Mechanical Engineering
Carnegie Mellon University

PupBuddy - Mobile Treat Dispensing Dog Toy

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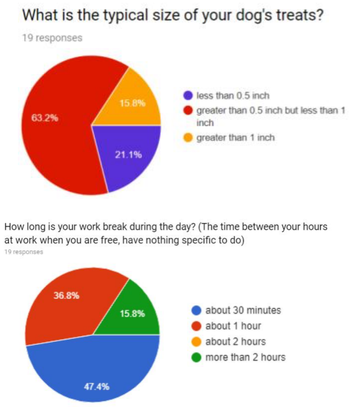
Senior Capstone Design Project

Problem Description

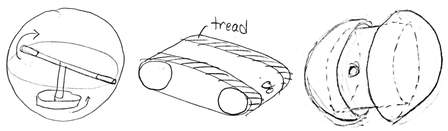
While away from home, pet owners cannot interact, feed, and exercise their dogs. Currently, no product has addressed all issues.

Customer Needs and Specs

- Velocity > 0.5m/s
- Self-rights when tipped over
- Shoots dog treats at least 0.5m
- Compatible for treat diameter 0.5-1 inch
- Durable for dog under 15lb
- Battery life is at least 30 minutes
- Easy to use and aesthetically pleasing
- Remotely controlled with at most .2 sec latency



Survey Results

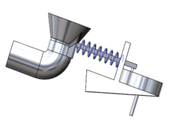


Drive System Design Ideas

Concept Generation and Selection

Drive System

The ability to self-right was important for a toy that interacts with dogs so we considered a spherical shaped drive system with weight at the bottom. We also considered treads as wheels that can still drive when flipped over. We selected two hemispherical wheels with center cylinder casing because this design can self-right and is easier to manufacture than a sphere or treads.

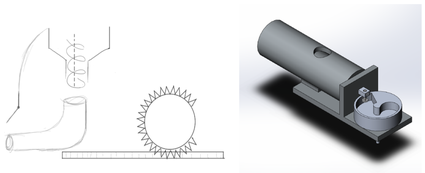


Side View

Top View

Launcher

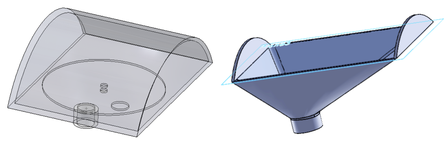
We considered multiple launcher designs including rack and pinion that physically pushes out the treats and a pair of spinning wheels that flings the treats.We selected a bean-spring mechanism because it required only one motor, which was the easiest to implement in the limited space.



Launcher Design Ideas

Loader

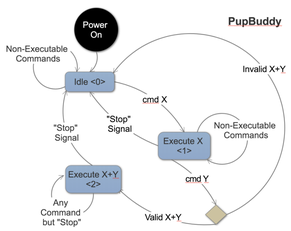
We started off with a flat-bottom design with a rotating disk that has an opening for the treats to fall out. However, this design failed to filter out all the treats, so we then considered a funnel design. Through multiple iterations, we narrowed down the width of the funnel to reduce treat jamming.



Loader Design Ideas

User Interface & Control

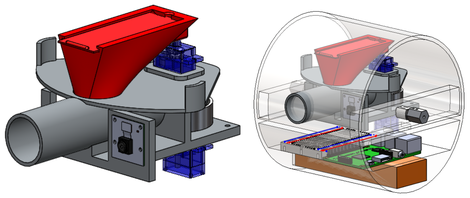
We considered a smartphone app and web app for user interface, and keyboard and joystick for user control. We selected web app and keyboard control because these are typically accessible to people at work and the implementation of the web app fell within the scope of our team's skillset.



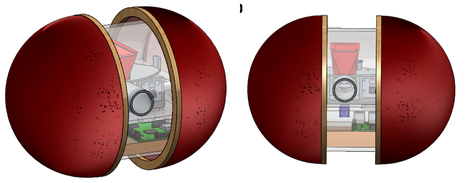
State Machine

Concept Description

Our system consists of a drive system, launcher, loader, and user interface and control. Our system is controlled remotely via a web app and has a camera through which the user can monitor his/her dog. The loader holds a handful of treats and the launcher shoots a few treats at a time at the user's command. The loader and launcher form an integrated key subassembly that performs treat launching. The cylinder encases all subsystems and electronics. Struts are used to hold the motors and resist compression on the wheels.



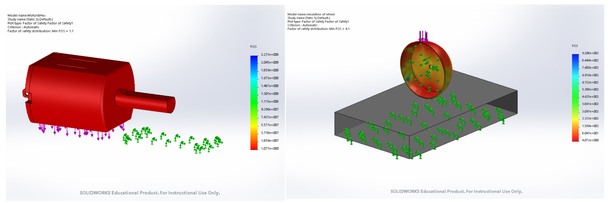
Loader-Launcher Sub-



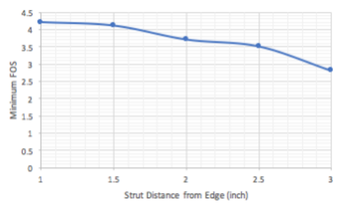
Full System Isometric and Front View

Analysis

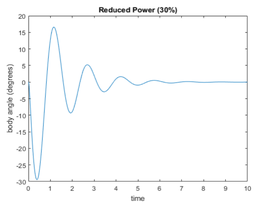
We performed static FEA on motor shaft to determine allowable dog weight. Based on the FEA, we restricted the maximum dog weight to 15lb. We also performed FEA on the wheels to determine the optimal location of the struts. We simulated dynamics to prevent aggressive tilting of the center cylinder and found that 30% power would maintain a 30° maximum angle.



Motor Shaft and Wheel Strut Analysis



FEA Results for Wheel Struts



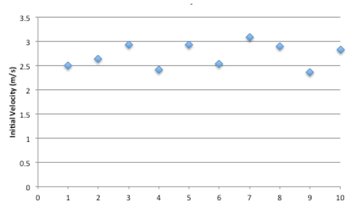
Dynamics Simulation

Testing

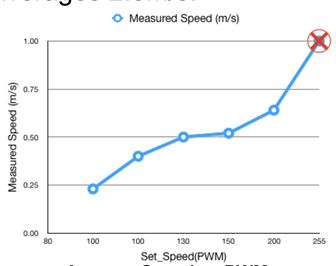
In mobility tests, we determined that 100/255 PWM signal is the maximum power before the tilt angle of the center cylinder increases beyond 30°. At this power, the average speed of the system is 0.4m/s. This can be improved with an acceleration curve that increases power after the initial acceleration. In launcher tests, we obtained initial velocities, which averages 2.5m/s.

Set Speed (PWM)	Measured Speed (m/s)	Approx. Tilt Angle (degree)
80	0.23	20
100	0.4	30
130	0.5	80
150	0.52	90
200	0.64	Roll Over
255	N/A	Roll Over

Tilt Angle Measurements



Initial Velocity vs Trial



Average Speed vs PWM power

Conclusions

Our final prototype meets most of the customer requirements. To meet all specifications, treat dispensing and body structure must be more robust. For mass manufacturing, parts would be redesigned for injection molding and assembly. We would also set up a cloud server as opposed to using the Raspberry Pi. Nevertheless, we have successfully created a minimum viable product that, unique among all competitors, performs all 3 functions: pet feeding, monitoring, and remote interaction.