Target Summary

The following table shows the critical targets and metrics along with their corresponding functions. This information was developed using the interpreted customer needs and functional decomposition shown in earlier sections.

Table 1: Critical Targets and Metrics

Function	**Metric**	**Target**
Sense Air Quality	Concentration range of sensors	Particulate sensors detect between 0.1 µg/m^3 and 1000 µg/m^3 [a] Gas sensors detect between 0 ppm and 250 ppm[b]
Measure Air Quality	Accuracy of sensors	Particulate sensors: ±15%[a] Gas sensors: ±3%[b]
Control Hardware	Reaction time of hardware components	6 seconds[a]
Propel Air	Volumetric flowrate of air leaving device per person in room	40 cfm[c]
Circulate Air	Number of air changes per hour	7[d]
Treat Air	Number of changeable filters needed to clean air	3 filters[e]
Filter Particulates	Minimum diameter of particles the device will filter	0.1 µm[f]
Control Air Humidity	Allowable range of air humidity	40% to 60% humidity[g]
Sanitize Contaminants	Percent of particulates removed from air by device	99%[h]

Note. Data are from (Honeywell, 2019)[a], (Honeywell, 2012)[b], (Environamental Protection Agency , 1990)[c], (Falke, 2016)[d], (Honeywell, n.d.)[e], (Honeywell , n.d.)[f], (M. Jeremiah Matson, 2020)[g], (Sylvane, n.d.)[h].

Critical Targets and Metrics

The critical targets and metrics correspond directly to the functions of the functional decomposition and can be seen in Table 3. The functions and their related targets and metrics include sense and measure air quality, control hardware, propel air, circulate air, treat air, purify air, filter particulates, humidify and dehumidify air, and sanitize contaminants. The full table of functions, targets, and metrics can be seen in Appendix C. The activate purifier, activate propeller, deactivate purifier, deactivate propeller, modulate purifier, and modulate propeller functions seen in the updated functional decomposition, shown in Figure 2, were all found to have the same target and metric, so have been condensed into one function, control hardware, in the critical targets and metrics. Similarly, the functions humidify air and dehumidify air were condensed into the single function control air humidity. The items listed above were chosen to be critical because the device will not be successful if the functions are not able to accomplish the targets that have been set for them. The device portability, device noise, and energy consumption functions, seen in the full catalogue in Appendix C, are not critical because the device will operate without them. However, they are still important to the project and will be considered during the concept generation and selection phases because they satisfy the customer needs of portability and creating minimal noise.

Determination of Targets and Metrics

To determine the critical targets and metrics seen in the table, research was done to see how each of the functions should be carried out and at what specific values they should optimally be performed at. Metrics were selected to quantify each of the functions and numerical values chosen for each of the targets. The targets and metrics associated with the sense air quality, measure air quality, control hardware, treat air, filter air, and sanitize contaminants functions were all derived from existing products. For these functions the products we used for reference

were made by our sponsor, Honeywell. This was done to ensure that our project is of high enough quality to be comparable to their existing devices. The target values shown in Table 3 were found in data sheets and devise specifications listed on Honeywell's website.

A Honeywell device, "HPM series Particulate Matter Sensor," features were used to set some of the targets and metrics. Two important features are that the HPM sensor series use a laser based light scattering particle sensor. This allows the sensor to have a concentrated range of 0 $\mu g/m^3$ to 1000 $\mu g/m^3$ and accuracy within 15%. Another device, the "E^3 Point" is a compatible Honeywell device that has a dual gas monitoring and alarm system. The accuracy of this compatible device is ±3% within a range of 10ft and has a concentration range of 0 to 250 ppm. These devices and their associated data sheets were used to set the targets and metrics for the sense air quality and measure air quality function. The data sheets of these devices also provided information regarding the reaction times of Honeywell hardware that was used for the control hardware target value.

The targets and metrics for the treat air, filter particulates, and sanitize contaminants functions were based on filters and air purifiers made by Honeywell. The treat air target relates to the number of filters used in the "True HEPA Whole Room Air Purifier with Allergen Remover". The sanitize contaminants target and metric are based on the air cleaning abilities of HEPA filters used in this purifier. The filter particulates target value was chosen in relation to another filter made by Honeywell, the "Filter A Universal Carbon Pre-Filter".

Other targets and metrics were based on industry standards or government suggestions. In a document by the CDC, "Effect of Environmental Conditions on SARS-CoV-2 Stability in Human Nasal Mucus and Sputum," 40% to 60% humidity in a controlled room was found to help reduce the spread of COVID-19. Therefore, this range was selected as the target for the

control air humidity function. The American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) published its "Standard 62-1989: Ventilation for Acceptable Indoor Air Quality." In this document the standard cfm range person is 15-60ft^3/min. The middle of this range was selected as the target for the propel air function. Finally, the target for the circulate air function was based on the typical number of air changes per hour for office buildings.

Methods of Validation

Methods of validation are needed to ensure that the critical functions meet their corresponding targets and metrics. Some of these functions can be validated using simple inspections and do not require any resources for testing. Among these functions are sense air quality and treat air. To validate that the chosen sensors operate with the ranges specified by the targets shown in Table 3, the data sheets of the sensors can be read, and their operating concentration ranges identified. The treat air function can be tested by counting the number of changeable air filters used in the device and checking that there are three or fewer.

Other functions can be tested and validated using calibrated sensors. These functions include measure air quality, filter particulates, control air humidity, and sanitize contaminates. The measure air quality function can be validated by comparing readings on the particulate and gas sensors used by the device to calibrated sensors and checking that the device's sensors are with the allowed range of accuracy. Similarly, it can be checked whether the humidity is in the allowable range for the control air humidity function by measuring the air humidity using a calibrated hygrometer. The filter particulates and sanitize contaminants functions can be tested and validated using calibrated particle sensors (Texas Instruments , 2016). These devices can measure the size and concentration of particulates. In the case of the sanitize contaminants

function, sensors would need to be placed at the opening and exit of the device and their readings compared to ensure the decrease in particulates matches the specified value in the targets. For the filter particulates function, only the sensor at the exit would need to be monitored to check that none of the particulates have diameters larger than 0.1 μm.

To verify the volumetric flow rate of the air, an anemometer will be used to measure air speed and a tape measure used to measure the area of the duct the air is flowing from. The volumetric flowrate of the air can then be calculated based on these measurements and compared to the target values given in Table 3. Furthermore, the total volume of the room can be measured using a tape measure and used in conjunction with the volumetric flowrate to calculate air changes per hour, to verify the circulate air function. Finally, to test the response time of the control hardware function, control signals for each piece of hardware will be sent and a stopwatch will be used to ensure that the reaction timing of the hardware is within acceptable levels.

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