 Dog Grooming tool

TEAM 17

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SPONSOR: ENGINEERING TO GO

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Background

Some dogs have fur that is prone to matting and tangling

Textures and characteristic of the coat vary by dog's size and breed

- Short and long hair
- Course and fine hair

Grooming issues

- Takes too long
- Tools not very ergonomic
- Unpleasant experience for dogs and groomers

Background Research

Various de-matting tools that currently exist
- Knot out
- FURminator
- Mat-Splitter

What makes a grooming tool successful?
- Safe for the pet and groomer
- Remove knots and tangles from hair
- Comfortable and easy for groomer to use

Current tools do not satisfy all these needs

Background Research

How do current tools remove knots?

- Cutting hair
- Pulling from bottom of knots

No current tools brush through knots

- Hypothesis: A rotating brush could gently de-tangle hair from the top down

Things to consider with a rotary style brush

- Will brush head run risk of getting tangled and twisted into dogs hair?
- Will spinning brush pull to hard and injure dog?

Rotary Head Hair Dryer

Rotary Head Grill Brush

Voice of the Customer

- Taken during Phase I of design project
  - Online Survey
  - Dog Groomer Shadowing
  - One on one Interviews with pet owners and groomers
- Used to refine Need Statement and Goal Statement
- Revealed current issues with dog grooming and the need for a better method
- Maintained and updated through consistent contact with potential customers and other established contacts

Need Statement

“De-matting a dog's hair can be an unpleasant experience for both the dog and the groomer, especially if the matting has advanced and is deep in the hair or fur. The de-matting process is considered to be time consuming and painful, for the groomer as well as the dog.”

Revised Goal Statement

Design and develop a grooming tool that provides both the user and dog with a pleasant, stress free, and time efficient grooming experience

Objectives vs. Constraints

Objectives

- Design tool for use by consumers and groomers
- Untangle pet's hair without harm to pet or groomer
- Develop tool that is stress free on dog and groomer

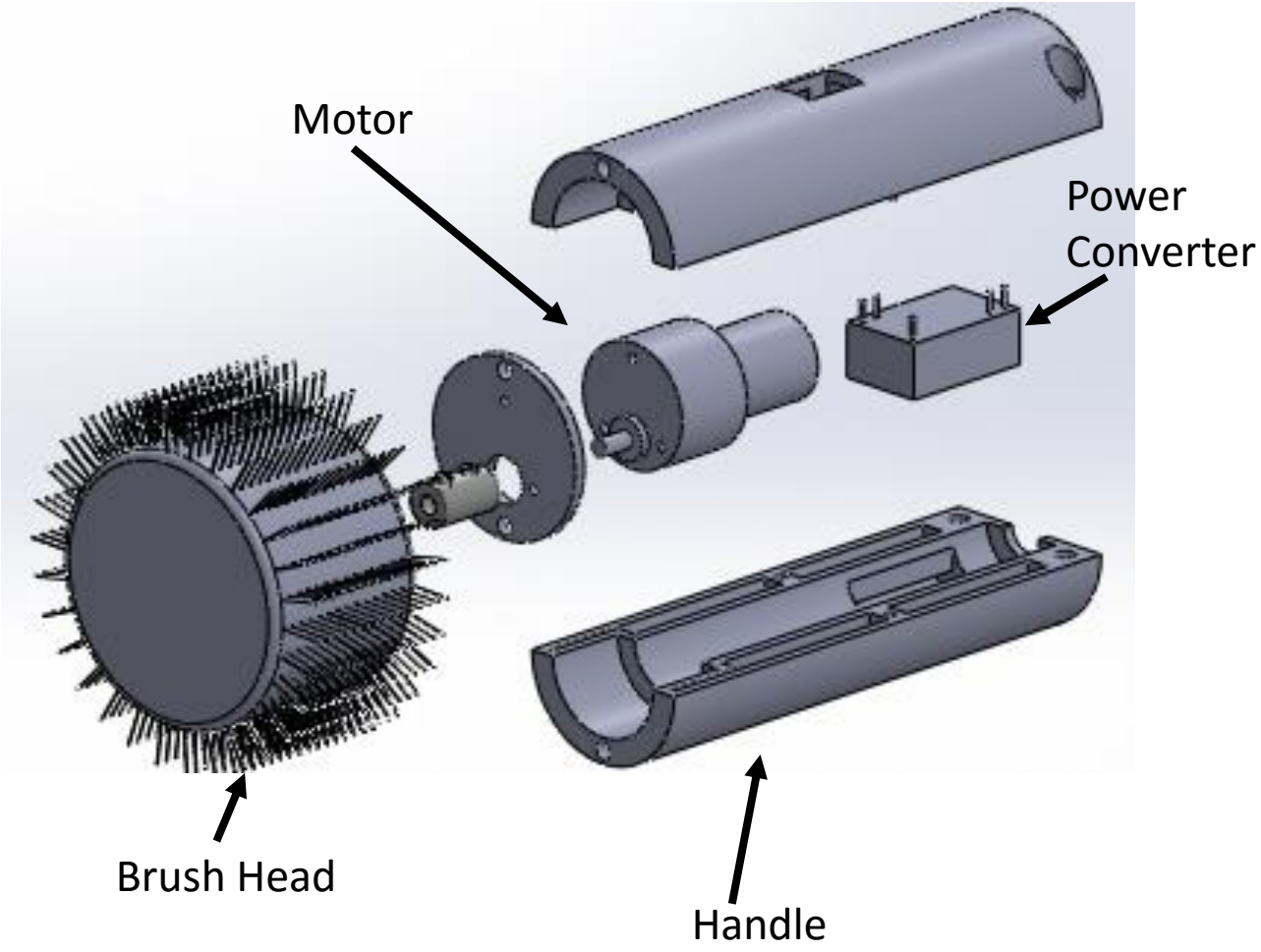
Constraints

- Tool must be handheld and ergonomic
- Tool works at low RPM to prevent further entanglement and injury
- Tool is easy to clean and sterilize
- Battery lasts at least 2 hours at 50% duty cycle
- Total weight is 1 pound or lower

