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Team 523: Mixed Reality Wearable for 3D Body Tracking

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Chapter 1: Abstract

From the toothbrush you hold in the morning to the seat in your car, ergonomic products make your life more comfortable. Since consumers dictate the market, 3D scanning has recently grown in popularity. This has caused increased demand for more consumer-friendly and ergonomic products. The team's sponsor works as a professional ergonomic engineer. He uses scanners to take 3D pictures of various body parts. This allows him to design ergonomic-oriented products such as cell phones, computer mice, and game controllers. Current scanners have a limited field of view. Increasing this field of view results in poor quality scans. Therefore, scan technicians must verbally navigate participants into the needed position and orientation. This causes participants to take 30 minutes or longer to find the correct scan position and orientation. Team 523's design strives to shorten these scan times. Shortening scan times will increase productivity and save money.

Team 523 has designed a mixed reality wearable. This wearable will track and display position and orientation of a user's hand. The AprilTag, similar to a QR code, will clip onto a bracelet. The bracelet uses a quick remove fastener to reduce motion blur. A 3D camera will track and compile position and orientation data from the wearable's AprilTag. The computer finds the AprilTag and display it as a 3D model on a nearby screen. Most likely a hand or head, the 3D model will allow the participant to match their position to the needed position shown on the monitor. Last, this allows participants to self-correct their position and orientation without any extra verbal direction. An ideal setup would not only allow the team's 3D camera to track full bodies but also track any body type without any verbal direction.

Keywords: Scanning, Wearable, AprilTag, and Position.

Disclaimer

Your sponsor may require a disclaimer on the report. Especially if it is a government sponsored project or confidential project. If a disclaimer is not required delete this section.

Acknowledgement

- We would like to thank our philanthropic sponsor and contributor, Dr. Yubin Xi, for financially giving us the opportunity to advance our practical skills through this real life engineering design project.
- Thanks to our team adviser and Senior Design Professor, Dr. Shayne McConomy. We would not have been able to accomplish our project goals without his technical and professional guidance.
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AAA	American Automobile Association
AARP	American Association of Retired Persons
AHP	Accelerator Heel Point
ANOVA	Analysis of Variance
AOTA	American Occupational Therapy Association
ASA	American Society on Aging
BA	Back Angle
BOF	Ball of Foot
BOFRP	Ball of Foot Reference Point
CAD	Computer Aided Design
DDI	Driver Death per Involvement Ratio
DIT	Driver Involvement per Vehicle Mile Traveled
	Difference between the calculated and measured
Difference	BOFRP to H-point
DRR	Death Rate Ratio
DRS	Driving Rehabilitation Specialist

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EMM	Estimated Marginal Means
FARS	Fatality Analysis Reporting System
FMVSS	Federal Motor Vehicle Safety Standard
GES	General Estimates System
GHS	Greenville Health System
H13	Steering Wheel Thigh Clearance
H17	Wheel Center to Heel Pont
H30	H-point to accelerator heel point
HPD	H-point Design Tool
HPM	H-point Machine
HPM-II	H-point Machine II
HT	H-point Travel
HX	H-point to Accelerator Heel Point
HZ	H-point to Accelerator Heel Point
IIHS	Insurance Institute for Highway Safety
L6	BFRP to Steering Wheel Center

Chapter 2: EML 4551C

Project Scope

Project Description:

The objective of this project is to provide a user interface for participants in a 3D scan environment, in order to improve the quality of the scan and reduce the amount of instructions given by the scan technician. This type of system will be specific towards illuminating the ideal location for a head/hand to be scanned in some fashion (Augmented Reality, Virtual Reality, hologram). After this position has been filled by the user being scanned, the user will be notified of completion.

Key Goals:

Find a means of providing a human agent with the ability to align their body exactly with a pre-specified pose. Such alignment could be achieved by giving the visual appearance of having suspended light particles in mid-air. These “light particles” should have a controllable structure or configuration. Upon introducing a human agent to the light structure, the agent should have the ability to three-dimensionally view and traverse the light field without directly affecting the light field’s location or structure in space-time. The light structure should have the additional ability to sense an agent’s interaction with the light field, possibly performing some sort of pre-specified task following or due to this interaction.

Goal Statement:

Design a device that will indicate the location that will yield the highest quality scans. This device must not interfere with the scanning process.

Constraints:

There will be multiple constraints that will impact the design. They include but may not be limited to:

- Budget
- Resources
- Knowledge

Markets:

- Security
    - This technology could be introduced into such security measures, such as the Transport Security Administration's (TSA's) full body airport scanner.
- Telecommunication
    - As featured in such films as the Star Wars series, this technology could be implemented in video communication.
- Video Games
    - Branching off of the VR and AR fads, this technology could serve for the foundation of Star Trek style 'Holodeck' video games.
- CAD/Modeling Design
    - Similar to the benefits of 3D printing a CAD design, this technology could allow for one to (spatially) visualize or create a model.
- Fitness & Health
    - This technology can be used in fitness tracking to accurately measure the dimensions of the body. These scans can be utilized in weight loss tracking and muscle tone growth or loss. The tracking can be beneficial in medical scanning situations as well, allowing the patient to see where to position him or herself to produce the best scan (MRI/CAT scans).

Stakeholders:

Aside from the project's main sponsor, Dr. Yubin Xi, Dr. Xi's employer, Apple, stands to hold significant stakes in the success of this project. The group could potentially see the integrated "hologram" technology incorporated into many future Apple products, software, and hardware.

1.2 Customer Needs

The initial meeting with Dr. Xi provided useful insight and knowledge about the specific needs for the anthropometric-scanner (Y. Xi, Video call, September 18, 2018). The team started with broad questions which eventually led to more specific questions; these questions include the following: the sponsor's primary end goal of the project and what the sponsor's expectations are for the team throughout the year. Utilizing the information from this meeting and the needs outlined in the project description, a list of customer statements is given in table 1. These customer statements were rewritten as interpreted needs; the interpreted needs allow to clearly outline what our final system needs to accomplish instead of how it should be accomplished. The table below shows the customer statements and the resulting interpreted need.

Table 1: *List of Customer Statements and Interpreted Needs*

#	CUSTOMER STATEMENTS	INTEPRETED NEED
1	Project something into space for the participant to aim their head/hand.	The device must indicate to the participant the ideal location and orientation for accurate scans.
2	The device must be a stand-alone system	The device must complete its intended function without the assistance of other devices.
3	It would be beneficial if the device could indicate to the user when the "sweet spot" is filled.	If possible, the device will be able to notify the user to hold the current orientation of the participant's head/hand.
4	The device must not interfere with the scanner.	The device must cease operating upon successful fulfillment of the "sweet spot"
5	The device must be able to be powered remotely.	The device requires a method for power control
6	The device must not create any safety hazards.	The device must minimally impact the participant

~~1.2 Customer Needs~~

1.3 Functional Decomposition

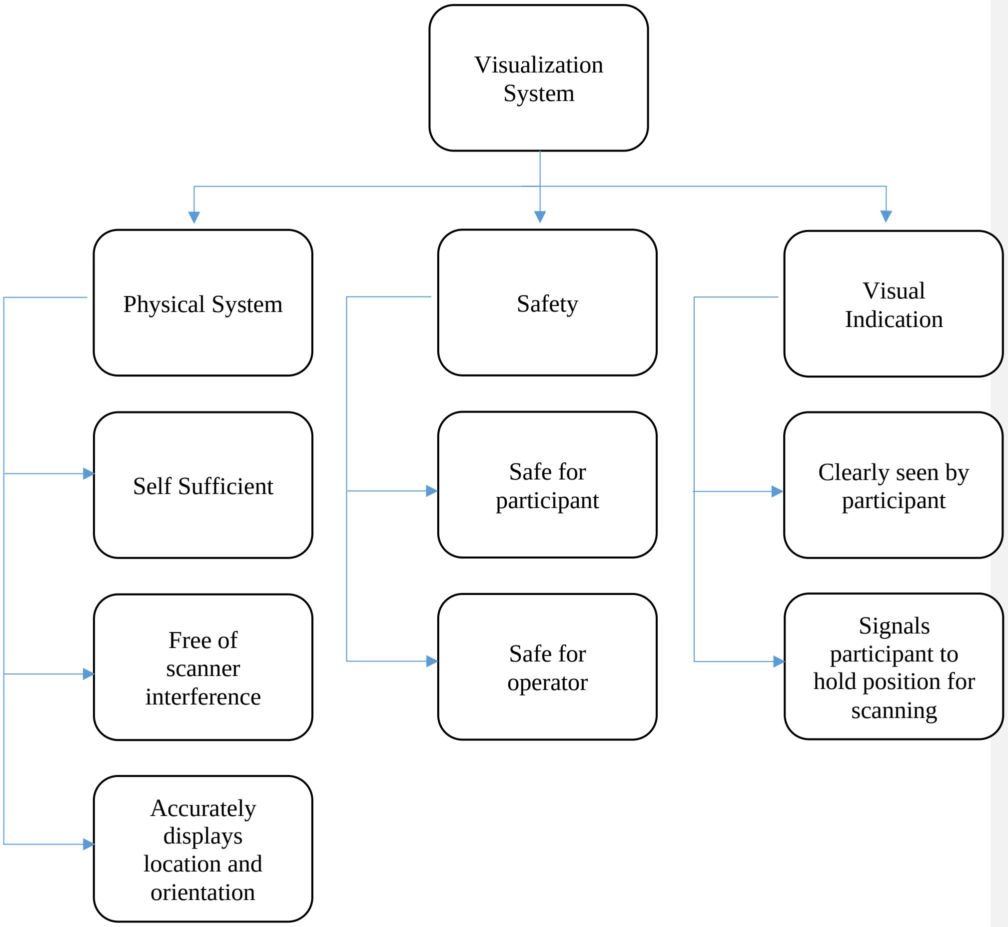


Figure 1: Functional Decomposition

1.4 Target Summary

*Critical Targets and Metrics

When looking at targets and metrics, one must not become distracted with concepts or potential designs. The customer needs and the functional decomposition serve as the focus of the targets and metrics (T&M). T&M give physical parameters to the desires and needs of the customer.

Hologram Anthropometric Scanner

Main Function	Sub-Functions	Metrics	Targets
Device	Self-Contained	Dimensions (in)	≤ 30 x 30 x 30
		*Weight (lb.)	≤ 25
	Free of Scanner Interference	*Distance from Scanner (m)	~ 1
	Accurately displays location and orientation	*Tolerance of depth Measurement (cm)	≤ 4
Safety	Safe for participant	*Brightness level (Lumen)	< 200
		Intensity level (Lux)	< 200
	Safe for operator	Operating temperature (°F)	< 150
Visual Indication	Clearly seen by participant	Perceived Brightness level (Lux)	100 - 200
		Resolution (Pixel)	≥ 480 [8]
	Signals participant to hold position	*Time in designated Location & Orientation (Second)	< 30
Power	Power supply	Power consumption (Watts)	< 11 [9]
		Operating voltage (Volts)	≤ 55 [10]

The design team based the targets on the functional decomposition and each sub function.

When using lights, display comfort of the user remains an important factor. Using referenced formulas, the design team calculated that the average Lux (measure of light intensity) for a 24-inch monitor [1]. This monitor can convey critical information to the participant. The design team determined that the amount of resolution of the video feed on the video monitor will not hold too much importance. Utilizing various displays, through video quality testing at multiple distances, it was determined that a high-quality resolution would only benefit the participant if he or she stood within a meter of the screen.

For the size of the device, the group did research into ADA regulations (Americans with Disability Act) [2]. These laws require businesses to meet building standards allowing people with disabilities to traverse the place of business. The team agreed that the dimensions of the device will fit within the size of an average wheelchair. Keeping the device to this size guarantees the user’s ability to transport the device to its destination without the interference of hallways or doorways. The design team derived the weight of the device, roughly 25 pounds, from the maximum weight a business might require some employees to carry [3]. Given that businesses do not typically require an employee to carry any more than 50 pounds, the employee must have previously agreed to this job requirement. From this, the team chose to try and keep the weight of the device to half of the potential 50lb weight limit. Should the device exceed the targeted weight of 25 pounds, it might require wheels for easier transportation.

For the internals of the device, the device’s target temperature will remain under 150°F [4]. At 150°F, should skin come into contact with the components, burns will not start to occur or form for several seconds. Ideally, operating temperatures will remain lower than this temperature. Thus, additionally ensuring excessive temperatures will not damage the components of the device or its operators.

For an affordable version of the scanner, the team will make use of a Microsoft designed device called a “Kinect” [5]. The “Kinect” stands as a device designed specifically for the “Xbox” gaming consoles. The Kinect proprietarily functions as a motion sensing input device; however, one can repurpose the device as a 3D scanner. The Kinect has a 4cm tolerance of depth measurement at a maximum distance of 5 meters [6]. This stands out as one critical key point. The scan subject must remain within a certain range of the Kinect in order to allow for the smallest errors in measurement. The device’s distance from scanner also stands out as a critical target/metric. To guarantee the device will not interfere with the scanner, the device, will ideally remain at least one meter away from the scanner.

The length of time it takes for the scan to run stands out as another critical target for the device. If the scan subject does not remain in the sweet spot for the entirety of the scan, then the output of the scan will not produce viable results. Therefore, the device must continue to indicate the sweet spot long enough for the participant to feel comfortable within the scan location. The design team has set this metric to 30 seconds [7]. The design group will test for this metric using the Kinect as previously mentioned.

Note: The references for this targets and metrics section only refer to the targets and metrics section, NOT the entire Evidence Manual. These references only help to explain our reasoning in more detail. The references for this section do not help further the Evidence Manual as a whole.

Additional Information and References:

[1] Lux based on

https://www.energyearth.com/general/categories/lighting/learn-more

http://www.lightsearch.com/resources/lightguides/formulas.html

[2] 30x30x30 inches is related to the dimensions of a wheelchair such that it could fit through any door

[3] 25 lbs was derived from half of the 50 lbs max required of some people to lift in the workforce

[4] 150°F is the temperature that will cause burns on skin after a one second of exposure.

[5] https://developer.microsoft.com/en-us/windows/hardware/3d-print/scanning-with-kinect

[6] The 4cm tolerance of depth measurement (at max distance of 5m) came from the link below

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3304120/

"- The random error of depth measurements increases quadratically with increasing distance from the sensor and reaches 4 cm at the maximum range of 5 meters"

[7] 30 seconds seems to be an arbitrary number for how long it takes for the entire scanning process. We have Emailed our sponsor to ask him directly. So after reading his response this particular metric may change.

[8] The resolution was based on a resolution less than 480 would be too pixelated/unclear

[9] 11 Watts was derived from the max amperage being 0.2A (the minimum lethal current) and the max voltage being 55V. P=I*V, 11 Watts = 0.2A * 55V

[10] 55 volts is half of the rated output voltage supplied by a standard outlet

1.5 Concept Generation

In concept generation the goal is to produce as many design ideas and concepts as possible without limiting. Below we have our best and most realistic concepts, while the bulk of our concepts are in appendix D.

