Active Roof System

Concept Generation and Selection

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Overview

- Brief Project Description
- Brief Description of Three Prototype Designs
- Design Requirements
  - For All Prototypes
  - For Only Passive Prototype
  - For Only Active Prototype
- Internal Temperature Measurements
- Internal Heating and Cooling System
- Control Systems
- Changes to Timeline and Progress
- Conclusions

Project Introduction

- Problem
  - The amount of power usage to keep the interior of large buildings at a comfortable, cool temperature is too high.

- Project Description
  - Project will investigate roof designs that will lower this power consumption.

Three Roof System Prototypes

- Passive Roof ~ Stationary Panels
- Active Roof ~ Solar Tracking Panels
- Control Roof ~ Plain White Roof

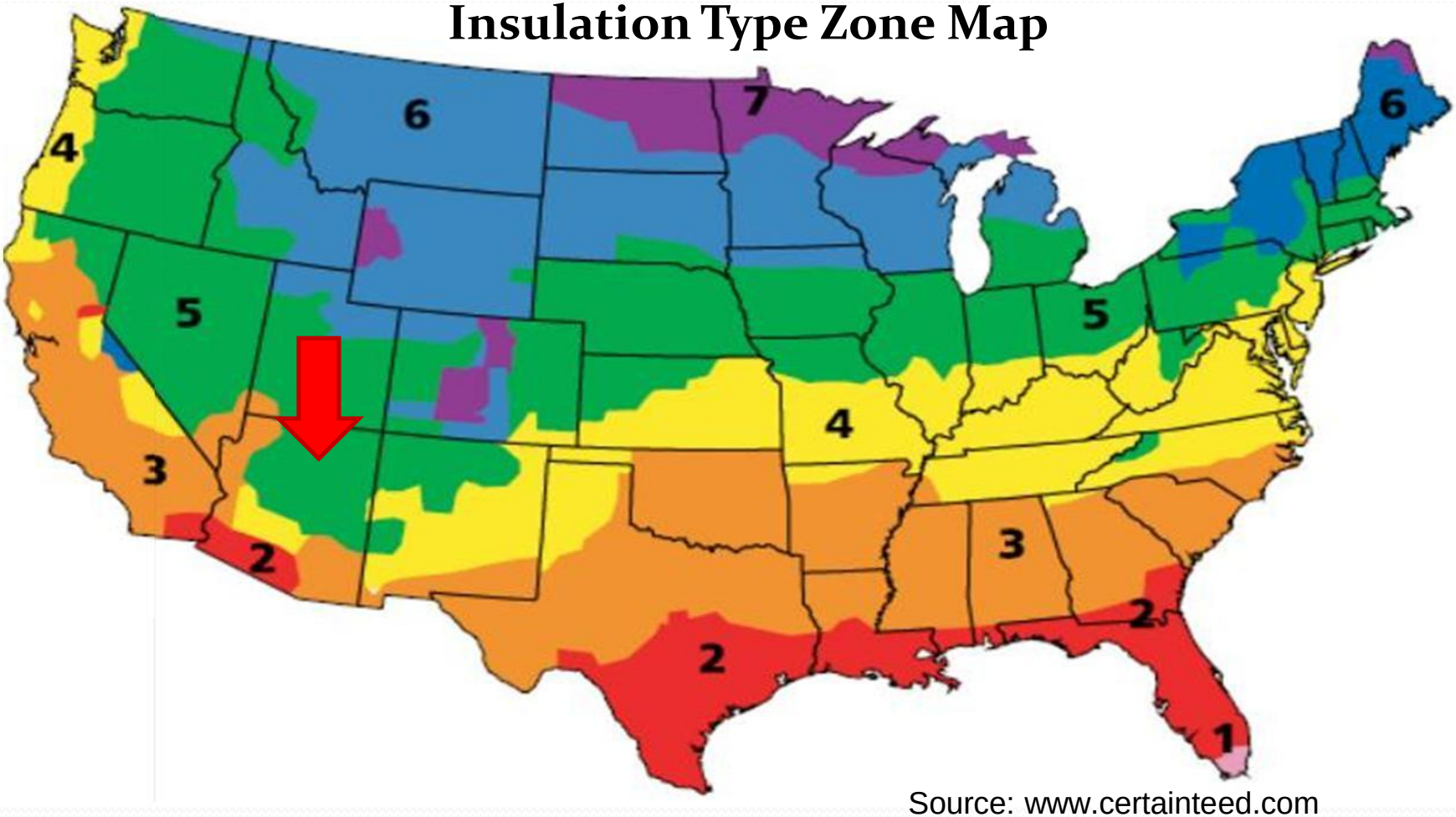
Prototype Design Requirements

- For all Prototypes:
  - Scaled to (smallest) Wal-mart Building
    - Chosen due to size limitations on Prototypes
    - Interior Dimensions
      - 30,000 sq ft (approx. 173.2ft x 173.2ft)
      - 25ft ceilings

Prototype Design Requirements Cont.

