Bio-Inspired Design for Energy Efficiency

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Project Description: First Semester

- To design a ventilation system that increases the energy efficiency of SBS West while bringing the building up to standard ventilation code. The design will be added on to the current HVAC system and to be inspired by nature.
- **Importance:** SBS West is inefficient with its energy use and does not meet current standards for ventilation.

Project Description: Second Semester

- Generate bio-inspired ventilation designs focused on venting excess pressure to replace the current vents in SBS West
- Create a Design of Experiments (DoE) to test the prototypes of the bio-inspired vents and other aspects which affect ventilation (i.e. surface area)
- Use funding to generate a full scale design

Updates: First Semester Proposed Design

- Replacement of the SBS West's roof ridge

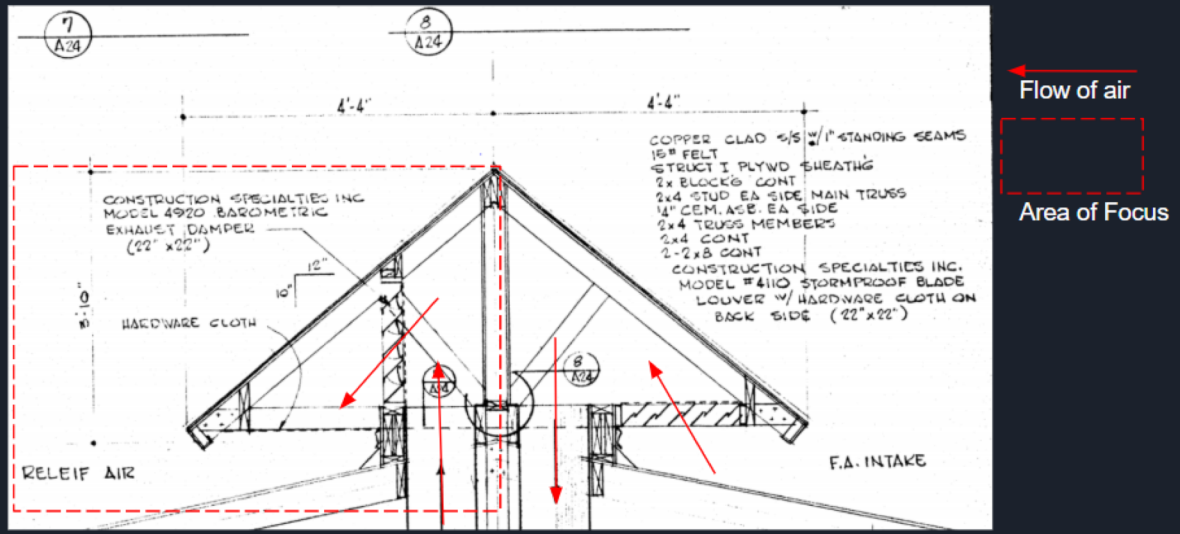

Figure 1: Current Ridge of SBS West

Updates: First Semester Proposed Design

- Replace current ridge on roof of SBS West
- New ridge will consist of solar panels on South side of building (3’ x 5’)
- Steel casing that houses the intake and exhaust air
- Vents actuated by smart material

