Team 10: Climatic Camera

Design Review V

Nash Bonaventura
Diego Gonzalez
Bryce Shumaker

Team Introductions

Diego Gonzalez
Design Engineer

Nash Bonaventura
Simulation Engineer

Bryce Shumaker
Project Manager

Stakeholders

Engineering Mentor
Kourosh Shoele, Ph.D.
Assistant Professor
FAMU-FSU College of Engineering

Sponsor
Vinayak Hegde,
Reliability Engineering Manager
Danfoss Turbocor Compressors, Inc.

Objective

The objective of the project is to design a product that will maintain operation of a recording device at extreme temperatures (-40 to 160 °C)

(-40 to 320 °F)

Diego Gonzalez

Background

- Air compressor manufacturer
- Components tested by reliability engineering department
- Components are tested using cyclic temperature tests
- Test Temperature range (-40 to 160 °C)
- Cameras operates between 0 and 45 °C

Diego Gonzalez

Customer Needs

Customer Statement	Interpreted Need
Test goes 24/7 until failure	The device provides continuous monitoring
Temperature ranges from -40 to 160 °C. Relative Humidity ranges from 10 to 90%	The device operates within the parameters of the test
Would like the device to be adjustable to different positions	The device can be adjusted to different orientations
I want to use an existing camera and make it work under the test conditions	The device is isolated from the testing environment
USB connection preferably	The device has computer connection capabilities

Diego Gonzalez

Markets

Primary Market

- Danfoss Turbocor Compressors, Inc.

Secondary Market

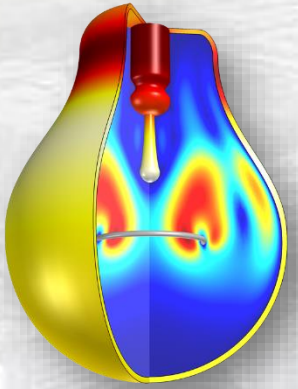
- Other Users/Manufacturers
- Aerospace
- Research
- Marine

