NANUK

AMPHIBIOUS ARCTIC RESEARCH STATION

Amphibious Arctic Research Station

Industrial Design Thesis Report

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Amphibious Arctic Research Station

by

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Amphibious Arctic Research Station

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ABSTRACT

As the planet and climate change around us, there is a push to further understand the impact that humans have on the complex ecosystem that we call home. The most diverse of these ecosystems, an area challenged with extreme inaccessibility is the Arctic. Current methods of understanding and exploring Arctic biology are primitive. Weather conditions, frigid temperatures and scarceness of wildlife make it nearly impossible for productive biological research to be conducted. How can we mitigate challenges facing polar bear biologists in the Canadian Arctic, promoting study of species at risk due to climate change? At the rate damage is being done, Arctic species will be extinct in 25 years if no action is taken to better protect them. Canadian marine biologists are the key contributors to understanding and protecting Arctic species. The success of their research efforts are influenced by inclement weather conditions and a primitive hands-on approach. This thesis proposes an in-depth study of daily processes and challenges facing marine biologists, using data collection methods such as observational studies, interviews and surveys. Detailed analysis of this data focuses on maximizing the positive impact on the scientific community. A one-to-one scale ergonomic buck aids in the evaluation of ergonomics, establishing proper human factors and full-bodied human interaction design. A solution will be developed for Arctic wildlife scientists, enhancing the understanding and appreciation of the natural world by enhancing the experience of Arctic marine biology research.

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TABLE OF CONTENTS

CHAPTER 1 PROBLEM DEFINITION 13

1.1 PROBLEM DEFINITION 13
1.2 INVESTIGATIVE APPROACH TAKEN 14
1.3 BACKGROUND / HISTORY / SOCIAL CONTEXT 15

CHAPTER 2 RESEARCH 18

2.1 USER RESEARCH 18
2.1.1 User profile / persona 19
2.1.1.1 Primary user 22
2.1.1.2 Secondary user 22
2.1.1.3 Tertiary user 22
2.1.2 Current user practice 22
2.1.2.1 Introduction 22
2.1.2.2 Method 23
2.1.3 Activity mapping 28
2.1.4 Ergonomic research (existing products) 30
2.1.5 Safety & health research 31
2.2 PRODUCT RESEARCH 32
2.2.1 Benchmarking-Benefits and Features 34
2.2.2 Benchmarking-Functionality 35
..... 36
2.2.3 Benchmarking-Aesthetics & Semantic Profile 36
2.2.4 Benchmarking-Materials & Manufacturing 38
2.2.5 Benchmarking-Sustainability 40

CHAPTER 3 ANALYSIS 43

3.1 NEEDS ANALYSIS 43
3.1.1 Needs / Benefits not met by current products 43
3.1.2 Latent needs 44
3.1.3 Categorization of needs 45
3.1.4 Needs analysis diagram 46
3.2 FUNCTIONALITY 48
3.2.1 Activity / Workflow mapping 48
3.2.2 Activity Experience Mapping 52
3.3 USABILITY & ERGONOMICS 53
3.4 AESTHETICS 72
3.5 SUSTAINABILITY 75
3.5.1 Safety 75
3.5.2 Health 76
3.5.3 Environment 78
3.6 COMMERCIAL VIABILITY 79
3.6.1 Materials and manufacturing selection 79
3.6.2 Cost 80
3.7 DESIGN BRIEF 81

CHAPTER 4 DESIGN DEVELOPMENT 84

4.1 IDEATION 84
4.1.1 Mind mapping 84
4.1.2 Inspiration board 85
4.2 PRELIMINARY CONCEPT EXPLORATION 85

4.2.1 Form study *85*
4.2.2 Ideation *86*
4.2.3 Concept development *89*
4.3 CONCEPT REFINEMENT 95
4.4 DETAIL RESOLUTION 102
4.5 SKETCH MODELS 105
4.5.1 Functionality (user observation) *105*
4.5.2 Ergonomics *112*
4.6 FINAL DESIGN 114
4.7 CAD MODELS 115
4.8 HARD MODEL FABRICATION HISTORY 124

CHAPTER 5 FINAL DESIGN 131

5.1 SUMMARY 131
5.1.1 Description *131*
5.1.2 Explanation *131*
5.1.3 Benefit statement *132*
5.2 DESIGN CRITERIA MET 133
5.2.1 Ergonomics *133*
5.2.2 Materials, processes & Technologies *137*
5.2.3 Manufacturing cost report *138*
5.3 FINAL CAD RENDERINGS 140
5.4 HARD MODEL PHOTOGRAPHY 145
5.5 TECHNICAL DRAWING 152
5.6 SUSTAINABILITY 154

CHAPTER 6 CONCLUSION 157

CHAPTER 7 REFERENCES 160

CHAPTER 8 APPENDIX 164

APPENDIX A – DISCOVERY 164
APPENDIX B – USER RESEARCH 181
APPENDIX C – PRODUCT RESEARCH 198
APPENDIX D – NEEDS ANALYSIS 210

LIST OF FIGURES

Figure 1 - Paul Nicklen, Polar Bear. Retrieved from https://paulnicklen.com/stills/polar-bears/ xii
Figure 2 - Retrieved from https://www.unis.no/course/ab-202-marine-arctic-biology 13
Figure 3 - Curious polar bear. Retrieved from https://paulnicklen.com/stills/polar-bears/#!jig[1]/ML/2215 17
Figure 4 - Retrieved from https://www.unis.no/course/ab-202-marine-arctic-biology/ 18
Figure 5 - Caucasian, brunette female for use in developing a user profile. Retrieved from https://eodetective.wordpress.com/2017/02/11/anna-hogg-antarctic-researcher/ 19
Figure 6 - Research Task Notes 24
Figure 7 - Research Task Notes 24
Figure 8 - Equipment Used Notes 32
Figure 9 - Arctic Oven Tent - Retrieved from https://arcticoventent.com/tents/all-tents/arctic-oven-12x24-with-vestibules/ 33
Figure 10 - Hagglunds BV206 - Retrieved from http://www.arctictracks.com/hagglunds-bv20633
Figure 11 - Paris PULK - Retrieved from https://www.skipulk.com/product/paris-pulk/ 33
Figure 12 - Mens Himalayan Suit - Retrieved from https://www.thenorthface.com/shop/mens-himalayan-suit-2-en-ca 34
Figure 13 - XY Product Functionality Graph 36
Figure 14 - XY Product Semantics Graph 37
Figure 15 - Arctic Oven Tent, use of Vapex material - Retrieved from https://arcticoventent.com/tents/all-tents/arctic-oven-12x24-with-vestibules/ 38
Figure 16 - Retreived from https://paulnicklen.com/stills/polar-bears/#!jig[1]/ML/2241 42
Figure 17 - Needs Analysis Diagram. 46
Figure 18 - Retrieved from https://www.youtube.com/watch?v=8iN7mC-aUpg 48
Figure 19 - Retrieved from https://www.youtube.com/watch?v=8iN7mC-aUpg 49
Figure 20 - Retrieved from https://www.youtube.com/watch?v=8iN7mC-aUpg 50
Figure 21 - Retrieved from https://www.youtube.com/watch?v=8iN7mC-aUpg 51
Figure 22 - Interior Space Consideration Notes 56
Figure 23 - Human Percentile Graphics 58
Figure 24 - Overhead view of interior research lab and standing work desk. 59
Figure 25 - Sitting Work Desk Ergonomic Drawing 60
Figure 26 - Research Lab Countertop and counter height dimensions. 60
Figure 27 - Observation Pod Internal Geometry 61
Figure 28 - Observation Pod Seating Geometry 62
Figure 29 - Styling Mood Board 74
Figure 30 - Retrieved from https://polarbearsinternational.org/news/article-research/learning-how-the-other-half-lives/ 77
Figure 31 - Tesla manufacturing facility. Retrieved from https://www.technologyreview.com/s/610889/tesla-says-its-factory-is-saferbut-it-left-injuries-off-the-books/ 79
Figure 32 - Retrieved from https://paulnicklen.com/stills/polar-bears/#!jig[1]/ML/2254 83
Figure 33- Mind Mapping Exercise 84

Figure 34 - Inspiration Board 85
Figure 35 - Preliminary Form Exploration 85
Figure 36 - Ideation Sketch 1 86
Figure 37 - Ideation Sketch 2 87
Figure 38 - Ideation Sketch 3 87
Figure 39 - Ideation Sketch 4 88
Figure 40 - Ideation Sketch 5 88
Figure 41 - Ideation Sketch 6 89
Figure 42 - Concept 1 - Direction 1 90
Figure 43 - Concept 1 - Direction 2 90
Figure 44 - Concept 1 - Direction 3 91
Figure 45 - Concept 1 - Direction 4 91
Figure 46 - Concept 1 - Direction 5 92
Figure 47 - Concept 2 - Direction 1 92
Figure 48 - Concept 2 - Direction 2 93
Figure 49 - Concept 2 - Direction 3 93
Figure 50 - Concept 2 - Direction 4 94
Figure 51 - Concept 2 - Direction 5 94
Figure 52 - Concept Refinement Sketches - Wheel Detailing 96
Figure 53 - Concept Refinement Sketches - Contour Detailing 96
Figure 54 - Concept Refinement Sketches - Layout Detailing 97
Figure 55 - Concept Refinement Sketches - Living Space Detailing 97
Figure 56 - Concept Refinement Sketches - Lab Detailing 98
Figure 57 - Concept Refinement Sketches - Lab Desk Detailing 98
Figure 58 - Concept Refinement Sketches - Exterior Detailing 99
Figure 59 - Concept Refinement Sketches - Lowering Pod Detailing 99
Figure 60 - Concept Refinement Sketches - Exterior Styling 100
Figure 61 - Concept Refinement Sketches - Exterior Styling 2 100
Figure 62 - Concept Refinement Sketches - Exterior Form Details 101
Figure 63 - Concept Refinement Sketches - Exterior Form Styling 101
Figure 64 - Concept Refinement Sketches - Lab Desk and Bench Detailing 102
Figure 65 - Detailing Sketches - A 103
Figure 66 - Detailing Sketches - B 103
Figure 67 - Detailing Sketches - C 104
Figure 68 - Detailing Sketches - D 104
Figure 69 - Detailing Sketches - E 105
Figure 70 - Sketch Model Side View 106
Figure 71 - Sketch Model Front View 106
Figure 72 - Sketch Model Side View 107
Figure 73 - Sketch Model Top View 107
Figure 74 - Sketch Model Rear View 108
Figure 75 - Sketch Model Sleeping Berths 108
Figure 76 - Sketch Model Work Desk 109

Figure 77 - Sketch Model Wheel Details 109
Figure 78 - Sketch Model Wheel Profile 110
Figure 79 - SKetch Model Observation Pod Side View 110
Figure 80 - Sketch Model Observation Pod Front 3/4 111
Figure 81 - Sketch Model Interior Shot 111
Figure 82 - Sketch Model Underside View 112
Figure 83 - Ergonomic Drawings 95th Percentile Male & 5th Percentile Female 112
Figure 84 - Ergonomic Drawings Observation Pod 113
Figure 85 - Ergonomic Drawings Upper View of Observation Pod 113
Figure 86 - Final Design Sketch 114
Figure 87 - CAD Process - Exterior 115
Figure 88 - CAD Process - Observation Pod 116
Figure 89 - CAD Process - Observation Pod Chairs 117
Figure 90 - CAD Process - Exterior Pod Walls 118
Figure 91 - CAD Process - Exterior Detailing 119
Figure 92 - CAD Process - Interior Spaces 120
Figure 93 - CAD Process - Rear Wheel Arm 121
Figure 94 - CAD Process - Wheels 122
Figure 95 - CAD Process - Front Wheel Arms 123
Figure 96 - Model Process Pictures 126
Figure 97 - Model Process Pictures 2 127
Figure 98 - Model Process Pictures 3 128
Figure 99 - Model Process Pictures 4 129
Figure 111 - Retrieved from https://paulnicklen.com/stills/polar-bears/#!jig[1]/ML/2239 130
Figure 112 - Final Design 132
Figure 113 - Interior Render, showcasing ergonomic considerations. 133
Figure 114 - Observation Pod Interior View 134
Figure 115 - Interior Research Space 135
Figure 116 - Interior Concept Layout 136
Figure 117 - Side Profile 140
Figure 118 - Rear Profile 141
Figure 119 - Upper Profile 141
Figure 120 - Cutaway Render 142
Figure 121 - Frog View 142
Figure 122 - Observation Pod Deployed 143
Figure 100 - Observation Pod Hard Model 146
Figure 101 - Observation Pod Hard Model 2 147
Figure 102 - Final Model Top View 147
Figure 103 - Final Model Front View 148
Figure 104 - Final Model - Lower 3/4 148
Figure 105 - Front 3/4 149
Figure 106 - Rear 3/4 Research Lab View 149
Figure 107 - Wheel Detail Photo 150

Figure 108 - Lower View 150
Figure 109 - Upper PerspectiveFigure 110 - Top View with observation pod 151
Figure 127 - Retrieved from https://paulnicklen.com/stills/polar-bears/#!jig[1]/ML/2244 156
Figure 128 - In Situ 157
Figure 129 - Retrieved from https://paulnicklen.com/stills/polar-bears/#!jig[1]/ML/2246 159

LIST OF TABLES

Table 1 - Investigative approach taken. 15
Table 2 - Fictitious User Profile 19
Table 3 - Cognitive task importance. 22
Table 4 - User Interview contact. 25
Table 5 - User Interview Key Takeaways 27
Table 6 - Current User Experience Map for tagging and documenting a polar bear. 30
Table 7 - Current benchmarked products 34
Table 8 - Benchmarked products key benefits and key features. 35
Table 9 - Benchmarked Materials Table 40
Table 10 - Latent needs developed through analysis of benchmarked products and user observation. 45
Table 11 - Benefits Relationship table 46
Table 12 - Analysis of Activity 1 from Video Analysis 48
Table 13 - Activity 2 Breakdown from Video Analysis. 49
Table 14 - Analysis of Activity 3 from Video Analysis. 50
Table 15 - Activity 4 Breakdown from Video Analysis. 51
Table 16 - Projected User Experience Map 52
Table 17 - Standing Desk Erogonomic Buck 63
Table 18 - Standing Desk Ergonomic Buck 64
Table 19 - Work surfaces and shelf viewing height ergonomic buck. 65
Table 20 - Observation Pod Seating and Desk surface ergonomic buck 66
Table 21 - Observation Pod Ergonomic Buck 67
Table 22 - Observation Pod Ergonomic Buck 68
Table 23 - Component Cost 80
Table 24 - Thesis Design Brief 82
Table 25 - Sand Paper Breakdown 125
Table 26 - Cost Breakdown 140

CHAPTER 1 PROBLEM DEFINITION

Figure 1 - Paul Nicklen, Polar Bear. Retrieved from https://paulnicklen.com/stills/polar-bears/

CHAPTER 1 PROBLEM DEFINITION

Figure 2 - Retrieved from https://www.unis.no/course/ab-202-marine-arctic-biology

1.1 PROBLEM DEFINITION

Ocean observation is fundamental to Canada's ocean science community. Expert Panel on Canadian Ocean Science 2013 report that identified poor coordination as a current fundamental weakness of Canadian marine science and the need for national governance structures to integrate existing regional efforts (Stewart et al. 2019). Canada has a substantial but aging research fleet. The Coast Guard operates the Canadian research fleet, which includes several large oceanographic vessels and have a dedicated research icebreaker that provides access to the Arctic. Half of these vessels were built over 25 years ago, and older vessels lead to

more breakdowns, higher costs and operational days lost to maintenance (Council of Canadian Academies, 2014).

This thesis report will examine how marine biologists facilitate their job, interacting with and documenting Arctic wildlife. The research and content therein is aimed at developing a cohesive design solution which enables marine biologists to conduct their job with greater efficiency, safety and comfort. In addition, it is essential to make a sustainably conscious and ergonomic solution for marine biologists to use.

1.2 INVESTIGATIVE APPROACH TAKEN

To gain a comprehensive understanding into the working routines and responsibilities of marine biologists, specifically those studying *Ursus Maritimus,* the polar bear, several tools will be utilized to gain data and information.

The scope of these research questions delves into understanding daily activities that are being performed, the order of these activities and their relevance to the research at hand. Likewise, understanding how these specialized marine biologists are interacting with polar bears in a field environment is important, reducing pain and risk of injury to both the animal and the human.

This thesis will use the following questions, information areas and research tools to obtain insight, information and data to inform the final design.

Questions addressed in this thesis:	**Information areas investigated:**	**Research tools utilized:**
How may we mitigate challenges facing marine researchers in the Canadian Arctic studying polar bears?	Current Arctic research solutions and practices.	Literature reviews

How can the comfort of Arctic research be enhanced and optimized?	Wildlife interactions with humans in the Arctic.	Information searches
What are the fundamental needs of marine biologists and Arctic researchers?	Target demographics (Primary, secondary, tertiary, stakeholders).	Existing solutions / benchmarking and current practices
What impact can marine biology have on Arctic sustainability?	Risks entailing Arctic research.	User interviews / observational studies
		Video analysis
		Ergonomic studies

Table 1 - Investigative approach taken.

The pertinent information gained from these research tools will go into developing a thesis solution centered around creating a comprehensive solution which satisfies the necessary sustainability, ergonomic and functional requirements of the thesis.

1.3 BACKGROUND / HISTORY / SOCIAL CONTEXT

Marine species and habitats are an essential part of our planet's vast ecosystem, as well as our human ability to interact with this chosen environment. Presently there is a lack of protected marine areas throughout the world's oceans. This puts these sensitive habitats and their inhabitants at risk. In Canada, there is current concern surrounding the lack of available vessel capacity to conduct critical research in our waters. (Council of Canadian Academies, 2014). This poses a difficult challenge for marine research infrastructure in Canada.

Unfortunately, due to a mix of government and society related factors, nothing is being done to address this problem. The Canadian Coast Guard has several high endurance multi-tasked vessels in their fleet, all of which have been in service for over 30 years and are not presently equipped with adequate dedicated scientific equipment. This problem encompasses the

full body interaction and ergonomics to assist marine researchers. By improving the ways in which Arctic researchers perform their job, enhancements to their working lifestyle at sea and on land can be developed. For marine research to be successful, all situations must be accounted for and resolved in a way which still allows for engagement, exploration and valid studies. Ocean observation is fundamental to Canada's ocean science community. (Stewart et al, 2019).

Challenges exist regarding methods of wildlife observation and monitoring, particularly in the Arctic. Other challenges remain with data integration and accessibility through the use of modern data portals. Addressing these challenges is especially important for research on global change, including climate change (Council of Canadian Academies, 2014). Until now, Canada has lacked a national vision and strategy for coordinated ocean observation, resulting in overlaps and gaps in our observation activities, from collection sharing and interpreting data (Stewart et al, 2019). Canada's extensive exposure to the ocean and the rapidly changing Arctic offers almost unlimited opportunities in fundamental research to improve understanding of ocean processes, as well as applied research on sustainable ocean and coastal development and management for the benefit of Canadian society (Council of Canadian Academies, 2014).

CHAPTER 2 RESEARCH

Figure 3 - Curious polar bear. Retrieved from https://paulnicklen.com/stills/polar-bears/#!jig[1]/ML/2215

CHAPTER 2 RESEARCH

Figure 4 - Retrieved from https://www.unis.no/course/ab-202-marine-arctic-biology/

2.1 USER RESEARCH

The objective of this thesis and the research therein is to asses a particular, focused research topic using scholarly and consumer / popular search tools. The research topic in question, is analyzing ways in which challenges which face marine biologists working in the Arctic, can be mitigated, to enhance the quality of research conducted. “Canada has the largest coastline of any nation in the world (244,000 km) along three ocean basins – Pacific, Arctic, and Atlantic. It has two major inland Seas, the Gulf of St. Lawrence, Hudson Bay, and the Laurentian Great Lakes. These waters are important to Canadians, serving as the backbone for the socio-economic well-being of Canada’s coastal communities” (Stewart et al. 2019). To gain an in depth understanding of this topic and the problems associated with it, search tools such as Humber Library Search Engine, Library Databases and Google Scholar will be used.