- Scaling Factor dependent on
  - Insulation material for model
    - Smallest thickness possible
    - Thermal resistance (R value)
      - Ability to reduce heat transfer

Prototype Design Requirements Cont.



Source: www.certainteed.com

Prototype Design Requirements Cont.

Insulation Type Zone Chart

Zone	Heating System	Attic	Cathedral Ceiling	Wall		Floor
				Cavity	Insulation Sheathing	
1	All	R30 to R49	R22 to R15	R13 to R15	None	R13
2	Gas, oil, heat pump Electric furnace	R30 to R60	R22 to R38	R13 to R15	None	R13 R19-R25
3	Gas, oil, heat pump Electric furnace	R30 to R60	R22 to R38	R13 to R15	None R2.5 to R5	R25
4	Gas, oil, heat pump Electric furnace	R38 to R60	R30 to R38	R13 to R15	R2.5 to R6 R5 to R6	R25 to R30
5	Gas, oil, heat pump Electric furnace	R38 to R60	R30 to R38 R30 to R60	R13 to R15 R13 to R21	R2.5 to R6 R5 to R6	R25 to R30
6	All	R49 to R60	R30 to R60	R13 to R21	R5 to R6	R25 to R30
7	All	R49 to R60	R30 to R60	R13 to R21	R5 to R6	R25 to R30
8	All	R49 to R60	R30 to R60	R13 to R21	R5 to R6	R25 to R30

Source: www.certainteed.com

Prototype Design Requirements Cont.

- Estimate Walmart Insulation
  - Walls - R14 (3.5 in thick)
  - Ceiling - R34
  - Floors - R27

- Prototype Insulation Selected
  - Cork (Roll)
    - Thickness = 3/32 inch
    - R value approx. = 3.6 per inch
    - Our R value = 0.3375

Prototype Design Requirements Cont.

- Approximated Prototype Dimensions
  - Interior Dimensions: 4.5ft x 4.5ft x 0.65ft
    - Using dimension scale of