Concept 1. Augmented Reality and Leap Motion

Uses Augmented Reality (AR) in order to virtually display a 3D indication. The down side to this concept is that it hinders scans of the participants head. But in all other situations and circumstances the VR option would satisfy all customer needs.

Leap Motion could work in tandem with the AR, providing a device that is mainly used in hand tracking for Virtual Reality (VR); however, this device additionally works independently from VR. This system tracks the position and can accurately display the position of the user's individual digits in his or her hands. This device would be majorly beneficial in instruction the participant where to put his or her hands along with the exact orientation the hands need to be in. Leap Motion is unable to track any other part of the human body. It only works as an addition to the AR headset.

Concept 2. Mirage Projection/Schlieren Imaging

One can easily project images onto solid, liquid, and gaseous surfaces. In a room environment such as this one, water or fog cannot flow into or through the scanning environment. As an alternative, such as with a mirage or Schlieren imaging, projecting an image onto or through a change in density/temperature in mid-air or onto a screen could act as a viable option for creating a real hologram.

Concept 3. BMW Inspired/McConomy Designed Holo-Touch Technology

This concept uses aspects of Pepper's Ghost Effect to project, what one can describe as the closest possible thing to a real hologram, in a light controlled environment. Rather than using the classic, single pane of glass or plastic, the designer uses multiple panes in order to provide the projection with dimensionality.

Such a stable idea, of course, comes with its many pitfalls. For one, the field of the participant's view is limited to 180 degrees on a single side of the pane of plastic or glass. As such, as soon as a participants out maneuvers the device, he or she could potentially get stuck looking at absolutely nothing. In addition to this, the environment in which such a device works is limited to a certain range of lighting. This idea would limit the brightness of the device's containing room; however, all other factors point to the legitimacy of this concept's ability to introduce a controlled and suspended light field into the scan room.

Concept 4. 3D Image Projected Onto Live Feed Camera

For this concept, a kinect would record various orientations to complete a 360° view of a human hand and a separate 360° view of a human head and then save these orientations as reference scans (RS's). Given that most human heads are relatively similar in shape/size while human hands are not, only one all encompassing (a scan from enough angles to complete a 360° view) reference scan (AERS) of a human head will be taken while three other AERF's of different sizes of hands will be taken. These AERF's will be used to populate a database of a head as well as small, medium, and large hands.

From here, whether scanning a hand or a head, the appropriate RS's inside of its designated AERF will be scaled, displayed, and cycled through onto a designated area (representative of the sweet spot) of the live feed camera in order for the participant to fill each orientation until completion. The live feed camera would be projected onto a monitor inside the scanning room. Ideally, this monitor would be relatively close to the sweet spot location so that the participant can see it clearly, but it will be far enough away so that it will not obstruct the view of the scanner (an Xbox "kinect" in this case). Given that only 2D images will be displayed onto the live feed camera, different infrared (IR) sensors will be incorporated into a user interface to allow the participant to know how far away their hand is from the sweet spot in reference to the x,y,z plane. For proof of concept, a Kinect will be set up nearby taking scans during each moment that a RS is presented to the participant so that these scans could be stitched together to render a 3D image.

Concept 5. Cast of a Hand or Head to Indicate the Sweet Spot

This concept will have a cast of a hand or head on a pole attached to motors where the participant would put their hand. The casting could be manipulated so that they could be positioned at different angles at different points in time. The motors would also raise the hand above where the participant hand would be placed so that the participant could fill the desired sweet spot position while maintaining the orientation of the casted model.

Concept 6. Adafruit VL53L0X Time of Flight Distance Sensors with 3D Camera

This concept will have a series of "Adafruit VL53L0X Time of Flight Distance Sensors" that can determine the user's x,y,z location at all time where this location (represented by a shape) is projected onto a monitor in front of the user in real time so that they can position this shape into the sweet spot location. A 3D camera/scanner would be coupled with the distance sensors to help project the desired orientation onto the same monitor that the distance sensors will be projected onto. For this to work, a series of 3D images of hands will be scanned with the 3D camera at various orientations in which these images will be cycled through sequentially with a time gap between each image so that the user has the capability to fulfill each orientation before moving onto the next image. Upon completion, the user will be notified via a message written on a user interface as well as an audio recording saying what is on the screen.

Concept 7. Large Illuminating Mirascope

A large mirascope can effectively project a small hologram above the mirascope's opening. The hologram size directly relates to the size of the mirascope and its geometry. Rather than using standard objects in the mirascope, three-dimensional, illuminated objects can better introduce a hologram in any light setting.

Concept 8. Manual Device on Caster Wheels with 3D Camera

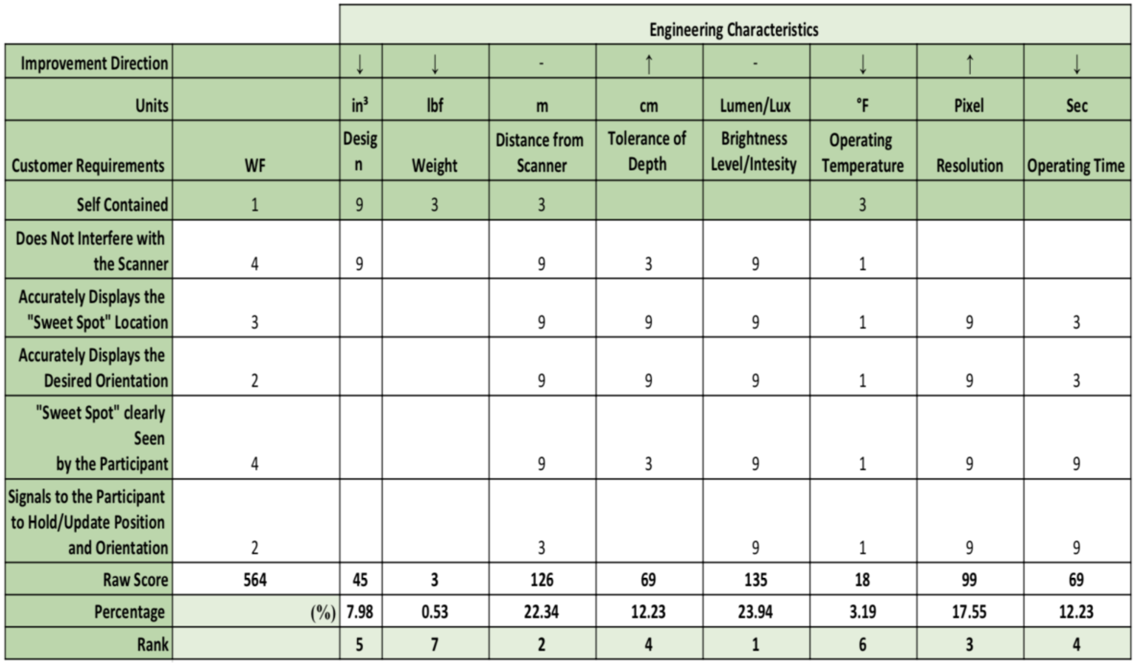
This concept will have a manual (or semi-automatic) device on caster wheels (they can lock/unlock) that can roll around and can be lifted and lowered to a desired height representative of the sweet spot. In reality it would be a little lower than the sweet spot, but there will be a type of body rest for the participant to put there hand,foot,arm,etc. on so that they will be able to position their body part within the sweet spot. Once there, as mentioned in Concept 6, a 3D camera/scanner would help project the desired orientation onto a monitor in front of the participant. For this to work, a series of 3D images of hands will be scanned with the 3D camera at various orientations in which these images will be cycled through sequentially with a time gap between each image so that the user has the capability to fulfill each orientation before moving onto the next image. Upon completion, the user will be notified via a message written on a user interface as well as an audio recording saying what is on the screen.

1.6 Concept Selection

House of Quality

Using the weights decided in the pairwise comparison, the team applied these weights to the actual weight factors in the house of quality. After filling out the house of quality, the group applied the weight factors to the values given to each comparison of customer requirements and engineering characteristics. Once the group added everything up, then found a raw score value. The group then multiplied 100% times the engineering characteristic values over the raw score to get the percentages of importance.

Using the house of quality, the design group determined that the brightness level stood out as the most important engineering characteristic. If the participant cannot see our device's display, then nothing else the device does matters. The distance from scanner took the spot of the second most important characteristic. Should the system end up too far away from the scanner, the group could run the risk of the participant not having the ability to see the information the group's device outputs. The House of Quality picked the screen resolution for the third most important characteristic. If the information on the screen drops below a certain quality, the participant will have a difficult time interpreting the displayed information. The operating time and the tolerance of depth measurement tied for fourth. The system should help speed up the time that the scanning process takes; however, the system should have a larger tolerance of the depth. If the system has a low tolerance, then the system's "sweet spot" would look too similar to the "sweet spot" of the scanner. If both have the same size "sweet spot", then it would make directing the participant to the correct location and orientation very difficult since the desired "sweet spot" would have fallen outside the field of view of the group-designed device's sensors. The design's volume or system's size took the place of the fifth most important characteristic. If the system's size ends up too large, then portability could end up hindered as a result. Additionally, the system itself could potentially interfere with the scanning process. The operating temperature of the device stands out as the second to last most important engineering characteristic. Since it acts mostly as a safety constraint, as long as the operating temperature does not harm its own components or the participant, the operating temperature remains nearly negligible to concept selection. Weight, ironically, holds the least weight out of all the group's engineering characteristics. The team can always add wheels to the device to compensate for higher device weights. With the addition of wheels, the system's weight would only play a major roll when lifting the device up or down for transportation.



		Engineering Characteristics							
Improvement Direction		↓	↓	-	↑	-	↓	↑	↓
Units		in^3	lbf	m	cm	Lumen/Lux	°F	Pixel	Sec
Customer Requirements	WF	Design	Weight	Distance from Scanner	Tolerance of Depth	Brightness Level/Intesity	Operating Temperature	Resolution	Operating Time
Self Contained	1	9	3	3			3		
Does Not Interfere with the Scanner	4	9		9	3	9	1		
Accurately Displays the "Sweet Spot" Location	3			9	9	9	1	9	3
Accurately Displays the Desired Orientation	2			9	9	9	1	9	3
"Sweet Spot" clearly Seen by the Participant	4			9	3	9	1	9	9
Signals to the Participant to Hold/Update Position and Orientation	2			3		9	1	9	9
Raw Score	564	45	3	126	69	135	18	99	69
Percentage	(%)	7.98	0.53	22.34	12.23	23.94	3.19	17.55	12.23
Rank		5	7	2	4	1	6	3	4

Figure 2: House of Quality

Pugh Matrix

The design team created the first Pugh matrix based off the Hypervsn Wall as the comparison datum. The group compared the top eight concepts to the Hypervsn Wall based on the following characteristics: self-containment, potential scanner interference, “sweet spot” display accuracy, “sweet spot” visibility, price, and the ability to signal to the participant to hold/update there orientation. Upon filling out the table, the group found the following top three concepts: 1. AR & Leap Motion, 2. 3D Image Live Feed Camera, and 3. Adafruit with 3D Camera. AR & Leap motion scored the highest with six (6) pluses and one (1) satisfactory. The 3D Image Live Feed follows with five (5) pluses, one (1) minus and one (1) satisfactory. Lastly, the Adafruit with the 3D camera took five (5) pluses and two (2) satisfactories.

All three perform better than the Hypervzn Wall in the price, ability to signal to the participant, and the ability to accurately and clearly display the “sweet spot” location and desired orientation categories. The 3D Image Live Feed Camera falls short with self-containment, while the Adafruit and AR & Leapmotion perform similarly and better, respectively. The group eliminated the Mirage/Schlieren concept upon comparison; it only rendered one plus. The remaining concepts, Illuminating Mirascope, Cast of Hand/Head, BMW Holo-Touch, and the Manual Device with 3D Camera, remained for further comparison, eventually all scoring five (5) pluses, one (1) satisfactory, and one (1) minus.

Despite the AR and Leap Motion idea presenting itself as the most viable concept, the group chose this concept as the datum for the second and final Pugh Matrix. Since the AR device the group selected stood as far as possible from a realistic price point, the group removed the concept’s opportunity for selection. In the second Pugh Matrix, the greatest contrast between ideas fell on the price of each. All six concepts in the second Pugh Matrix scored “+” marks for the price category. In this matrix, the group eliminated most ideas relating to the ideation of an actual hologram based on the assumed scanner interference that would most likely occur due to the emitted light off of the created apparition. From this Matrix, though, three front runners emerged. All three ideas honed in on the general idea of having a contained mechanism position itself, either manually or autonomously, in the scan room and then, using an array of highly specialized sensors, indicate on some sort of display how and where the participant should orient themselves. The sensors would act as a sort of control system, sensing the current position and orientation of the participant and relating it visually to the correct position and orientation (the “sweet spot”).

Selection Criteria		BMW Holo-Touch	3D Image Live Feed Camera	Cast of Hand/Head	Adafruit w/ 3D Camera	Illuminating Mirascope	Semi-Automatic Robot w/ 3D Camera
1) Self Contained		-	-	S	+	+	+

Selection Criteria	DATUM: Hypervsn Wall	AR & Leap Motion	Mirage/ Schlieren	BMW Holo-Touch	3D Image Live Feed Camera
1) Self Contained		+	-	+	-
2) Does Not Interfere with the Scanner		+	-	S	+
3) Accurately Displays the "Sweet Spot" Location		+	-	+	+
4) Accurately Displays the Desired Orientation		+	-	+	+
5) "Sweet Spot" clearly Seen by the Participant		S	-	-	+
6) Signals to the Participant to Hold/Update Position and Orientation		+	-	+	+
7) Price		+	+	+	+
# of Pluses (+)		6	1	5	6
# of Minuses (-)		0	6	1	1

Figure 3a: Pugh Matrix Part A

Cast of Hand/Head	Adafruit w/ 3D Camera	Illuminating Mirascope	Semi-Automatic Robot w/ 3D Camera
+	S	+	+
S	S	+	+
+	+	S	+
+	+	+	+
+	+	-	-
-	+	+	S
+	+	+	+
5	5	5	5
1	0	1	1

Figure 3b: Pugh Matrix Part B

Analytical Hierarchy Process Justification(AHP)

The purpose of the Analytical Hierarchy Process Justification(AHP) is used to justify selection of the final concept. The process starts by using a pairwise comparison to examine the individual engineering criteria. Each criteria is evaluated and ranked from 1-9. This matrix is called the [c] matrix. Once the table is filled out each row and column is normalized using the equation Norm element = elementsum. The rows are averaged and this is the engineering criteria weight. The next step is to calculate the weight sum vector(WS=[c]*W). Consistency Vector is the next step and is calculated by WSW. The Consistency vector is used to compare for each criteria. We found our consistency comparison to be 0.098 which is within the CR<0.10. The table below shows the process of calculating the Consistency Comparison and also shows the weight factors for each criteria.