Areas of focus for the information search will include benchmarked products, user needs, user demographics, surveys and interviews as well as an analysis of the potential for full bodied human interaction design. “Ocean science draws on highly qualified personnel from many programs and departments, which makes human capacity one of the most challenging categories to assess” (Council of Canadian Academies, 2014).

2.1.1 USER PROFILE / PERSONA

Figure 5 - Caucasian, brunette female for use in developing a user profile. Retrieved from https://eodetective.wordpress.com/2017/02/11/anna-hogg-antarctic-researcher/

Name	***Tyra Stewart***
Age	33 (Caucasian)
Occupation	Marine Biologist (specializing in Polar Bear foraging ecology)
Education	Bachelors of Marine Biology, Masters in Arctic and Sub-Arctic Marine Sciences, PhD in Marine Science (MarS in progress)
Family	Long-term boyfriend (7 years), live together
Location	St. Johns, Newfoundland
Frequency	Monday-Saturday
Duration	50-60 hours / week
Social / Solitary	A fourth year PhD student at Memorial University, studying the effects that environmental change is having on Arctic marine mammals. Works with a PhD advisor and 6 other students / researchers.
Other Activities	Mountain bikes with her boyfriend on weekends, amateur photographer, coffee enthusiast.

Table 2 - Fictitious User Profile

A marine biologist persona is developed, a fictitious person, who fits the demographic, motivation and background based off demographic research. The use of the persona aims to

refocus the design intent from the product, to the user. A fictional breakdown of the user profile is described below:

> *"Tyra was inspired to pursue marine biology as a career from her childhood spent fishing with her father and watching whales from the coast of Newfoundland. A love of animals and the environment pushed her down the marine biology path. Since her work experience before starting her PhD in Churchill, Manitoba, Tyra has been drawn back to the northern town and is looking at accepting a position in a remote Arctic research project. She can justify the time commitment as it will support research for her PhD and gives her more Arctic work experience. Tyra has spent time in Churchill, a naturally cold environment, but has never had a true Arctic experience dealing with extreme temperatures and severe weather."*

Based off research, marine biologists tend to be middle aged females, of Caucasian ethnicity. The demographic distribution sits between 30 years old and 45 years old. This is due primarily to the years spent in Universities, obtaining advanced degrees in marine science.

Most marine biologist volunteers are under 23 years of age, as they are still in University or post-secondary school. Volunteer experience is used to generate industry contacts and field experience before taking on a doctorate degree. See *Appendix B – User Research*, for a breakdown of user demographic research used to inform the fictitious user profile.

For marine biologists, an average working day consists of two main types of work: laboratory work and field work. Lab work typically operates for 8-10 hours a day whereas field work can be more intensive, sometimes operating for 12-15 hours daily. Marine biologists often operate in a team setting, working with at least one other individual.

On research expeditions, which can last anywhere from one week up to three months, marine researchers are often stuck in remote locations with limited access. These expeditions are often research intensive, with groups of researchers from multiple countries and varying marine backgrounds.

In an interview with Luana Sciullo PhD, context about collecting measurements from sedated polar bears was given, to understand work procedures, “Measurements such as length, girth, mass, fat samples, jaws and head size. A GPS collar is used to track these individuals. All of this is done with the researchers, typically a group of 4 to 5 people, maintaining a feeling of safety, as Luana noted in the interview.” (See Appendix B – User Research).

An extensive education is required to pursue marine biologists. A master’s degree is a minimum requirement for conducting field research and analyzing data. Marine biologists often pursue a doctorate degree after a few years in the industry, typically focusing on a specific animal species or aquatic environment.

During their personal downtime off the job or outside of the lab, many marine biologists participate in outdoor activities, photography, yoga and meditation. These activities may be due to a subliminal connection to the environment as a result of their education and attachment to animals.

Marine biologists have a mid-level income, as it is a career which does not pay traditionally well. Most marine biologists will earn between $40,000-$70,000 per year. There is the potential to earn more working for Universities or government agencies. This suggests that the motivation of the career is not necessarily money, but the environmental benefit, an element of social exclusivity. Specific user research can be found in Appendix B.

Arctic marine biologists require an in-depth background of content and fact-based knowledge, going through a minimum of 6 years of school to work as a marine biologist. Technical skill in operating research equipment such as satellite tags, microscopes, handling bio samples and taking note of direct observations is important. In an Arctic environment, minimizing risk in a dangerous climate is key, just as self-efficacy is, adding value to the overall research project and eventually adding value to the individuals involved.

Personality		**Cognitive Aspect**	
'Locus of control'	↑	**Technical Skill**	↑
Self-Efficacy	↑	**Pre-req. content knowledge**	↑↑↑
Changeability	--		
Uncertainty Avoidance	↑		

Table 3 - Cognitive task importance.

2.1.1.1 PRIMARY USER

Primary users can be described as marine biologists, zoologists, Arctic scientists, marine biology professors, polar bear ecologists.

2.1.1.2 SECONDARY USER

Secondary users can be described as research assistants and volunteers.

2.1.1.3 TERTIARY USER

Tertiary users can be described as helicopter pilots, icebreaker captains, plane pilots and field station management, university faculty.

2.1.2 CURRENT USER PRACTICE

2.1.2.1 INTRODUCTION

The purpose of accumulating this data is to aid in the understanding of the various uses and product scenarios experienced by marine biologists. Further, understanding how and why

they use particular items and the context in which events unfold. This information and data will inform the design process for this thesis solution.

2.1.2.2 METHOD

User research was conducted in the form of interviews both in person and via email, as well as user observation. (See Appendix B – User Research for a complete overview).

Weather conditions vary dramatically in Arctic and Sub-Arctic regions, varying from 22 degrees Celsius in the fall to frigid, below zero temperatures. It was also indicated in the interview that absolutely zero risk is taken when it comes to weather, such as reduced visibility, fog, snowfall and windchill. In the event of severe weather, all field work is stopped. As noted in Appendix B, Luana identified that there is a tremendous safety buffer, that the researchers always ensure exists.

The environmental conditions experienced are as follows:

Cold temperatures (below zero degrees Celsius, plus additional windchill, researchers still had skin exposed during their tests).

- Blowing wind (inferred from gusting snow drifts in the video).
- Bright sunlight (tests were conducted during mid-day to late afternoon).
- Clear skies, no signs of clouds or turbulent weather.

Packing and supplies are kept to a minimum, as transport to research sites is often compact and limited. The technical equipment brought into the field for testing on polar bears is kept to a minimum, held in a black doctors' style bag with a freezer used to transport fat samples.

An information binder, acting as a physical database of wildlife information is also taken on research trips. These would typically be the largest items taken on a field expedition.

The key activities are listed below, following each other in sequential order:

- Locating marine wildlife (eg. Polar Bear is considered a marine mammal).
- Darting animal using a tranquilizer or sedative, usage of tranquilizing rifle.
- Obtaining measurements from the animal, as well as biological samples such as blood, fat samples.
- Using equipment, explaining gear significance and the purpose of various instruments.

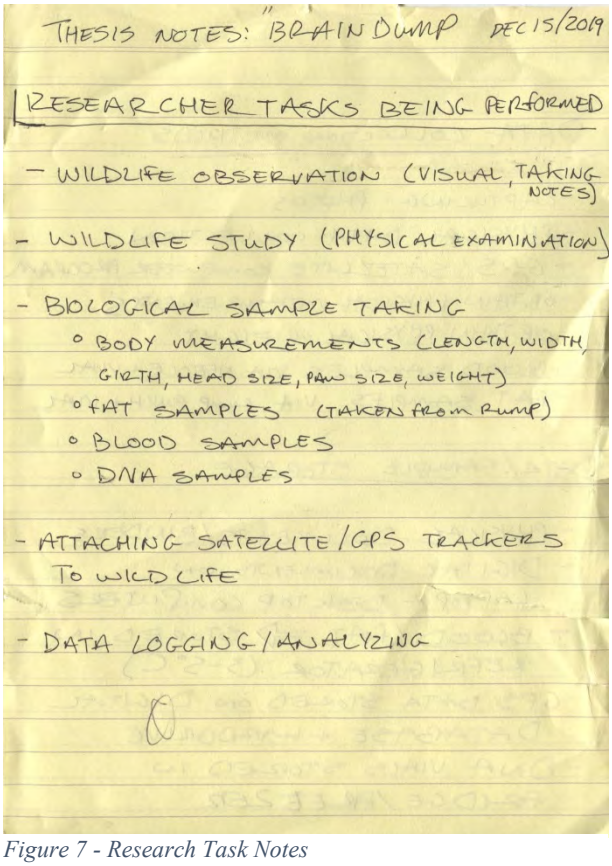


Figure 7 - Research Task Notes

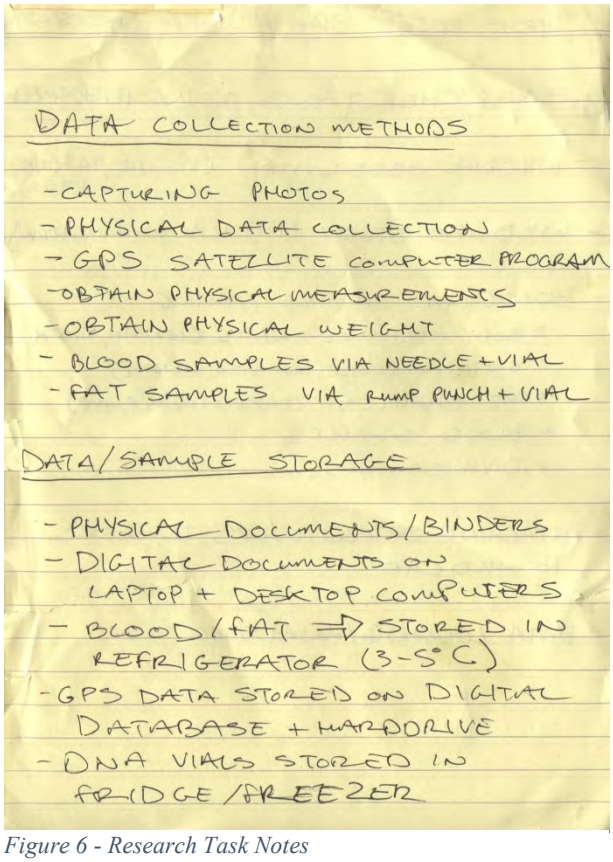


Figure 6 - Research Task Notes

Research equipment and technology varies depending on the research subject matter. As was noted in Interview One, biopsy punches were used to take fat samples from Polar Bears.

The interview with Luana Sciullo, PhD, was conducted in the University of Guelph-Humber. Luana graciously agreed to sit down for an hour long interview and discussion about her PhD and it's relevance to this industrial design thesis, as she has prolific experience in Arctic and Sub-Arctic research methods, studying polar bear foraging ecology in Western Hudson's Bay.

Name	Email	Basis of expertise
***Luana Sciullo*, PhD**	Luana.sciullo@humber.ca	Polar bear foraging ecology Environmental Science and Ecology

Table 4 - User Interview contact.

Questions were prepared in advance prior to the interview, aimed at gaining unique individual insight from personal experience working in Arctic environments, interacting with Arctic wildlife and conducting biological research. In the context of this interview, questions were specified towards the interviewee and her own unique work and background. The questions used in the interview are as follows:

- Why did you decide to pursue a career in environmental science?
- May you explain the process of observing and documenting a polar bear?
- Were there any moments of tribulation or extreme challenges that you experienced during this time?
- Can you 'paint a picture' of what a day may look like for you working in Western Hudson's Bay?

- What has been your favorite day working in the field and why?
- How might weather or conditions beyond your control, affect a research expedition?
- How would you best describe the importance of Arctic research?
- Did you ever feel homesick, frustrated or isolated during your time conducting research?
- How might a person go about preparing for a research expedition such as yours?
- How do you determine the technical gear needed, and technology to conduct research, considering storage, transport and usage?
- What can Arctic researchers do to mitigate their own negative presence in the Arctic, considering damage to the ecosystem, pollution and transport?

The questions are asked in a simple, conversation style between the interviewer and the interviewee, Luana Sciullo. In some instances, the exact phrasing of these interview questions was changed within the context of the situation, and additional questions were asked. The key takeaways which informed this thesis design are listed in the table below. The full interview with questions and responses is located in Appendix B.

Key takeaways – Luana Sciullo Interview
Collecting measurements from polar bears, sedated with a tranquilizer. Measurements such as length, girth, mass, fat samples, jaws and head size. A GPS collar is used to track these individuals. All of this is done with the researchers, typically a group of 4 to 5 people, maintaining a feeling of safety, as Luana noted in the interview.
The notion of separate field seasons was unique and unforeseen before the interview. These are pre-determined times which researchers use to differentiate seasons. The spring field season occurs in the middle of winter, in February. The fall field season is around the time of September. A field season is used to sanction times where researchers could go out into the field and conduct their necessary research.
Weather conditions vary dramatically in Arctic and Sub-Arctic regions, varying from 22 degrees in the fall to frigid, below zero temperatures. It was also indicated in the interview that absolutely zero risk is taken when it comes to weather, such as reduced visibility, fog, snowfall and windchill. In the event of severe weather, all field work is stopped. Luana noted that there is a tremendous safety buffer, that the researchers always ensure exists.
Research labs used by marine biologists are standard and similar to academic and high school labs. Lab benches to do work, data analysis, funnels and attachments for gases, fume hoods and solvents. Working areas within the remote field station, as described by Luana, are equipped with lab benches to conduct work however not much else, as most of the research and analysis is done at the University of the lead researcher.
Packing and supplies are kept to a minimum, as transport to research sites is often compact and limited. In the case of Luana's experience, most of the travel to research sites was done via helicopter. As space was limited, the technical equipment brought into the field for testing on polar bears is kept to a minimum, held in a black doctors' style bag with a freezer used to transport fat samples. An information binder, acting as a physical database of wildlife information is also taken on research trips. These would typically be the largest items taken on a field expedition.

Table 5 - User Interview Key Takeaways

Keywords and phrases extracted from the interviews are:

Safety buffer-enforced by the researchers, ensuring that there is a safe working environment at all times, given the current working conditions.

Field season-a period of time dedicated to scientific field research, split into the Spring Field Season and the Fall Field Season.

Information binder-in Luana's context, the information binder is used as an analogue documentation of Polar Bear statistics, ID numbers and relevant information, to be referenced in the field and updated throughout field seasons.

Field expedition-is typically a trip taken by helicopter, where researchers in teams of 4-5 are flown around dedicated regions in search of wildlife to study and observe.

Research lab-the labs used by marine biologists and Polar Bear biologists are typically standard science labs including benches, workspace, funnels and attachments, fume hoods, sinks.

2.1.3 ACTIVITY MAPPING

Information and data from the activities conducted were gathered and organized to develop potential improvements in the user experience.

- Preparing for research expedition
- Gear is packed into bags *(as few as possible).*
- Bags are packed into a helicopter, lifting them up, into helicopter. *(Lots of weight, potential to break items if mis-handled).*
- Bending, crouching and lifting to put gear into helicopter.
- Researchers board helicopter, cramped inside. *(Small interior).*
- Documenting the wildlife (Polar Bear)

- Researchers set up gear in a small perimeter around Polar Bear. *(Close proximity for efficiency).*
- Hands are exposed for dexterity when operating equipment. *(Exposed to frigid temperatures).*
- Working quickly and efficiently as possible while bear is still asleep.
- Packing up and evacuation
- Packing up all gear used, ensuring all items are returned to their bag/case.
- Lots of back and forth between helicopter, packing gear and the animal.
- Must return to helicopter and repack helicopter before leaving as the bear awakes.

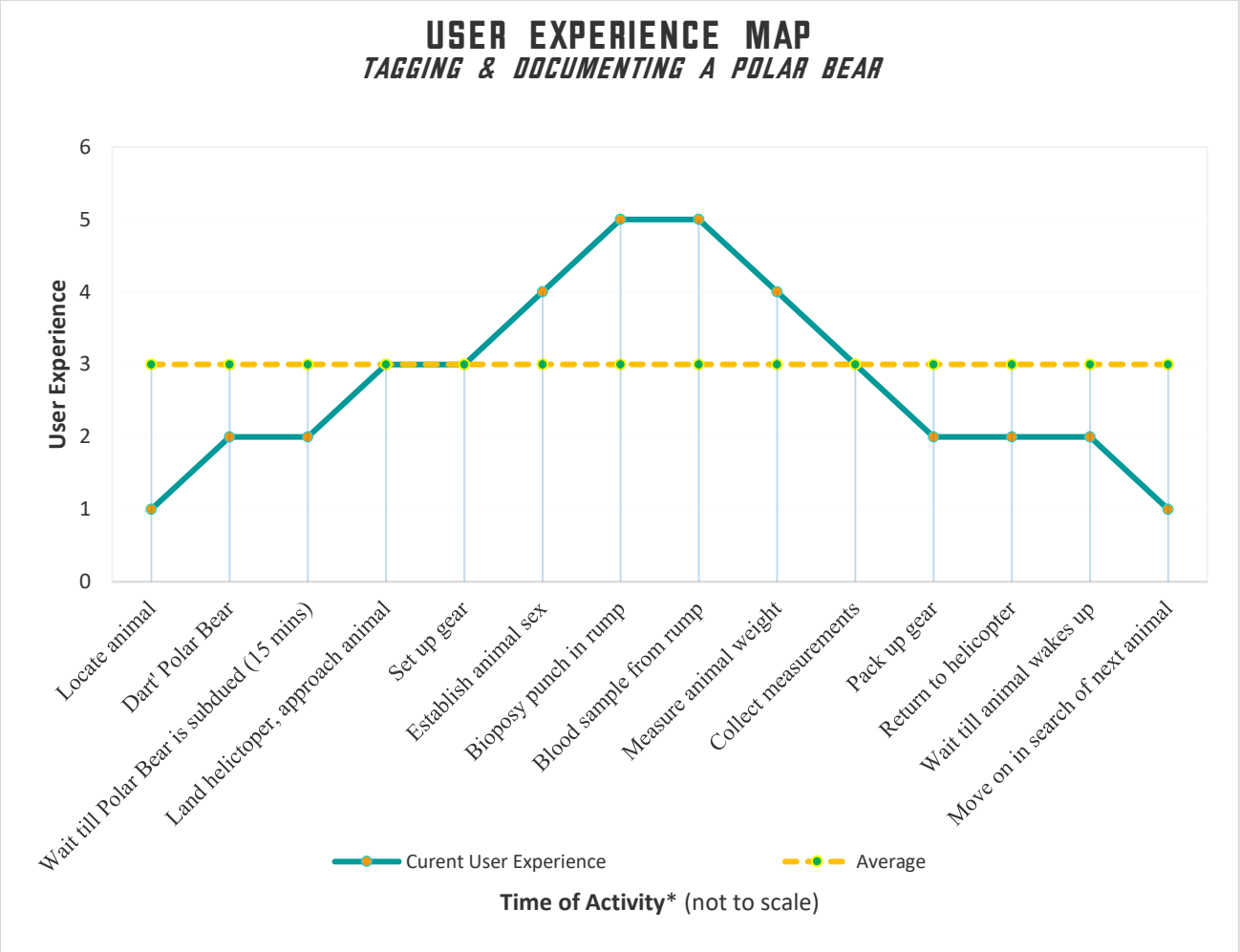


Table 6 - Current User Experience Map for tagging and documenting a polar bear.

1 (Very Poor -ve), 2 (Poor -ve), 3 (Average), 4 (Good +ve), 5 (Very Good +ve)

2.1.4 ERGONOMIC RESEARCH (EXISTING PRODUCTS)

Ergonomics associated with conducting marine biology research in an Arctic environment is difficult to come by naturally. Working in an Arctic environment is challenging due to several factors. “Recent and upcoming investments in icebreakers and research labs in the Arctic will create opportunities to address research questions on the Arctic Ocean” (Council of Canadian Academies, 2014). Looking into existing research labs and equipment used by marine

biologists will help in understanding the fundamental features and abilities that need to be implemented and innovated upon for the design solution.

The average working day corresponds to two primary types of work: laboratory work and field research. Lab work typically operates for 8-10 hours a day, whereas field work can be more intensive, sometimes operating in upwards of 12-15 hours daily. Marine biologists are often operating in a team setting, working with at least one other individual.

