



Virtual Design Review 2

"Sweet Spot" Indicator for Anthropometric Scanning

20 November 2018

Group Members



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Project Manager



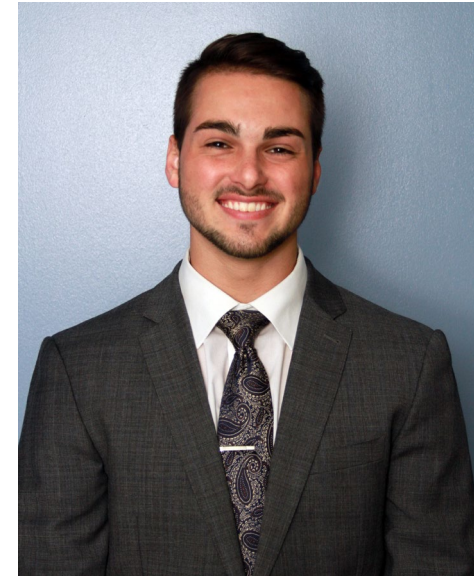
Joshua Segall
Design Engineer



Caleb Pitts
Fabrication Engineer



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Review

- Anthropometric scanners scan individuals and produce 3D rendered images
- The objective of this project is to provide a user interface for participants in a 3D body scan environment to improve the quality of the scan by reducing the amount of instructions given by the scan technician

Presented by: Caleb Pitts

Customer Needs Review

#	CUSTOMER STATEMENTS	INTEPRETED NEED
1	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.
2	The device must not interfere with the scanner.	The device must cease operating upon successful fulfillment of the “sweet spot”
3	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.
4	The device must be a stand-alone system	The device must complete its intended function without the assistance of other devices.
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

Table 1: Customer Needs Table

Presented by: Caleb Pitts

Targets and Metrics

"Sweet Spot" Indicator For Anthropometric Scanners			
Main Function	Sub-Functions	Metrics	Targets
Device	Self-Contained	Dimensions (in)	$\leq 30 \times 30 \times 30$
		*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 ($^{\circ}$ 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

Table 2: Targets and Metrics Table

Presented by: Caleb Pitts

Targets and Metrics

- The device must be self contained
- Does not interfere with the scanner
- Accurately displays where the participant should be and how they should be orientated

"Sweet Spot" Indicator For Anthropometric Scanners			
<u>Main Function</u>	<u>Sub-Functions</u>	<u>Metrics</u>	<u>Targets</u>
Device	Self-Contained	Dimensions (in)	$\leq 30 \times 30 \times 30$
		*Weight (lb.)	≤ 25
	Free of Scanner Interference	*Distance from Scanner (m)	~ 1
	Accurately displays location and orientation	*Tolerance of depth Measurement (cm)	≤ 4

Table 2a: Targets and Metrics Table Row 1

Presented by: Caleb Pitts

Targets and Metrics

- The device should be safe for the participant and the operator

"Sweet Spot" Indicator For Anthropometric Scanners			
<u>Main Function</u>	<u>Sub-Functions</u>	<u>Metrics</u>	<u>Targets</u>
Safety	Safe for participant	*Brightness level (Lumen)	< 200
		Intensity level (Lux)	< 200
	Safe for operator	Operating temperature (°F)	< 150

Table 2b: Targets and Metrics Table Row 2

Presented by: Caleb Pitts

Targets and Metrics

- The “sweet spot” must be clearly seen by the participant
- Device will signal them to hold the current position

“Sweet Spot” Indicator For Anthropometric Scanners			
<u>Main Function</u>	<u>Sub-Functions</u>	<u>Metrics</u>	<u>Targets</u>
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

Table 2C: Targets and Metrics Table Row 3

Presented by: Caleb Pitts

Targets and Metrics

- Power is important for
 - Safety
 - Efficiency

"Sweet Spot" Indicator For Anthropometric Scanners			
<u>Main Function</u>	<u>Sub-Functions</u>	<u>Metrics</u>	<u>Targets</u>
Power	Power supply	Power consumption (Watts)	< 11
		Operating voltage (Volts)	≤ 55

Table 2d: Targets and Metrics Table Row 4

Presented by: Caleb Pitts

Concept Generation

- *"No Good Ideas"*
- **87 Total Idea**
 - Brainstorming
 - Nature
 - People, Actions, and Device Functions
 - Index Card Flip
 - Anti-Solutions
- **13 Partial Concepts Combined**
 - Partial Ideas
 - Standalone Cameras and Sensors
- **Compressed into 8 Final Contenders**