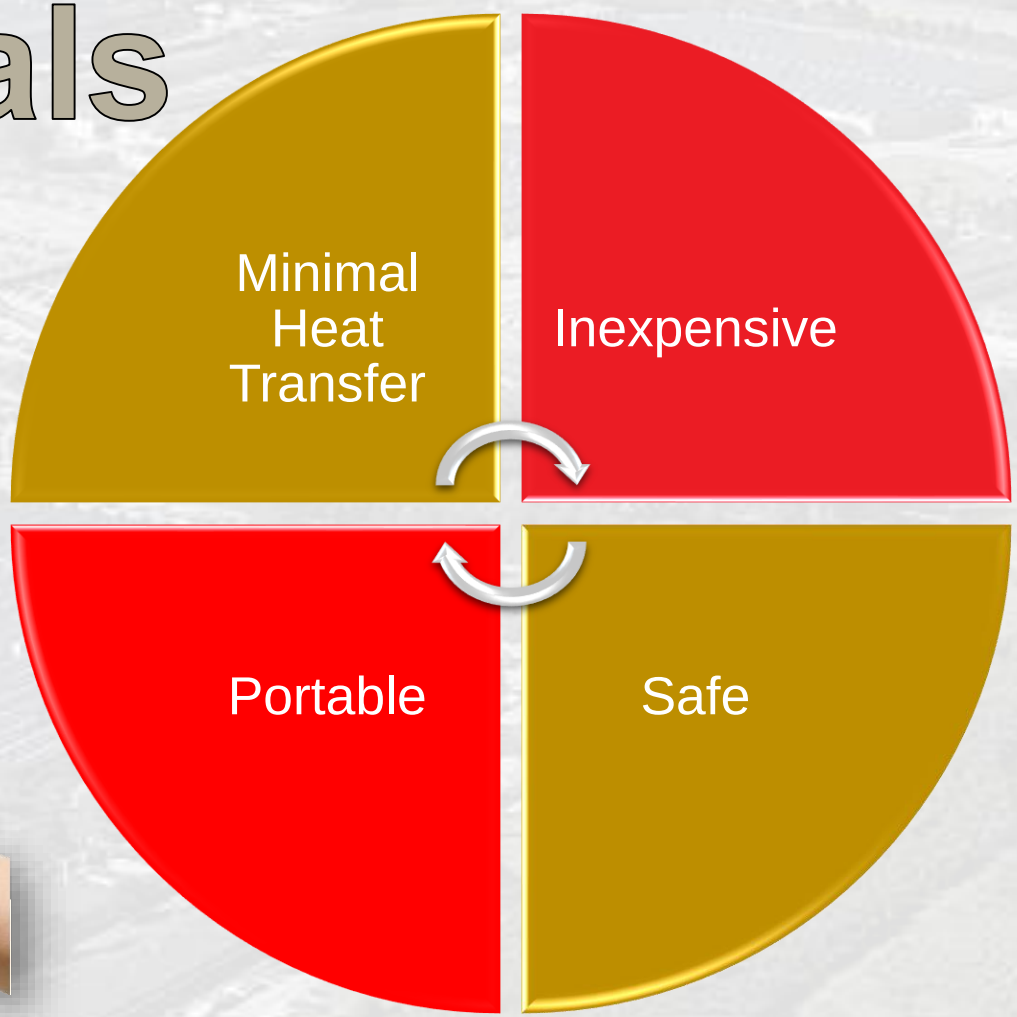
NSF

MARINE EDUCATION & RESEARCH SOCIETY

Diego Gonzalez

Key Goals

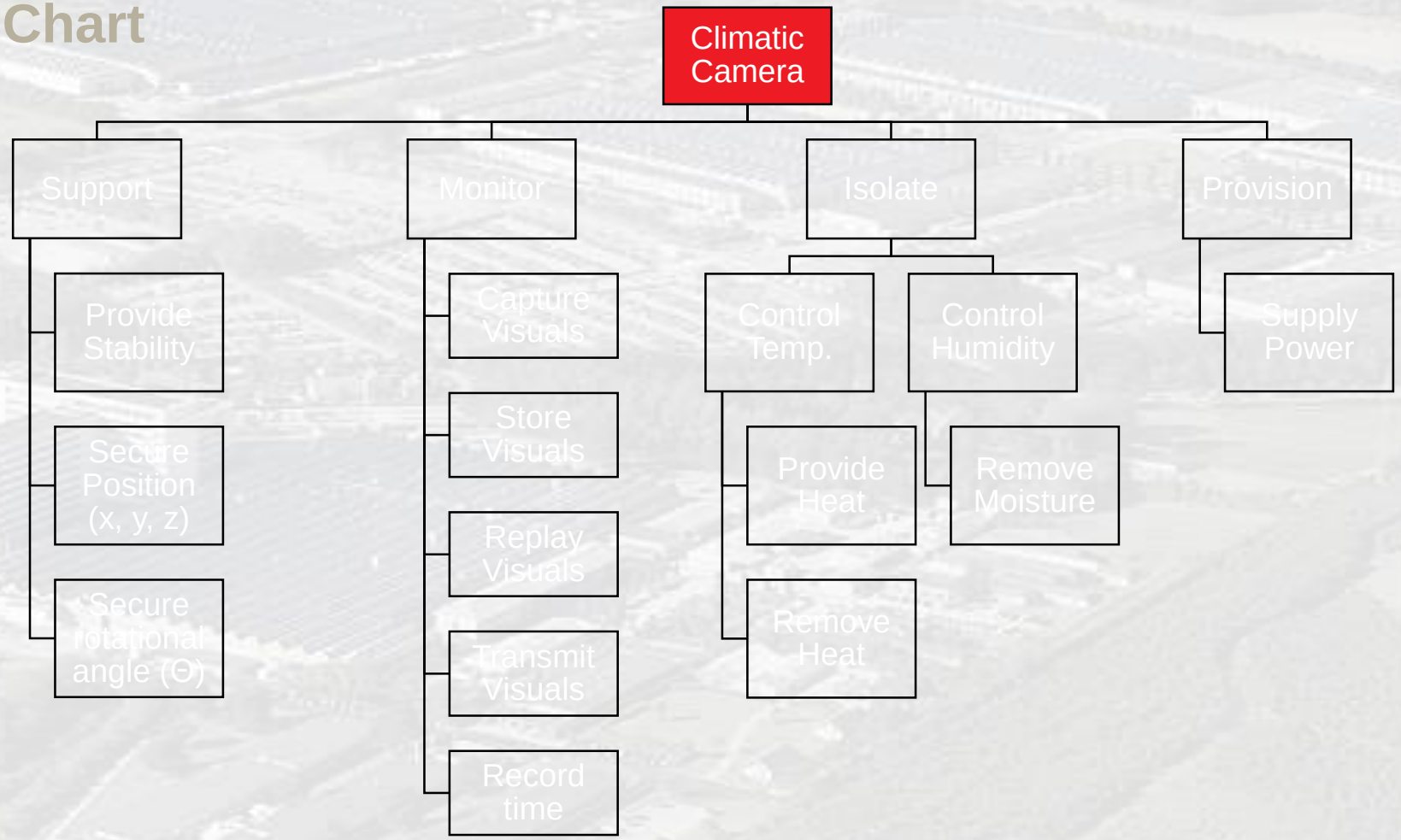




Diego Gonzalez

Functional Decomposition

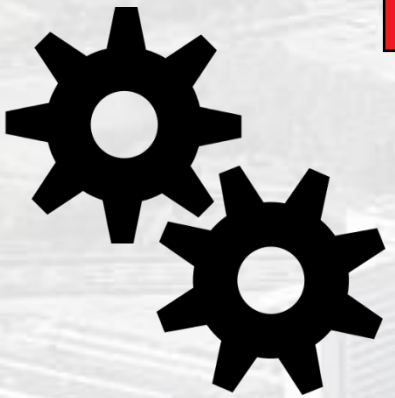
Hierarchy Chart

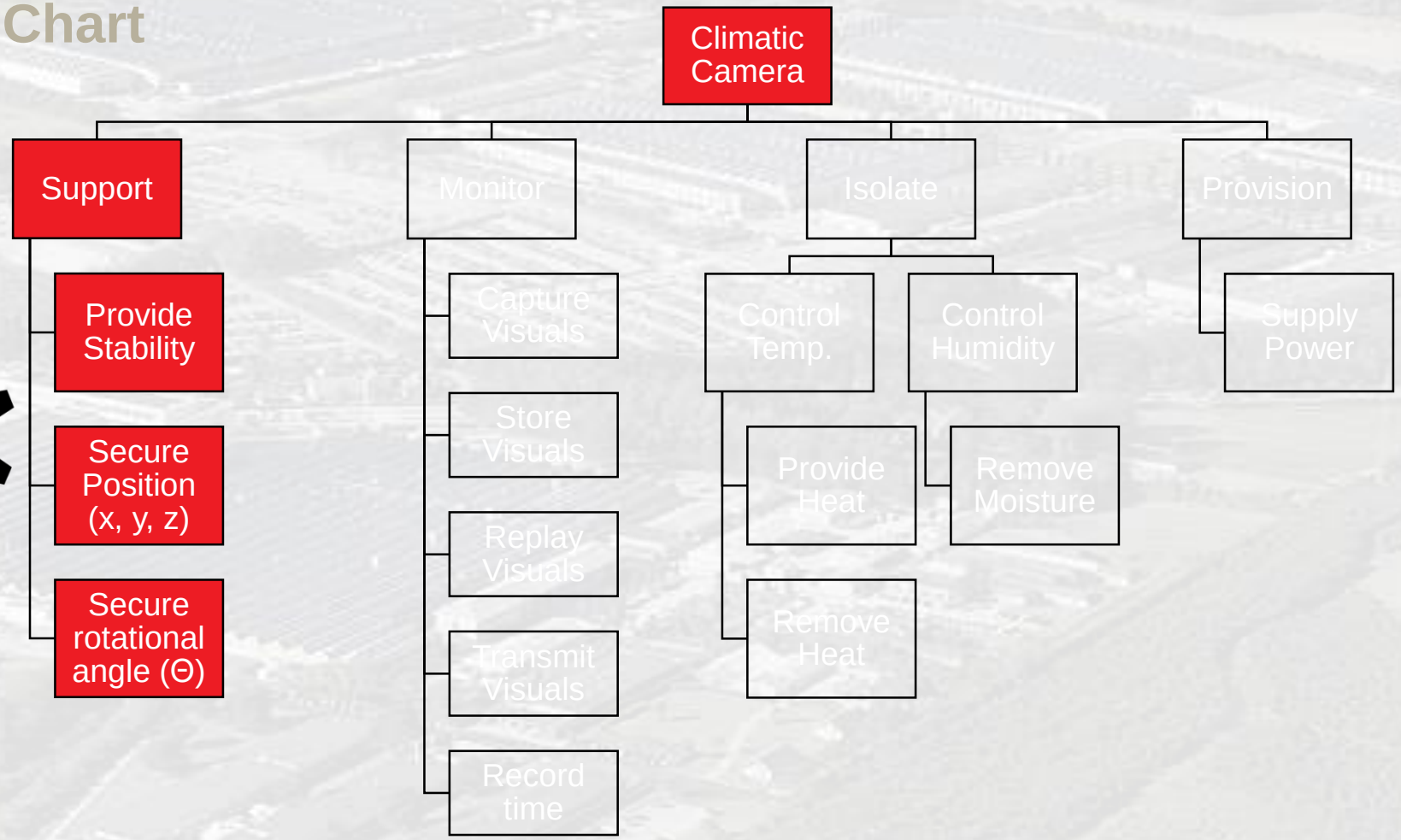


Diego Gonzalez

Functional Decomposition

Hierarchy Chart

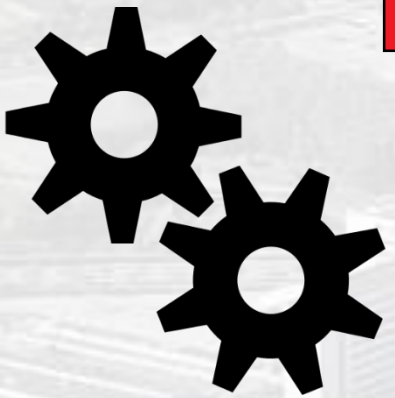




Diego Gonzalez

Functional Decomposition

Hierarchy Chart

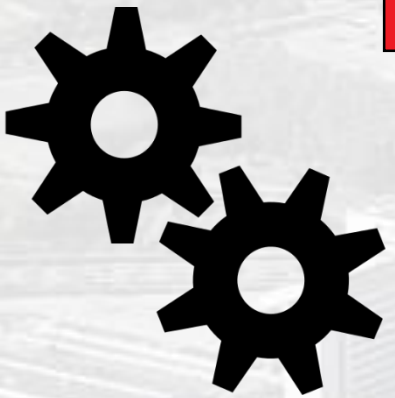


- Climatic Camera
  - Support
    - Provide Stability
    - Secure Position (x, y, z)
    - Secure rotational angle (Θ)
  - Monitor
    - Capture Visuals
    - Store Visuals
    - Replay Visuals
    - Transmit Visuals
    - Record time
  - Isolate
    - Control Temp.
      - Provide Heat
      - Remove Heat
    - Control Humidity
      - Remove Moisture
  - Provision
    - Supply Power

Diego Gonzalez

Functional Decomposition

Hierarchy Chart

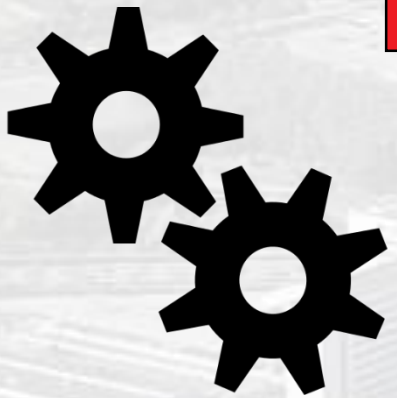


- Climatic Camera
  - Support
    - Provide Stability
    - Secure Position (x, y, z)
    - Secure rotational angle (Θ)
  - Monitor
    - Capture Visuals
    - Store Visuals
    - Replay Visuals
    - Transmit Visuals
    - Record time
  - Isolate
    - Control Temp.
      - Provide Heat
      - Remove Heat
    - Control Humidity
      - Remove Moisture
  - Provision
    - Supply Power

Diego Gonzalez

Functional Decomposition

Hierarchy Chart



- Climatic Camera
  - Support
    - Provide Stability
    - Secure Position (x, y, z)
    - Secure rotational angle (Θ)
  - Monitor
    - Capture Visuals
    - Store Visuals
    - Replay Visuals
    - Transmit Visuals
    - Record time
  - Isolate
    - Control Temp.
      - Provide Heat
      - Remove Heat
    - Control Humidity
      - Remove Moisture
  - Provision
    - Supply Power

Diego Gonzalez

Available Resources

- Compressed Air – temperature regulation
- Laptop – power supply, software interface, data storage
- Chamber Port – connection with auxiliary systems
- Racks – mounting
- Machine Shop