2.1.5 SAFETY & HEALTH RESEARCH

Safety from the elements and storage, along with durability are crucial elements to Arctic research vehicles and vessels. Common elements identified from current benchmarked products are as follows:

- Traction and durability
- Heavy duty storage
- Operating Space
- Visibility / Reflectivity
- Warmth and comfort

Health and safety within the field of marine biology and Arctic research are vital. The health and safety of both the researchers and the wildlife they are studying is of the utmost importance.

Current research practice and techniques, especially those involving marine mammals such as Polar Bears, Walrus and whales, emphasize the importance of maintaining a safe observation distance between the researcher and the animal. The use of tranquilizers is used to

safely sedate the animal, allowing researchers to document, take measurements and samples from the animal, however highly trained individuals only do this. If there is suspicion that the tranquilizer will jeopardize the animal's safety, the shot will not be taken.

2.2 PRODUCT RESEARCH

The followings section of this thesis report examines various pieces of equipment and transport used by marine biologists and Arctic researchers, to identify key benefits and features while highlighting areas for innovation.

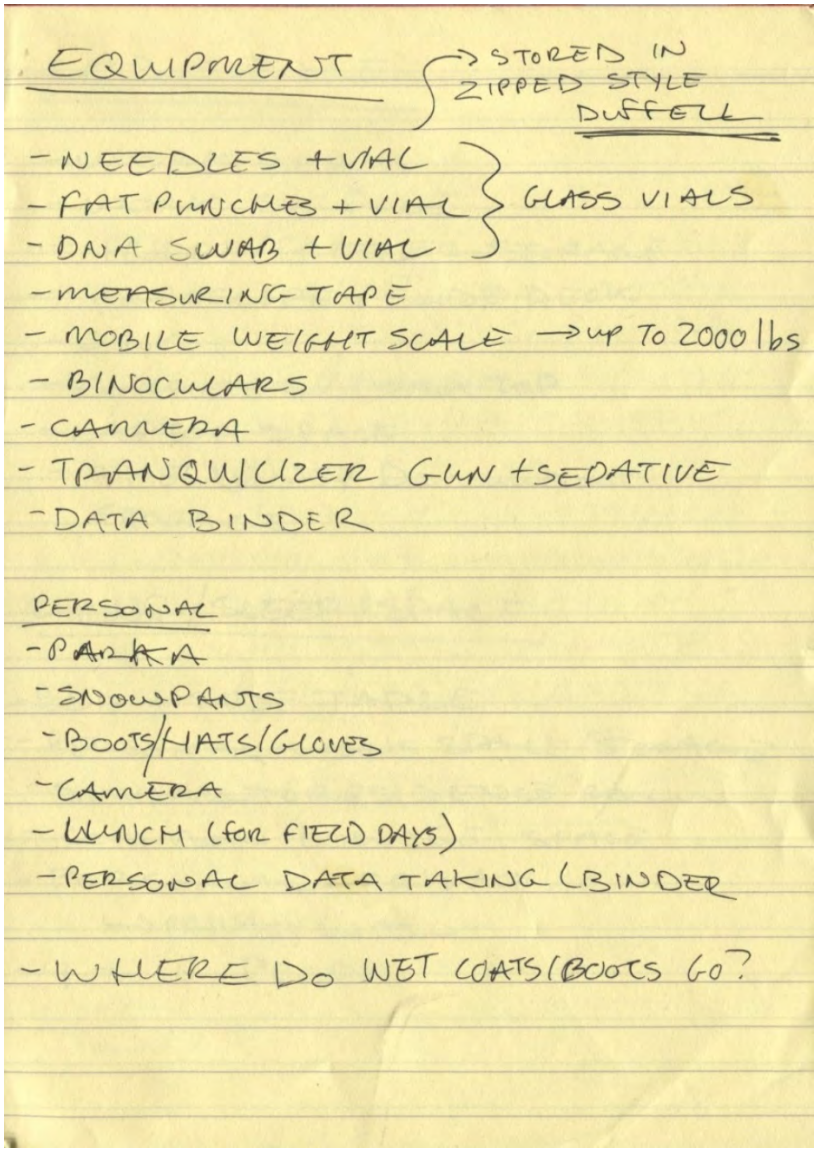


Figure 8 - Equipment Used Notes

A pool of 10 initial products were selected, with 4 being critically analyzed for the sake of this report.

Product Name	Product Image	Product Reference
Arctic Oven 12x24 with vestibules		Figure 9 - Arctic Oven Tent - Retrieved from https://arcticoventent.com/tents/all-tents/arctic-oven-12x24-with-vestibules/
Hagglunds BV2016 – Arctic Tracks	 /	Figure 10 - Hagglunds BV206 - Retrieved from http://www.arctictracks.com/hagglunds-bv206
Paris PULK		Figure 11 - Paris PULK - Retrieved from https://www.skipulk.com/product/paris-pulk/

Himalayan Suit **(Mens)**		Figure 12 - Mens Himalayan Suit - Retrieved from https://www.thenorthface.com/shop/mens-himalayan-suit-2-en-ca

Table 7 - Current benchmarked products.

2.2.1 BENCHMARKING-BENEFITS AND FEATURES

Product benchmarking for this thesis relied heavily on a pool of data from general use products which are commonly used by Arctic researchers for a broad range of uses. The pool of products was selected due to their range in price, function and ergonomic attributes which can be enhanced and innovated upon later in the thesis process. Using literature provided from existing products, features and benefits have been sorted through and highlighted. The full breakdown of benefits and features is highlighted in *Appendix C – Product Research*, along with all benchmarked products.

Key Benefits	Key Features
Easy to find / Product reflectivity	Vestibule Storage / Storage
Lightweight and durability	Accommodate groups of 9 to 11 people
Warmth	Insulation / Goose down

Traction	Heavy duty storage
Condensation Free	Durable material use (Vapex, Nylon, Arctic-Grade bungee cords)

Table 8 - Benchmarked products key benefits and key features.

2.2.2 BENCHMARKING-FUNCTIONALITY

After being broken down to their most essential form, two distinct product categories arose during the benchmarking process. On a basic level, the pool of benchmarked products offer varying modes of transportation on one spectrum and on another, are designated for personal utility. Both product categories have their own unique features and benefits which apply themselves to an informed design solution.

Basic functionality enables users to transport themselves in Arctic conditions with efficiency and the ability to transport researchers and their equipment. Personal amenities offer shelter and comfort.

On a practicality scale, products which offer a less practical mode of transportation often offer little in the way of comfort and shelter. The benchmarked product pool is spread widely across the X-Y axis as seen in Figure 8, a design opportunity zone has been highlighted which shines a light on the most ideal features and functions of the design solution for this thesis.

The solution should be developed in an area where opportunity for effective and comfortable shelter is provided, with the addition of functional transportation.

As per the X-Y graph measuring functionality, a design opportunity zone has been highlighted which shines a light on the most ideal features and functions of the design solution for this thesis.

The solution should be developed in an area where opportunity for effective and comfortable shelter is provided, with the addition of functional transportation.

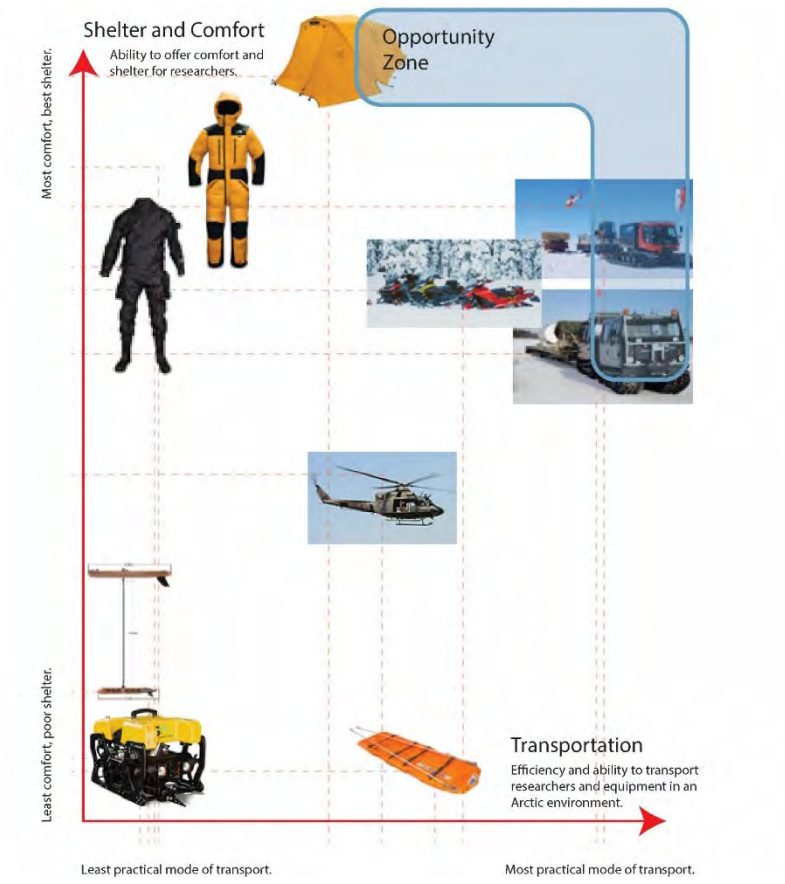


Figure 13 - XY Product Functionality Graph

2.2.3 BENCHMARKING-AESTHETICS & SEMANTIC PROFILE

Taking note of Figure 14 on the following page, it is apparent that there is a current lack of humanistic form in the pool of benchmarked products. It is evident that current designs of equipment and existing solutions are saturated with traditional, vehicular and rectangular forms with a very utilitarian aesthetic.

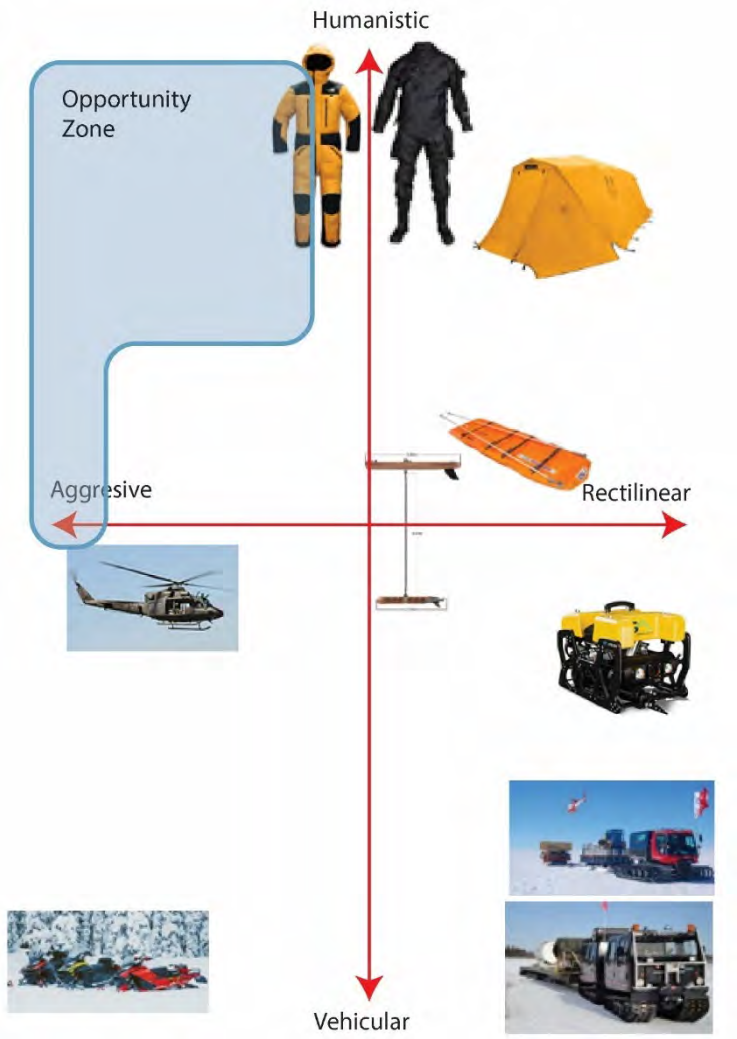


Figure 14 - XY Product Semantics Graph

The general aesthetics are mechanical and strong in appearance, with little emphasis on strong styling and aesthetic consideration. Visually, these designs are heavy, with both implied and physical mass. Reducing the visual weight of these products and enhancing the visual appeal of a workspace offers potential to develop innovative solutions for a marine biologist and other Arctic researchers.

Bright colors are used, including various shades of high visibility orange and yellow, contrasting with a darker shade such as gray or black. These colors may be valuable to consider in the final solution design. Surfaces, excluding windows, often appear to have a matte or satin finish, apart from Arctic soft goods. These soft goods take on the texture of the material which they are made of, typically smooth, soft and fluffy for comfort and insulation.

The vehicular solutions lack a great deal of emotion and expression. They have been designed with a strong, utilitarian aesthetic in mind which is clearly reflected through the vehicle's design and form. This notion of utilitarianism is also complimented by the stiff, rigid accessories such as wheels, tracks and storage racks which accommodate the vehicle.

2.2.4 BENCHMARKING-MATERIALS & MANUFACTURING

Figure 15 - Arctic Oven Tent, use of Vapex material - Retrieved from https://arcticoventent.com/tents/all-tents/arctic-oven-12x24-with-vestibules/

Materials which appear in current benchmarked products are as follows:

Material	Benefits	Reference
800 Fill Synthetic Down	800 Fill Synthetic down acts as a strong insulator against cold temperatures, resulting in more warm air trapped with better insulating power. Use of synthetic down eliminates animal cruelty as standard Goose down is taken from mature birds.	https://www.downandfeathercompany.com/pages/how-to-choose-fill-power
6063 Aluminum Alloy	6063 Aluminum is a commercially available alloy which is commonly used. When used as a substrate and coated with the DMF-STA-H20 solution, it created a hydrophobic coating around the aluminum, making it nearly impossible for moisture, ice or frost to form on the surface. Aluminum is also a beneficial material as it increases in strength when its core temperature drops while still maintaining its light weight qualities.	https://ezproxy.humber.ca/login?url=https://search.ebscohost.com/login.aspx?direct=true&AuthType=ip,url&db=a9h&AN=128311252&site=ehost-live&scope=site

Automotive Grade Plastics	Automotive Grade plastics are used for interior finishing and simple elements. This can be produced using current recycled plastics from automotive manufacturers, to repurpose parts that would otherwise be disposed of, eliminating negative waste.	https://doaj.org/article/e02e60c7062e4f3f8234f94404b4d846
Arctic Grade Bungee Cords	A nylon coating is weaved around a cold weather elastomer, typically silicone as it has the best low temperature flexibility.	https://www.wcrp.uk.com/technical/material-selection/which-elastomer-offers-the-best-low-temperature-flexibility/
DMF–STA-H2O solution	Dimethylformamide (DMF) is combined with stearic acid (STA) and oxygen to develop a solution which has anti-icing, anti-frosting and self cleaning properties. This can be utilized on the exterior of the vehicle to eliminate ice build up, which has benefits as far as exterior maintenance on the vehicle.	https://ezproxy.humber.ca/login?url=https://search.ebscohost.com/login.aspx?direct=true&AuthType=ip,url&db=a9h&AN=128311252&site=ehost-live&scope=site
HDPE	High Density Polyethylene is a sturdy and rigid material with increased stiffness and works well in cold temperatures. Can be utilized for developing storage compartments and rigid plastic componentry.	https://www.sciencedirect.com/science/article/abs/pii/S0008622303003877
HOIZ Wood Shavings Insulation	HOIZ is an insulation material which is produced using shavings from untreated spruce wood trips. This can have a strong environmental impact, repurposing waste from lumber mills.	https://www.c2ccertified.org/products/scorecard/insulation-material-baufritz-gmbh-co-kg-seit-1896
PrimaLoft Gold Insulation	PrimaLoft Gold insulation is common in the apparel industry, known for its warmth, soft comfort and compressibility. It uses a proprietary microfibre structure to	https://www.patagonia.com/primaloft.html

	aid in heat retention and energy conservation. This can be implemented into the sleeping quarters of the vehicle and clothing for the crew of the vehicle. It also uses 55% post-consumer recycled fibers.	
Vapex	Vapex is a lightweight fabric used in tents, specifically the Arctic Oven tent. Vapex is able to eliminate condensation insight the tent and is fire resistant. Vapex can be sourced in off-cuts and scrap material from tent manufacturers to eliminate negative waste.	http://alaskatent.com/wallte nts/vapex.html

Table 9 - Benchmarked Materials Table

Material choice and the manufacturing processes associated with the materials specified in Table 9, is vital for items used in extreme cold environments, such as the Arctic. Materials used in products analyzed during the benchmarking phase, include Goose Down and Synthetic down for insulation, Vapex and HDPE. These materials are required to be reliable under stress, durable for extended periods of time and offer thermal properties such as keeping heat in, cold out, cutting the wind and preventing moisture leaks. In addition to their raw qualities, many of these materials require further treatment which allows them to perform in freezing temperatures. “In the vulnerable Arctic environment, the impact of especially hazardous wastes can have severe consequences” (Belmonte et al 2018). Using closed loop manufacturing systems can reduce the environmental cost of producing the materials necessary for construction. Mitigating these effects for the final design through use of recycled or upcycled material can aid in creating a cyclical material use process.

2.2.5 BENCHMARKING-SUSTAINABILITY

Sustainability is an essential element to consider, as the solution will have direct impact on individuals, a fragile Arctic environment and wildlife species at risk, such as Narwhals,

Hooded seals and other pinnipeds. Companies such as Patagonia have made significant efforts to improve their environmental and sustainability programs, attempting to minimize the negative impact which their products have on the environment. Perhaps most notable of these efforts is the use of PrimaLoft Insulation, which uses up to 55% of post-consumer recycled materials ("PrimaLoft® Insulation").

"Research on the relationship between the ocean and human health and well-being is undergoing a paradigm shift from a focus on contaminants and disease towards a more holistic understanding of the social and environmental determinants of health" (Council of Canadian Academies, 2014).

The use of materials and manufacturing processes which have minimal to no negative impact on the environment, will be an added benefit to the success of the Amphibious Arctic Research Station, NANUK.

CHAPTER 3 ANALYSIS

Figure 16 - Retreived from https://paulnicklen.com/stills/polar-bears/#!jig[1]/ML/2241

CHAPTER 3 ANALYSIS

3.1 NEEDS ANALYSIS

The Arctic and polar regions are the most remote and unexplored regions on the planet, with the exception of the bottoms of our oceans. Conducting scientific research in these harsh and challenging conditions is next to impossible without proper technical gear, equipment and training. With the earth's climate changing at a dramatic rate, scientists need to be able to understand how this climate change is affecting the marine wildlife that calls the Arctic home.

"As the Arctic changes, populations of whales, seals, walruses and polar bears become increasingly at risk of decline" (WWF, 2019).

Marine biologists, whose job it is to study and document these animals for conservation and research purposes face numerous challenges when trying to study these animals. Their success relies on luck, safe weather and perfect timing. The need for consistent and impactful wildlife data is relevant.

3.1.1 NEEDS / BENEFITS NOT MET BY CURRENT PRODUCTS

Current products and tools used by marine researchers cover a very broad spectrum. Through research, two main product categories revealed themselves through analysis. Excluding technical equipment such as satellites and ROVs, most of the products which marine biologists use during Arctic research expeditions fall into a transportation themed category, or a personal utilities category.

Marine biologists currently lack a proper sense of human aesthetic in their products, leading to a more utilitarian aesthetic, which can be rectified through design solutions. Current vehicular solutions are all very traditional, with a consistent lack of differentiation between models, apart from the product name. These vehicles also lack the appropriate space and

resources to conduct and catalogue research in the field. Instead, the researchers are forced to return to a field station (up to X miles away) and finalize their research there.

Traditionally, polar bear researchers will take flight in a helicopter and survey the land where bears have been known to frequent until a bear is located. The researchers will attempt to dart (tranquilize) the bear, land the helicopter, unpack the helicopter, capture their measurements, pack up the helicopter, wait for the bear to wake up and depart until they can locate another, more detail in Appendix B. This is an arduous, expensive and complex scenario that lacks proper consideration for the lifestyle of the researchers.