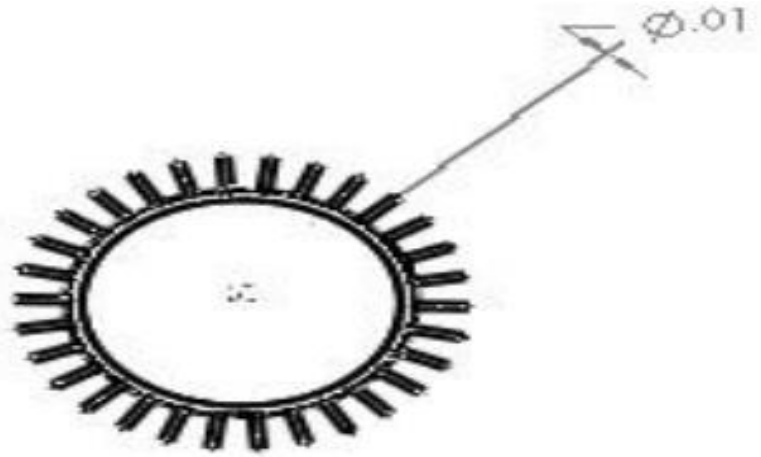
Initial Prototype Design

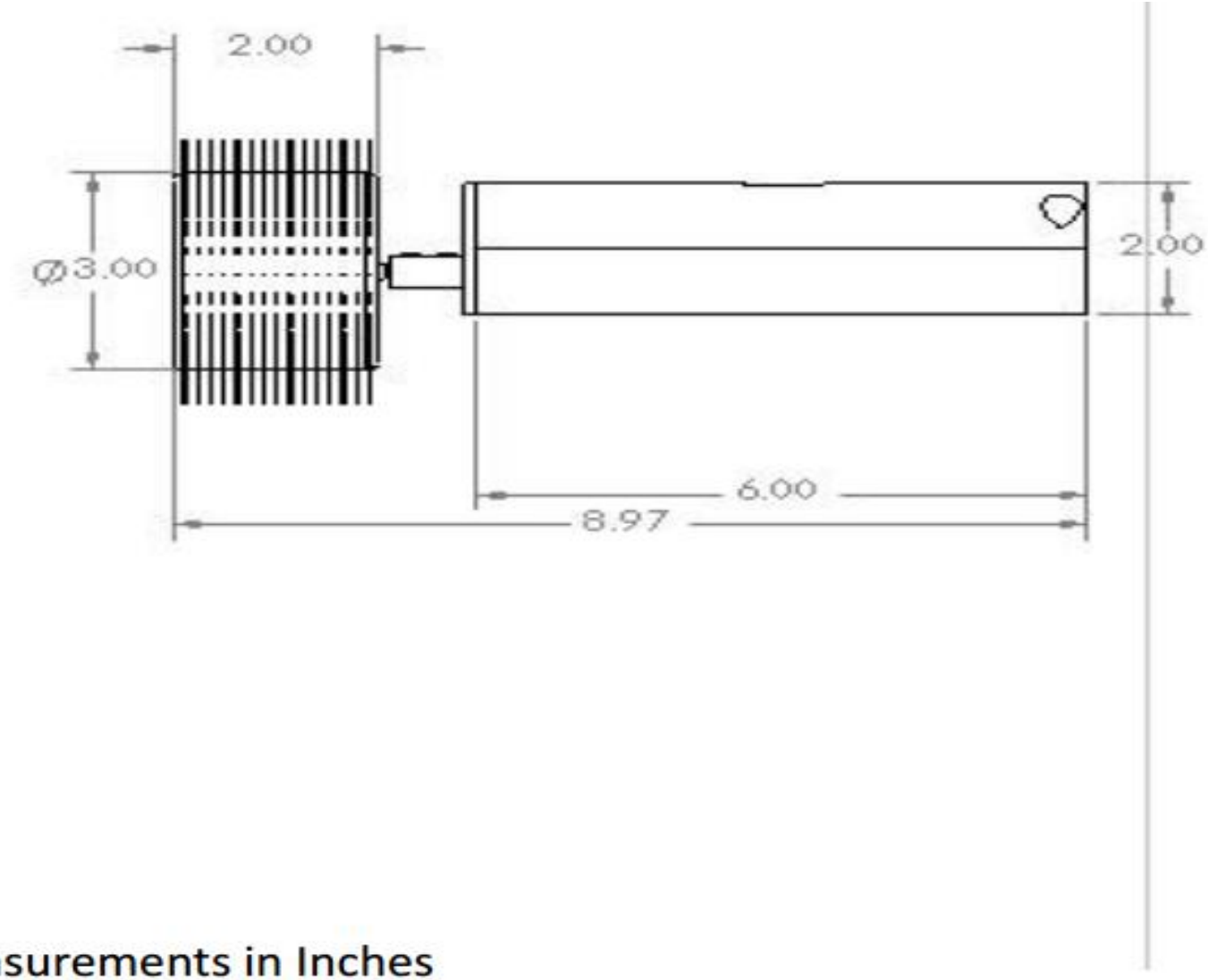
Specifications

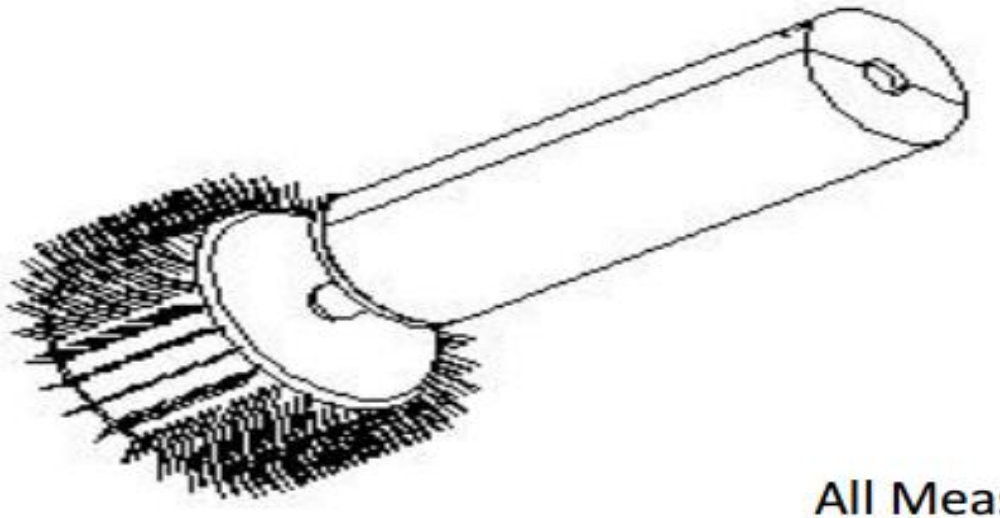
- Simple handle design to be 3D printed out of ABS plastic
- Uses a 12V DC gearmotor spinning at 72 RPM
- Power is transferred through a small AC to DC converter and a simple on/off switch
- The brush bristle are 0.01” diameter 304 stainless steel wire
- This design should be compact, lightweight, and easy to use