Diego Gonzalez

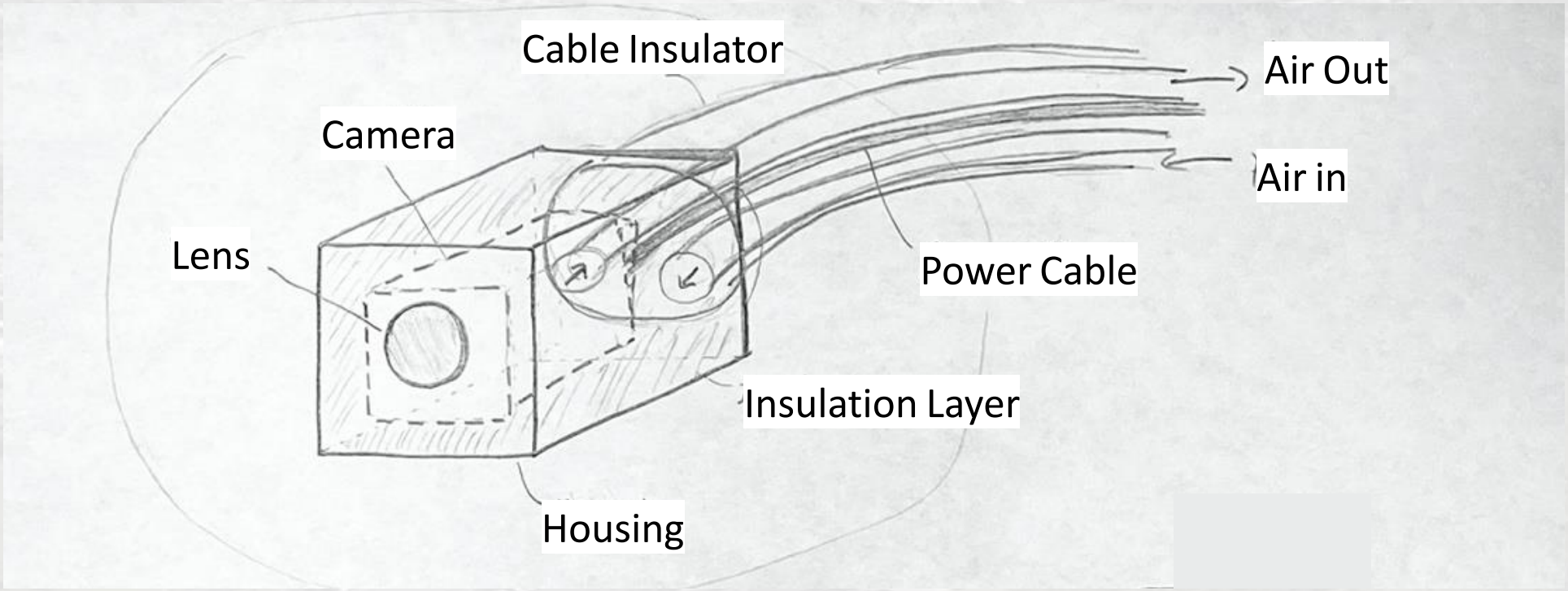
Current Problems

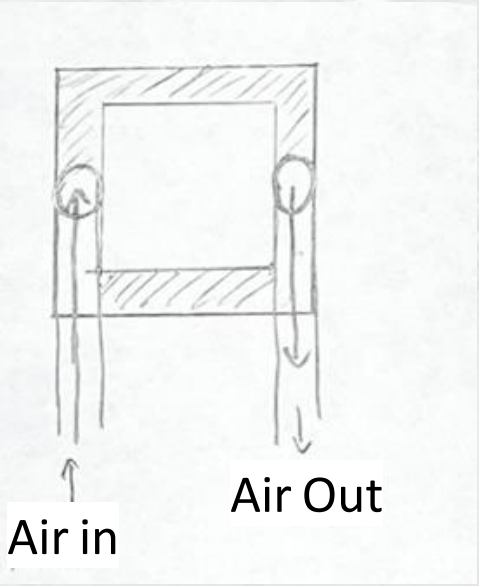
- Physical presence is necessary to monitor
- Window gets foggy and obstructs view
- Reflection from window
- Outside Visuals
  - Fixed viewing distance
  - Low reachability

