DESIGN OF A QUIETER HAIR DRYER

MARCH 15, 2016

TEAM 6

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Presentation Overview

- Project Scope
- Review of Performance and Sound Testing
- Fan System Analysis
- Entrepreneurial Update
- Gantt Chart

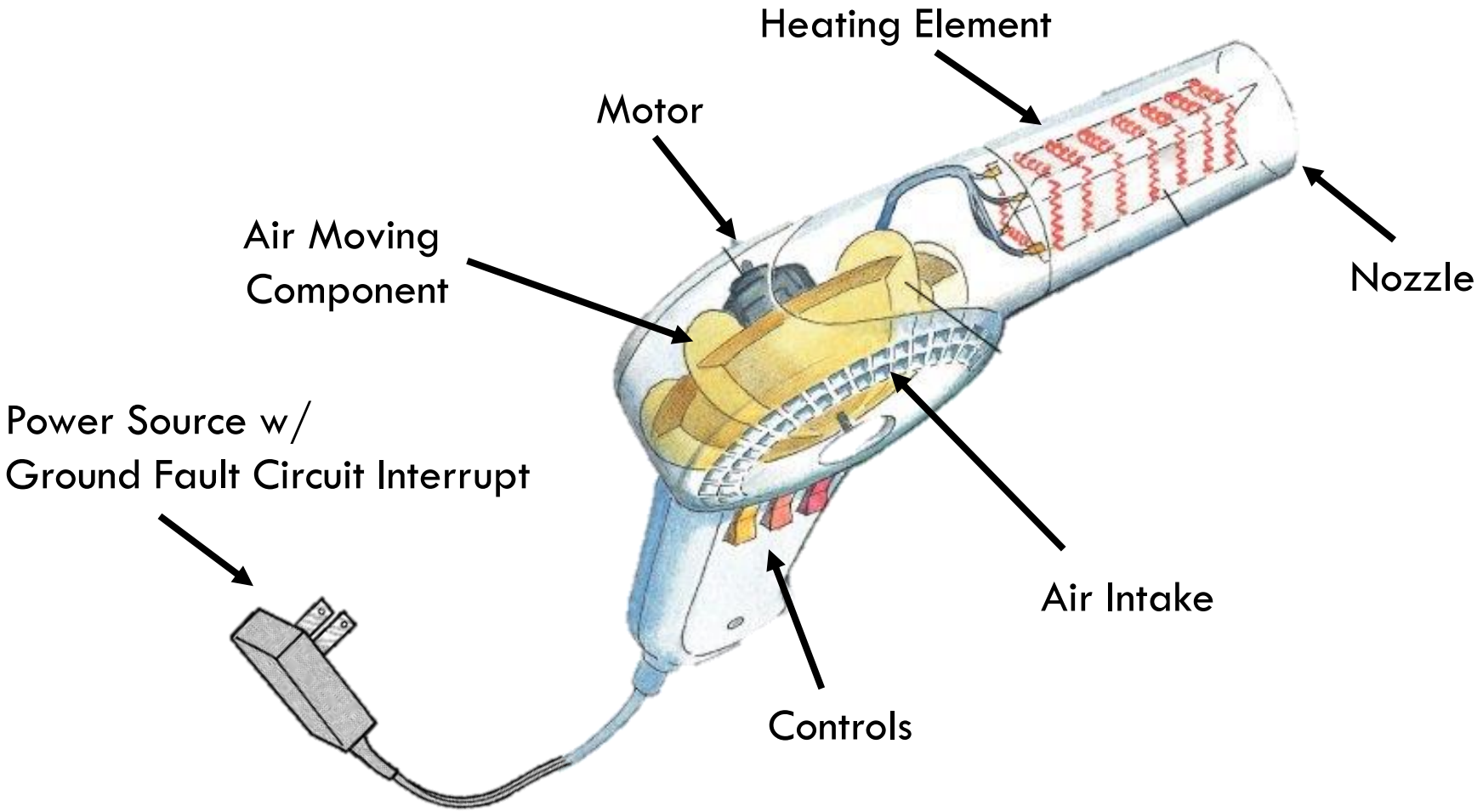
Current Problem

- Hair dryers can be very loud
- Causes unwanted noise in areas meant to be peaceful
  - Pet Grooming
  - Salons
  - Household Bathrooms

Project Scope

Our project scope is to identify the primary source of noise within a centrifugal type hand-held hair dryer, then make repeatable and measureable noise reduction improvements through modifications via design aspects, while maintaining its overall flow performance.

Standard Hair Dryer Components



Observed "Quiet" Models

- Centrix Q-Zone
  - Insanely Quiet™ Technology
  - Dual Vertical Air Intake
  - Horizontally Positioned Centrifugal Housing
  - Forward Curved Airfoil Blades
  - Weight: 1lb, 8 oz.

- Bio-Ionic Whisper Light
  - Ranked as one of the Quietest Dryers in the World in 2012, according to Quiet Mark
  - Dual Horizontal Air Intake
  - Vertically Positioned Centrifugal Housing
  - Forward Curved Airfoil Blades
  - Weight: 1lb, 2 oz.

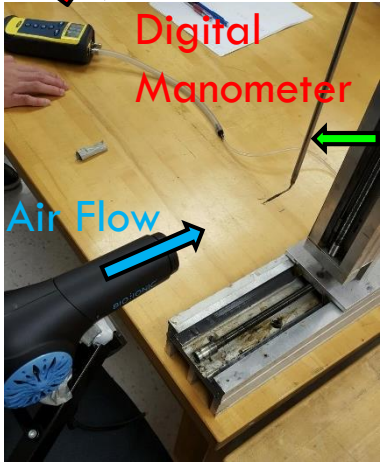
Experimental Setups Applied to Determine Performance and Sources of Noise

Mark Johnson

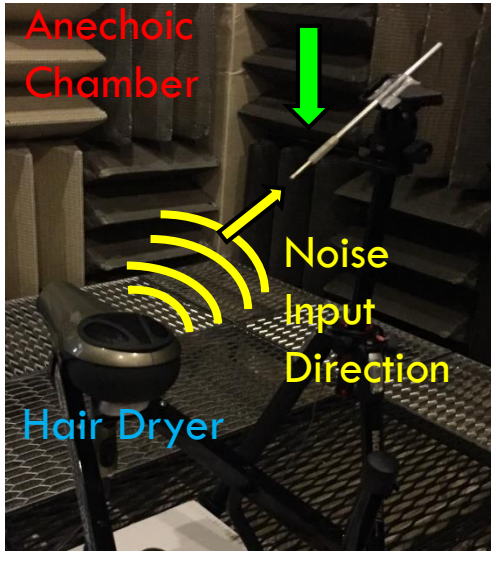
- Temperature Output
  - Tools Used: Infrared Thermometer
  - Performance based on rate of heat transfer
    - $\dot{Q} = \dot{m} * C_p * \Delta T$