Initial Prototype Design



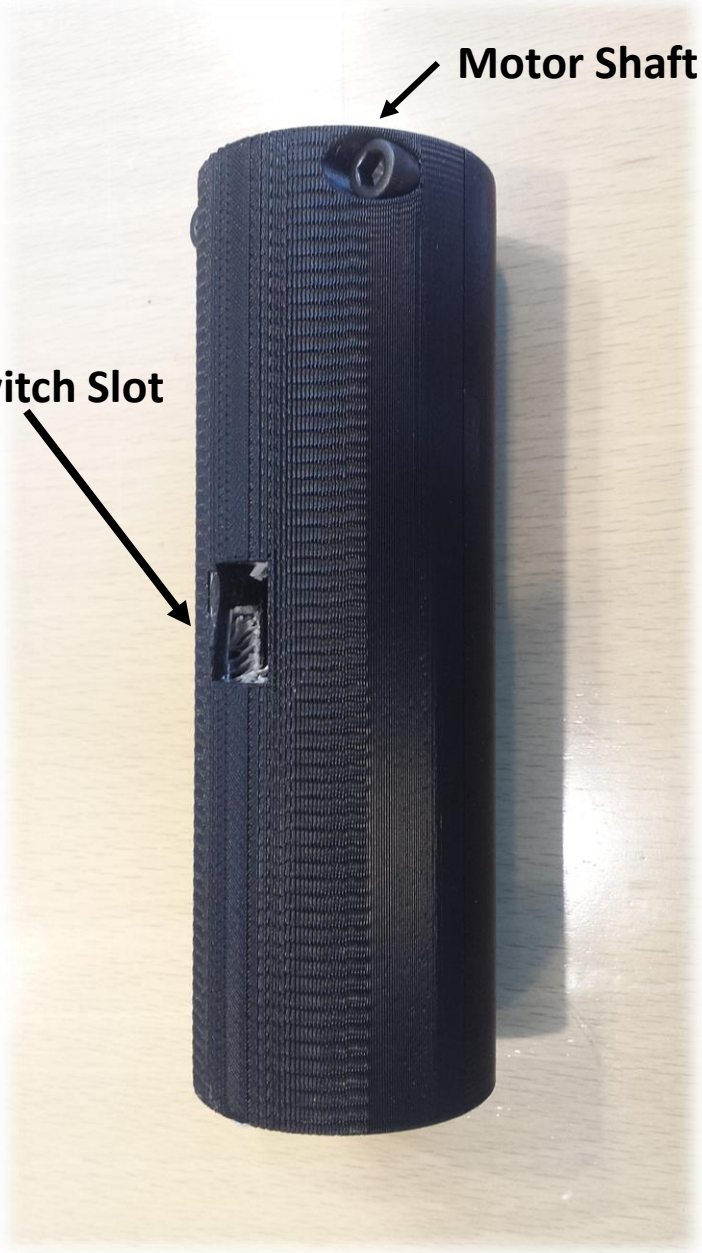




All Measurements in Inches

Handle Design One

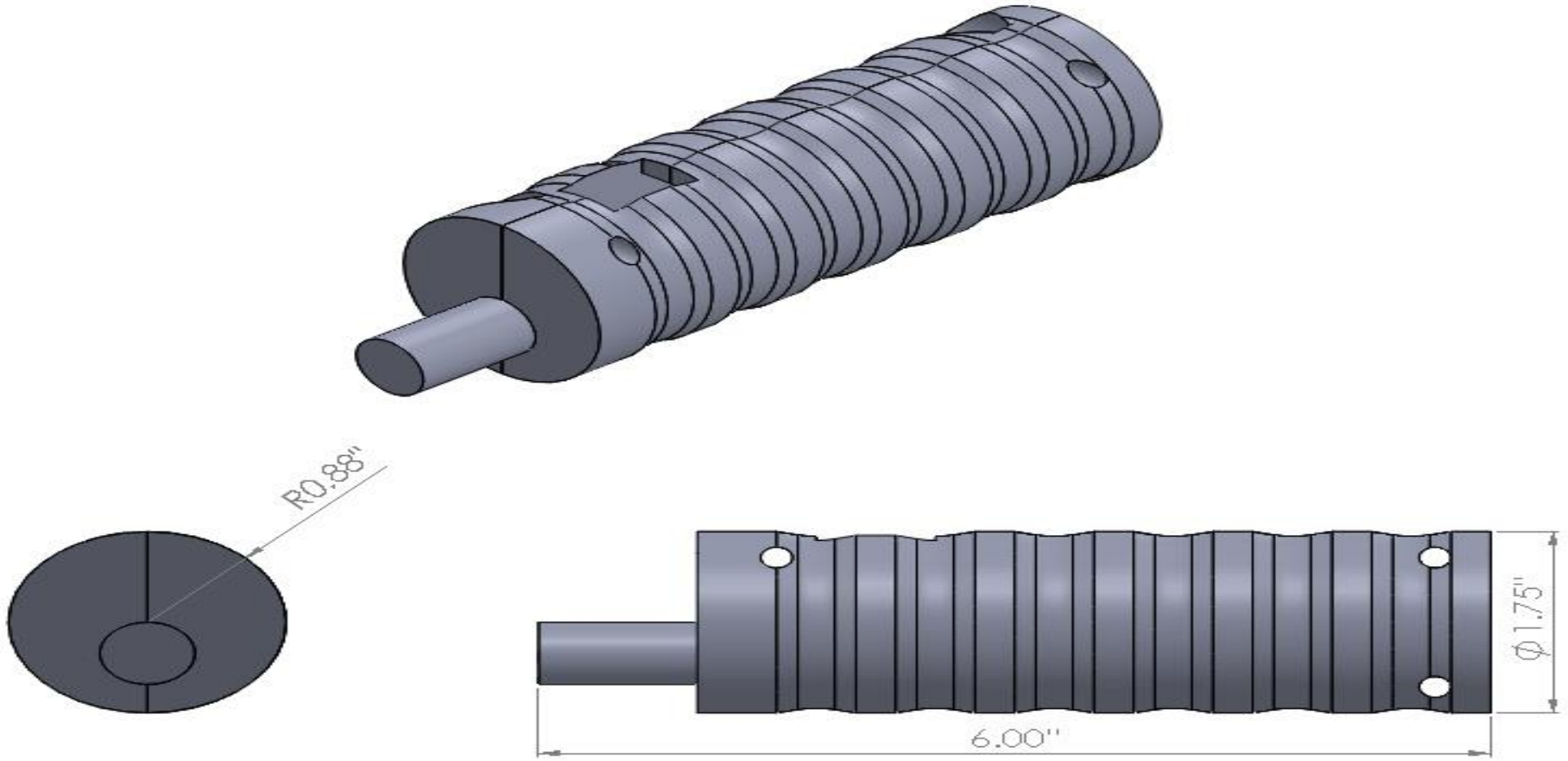
- 3D printed
- Not designed for all internal components
  - No bearing slots
  - Loose internal fit
- Ergonomics
  - Diameter excessively large
  - Uncomfortable to hold
  - Does not provide adequate grip