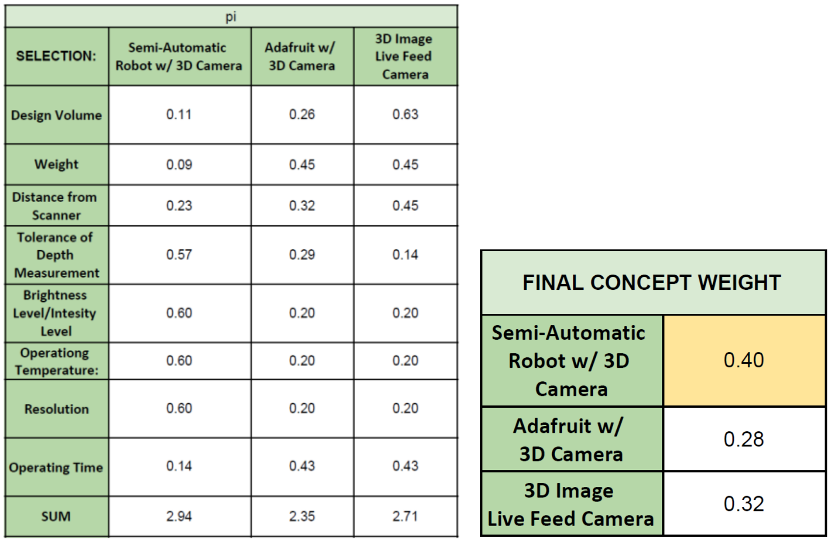
Table #a: *Consistency Comparison Part A*

				Normalized [C]		
Evaluation Criteria	Design Volume	Weight	Distance from Scanner	Tolerance of Depth Measurement	Brightness Level/Intesity Level	Operating Temperature
Design Volume	0.060	0.100	0.041	0.115	0.029	0.150
Weight	0.020	0.033	0.029	0.038	0.016	0.050
Distance from Scanner	0.300	0.233	0.205	0.346	0.146	0.150
Tolerance of Depth Measurement	0.060	0.100	0.068	0.115	0.438	0.050
Brightness Level/Intesity Level	0.300	0.300	0.205	0.038	0.146	0.250
Operating Temperature	0.020	0.033	0.041	0.115	0.029	0.050
Resolution	0.180	0.100	0.205	0.115	0.146	0.150
Operating Time	0.060	0.100	0.205	0.115	0.049	0.150
	1.000	1.000	1.000	1.000	1.000	1.000

Table #b: *Consistency Comparison Part B*

Once the weight factors are found for the engineering criteria the next step is to evaluate each concept in a pairwise comparison with respect to an individual engineering criteria. We did this once for each criteria(eight times) and found the weight for each concept with respect to the engineering criteria. This makes up a 8 x 3 matrix that is used to calculate the final concept for our project. We found that from the three final concepts, the semi-automatic robot with a 3D camera is the best design concept with respect to our 8 engineering criteria.

Resolution	Operating Time	Weight Factor	WS	Consistency			
0.056	0.115	0.083	0.726	8.717	Lambda	8.956	
0.056	0.038	0.035	0.300	8.543			
0.167	0.115	0.208	1.919	9.231	CI	0.137	Reference
0.167	0.115	0.139	1.370	9.837	CR	0.098	CR < 0.10
0.167	0.346	0.219	1.954	8.918			
0.056	0.038	0.048	0.425	8.870			
0.167	0.115	0.147	1.333	9.046			
0.167	0.115	0.120	1.020	8.490			
1.000	1.000	1.000					



pi			
SELECTION:	Semi-Automatic Robot w/ 3D Camera	Adafruit w/ 3D Camera	3D Image Live Feed Camera
Design Volume	0.11	0.26	0.63
Weight	0.09	0.45	0.45
Distance from Scanner	0.23	0.32	0.45
Tolerance of Depth Measurement	0.57	0.29	0.14
Brightness Level/Intesity Level	0.60	0.20	0.20
Operationg Temperature:	0.60	0.20	0.20
Resolution	0.60	0.20	0.20
Operating Time	0.14	0.43	0.43
SUM	2.94	2.35	2.71

FINAL CONCEPT WEIGHT	
Semi-Automatic Robot w/ 3D Camera	0.40
Adafruit w/ 3D Camera	0.28
3D Image Live Feed Camera	0.32

Figure 5: Final Selection Criteria

1.7 Spring Project Plan

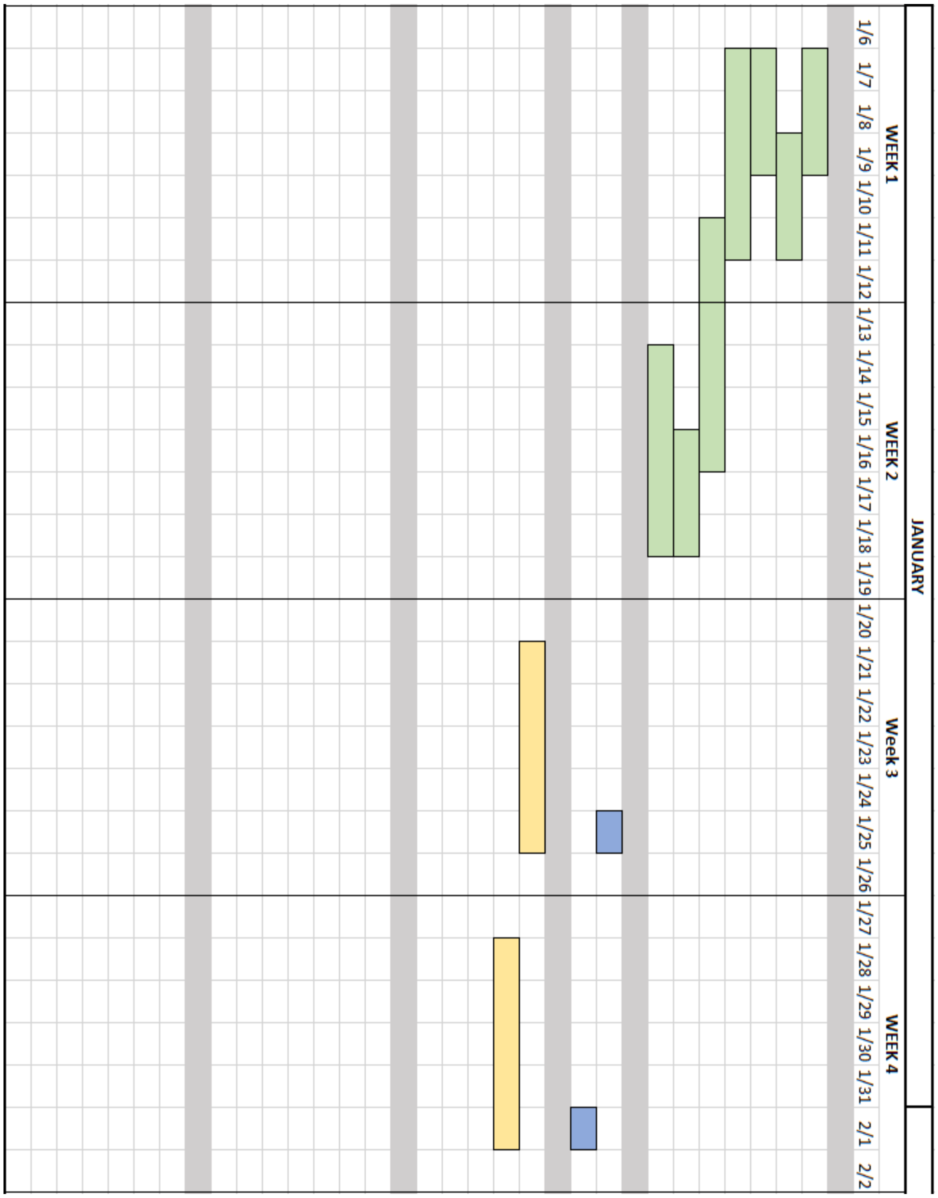
Our Spring Project Plan is a combination of a Work Breakdown Structure and a Gantt Chart. It starts on the first day of the spring semester (January 7, 2019) and ends on Graduation Day (May 4, 2019). The goal of the Spring Project Plan is to map out and schedule our “road map” for the semester. The dates chosen for checkpoints and deadlines were chosen to keep us moving forward with our project in order to complete the project well in advance of Engineering Design Day (EDD).

We broke our Spring Project Plan into 5 sections(phases). Section 1, “Design Process”, is focused on completing the final design work for our wearable, software, and hardware components. Section 2, “Project Management”, includes a budget analysis and a hard deadline for all ordering. We hope to have our ordering done well in advance of this deadline, but a hard deadline will help insure completion. Section 3, “Project Assembly Implementation”, focuses on the completion of all physical components and the completion of Robot Operating System (ROS) coding. One challenge with assigning a schedule to computer programming is that we will be continually working on ROS code for most of January and February. To communicate the ongoing work being done with ROS in the Work Breakdown Structure(WBS) and the Gantt Chart, several ROS checkpoint dates were added throughout the plan. Section 4, “Testing and Troubleshooting”, gives us a schedule for testing and completing all work on all components. The goal is to be done with testing and troubleshooting by Spring Break (roughly a month before Engineering Design Day). Section 5, “Project Finalization”, allots time for website completion, time for our team EDD Poster, and has EDD, finals week, and graduation day as our last tasks.

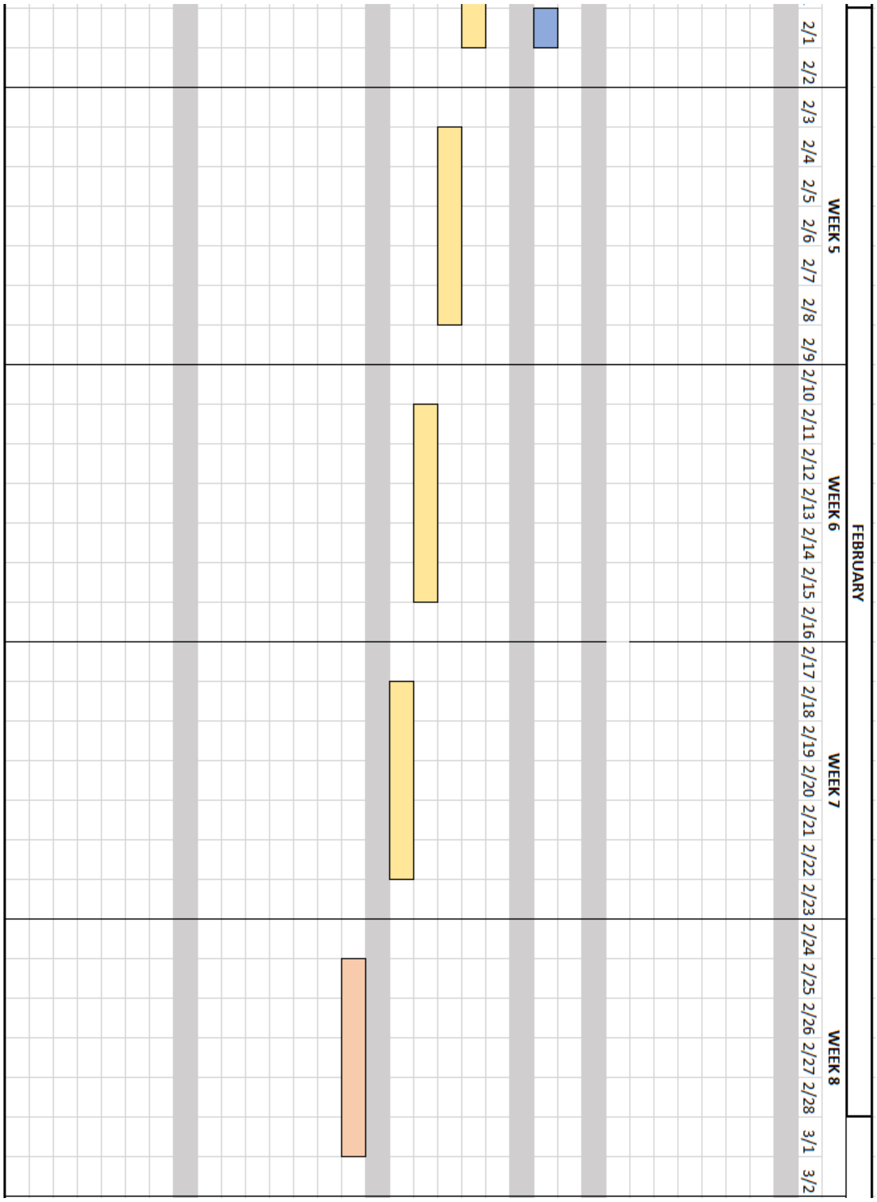
We feel that this plan gives us a good grasp of the work to be done and gives us enough time to complete the project. As the tasks progress, we will be able to keep track of completion using the “% complete” column of the WBS. If for some reason we get behind schedule, weekends will be used to get on track. Spring Break has also been left free as a buffer if needed.

WBS #	Project Tasks	Start Date	Finish Date	Task Duration	% Complete
1	Design Process				
1.1	Research April Tags and Potential Limitations	1/7/2019	1/9/2019	3	0%
1.1.1	Complete Final Wearable Design	1/9/2019	1/11/2019	3	0%
1.2	Complete Final Display and Computer Case Design	1/7/2019	1/11/2019	3	0%
1.3	Background Research on ROS	1/7/2019	1/11/2019	5	0%
1.4	Complete Final Camera/Sensor Mount Design	1/11/2019	1/16/2019	2	0%
1.5	Complete Final Casing and Sensor Thermal Fluids Designs	1/16/2019	1/18/2019	3	0%
1.6	ROS: Track the X,Y,Z Position of an Apriltag	1/14/2019	1/18/2019	5	0%
2	Project Management				
2.1	Team Deadline for Ordering	1/25/2019	1/25/2019	1	0%
2.2	Project Budget Analysis	2/1/2019	2/1/2019	1	0%
3	Project Assembly Implementation				
3.1	ROS: Track the X,Y,Z Orientation of an Apriltag	1/21/2019	1/25/2019	5	0%
3.2	Wearable Fabrication	1/28/2019	2/1/2019	5	0%
3.3	ROS: Operating User Interface	2/4/2019	2/8/2019	5	0%
3.4	Assemble Camera/Sensor Module	2/11/2019	2/15/2019	5	0%
3.5	Assemble Computer Module	2/18/2019	2/22/2019	5	0%
4	Testing and Troubleshooting				
4.1	Test ROS Code with Wearable Design and Monitor	2/25/2019	3/1/2019	5	0%
4.1.1	Troubleshoot ROS Code	3/4/2019	3/8/2019	5	0%
4.1.2	Troubleshoot Wearable Design	3/4/2019	3/8/2019	5	0%
4.1.3	Troubleshoot Thermal Fluid Regulation	3/4/2019	3/8/2019	5	0%
4.1.4	Troubleshoot Camera/Sensor Placement	3/4/2019	3/8/2019	5	0%
4.2	ROS: Fully Commented/Debugged Code	3/11/2019	3/15/2019	5	0%
4.3	Spring Break (Project buffer if needed)	3/18/2019	3/22/2019	5	0%
5	Project Finalization				
5.1	Design Poster for Engineering Design Day	3/25/2019	3/27/2019	3	0%
5.1.1	Finalize Proof of Concept for Poster	3/27/2019	3/29/2019	3	0%
5.2	Complete Team 523 Website	4/1/2019	4/5/2019	5	0%
5.3	Finalize Evidence Manual	4/8/2019	4/12/2019	5	0%
5.4	Engineering Design Day	4/18/2019	4/18/2019	1	0%
5.5	Final Exams	4/29/2019	5/3/2019	5	0%
5.6	Graduation	5/4/2019	5/4/2019	1	0%