Infrared Thermometer measuring surface temperature

- Velocity and Pressure
  - Tools Used: Pitot Tube, Digital Manometer, Adjustable Measurement Device
  - Allows us to determine velocity profile



- Noise
  - Tools Used: Anechoic Chamber, Free Field ¼" Microphone
  - Measurements taken around the device at locations above, level and below



Comparing Performance Results

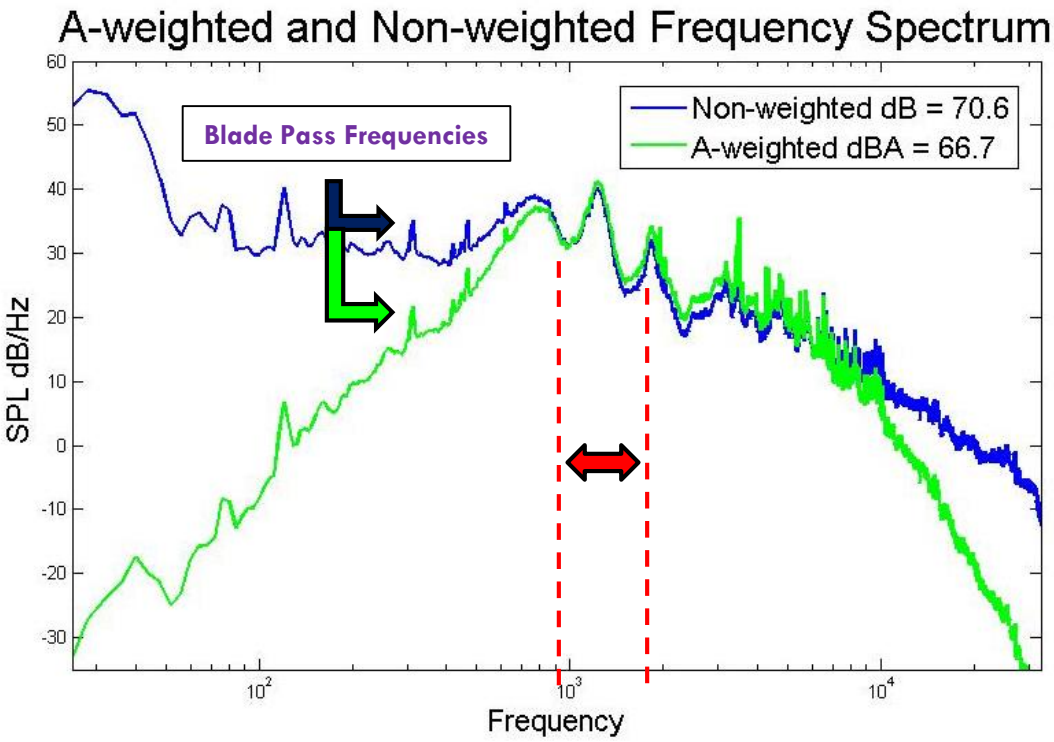
	Centrix Q-Zone		Whisper Light	
	High	Low	High	Low
Quoted Power Rating	$1500\ W$		$1400\ W$	
Temperature 6 in. from nozzle	$55^o\ C$ $\mathbf{131^o\ F}$	$41^o\ C$ $106\ ^o\ F$	$65^o\ C$ $\mathbf{150^o\ F}$	$50^o\ C$ $122\ ^o\ F$
Volume Flow Rate	$\mathbf{0.0284}\ \frac{\mathbf{m^3}}{\mathbf{s}}$ $60\ cfm$	$0.0201\ \frac{m^3}{s}$ $39\ cfm$	$\mathbf{0.0226}\ \frac{\mathbf{m^3}}{\mathbf{s}}$ $50\ cfm$	$0.0142\ \frac{m^3}{s}$ $30\ cfm$
Motor RPM	514	360	730	520
Heating Rate ($\dot{Q}$)	**1190 W**	**495 W**	***1227W***	**508 W**

Table comparing performance characteristics of two dryers

*cfm = cubic foot per minute

Noise Analysis Overview

- *Sound Pressure Level* determined by taking area under the spectrum
- A-weighted filter models human hearing; reducing contribution to SPL of low and high frequencies
- Human hearing is most sensitive between 1-2 kHz
- Blade Pass Frequency
  - $BPF = \frac{(RPM)*(\#\ of\ Blades)}{60}$
- Design aims are to push noise to lower frequencies to take advantage of A-weighted filter
- Examine noise contribution amongst various hairdryer components
  - Heating Element
  - Intake Covers
  - Fan Speed