Prototype Redesign

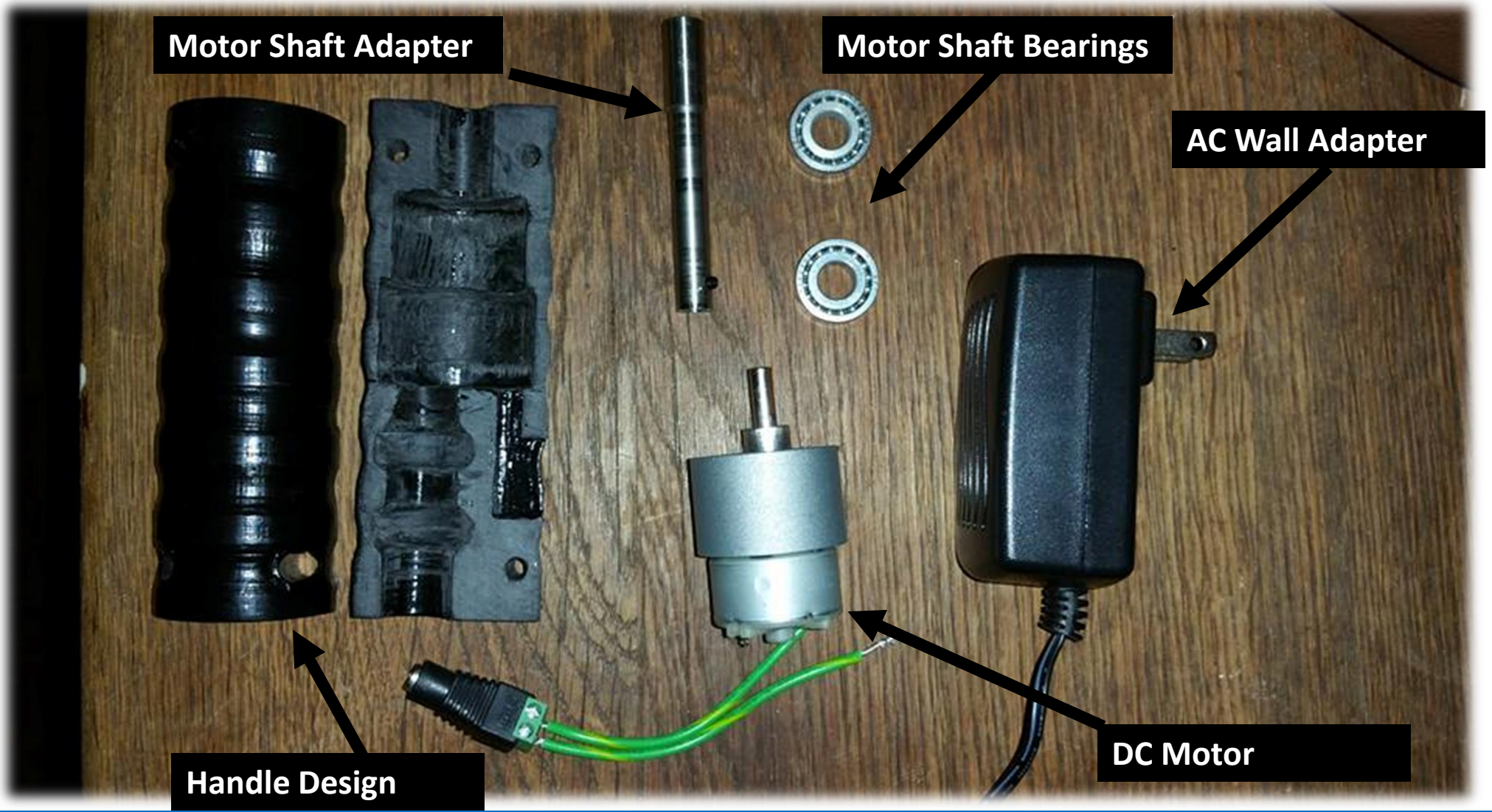
- Improved ergonomic handle, 3D printed for convenience
- Uses a 12V DC gearmotor spinning at 60 RPM and dual bearings to handle lateral load placed on the motor shaft
- Power is transferred through a small AC to DC wall adapter and a simple on/off switch
- The brush bristles are soft plastic taken from a human brush
- This design is more ergonomic, compact, and safe for the pet and groomer
- Total weight of brush assembly is ~15.3 oz. (0.96 lbs.), less than 1 lbs. constraint

