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Team 510: Climatic Camera

Targets and Metrics

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Targets and Metrics

After conducting the functional decomposition, the targets and metrics were determined and can be seen in

1. *identifies *critical target*

Table 2 shows other targets and metrics that were not included in the functional decomposition.

Each function above was associated with a target and a metric to verify the final product is successful. The first set of functions deal with position of the device. Some functions have harder targets to measure, for example “Provide Stability,” refers to having the recording device in an unchanging location. This function could be measured with a sensor inside the enclosure of the recording device to check the acceleration within the device (e.g. accelerometer). As mentioned in previous activities, the nature of the test is continuous for days to even months (up to 71 days), so access to the device only occurs prior to the commencement of the test and at culmination. Having a stable frame for recording purposes, the function “Secure Position” is also related to stability of the device, but this time the function is centered in a specific area of the climatic chamber. The target given to this function was in the units of translational distance (meters). For the most stable image the camera should not move (in the x, y, and z directions). The third metric “Translation,” deals with securing the recording device ensuring it does not move, with units in meters. The function “Secure Rotational Angle,” serves a similar purpose as the previous function to secure the desired angle in degrees with a 0-degree change. The difference being that the recording device has a different degree of freedom, this time around, rotational.

The functions that deal with visuals are associated with data handling. The function "Capture Visuals," deals with recording the test subjects and how often the device takes a picture. This target is heavily dependent on how precise Danfoss needs to be when determining time of failure. 1 frame per second will give enough without requiring excessive data logging reflect time. The previous target greatly affects the following: Store Visuals and Record Time. The function "Store Visuals," as the name suggests is where the captured visuals are stored into the computer and available for future access. The memory capacity will depend on the computer in use or storage capacity available through other means in Danfoss (e.g. memory drive, cloud, etc.). The record time also has an effect on the amount of data generated. Again, the duration for current Danfoss tests can go up to 71 days, so the device must be able to record for 71 days continuously. The two functions involving data handling for "Transmit Visuals," and "Replay visuals" are binary. Transmit visuals implies that the device should not have its own data logger, but instead attached to a computer to be replayed and examined to determine where and when the failure occurs.

Under the function "isolate" there are 2 parameters which need to be met. Controlling the temperature is a target for the device to be operable. The test chambers range from -70°C to 190°C, and 5-95% relative humidity so the device must be isolated from this extreme environment for operation. Since zero heat transfer is not thermodynamically possible, the insulated device can have a range temperatures from $0°C \leq T \leq 45°C$. The range of temperature $0°C \leq T \leq 45°C$ and 0-50% Relative Humidity are considered to be "acceptable" operating ranges for a camera.

The device is not powered by a battery so sufficient power must be provided from the computer. A USB can put out 2.5 Watts of Power.

Upon observation of the chambers in person additional targets were noticed. There is a chamber cable opening that cables can be run through. This diameter is roughly 10cm which is a constraint on the amount of constant access into chamber. The cables must also have a minimum length in order to reach the computer. This length was calculated to be 2 meters. In order for the device to record quality images, condensation on lens should be minimized, ideally 0 mL. The device was also requested to be inexpensive. Research on borescope type cameras ranged from $30 for low range cameras with waterproofing to several thousand dollars for specialty furnace and cryogenic cameras. Based on these extremities, the camera was decided to be less than $100. There is limited space inside the climatic chamber; the dimensions are 97x97x97cm. If testing subjects are taken into account when in operation, the device must be significantly smaller as a physical constraint.

Methods of Validation

Majority of validation will be done during the prototyping and design phase. For the function “support” there should be no visible image issues within the playback. This can be validated physically by measuring any camera movements using a caliper and its original position. However, just because the camera moves, doesn’t mean that the image will. The end product is the quality of the image, so this will be validated by a computer to see if the image is stable and the amount of fluctuations between frames. Adobe Premier pro is a sufficient software for video editing and image stabilization.

Capture Visuals, Transmit Visuals, Store Visuals, Replay Visuals, and Record Time are all parameters that are taken into account with the recording device selection. These will be validated by the manufacturer's specifications.

Control Temperature and Control Humidity will both be validated in simulation using Finite Element Methods (FEM) as well as physically during prototyping. Temperature can easily be measured using a thermocouple or similar temperature obtaining device. Humidity would be measured using a hygrometer.

Critical Targets

The targets that are critical in this project are those for the functions*: Record time, Control temperature,* and *inexpensive*. These targets are marked with asterisk in

1 and *identifies *critical target*

Table 2. Record time is a very critical target due to the duration of the tests. 71 day tests means that longevity of the components will have to be taken into account. The climatic chamber cannot be opened during testing to replace any broken or malfunctioning parts. Control Temperature is also a critical target. Standard cameras/ recording devices are not able to be operated in the temperature range of the climatic chamber. Without an operational camera the project is not complete and therefor all other targets are unobtainable and valid. Inexpensive is the final critical target. The purpose of the senior design project is to make a generic device work in said extreme conditions. If the camera itself was too expensive, than there would be no market for the device and one would simply purchase an expensive existing camera that can work in said environment. If these three functions fail to meet the target, the device would not fulfill the project objective.

Appendix

Table 1 - Targets and Metrics

Function	Target	Metric
Provide Stability	0 m/s^2	Acceleration
Secure Position	Change in x,y,z=0 m	Translation
Secure Rotational Angle	0-degree change	Degrees
Capture Visuals	≥ 1 frame/second	Frame Rate
Transmit Visuals	Yes	N/A
Store Visuals	Giga Bytes	Storage Memory
Replay Visuals	Yes	N/A
Record Time*	71 Days*	Time
Control Temperature*	$0\,^{o}C \leq T \leq 45\,^{o}C$*	Temperature
Control Humidity	0-50%	Relative Humidity
Supply Power	2.5 Watts	Power

**identifies critical target*

Table 2 – Targets and Metrics cont.

Need	Target	Metric
Chamber Cable Opening	10 cm	Diameter
Cable Length	2 m	Length
Condensation on lens	0 ml	Volume
Inexpensive*	≤ $100*	Price
Compact	≤ 97 x 97 x 97cm	volume

**identifies critical target*