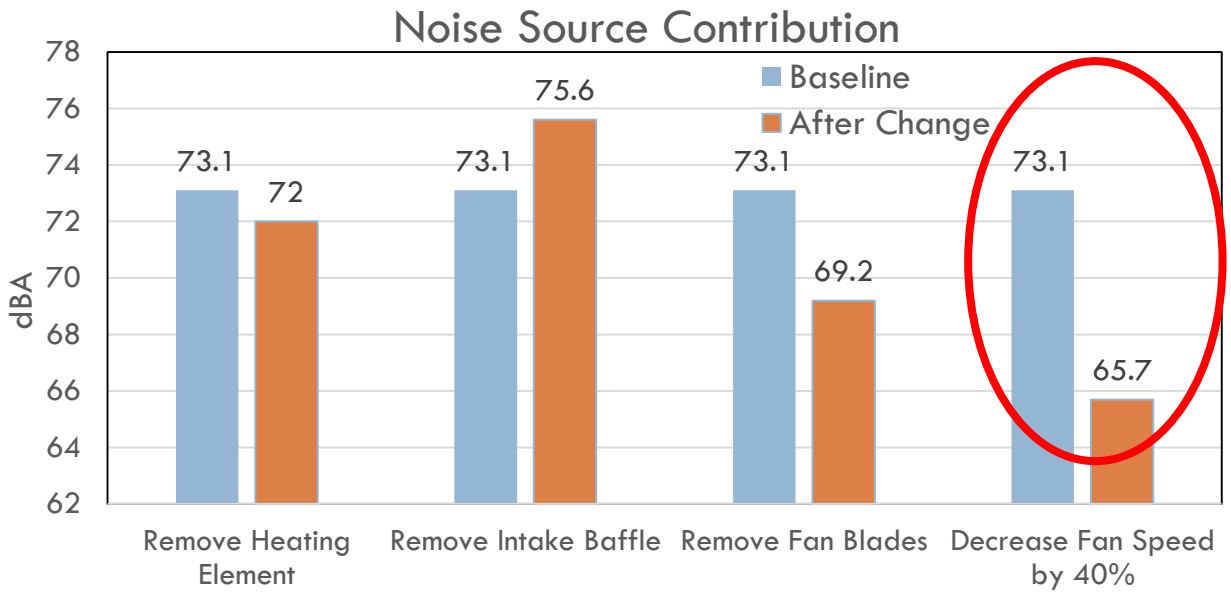


Note: Frequency spectrum observed at side of intake of "Whisper" during low speed operation

Noise Source Contributions

Heating element removed for unimpeded flow through nozzle

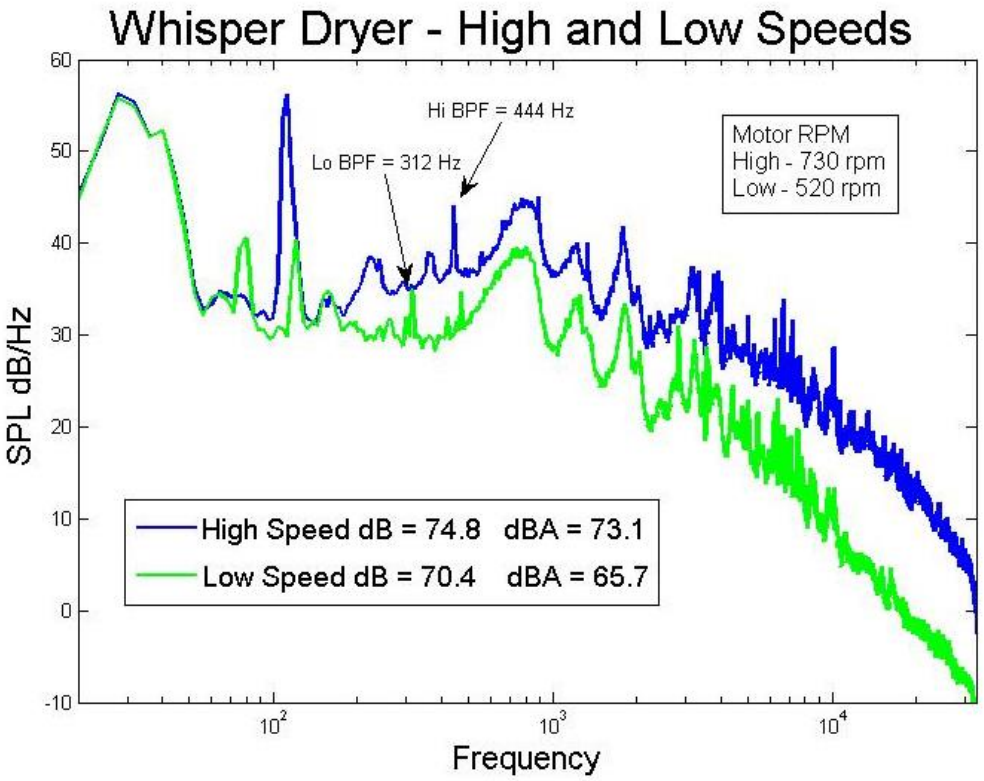
Cover and baffle removed from intake



- Evaluation:
  - Noise generated by heating element is minimal
  - Baffles are necessary and must be used efficiently
  - Fan speed is largest contributor to noise level

“Hi” vs. “Lo” Fan Speeds

- A 40% increase in fan speed results in a SPL increase of 6-8 dB(A)
- Conclusion:
  - Improvements to the fan and blades will create an improved flow rate, this will allow for fan speed reductions
- Seeking noise reductions from fan modifications



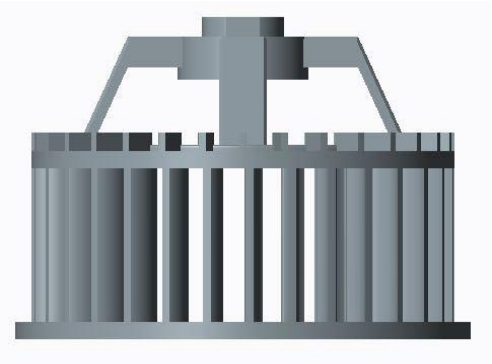
Frequency spectrum at side of nozzle for high and low speed settings

Fan Blade System Modifications

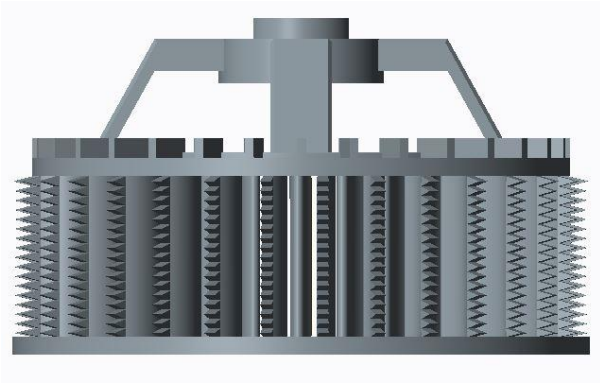
- "Whisper Light" chosen for modifications
  - Justification:
    - Simple fan attachment mount
    - Louder of the two hair dryers

Current Fan Features	
# of Blades	36
Blade Height	0.935 in.
Outer Diameter	3.05 in.