Prototype Redesign



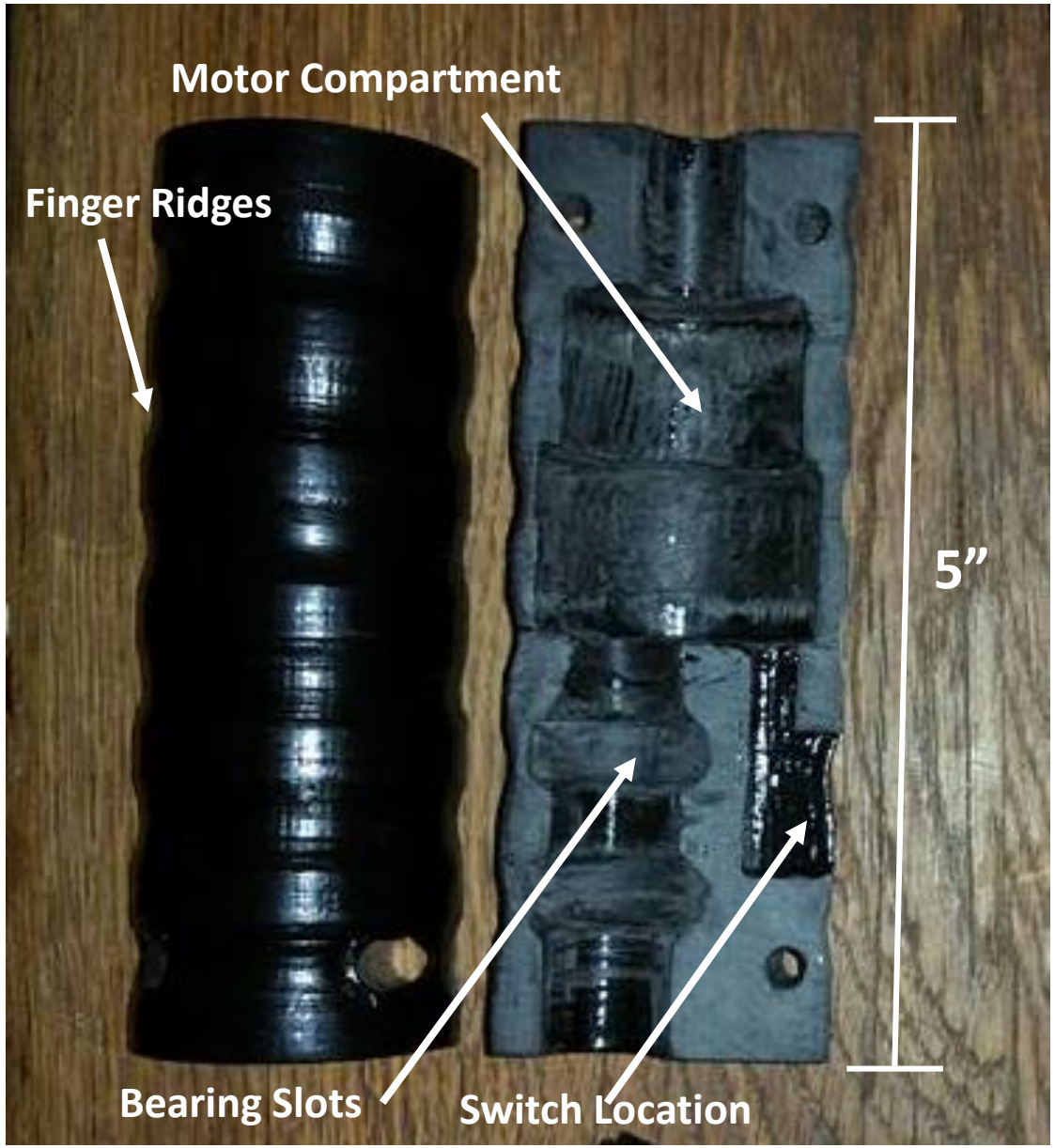
Redesigned Prototype Close Exterior

Prototype Redesign Components



Handle Design Two

- 3D printed
- Designed with internal components and user comfort in mind
  - All electrical components successfully housed
- Smaller diameter but still slightly large
- Comfortable to hold with finger grooves
- Internal dimension tolerances not correct
  - 3D printer error



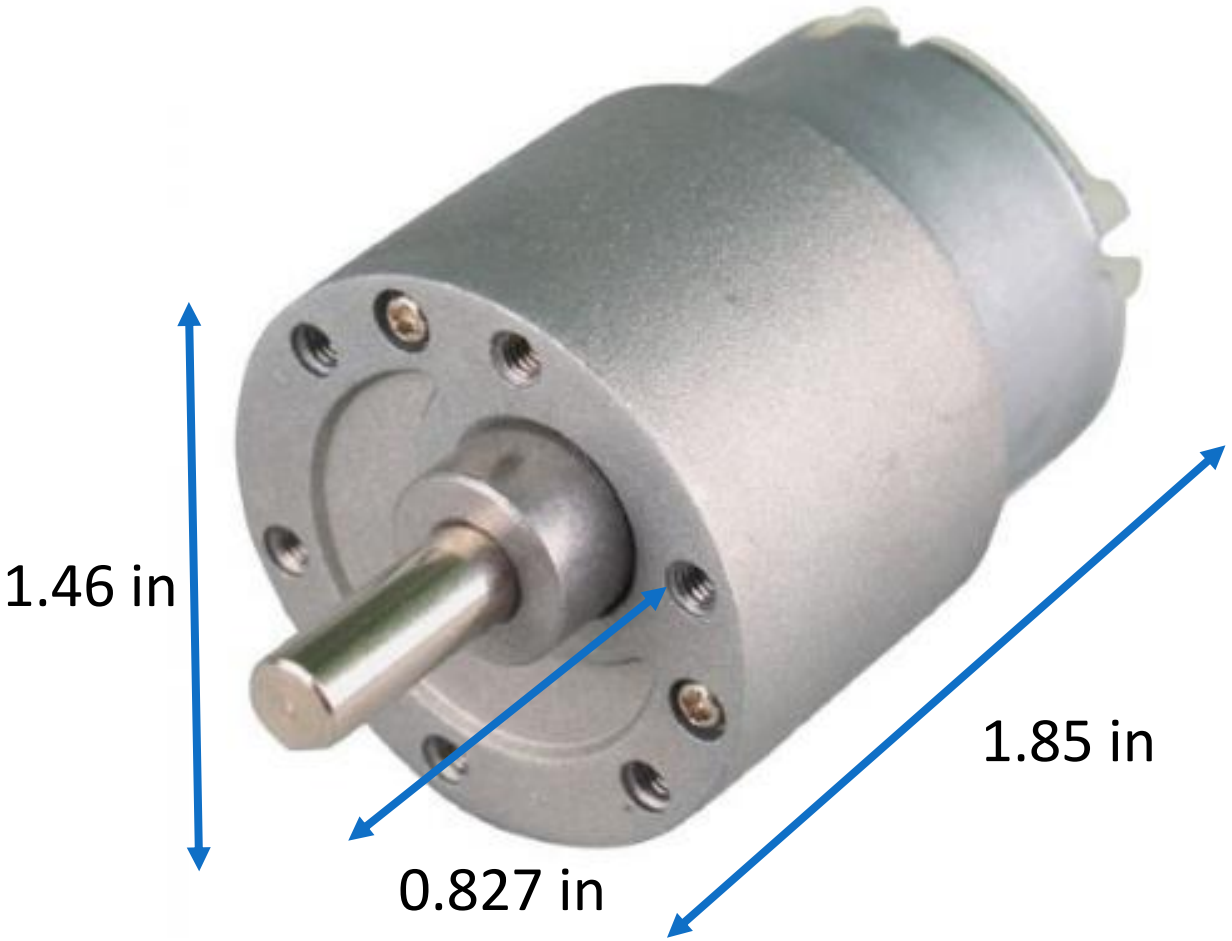
Updated Motor Selection

Type

- Hossen 12V DC

Specifications

- Torque: 2.655 in-lbs.
- Voltage: 12 V
- Speed: 60 RPM
- Diameter: 1.46 in.
- Length (excluding shaft): 1.85 in.
- Shaft Length: 0.827 in.
- Shaft Diameter: 0.236 in.
- Weight: 4.87 oz.