      (3/32in)/3.5in = 0.026
    - Using R scale of

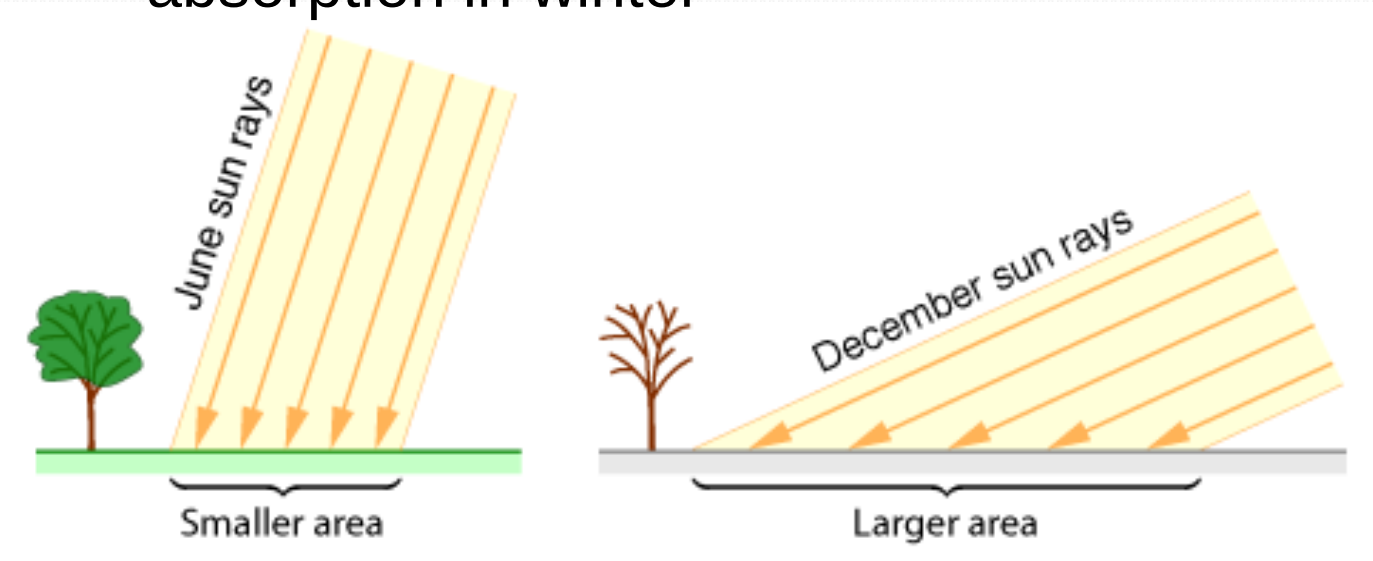
      0.3375/14 = 0.024

Prototype Design Requirements Cont.

- For all Prototypes:
  - Must include heating/cooling system
    - Use to keep interior constantly at 70 F
    - Be able to measure power consumption
  - Measure/Record Interior Temperature
    - Every 10 min
    - Without opening Prototype

Prototype Design Requirements Cont.

- For Only Passive Prototype:
  - Reflective Panels must be at optimum angle
    - Angled to allow reflection in summer and absorption in winter



Source: http://physics.weber.edu

Prototype Design Requirements Cont.

- Also based on latitude of location
  - Flagstaff latitude: 35.1992° N
    - Average sun angles between:
      - Spring and Summer: 66.5508°
      - Fall and Winter: 43.0508°

      Recommended passive panel angel: ***43°***

Prototype Design Requirements Cont.

- Sun moves from a southern position to a more northern position from winter to summer
  - Panels should be pointed at a southeastern angle for winter absorption

Prototype Design Requirements Cont.

- For Only Active Prototype:
  - Reflective Panels must rotate automatically to correct angle throughout the day
    - Angle to allow reflection in summer and absorption in winter
      - Based on Flagstaff latitude: 35.1992^{o} N

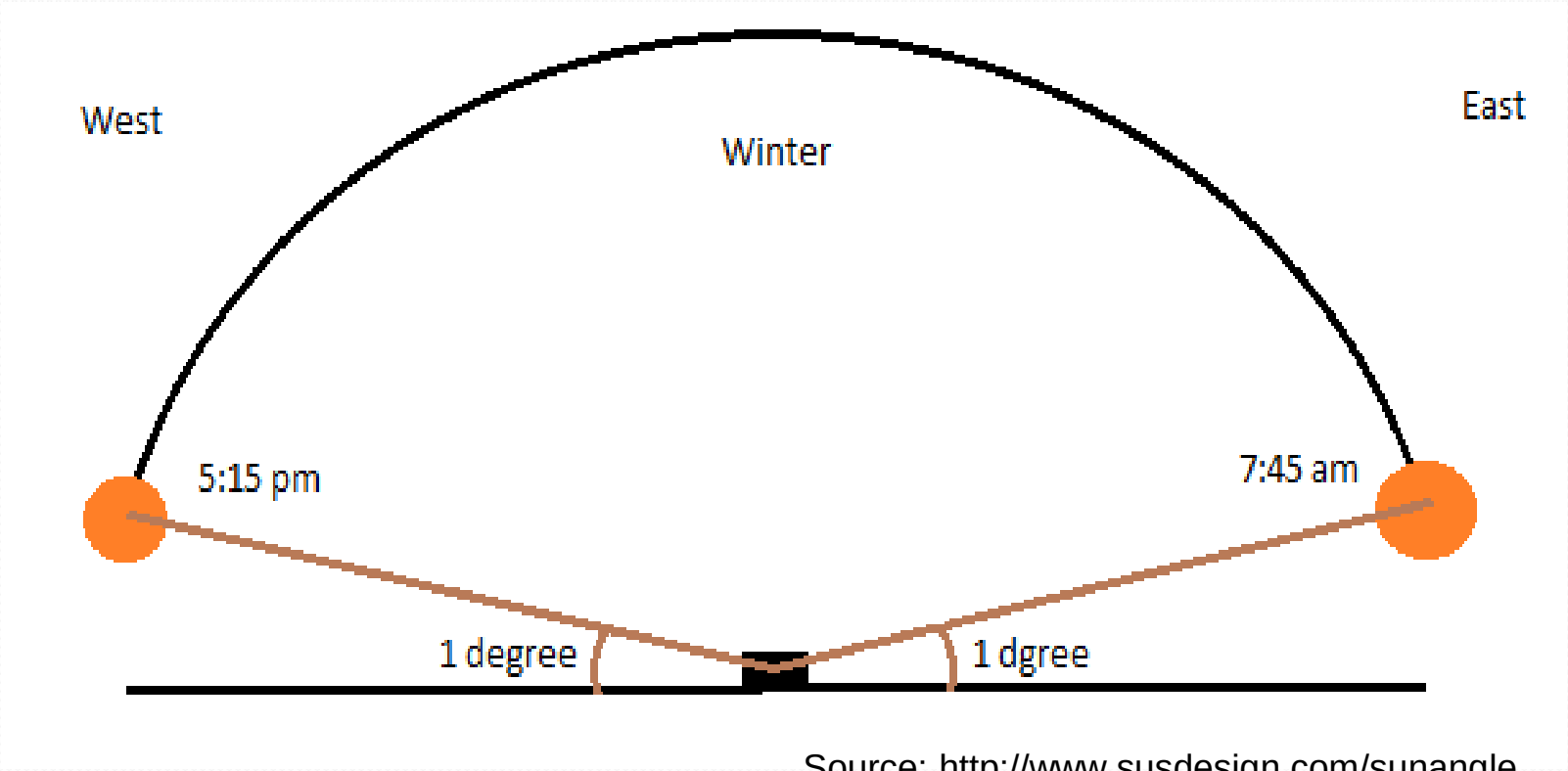
Prototype Design Requirements Cont.