Diego Gonzalez

Top Concepts

1. Compressed air, USB Borescope Camera

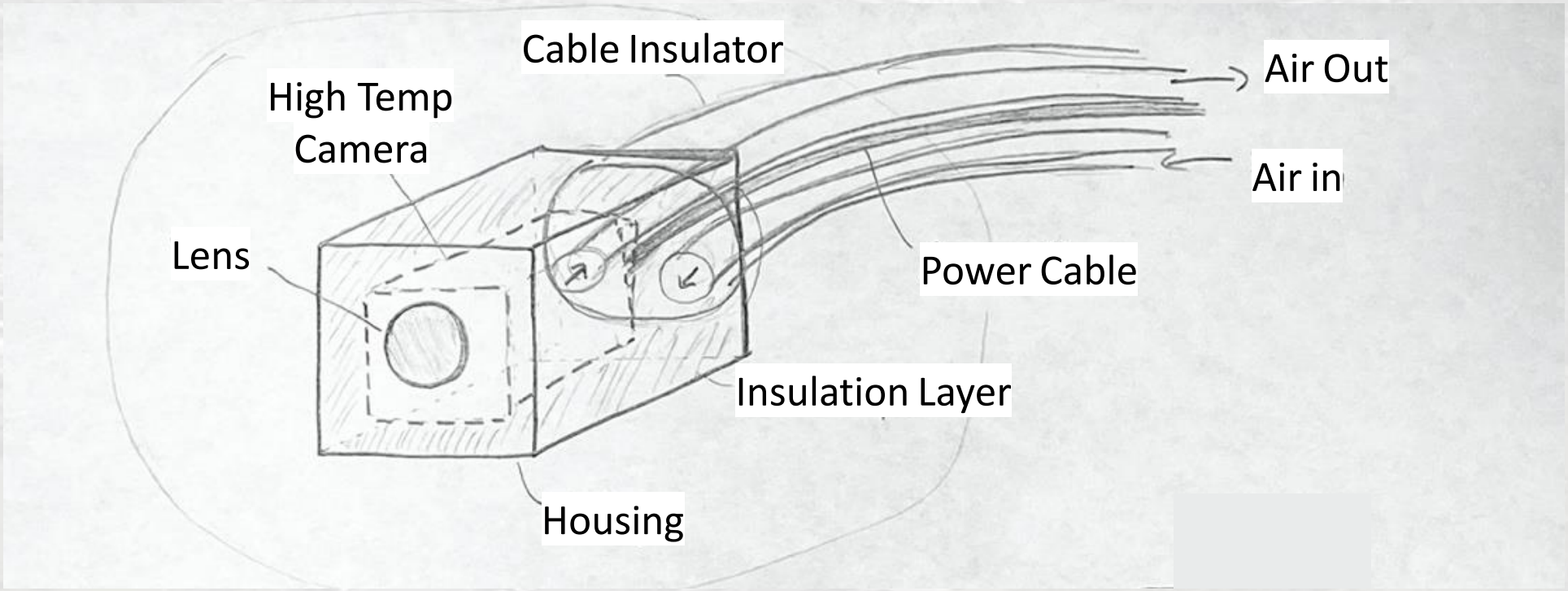


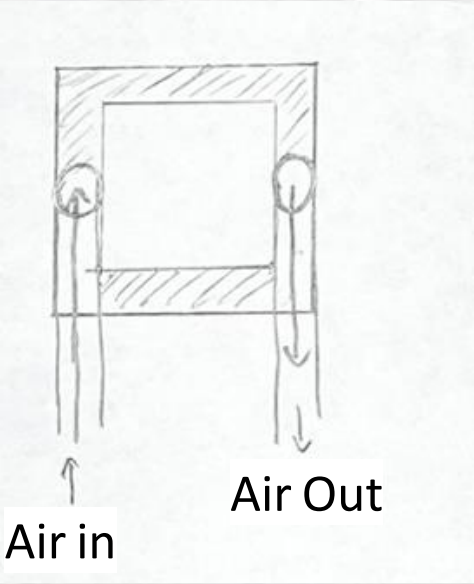


Diego Gonzalez

Top Concepts

2. Compressed air, High Temp Camera

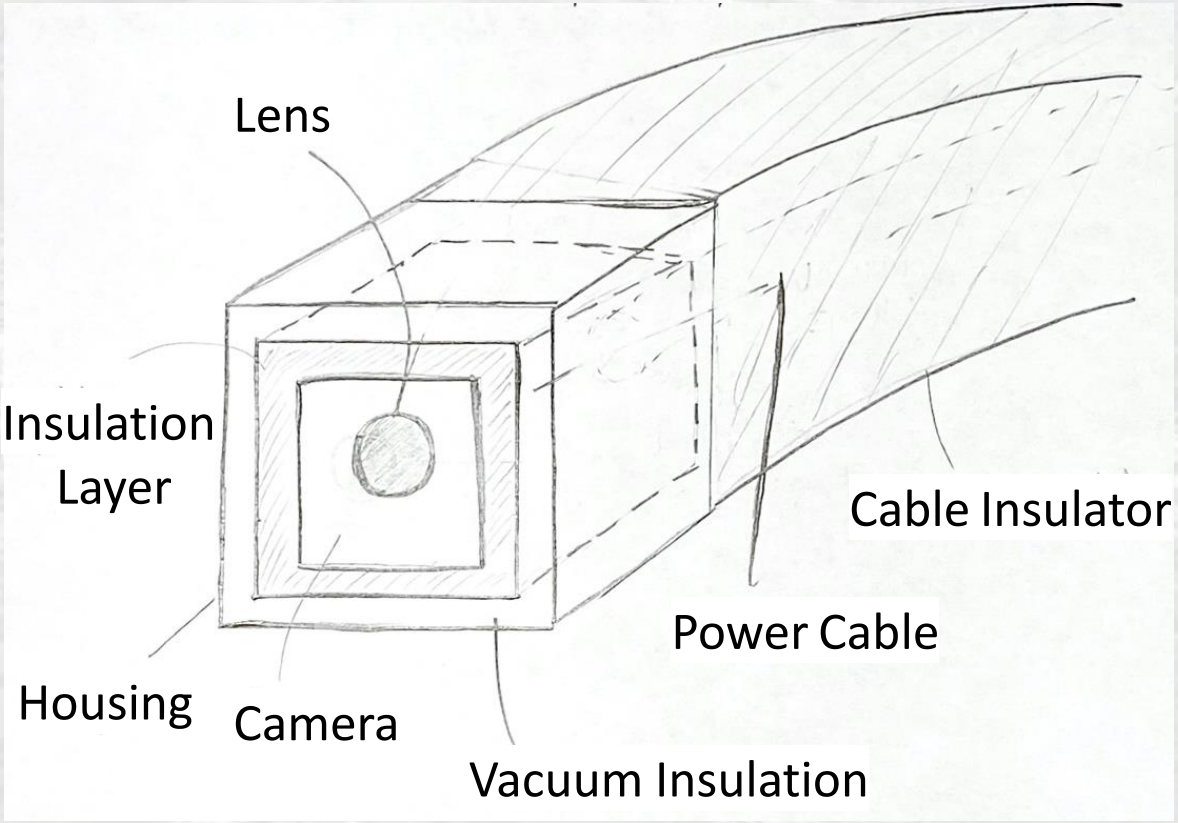




Diego Gonzalez

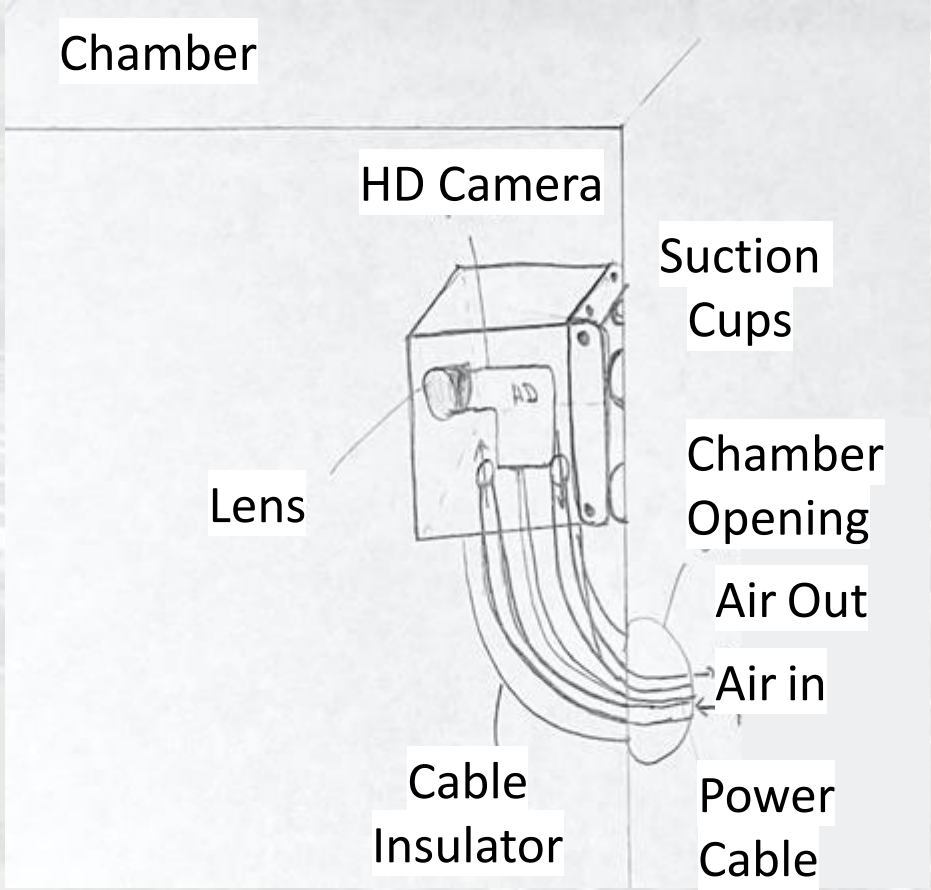
Top Concepts

2. Vacuum insulated, USB Borescope Camera



Diego Gonzalez

Top Concepts



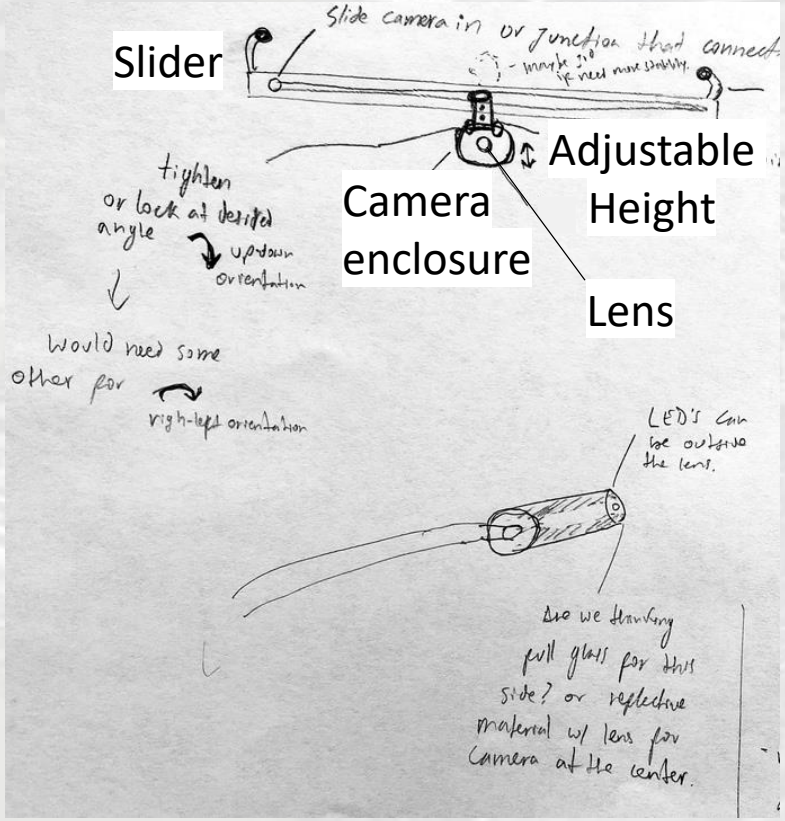
3. Compressed Air

+

Vacuum insulated USB Borescope Camera

Diego Gonzalez

Top Concepts



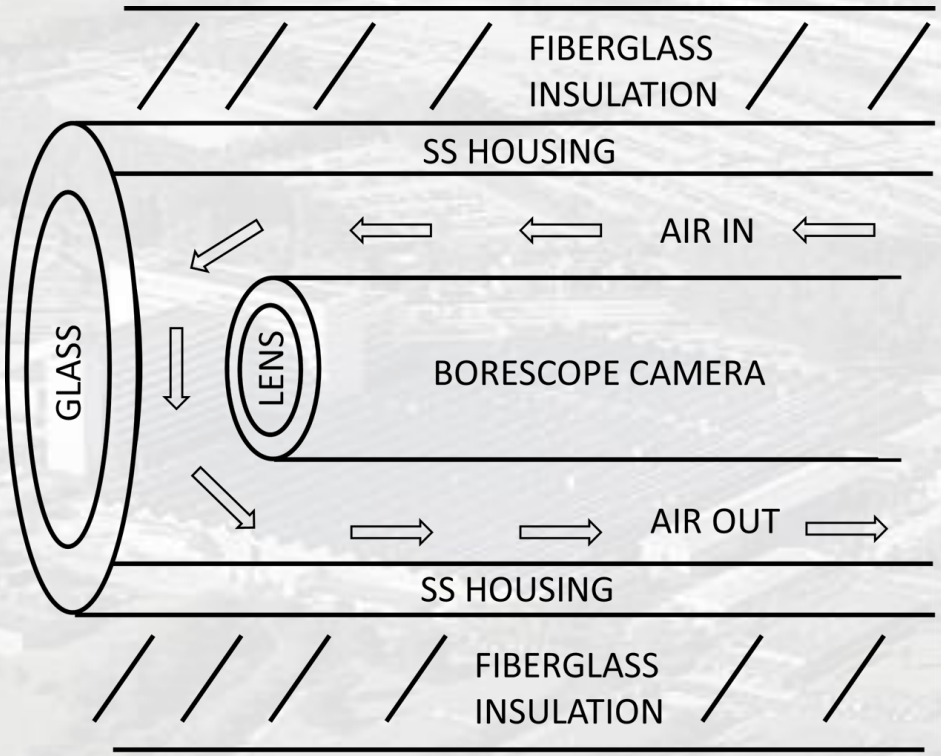
4. Compressed Air, Slider Linkage, HD Camera