- Reduce the number of blades to a prime number
  - Decreases BPF
  - Tonal frequencies are spread out to reduce annoyance



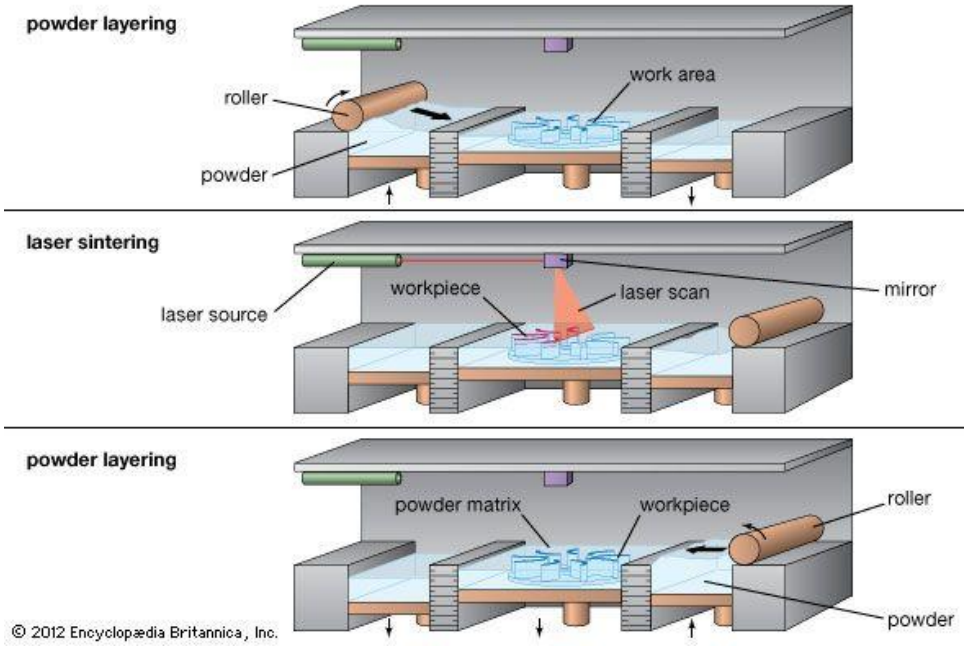
- Increase blade size and surface area
  - Maintain volume flow
  - Reduce motor speed



- Add serrations to blades trailing edge
  - Break-up packets of air exiting blades

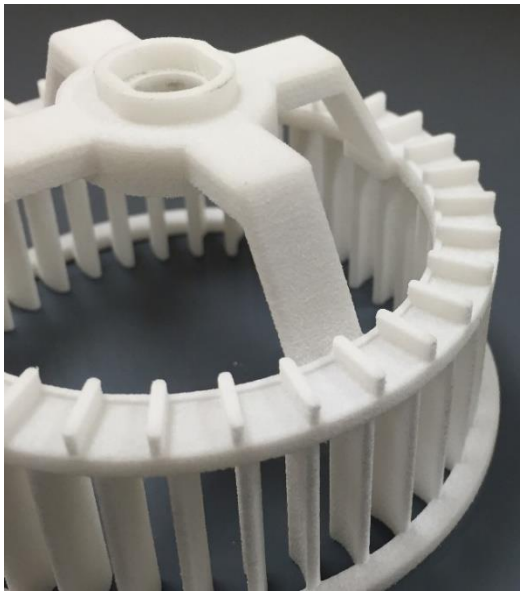
Product Development Process & Results

- Produced new fan blades via selective laser sintering (SLS) 3D printing method thru 3DSystems supplier
- Prints in one solid part
- Has layer thickness of 0.1 mm



Schematic of SLS 3D printing process

- Printed, exact replica of original and also one with fewer blades
- Rougher surface finish than original
- Slightly heavier than original fan blade
  - Original – 18 grams
  - 31 Blade – 20 grams
  - 36 Blade – 22 grams

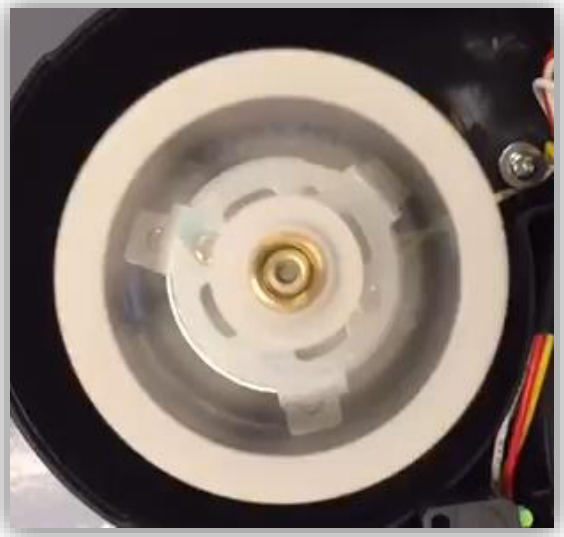


SLS 3D printed fan

Testing 3D Printed Blades

- Inserted blades into housing and ran on high speed
- Obvious imbalances in fan rotation
  - Generated amplified noise due to increased vibrations
- Seemed to produce comparable flow output