Comfort for the marine biology researchers will be paramount when designing, keeping their morality high to maintain productivity while also allowing for important research to be conducted. Adequate storage which integrates itself as part of a larger design solution, rather than a separate identity which can be towed along behind a vehicle, such as the Paris PULK analyzed in Appendix C.

3.1.2 LATENT NEEDS

Latent Needs	Benefit Statement
Comfort	Offers creature comforts, feelings of home within the design. Comfortable to live in for up to 3 days at a time.
Storage	Adequate storage for personal belongings, research equipment and data.
Shelter	Shelter from the elements, cold wind, snow, ice, severe weather. Protection from animals if necessary.
Transportation	Traverse Arctic terrain with ease in an efficient manner. Unique attention paid to the ergonomics of transportation and how it compliments morality of the user.

Work / Productivity	Enables productive work to be conducted. Needs of a research lab are met with attention paid to the ergonomics and how it relates to the rest of the solution. Enables research to be conducted in the field, eliminating travel time to and from field station.
Observation	Darting (tranquilizing) animals for documentation. Visual space for distance observation, underwater observation, allows animals to get close without risk.

Table 10 - Latent needs developed through analysis of benchmarked products and user observation.

3.1.3 CATEGORIZATION OF NEEDS

Through user observation and product benchmarking analysis, needs have been divided into categories based off their importance to the design and function of the design solution. This is intended to link product benefits with corresponding fundamental human needs. Referencing Maslow's 'Hierarchy of Human Needs', a table has been generated to summarize these needs and their respective categories.

Need	Benefit Statement	Relationship with Benefit
Long Distance Travel	Enables marine biologists to travel long distances in one day, rather than multiple short, frequent trips.	***STRONG***
Wildlife location	Quick location of wildlife, tracking capabilities. Safely locate and observe wildlife.	***STRONG***
Research Workspace	Ability to analyze and document research data in the field, without having to return to field station. Mobile research workspace.	***STRONG***
Latent Needs	**Benefit Statement**	
Comfort	Offers creature comforts, feelings of home within the design. Comfortable to live in for up to 3 days at a time.	*MODERATE*

Storage	Adequate storage for personal belongings, research equipment and data.	*MODERATE*
Shelter	Shelter from the elements, cold wind, snow, ice, severe weather. Protection from animals if necessary.	***STRONG***
Transportation	Traverse Arctic terrain with ease in an efficient manner. Unique attention paid to the ergonomics of transportation and how it compliments morality of the user.	***STRONG***
Work / Productivity	Enables productive work to be conducted. Needs of a research lab are met with attention paid to the ergonomics and how it relates to the rest of the solution. Enables research to be conducted in the field, eliminating travel time to and from field station.	***STRONG***
Observation	Darting (tranquilizing) animals for documentation. Visual space for distance observation, underwater observation, allows animals to get close without risk.	*MODERATE*
Wants	**Benefit Statement**	
Cost Effective	Easy / affordable to maintain	*MODERATE*
Stylish Aesthetic	Void of utilitarian aesthetic, stylish, futuristic appeal	***STRONG***

Table 11 - Benefits Relationship table

3.1.4 NEEDS ANALYSIS DIAGRAM

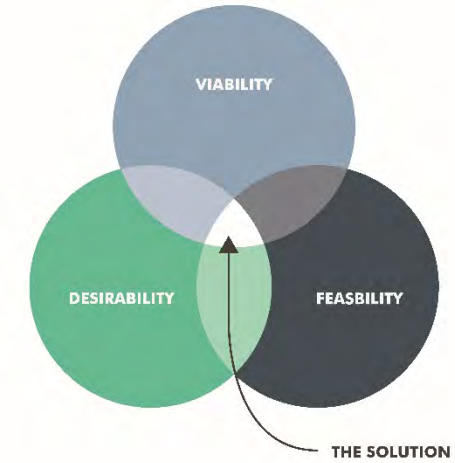


Figure 17 - Needs Analysis Diagram.

Desirability

Marine biologists have a passion for wildlife, conservation and the environment which they are studying. They rely on scientific equipment and Arctic wildlife to fulfill their passions and inform their research. The objective of this thesis is to satisfy the desirable needs of marine biologists, giving them a consistent and

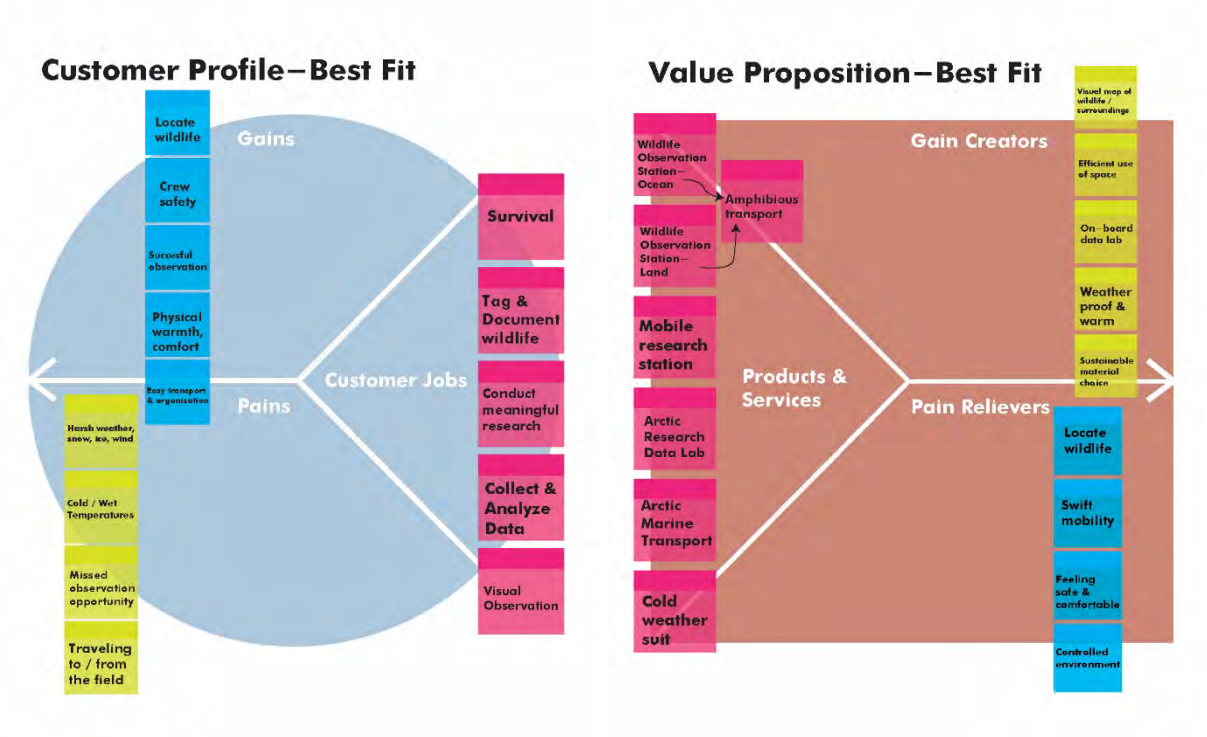
reliable mode of transportation in an Arctic environment, which is reliable to function for the full 24 hours in a day, with enough provisions to survive in a remote environment.

Viability

As climate change and animal welfare becomes a more prominent topic for discussion in society, people are willing to assist in funding and donating to causes which promote the conservation and sustainability of Arctic wildlife.

Feasibility

Existing technologies in animal data collection and species tracking are utilized with a high degree of effectiveness, once that research is taken back, collected and analyzed. The challenge is that this process takes valuable time, which for species at risk, is less than ideal. Product innovation occurs when the technology used to collect animal data and tracking is combined with the intellectual workflow of field research.



3.2FUNCTIONALITY

3.2.1 ACTIVITY / WORKFLOW MAPPING

User observation is used to develop an activity map, identifying stages of use in various contexts. The activities observed are analyzing scientists darting a polar bear, taking the anthropometric measurements of the animal and cataloguing the data.

Figure 18 - Retrieved from https://www.youtube.com/watch?v=8iN7mC-aUpg

Activity 1	Steps / Process	Base User Experience	Potential for Improvement
Preparing for research expedition	-Gear is packed up into bags to be loaded onto helicopter -Helicopter is loaded with gear and organized, as researchers and pilot board	-carrying bags from lab/research station to the helicopter -climbing up into helicopter, cramped interior due to gear bags	-Refined interiors (more space, relaxing) -Efficient way to load gear (lower down to reduce stress of lifting)

Table 12 - Analysis of Activity 1 from Video Analysis

The first activity conducted is the preparation for the research expedition. This is typically overseen by the head researcher, typically a professor or high level expert in the field. The proper equipment and tools are gathered, with the various logistics sorted out a head of time.

In the instance of this activity, the gear and users were loaded into a helicopter in preparation for the expedition.

Figure 19 - Retrieved from https://www.youtube.com/watch?v=8iN7mC-aUpg

Activity 2	Steps / Process	Base User Experience	Potential for Improvement
Locating animal	-Animal is located, typically by air, using a helicopter -animal is 'darted' using a tranquilizer shot from a rifle -Researchers must then hover and wait until the sedative takes effect	-Lots of waiting, aimless searching -Difficult to dart bear from the air (lots of training) -Travel time with potential for no bears	-Improved location / wildlife finding (using Sonar, Radar, infrared imaging) -Easier darting techniques

Table 13 - Activity 2 Breakdown from Video Analysis.

The second activity is the act of observing the animal in its natural habitat after locating it and darting it. Once the polar bear is located and darted, the helicopter lands and the research crew will disembark and unpack their research gear as the animal falls asleep. Through the process of darting, a tranquilizer is administered to the animal causing it to fall asleep for up to 45 minutes.

Figure 20 - Retrieved from https://www.youtube.com/watch?v=8iN7mC-aUpg

Activity 3	Steps / Process	Base User Experience	Potential for Improvement
Documenting animal	-Researchers approach the animal, bringing their gear and equipment -gear is set up / unpacked -the polar bear's sex is established -fat samples, blood samples and other biological samples are taken -bodily measurements are taken -stats are documented and cross-referenced	-Quick, streamlined process -limited time due to effects of tranquilizer -animals can be unpredictable, even when sedated -conducting delicate tests in cold temperatures	-easier method of transporting gear -more safe working time with animal (safe for humans and the bear) -tools designed for dexterity, use with gloves (for colder days)

Table 14 - Analysis of Activity 3 from Video Analysis.

The third activity which is observed is taking the body measurements of the polar bear such as length, girth, mass, fat samples, jaws and head size are taken. A GPS collar is attached to the animal in most cases for future tracking. This is all done in a streamlined process which the research team has perfected.

Figure 21 - Retrieved from https://www.youtube.com/watch?v=8iN7mC-aUpg

Activity 4	Steps / Process	Base User Experience	Potential for Improvement
Pack-up & departure	-gear is packed up in a timely manner -all researchers retreat to helicopter (mode of transport) -wait safely until animal wakes up and moves on -researchers move on in search of next bear to study	-many steps and items to pack up -must be done before animal wakes up -requires team members to bring back gear back to helicopter / transport by hand	-easy set up / takedown of equipment -reduction of time spent setting up / taking down gear

Table 15 - Activity 4 Breakdown from Video Analysis.

An analysis of the fourth activity identifies the researchers packing up their equipment from the location site of the polar bear, ensuring that it is done so in a timely manner. The researchers then retreat to the helicopter and board, in preparation for the animal to wake up. A safe distance between the human researchers and the polar bear is always maintained, typically 50 to 75 feet. Once the bear wakes up and goes on its way, the helicopter takes off and the researchers will go off in search of another polar bear.

3.2.2 ACTIVITY EXPERIENCE MAPPING

Experiencing mapping proved to be a useful tool in the data analysis, offering a visual representation of the data collected to inform the primary pain points as the user completes their desired task. The activity map is used to benchmark the average experience which a person may have during the activity and the actual level of satisfaction that they experience. This can be used then to analyze places for improvement, which can inform the thesis design solution.

Shown in the graph below, is an activity map for an individual darting a polar bear in the Arctic and collecting data samples from it and the potential areas for enhancing the experience.

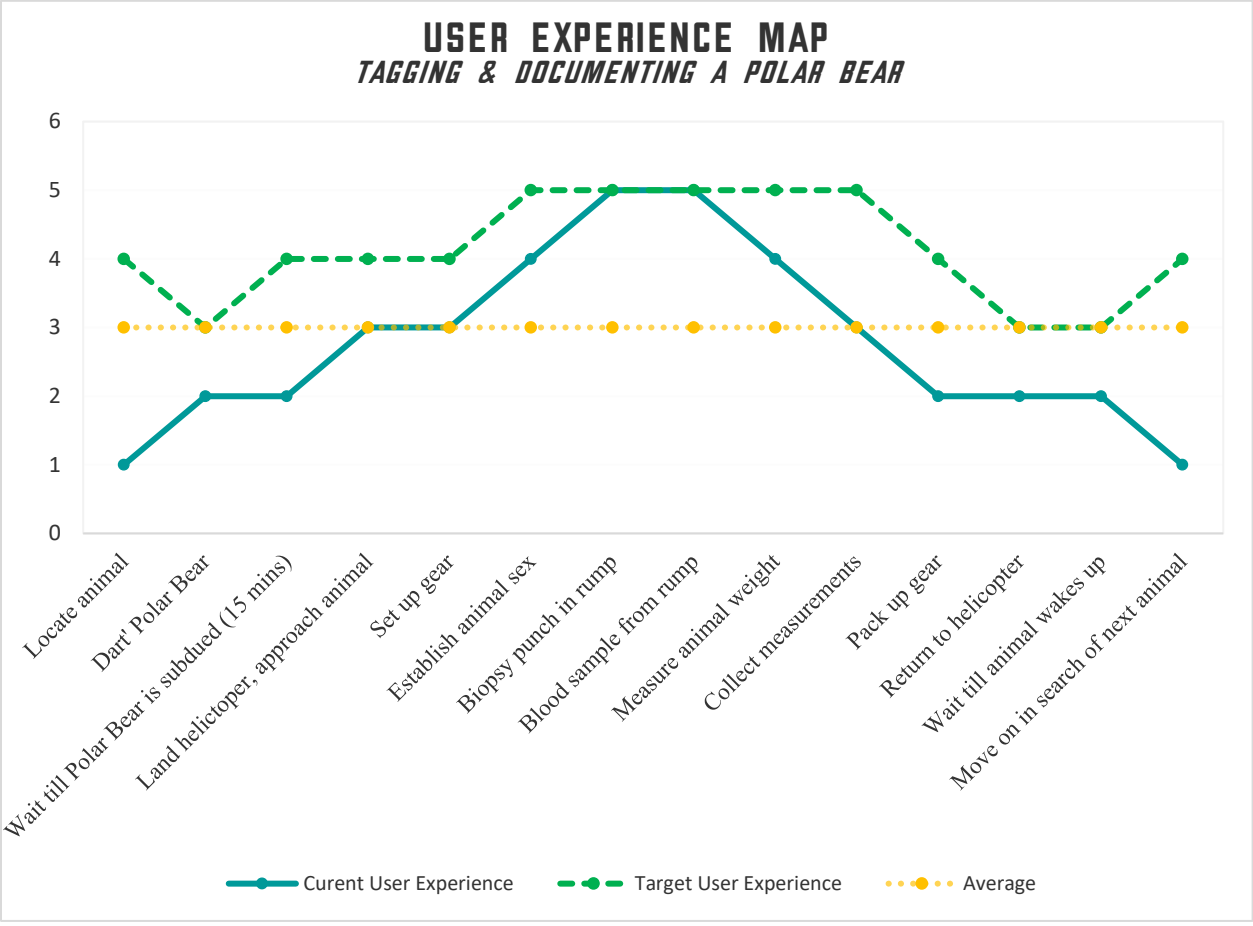


Table 16 - Projected User Experience Map

1 (Very Poor -ve), 2 (Poor -ve), 3 (Average), 4 (Good +ve), 5 (Very Good +ve)

As observed, the user starts the activity with a low level of satisfaction, due primarily to the lengthy period of time which is spent locating an animal in the wild. This is often a long and bland part of the activity as researchers will typically be looking for a white colored bear against snow, which is quite challenging. Once a bear is located and is being tracked by the helicopter, the user experience starts to rise. The euphoria and excitement of locating a polar bear drives this user experience level up above average and the animal is successfully darted (tranquilized) and the helicopter lands. Now, the excitement rises higher as researchers get the opportunity to work on and study the polar bear as it is sedated. This is often the peak of the user experience during the activity. Packing up equipment once data has been collected, retreating to the helicopter and moving off again in search of more bears to study is another point where the user experience drops below average. Excitement from the experience with the bear has worn off and now the researchers must return and go off searching once more. Minimizing these pains and enhancing their experience in these areas will add value and credibility to the design solution.

3.3 USABILITY & ERGONOMICS

Introduction

Marine biologists and Arctic wildlife scientists are critical to understanding the ecological future of the planet. It is these individuals who dedicate their lives to conservation and wildlife study. Working conditions vary greatly and pose significant risk to health and productivity, especially the Arctic and sub-Arctic environments. Field research experiences lack adequate ergonomic consideration and the organization of data collection and analysis risk damage to the environment, all of which can be innovated upon with this thesis solution. The ergonomic interactions which this report focuses on make use of the user experience while

conducting wildlife research in an Arctic environment. Important factors to focus on within the context of ergonomic testing were:

- Determining level of control of user when collecting data and samples from a wild animal
- Innovating laboratory working conditions in the field
- Enabling a comfortable work / life balance in an Arctic environment

Extreme considerations which focus on the environmental sustainability and 'give-back' nature will also be analyzed, ensuring the thesis solution has minimal negative environmental impact.

Literature Review

Anthropometric data which is referenced in this report is retrieved from The Measure of Man and Woman (Tilley & Dreyfuss, 2002). Overall dimensions of 97.5 percentile male and 2.5 percentile females will be used in this report. The specific dimension considerations are seating variations, sleeping space, computer stations and analyzing agriculture and industrial equipment. Notes on research specifications, equipment and interior features was extracted from (Canada, 2019).

Methodology

There were two primary mock-up's that were constructed to conduct ergonomic testing. This includes an ergonomic buck being constructed for the following elements:

Interior Research Lab Space Standing Analysis Desk Lab Counter surfaces and storage	These ergonomics will focus around the workspace layout for the marine biologists and how it can accommodate the necessary lab equipment (sinks, power, microscopes, vial storage) which are used. A workspace with adjustable height and collaborative considerations with focus on creating a comfortable and productive environment. Studying how the geometry of this space relates to the remaining elements of the solution will also be analyzed.
Underwater Observation Pod Observation positions and data collection techniques	Ergonomics of the Underwater Observation Pod will enable a comfortable observation space with a focus on the natural viewing of marine wildlife. Comfort will be a paramount consideration, expanding the observation space from the larger solution.

Objective(s)

The ergonomic evaluation and analysis of the chosen elements were conducted with the intent to mitigate challenges facing marine biologists when conducting field research.

The aim is to evaluate the full-bodied human interaction design of the thesis solution and how it works in conjunction with the full-bodied ergonomics for a marine biologist. In relation to this thesis project, the term ‘full-bodied’ refers to emphasizing three distinct major body part areas which are relevant to the design (Chong, Kappen & Burke, 2018).

Decision(s) to be made

The following user interactions were investigated for this project to identify any negative or impractical interactions which a marine biologist may have with the research laboratory, research PULK or in an underwater observation space.