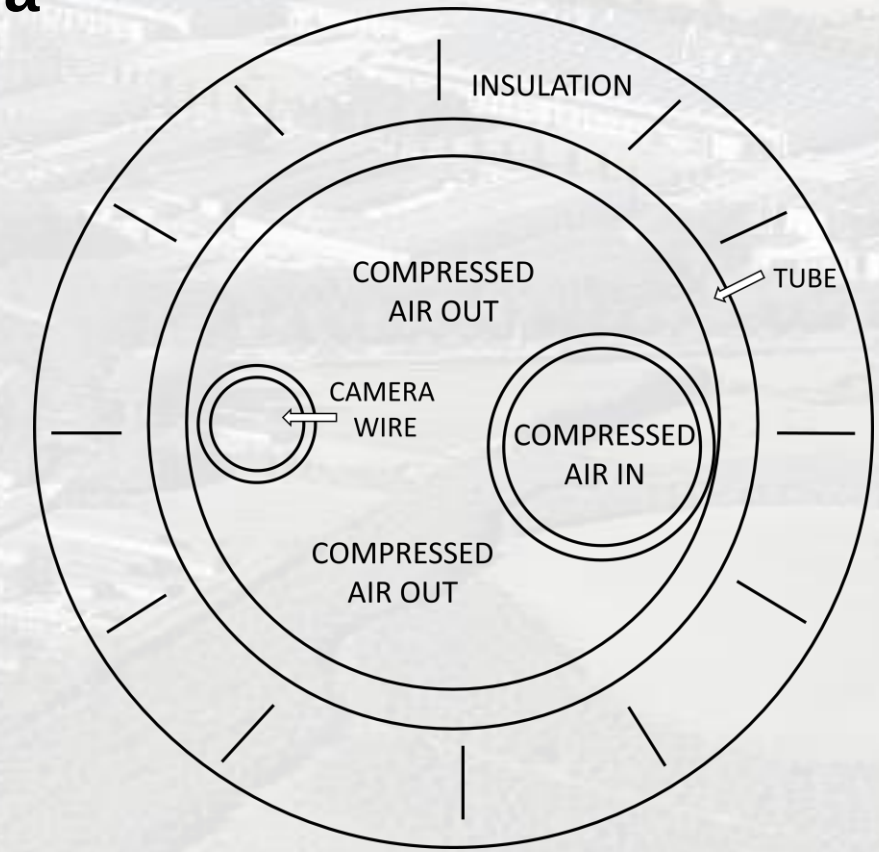
Use existing rack support to aid mobility of the design

Diego Gonzalez

Selected Design

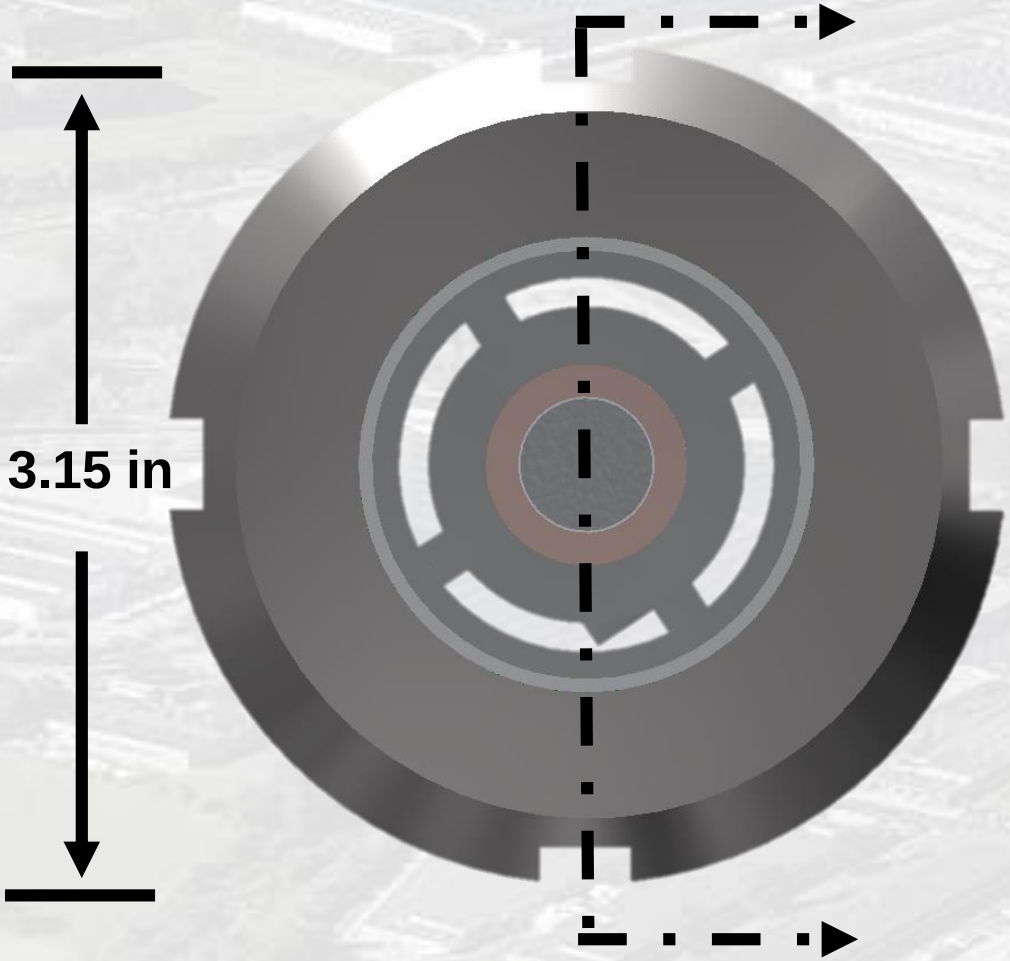
1. Compressed Air, USB Borescope Camera

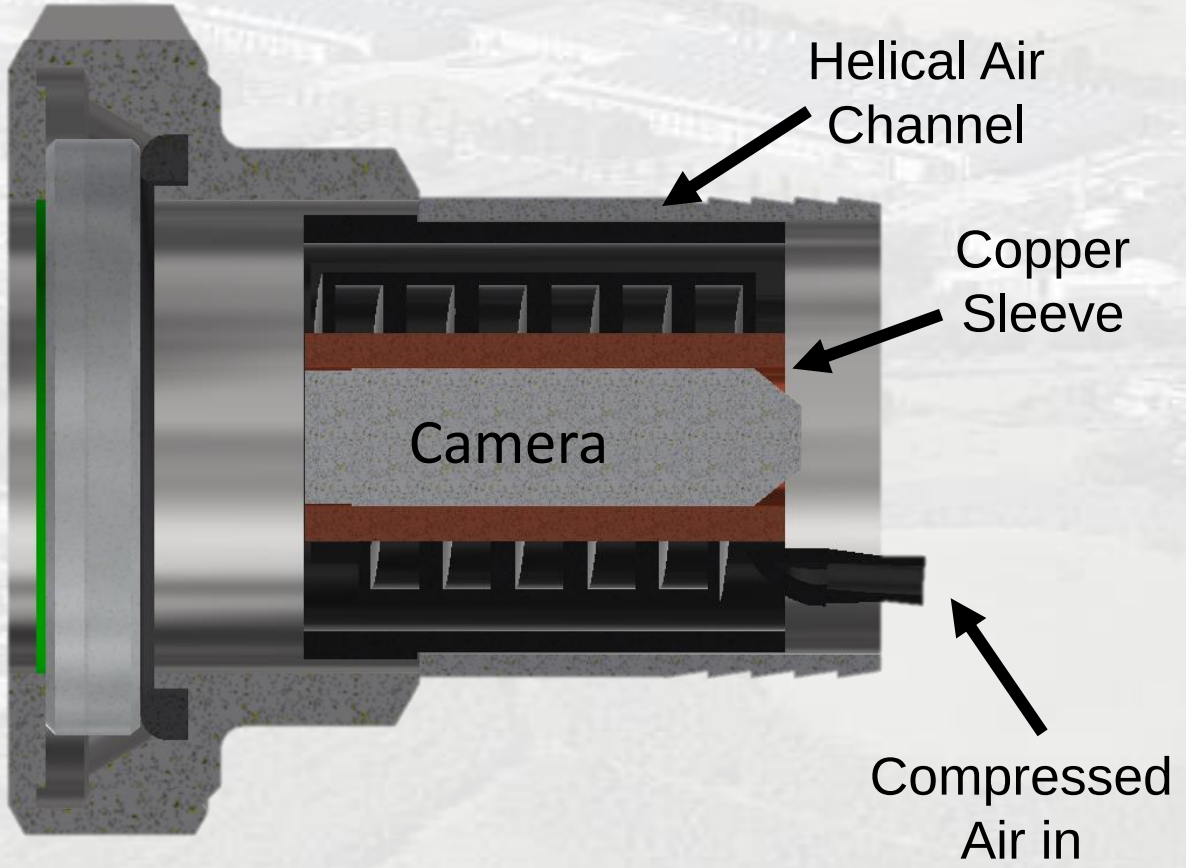




Bryce Shumaker

Detailed Design





Bryce Shumaker

Budgeting

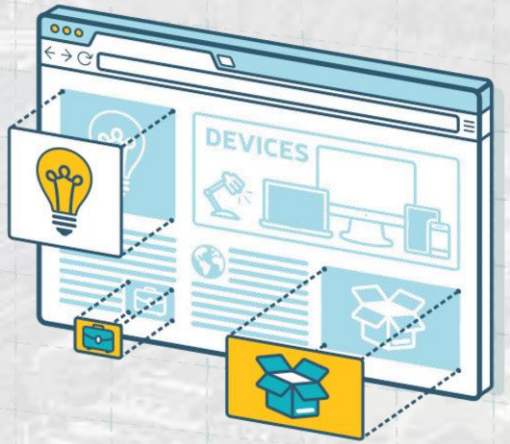
Item #	Item Description	$/unit	Quantity	$
1	Borescope Camera	$49.99	1	$49.99
2	Glass Housing	$22.52	1	$22.52
3	Housing Body	$12.22	1	$12.22
4	Clamp for Housing	$11.39	1	$11.39
5	Clamp Set	$11.90	1	$11.90
6	Goose Neck	$9.95	1	$9.95
7	Magnetic Base	$16.99	1	$16.99
8	Return Pipe Insulation	$47.92	1	$47.92
9	Return Air pipe	$0.50	60	$30.00
10	Anti-reflective Glass	$60.00	1	$60.00
11	Supply Air Hose	$2.95	1	$2.95
12	Desicant Air Dryer	$129.99	1	$129.99
13	Main Line to Supply Adapter	$2.99	2	$5.98
14	Copper Sleeve	$25.49	1	$25.49
			Total	**$437.29**