Presented by: Joshua Segall

8 Final Design Contenders

Final Design Concepts
AR and Leap Motion
Mirage/Schlieren Imaging
BMW Holo-Touch
3D Image Live Feed Camera
Cast of Hand/Head
Adafruit with 3D Camera
Illumination Mirascope
Semi-Automatic Robot with 3D Camera

Table 3: List of 8 Final Design Concepts

Presented by: Joshua Segall

Concept Selection: Overview

- House of Quality compares Customer Characteristics vs Engineering Characteristics
- Pair Wise Comparison evaluated the importance of each Customer Requirements
- Pugh Matrix was used to compare concepts
- AHP was used as a consistency check after selection

Concept Selection Process:
Pair Wise Comparison
House of Quality
Pugh Matrix
Analytical Hierarchy Process(AHP)

Table 4: Concept Selection table

Presented by: Timothy Rubottom

Concept Selection: Pair Wise Comparison

Concept Selection Process:

Pair Wise Comparison

Customer Requirements	Weight	Importance
1) Self Contained	1	6
2) Doesn't interfere with scanner	4	1
5) Clearly seen by participant	4	2
3) Accurately displays "Sweet Spot" Location	2	3
6) Signals to hold position and orientation	2	4
4) Accurately displays desired orientation	2	5

Table 5: Pair Wise Comparison Results for Customer Requirements

Presented by: Timothy Rubottom

Concept Selection: House of Quality

Concept Selection Process:		Engineering Characteristics							
House of Quality		↓	↓	-	↑	-	↓	↑	↓
Improvement Direction	Units	in ³	lbf	m	cm	Lumen/Lux	°F	Pixel	Sec
Customer Requirements	WF	Design Volume	Weight	Distance from Scanner	Tolerance of Depth	Brightness Level/Intensity	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

Table 6: House of Quality

Presented by: Timothy Rubottom

Concept Selection: Pugh Matrix

Concept Selection Process:

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

"S" – Similar

"+" – Concept plus

"-" – Concept negative

Table 7: First Pugh Chart for final 8 concepts

Presented by: Timothy Rubottom

Concept Selection: Pugh Matrix

Concept Selection Process:

Pugh Matrix

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

"S" – Similar

"+" – Concept plus

"-" - Concept negative

Table 8: Second Pugh Chart for final 8 concepts

Presented by: Timothy Rubottom

Concept Selection: AHP

Concept Selection Process:

AHP

Evaluation Criteria	Design Volume	Weight	Distance from Scanner	Normalized [C]							WS	Consistency			Reference
				Tolerance of Depth Measurement	Brightness Level/Intensity Level	Operating Temperature	Resolution	Operating Time	Weight Factor						
Design Volume	0.060	0.100	0.041	0.115	0.029	0.150	0.056	0.115	0.083	0.726	8.717	Lambda	8.956		
Weight	0.020	0.033	0.029	0.038	0.016	0.050	0.056	0.038	0.035	0.300	8.543				
Distance from Scanner	0.300	0.233	0.205	0.346	0.146	0.150	0.167	0.115	0.208	1.919	9.231	CI	0.137	Reference	
Tolerance of Depth Measurement	0.060	0.100	0.068	0.115	0.438	0.050	0.167	0.115	0.139	1.370	9.837	CR	0.098	CR < 0.10	
Brightness Level/Intensity Level	0.300	0.300	0.205	0.038	0.146	0.250	0.167	0.346	0.219	1.954	8.918				
Operating Temperature	0.020	0.033	0.041	0.115	0.029	0.050	0.056	0.038	0.048	0.425	8.870				
Resolution	0.180	0.100	0.205	0.115	0.146	0.150	0.167	0.115	0.147	1.333	9.046				
Operating Time	0.060	0.100	0.205	0.115	0.049	0.150	0.167	0.115	0.120	1.020	8.490				
	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000					

Table 9: Analytical Hierarchy Process

Presented by: Timothy Rubottom

Final Concept Selection: AHP

Concept Selection Process:

AHP

- The final concept was determined using multiple pair wise comparisons for each engineering characteristic
- The output is the weighted number ranking of the final 3 selections

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/Intensity Level	0.60	0.20	0.20
Operating 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