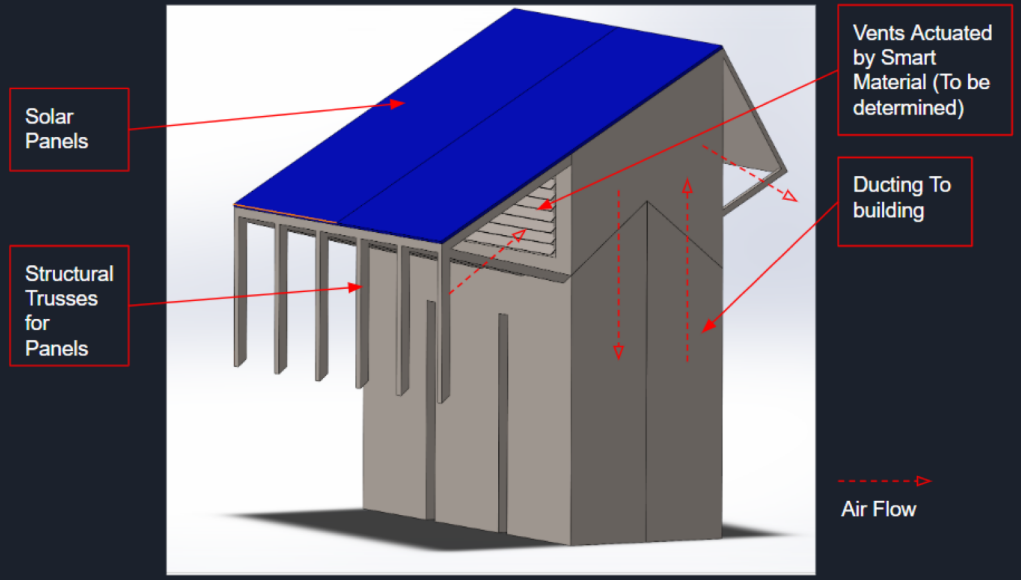

Figure 2: CAD Model of Proposed Design

Updates and Moving Forward: Manufacturing

- Design four different bio-inspired vents with a standardized area of relief (~10 square inches)
  - Fibonacci vent design
  - Termite mound vent design
  - Pine cone vent design
  - Flower vent design
- Have the vents 3D printed via 3D Systems

Fibonacci Vent Design

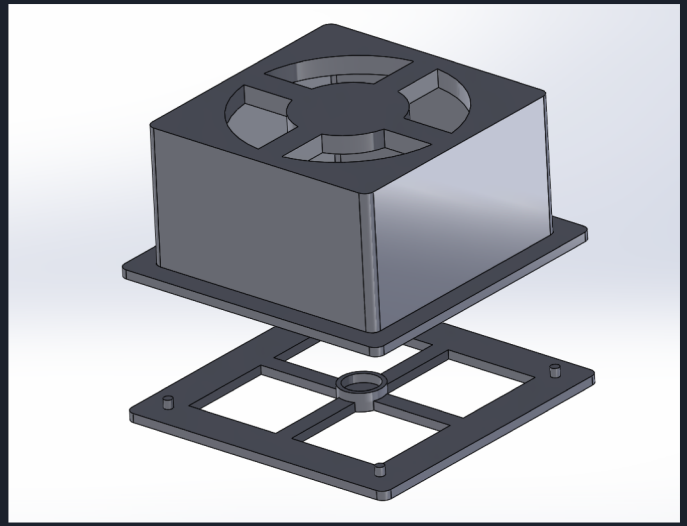

Figure 3: Fibonacci Vent Shell

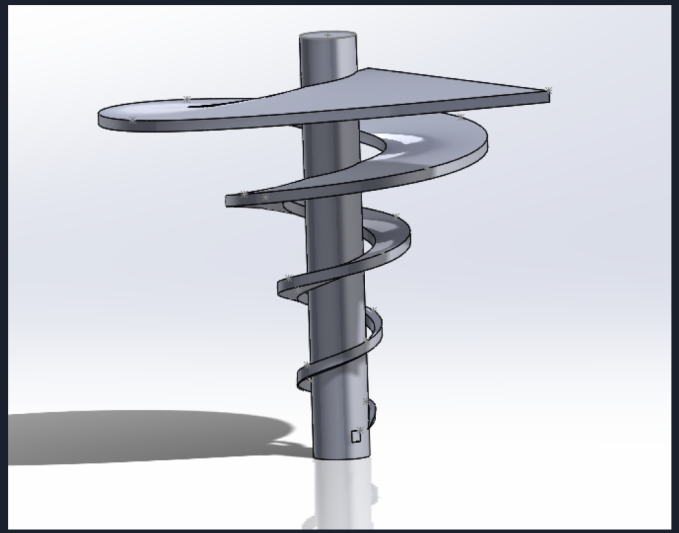

Figure 4: Fibonacci Fan Blade
(still debugging)