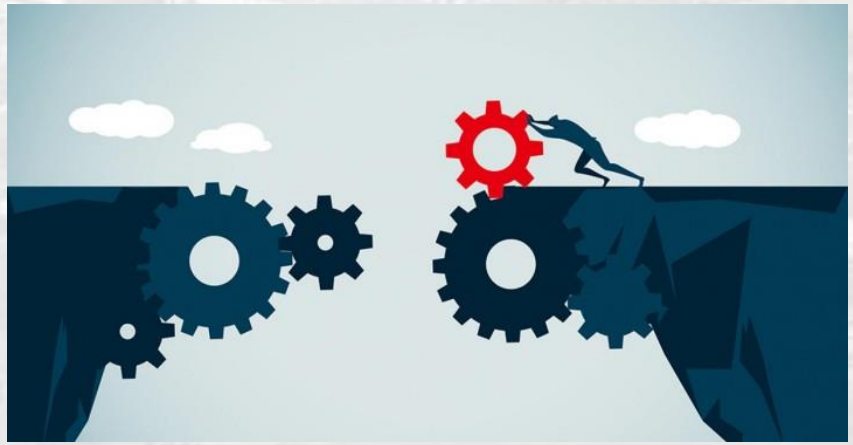
Items Received
Items Requested

Bryce Shumaker

Current Work

- Receive ordered materials from Danfoss
- Website
- Test individual components (Validation)
- Assemble prototype

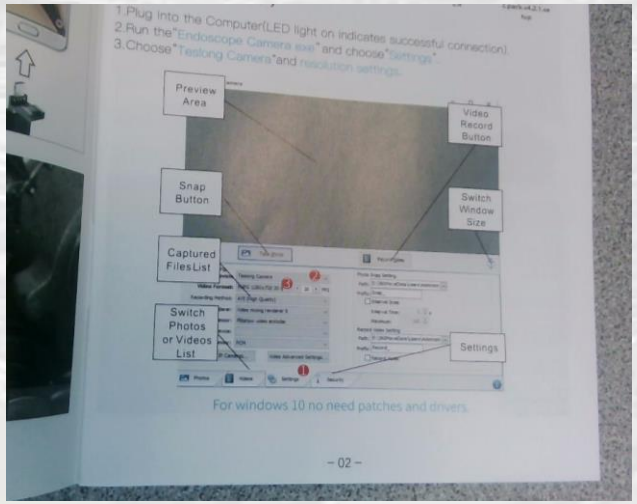




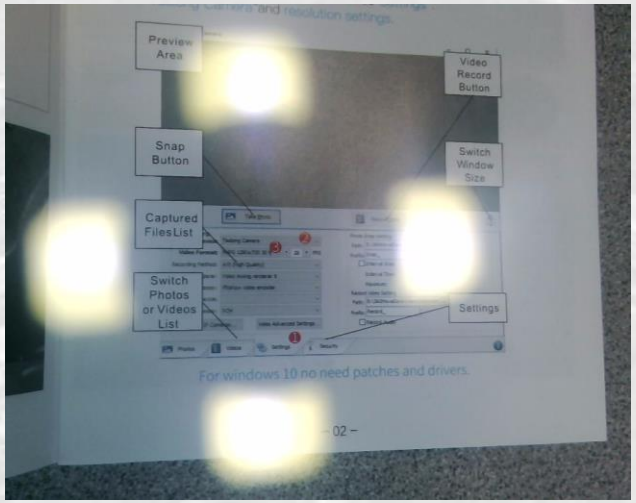
Bryce Shumaker

Current Design Problems

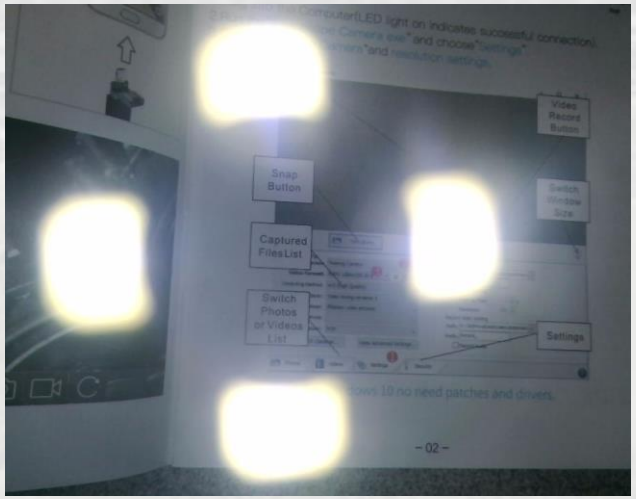
- Borescope camera LED light reflection in Glass
- Temperature failure detection
- Thickness of the insulation