Hossen 12V DC Motor

Testing and Analysis: Motor Stall Force

Test Conducted:

- Wire attached to brush at some known diameter
- Brush head rotates wrapping wire around head/shaft
- Wire pulls on spring scale until motor stalls

Test Purpose:

- Calculate maximum applied tangential force at which motor stalls
- Calculate maximum applied torque that causes the motor to stall

Testing of Prototype

Motor Test Results

- High required stalling force is dangerous
- If brush head gets tangled in fur, spinning will not stop.
- Brush could rip out hair and tear skin

Table 1: Motor Stall Force Test Results

Radius Tested	Tangential Stalling Force	Applied Stalling Torque
0.6875 in.	4.68 lbs.	3.2175 in.-lbs.
0.1181 in. (motor shaft)	20 lbs.	2.3627 in.-lbs.

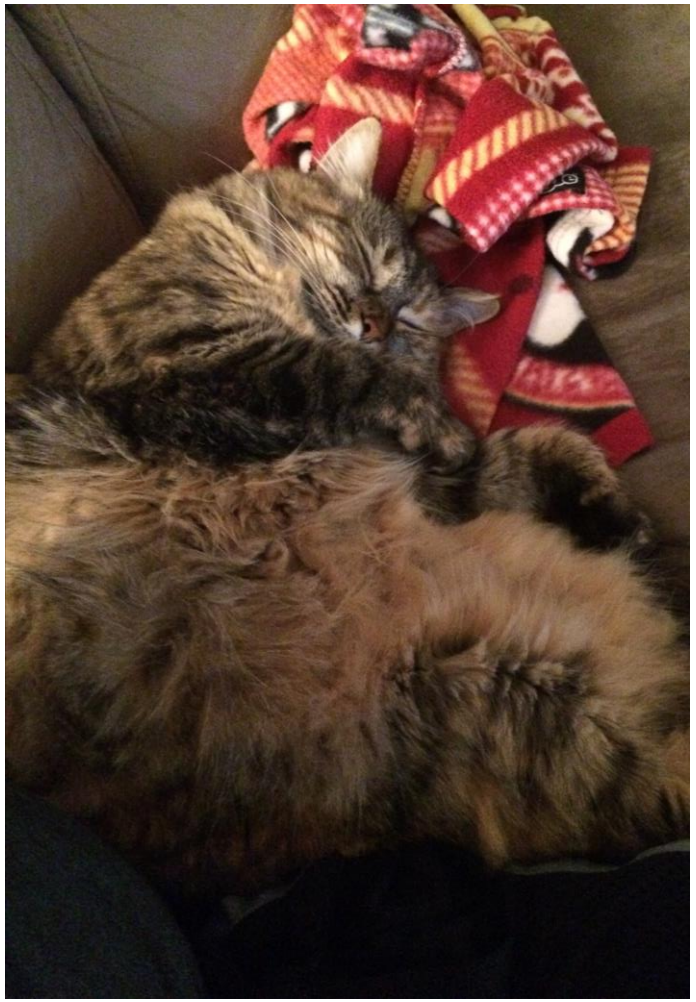
Testing and Analysis: Required Force

Test Conducted:

- Attach regular grooming brush to spring scale
- Pulled spring scale causing brush to go through fur

Test Purpose:

- Calculate the approx. force used to pull ordinary brush through fur
- Creates applied force limit for rotary grooming brush

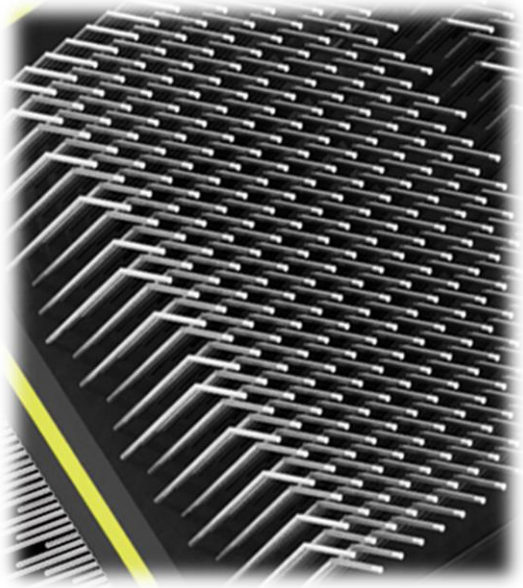


Brush Head Design

Adopting already fabricated brush heads

Parameters to consider:

- Bristles
  - Material
  - Diameter
  - Shape
    - Straight vs Bent ends
    - Smoothed ends vs Balled ends
- Optimal Head Diameters
  - Increases and decreases as fur length increases and decrease
- Optimal Head Length



Bent Bristle Tips

Straight Bristles

Ball Bristle Tips

Brush Head Design

Brush Head 1

Brush Head 2

Brush Head 3

Brush Head 4

Brush Head Design

Table 2: Brush Head Dimensions

Brushes	1	2	3	4
Diameter (inches)	2.7	1	1.7	1.9
Length (inches)	3.4	5	4.75	5
Weight (ounces)	5.23	1.9	3.7	4.7

Testing and Analysis: Bending Moment of Shaft

Rated Radial Bearing Force:

- Static: 145 lbs
- Dynamic: 445 lbs

Known

- Bearing will eliminate all lateral force on motor
- Maximum allowable force on bearings
- Length of brush head and motor shaft
  - Moment Arm
- Location of the bearings on shaft

