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Team 510: Climatic Camera

Concept Generation

Nash Bonaventura, Diego Gonzalez, Bryce Shumaker

FAMU-FSU College of Engineering 2525 Pottsdamer St. Tallahassee, FL. 32310

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Concept Generation Tools

In order to generate an array of concepts, various technical tools and methods were employed. First, individual research and brainstorming was performed by the group members, once each member had a few ideas and knowledge on functionality of the design such as, insulation techniques, types of camera's, mounting, and general knowledge about what it is desired to accomplish. Then, the group gathered and engaged in a brainstorm session where roughly twenty concepts were devised. Eight relatively functional ideas were developed, which became the foundation for further analysis. The group then considered biomimicry, relating the cooling process that can be seen in humans for other sources of inspiration to model. The group examined how the body regulates the temperature inside in order to keep stability within. Also, the attachment for the enclosure was envisioned by tracing how an octopus can attach itself through its tentacles. The group then tried the Anti-problem method, by thinking about ways to increase heat transfer to the device. Examples such as fins, conductive fluids and large surface areas all came to mind. The opposite should be taken to reduce heat transfer (flat surface, vacuum insulation and small surface area). To come up with various design options, a morphological chart was created. The group developed a set of variations for each system to achieve a higher number of possible designs. Categories varied in the source for securement, insulation technique, temperature regulation, type of camera, and condensation prevention. A total of 162 concepts were devised from the morphological chart. However, out of these, there were various redundancies as well as illogical designs, so only the fifty most realistic were kept in the concept list. See Table 1 below to see the variations applied in the systems mentioned.

Table 1: Morphological Chart

Temperature Regulation	Securement Method	Camera Type	Insulation Technique	Condensation Prevention
No Temperature Regulation	Clamp	Borescope	No Insulation	Resistive Heater
Compressed Air	Suction Cup	Infrared	Vacuum	Constant warm air flow over interior
	Velcro Strap	FireCam™	Polyurethane	Hydrophobic Coating

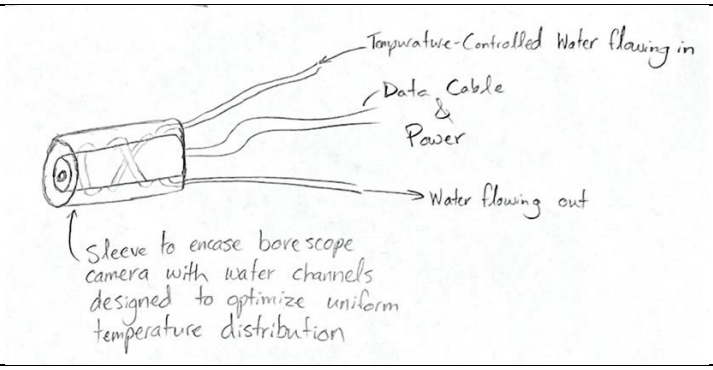
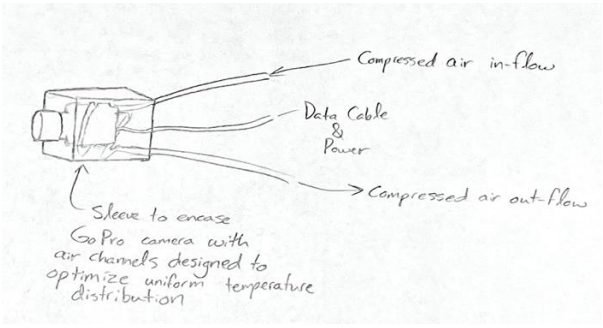
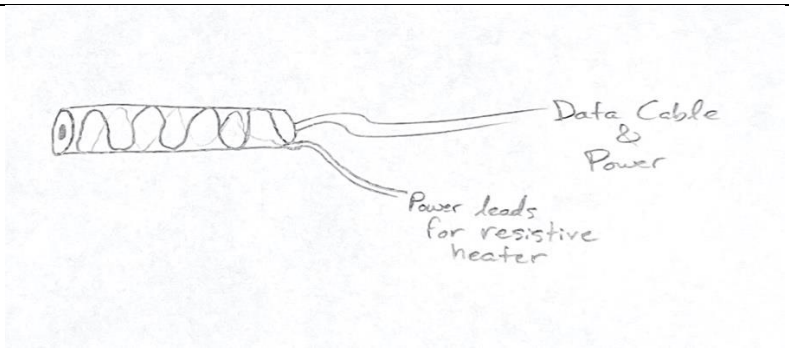
A full list of one hundred concepts was devised using the methods mentioned and can be found in Appendix A.