Table 10: Analytical Hierarchy Process

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

Table 11: Final Selection

Presented by: Timothy Rubottom

Bill of Materials

TEAM 523 - "SWEET SPOT" INDICATOR BILL OF MATERIALS							
Part #	Part Name	Description	Quantity	Vendor	Price	Price (after 7.5% tax)	BoM Maturity
1	Base Plate	Plytanium 15/32" CAT PS1-09 Pine Sanded Plywood, 4' x 8'	1	Lowe's	\$27.85	\$29.94	50%
2	Linear Actuator	Okin Refined Power Recliner Motor Actuator Model JLDQ-11	1	Sears	\$121.71	\$130.84	50%
4	AL 8020 T-slotted Bar	Single Rail, Silver, 30 mm High x 30 mm Wide, Hollow	4	McMaster-Carr	\$159.76	\$171.74	50%
5	M4 Screw	Alloy Steel Low-Profile Socket Head Screw	32	McMaster-Carr	\$10.83	\$11.64	50%
6	M4 Washer	18-8 Stainless Steel Washer for M4 Screw Size, 4.3 mm ID, 9 mm OD	32	McMaster-Carr	\$1.86	\$2.00	50%
7	M4 Nut	Steel Hex Nut, Medium-Strength, Class 8, M4 x 0.7 mm Thread	32	McMaster-Carr	\$1.32	\$1.42	50%
8	M3 Screw	Alloy Steel Low-Profile Socket Head Screw	12	McMaster-Carr	\$7.00	\$7.53	50%
9	Inside Corner Bracket	10pcs Of 3030 Corner Fitting Angle 30x30 Decorative Brackets Aluminum Profile Accessories L Connector	1	Aliexpress	\$7.79	\$8.37	50%
10	Idler Pulley	GT2 5mm Bore Aluminum Toothless Timing Belt Idler Pulley	4	DHgate	\$11.00	\$11.83	50%
11	Timing Belt Pulley	Aluminum GT2 Timing Pulley - 6mm Belt - 20 Tooth - 8mm Bore	4	Adafruit	\$31.80	\$34.19	50%
12	Timing Belt Tensioner	Tensioner Locking Spring for GT2 Timing Belt (pack of 50)	1	Adafruit	\$2.75	\$2.96	50%
13	Timing Belt	Timing Belt GT2 Profile - 2mm pitch - 6mm wide 1164mm long	1	Adafruit	\$9.95	\$10.70	50%
14	Motor Mount Kit	Mounting bracket chassis mount for timing belt motors	2	Digi-Key Electronics	\$15.98	\$17.18	50%

Table 12a: Bill of Materials for Semi-Automatic Robot with 3D Camera

The thumbnail shows a smaller version of the full Bill of Materials table, including parts like the 3D Printer Filament, 3D Camera, LCD Display, Microcontroller, LED Lights, Motor Driver, Motor Mount Kit, Jumper Wires, Battery Pack for Microcontroller, Battery Pack for Arduino, Aluminum Plate, Electrical Tape, and Voltmeter Kit. The total price is listed as \$1,000.00.

Table 13a: Full Bill of Materials

Presented by: Joshua Segall



Bill of Materials Cont.

15	Wheel Motors	Cytron Power Window Motors w/ 5" Wheels (Pair)	2	Robotshop	\$125.00	\$134.38	50%
16	Timing Belt Motor	Brushed DC Motor Gearmotor	4	Digi-key Electronics	\$79.96	\$85.96	50%
17	3D Printer Filament	1.75 mm and 1 kg per Spool	1	Hatchbox	\$23.99	\$25.79	50%
18	3D Camera	ZED Camera High-Resolution and High Frame-rate 3D Video Capture	1	Stereolabs	\$449.00	\$482.68	50%
19	LCD Display	7" 1024 x 600 IPS Display	1	DFRobot	\$34.00	\$36.55	50%
20	Microcontroller	Raspberry Pi 3 Model B	1	Raspberry Pi	\$27.49	\$29.55	50%
21	LED Lights	5mm LEDs assorted colors (Yellow, Green & Red)	1	MS Direct	\$12.99	\$13.96	50%
22	Motor Driver for Robot Wheel	Sabertooth Dual 2x32A 6V-24V Regenerative Motor Driver	1	Robot Shop	\$119.99	\$128.99	50%
23	Motor Driver for V-Wheels	L298 Dual H-Bridge DC Motor Controller	2	Robot Shop	\$15.76	\$16.94	50%
24	Jumper Wires	SIM&NAT 12inch / 30cm 40 Pin Male to Female Dupont Wire, 40 Pin Male to Male, 40 Pin Female to Female Breadboard Jumper wire Ribbon Cables kit	1	Newegg	\$7.49	\$8.05	50%
25	Battery Pack for Microcontroller	5200mAh battery pack w/ micro USB	1	Grainger	\$33.20	\$35.69	50%
26	Battery Pack for Wheels	12V DC Battery Power Supply- 8 Cell D Battery Holder	1	SuperBrightLEDs	\$3.49	\$3.75	50%
27	Aluminum Plate	Mounting for LCD screen; 1/8th inch thickness	1	Online Metals	\$16.67	\$17.92	50%
28	Electrical Tape	Scotch Super 33+ 66-ft Electrical Tape	1	Lowes	\$3.98	\$4.28	50%
29	V-Wheel Kit	V-Wheel Kit B	1	ServoCity	\$29.99	\$32.24	50%
Total:					\$1,497.05		