- Average Sunrise and Sunset Times for each Season Based on Flagstaff

Season	Average Sunrise Time	Average Sunset Time
Winter	7:45 am	5:15 pm
Spring	6:45 am	6:30 pm
Summer	5:20 am	7:30 pm
Fall	6:20 am	6:20 pm

Prototype Design Requirements Cont.

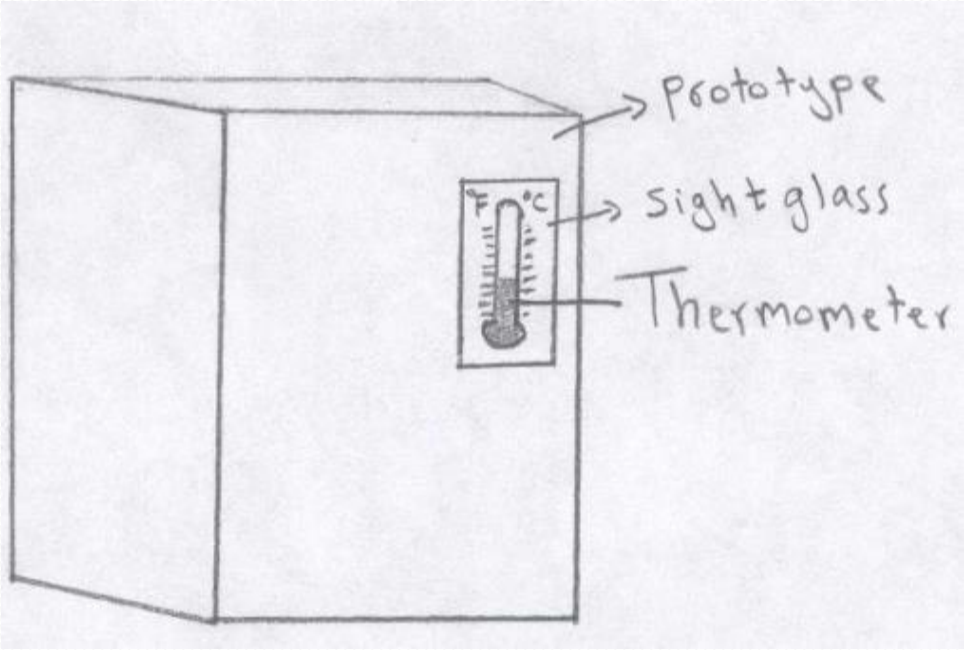
- Ex. Sunrise and Sunset Angle Based on Flagstaff