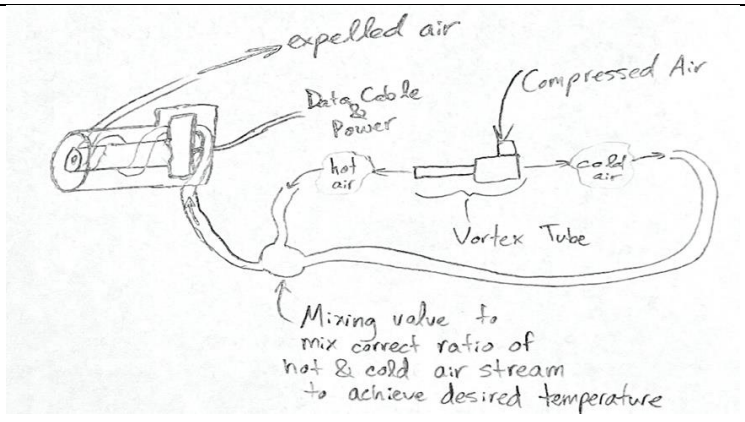
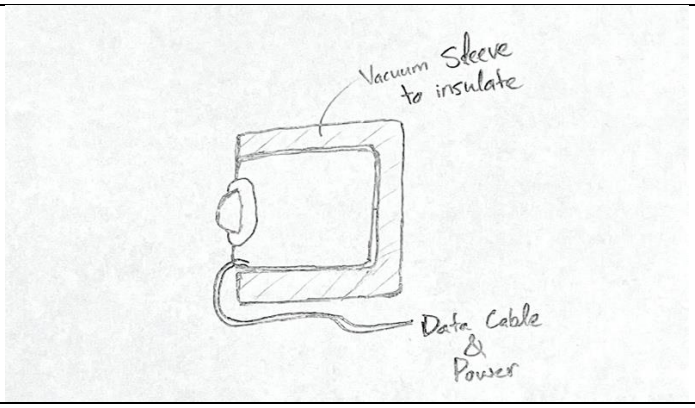
Medium Fidelity Concepts

The *Water-Cooled Borescope* concept in Table 2 utilizes an inexpensive borescope camera as the viewing the device. To maintain the device in operating temperature and prevent condensation, water channels would be guided around the camera. The *Compressed-air cooled GoPro™ Camera* concept uses a traditional GoPro™ as the recording device. This camera is resistive to the elements already, but in order to maintain operating temperature and prevent condensation it will be cooled by compressed air channels. The *Borescope Camera with resistive heater* concept utilizes a special borescope that can withstand hot temperatures. To protect it from the cold temperatures a resistive heater will be put around the camera. This will also prevent condensation accumulation around the lenses. The *FireCam™ with vortex tube* uses a small camera that is capable of temperatures up to 482 degrees Celsius. To protect the device from the cold temperatures, a vortex tube is used to channel hot compressed air around the

FireCam™ The *Infrared Camera* concept is an infrared camera that is maintained at operating temperature through vacuum insulation, a special lens would be required in order to minimize the difference in temperatures captured by the camera (considering polarized lens or similar effect lens).