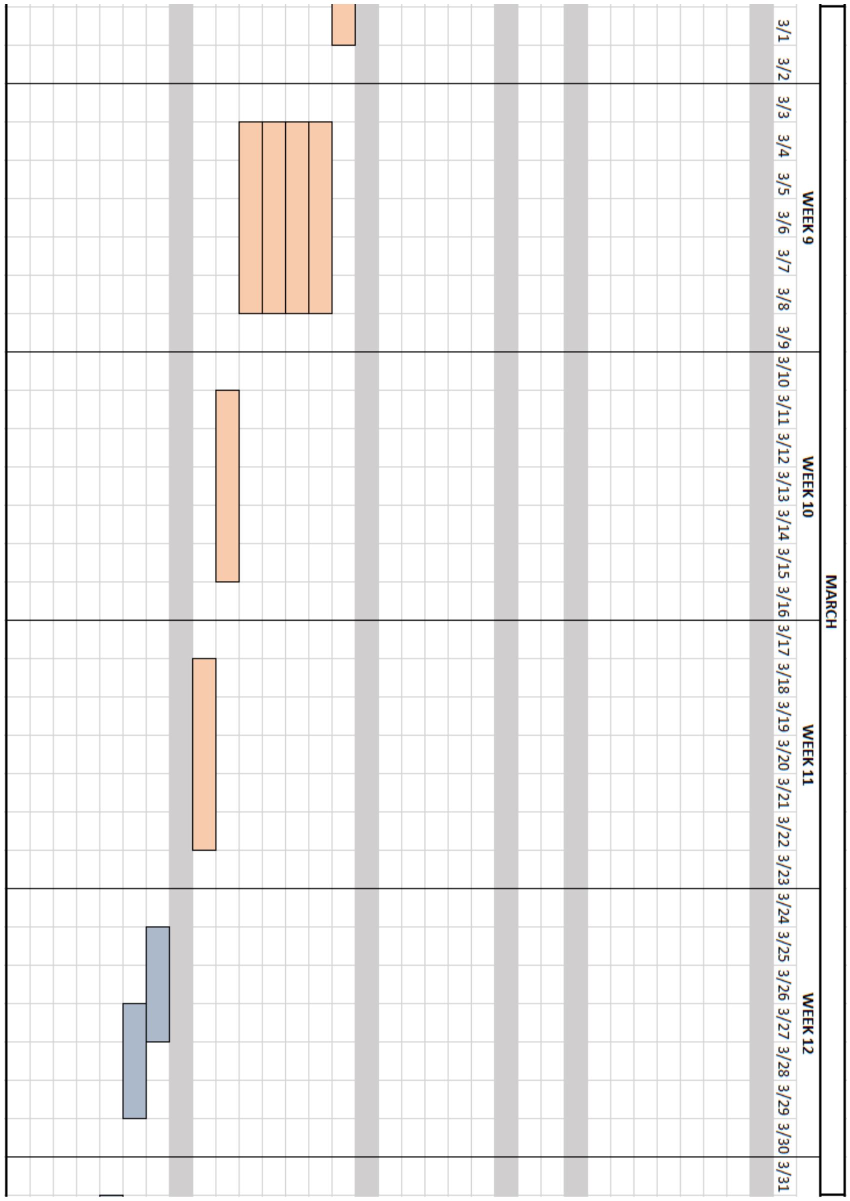
Spring Project Plan Part 1: Work Breakdown Structure



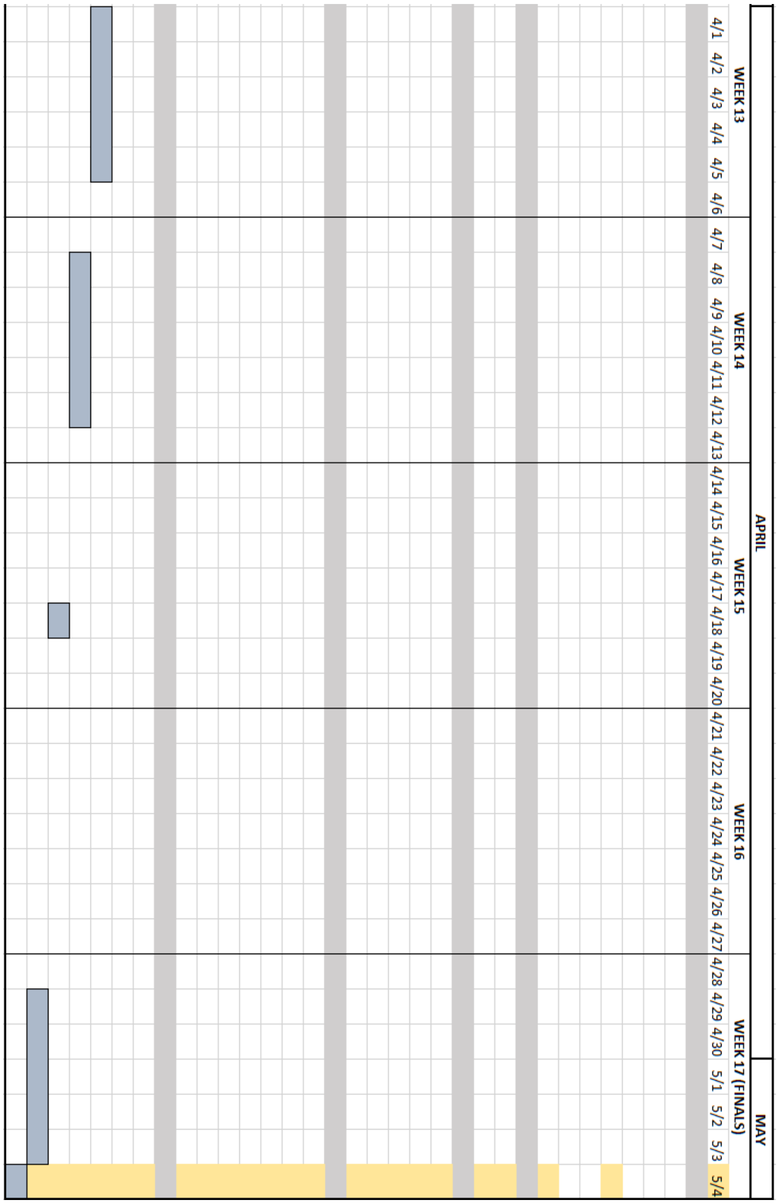
Spring Project Plan Part 2: January Gantt chart



Spring Project Plan Part 3: February Gantt chart



Spring Project Plan Part 4: March Gantt chart



Spring Project Plan Part 5: April/May Gantt chart

Chapter 3: EML 4552C

2.1 Spring Plan

Project Plan.

Build Plan

Chapter 4: Appendices

Appendix A: Code of Conduct

Mission Statement:

The team is dedicated to excellence in all aspects of their work whether that be in communication, design, research, or problem solving.~~ ~~ The individuals of the team are committed to incorporating integrity among engineering principles in addition to all~~ of~~ of their knowledge to produce solutions that best fit the sponsor's needs. Additionally, the team is determined to represent our sponsor, Dr. Yubin Xi, and his vested interests through our professional work ethic.

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Team Member Roles:

Each member of the team is assigned a role based on preference for the role or prior experiences, but they will not have sole ownership of their related task(s). The individual roles are merely a tool to assist in the completion of tasks and to ensure team accountability.

Systems Integration and Project Manager: Timothy Rubottom

The role of the Project Manager is to organize team efforts, maintain up to date evidence manual, produce organization and schedule related tools (Gantt chart and a "One Page Project Manager"), set meeting agendas, record meeting minutes, and prepare power point presentations. They will be responsible for turning in assignments on time and keeping the team on track for project due dates. They will also be responsible for communication with the Team advisor, Dr. McConomy.

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Design Engineer: Joshua Segall

The Design Engineer finds himself tasked with a substantial portion of the project's concept generation and research, in addition to helping lead the group through any CAD difficulties that may arise. While the whole team should carry knowledge of the involved technologies and publications, the Design Engineer must stay at the forefront of all information relevant to this project and its final deliverable(s). It is the sole responsibility of the Design Engineer to keep the group up to date on the latest relevant technological breakthroughs and publications. This helps the group hone in on only viable solutions, rather than in on the abstract or irrelevant. The Design Engineer helps promote healthy concept generation and makes sure to keep the group from dawdling over partially thought-through ideas with little functional application.

~~Research & Construction Engineer~~ Fabrication Engineer: Caleb Pitts

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The Fabrication Engineer's job would consist of the prototyping, CAD designing parts, along with ordering parts. All surface/solid modeling and engineering drawings will be created through PTC Creo parametric. Computer models will be used to machine parts and/order parts that fit the need.

Test Engineer: Matthew Bigerton

The test engineer will be responsible for planning, designing and evaluating products/prototypes. These responsibilities will involve frequent collaboration with the fabrication engineer, and to act as a liaison between the fabrication engineer, the design engineer and the mechatronics engineer, to ensure proper production management. Furthermore, the test engineer determines the best possible method to test a particular product/prototype so it meets the specified standards. Lastly, the test engineer makes sure that the finished product/prototype can be identified easily and tested thoroughly.

Mechatronics ~~odeling~~ Engineer: Josiah Bazyler

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The Mechatronics Engineer's tasks will revolve around work that requires MatLab, mechanical design, and electrical design. The team will formulate mathematical equations and incorporate them into the project to identify component specifications vital to the Design and the Fabrication Engineers' capacity to create engineering drawings essential to the manufacturing process of various components. Ultimately, any debugging and electrical/mechanical setup will be mainly performed by the Mechatronics Engineer.

Additional Duties:

As progress is made with the project, additional tasks/roles will be assigned. They will be assigned on a case by case basis and will be reported accordingly. These include but are not limited to the following: web design, constructing the bill of materials, and maintaining financial records of parts/services purchased.

Methods of Communication:

For Team 523, the main methods of communication will be through group text messages ~~in a group chat~~, an application called “Group Me”, ~~and~~ occasional phone calls, and emails. The response time will need to be within 24hrs.~~For the items that are not time sensitive the team will be using e-mail.~~ The team will meet during scheduled class time along with a weekly meeting outside of class. For sharing files between~~ the~~ group members, we will utilize Microsoft's application "OneDrive" and/or Google's "Google Drive".

Dress Code:

Team 523 will strive to facilitate a professional work environment by adhering to a specific dress code for various events.~~–~~ Team presentations & sponsor/advisor meetings will require coordinated business attire (i.e. Team polo's/khakis for presentations and matching dress shirts/slacks for professional interactions). Lastly, team meetings are a casual affair; thus, casual attire will be deemed fitting. This dress code will ensure that Team 523 represents its sponsor, adviser, and the FAMU-FSU College of Engineering properly and respectfully.

Attendance Policy:

For the rules, regarding attendance, communication is the most important factor. Attendance is defined as not only physically being present to the meeting on time, but also actively participating in whatever work is being completed. Attendance is mandatory and will be recorded through an Excel spreadsheet. If a teammate has an event arise during the same time that we plan on meeting, then that teammate will need to communicate their dilemma with the rest of the group no less than 1 hour before the start of the meeting. For known appointments/traveling dates, these dates will be gathered at the beginning of the semester and culminated throughout the rest of the semester. In accordance, for teammates that are present during the meetings, social media use will not be allowed, but important phone calls/texts can be answered within reason. If, however, the meeting is with our sponsor, then all phones must be turned off prior to the meeting. For additional support, we will schedule meetings with our advisors via email with no less than a 48hr notification, if possible.

Updating the Statement of Understanding:

If there needs to be an update to the statement of understanding, then all teammates will need to be physically present and agree to sign off on a "Verification of Updating the Statement of Understanding" document in order to complete this process.

Statement of Understanding:

By signing this document, the members of Team 523 agree with all the above and will abide by the code of conduct.

Name:	Signature:	Date:
______________________________	______________________________	_______________
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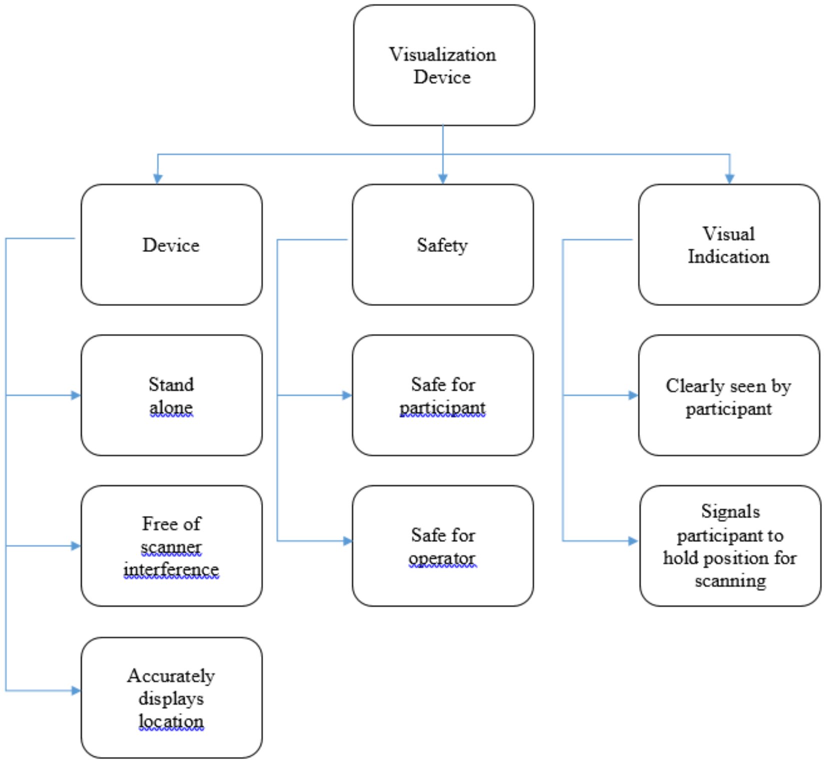
Appendix B: Functional Decomposition



Appendix C: Target Catalog

*Critical Targets and Metrics

Hologram Anthropometric Scanner

Main Function	Sub-Functions	Metrics	Targets
Device	Self-Contained	Dimensions (in)	≤ 30 x 30 x 30
		*Weight (lb.)	≤ 25
	Free of Scanner Interference	*Distance from Scanner (m)	~ 1
	Accurately displays location and orientation	*Tolerance of depth Measurement (cm)	≤ 4
Safety	Safe for participant	*Brightness level (Lumen)	< 200
		Intensity level (Lux)	< 200
	Safe for operator	Operating temperature (°F)	< 150
Visual Indication	Clearly seen by participant	Perceived Brightness level (Lux)	100 - 200
		Resolution (Pixel)	≥ 480
	Signals participant to hold position	*Time in designated Location & Orientation (Second)	< 30
Power	Power supply	Power consumption (Watts)	< 11
		Operating voltage (Volts)	≤ 55

Appendix D: Concept Generation

1. 3D Positioning (XeThru IR-UWB Radar Sensor)

The Xethru Impulse Ratio Ultra-Wideband (IR-UWB) Radar Sensors are capable of positioning and displaying the position on a 3D display. The XeThru IR-UWB Radar Sensor is unique in that it can detect distance, presence, and motion. Furthermore, it has adaptive sensing which allows for the radar sensor to seamlessly switch between features and adjust parameters such as detection range and sensitivity during operation. This device would allow for the participant to visualize their positioning in space and could position themselves for an accurate scan by following their position on the output display to the “sweet spot”.