- Conducting research in a laboratory environment on-site (legs, hand, arms, head, neck)
- Interacting with wildlife, obtaining data and samples (hand and arms)
- Observing wildlife underwater in a safe environment (head, neck, hands)

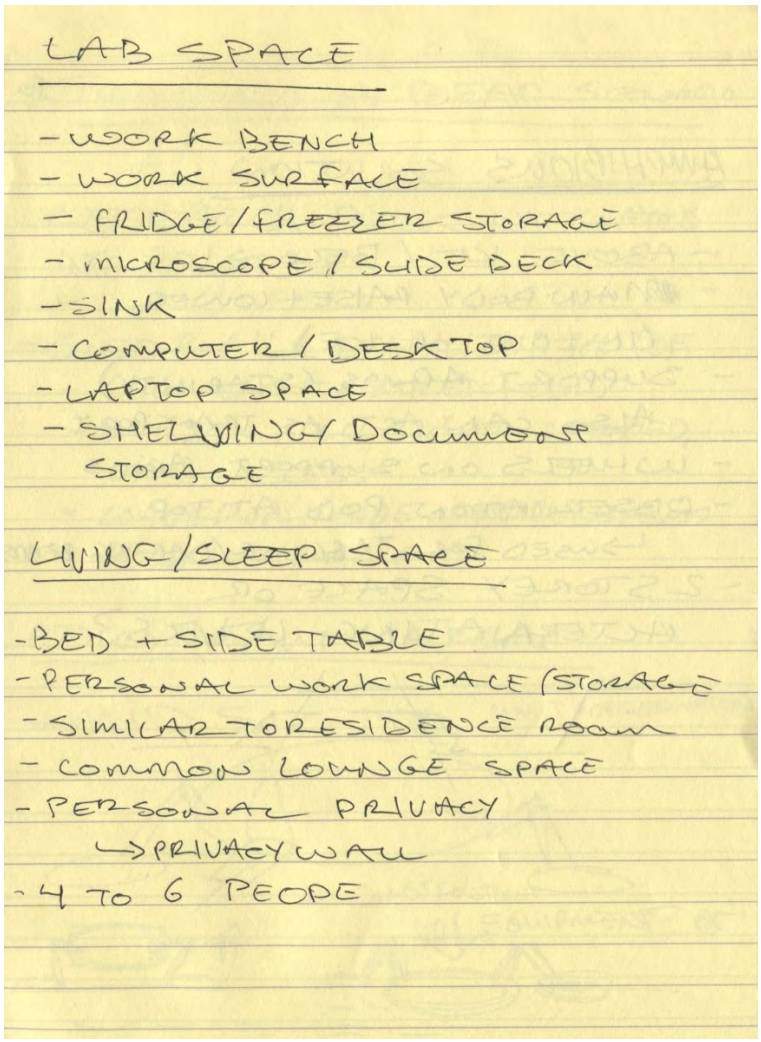


Figure 22 - Interior Space Consideration Notes

Description of Users Targeted by Product

The following traits were used during the consideration process of the various components of the ergonomic buck:

- The target demographic is marine biologists / Arctic biologists who are studying marine wildlife such as Polar Bears, Walrus, Whales.
- Ages range from 28-60 with 60% of the demographic consisting of females and the remaining 40% consisting of males.
- For the user observation report, individuals were observed interacting with a sedated Polar Bear and the interior space of a biology lab was investigated.

Evaluation Process

The ergonomic evaluation process consisted of the design, construction and testing of a full-scale ergonomic buck of the key components of the larger design. This will enable relevant and credible user observation to identify how a marine biologist may:

- Analyze data from field research in a lab environment *(Hands / Arms and Head / Neck)*
- Interact with other biologists and analyze data on site *(Hands / Arms)*
- Observe the critical human dimensions for an interior research space, living space and underwater observation space *(Legs and Back / Lumbar and Head)*
- Observe wildlife in new ways underwater through development of an observation pod with dedicated amenities for documentation and study *(Head / Neck)*

Description of User Observation Environment Used in this Study

The ergonomic buck was created in a home woodworking shop located in Aurora, Ontario. Materials such as corrugated cardboard, polystyrene sheets, pink foam and existing furniture were used to construct the architecture of the buck. Users were then invited to interact with the product while under observation from the researcher. In some instances, the bucks were taken outside into the snow to test how they handled uneven terrain in Arctic-like conditions.

Location and Timeframe

Observation date(s):	January 2nd, 3rd 2019
Observation Location(s):	Aurora, Ontario

Results

The results of ergonomic testing are illustrated below. Anthropometric data is combined with visuals of the ergonomic buck to depict natural, in use photographs. Any ergonomic drawings were created using the relevant dimensions of a 95th percentile male and a 5th percentile female, as well as a 50th percentile female (*as this is the primary demographic for the proposed design).* The physical evaluation was conducted with a broad range of human percentiles, consisting of family members and friends of the researcher.

Analysis

The following graphic elements are used to depict the various human percentiles in the ergonomic drawings, color coordinated to distinguish these percentiles and are used in all drawings.

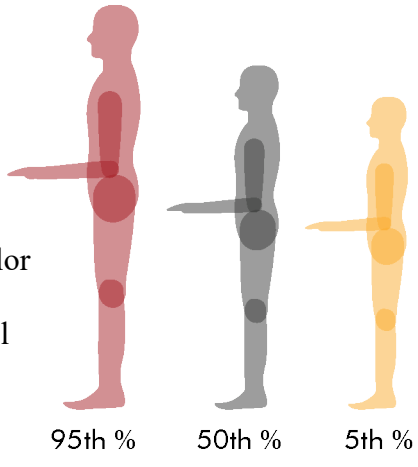


Figure 23 - Human Percentile Graphics

Ergonomic Drawings

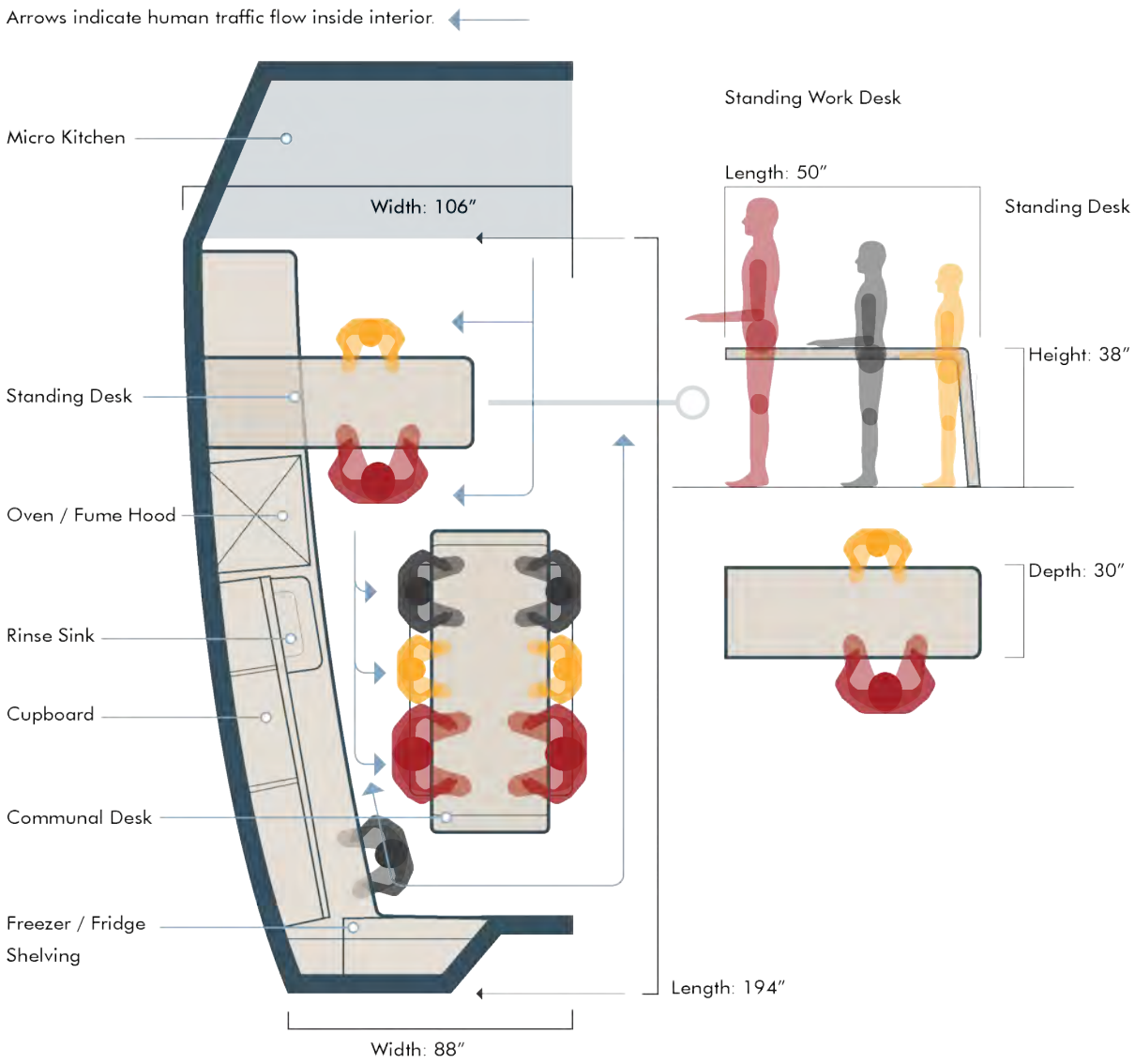


Figure 24 - Overhead view of interior research lab and standing work desk.

Pictured in *Figure 19,* is an overhead projection of the designated research lab space for the marine biologists. The research lab is equipped with the minimum technological requirements that marine biologists would require to conduct their necessary research.

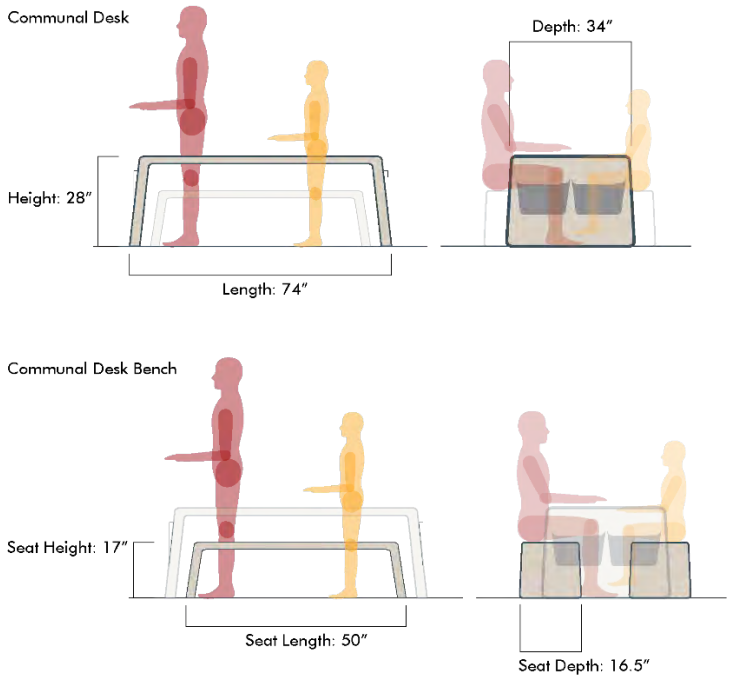


Figure 25 - Sitting Work Desk Ergonomic Drawing

In Figure 20, ergonomic considerations and geometry are shown for the sitting work desk and the accompanying work bench which can accommodate up to 6 researchers (3 on each side) with a 15” laptop placed on the work surface, still allowing for ample work room.

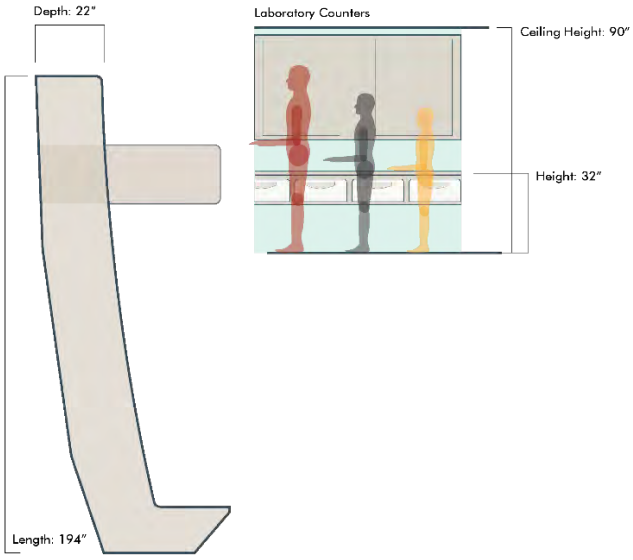


Figure 26 - Research Lab Countertop and counter height dimensions.

Figure 21 indicates the research lab countertop length and overall depth, where cupboards, sample trays and lap equipment can be placed and utilized. Likewise, the overall counter height is shown in relation to the ceiling height on the interior of the vehicle.

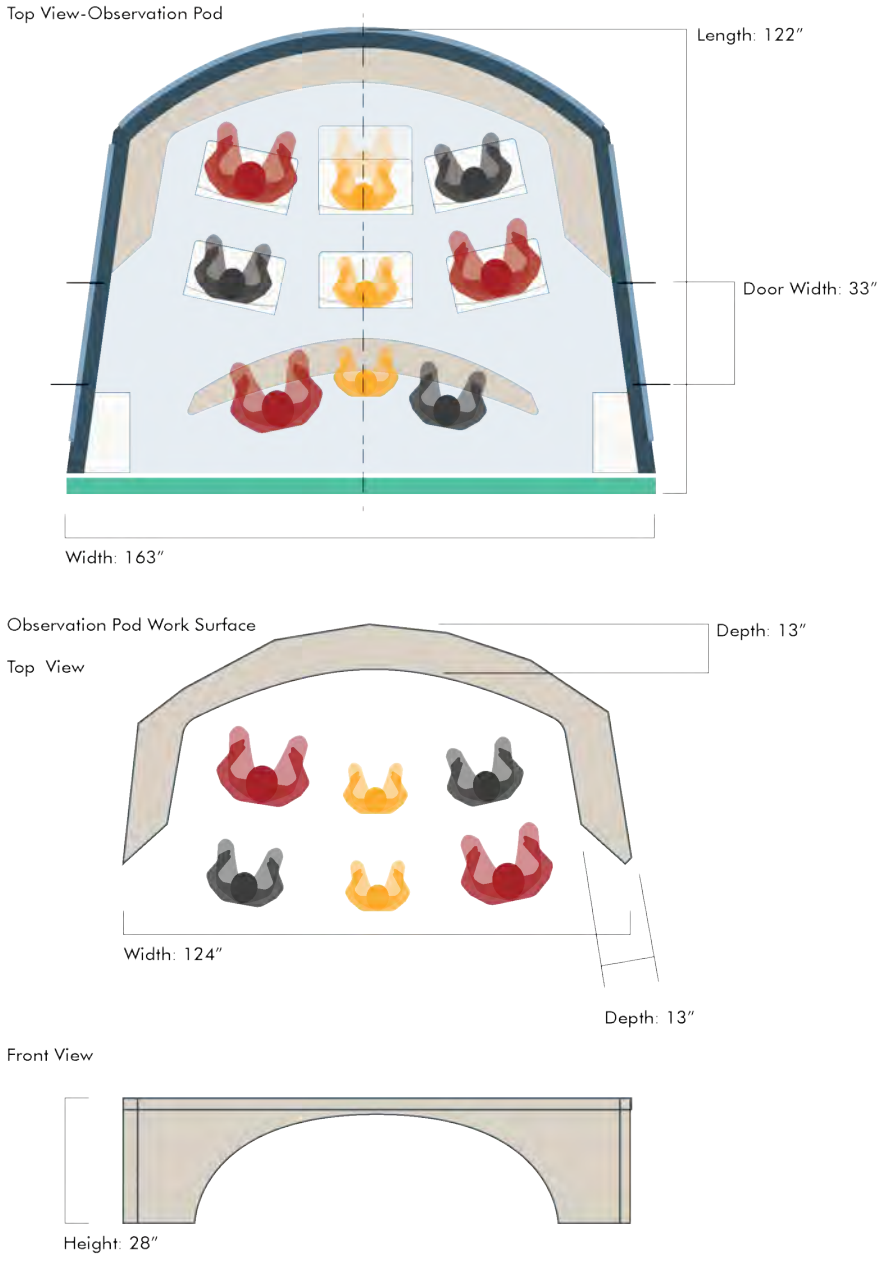


Figure 27 - Observation Pod Internal Geometry

Figure 22 shows the observation pod geometry, which can accommodate up to 6 researchers at a wide, overarching desk which encapsulates the entire width of the observation pod. This area is enclosed and can be opened or sealed from the remainder of the vehicle. In Figure 23 below, the ergonomic considerations for the seating within the observation pod is laid out.

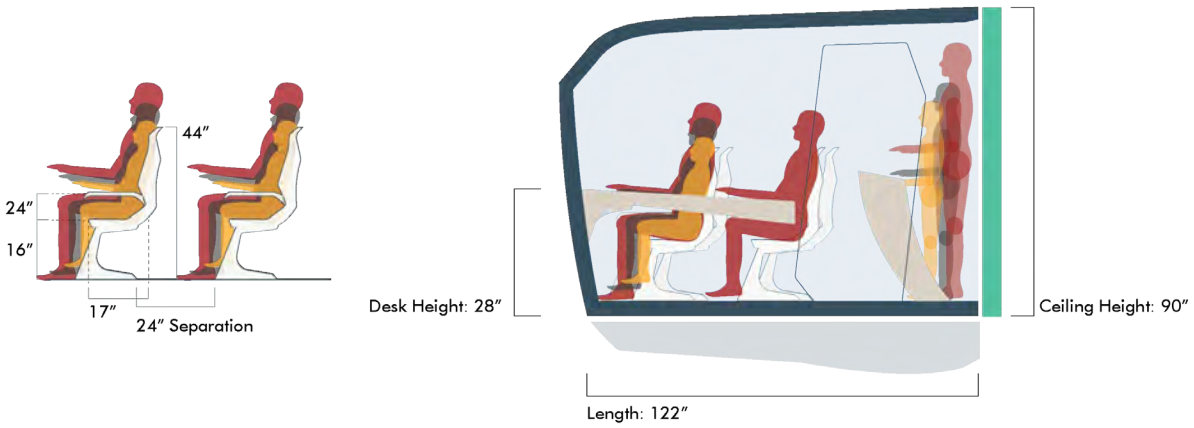


Figure 28 - Observation Pod Seating Geometry

This concludes the ergonomic drawings for the interior research lab. The following section depicts the construction and analysis of the ergonomic bucks for this thesis.

Ergonomic Buck Interaction & Analysis

Standing Work Desk *(Field Data Analysis)*	
	
This image depicts a 50th percentile male simulating a data analysis process, referencing data from his field binder, utilizing the standing work desk to do so.	In this image, a 50th percentile male interacts with the standing work desk. The desk surface is positioned 38” above the ground (floor of vehicle), allowing the 50th percentile male to comfortably utilize the worksurface with no strain.
This study focuses on the ergonomics surrounding the hands / arms and how they interact with the work surface as well as minimizing neck strain when spending time studying field data.	

Table 17 - Standing Desk Erogonomic Buck

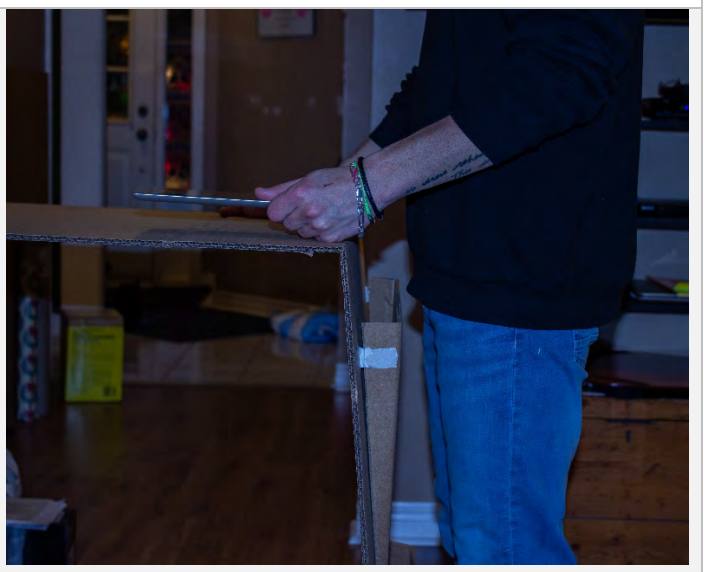
Standing Work Desk *(Storage solutions)*	
 	
This image depicts a 50th percentile male taking an iPad (used for referencing field notes) in and out of the proposed storage capsule located on the side of the standing work desk.	In this image, a 50th percentile male stands at the end of the standing desk covering the storage capsules and using the iPad on the work surface. Arms and hands are placed comfortably on the desk surface and elbows are not over or under extended.
This study focuses on the ergonomics surrounding the hands / arms and how they interact with the work surface as well as minimizing neck strain when spending time studying field data.	