Table 2: Medium Fidelity Concepts

Water Cooled Borescope	
Compressed air-cooled GoPro™ Camera	
Borescope Camera with resistive Heater	

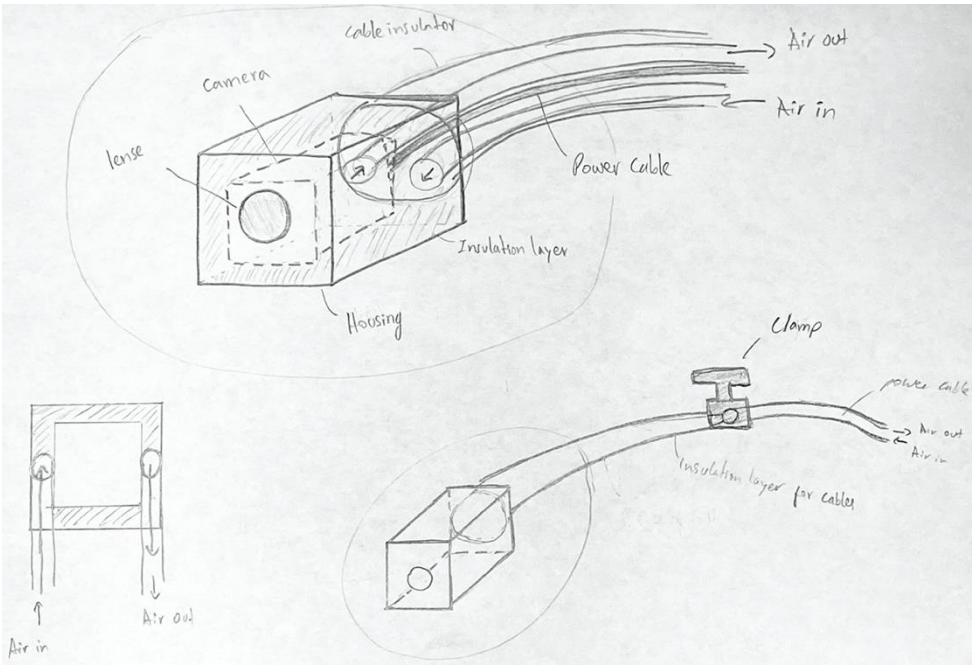
FireCam™ with vortex tube	
Infrared camera with vacuum insulation	