This concept option does have drawbacks to consider. The amount of coding and algorithm generation is substantial. Furthermore, even with an efficient algorithm, upwards of eight (8) sensors would potentially be needed, which would drive up cost to over $2,000 alone for just the sensors. Lastly, with using 1D and 3D Kalman filters, the output would only give estimations of the position. Moreover, these sensors track and display positioning of the whole body, when position/orientation of the head and/or hand are what is specifically needed. The UWB Radar sensor could be used along with another concept- the UWB radar positioning the body as the whole and another concept positioning the head and/or hand specifically.

2. Laser Sensor Coordinate location

This concept uses a combination of triangulation of lasers to show a particular point in X-Y-Z space and motion detectors communicating with indicator lights. The lasers could be on a track system and coded so that they are always triangulated together even when the sweet spot has to be recalibrated or moved. The lasers will be weak enough not to cause damage to participants, but strong enough to be visible at the meeting point.

The lasers will be the visual indicator to the participant, but a strong and accurate motion sensor will be tracking the location of the participant. When the participant gets to the desired location, indicator lights in the scan room will activate to communicate that the participant is in the correct position. In tandem, there will need to be a series of images displaying the desired orientation for the scan.

3. Leap Motion

Leap motion is a device that is mainly used in hand tracking for Virtual Reality (VR), this device can be used independently from VR. This system tracks the position and can accurately display the position of the user's individual digits in his or her hands. This device would be majorly beneficial in instruction the participant where to put his or her hands along with the exact orientation the hands need to be in.

This device, however, works strictly with hands. Leap Motion is unable to track any other part of the human body. If this concept was to be selected it would be considered an add-on to another concept. Leap Motion was still considered a concept generation due to its highly accurate hand tracking abilities. Another major drawback to the Leap Motion is the position of the device in reference to the user. The device has to be within two feet of the user’s hands. The user’s hands must also stay parallel to the device’s surface. If the hand become perpendicular to the surface of the device it loses the ability to track individual fingers and interprets the hand as something similar to a crab’s claw.

If used correctly the Leap Motion can track the orientation of the user's hands and fingers more accurately than any of the other concept generations. The Leap Motion's price point is very affordable, which would allow it to be used alongside another concept.

4. 3D Image projected onto live feed camera

For this concept, a Kinect would record various orientations to complete a 360° view of a human hand and a separate 360° view of a human head and then save these orientations as reference scans (RS's). Given that most human heads are relatively similar in shape/size while human hands are not, only one all-encompassing (a scan from enough angles to complete a 360° view) reference scan (AERS) of a human head will be taken while three other AERF's of different sizes of hands will be taken. These AERF's will be used to populate a database of a head as well as small, medium, and large hands.

From here, whether scanning a hand or a head, the appropriate RS's inside of its designated AERF will be scaled, displayed, and cycled through onto a designated area (representative of the sweet spot) of the live feed camera in order for the participant to fill each orientation until completion. The live feed camera would be projected onto a monitor inside the scanning room. Ideally, this monitor would be relatively close to the sweet spot location so that the participant can see it clearly, but it will be far enough away so that it will not obstruct the view of the scanner (an Xbox "Kinect" in this case). Given that only 2D images will be displayed onto the live feed camera, different infrared (IR) sensors will be incorporated into a user interface to allow the participant to know how far away their hand is from the sweet spot in reference to the X-Y-Z plane. For proof of concept, a Kinect will be set up nearby taking scans during each moment that a RS is presented to the participant so that these scans could be stitched together to render a 3D image.

5. BMW Inspired/McConomy Designed Holo-Touch Technology

This concept uses aspects of Pepper's Ghost Effect to project, what one can describe as the closest possible thing to a real hologram, in a light controlled environment. Rather than using the classic, single pane of glass or plastic, the designer uses multiple panes in order to provide the projection with dimensionality.

Such a stable idea, of course, comes with its many pitfalls. For one, the field of the participant's view is limited to 180 degrees on a single side of the pane of plastic or glass. As such, as soon as a participant out maneuvers the device, he or she could potentially get stuck looking at absolutely nothing. In addition to this, the environment in which such a device works is limited to a certain range of lighting. This idea would limit the brightness of the device's containing room; however, all other factors point to the legitimacy of this concept's ability to introduce a controlled and suspended light field into the scan room.

6. Smart Sound Locating System (In room Haptic Feedback/Room Doppler)

The Doppler effect states that as the origin of a sound get closer or further away from the microphone measuring it, the pitch of the sound (the sound the microphone records) respectively gets higher and lower.

As such, a smart sound system can help to indicate the sweet spot to the introduced participant. As the participant moves closer and further away from the sweet spot, as a tracking system follows their location in the room, the smart sound system can play a respectively higher or lower pitch.

In addition to utilizing the human hearing range, some much deeper, bass tones can act as a sort of in-room haptic feedback to vibrate the participant or their respective body part as they move into the sweet spot.

7. Air Density Change--Mirage Projection

One can easily project images onto solid, liquid, and gaseous surfaces. In a room environment such as this one, water or fog cannot flow into or through the scanning environment. As an alternative, projecting an image onto a change in density/temperature, such as with a mirage, could act as a viable option for creating a real hologram.

8. Occipital Structure sensor

The Occipital Structure Sensor allows the user to identify the X-Y-Z position of the sweet spot as well as the orientation of the desired hand/head) where the image is projected onto a screen in front of the user. An audio recording/visual message on a screen/series of LEDs can be implemented to indicate to the user about the start/in progress/ end states of the device.

9. Intel Realsense Camera SR300

Have an Intel Realsense Camera SR300 that can sense the user’s position as well as indicate the x,y,z position and the proper orientation of the scanner’s sweet spot. It creates a CAD model of the user that can be projected into the camera feed in real time.

10. Hololens

Have a Hololens that can be placed on the user’s head which can project a series of 3D hand orientations into the real world at the desired sweet spot for the user to fill.

11. Adafruit VL53L0X Time of Flight Distance Sensors

Have a series of Adafruit VL53L0X Time of Flight Distance Sensors that can determine the user’s X-Y-Z location at all-time where this location (represented by a shape) is projected onto a screen in front of the user in real time so that they can position this shape into the sweet spot location. A series of images can be flashed across a separate screen in order to enable the user to fulfill various orientations of specified body parts.

12. Manual device on caster wheels

Have a manual device on caster wheels (they can lock/unlock) that can roll around and can be lifted and lowered to a desired height representative of the sweet spot. A series of pictures can be cycled through to allow the user to complete various orientations.

13. Semi-automatic device on caster wheels

Have a semi-automatic device on caster wheels (they can lock/unlock) that can roll around, but has a switch to lock/unlock the wheels as well as lock/unlock the desired height. A series of pictures can be cycled through to allow the user to complete various orientations.

14. Using EDI Body motion sensor which uses a form of motion tracking developed by Facebook. It is a similar technology to Xbox Kinect. It tracks the body motions through a sensor and displays it on a screen.

15. Moving platform that will place the participant to the specified location. The participant would step on the platform and it would slowly be driven to the specific location of the sweet spot.

16. Line of lights that will change from red to green when you enter the correct location/orientation. Having strip of LED lights with a single light lit up that would stay red as you walk through the room, once you reach the right location in the room the single light would change from red to green.

17. Images on a screen that display how the participant should position their body. Instead of spending unnecessary money on a device or program that would guide the participant to the correct body orientation, have a poster that could show the participant how to position his or her body.
18. Footprint on a mat in the sweet spot scanning location. This could be moved around as the sweet spot moves after calibration the mat could simply be moved to the correct location. Once the participant enters the room it will become apparent where they should stand.
19. A human figure that is in the correct scanning orientation that will indicate how the participant should position his or her own body. The human figure can move to adapt to the different positions the participant should be in.
20. Instructional video displaying and describing how the participant should be positioned. The video could be played constantly without need for an individual to have to present to tell them how they should stand and position their body.
21. Technician in the room with the participant placing them in the correct position and orientation. No need for any fancy programs or devices. Have someone that walk the participant to the sweet spot location, and then orientate the body parts in to desired position.
22. Projection of light on the floor indicating the sweet spot to the participant. Much like how the store “Ikea” uses arrows on the floor to indicate the path you should follow through the store. This is beneficial because this can be easily positioned as the sweet spot changes.
23. Directional speakers that produce sound only in the sweet spot of the scanner. Directional speakers have a finite location where the sound can actually be heard. The participant will be able hear the sound once in the sweet spot.
24. Light up line on the floor that you follow to the standing sweet spot. There would be a strip of LEDs blinking that the participant would follow.
25. Instructions from the technician room on how to position the participant. Auditory instructions using words like left, right, forward or back.
26. Moving the scanner to the participant location. This way the sweet spot would be placed on the participant.
27. Using hand scanners so the participant would not have to move and could get closer scans of the part of body that they are interested in scanning.
28. Having a hand casting on a string attached to a motor where the participant would put their hand. The motor would raise the hand to above the where the participant hand would be placed showing the exact position and orientation. When it comes time for the scan raise the hand completely out of the way so it would not interfere with the scanner.
29. Vibration in the floor panels to notify participant of location. The Vibration frequency and pattern can change as participant approaches sweet spot.
30. Small hoop hung on a string with a mechatronic track system to move around on the ceiling. The hoop is lowered to the sweet spot. When the participant is in the correct location, the technician retracts the hoop.
31. Utilizing a form of biomimicry, we will be using a form of radar location to indicate on a screen the location of the participant vs the sweet spot.
32. Noticeable temperature change that physically use the Hot and Cold idea to lead participant to sweet spot.

33. Use something similar to a planetarium projector that could project a 3D “sweet spot” in air.
34. Program a pattern of small drones that indicate the location and orientation for the participant. The drones would be programmed to stay in formation until the scan begins, at which point the drones will move away from the sweet spot.
35. Have a portable/lightweight tent like structure (think something similar to the portable medical tents on the sidelines of football games) within the scan room that indicates either head or hand location. When the participant is in position, the structure will retract and leave the space clear to be scanned.
36. Design pictures for each step of the orientation position and indicate on the floor with a piece of tape where the participant is to stand.
37. Have a powerful beam of light shine from the ceiling to the floor, and a second powerful beam of light shine from side to side so that where the light paths cross is where the sweet spot will be.
38. Have a recorded instructional message to give instructions for where the participant will position their head or hand.
39. Use Virtual Reality glasses and some kind of hand held device that can be attached without impairing the scan. For head scans the goggles can just be removed upon positioning. For hand scans, the hand device will be so small that it will not affect the scan.
40. Use smells to lead the participant to the right spot.
41. Have something come from the floor that indicated where the hand should be placed. Once the hand is in place, the object retracts into the floor.
42. Dim lights and have a mechanical arm quickly rotates a light in a circle about the sweet spot. Once participant is in place the technician can remotely retract the mechanical arm.
43. Have an inflatable 3d objects coming from the floor (think used car lot waving inflatable man) and ceiling will indicate the bottom and top of the sweet spot. When the participant is in place, objects deflate and retract.
44. Have a dark room with a single light indicating the sweet spot.
45. The temperature of participant’s location gets colder and hotter as he or she moves further and closer from and to the sweet spot.
46. Large Mirascope
47. Pepper’s Ghost Projection
48. Large paper diagram instructing the participant how and where to position themselves relative to other features in the scan room.
49. Provide the participants with a short instructional video prior to entering the scan room, indicating to them how and where to position themselves.
50. Change the texture of the room’s features and floor to inherently coax participants into the proper scan location.
51. Provide the participant with in-scan-room robotic assistance to help them orient and locate themselves within the scan room.
52. Introduce the room to a controlled magnetic field that allows for the suspension or projection of essential scanning room cues.
53. Change the location of the scan sweet spot based on the participant’s location.

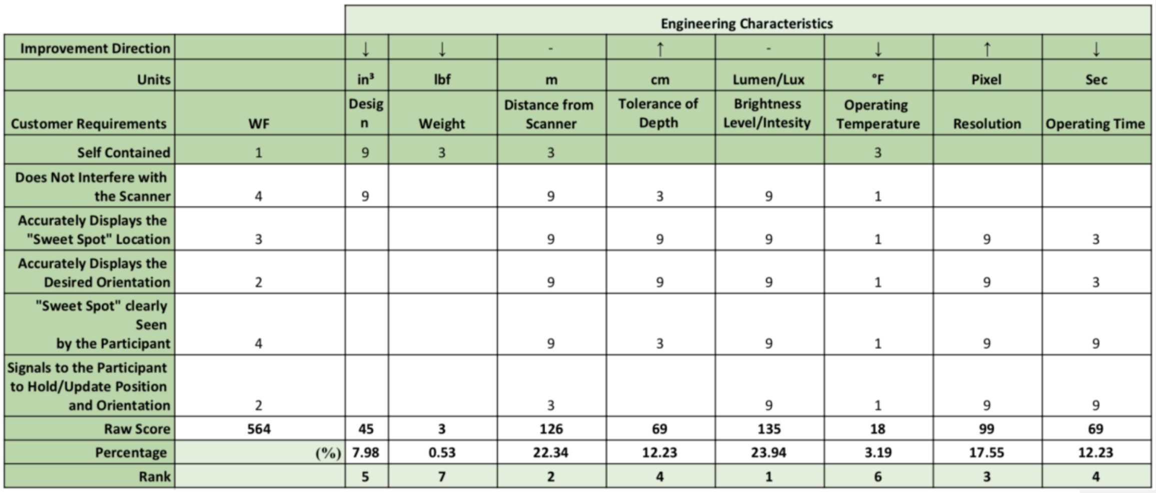
54. Introduce a pulley system into the room that would connect to the participant or their clothing and pull respective body parts and limbs into the necessary sweet spot.
55. Introduce the participant to an in-scan-room 2D optical illusion, painted on the floor and/or walls that indicates how and where the participant should stand.
56. Make any location in the scan room where the sweet spot is not uninhabitable.
57. Gives the participant AR goggles (ie Magic Leap) that will create a hologram for the participant's eyes only that would indicate how and where he or she should stand in the room.
58. Gives the participant AR contact lenses that will create a hologram for the participant's eyes only that would indicate how and where he or she should stand in the room.
59. Introduce a controlled volume of fog with respect to time into the room that light can be projected onto to create a hologram.
60. Introduce a controlled volume of water with respect to time into the room that light can be projected onto to create a hologram.
61. Use Morse code to communicate to the participant how to reposition themselves and get to the sweet spot.
62. Have every person in the scan staff silently point at the sweet spot.
63. Spin LED lights quickly in a circle to create a flat hologram surface with the appearance of depth ("Holographic Fan Projector") that can help the participant find the sweet spot.
64. Indicate to the participant where the sweet spot is using braille.
65. Incorporate plasma emission where different light particles emitted from different x,y locations are "activated" in space at a desired height to create 3D images.
66. Incorporate a "Holovect" concept that projects green dots into 3D space while also connecting the dots representative of vectors. The cumulation of vectors can be projected into space in the shape of a desired body part for the user to fill.
67. A moving laser that directs the participant to the sweet spot location.
68. A bracelet/glove and/or headband that can be tracked and projected on a 3D display that can match up to the desired sweet spot shown on the coordinate display.
69. Fly on the wall--a robotic fly (drone) would be followed to the location and then give auditory cues (from the technician in the scanning room) on how to position their hand/head orientation- once the sweet spot is filled, then the fly goes away.
70. Turning a wall into a moving canvas- utilizing concepts of projection mapping, the participant would look at the wall giving directions. These cues could show a 3D image in space for the participant to mimic/mirror.
71. Dynamic projection mapping- this is similar to the moving canvas, except this allows for a 3D image to be projected onto the participant that they can follow to the sweet spot. A proposed marker is drawn onto the target with infrared ink, invisible to the human eye, which allows for robust and high speed non-rigid surface tracking, even in the presence of occlusions.
72. Indicate the sweet spot using American Sign Language (ASL).
73. A vertical gurney that is on a moving track- the participant would be gently secured in and a mechanical linkage attached to the arms and hands would position their orientation/location of their hand to the sweet spot.