Source: http://www.susdesign.com/sunangle

Internal Temperature Measurements

- **Manual Data**



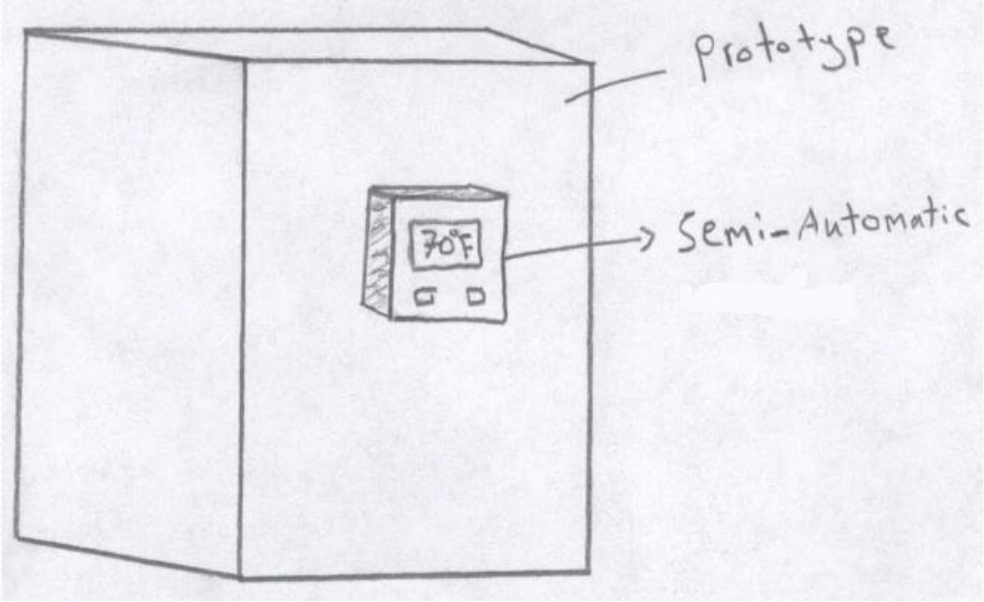
  - Advantage
    - Inexpensive
  - Disadvantage
    - Not accurate
    - Time consuming

    - Manually read and record internal thermostat temperature

Internal Temperature Measurements Cont.

- **Semi-Automatic**

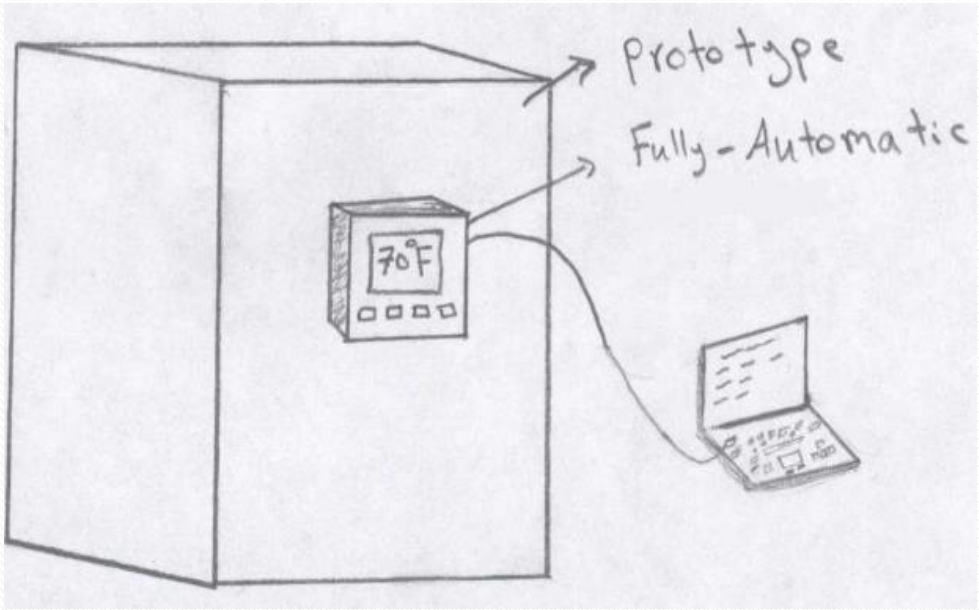
  - Advantage
    - Accurate
    - Inexpensive
  - Disadvantage
    - Time comsuming



    - Use device that constantly reading temperature & manually record

Internal Temperature Measurements Cont.