LED's 0% Brightness



LED's 50% Brightness



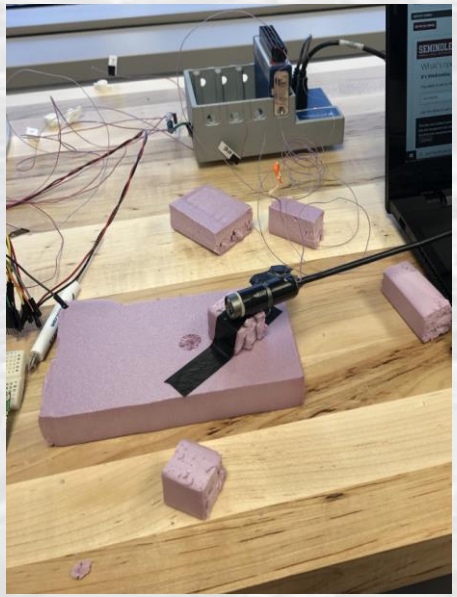
LED's 100% Brightness

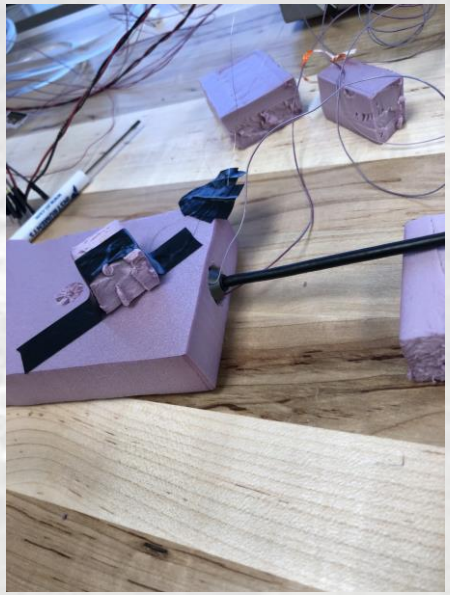
Bryce Shumaker

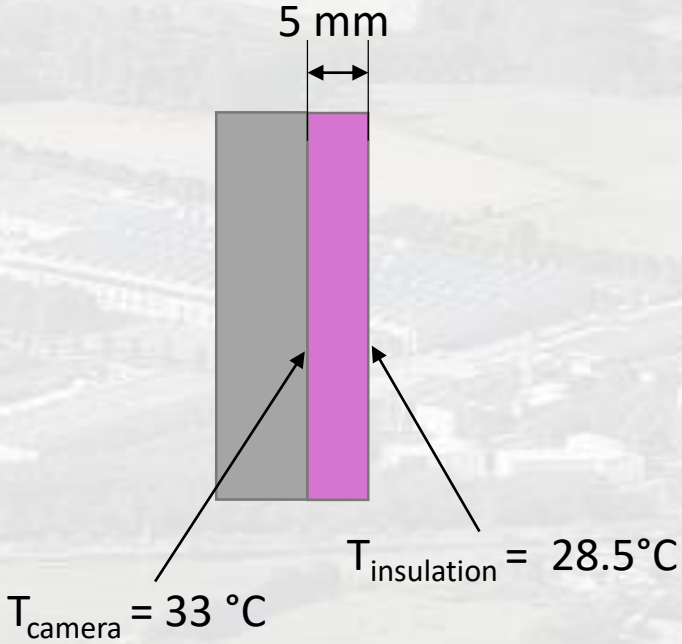
Validation

- Approximating camera heat generation with thermocouples

T_{max} = 33 °C







$$Heat\ Flux = \frac{Q}{A} = \frac{k\Delta T}{thickness}$$

= 27 W/m^2

Q = 27 W/m^2 x A_s ≈ 0.0025 W

Nash Bonaventura

Simulation

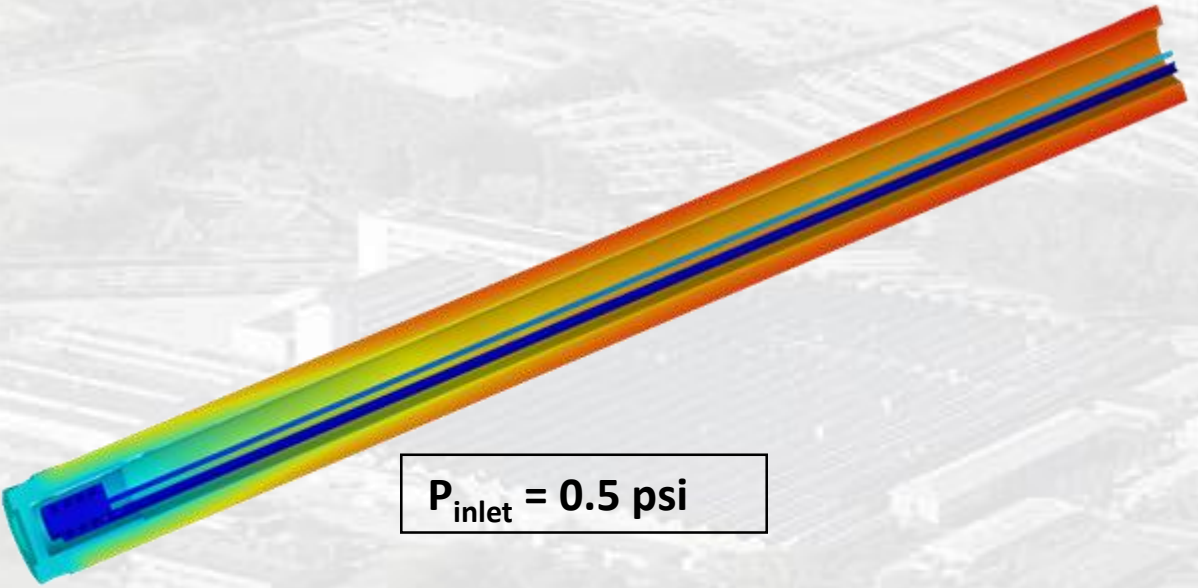
COMSOL Problem Setup

- Heat transfer simulated in steady-state
- L-VEL turbulence model
- Natural convection on exterior surfaces
- Pressure at the air inlet of the model tested at 0.5 psi and 1.0 psi
- Air entering the device at the inlet is at ambient temperature
- Heat generation of the camera is negligable