74. A full-body morph suit that can be tracked and projected onto a 3D plane. The sweet spot would be on the 3D plane and the participant would move until their coordinates match with the sweet spot.

75. A belt is fastened around the participant that is attached to two cables that are attached to a moving track. The moving track will gently position the participant to the ideal location for the sweet spot.

Appendix E:Concept Selection

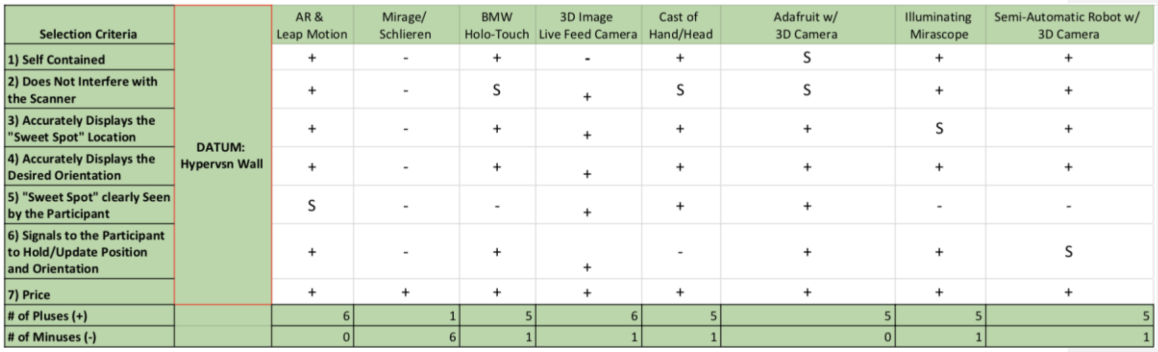
House of Quality



		Engineering Characteristics							
Improvement Direction		↓	↓	-	↑	-	↓	↑	↓
Units		in³	lbf	m	cm	Lumen/Lux	°F	Pixel	Sec
Customer Requirements	**WF**	**Design**	**Weight**	**Distance from Scanner**	**Tolerance of Depth**	**Brightness Level/Intesity**	**Operating Temperature**	**Resolution**	**Operating Time**
Self Contained	1	9	3	3			3		
Does Not Interfere with the Scanner	4	9		9	3	9	1		
Accurately Displays the "Sweet Spot" Location	3			9	9	9	1	9	3
Accurately Displays the Desired Orientation	2			9	9	9	1	9	3
"Sweet Spot" clearly Seen by the Participant	4			9	3	9	1	9	9
Signals to the Participant to Hold/Update Position and Orientation	2			3		9	1	9	9
Raw Score	**564**	**45**	**3**	**126**	**69**	**135**	**18**	**99**	**69**
Percentage	**(%)**	**7.98**	**0.53**	**22.34**	**12.23**	**23.94**	**3.19**	**17.55**	**12.23**
Rank		**5**	**7**	**2**	**4**	**1**	**6**	**3**	**4**

Figure 1: House of Quality

Pugh Matrix



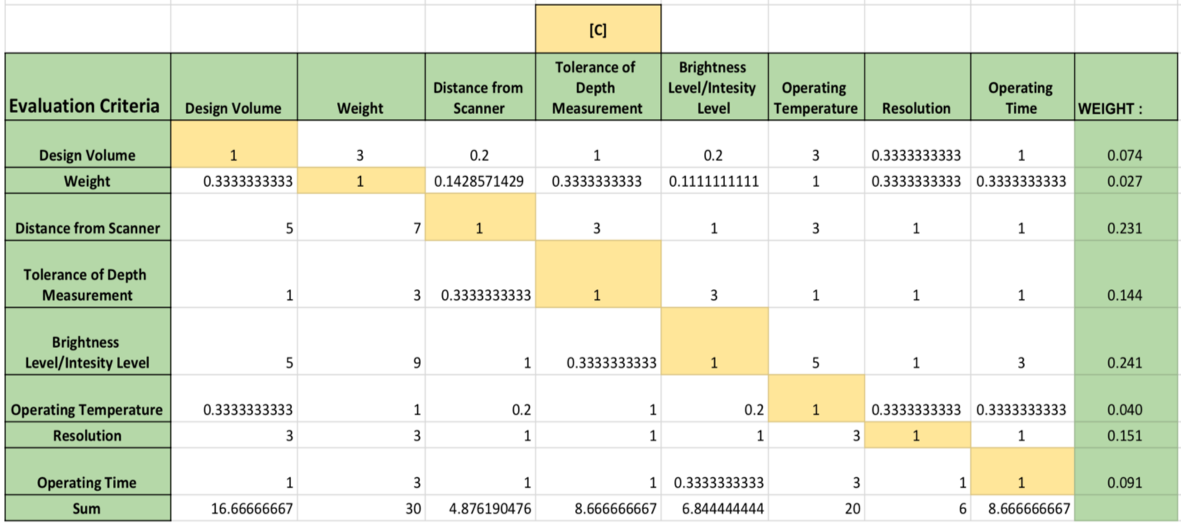
Selection Criteria		AR & Leap Motion	Mirage/ Schlieren	BMW Holo-Touch	3D Image Live Feed Camera	Cast of Hand/Head	Adafruit w/ 3D Camera	Illuminating Mirascope	Semi-Automatic Robot w/ 3D Camera
1) Self Contained	**DATUM: Hypervsn Wall**	+	-	+	-	+	S	+	+
2) Does Not Interfere with the Scanner		+	-	S	+	S	S	+	+
3) Accurately Displays the "Sweet Spot" Location		+	-	+	+	+	+	S	+
4) Accurately Displays the Desired Orientation		+	-	+	+	+	+	+	+
5) "Sweet Spot" clearly Seen by the Participant		S	-	-	+	+	+	-	-
6) Signals to the Participant to Hold/Update Position and Orientation		+	-	+	+	-	+	+	S
7) Price		+	+	+	+	+	+	+	+
# of Pluses (+)		6	1	5	6	5	5	5	5
# of Minuses (-)		0	6	1	1	1	0	1	1

Figure 2: First Pugh Matrix with Datum from market

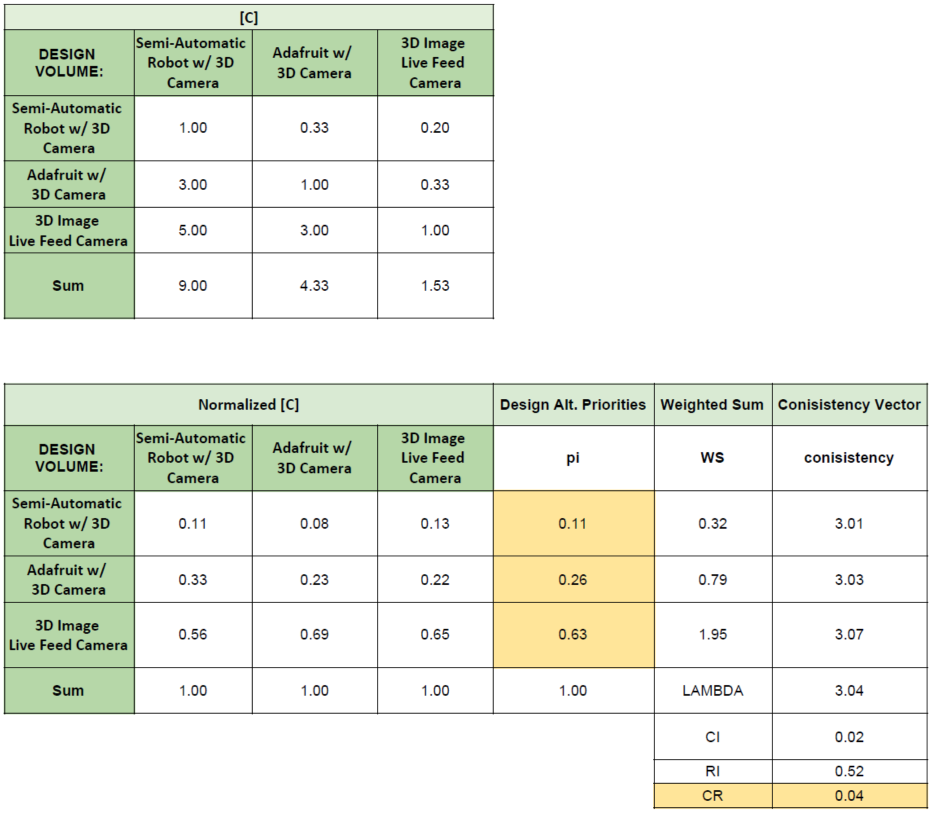
Selection Criteria		BMW Holo-Touch	3D Image Live Feed Camera	Cast of Hand/Head	Adafruit w/ 3D Camera	Illuminating Mirascope	Semi-Automatic Robot w/ 3D Camera
1) Self Contained	**New Datum** **AR & Leap Motion**	-	-	S	+	+	+
2) Does Not Interfere with the Scanner		-	+	+	-	-	S
3) Accurately Displays the "Sweet Spot" Location		-	S	-	S	-	S
4) Accurately Displays the Desired Orientation		S	S	-	S	S	S
5) "Sweet Spot" clearly Seen by the Participant		-	S	S	S	-	-
6) Signals to the Participant to Hold/Update Position and Orientation		S	S	-	S	S	S
7) Price		+	+	+	+	+	+
8) Multi Purposed		+	+	+	+	+	+
# of Pluses (+)		2	3	3	3	3	3
# of Minuses (-)		4	1	3	1	3	1

Figure 3: Second Pugh Matrix

Analytical Hierarchy Process Justification (AHP)



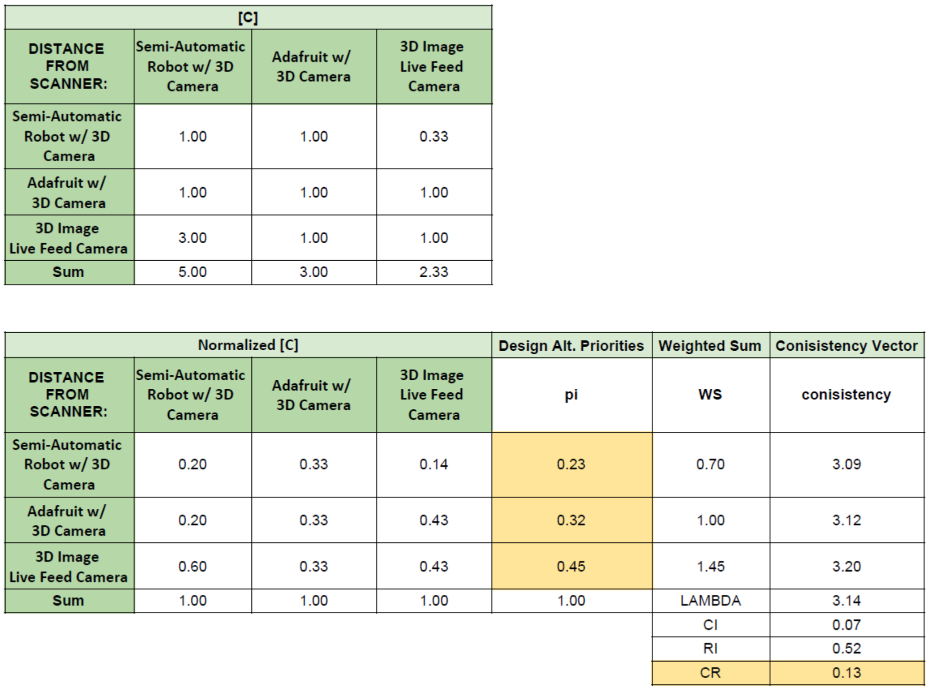
				[C]					
Evaluation Criteria	**Design Volume**	**Weight**	**Distance from Scanner**	**Tolerance of Depth Measurement**	**Brightness Level/Intesity Level**	**Operating Temperature**	**Resolution**	**Operating Time**	**WEIGHT :**
Design Volume	1	3	0.2	1	0.2	3	0.3333333333	1	0.074
Weight	0.3333333333	1	0.1428571429	0.3333333333	0.1111111111	1	0.3333333333	0.3333333333	0.027
Distance from Scanner	5	7	1	3	1	3	1	1	0.231
Tolerance of Depth Measurement	1	3	0.3333333333	1	3	1	1	1	0.144
Brightness Level/Intesity Level	5	9	1	0.3333333333	1	5	1	3	0.241
Operating Temperature	0.3333333333	1	0.2	1	0.2	1	0.3333333333	0.3333333333	0.040
Resolution	3	3	1	1	1	3	1	1	0.151
Operating Time	1	3	1	1	0.3333333333	3	1	1	0.091
Sum	16.66666667	30	4.876190476	8.666666667	6.844444444	20	6	8.666666667	



[C]			
DESIGN VOLUME:	**Semi-Automatic Robot w/ 3D Camera**	**Adafruit w/ 3D Camera**	**3D Image Live Feed Camera**
Semi-Automatic Robot w/ 3D Camera	1.00	0.33	0.20
Adafruit w/ 3D Camera	3.00	1.00	0.33
3D Image Live Feed Camera	5.00	3.00	1.00
Sum	9.00	4.33	1.53