- **Fully Automatic**



  - Advantage
    - Accurate
  - Disadvantage
    - Expensive

    - Use device that can be programmed to read and record the temperature

Internal Temperature Measurements Cont.

- Internal Temperature Measurements Decision Matrix Criteria
  - Accuracy
  - Ease of Construction
  - Response Time
  - Cost
  - Automatic Data Output

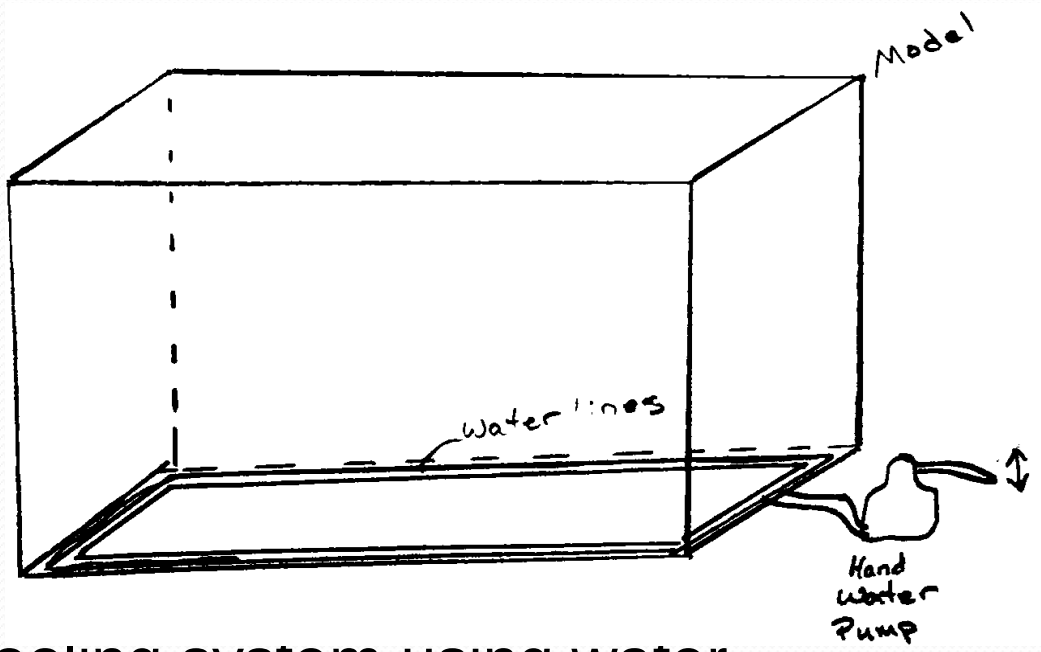
Internal Temperature Measurements Cont.

- Internal Temperature Measurements Decision Matrix

		Designs		
Criteria	**Weight**	**Manual Data**	**Semi-Automatic**	**Fully Automatic**
Accuracy	9	4x9 = 36	9x9 = 81	10x9 = 90
Ease of Construction	7	7x7 = 49	5x7 = 35	7x7 = 49
Response Time	4	5x4 = 20	7x4 = 28	10x4 = 40
Cost	10	9x10 = 90	6x10 = 60	4x10 = 40
Automatic Data Output	8	0x8 = 0	7x8 = 56	10x8 = 80
	TOTAL	195	260	299