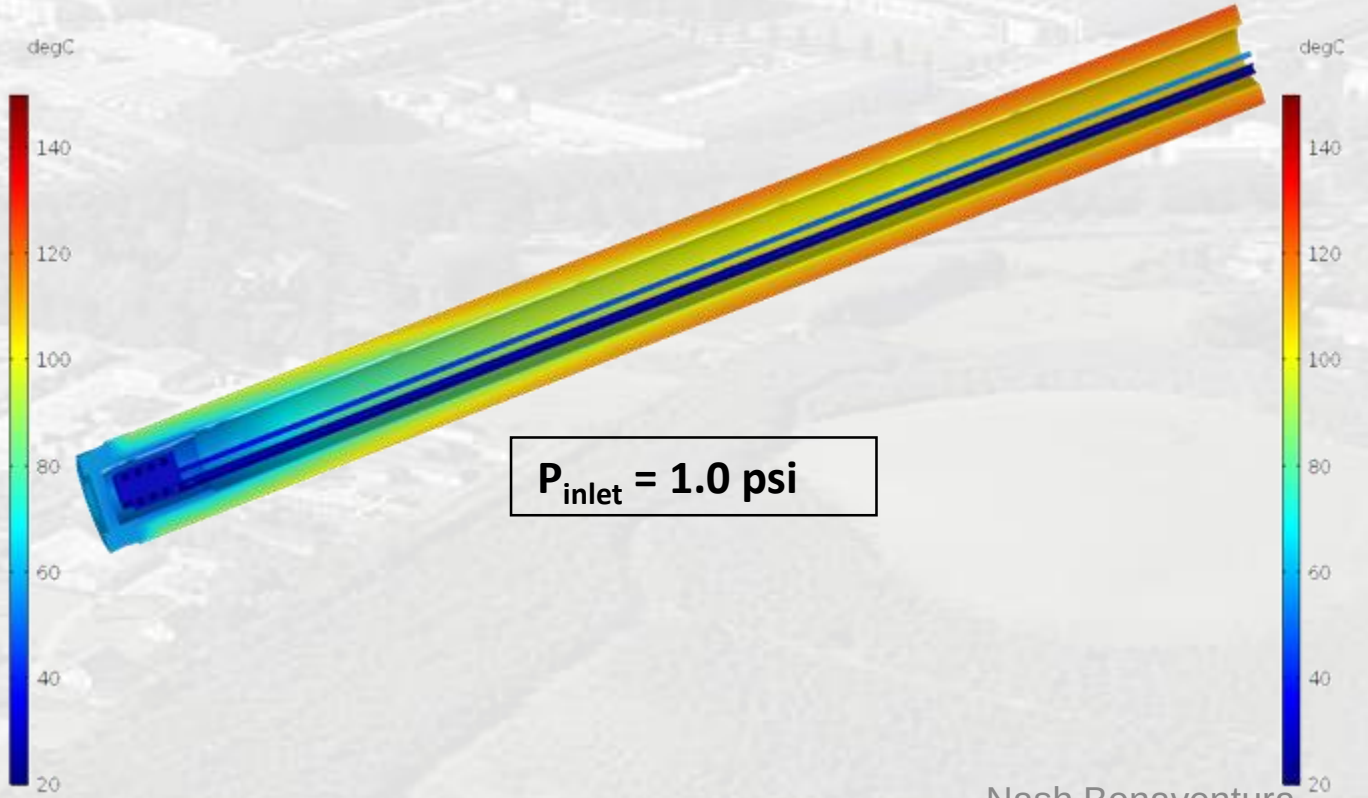
Nash Bonaventura

Simulation

$T_{chamber}$ = 160°C



P_{inlet} = 0.5 psi

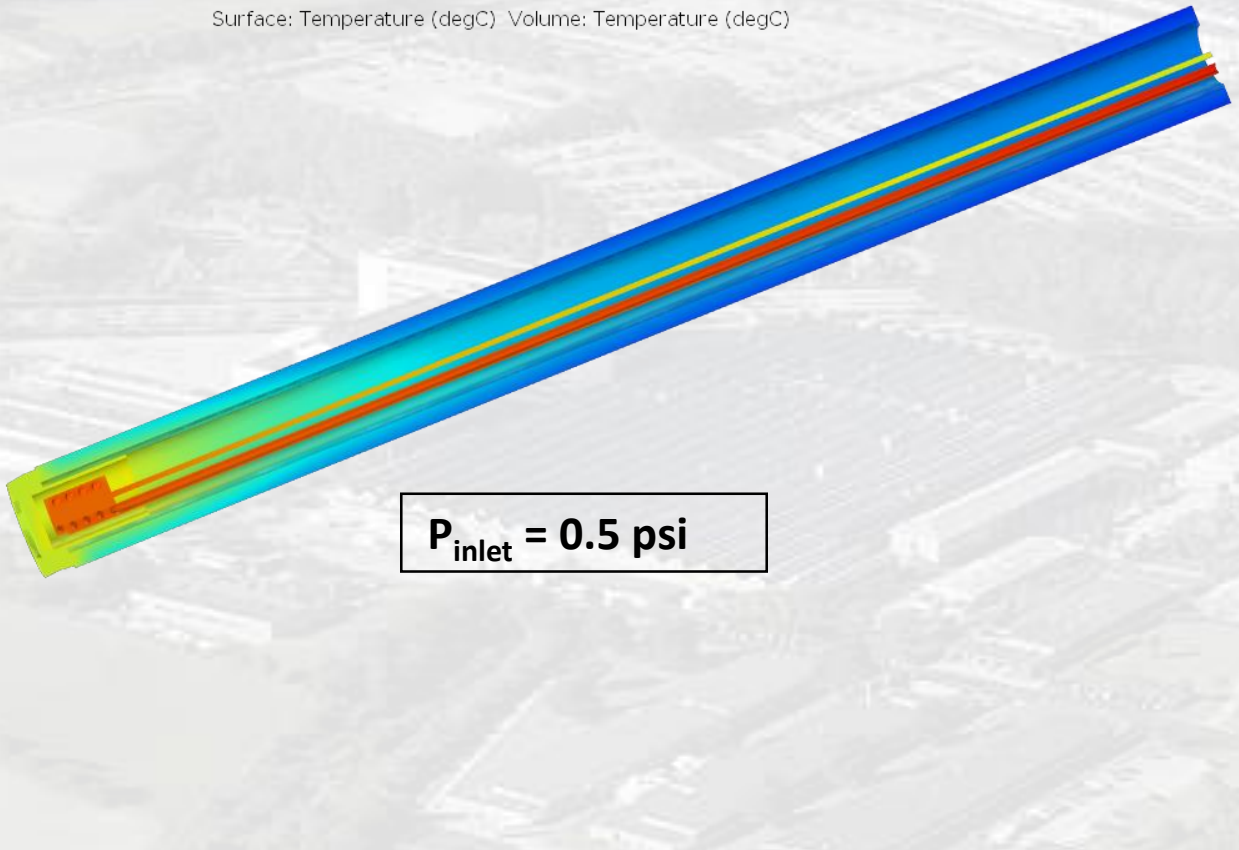


P_{inlet} = 1.0 psi

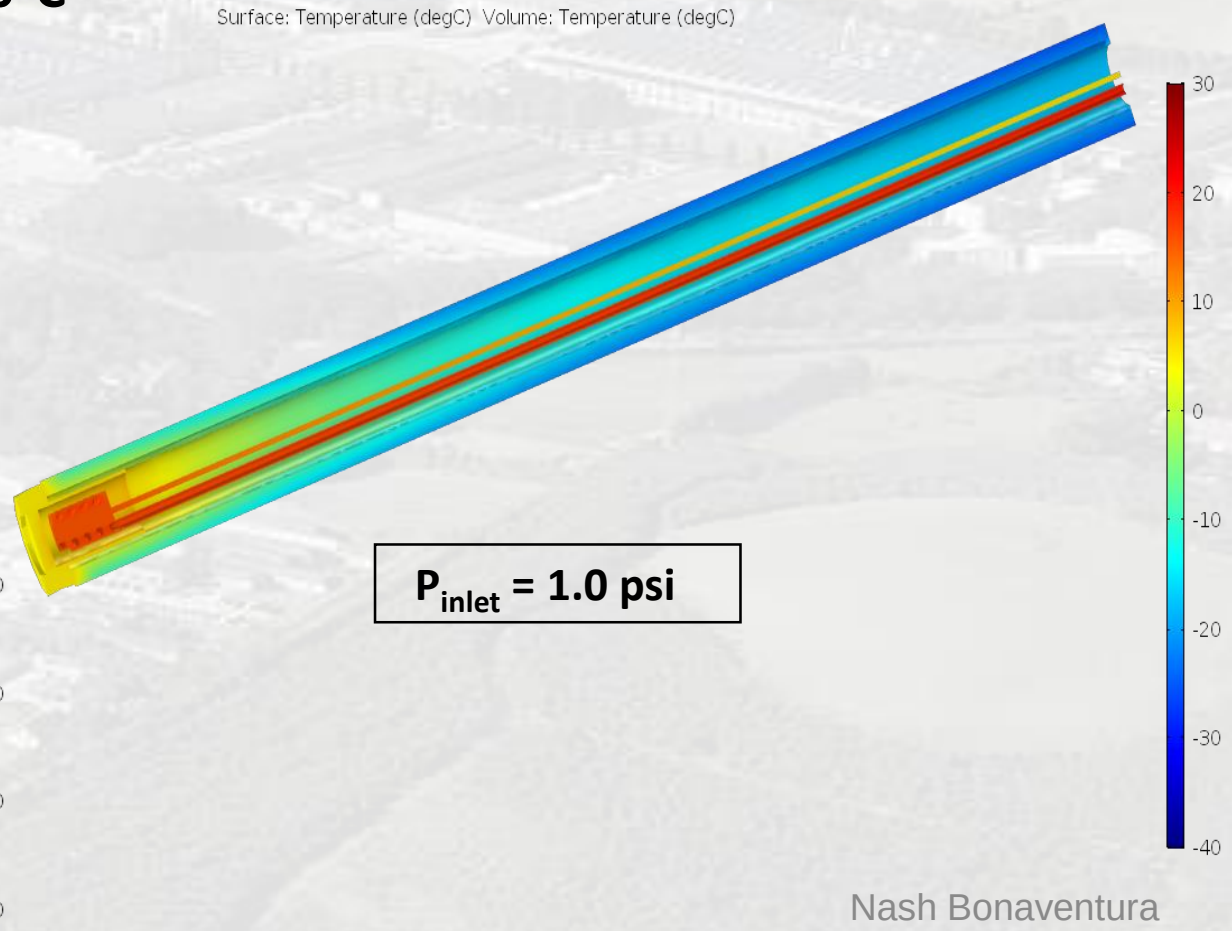
Nash Bonaventura

Simulation

$T_{chamber}$ = - 40°C



P_{inlet} = 0.5 psi



P_{inlet} = 1.0 psi

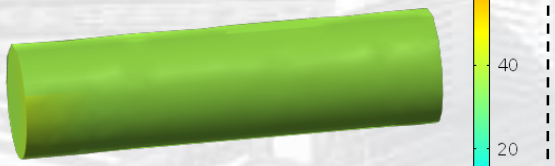
Nash Bonaventura

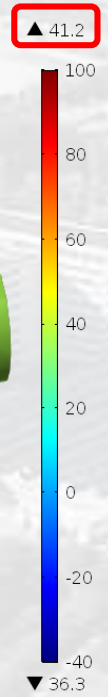
Simulation

Surface Temperature of Camera

T_{max} = 41.2°C

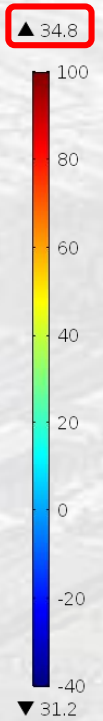
P_{inlet} = 0.5 psi
$T_{chamber}$ = 160°C





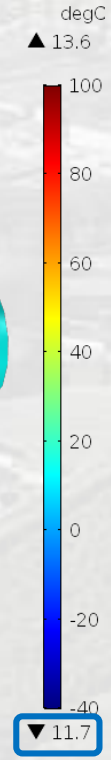
T_{max} = 34.8°C

P_{inlet} = 1.0 psi
$T_{chamber}$ = 160°C



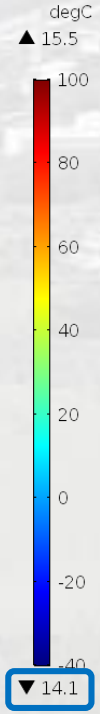
T_{min} = 11.7°C

P_{inlet} = 0.5 psi
$T_{chamber}$ = - 40°C



T_{min} = 14.1°C

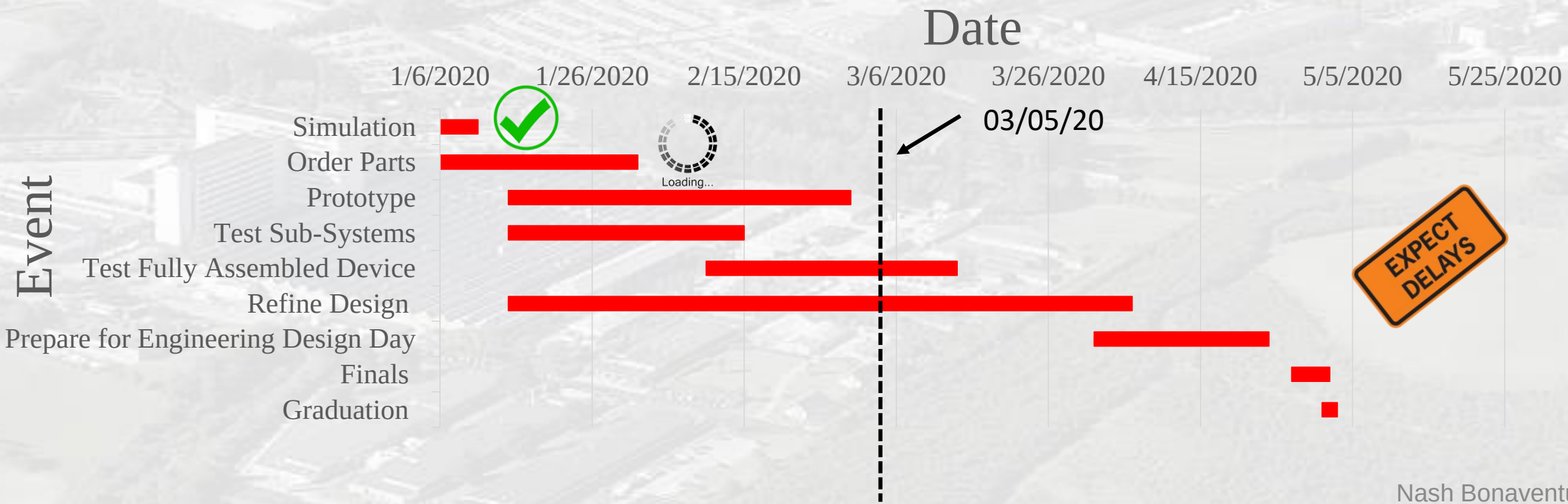
P_{inlet} = 1.0 psi
$T_{chamber}$ = - 40°C



Nash Bonaventura

Spring Project Plan Standing

Climatic Camera Spring Project Plan



Nash Bonaventura

Moving Forward

- Validate design through ordered parts
- Update simulation
- Prototype assembly
- Test
- Refine

Nash Bonaventura

References

McConomy, S. (2019, February 2). Engineering Characteristics, Functions, Targets, and Metrics. FAMU-FSU College of Engineering.'

Industrial, C. S. Z. (2010). Z-Plus Temperature & Humidity Chambers. Retrieved October 1, 2019, from https://www.cszindustrial.com/Products/Temperature-Humidity-Chambers/Z-Plus.aspx.

SE-1000-10-10 Environmental Chamber. (2014). Retrieved October 1, 2019, from https://thermotron.com/equipment/se-series-detail/se-1000-10-10-environmental-chamber/.

Anton Pilipenko, Karapet Ter-Zakaryan, Ekaterina Bobroova, Alexey Zhukov. "Insuation systems for extreme conditions." *Materials Today: Proceedings* (2019): 4.

Haoran Sun, Sichao Zhang, Shuguang Chen, Guanghai Wang, Liushi Tao, and Yufeng Chen. "Effect of Moisture Absorption on High Temperature Thermal Insulation Performance of Fiber Insulation Materials." *Key Engineering Materials* (2016): 445-448.

"It's not a problem it's an opportunity"

This is the end of the Presentation

Backup Slides