Normalized [C]				Design Alt. Priorities	Weighted Sum	Conisistency Vector
DESIGN VOLUME:	**Semi-Automatic Robot w/ 3D Camera**	**Adafruit w/ 3D Camera**	**3D Image Live Feed Camera**	**pi**	**WS**	**conisistency**
Semi-Automatic Robot w/ 3D Camera	0.11	0.08	0.13	0.11	0.32	3.01
Adafruit w/ 3D Camera	0.33	0.23	0.22	0.26	0.79	3.03
3D Image Live Feed Camera	0.56	0.69	0.65	0.63	1.95	3.07
Sum	1.00	1.00	1.00	1.00	LAMBDA	3.04
					CI	0.02
					RI	0.52
					CR	0.04

Figure 2: AHP--Design Volume



[C]			
DISTANCE FROM SCANNER:	**Semi-Automatic Robot w/ 3D Camera**	**Adafruit w/ 3D Camera**	**3D Image Live Feed Camera**
Semi-Automatic Robot w/ 3D Camera	1.00	1.00	0.33
Adafruit w/ 3D Camera	1.00	1.00	1.00
3D Image Live Feed Camera	3.00	1.00	1.00
Sum	5.00	3.00	2.33

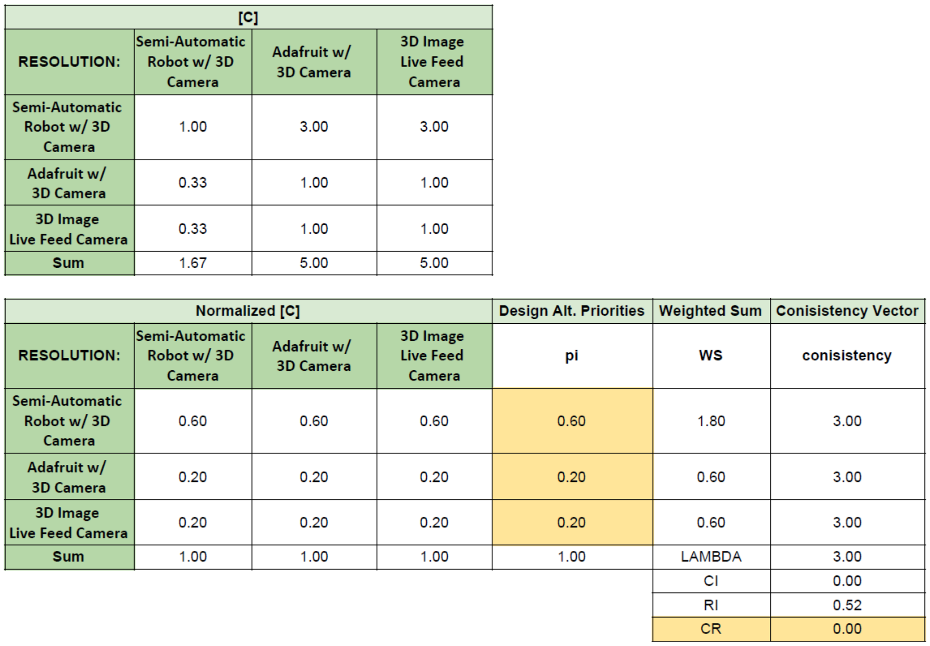
Normalized [C]				Design Alt. Priorities	Weighted Sum	Conisistency Vector
DISTANCE FROM SCANNER:	**Semi-Automatic Robot w/ 3D Camera**	**Adafruit w/ 3D Camera**	**3D Image Live Feed Camera**	**pi**	**WS**	**conisistency**
Semi-Automatic Robot w/ 3D Camera	0.20	0.33	0.14	0.23	0.70	3.09
Adafruit w/ 3D Camera	0.20	0.33	0.43	0.32	1.00	3.12
3D Image Live Feed Camera	0.60	0.33	0.43	0.45	1.45	3.20
Sum	1.00	1.00	1.00	1.00	LAMBDA	3.14
					CI	0.07
					RI	0.52
					CR	0.13

Figure 3: AHP--Distance from Scanner

[C]			
BRIGHTNESS LEVEL / INTENSITY LEVEL:	**Semi-Automatic Robot w/ 3D Camera**	**Adafruit w/ 3D Camera**	**3D Image Live Feed Camera**
Manual Device Caster Wheels w/ 3D Camera	1.00	3.00	3.00
Adafruit w/ 3D Camera	0.33	1.00	1.00
3D Image Live Feed Camera	0.33	1.00	1.00
Sum	1.67	5.00	5.00

Normalized [C]				Design Alt. Priorities	Weighted Sum	Conisistency Vector
BRIGHTNESS LEVEL / INTENSITY LEVEL:	**Semi-Automatic Robot w/ 3D Camera**	**Adafruit w/ 3D Camera**	**3D Image Live Feed Camera**	**pi**	**WS**	**conisistency**
Manual Device Caster Wheels w/ 3D Camera	0.60	0.60	0.60	0.60	1.80	3.00
Adafruit w/ 3D Camera	0.20	0.20	0.20	0.20	0.60	3.00
3D Image Live Feed Camera	0.20	0.20	0.20	0.20	0.60	3.00
Sum	1.00	1.00	1.00	1.00	LAMBDA	3.00
					CI	0.00
					RI	0.52
					CR	0.00

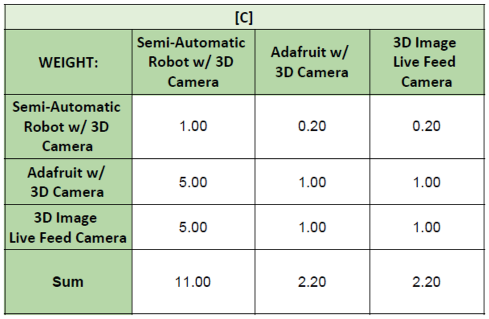
Figure 4: AHP--Brightness/Intensity Level



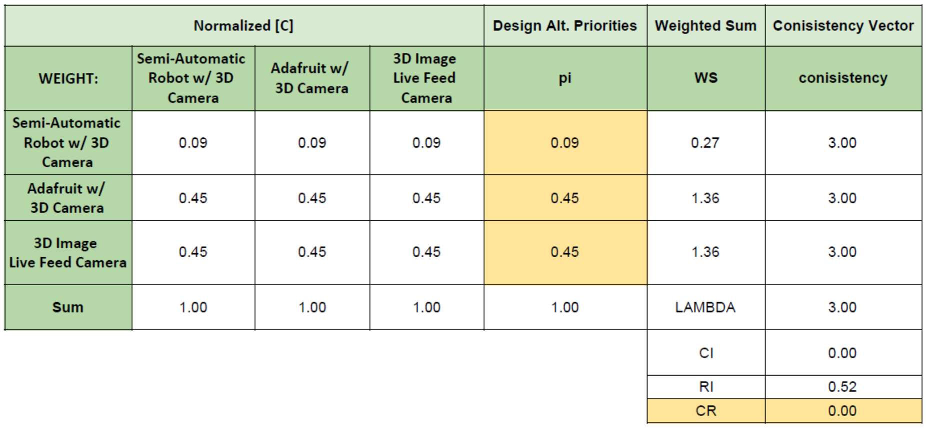
[C]			
RESOLUTION:	Semi-Automatic Robot w/ 3D Camera	Adafruit w/ 3D Camera	3D Image Live Feed Camera
Semi-Automatic Robot w/ 3D Camera	1.00	3.00	3.00
Adafruit w/ 3D Camera	0.33	1.00	1.00
3D Image Live Feed Camera	0.33	1.00	1.00
Sum	1.67	5.00	5.00

Normalized [C]				Design Alt. Priorities	Weighted Sum	Conisistency Vector
RESOLUTION:	Semi-Automatic Robot w/ 3D Camera	Adafruit w/ 3D Camera	3D Image Live Feed Camera	pi	WS	conisistency
Semi-Automatic Robot w/ 3D Camera	0.60	0.60	0.60	0.60	1.80	3.00
Adafruit w/ 3D Camera	0.20	0.20	0.20	0.20	0.60	3.00
3D Image Live Feed Camera	0.20	0.20	0.20	0.20	0.60	3.00
Sum	1.00	1.00	1.00	1.00	LAMBDA	3.00
					CI	0.00
					RI	0.52
					CR	0.00

Figure 5: AHP--Resolution

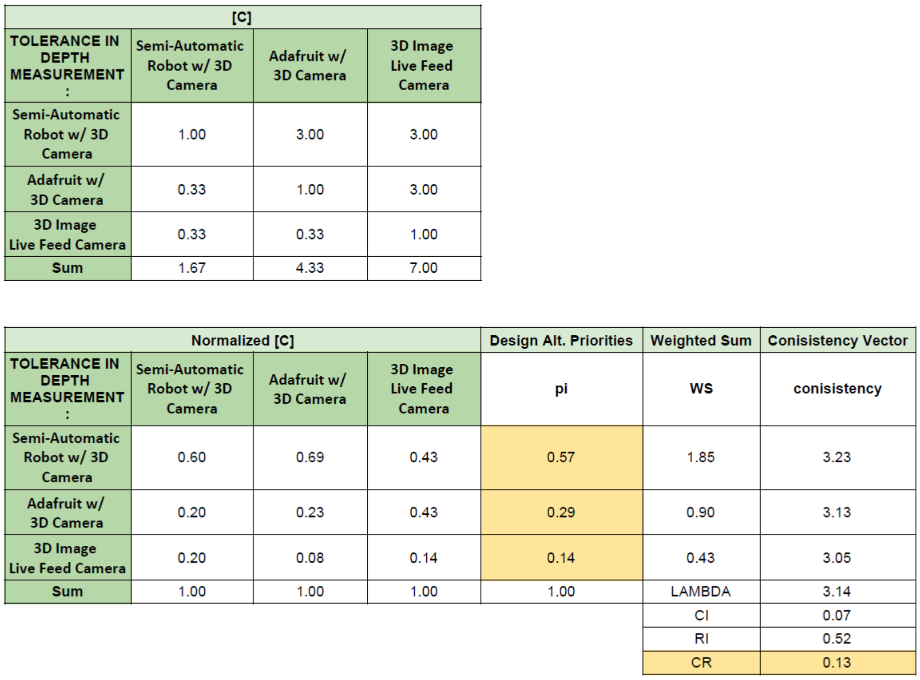


[C]			
WEIGHT:	Semi-Automatic Robot w/ 3D Camera	Adafruit w/ 3D Camera	3D Image Live Feed Camera
Semi-Automatic Robot w/ 3D Camera	1.00	0.20	0.20
Adafruit w/ 3D Camera	5.00	1.00	1.00
3D Image Live Feed Camera	5.00	1.00	1.00
Sum	11.00	2.20	2.20



Normalized [C]				Design Alt. Priorities	Weighted Sum	Conisistency Vector
WEIGHT:	Semi-Automatic Robot w/ 3D Camera	Adafruit w/ 3D Camera	3D Image Live Feed Camera	pi	WS	conisistency
Semi-Automatic Robot w/ 3D Camera	0.09	0.09	0.09	0.09	0.27	3.00
Adafruit w/ 3D Camera	0.45	0.45	0.45	0.45	1.36	3.00
3D Image Live Feed Camera	0.45	0.45	0.45	0.45	1.36	3.00
Sum	1.00	1.00	1.00	1.00	LAMBDA	3.00
					CI	0.00
					RI	0.52
					CR	0.00

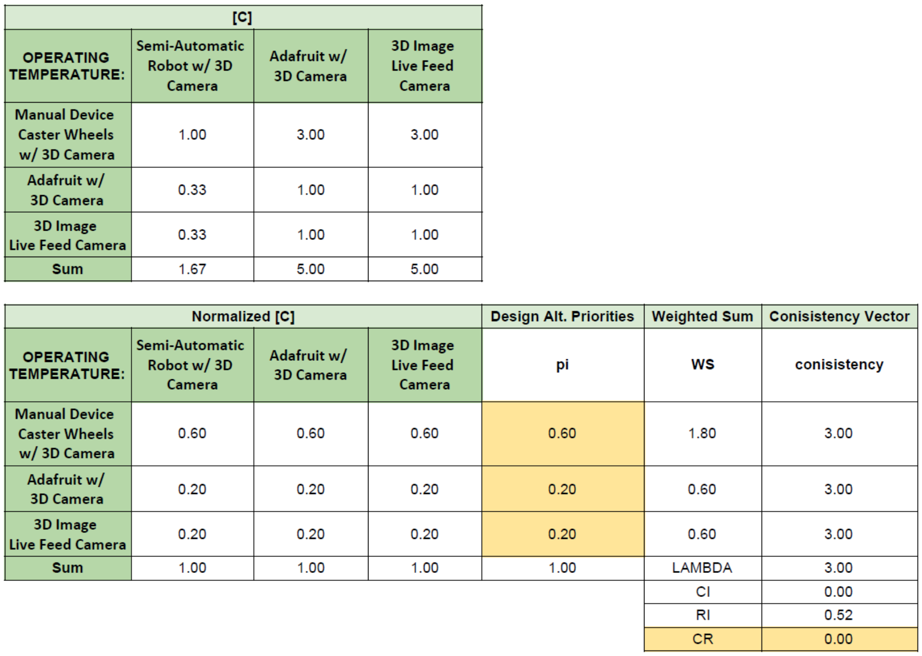
Figure 6: AHP--Weight



[C]			
TOLERANCE IN DEPTH MEASUREMENT :	Semi-Automatic Robot w/ 3D Camera	Adafruit w/ 3D Camera	3D Image Live Feed Camera
Semi-Automatic Robot w/ 3D Camera	1.00	3.00	3.00
Adafruit w/ 3D Camera	0.33	1.00	3.00
3D Image Live Feed Camera	0.33	0.33	1.00
Sum	1.67	4.33	7.00

Normalized [C]				Design Alt. Priorities	Weighted Sum	Conisistency Vector
TOLERANCE IN DEPTH MEASUREMENT :	Semi-Automatic Robot w/ 3D Camera	Adafruit w/ 3D Camera	3D Image Live Feed Camera	pi	WS	conisistency
Semi-Automatic Robot w/ 3D Camera	0.60	0.69	0.43	0.57	1.85	3.23
Adafruit w/ 3D Camera	0.20	0.23	0.43	0.29	0.90	3.13
3D Image Live Feed Camera	0.20	0.08	0.14	0.14	0.43	3.05
Sum	1.00	1.00	1.00	1.00	LAMBDA	3.14
					CI	0.07
					RI	0.52
					CR	0.13