Original Fan



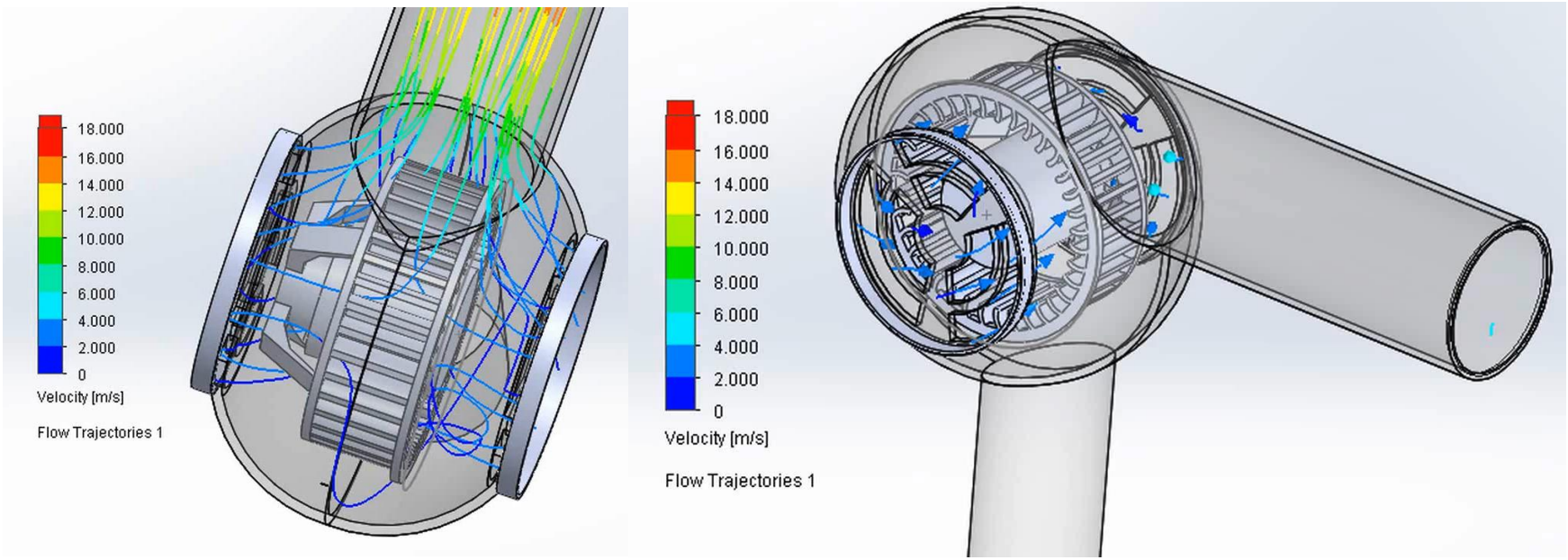
Replica Fan

Original and replica fans on high speed setting recorded in slow motion video on IPhone 6

Flow Simulations

Shawn Eckert

- Performed using SolidWorks
- Can measure flow rates, pressures and velocities for different fan configurations
- Visualize flow paths



Flow visualization lines with velocity contours

Future Design Plans

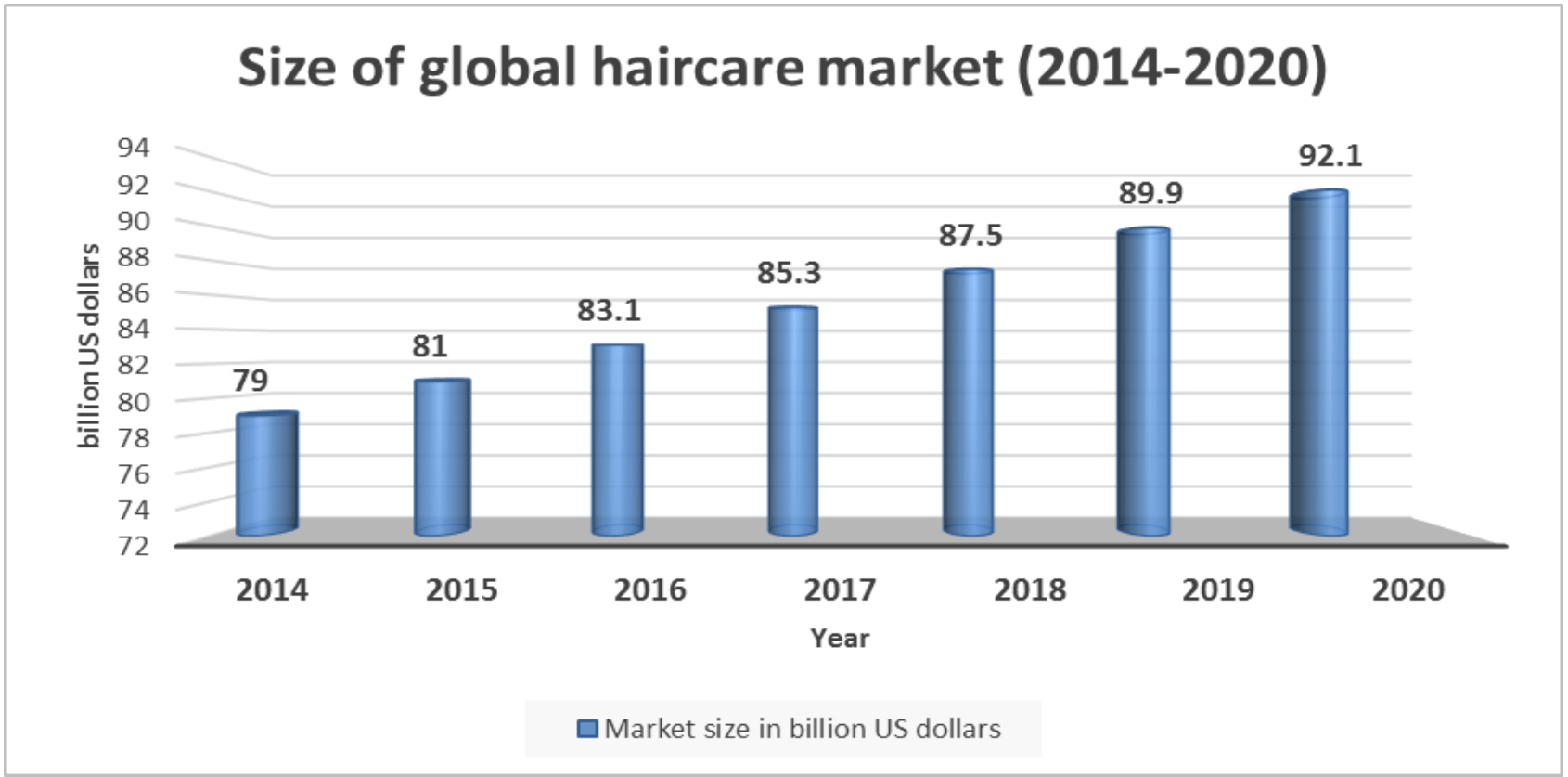
- Looking into methods to balance fans and reduce vibrations
  - Determine heavy side using a spindle
  - Add weight to lighter side to balance
  - Trial and error process
  - Increase stability of motor mount
- Will measure vibrations levels using a 3-axis accelerometer
- Perform flow simulation study using SolidWorks to test how fan modifications affect performance
  - Number of blades
  - Rotation speed
  - Added serrations

Entrepreneurial Progress

- Global Market
- Potential Customer Survey
- Business Model Canvas
- Engineering Shark Tank