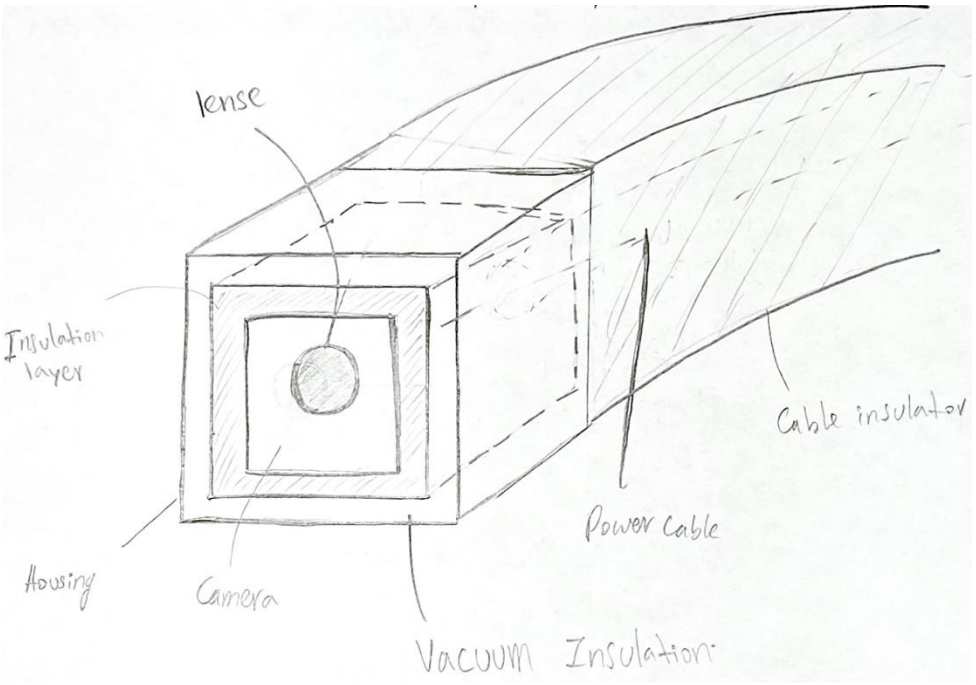
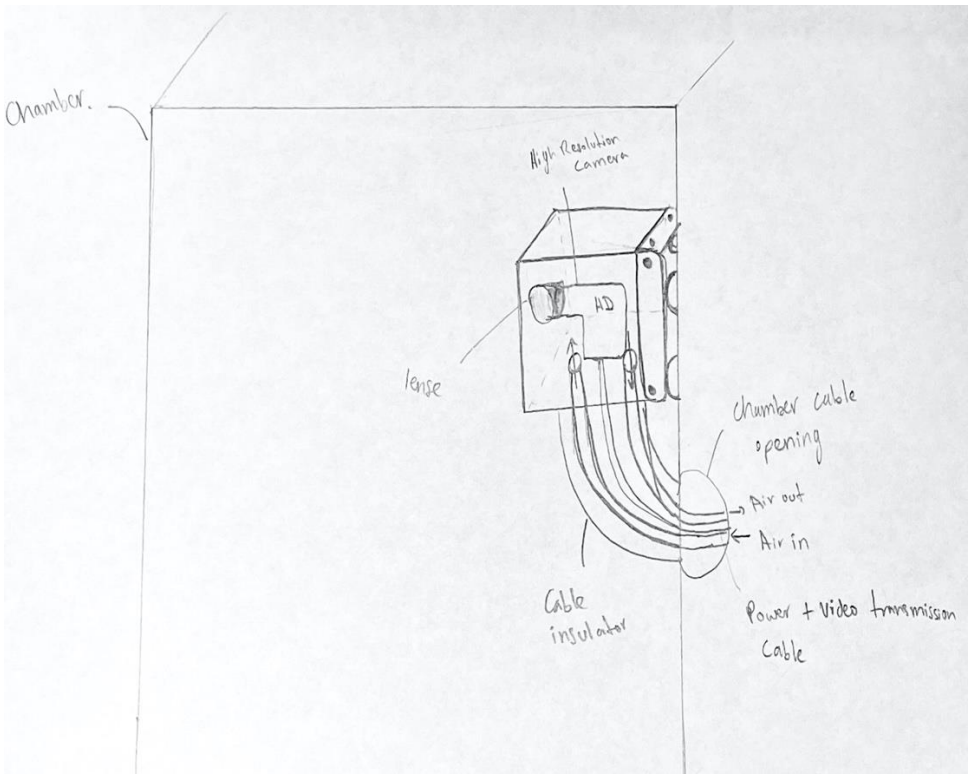
High Fidelity Concepts

The *Compressed Air, clamped, borescope with USB power* is an inexpensive borescope camera, in this design the temperature is controlled by using compressed air channels. The compressed air channels will prevent any condensation build up. The camera will be powered by a USB cable which will also be used for data transfer. The clamp will secure the device to the racks with minimal movement. The *Vacuum insulated, clamped, borescope with USB power* is an inexpensive borescope camera that prevents heat transfer by having a vacuum wall. The vacuum layer will prevent any condensation build up. The camera will be powered by a USB cable which will also be used for data transfer. The clamp will secure the device to the racks with minimal movement. The *Vacuum and compressed air, suction cup, borescope with USB power* an inexpensive borescope camera that maintains temperature by compressed air channels and a

vacuum insulated wall. The vacuum layer will prevent any condensation build up. The camera will be powered by a USB cable which will also be used for data transfer. The clamp will secure the device to the racks with minimal movement.