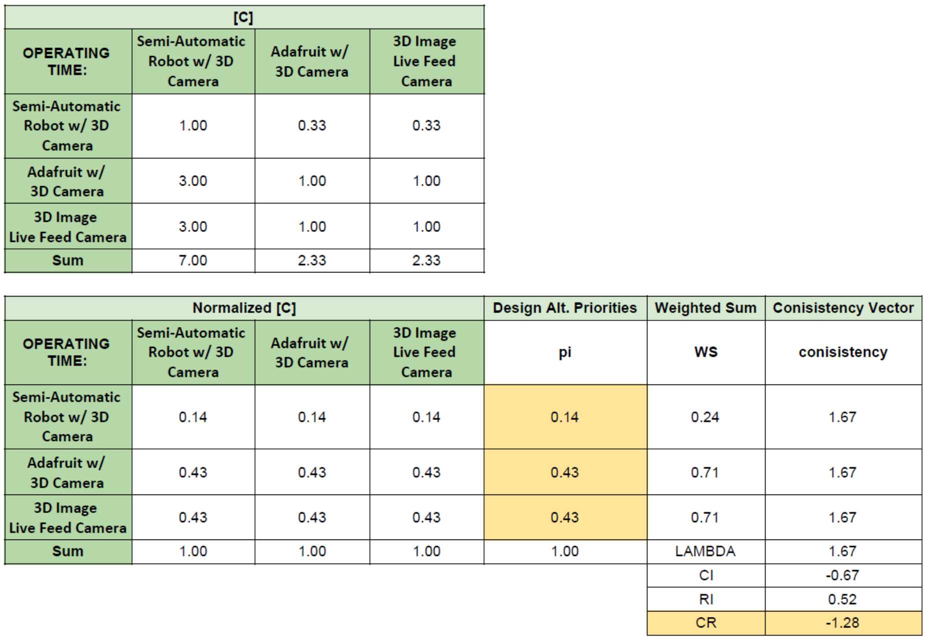
Figure 7: AHP--Tolerance in Depth Measurement



[C]			
OPERATING TEMPERATURE:	**Semi-Automatic Robot w/ 3D Camera**	**Adafruit w/ 3D Camera**	**3D Image Live Feed Camera**
Manual Device Caster Wheels w/ 3D Camera	1.00	3.00	3.00
Adafruit w/ 3D Camera	0.33	1.00	1.00
3D Image Live Feed Camera	0.33	1.00	1.00
Sum	1.67	5.00	5.00

Normalized [C]				Design Alt. Priorities	Weighted Sum	Conisistency Vector
OPERATING TEMPERATURE:	**Semi-Automatic Robot w/ 3D Camera**	**Adafruit w/ 3D Camera**	**3D Image Live Feed Camera**	**pi**	**WS**	**conisistency**
Manual Device Caster Wheels w/ 3D Camera	0.60	0.60	0.60	0.60	1.80	3.00
Adafruit w/ 3D Camera	0.20	0.20	0.20	0.20	0.60	3.00
3D Image Live Feed Camera	0.20	0.20	0.20	0.20	0.60	3.00
Sum	1.00	1.00	1.00	1.00	LAMBDA	3.00
					CI	0.00
					RI	0.52
					CR	0.00

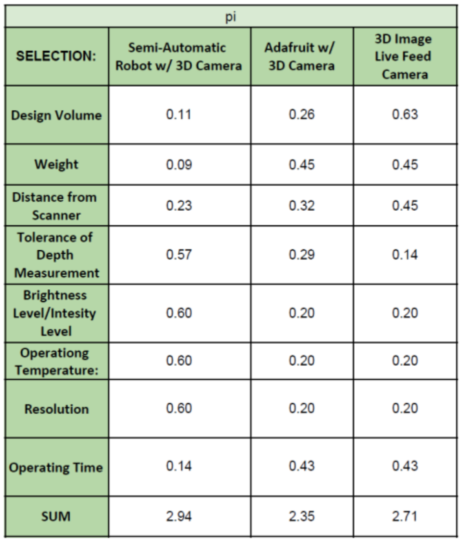
Figure 8: AHP--Operating Temperature



[C]			
OPERATING TIME:	**Semi-Automatic Robot w/ 3D Camera**	**Adafruit w/ 3D Camera**	**3D Image Live Feed Camera**
Semi-Automatic Robot w/ 3D Camera	1.00	0.33	0.33
Adafruit w/ 3D Camera	3.00	1.00	1.00
3D Image Live Feed Camera	3.00	1.00	1.00
Sum	7.00	2.33	2.33

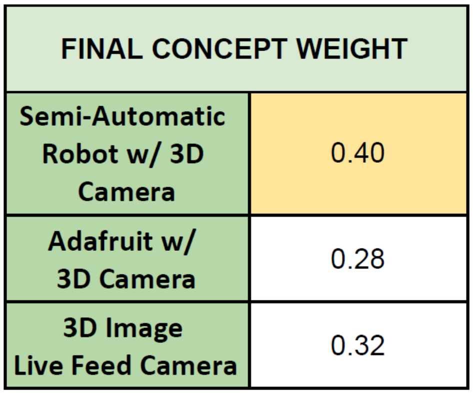
Normalized [C]				Design Alt. Priorities	Weighted Sum	Conisistency Vector
OPERATING TIME:	**Semi-Automatic Robot w/ 3D Camera**	**Adafruit w/ 3D Camera**	**3D Image Live Feed Camera**	**pi**	**WS**	**conisistency**
Semi-Automatic Robot w/ 3D Camera	0.14	0.14	0.14	0.14	0.24	1.67
Adafruit w/ 3D Camera	0.43	0.43	0.43	0.43	0.71	1.67
3D Image Live Feed Camera	0.43	0.43	0.43	0.43	0.71	1.67
Sum	1.00	1.00	1.00	1.00	LAMBDA	1.67
					CI	-0.67
					RI	0.52
					CR	-1.28

Figure 9: AHP--Operating Time



pi			
SELECTION:	**Semi-Automatic Robot w/ 3D Camera**	**Adafruit w/ 3D Camera**	**3D Image Live Feed Camera**
Design Volume	0.11	0.26	0.63
Weight	0.09	0.45	0.45
Distance from Scanner	0.23	0.32	0.45
Tolerance of Depth Measurement	0.57	0.29	0.14
Brightness Level/Intesity Level	0.60	0.20	0.20
Operationg Temperature:	0.60	0.20	0.20
Resolution	0.60	0.20	0.20
Operating Time	0.14	0.43	0.43
SUM	2.94	2.35	2.71

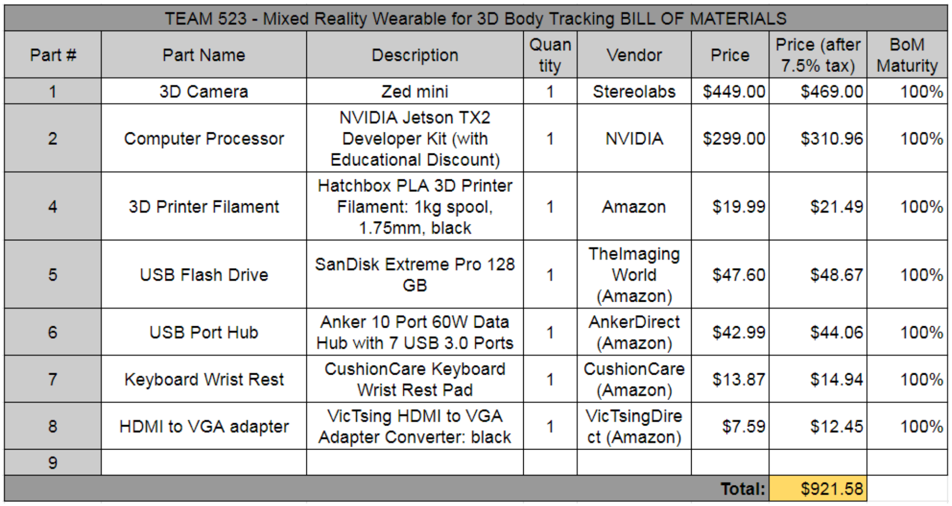
Figure 10: AHP—Selection



FINAL CONCEPT WEIGHT	
Semi-Automatic Robot w/ 3D Camera	0.40
Adafruit w/ 3D Camera	0.28
3D Image Live Feed Camera	0.32

Figure 11: AHP--Final Concept Weight

Appendix F: Bill of Materials



TEAM 523 - Mixed Reality Wearable for 3D Body Tracking BILL OF MATERIALS

Part #	Part Name	Description	Quantity	Vendor	Price	Price (after 7.5% tax)	BoM Maturity
1	3D Camera	Zed mini	1	Stereolabs	$449.00	$469.00	100%
2	Computer Processor	NVIDIA Jetson TX2 Developer Kit (with Educational Discount)	1	NVIDIA	$299.00	$310.96	100%
4	3D Printer Filament	Hatchbox PLA 3D Printer Filament: 1kg spool, 1.75mm, black	1	Amazon	$19.99	$21.49	100%
5	USB Flash Drive	SanDisk Extreme Pro 128 GB	1	TheImaging World (Amazon)	$47.60	$48.67	100%
6	USB Port Hub	Anker 10 Port 60W Data Hub with 7 USB 3.0 Ports	1	AnkerDirect (Amazon)	$42.99	$44.06	100%
7	Keyboard Wrist Rest	CushionCare Keyboard Wrist Rest Pad	1	CushionCare (Amazon)	$13.87	$14.94	100%
8	HDMI to VGA adapter	VicTsing HDMI to VGA Adapter Converter: black	1	VicTsingDirect (Amazon)	$7.59	$12.45	100%
9							
					Total:	$921.58	

Appendix G: Risk Assessment

Project information:

Mixed Reality Wearable for 3D Body Tracking — February 28, 2019

Name of Project — Date of submission

Team Member	Phone Number	e-mail
Caleb Pitts	(850) 832-0531	clp16d@my.fsu.edu
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Joshua Segall	(954) 817-9300	jms15m@my.fsu.edu
Matthew Bigerton	(561) 573-6206	mjb14b@my.fsu.edu
Faculty mentor	**Phone Number**	**e-mail**
Dr. McConomy	(850) 410-6624	smcconomy@eng.famu.fsu.edu

I. Project description:

The objective of this project is to provide a user interface for participants in a 3D scan environment, in order to improve the quality of the scan and reduce the amount of instructions given by the scan technician. This type of system will be specific towards illuminating the ideal location for a head/hand to be scanned in some fashion (Augmented Reality, Virtual Reality, hologram). After this position has been filled by the user being scanned, the user will be notified of completion.

II. Describe the steps for your project:

The team constructed an official bill of materials, encompassing all foreseen project components, from the selected concept. This paper stands as the group's risk assessment. For the prototyping phase, the group will first order the electrical components and connect them. A protective case for our processor will be laser cut. Next the wearable will be made; the strap will be hand stitched and the latch will be latch will be 3D printed. Following the former steps, code will be written and debugged leading into the testing phase. Lastly, the group must refine the device into the final product that will have the capacity to fulfill all project requirements.

III. Given that many accidents result from an unexpected reaction or event, go back through the steps of the project and imagine what could go wrong to make what seems to be a safe and well-regulated process turn into one that could result in an accident. (See examples)

Phase one is focused mainly on planning and design, so the bulk of any potential accidents would occur during the second phase. Potential accidents from laser cutting materials include: fires, the generation of airborne carcinogens causing potential damage to eyes and skin. Also, cuts or scratches can occur when finishing and refining 3D prints. Sewing the wearable could lead to accidental finger pricks that could result in blood borne illness. Lastly, working with computers for a long time could lead to carpal tunnel and eye strain from the screen time.

IV. Perform online research to identify any accidents that have occurred using your materials, equipment or process. State how you could avoid having this hazardous situation arise in your project.

Laser cutting: Standard laser cut safety must be followed: eye protection, professional supervision, closed toed shoes, long-legged pants, shirts tucked in.

Sewing: Use protective finger covers when stitching fabric to avoid fingers getting pricked

3D Printing: Never touch the filament erxtruder during operation, plastic pieces must be sanded for burrs

Coding: Use an ergonomic mouse to avoid carpal tunnel, and work with tolerable screen brightnesss to avoid eye strain

Source: Current OSHA Safety and Health Standards

V. For each identified hazard or “what if” situation noted above, describe one or more measures that will be taken to mitigate the hazard. (See examples of engineering controls, administrative controls, special work practices and PPE).

Laser cutting: While working on the laser cutter, the user’s skin is burned and carcinogens are inhaled--Utilize personal protective equipment (PPE).

Sewing: While sewing the wearable, a member pricks his finger—Keep a first-aid kit nearby.

Coding: After coding for countless hours, carpal tunnel occurs in a member’s hand and his eyes are strained- Use Bengay and adjust computer brightness

3D Printing: The finished print cuts a member’s hand—Keep first-aid kit nearby; handle properly before deburred.

Laser cutting: While working on the laser cutter, the user’s skin is burned and carcinogens are inhaled--Utilize personal protective equipment (PPE).

VI. Rewrite the project steps to include all safety measures taken for each step or combination of steps. Be specific (don’t just state “be careful”).

Following concept selection (and risk assessment), wearing all proper PPE with no loose jewelry, clothes, or hair, the group can carry out the laser cutting process. The connection phase requires common sense and proper precautions to prevent injury and hazards. 3D printing the wearable’s latch must be done with attention to the filament extruder and finished prints must be handled properly and sanded. Sewing the wearable’s strap must be done with protection on the fingers to avoid pricks.

Coding and debugging must be completed using an ergonomic mouse and at an appropriate screen brightness, with occasional breaks all to account for carpal tunnel and eye strain.

VII. Thinking about the accidents that have occurred or that you have identified as a risk, describe emergency response procedures to use.

If an emergency occurs, the first task is to assess the situation. If there is an injury, the priority should be to provide immediate medical attention to the injured party and alert the appropriate individuals. If necessary, contact the appropriate authorities.

In the event of a chemical spill, an eyewash/shower station must be present.

Administer CPR in the event of cardiac arrest.

In the event of catching on fire: Stop, drop, roll, and pull the fire alarm.

Use tunicates and localized pressure on non-shrapnel wounds in the event of blood loss.

In the event of any amount of electrical shock, a medical professional should be consulted immediately.

VIII. List emergency response contact information:

- Call 911 for injuries, fires or other emergency situations
- Call your department representative to report a facility concern

Team member Emergency Contacts	Phone Number	Faculty or other COE emergency contact	Phone Number
Jeff Pitts	(850) 258-5960	Dr. Shayne McConomy	(850) 410-6624
Alex Rubottom	(850) 619-7247	Dr. Eric Hellstrom	(850) 645-7489
Linda Segall	(754) 234-4567	Jared Gremley	(813) 394-6231
Simon Bazyler	(904) 719-1085	Dr. Shayne McConomy	(850) 410-6624
Mike Bigerton	(786) 295-4529	Dr. Shayne McConomy	(850) 410-6624

IX. Safety review signatures

- Faculty Review update (required for project changes and as specified by faculty mentor)
- Updated safety reviews should occur for the following reasons:
  1. Faculty requires second review by this date:
  2. Faculty requires discussion and possibly a new safety review BEFORE proceeding with step(s)
  3. An accident or unexpected event has occurred (these must be reported to the faculty, who will decide if a new safety review should be performed.

4. Changes have been made to the project.

Team Member	Date	Faculty mentor	Date
Joshua Segall	02/28/2019		
MJB	02/28/2019		
Caleb	02/28/2019		
Josiah Bazyk	02/28/2019		
	02/28/2019		

Report all accidents and near misses to faculty mentor.