Termite Mound Vent Design

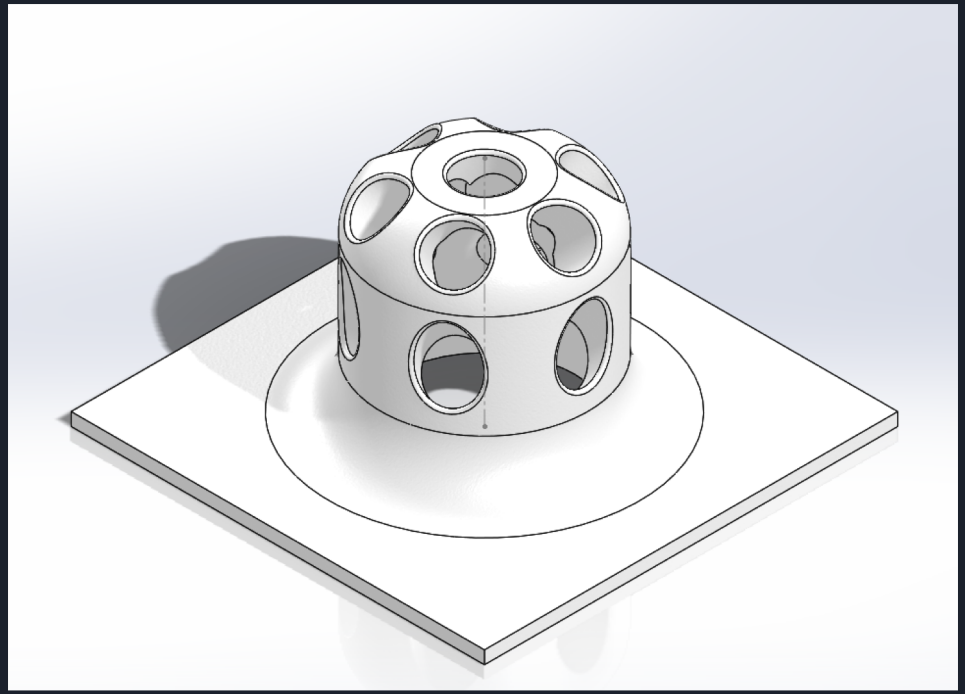

Figure 5: Termite Mound Vent Design

Pine Cone Vent Design

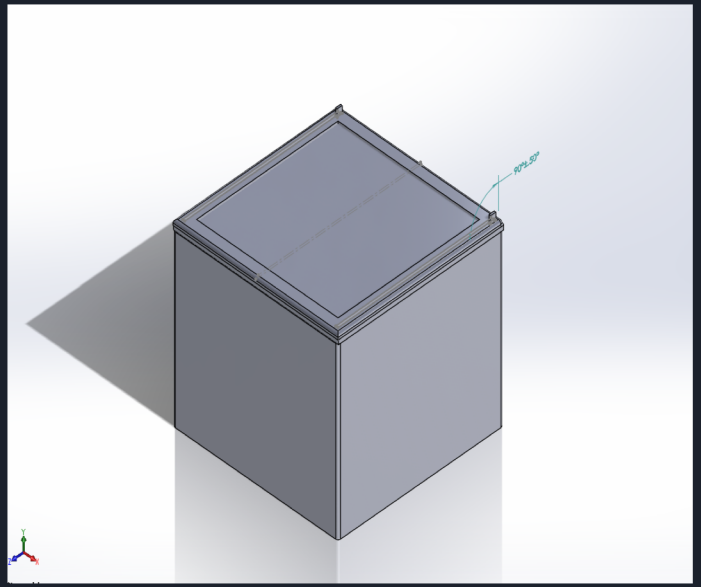

Figure 6: Closed Roof Pine Cone Vent Design.