Table 3 – High Fidelity Concepts

Compressed Air, clamped, borescope with USB power	

Vacuum insulated, clamped, borescope with USB power	
Vacuum insulated with compressed air, suction cup, high resolution camera, with USB power	

Appendix A: Generated Concepts

Table 4: Concept Generation and Description

Concept	Description
1.	Water cooled Borescope camera
2.	Compressed air-cooled go pro
3.	FireCam with Vortex tube temperature regulation
4.	GoPro with Vortex tube temperature regulation
5.	Camera with open flame heater
6.	Camera with isolated negative pressure enclosure
7.	Camera with negative pressure enclosure to exchange air with ambient environment outside chamber
8.	Large concrete bunker to create enclosure so large heat transfer with chamber environment negligible
9.	Wrap camera in a blanket
10.	Camera mounted with wheeled structure for easy maneuverability
11.	Camera mounted with magnetic mount for versatile positions
12.	Camera outside of chamber entirely
13.	Inside fan for camera
14.	PID temperature control
15.	Fan on outside of camera housing to mitigate lens condensation
16.	Triple-layer Ziploc bag housing
17.	Electric heater in housing
18.	Use natural convection flow inside housing to regulate temperature
19.	Use CO2 inside enclosure to aid in insulation
20.	Borescope camera with fiberglass insulation no temperature regulation clamp hydrophobic coating
21.	Borescope camera with fiberglass insulation no temperature regulation clamp resistive heater
22.	Borescope camera with fiberglass insulation no temperature regulation clamp compressed air flow on interior of lens
23.	Borescope camera with fiberglass insulation no temperature regulation suction cups hydrophobic coating
24.	Borescope camera with fiberglass insulation no temperature regulation suction cups resistive heater
25.	Borescope camera with fiberglass insulation no temperature regulation suction cups compressed air flow on interior of lens
26.	Borescope camera with fiberglass insulation compressed air temperature regulation clamp hydrophobic coating
27.	Borescope camera with fiberglass insulation compressed air temperature regulation clamp resistive heater
28.	Borescope camera with fiberglass insulation compressed air temperature regulation clamp compressed air flow on interior of lens

29.	Borescope camera with fiberglass insulation compressed air temperature regulation suction cups hydrophobic coating
30.	Borescope camera with fiberglass insulation compressed air temperature regulation suction cups resistive heater
31.	Borescope camera with fiberglass insulation compressed air temperature regulation suction cups compressed air flow on interior of lens
32.	Borescope camera with polyurethane insulation no temperature regulation clamp hydrophobic coating
33.	Borescope camera with polyurethane insulation no temperature regulation clamp resistive heater
34.	Borescope camera with polyurethane insulation no temperature regulation clamp compressed air flow on interior of lens
35.	Borescope camera with polyurethane insulation no temperature regulation suction cups hydrophobic coating
36.	Borescope camera with polyurethane insulation no temperature regulation suction cups resistive heater
37.	Borescope camera with polyurethane insulation no temperature regulation suction cups compressed air flow on interior of lens
38.	Borescope camera with polyurethane insulation compressed air temperature regulation clamp hydrophobic coating
39.	Borescope camera with polyurethane insulation compressed air temperature regulation clamp resistive heater
40.	Borescope camera with polyurethane insulation compressed air temperature regulation clamp compressed air flow on interior of lens
41.	Borescope camera with polyurethane insulation compressed air temperature regulation suction cups hydrophobic coating
42.	Borescope camera with polyurethane insulation compressed air temperature regulation suction cups resistive heater
43.	Borescope camera with polyurethane insulation compressed air temperature regulation suction cups compressed air flow on interior of lens
44.	Borescope camera with vacuum insulation no temperature regulation clamp hydrophobic coating
45.	Borescope camera with vacuum insulation no temperature regulation clamp resistive heater
46.	Borescope camera with vacuum insulation no temperature regulation clamp compressed air flow on interior of lens
47.	Borescope camera with vacuum insulation no temperature regulation suction cups hydrophobic coating
48.	Borescope camera with vacuum insulation no temperature regulation suction cups resistive heater
49.	Borescope camera with vacuum insulation no temperature regulation suction cups compressed air flow on interior of lens
50.	Borescope camera with vacuum insulation compressed air temperature regulation clamp hydrophobic coating
51.	Borescope camera with vacuum insulation compressed air temperature regulation clamp resistive heater
52.	Borescope camera with vacuum insulation compressed air temperature regulation clamp compressed air flow on interior of lens