Global Hair Products Market

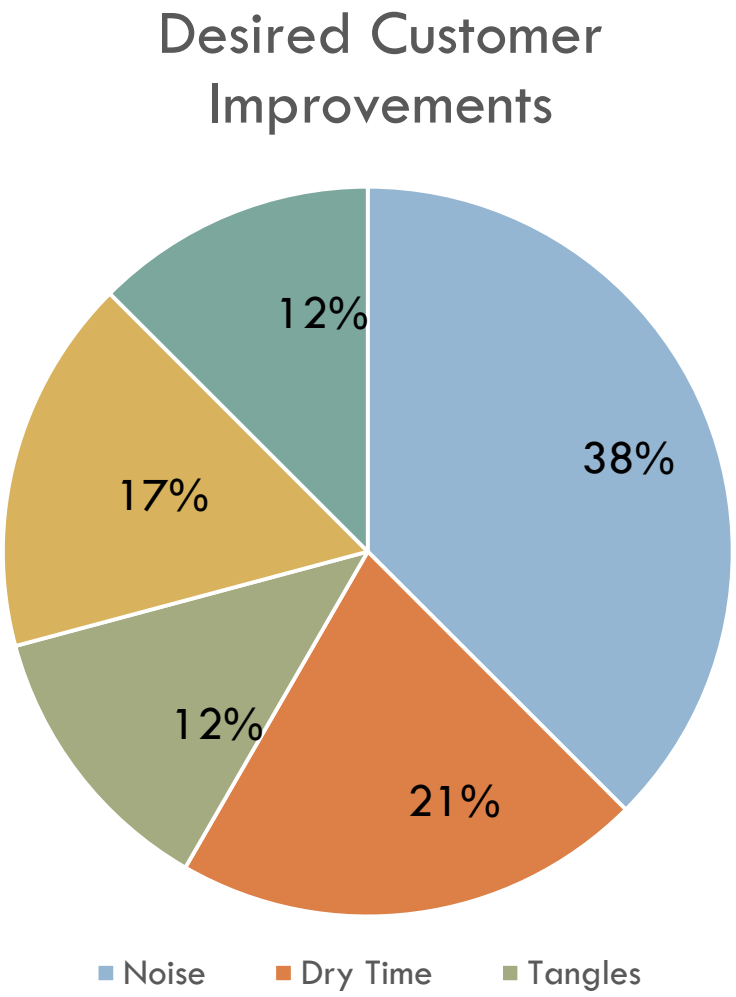
- The hair care market is growing
  - Shampoos, Conditioners, Relaxers, Gels, Hair Straighteners,…
  - Most importantly Hairdryers!

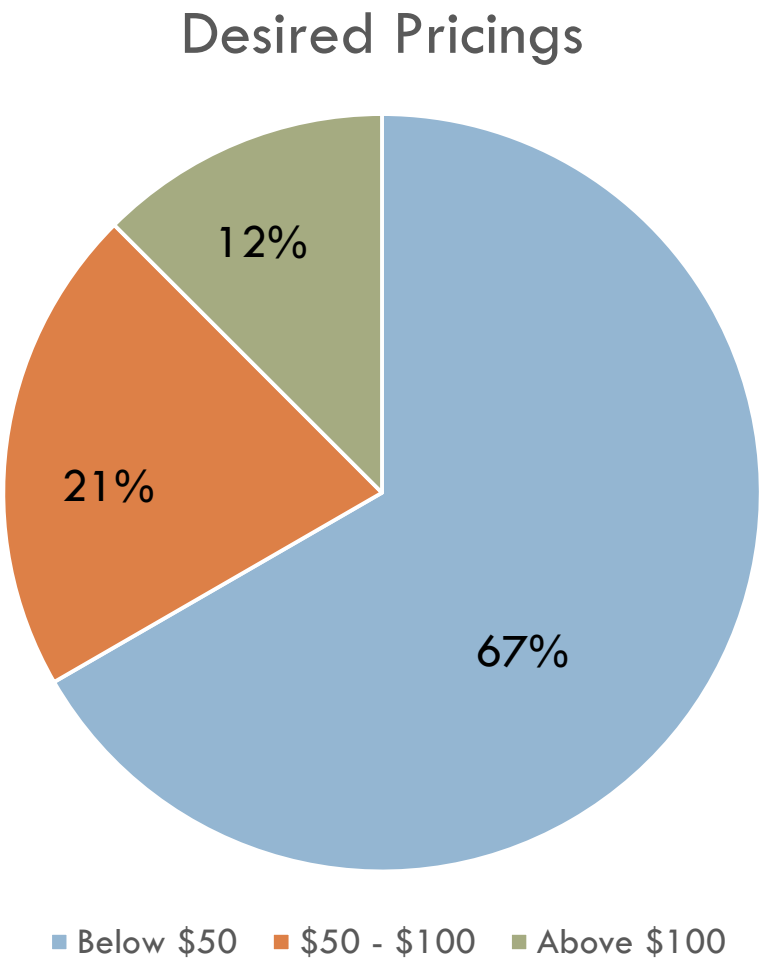


Today's Customers

- Mostly women have been consumers
- Men are now becoming consumers
- Pet groomers are also consumers
  - Pets with long and short hair
  - Animals are sensitive to loud sounds