Table 18 - Standing Desk Ergonomic Buck

Lab Counter Surface and Cupboards *(Biological Sample Study Areas)*	
	
This image depicts a 50th percentile male placing his hands on the countertop surface while facing the storage cupboards. The storage cupboards are used to store spare materials and tools such as biopsy punches, tranquilizer vials and satellite tags. The countertop surface is 32” high with a depth of 22”. It is easy to identify that picking up objects such as sample trays or documents will be easy, with no physical strain.	In this image, a 50th percentile male is reading a reference document. He is able to stand up fully, lowering his neck at roughly a 30-degree angle to view the document as it is placed on the counter surfaces.
This study focuses on the ergonomics surrounding the hands / arms and the head / neck, in attempts to minimize strain from looking up or down for long periods of time and allowing ease of access to objects located in cupboards with minimal lifting strain from the user.	

Table 19 - Work surfaces and shelf viewing height ergonomic buck.

Marine Observation Pod *(Seating and Desk Surface)*	
	
This depicts a 50th percentile male sitting in the rightmost seat (1 of 3) located in the first row of seats in the observation pod. The chair has a seat height of 16” and a back height of 44”, with a seat depth of 17”. This fits the 50th percentile male comfortably, allowing him to interact with the worksurface. Chairs should be adjustable in their position and location to optimize usage of the work surface.	This depicts a 50th percentile male sitting in the middle of the front 3 seats in the observation pod. His left arm is extended on the work surface, demonstrating a full range of motion with the windows placed directly in front, optimizing visibility for observation inside the pod as well as access to the work surface. The work surface is located 28” above the ground (floor of vehicle) with a 4-degree slope towards the user. A small lip prevents documents or items from rolling down and off the surface.
This study focuses on the ergonomics surrounding the legs and their interaction beneath the worksurface as well as the head / neck and the ability to maintain a comfortable position during observation sessions. Hands / arms are also analyzed in their ability to make use of the work surface directly in front of the user.	

Table 20 - Observation Pod Seating and Desk surface ergonomic buck

Marine Observation Pod *(Underwater Observation)*	
	
These images simulate an underwater observation session, whether the pod is deployed and submerged under Arctic ice and water. The 50th percentile male can comfortably use the work surface while looking straight ahead observing the marine environment. The location of the windows directly in front of the user, maintaining an open range of sight, optimizes visibility and minimizes neck strain.	Here the 50th percentile male maintains the same seating position at the work surface while turning his head all the way to the left (as if to observe a subject on the exterior of the observation pod). By turning his head, he is still able to comfortably interact with the work surface in front of him without impeding a secondary researcher next to him.
This study focuses on the ergonomics surrounding the legs and their interaction beneath the worksurface as well as the head / neck and the ability to maintain a comfortable position during observation sessions. Hands / arms are also analyzed in their ability to make use of the work surface directly in front of the user.	

Table 21 - Observation Pod Ergonomic Buck

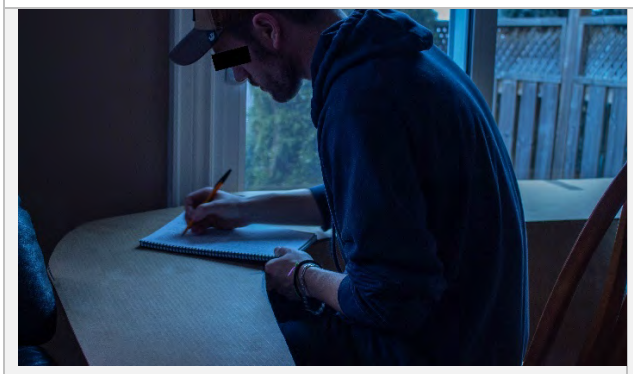
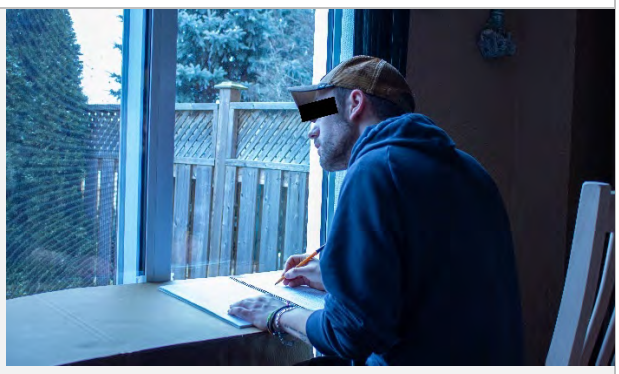
Marine Observation Pod ***(Utilizing worksurface for observation notes and analysis)***	
	
The 50th percentile male is utilizing the work surface in front of him to make notes during the observation session below water. He is moved forward from the back of his chair roughly 7” to comfortably make use of the desk space. Elbows rest comfortably, making use of the 13” deep desk space which is available to the user all around the observation pod.	The 50th percentile male is currently looking out of the proposed marine observation pod whilst making use of the work surface. Again, he has moved forward from the back of the chair roughly 7” which allows his body to be located overtop of the work surface when writing or making notes. The desk depth is 13”. His neck is crooked and looking left , still showing minimal strain thanks to the vast dimension of the observation window.
This study focuses on the ergonomics surrounding the legs and their interaction beneath the worksurface as well as the head / neck and the ability to maintain a comfortable position during observation sessions. Hands / arms are also analyzed in their ability to make use of the work surface directly in front of the user.	

Table 22 - Observation Pod Ergonomic Buck

Ergonomic Buck Analysis

This proposed thesis solution along with the human interaction study enforces the efficiency which a cohesive marine biology research vehicle can offer. The ergonomic study demonstrates the various methods of research which can be conducted in a central and inclusive vehicle without the need for transport by helicopter or snowmobile or refuge in a remote field station.

The interactions that the 50th percentile male had with the ergonomic bucks which were constructed, focus on the primary attributes of this thesis, which is mitigating challenges facing marine biologists in the Canadian Arctic. These marine biologists focusing specifically on the study of *Ursus Maritimus,* the Polar Bear. Physical limitations such as weather, body temperature and access to realistic bio-samples were not possible, which leaves some room for error and inference.

Marine biologists play an important role to the future and development of our ecosystems, especially a system as fragile as the Arctic. Negative environmental impacts and negative wildlife interactions are essential to avoid. As well as maintaining the safety of Arctic marine researchers, basic human needs must be met.

A standing desk was selected to be a part of the design for several reasons. It diversifies the available working space within the confines of the research lab, promoting new ways of conducting research. “Standing tables became ‘offices’ that drew people together” (TEKNION BOOK, p 40). The ergonomics of the standing desk are based off the elbow height of a 50th percentile male at 38”. Establishing the height of the work surface from the elbow height ensured that the greatest percentage of people would be able to use the standing work surface comfortably, when analyzing biological samples from field expeditions or conducting tests or taking notes. The 38” height dimension also requires minimal adjustment in arm and shoulder position from the 5th and 95th percentile humans. This can be seen in the Table 17: Standing Work Desk *(Field Data Analysis).*

The 30” depth of the desk allows for comfortable interactions from individuals on both sides of the desk without straining arms or shoulders. Including a method for storing documents, binders, tablets or laptops was a positive consideration, allowing these items to take up less space

on the work surfaces or in personal space. Shelving solutions are traditionally effective, put pose challenges in unstable conditions (items can slide or fall off of shelves on uneven ground). Developing an ergonomically sound solution which resides on the side of the standing desk, where users can easily take items in or out by lifting, makes more sense and still allows for the same working efficiency. These storage solutions have a height of 13” and a depth tapering from 3” at the opening down to 0.5” at the bottom. This can be seen in the Table 18: Standing Work Desk *(Storage solutions).*

The construction for the countertop worksurface within the research lab determines how researchers inside the lab are able to carry out specific tasks such as sample analysis, sample packing and storage as well as conducting tests using the rinse sink or oven / fume hood (depicted in Figure 1). The countertop is established at a height of 30”, using the base elbow height of a 5th percentile female. This height dimension is then increased to 32” from this base elbow height to allow for a more comfortable experience in higher percentiles. This ensures that comfortable and efficient access to this working surface and the contains therein will be efficient for all percentiles of humans.

The storage cupboards are then located another 24” above the countertop height and extend up to the ceiling (90”) high. Access to the cupboards is achieved with a comfortable range of motion from a 50th percentile user, as this user is able to look straight on to identify contents within the cupboard without straining their neck. A 5th percentile individual will be required to look up and a 95th percentile individual will be required to look slightly down. These are minimal inhibitions and will not have a great negative effect to the success of the thesis. Lifting items out of or into these cupboards is also efficient thanks to their dimensional qualities and their location.

This ensures that a marine biologist of any percentile can comfortably lift biological fat or blood samples into the cupboard storage area with minimal strain to their body.

An ergonomic buck created for the marine observation pod, depicts half of the interior layout, as it would be directly mirrored on both sides. The marine pod consists of six chairs on swivels, allowing for complete range of motion in any direction. An important element of the marine observation pod is the wide degree of visibility and how the researchers are able to make use of that visibility. As the observation pod is submerged in Arctic waters, the full width of the observation pod (162”) is optimized for observational research. The ceiling height is the same as the rest of the vehicle, including the research lab space, at 90”, providing ample room for a 95th percentile human without hitting their head.

The marine observation space is also equipped with work surface spanning the front curved width of the space, at a depth of 13” and located 28” above the floor of the vehicle. This allows for comfortable usage from researchers of all percentiles in their chairs. The chairs themselves in this design have a seat base of 17” deep and a seat height of 16” with armrests at 24” above the ground. This 24” height comfortably fits underneath the 28” desk height.

This proposed design solution has three separate regions which make up the cohesive design. A living section is a direct mirror of the research lab, with optimal space for 6 bunks, a bathroom and lounge space to reduce stress and relax after long days in the field. This is directly across from the research lab space with access from the back via an extending ramp and from the front, through the observation pod. The observation pod is equipped with a control desk located behind the 6 observation chairs, where the vehicle can be controlled manually or autonomously. This section can be sealed off from the research lab and living space via an airtight and watertight door, as the observation pod can be lowered into open water or breaking through ice,

fully submerging the pod. Innovative design allows for a new research experience for marine biologists as they are now able to comfortably and safely observe marine wildlife with the ability to document their findings in context.

The dimensions of 122” length, 163” width and a 90” ceiling height are the established minimum requirements in which 6 people can comfortably maneuver with chairs and including research documents such as a binder and a digital tablet. This was the final key dimension which needed to be established, allowing for adequate leg room and range of motion for the users.

Limitations and Conclusion

Identifying the critical human dimensions affecting users and product use were as follows:

- Optimizing desk space and work surfaces for biological sample analysis increases research productivity.
- Marine biologists have access to the underwater Arctic environment in a comfortable and safe environment with abilities to document their experience.
- Researchers can live and conduct field research in the same environment without need of excessive or arbitrary transportation.

3.4 AESTHETICS

Considering the environment of use, the Canadian Arctic, in which this solution will ideally be used, the look and feel of the solution should match accordingly. Additionally, it will be heavily reliant on the pure functionality of the design, with no room for expressive architecture or whimsical form exploration. Function will be the primary driver of this design, enhancing the uniqueness that the form may be able to provide.

As it lends itself to a vehicular solution, the look and feel of the wheels or tracks will dictate how the form is received. Care will be taken to address the durability and rigidness of the

architecture, whilst still allowing for an interior solution which is visually light, unobtrusive and intuitive. Maximum visual observation area is key to the viability of this design, as well as protection from Arctic elements such as ice, snow, wind and occasionally, wildlife.

Concept vehicles offer an interesting insight into explorations of form and function. Using the blue-sky technique to approach the design, studying forms which may be more abstract and unique enable some level of creativity to be tapped into which was not present before.

The goal of this aesthetic exploration is used to encourage innovation and diverse styling solutions with a visually appealing shape. The following mood board was developed to ensure a consistent and sophisticated styling approach to the design solution.

Figure 29 - Styling Mood Board

3.5 SUSTAINABILITY

3.5.1 SAFETY

The Arctic is a harsh and unforgiving environment. Safety concerns surrounding lifestyle and longevity must be addressed in order to satisfy the essential and basic needs of the user. In an Arctic environment, the safety of the marine biologists and the wildlife is very important. As Luana Sciullo outlined in the user interviews (see Appendix C) a polar bear will not be sedated if the weather is dangerous or poses a potential risk to the animal or the research scene. There is a consistent safety buffer which exists, for the benefit of humans and the animal. Sub-zero temperatures, wind chills and terrain will all need to be assessed properly to confirm the safety for those involved. Marine biologists, specifically those studying endangered Polar Bears, need to be confident that the environment in which they are operating will not be dangerous, minimizing all risks where possible.

The users must be able to operate a tranquilizer gun at a safe distance in order to safely sedate a polar bear or other wildlife. This is a solely manual task which requires a lot of training. Weather conditions must also be safe, with minimal wind gusts, good visibility and a safe place to land, otherwise the expedition can be jeopardized, and lives are at risk. This can easily be done from within the confines of the vehicle, using cutaways in the exterior to aim a rifle through, ensuring a safe, accurate and calculated tranquilizer shot from a safe distance.

“Ocean science draws on highly qualified personnel from many programs and departments, which makes human capacity one of the most challenging categories to assess. This is a particular concern, since human capacity determines the user and productivity of all other elements of ocean science capacity” (Council of Canadian Academies, 2014).

The primary function of a marine biologist is to study wildlife (particularly in a marine environment) with the intent to assist in conservation efforts, scientific understanding and sample collection. Those biologists specializing in the study of Ursus Maritimus are in tune with the biological requirements of these creatures, understanding their basic physical needs and behavioral patterns. Polar bears (*Ursus Maritimus)* are marine top predators that use annual sea ice as their primary habitat for hunting marine mammal prey (Stirling and Derocher, 1993). It is within their morality as a biologist to never put an animal or themselves at risk. Marine biologists are often working near potential lethal body parts of polar bears, claws, teeth and paws, next to their sheer weight and mass. Attaching technology used to study polar bears, ear tags, satellite collars, must be applied and attached by hand, all done in the cold, harsh winter environment. Several design considerations must be made to ensure the safety of marine biologists and the animals they study. This includes an enclosed space, shielded from Arctic weather elements that allows the biologists to safely and responsibly observe wildlife in both a land and marine environment, as well as easy access to the outside, for improved efficiency in their field work.

3.5.2 HEALTH

As mentioned in section 3.5.1, users will be subject to extreme cold and weather conditions, as well as potentially dangerous animals. The physical, day to day health is addressed through considerable design in the interior, as researchers can spend up to three months working in isolation in the Arctic. Color consideration, surface detailing and enabling the interior to ‘feel like home’ can have a positive effect on minimizing mental strain for the biologists. The design aims to offer feelings of relief and relaxations, providing space and amenities for personal down time from arduous research work in the field. The interior solution of this thesis has allowed for a

personal / living space, separate from the research lab and observation space. Mental health is just as crucial to the success of Arctic research, as physical health.

Figure 30 - Retrieved from https://polarbearsinternational.org/news/article-research/learning-how-the-other-half-lives/

Allowing researchers and marine biologists to operate comfortably, collect their necessary data without risk of injury or exposure to the elements will be implemented into the final design. Therefore, the design decision was made to focus on an enclosed interior solution, shielding the occupants from weather and wildlife risks, should they arise.

Ensuring that the health and safety of the wildlife is maintained throughout the research and observation process is equally as critical. The design uses an electric battery as a power source, which minimizes noise pollution. The exterior of the design makes use of colors which are not clearly visible to the Polar Bear's dichromatic vision spectrum, in a relatively colorless

environment (Peichl et al 2005). This allows for researchers to approach bear's without immediate stress to the animal. Bears are to be immobilized via tranquilizer, using a 1:1 mixture of tiletamine hydrochloride and zolazepam hydrochloride (Sciullo, 2017).

3.5.3 ENVIRONMENT

The environment which the design solution will be utilized directs some of the most prominent design considerations. Power sources, tracking, autonomy and personal sustainability are all aspects of the design which will be heavily analyzed. Taking these elements and placing them in an Arctic environment is another challenge which needs to be considered.

The Amphibious Arctic Research Station: NANUK relies heavily on the sustainability to inform the final design. This comes down to materials which can be upcycled or repurposed at the end of the product life, and work in conjunction with the frigid environment.

NANUK focuses heavily on resolving environmental issues associated with Arctic research, allowing marine biologists to conduct important and valuable research. Conservation efforts and wildlife sustainability are of utmost importance to these marine biologists. This thesis solution focuses on the environment, wildlife that call it home and the researchers in charge of attempting to understand this ecosystem. As a general standard, the solution should produce zero harmful emissions, be easy to transport and implement into existing practices, with a simple power source and the ability to act as a multi-purpose solution. Electric power is a potential avenue for power source technology, finding a way to combat cold temperatures and prolong battery life. End of life for the batteries is another element which needs to be considered to minimize overall negative environmental impact. Materials and colors used in the design should reflect the Arctic, the wildlife being studied, attempting to create a cohesive design solution which visually integrates the design into the environment.

Conservation efforts, wildlife sustainability and marine biologist welfare are the focus of this thesis, driving the inspiration and innovation behind this proposal. It is important that these points be reflected in every facet of the design.

3.6 COMMERCIAL VIABILITY

The following section investigates similar products and technology solutions for the proposed amphibious mobile research station to determine various materials and financial costs which will directly impact the feasibility of the proposed solution.

3.6.1 MATERIALS AND MANUFACTURING SELECTION

Figure 31 - Tesla manufacturing facility. Retrieved from https://www.technologyreview.com/s/610889/tesla-says-its-factory-is-saferbut-it-left-injuries-off-the-books/

Regarding manufacturing, the exterior of the proposed concept would likely be manufactured using methods and practices similar to aviation and military vehicles. The outer shell, comprising of double-walled insulated aluminum sheeting could easily be mass produced and assembled, like a car body. The interior can be produced with modular components like

contract furniture. This enables a wide range of scientific and functional applications for the interior, not restricting the solution to Arctic biology research.

3.6.2 COST

As depicted in the cost estimate below, costs for interior features, lab equipment and structural elements totaled $589,000 per unit, as a rough cost. At the time of writing this report, there is little to no estimates surrounding this type of vehicle. Speculative technology and similar construction techniques, material processes and finishes were utilized to generate this cost estimate.

Component	Cost (USD)
Vehicle structure	Aluminum frame and body panels ($400,000)
Observation Pod interior, seating, desks, control panels	$80,000
Li-Ion Batteries, Electronic Panels	$40,000
Research Lab Facilities	$5000
Lab Equipment / Storage	$5000
Living space amenities	$4000
Observation Pod Lowering Components	$18,000
Wheels / Navigation	$4400
Plumbing / Air filtration / Internal power	$15,000
Assembly / Material Finishing	Varies greatly
Pneumatic hydraulic componentry	$18,000

Table 23 - Component Cost

3.7 DESIGN BRIEF

A design brief is intended to focus the thesis research towards a specific set of points. In the case of this thesis, the design brief focuses around creating a solution which mitigates challenges faced by marine biologists conducting wildlife research on polar bears in the Canadian Arctic. The design brief will be enhanced and refined throughout the thesis development process.

Thesis Design Brief

This design brief will act as an aid as the design progresses through concept development stages. The goal of this thesis project is to design a transportation solution for the Canadian Arctic for marine biologists studying Polar Bears. This transportation solution should be able to travel over snow, ice and merge the two worlds above and below the ice, bringing researchers into the marine environment of Ursus Maritimus (Polar Bear).