Internal Heating and Cooling System

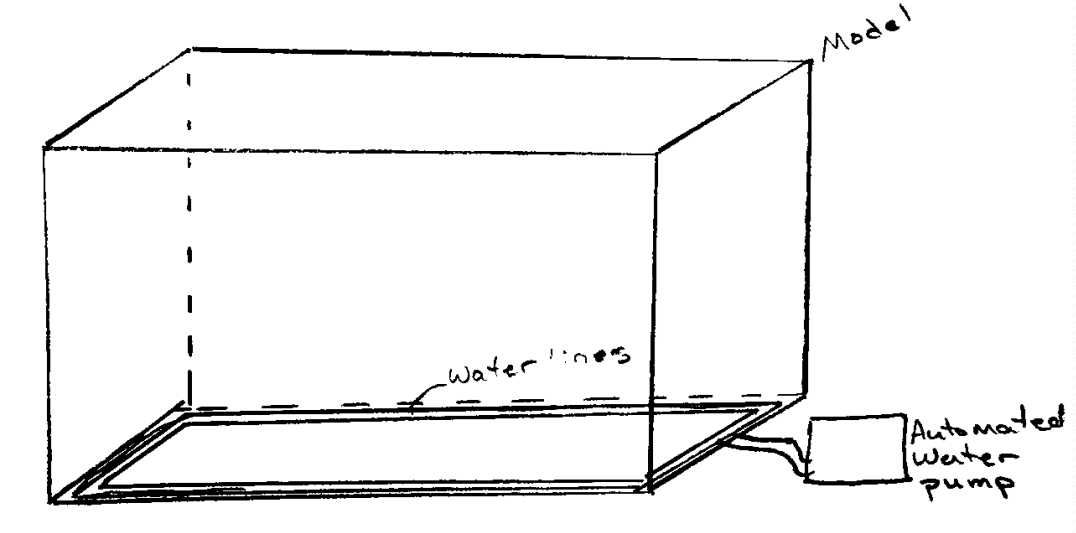
- **Manual Control**



  - Heating/cooling system using water
  - Manually controlled by and pump or crank

Internal Heating and Cooling System Cont.

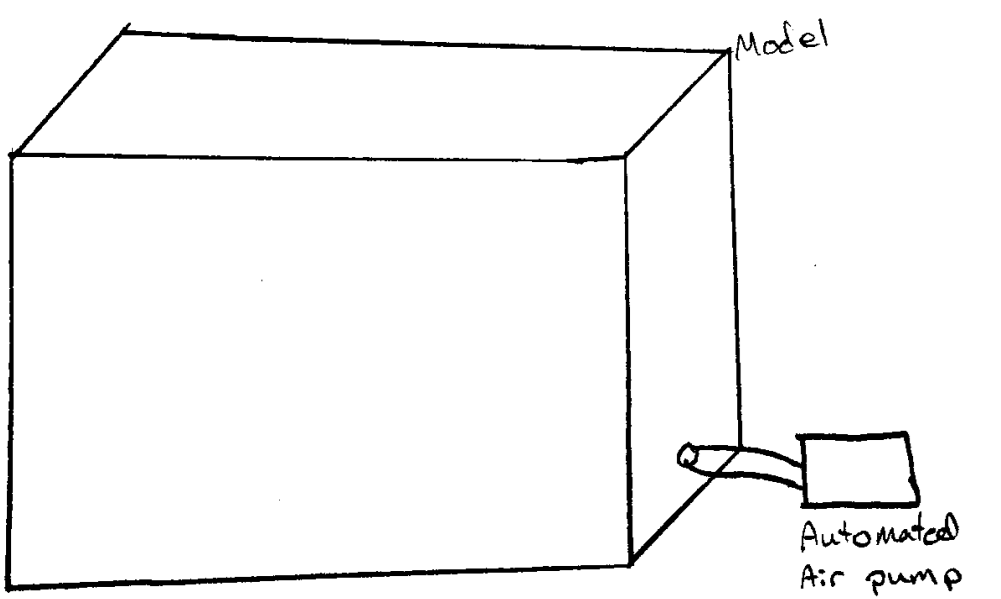
- **Automated Water**



  - Automated heating/cooling system using water
  - Programmed device controls heating/cooling

Internal Heating and Cooling System Cont.

- **Automated Air**



  - Automated heating/cooling system using air
  - Program device to pump hot/cold air
  - Similar to A/C

Internal Heating and Cooling System Cont.

- Internal Heating and Cooling System Decision Matrix Criteria
  - Accuracy
  - Ease of Use
  - Efficiency
  - Cost
  - Data Collections

Internal Heating and Cooling System Cont.

- Internal Heating and Cooling System Decision Matrix

		Designs		
Criteria	**Weight**	**Hand Pump**	**Water Pump**	**Air Flow**
Accuracy	7	4x7 = 28	9x7 = 63	10x7 = 70
Ease of Use	6	6x6 = 36	8x6 = 48	8x6 = 48
Efficiency	6	3x6 = 18	8x6 = 48	10x6 = 60
Cost	10	3x10 = 30	6x10 = 60	8x10 = 80
Data Collections	8	0x8 = 0	7x8 = 56	9x8 = 72
	TOTAL	112	275	330