Understanding Customers

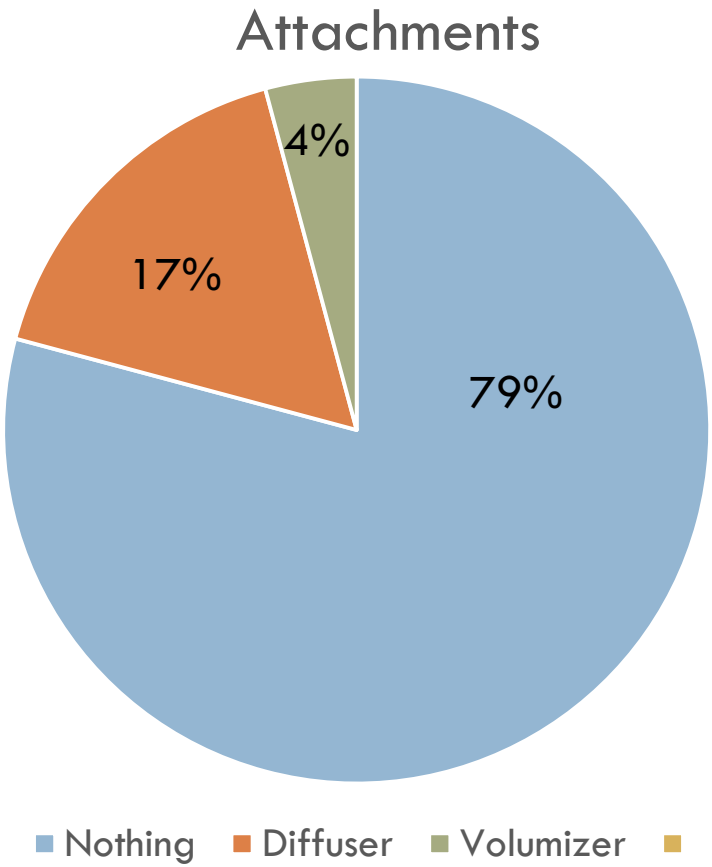


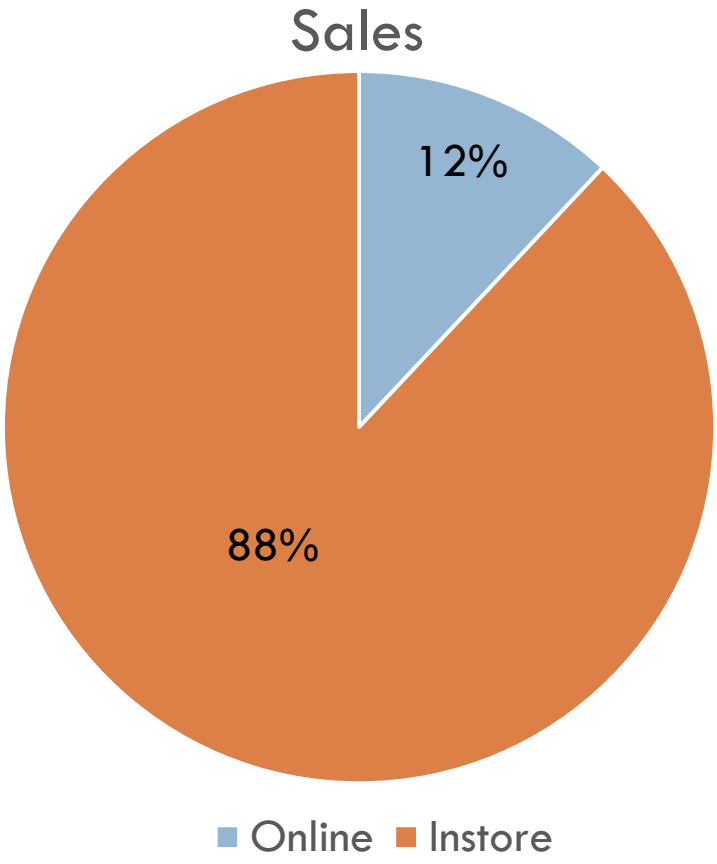


Note: Data gathered using *surveymonkey*

Understanding Customers

- Selling point
  - Noise cancelling technology used in modern day aircraft (Can be Sold as a Premium)
  - Indulgence of Luxury items something innovative is interesting and desirable





Competition

- Competing Silencing Designs
  - Attachable silencers
  - Said to reduce noise level by 8 dB
  - Only fits Parlux 3200 (Axial Fan Design)
  - Adds weight to overall design
  - Purchase separately (Not Integrated)
- Centrifugal Style Hairdryer
  - Centrifugal blade design quieter than axial design

Silencer

Centrifugal

Axial Fan Design

Business Model Canvas

23 Kiet Ho

The Business Model Canvas

Team or Company Name
Hushdryer

Date:
03/2016

Primary
Alternative

Key Partners

Funders
- FAMU & FSU COE
- Dr. Devine

Advisor
- Dr. Cattafesta
  - Acoustics & Permission Access
- Dr. Gupta & Shih
  - Mechanical & Electrical

Testing
- Aero-Propulsion Mechatronics and Energy Building

Vendors
- Function 3D
- 3D systems- Quickparts
- Anaheim Automation
- Mouser Electronics

Key Activities

- R&D to improve on current hairdryers
- Good Sales team
- Upfront in Retail Stores
- Online Shipping & Delivery Accessibility

Key Resources

Function 3D
- Tallahassee, FL

Helpful Staff
- FAMU-FSU COE

High Quality Parts
- Outsourced

Value Proposition

Product
- High Performing & Quiet Hairdryer
- Injection Molded High performing Centrifugal Blades
- Noise Cancelling Technology
- Reliable DC motor for Longevity
- Three Colors
  - Purple
  - Blue
  - Green

Customer Relationships

Purchasing
- By Self(Online based, Pre-caution prior to FAQs)
- By Engagement (Retail Stores, One-on-One Assistance with FAQs)