53.	Borescope camera with vacuum insulation compressed air temperature regulation suction cups hydrophobic coating
54.	Borescope camera with vacuum insulation compressed air temperature regulation suction cups resistive heater
55.	Borescope camera with vacuum insulation compressed air temperature regulation suction cups compressed air flow on interior of lens
56.	FireCam with fiberglass insulation no temperature regulation clamp hydrophobic coating
57.	FireCam with fiberglass insulation no temperature regulation clamp resistive heater
58.	FireCam with fiberglass insulation no temperature regulation clamp compressed air flow on interior of lens
59.	FireCam with fiberglass insulation no temperature regulation suction cups hydrophobic coating
60.	FireCam with fiberglass insulation no temperature regulation suction cups resistive heater
61.	FireCam with fiberglass insulation no temperature regulation suction cups compressed air flow on interior of lens
62.	FireCam with fiberglass insulation compressed air temperature regulation clamp hydrophobic coating
63.	FireCam with fiberglass insulation compressed air temperature regulation clamp resistive heater
64.	FireCam with fiberglass insulation compressed air temperature regulation clamp compressed air flow on interior of lens
65.	FireCam with fiberglass insulation compressed air temperature regulation suction cups hydrophobic coating
66.	FireCam with fiberglass insulation compressed air temperature regulation suction cups resistive heater
67.	FireCam with fiberglass insulation compressed air temperature regulation suction cups compressed air flow on interior of lens
68.	FireCam with polyurethane insulation no temperature regulation clamp hydrophobic coating
69.	FireCam with polyurethane insulation no temperature regulation clamp resistive heater
70.	FireCam with polyurethane insulation no temperature regulation clamp compressed air flow on interior of lens
71.	FireCam with polyurethane insulation no temperature regulation suction cups hydrophobic coating
72.	FireCam with polyurethane insulation no temperature regulation suction cups resistive heater
73.	FireCam with polyurethane insulation no temperature regulation suction cups compressed air flow on interior of lens
74.	FireCam with polyurethane insulation compressed air temperature regulation clamp hydrophobic coating
75.	FireCam with polyurethane insulation compressed air temperature regulation clamp resistive heater
76.	FireCam with polyurethane insulation compressed air temperature regulation clamp compressed air flow on interior of lens
77.	FireCam with polyurethane insulation compressed air temperature regulation suction cups hydrophobic coating
78.	FireCam with polyurethane insulation compressed air temperature regulation suction cups resistive heater
79.	FireCam with polyurethane insulation compressed air temperature regulation suction cups compressed air flow on interior of lens

80.	FireCam with vacuum insulation no temperature regulation clamp hydrophobic coating
81.	FireCam with vacuum insulation no temperature regulation clamp resistive heater
82.	FireCam with vacuum insulation no temperature regulation clamp compressed air flow on interior of lens
83.	FireCam with vacuum insulation no temperature regulation suction cups hydrophobic coating
84.	FireCam with vacuum insulation no temperature regulation suction cups resistive heater
85.	FireCam with vacuum insulation no temperature regulation suction cups compressed air flow on interior of lens
86.	FireCam with vacuum insulation compressed air temperature regulation clamp hydrophobic coating
87.	FireCam with vacuum insulation compressed air temperature regulation clamp resistive heater
88.	FireCam with vacuum insulation compressed air temperature regulation clamp compressed air flow on interior of lens
89.	FireCam with vacuum insulation compressed air temperature regulation suction cups hydrophobic coating
90.	FireCam with vacuum insulation compressed air temperature regulation suction cups resistive heater
91.	Wi-Fi enabled camera for wireless distribution of data transfer, heat insulation by vacuum enclosure and fans inside enclosure, the source of power is an internal Battery that can last over 2 months in continuous use
92.	Housing with self-contained heat pump
93.	Mini climatic chamber to protect camera from main climatic chamber
94.	Nanotechnology Camera
95.	Wide angle lens high resolution camera mounted to inside wall of chamber
96.	Nanotechnology Camera
97.	Wide angle lens high resolution camera mounted to inside wall chamber
98.	Wiper actuated condensation removal with borescope camera
99.	Tool Holder mounted borescope camera with arm adjustment
100.	High temperature dryer vent insulation around borescope camera with clamp base tool holder