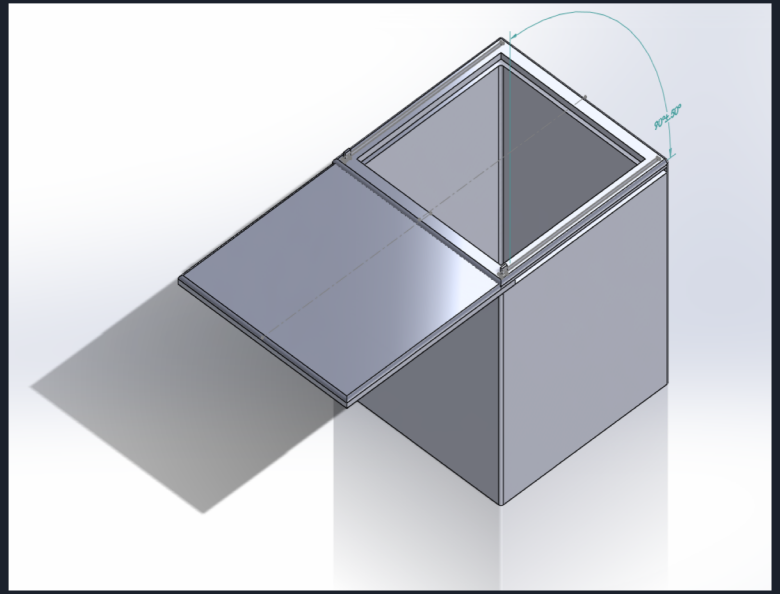

Figure 7: Opened Roof Pine Cone Vent Design.

Flower Vent Design

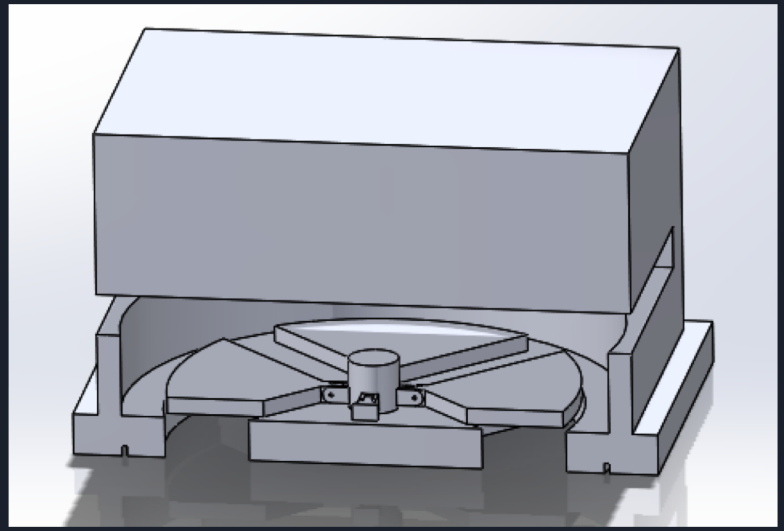

Figure 8: Section View of Vent

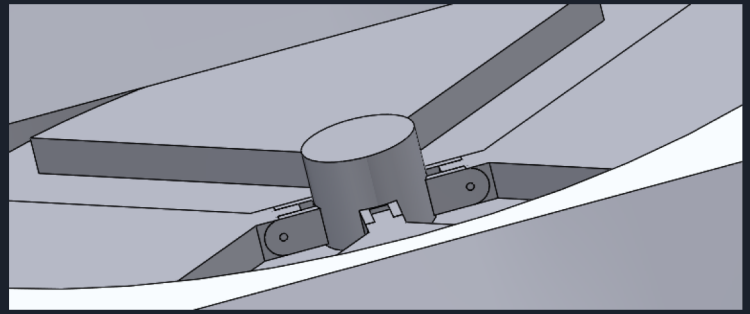

Figure 9: Pedals of Vent

Moving Forward: Analytical Analyses

- Analyses done:
  - Estimated time to bring pressure in the chamber to equilibrium
  - Analyzed the heat transfer aspects of the pressure chamber
  - Structural analysis of pressure chamber under load
  - Analyzed Free vs. Forced ventilation
- Takeaways
  - Time to vent is a concern (to fast?)
  - Take about 12 seconds for the pressure chamber to cool from 82°F to 72°F
  - Flow rate of air out the pressure chamber: 0.53 cubic meters per second
  - Forced Ventilation: Utilizes fans or blowers to vent building
  - Free Ventilation: wind driven ventilation and stack driven ventilation