Bending Moment Calculations

- $\sum M = 0$
- $\tau = r \; x \; F$

Results

- Maximum load on end of brush head
  - **Static: 8.4 lbs. (safety factor of 2)**
  - **Dynamic: 25.7 lbs. (safety factor of 2)**

Testing and Analysis: Brush Head Bristles

Test Conducted:

- Applied rotary bush with different heads to faux animal fur
- Fur texture and length kept constant

Test Purpose:

- Determine optimal diameter for brush head
- Determine optimal bristles for animal fur
  - Tip design
  - Material
  - Orientation

Testing and Analysis: Bristle Deflection

Calculations Conducted:

- Displacement: $x = -\frac{PL^3}{(3EI)}$
- Deflection Angle: $\theta_d = -\frac{PL^2}{(2EI)}$
- Inertia: $\mathrm{I} = -\frac{mL^2}{3}$
- Volume: $V = \pi r^2 h$
- Mass: $m = \rho V$

Known:

- Force: $\mathrm{P} = 4.68\ lbs.$
- Length: $\mathrm{L} = 0.5\ in.$
- Elastic Modulus: $\mathrm{E} = 28{,}000\ ksi$
- Bristle Density $\rho = 0.29\ \frac{lbs.}{in^3}$
- Radius: $\mathrm{r} = 0.001\ in.$
- Height: $\mathrm{h} = 0.5\ in$

Results:

- $x = 0.183\ in.$
- $\theta_d = 15.6^o$

Calculation Purpose:

- Determine how much each bristle will deflect when force applied
- Help indicate optimal bristle material
- Low deflection is desired

Future Work: Test Plans

Table 3: Test Plans

Components	Test	Purpose
Motor	Have spinning motor shaft pull on wire attached to spring scale until motor stalls	Determine the force required to stall the motor for more brush diameters and bristle styles
Bristle	Apply tool to faux fur, allowing for only one varying characteristic per test	Collect useful data to determine most effective bristle form, dimensions, and material
Brush Head	Use different diameter brush heads on constant length furs	Determine effective range for brush head diameter for specific length fur
Bristle	Use bristles made of stainless steel and plastic to brush fur	Select best material to use for bristles, and determine desired deflection

Current Design Adjustments

Brush Head

- Longer haired dogs will require large diameter to prevent fur from tangling
- Metal bristles were found to have lower deflection, so plastic bristles will be tested

Handle

- Needs to provide balanced weight distribution
- Needs to have increased interior tolerances

Future Work: Procurement

Brush Heads

- Buy brush heads of the same diameter and different bristles design
- Buy brush head with different diameter and same bristle design

Testing Materials

- Faux fur

Brush Handle

- 3D print one more dimensionally accurate

Future Work: Field Trials and Finalizations

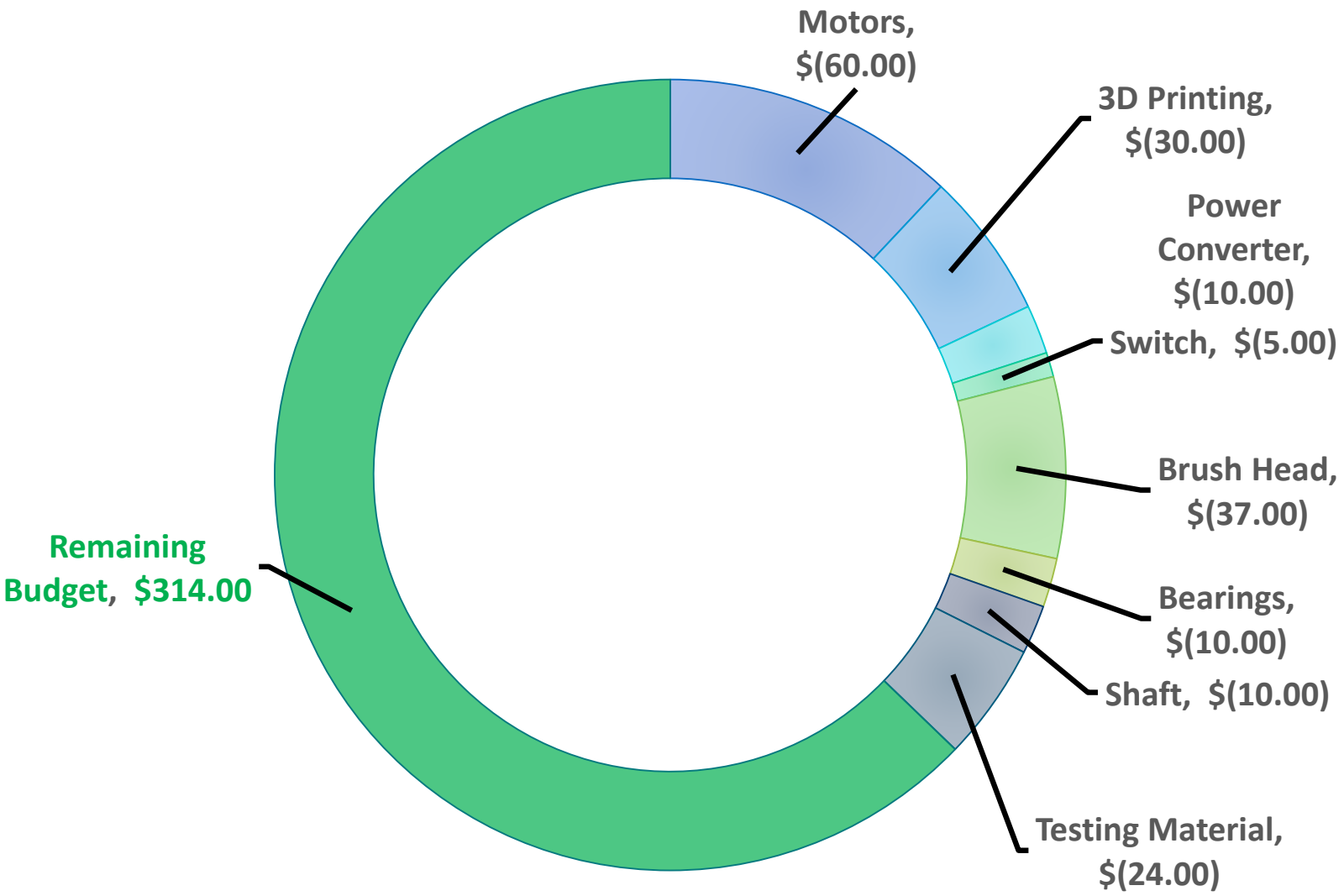
- Continue to optimize final prototype
- Distribute to selected groomers and dog owners for trials
- Gather feedback on performance from trials
  - Likes and Dislikes
  - Areas for improvement
- Research additional methods and techniques for dog grooming