Safety	Creating a safe environment for the marine biologists when in or out of the water, interacting with wild animals or exposure to the elements in the Arctic.
Ergonomics	Curate new working experiences for marine biologists and Arctic researchers, allowing them to analyze data on site in an optimized lab environment, without the need to travel to and from a field station.
Aesthetics	The aesthetics must inspire confidence for the user, motivating them for the task at hand with the potential to enhance research for an endangered species and conservation efforts.
Intuitive and Trustworthy	Technology, tools and solutions implemented into this design should be intuitive for the user and easily accessible. These solutions should inspire trust and confidence for the user, enabling them to commit to the meaningful work they are doing.

Integration of New Technology	Adopting current scientific observation technologies and entertaining the ideas for new and adapting technologies will be critical to this thesis. Most scientific field samples are sent away to Universities and laboratories for analysis with advanced technology. Implementing that advanced technology into a refined, compact package can be useful.
Versatile	This thesis solution will need to be versatile in its functions and its form. Being able to accommodate work on land, snow and in the water, crossing all amphibious habitats. Its versatility will also be considered with regard to research / workspace, living / sleeping space and storage considerations.
Sustainability / Less harmful to environment	Ensuring that the materials used in this thesis have minimal to no environmental impact is essential, as the Arctic is a fragile ecosystem. Consideration for proper methods to manage human waste products from expeditions should also be taken into consideration.
Comfort	The Arctic is a cold, frigid environment, resulting in cramped and uncomfortable living conditions. Providing researchers with a space that offers physical comfort from the cold as well as mental comfort from the stress of the job.
Adaptable Storage Solutions	Internal storage solutions, allowing space for research equipment, tranquilizer material, research documents as well as personal items will need to be considered. Food, clothing and utility storage will also need to be implemented.

Table 24 - Thesis Design Brief

CHAPTER 4 DESIGN DEVELOPMENT

Figure 32 - Retrieved from https://paulnicklen.com/stills/polar-bears/#!jig[1]/ML/2254

CHAPTER 4 DESIGN DEVELOPMENT

4.1 IDEATION

To start the design process, a mind map was initially developed to direct the design solution *away* from a traditional and expected solution. As the thesis warrants itself towards a marine focused product, ensuring that the design did not become a simple boat was very important. From the beginning of the project, it was a challenge to stay away from this type of solution. Likewise, refraining from implementing styling decisions which twist the design towards a more utilitarian aesthetic were avoided. The ideation phase involves many visual and aesthetic directions, focusing on organic and refined forms with a great emphasis on styling and implementing a scientific attitude to the design.

4.1.1 MIND MAPPING

Figure 33- Mind Mapping Exercise

4.1.2 INSPIRATION BOARD

Figure 34 - Inspiration Board

This inspiration board was developed to better understand the design process and generate new ideas, challenging traditional styling direction.

Companies such as Polestar were used from a stylistic point of view and image data bases such as Sink00 and SimKom were likewise used to gather a range of detailing and styling features for the design.

4.2 PRELIMINARY CONCEPT EXPLORATION

4.2.1 FORM STUDY

At the beginning of the design process, well before concept ideation, quick form studies were conducted, using simple and dynamic lines to generate visual inspiration for unique forms which can be formed and molded into a product.

These form studies are pictured in the sketches below:

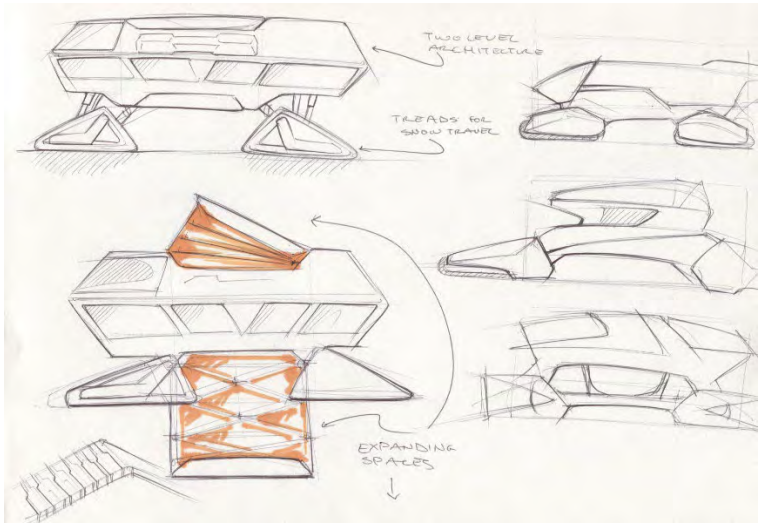


Figure 35 - Preliminary Form Exploration

4.2.2 IDEATION

With initial forms developed through the form study, concept ideation was done in class, where an intensive six hours was spent developing six uniquely distinct aesthetic directions for two different concepts. This resulted in ten unique styling directions for two different concepts after twelve hours of intensive, focused sketching. The aim of this process was to generate as many ideas as possible and generate a general package layout of numerous directions that the design could evolve into.

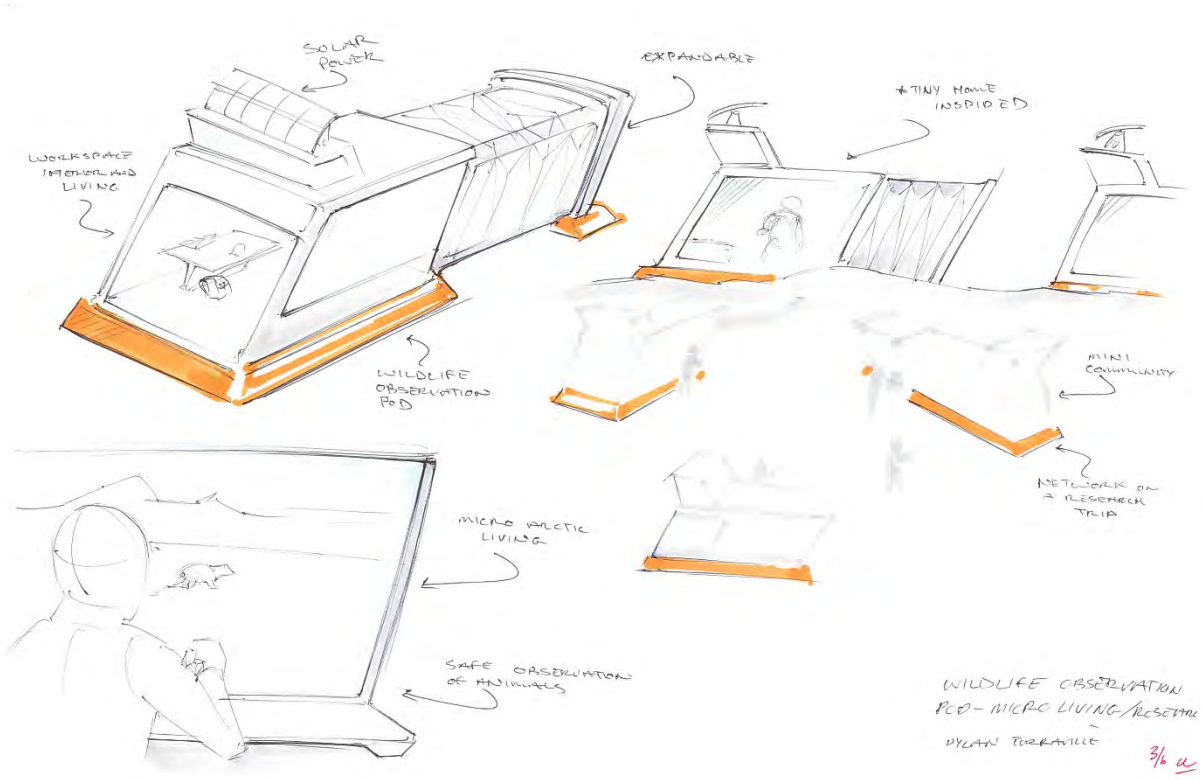


Figure 36 - Ideation Sketch 1

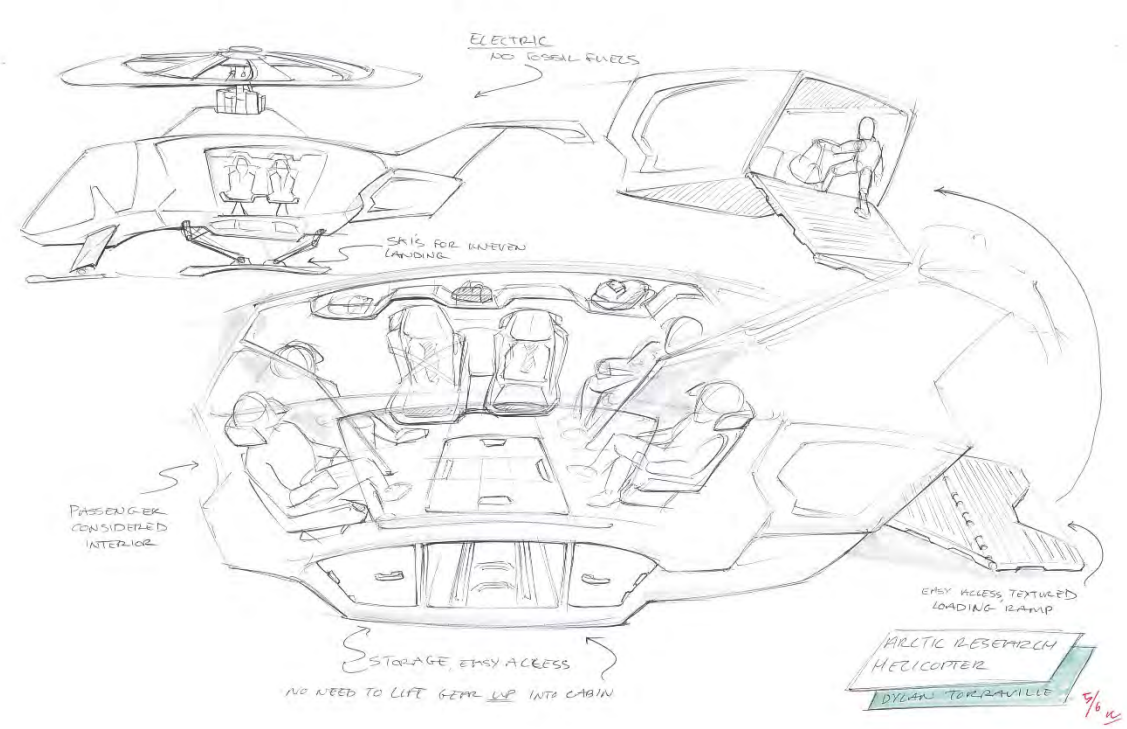


Figure 37 - Ideation Sketch 2

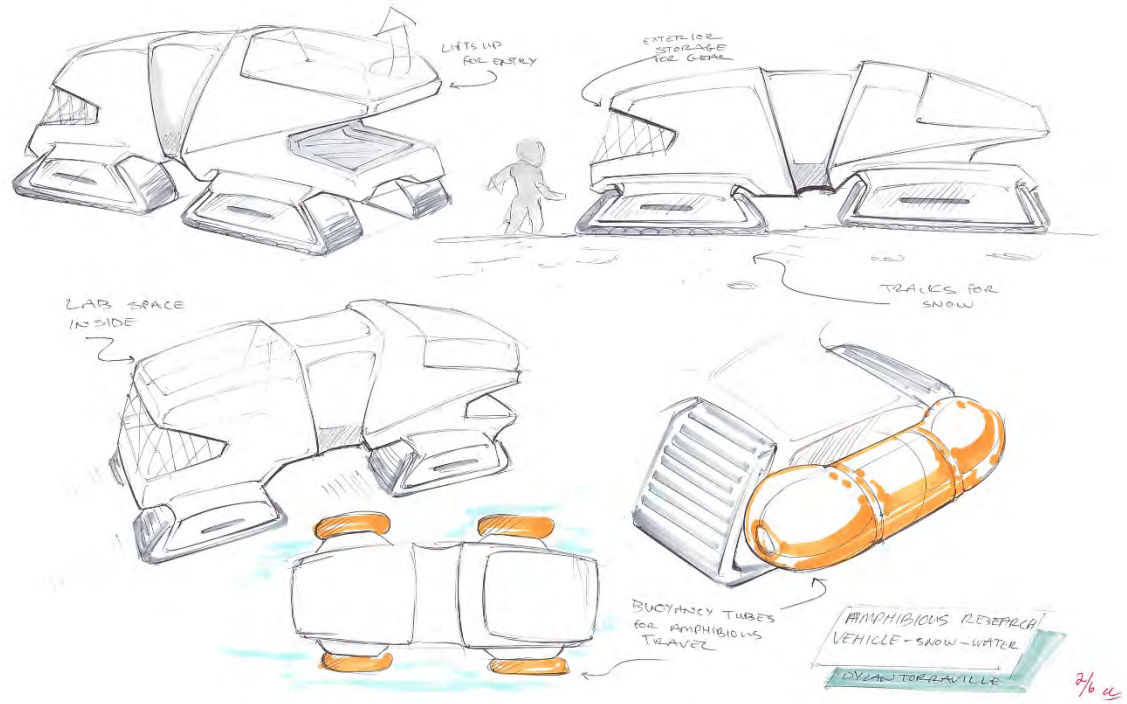


Figure 38 - Ideation Sketch 3

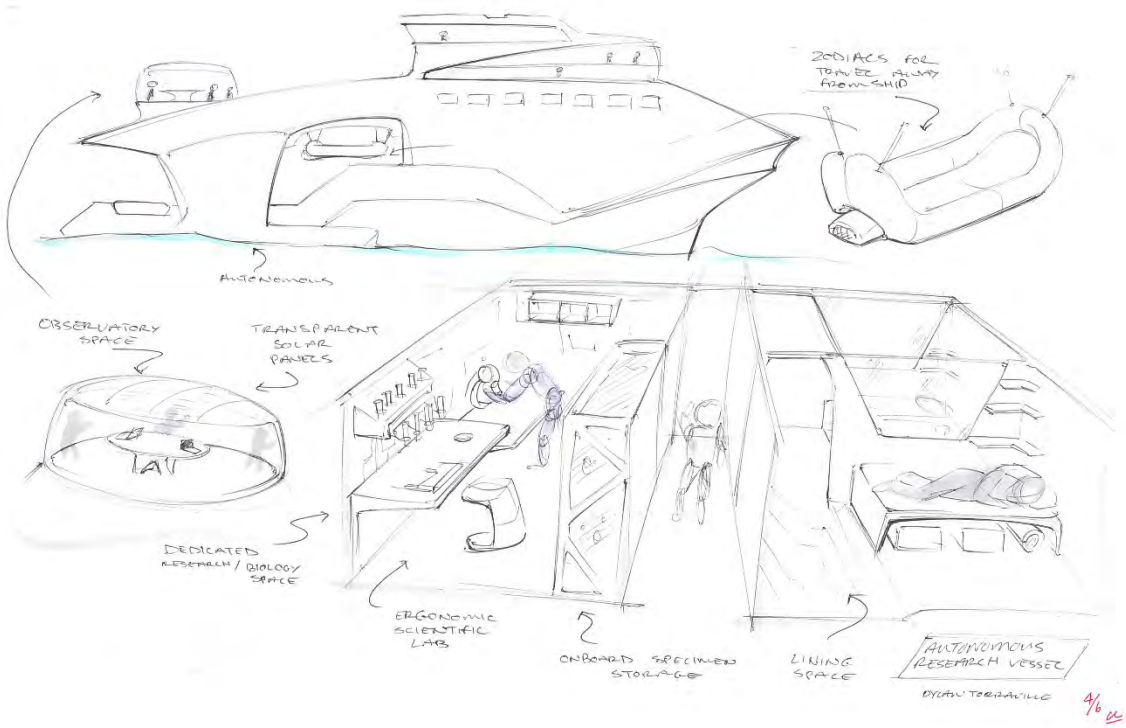


Figure 39 - Ideation Sketch 4

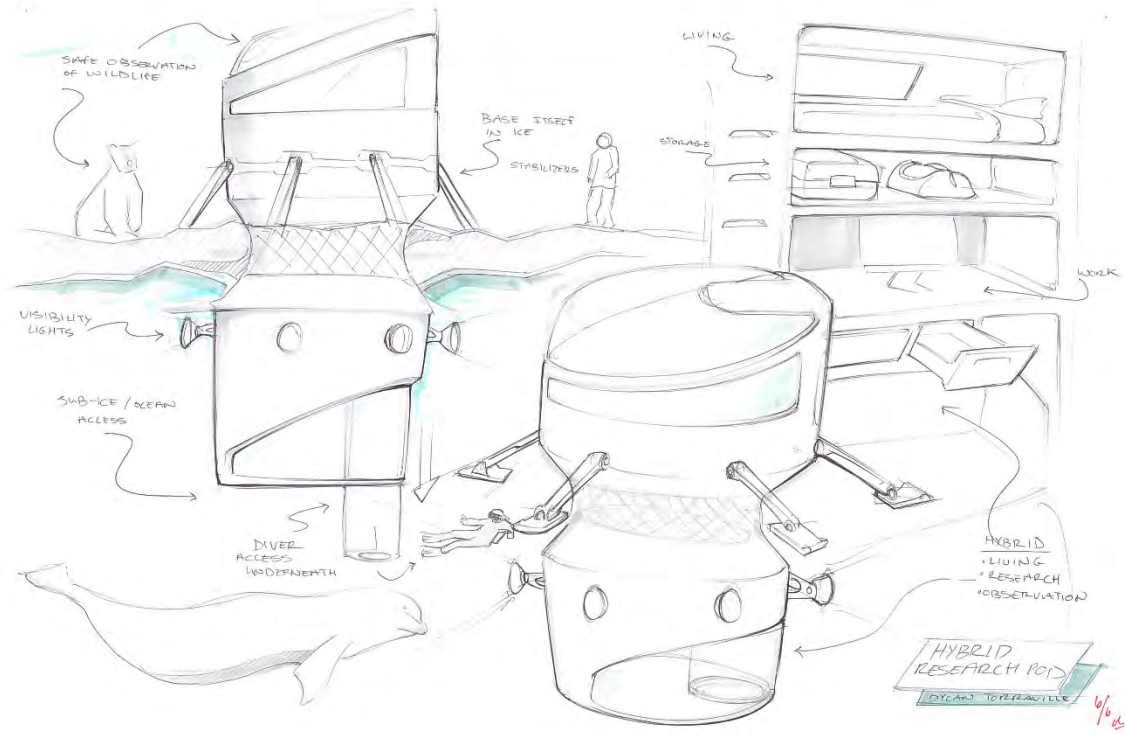


Figure 40 - Ideation Sketch 5

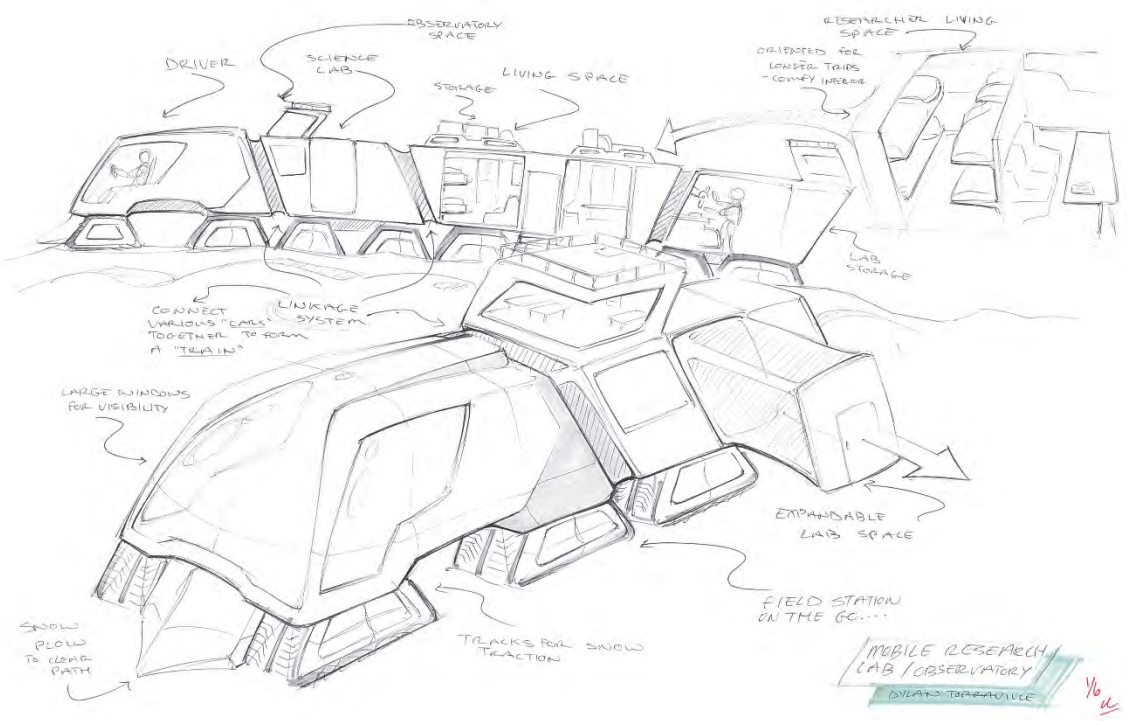


Figure 41 - Ideation Sketch 6

4.2.3 CONCEPT DEVELOPMENT

Concept development for this thesis involved taking the six initial directions as derived from the ideation process, selecting two of the most practical and relevant ideas to pursue in the concept development phase. These two ideas were then exploded further, as the aim of the concept development phase was to turn each concept into five distinctly different directions to ensure a broad outlook for the potential solutions and the opportunity to incorporate a variety of features and benefits.