Moving Forward: DoE

- Focus on the pressure relief of the four different bio-inspired vent designs
- Vents will be sealed on top of a sealed pressure chamber
  - Pressure chamber: 12” x 12” x 12”
- Pressure transducer attached to the pressure gauge to record the pressure of the chamber
- Variables for DoE:
  - Pressure (Exp. 1 and 2)
  - Outlet chamber surface area: (4:4:36)in^2

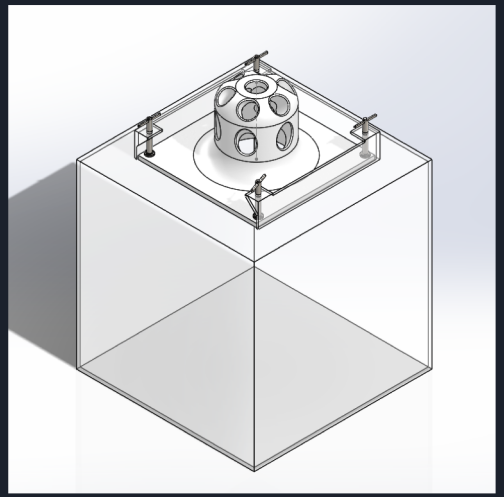

Figure 10: Pressure Chamber with Vent attachment

DoE Assumptions

- Constant surface area of outlet of each vent
- Constant volume of air: 1 cubic foot
- Same measuring devices
- Experiment One
  - Constant pressure
  - Constant temperature
- Experiment Two
  - Constant flow rate of air
  - Constant temperature
- Experiment Three
  - Constant flow rate of air
  - Constant temperature

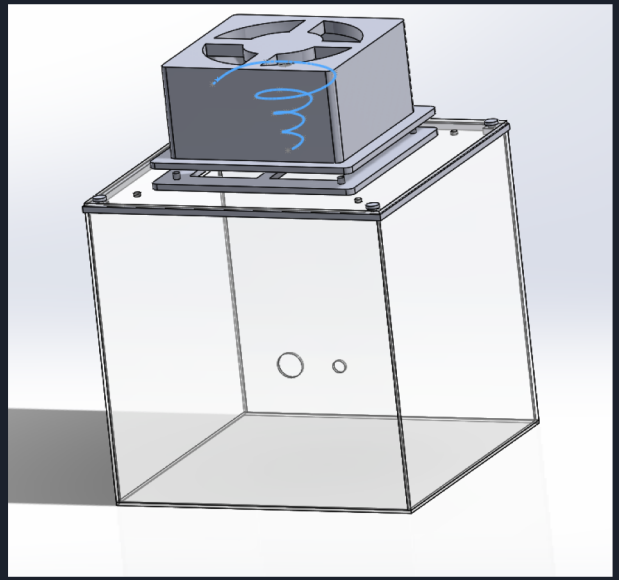

Figure 11: Hypothesized Setup for DoE (CAD)

Experiment One (Will be Analyzed)

- Record the ambient temperature and atmospheric pressure
- Vary the pressure from 0.5 atm (~7 psi) to 2atm (~29 psi)
- Open vent
- Collect data
  - Time lapsed
  - Pressure change
- Repeat with free and forced ventilation
- Repeat with three other vents

Experiment Two (Should be analyzed)

- Record the ambient temperature and atmospheric pressure
- Keep vent open
- Provide a constant flow rate of air into the chamber
- Collect data
  - Time lapsed
  - Pressure change
- Repeat with free and forced ventilation
- Repeat with three other vents