Table 12b: Bill of Materials for Semi-Automatic Robot with 3D Camera

Table 13b: Full Bill of Materials

Table 13b: Full Bill of Materials

Presented by: Joshua Segall

Summary

➤ Major Targets and Metrics

- Brightness: 100 – 200 lumens
- Distance from Scanner: 1 meter

➤ Concept Generation

- 85 concepts
- Narrowed down to 8 final concepts

➤ Concept Selection

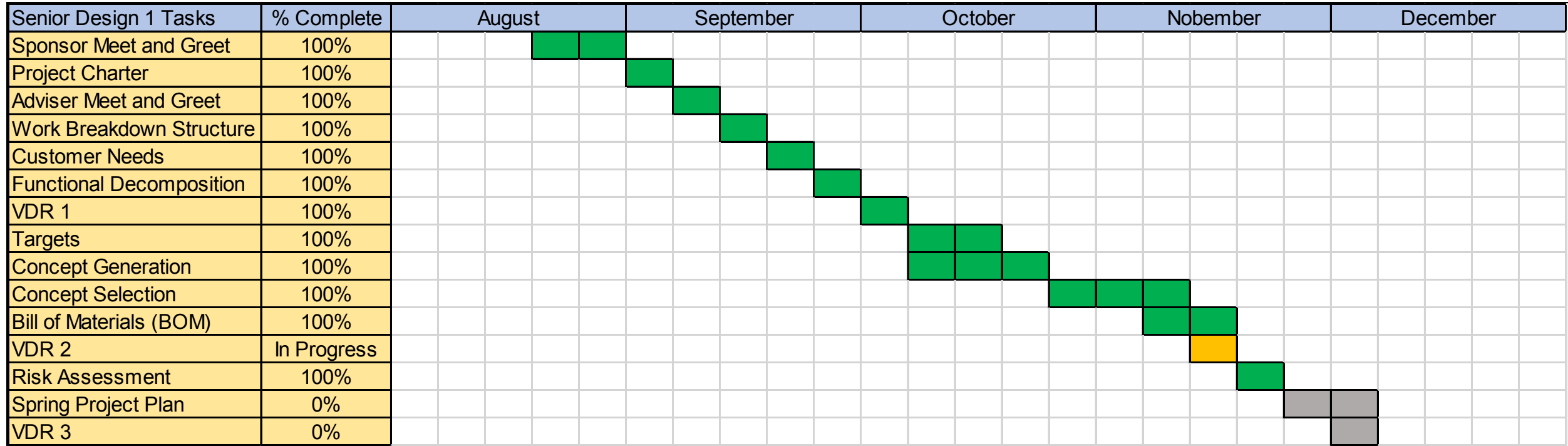
- The final 8 concepts were examined and narrowed down to 3 concepts
- The semi-automatic robot with 3D camera was found to be the best concept

➤ Bill of Material

- BoM maturity is 50% at this stage of the project

Presented by: Timothy Rubottom

Gantt Chart



█ - Completed
 █ - In Progress
 █ - Not Started

Table 14: Gantt Chart for Fall Semester of Senior Design

Presented by: Timothy Rubottom

Future Work

- Risk Assessment
- Spring Plan
- VDR 3 Poster
- Begin Ordering process before Christmas break

Presented by: Timothy Rubottom

Questions?

Presented by: Josiah Bazylar