Control Systems

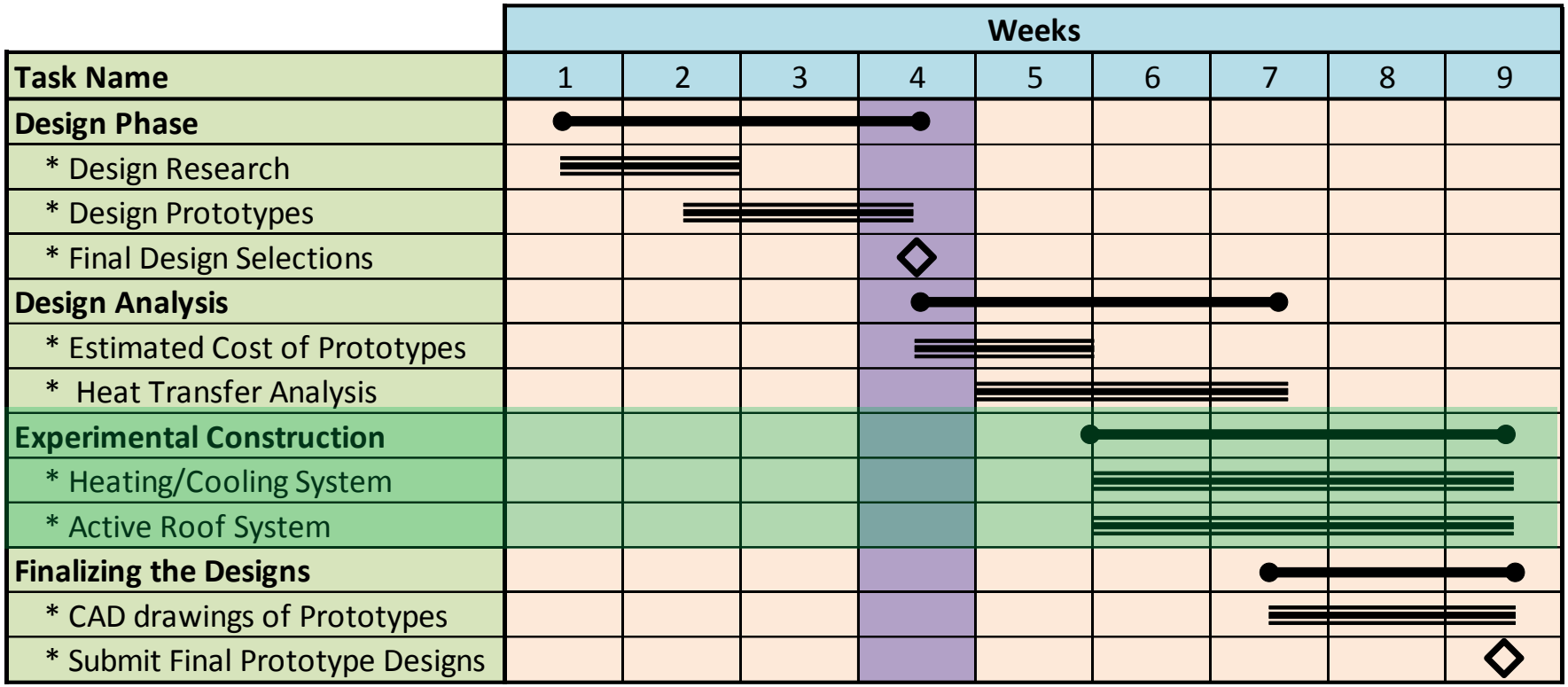
- Two arduino board control systems
  - 1 ~ Programmed to turn on and off a motor that will rotate the refective panels on active roof design
    - Panels will be attached on one shaft mechanism and a motor will rotate them simultanteous
  - 2 ~ Recieves interior temperature measurements and switiching on or off the heating or cooling system accordingly.

Control Systems Cont.

- Benefits:
  - Easy to connect
  - Easy to program
  - Inexpensive

Changes to Timeline and Progress

Detailed Fall Timeline (Design & Initial Construction)



Conclusions

- Building 3 prototype based on small Wal-mart size
  - Each will have different roof design: Active, Passive, Control
  - Interior Dimensions: 4.5ft x 4.5ft x 0.65ft
  - Scale factor based on chosen prototype insulation
    - 3/32 inch Cork
- For passive roof system
  - Recommended panel angel: 43°

Conclusions Cont.

- For active roof system
  - Based on Flagstaff's
    - Angle of sunrise and sunset
    - Average time for sun rise and set for each season
- Plan to use these internal systems
  - Internal Temperature Measurement System
    - Fully-Automatic temperature recorder
  - Heating and Cooling System
    - Automated Air

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