward.

To the Future: Our Solution



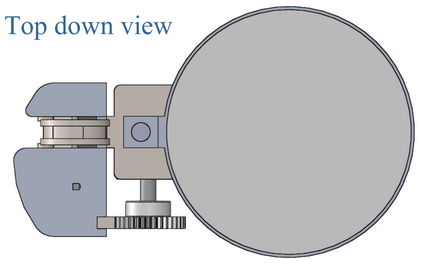






Side view

Top down view



Did it work? Verifying the design

1. SolidWorks Simulation

Using SolidWorks to build a virtual model including all features. Animations worked synchronously with the simulation. Simulation was able to bring real-world physics and mechanics, and simulate our model as if we built a full-scale one. We can definitively say that our design meets the requirements set.

2. 1:10 scaled physical prototype

Minimizing any complicated mechanism to just show a "proof of concept." We required the stepper motor to accelerate at 1067 rad/s^2 for 0.25 seconds to match the acceleration and velocity of the falling package, which we could not do because of inadequate power. Other problems such as rack/pinion friction, stepper motor and gear slippage.

Recommendations and/or Improvements

- Use of low weight material such as aluminum 6061 or special alloy blend with low friction and high heat resistance for greater mechanical reliability
- Model is designed for a 2 story building, 18 feet. To improve marketing, we recommend to scale a model down to 10 feet to accommodate those who live in single story homes.
- Combining receiving station with modern day cluster unit mailboxes. One receiving station can service multiple mailboxes. The system would receive each package, and allocate it to the right consumer's mailbox and hold it for protection. Cheaper than having one system per house.