Experiment Three (Hope to analyze)

- Record the ambient temperature and atmospheric pressure
- No sealing of vent
- Actuate fans and blowers to heat and cycle air inside the pressure chamber
- Collect data
  - Time lapsed
  - Change in temperature
- Repeat with free and forced ventilation
- Repeat with three other vents

Schedule

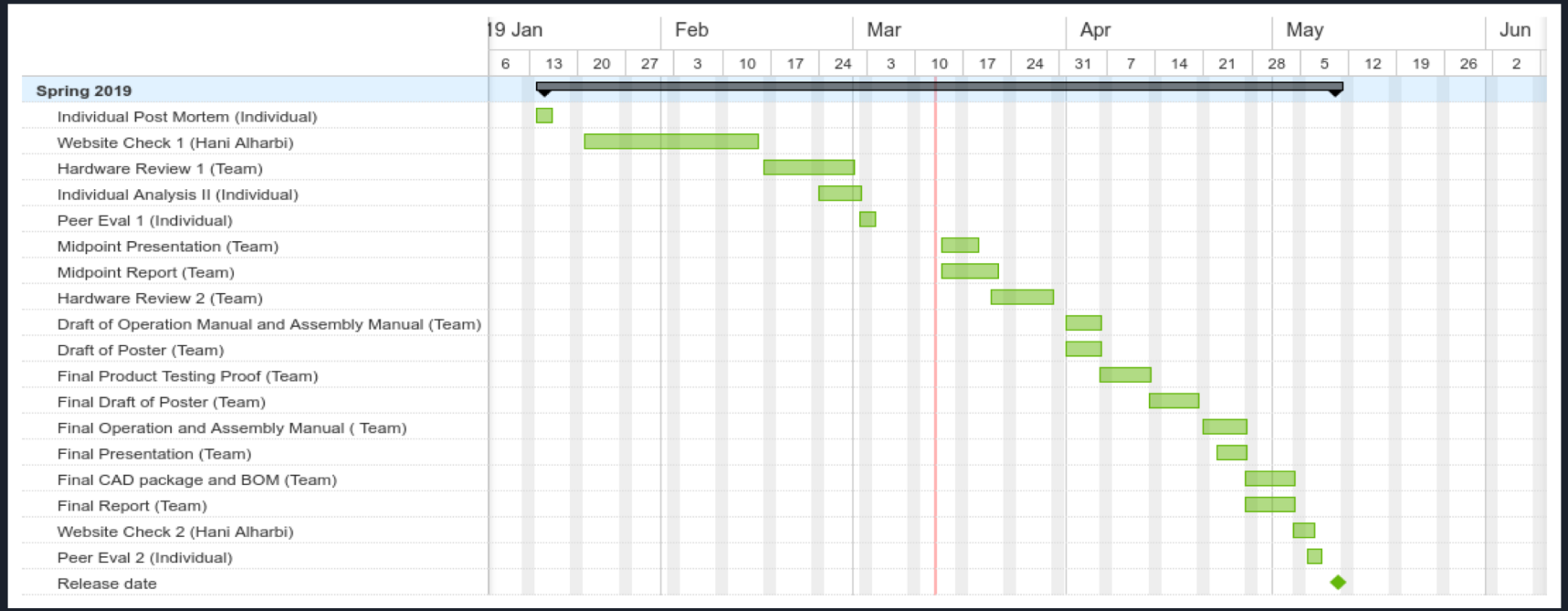

Figure 11: Current Semester Gantt Chart

Talon, 03/12/19, BID 16

Budget

- Budget: $700
- Current expenses: $200
  - Plexiglass, 12inX12in sheets
  - Arduino, Full starter kit
  - Epoxy, 8 bottles
  - Valve stems , 4ct
  - Plexiglass cutter
- Remaining Budget: $500
- Anticipated expenses: ~$250
  - 3D printing for vents (free with the help of 3D Systems)
  - Pressure Transducer and temperature sensor
  - Modeling of scaled final design (time permitting)

Questions?