Current Budget

Total Budget Allocated
- $500.00*

Amount Spent
- $186.00

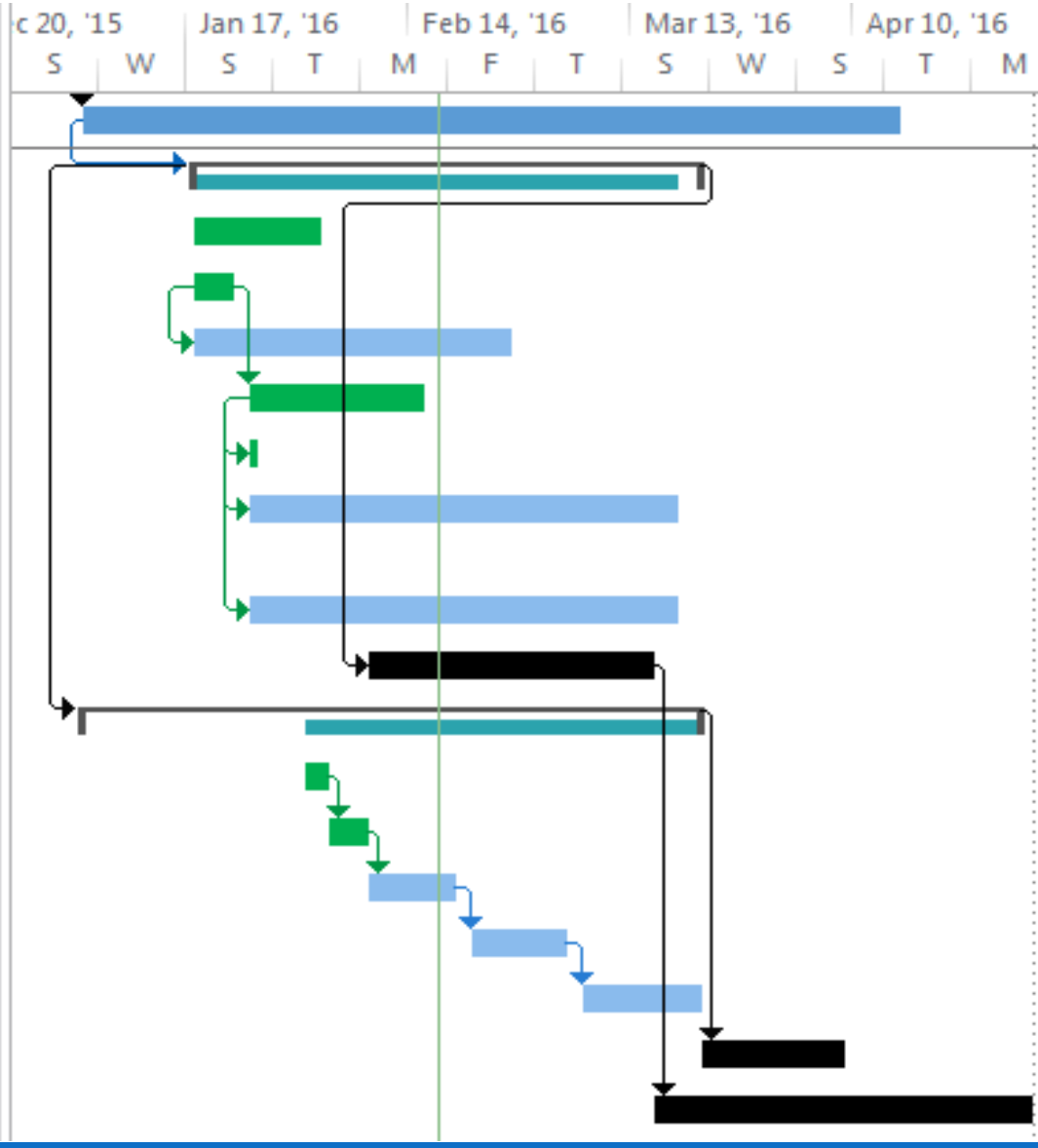
Remaining Amount
- $326.00



*Sponsor has expressed flexibility with budget

Updated Gantt Chart: Phase II

	Task Name	Duration	Start	Finish
30	***Phase II (January - April)***	***75 days***	***Mon 1/4/16***	***Fri 4/15/16***
31	**Test and Analysis**	**46 days**	**Mon 1/18/16**	**Mon 3/21/16**
32	Analyze Ergonomics	12 days	Mon 1/18/16	Tue 2/2/16
33	Test Planning	5 days	Mon 1/18/16	Fri 1/22/16
34	Procure Test Materials	30 days	Mon 1/18/16	Fri 2/26/16
35	Test Motor Stall Force	16 days	Mon 1/25/16	Mon 2/15/16
36	Test Power Source	1 day	Mon 1/25/16	Mon 1/25/16
37	Test Optimal Brush Head Diameter	40 days	Mon 1/25/16	Fri 3/18/16
38	Test Bristle Design	40 days	Mon 1/25/16	Fri 3/18/16
39	**Voice of the Customer II**	**26 days**	**Tue 2/9/16**	**Tue 3/15/16**
40	**Redesign**	**56 days**	**Mon 1/4/16**	**Mon 3/21/16**
41	Review FMEA	3 days	Mon 2/1/16	Wed 2/3/16
42	Design Approval	3 days	Thu 2/4/16	Mon 2/8/16
43	Fabricate Redesigned Parts	9 days	Tue 2/9/16	Fri 2/19/16
44	Rebuild Prototype	10 days	Mon 2/22/16	Fri 3/4/16
45	Test and Analysis II	11 days	Mon 3/7/16	Mon 3/21/16
46	**Field Trials**	**14 days**	**Tue 3/22/16**	**Fri 4/8/16**
47	**Voice of the Customer III**	**34 days**	**Wed 3/16/16**	**Mon 5/2/16**



Conclusion

- Redesign phase has begun
- Testing plans have been established
- More testing materials need to be procured
- Product component testing will continue
  - Brush head diameter and length
  - Bristles design and placement
- Testing results and data to be reported and used to improve product
- Prototype functions, but with further testing it will be improved in safety and performance

Questions?