Channels

- Retail Stores (In Person)
- Online Stores (Amazon)
- Online Market

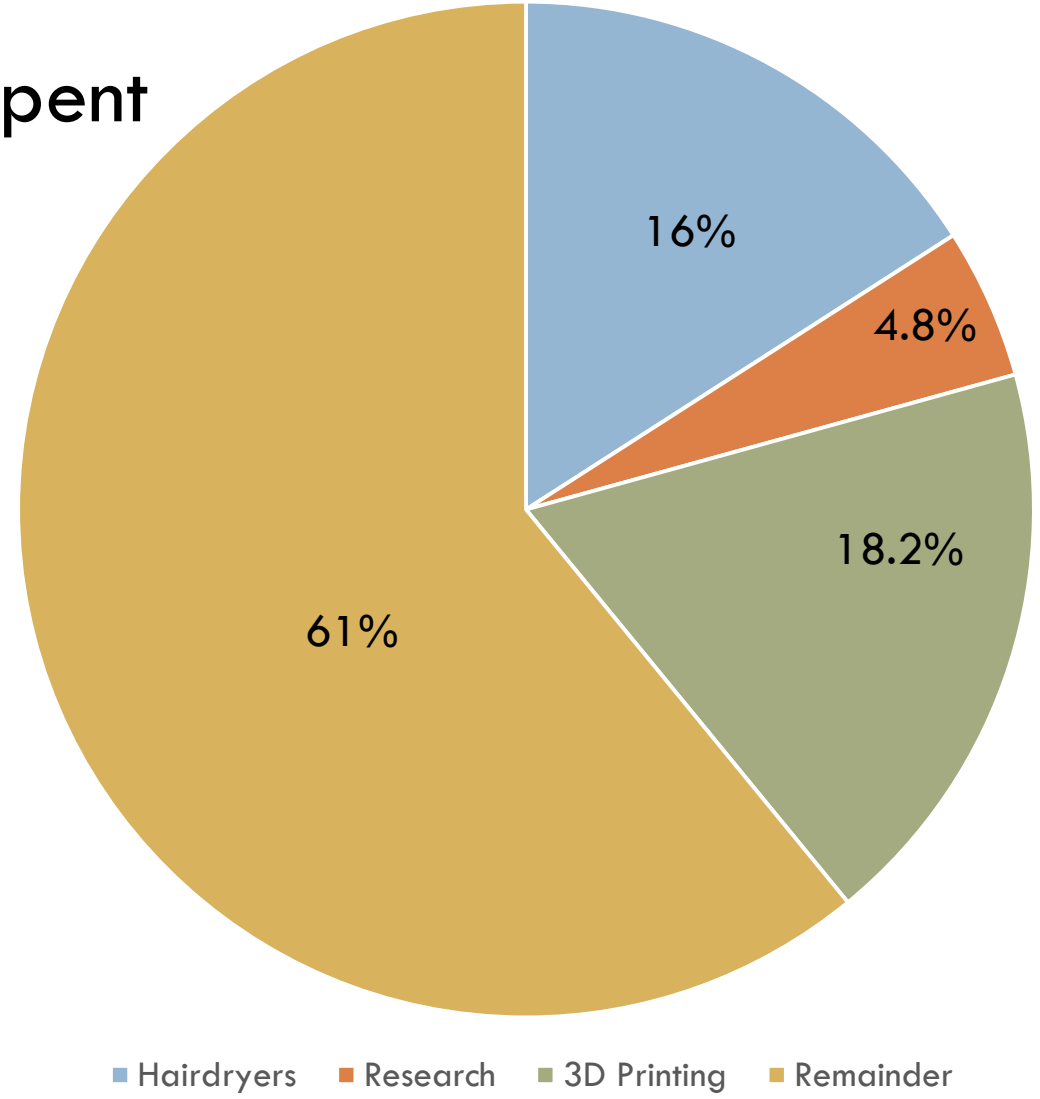
Customer Segments

Individual
- Independent Customers
  - Male
  - Female

Professional
- Hair Salons
- Pet Grooming
- Painters

Financial Status

- Total amount spent
  - $586.09
- Total left
  - $913.91



Engineering Shark Tank

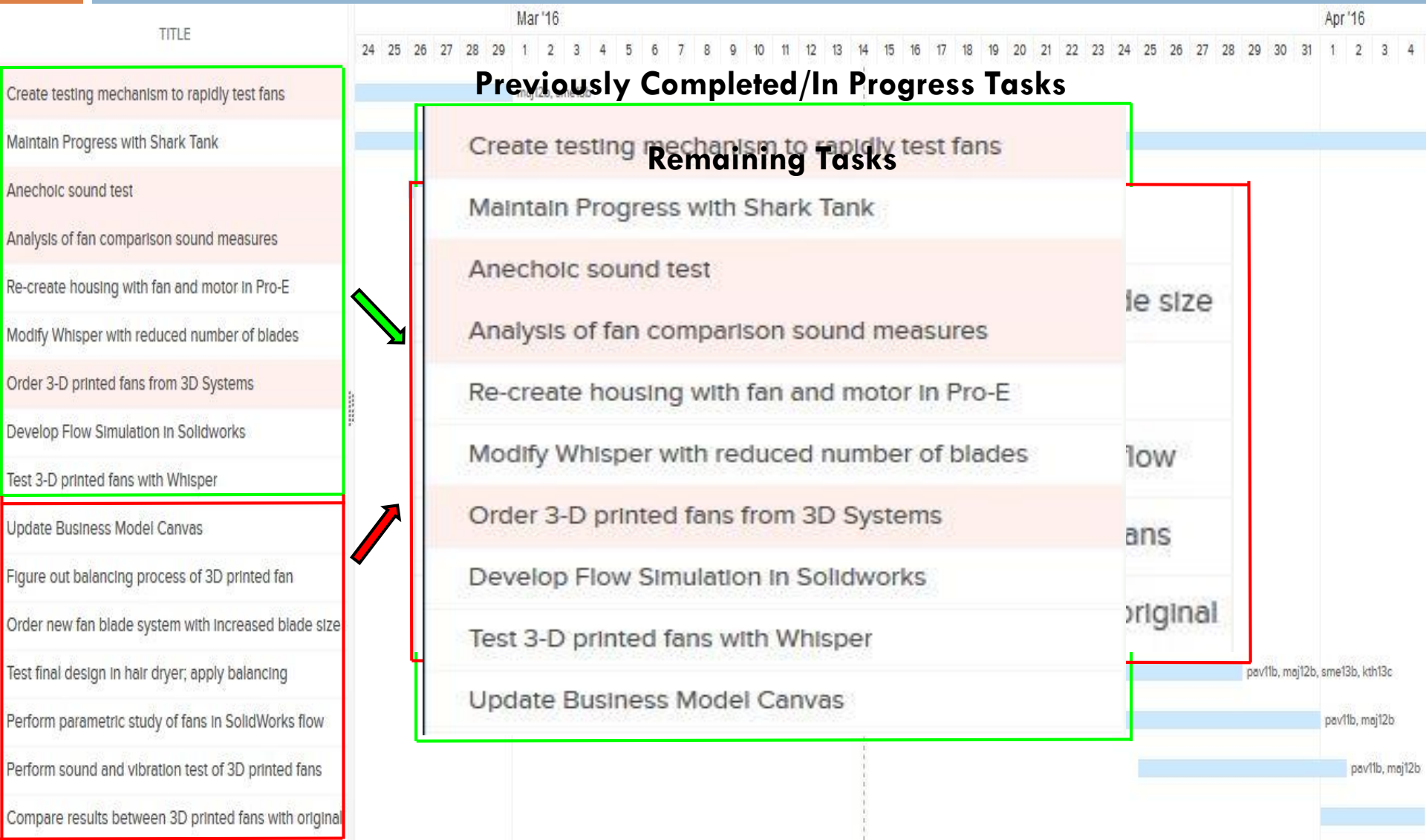
1st Annual College of Engineering
Technology Business Pitch Competition
Thursday, April 14, 2016 | 3:00pm-4:30pm,
Engineering Room B-221

ENGINEERING SHARK TANK

- A panel of 7 Judges
  - Faculty of FAMU-FSU COE
  - Alumni
  - Entrepreneurs
- *First Round March 24 & 25*

Future Plans/Gantt Chart

Kiet Ho



Any Questions?