These concept development sketches were all done with a Bic Golden Yellow ballpoint pen with black ink, Chartpak AD and Copic markers on standard 11x17 paper. All sketches are done freehand and annotations are added with a 0.5 mm Muji gel pen.

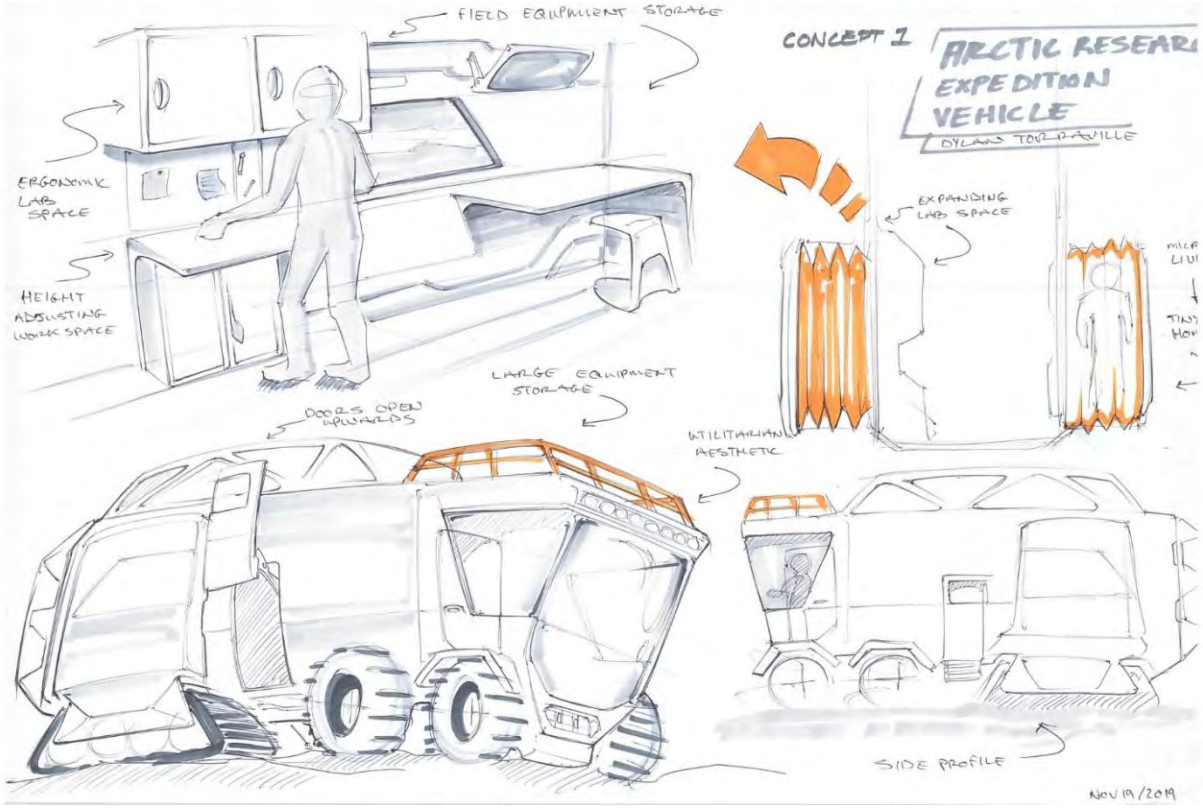


Figure 42 - Concept 1 - Direction 1

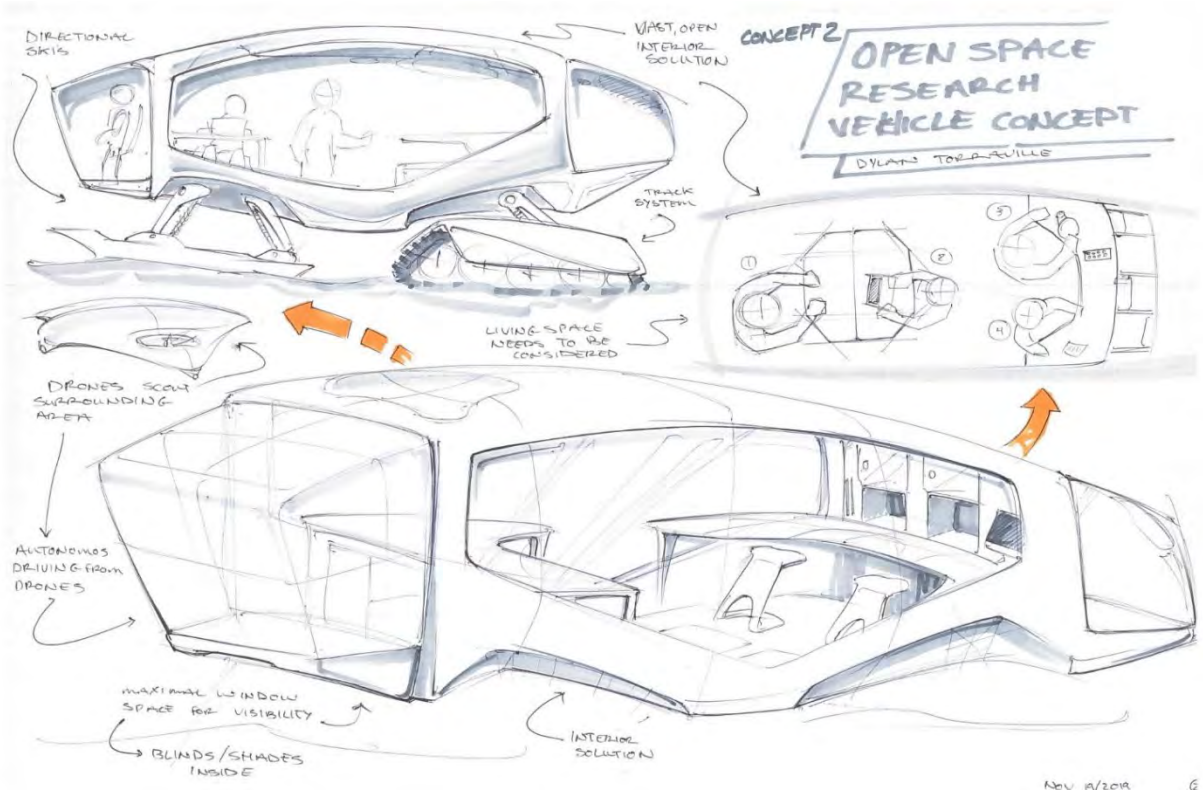


Figure 43 - Concept 1 - Direction 2

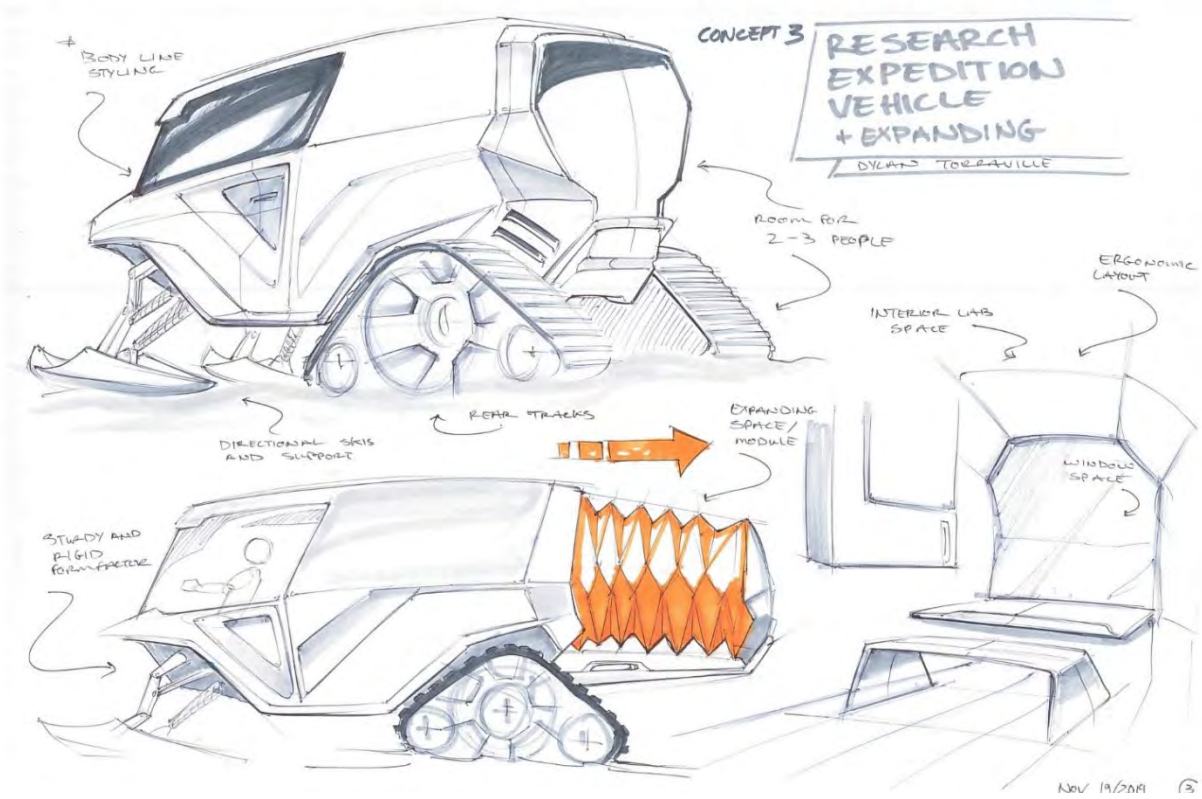


Figure 44 - Concept 1 - Direction 3

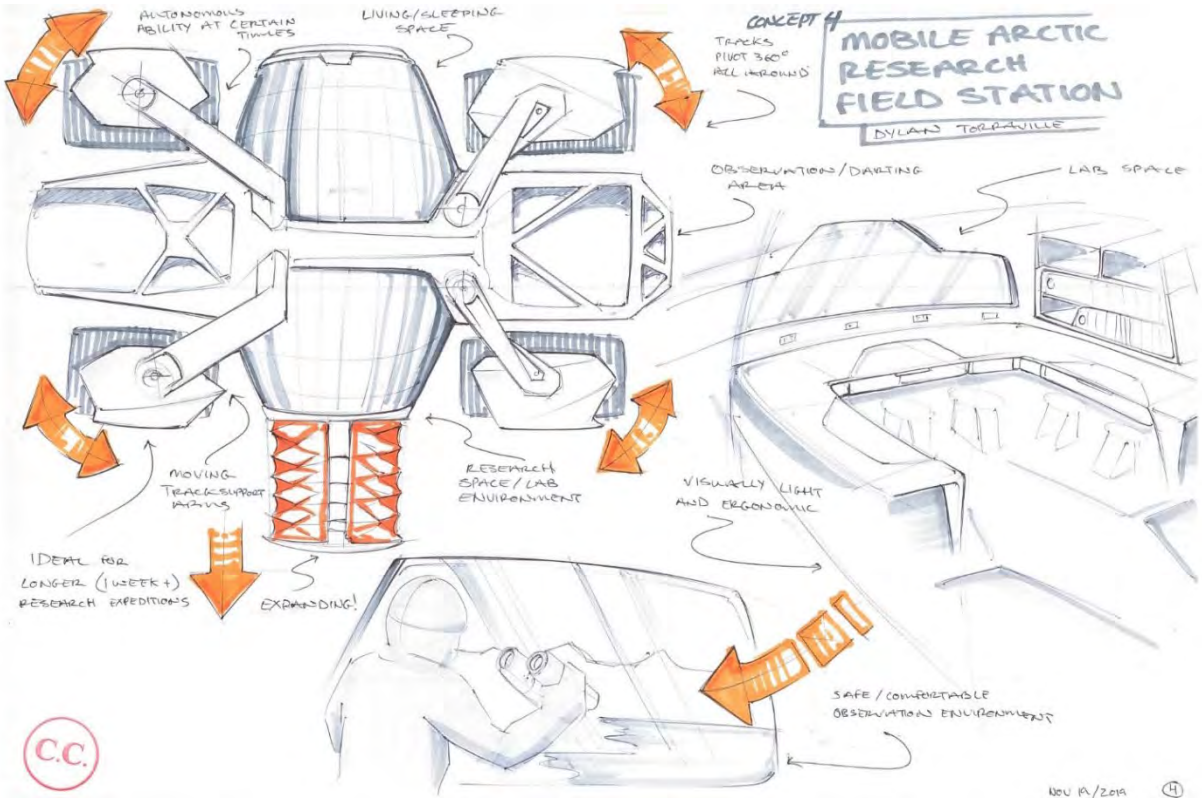


Figure 45 - Concept 1 - Direction 4

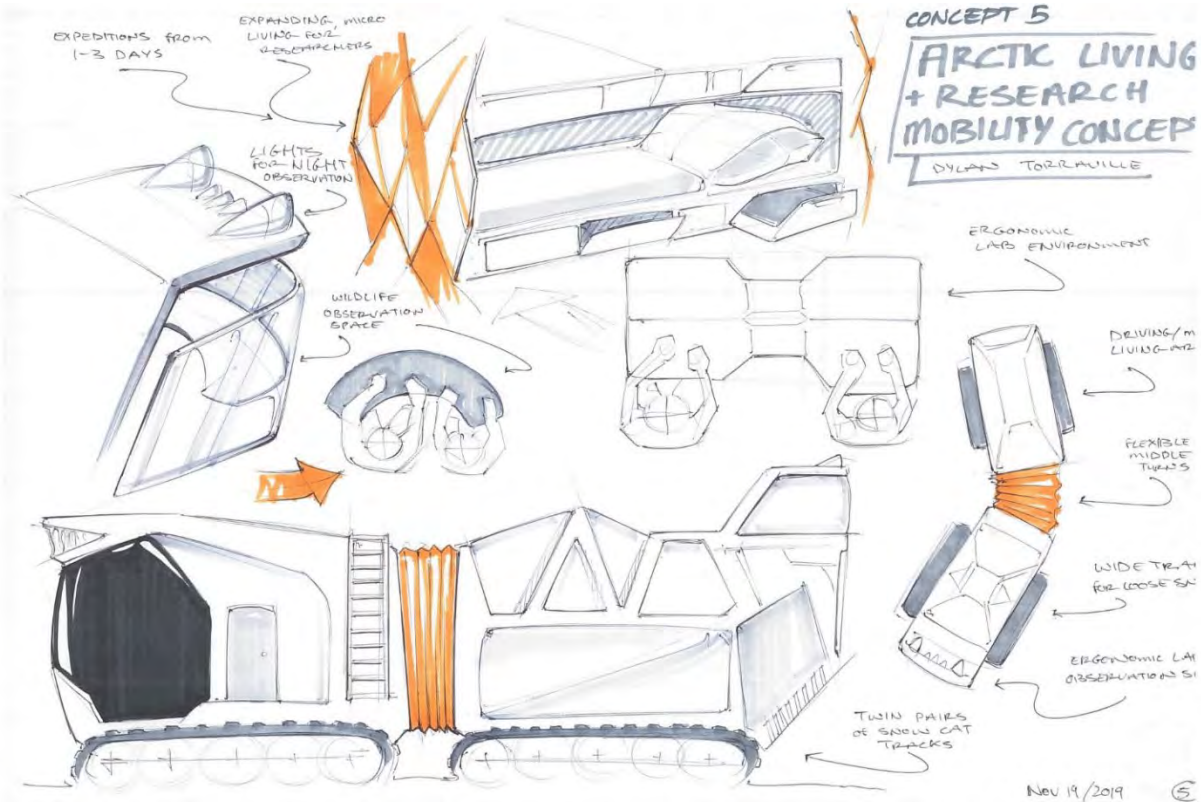


Figure 46 - Concept 1 - Direction 5

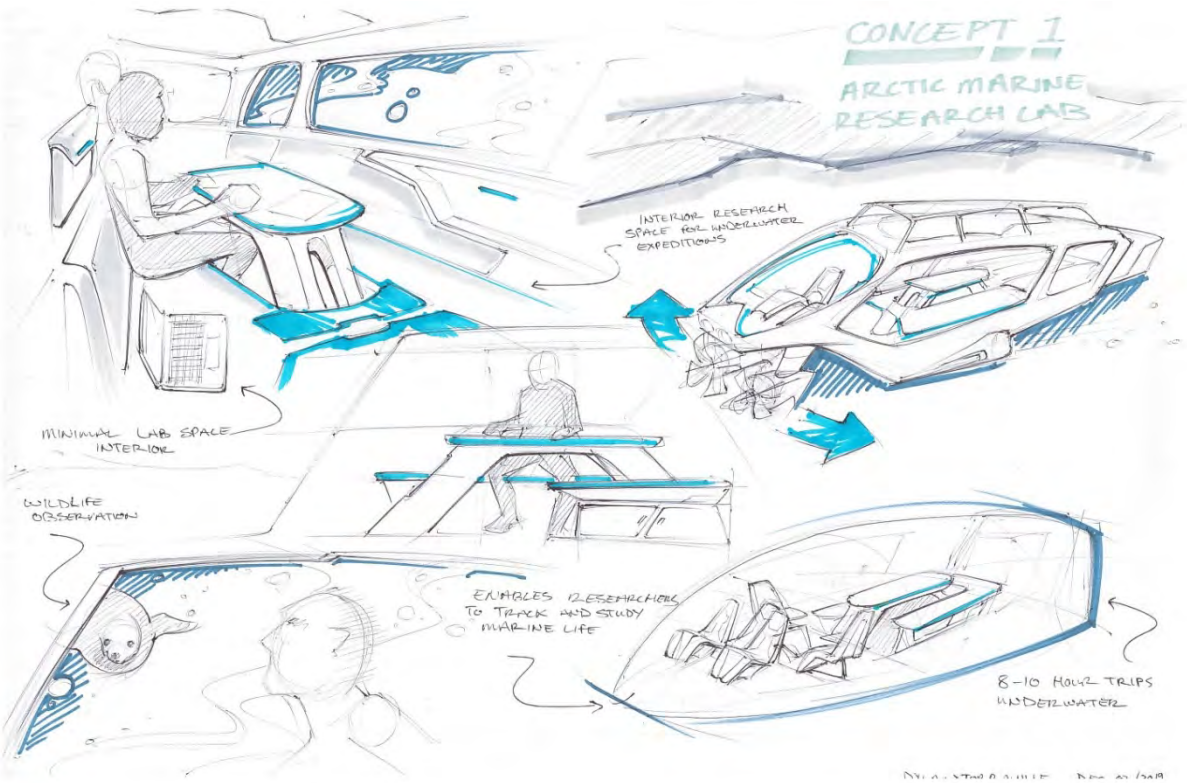


Figure 47 - Concept 2 - Direction 1

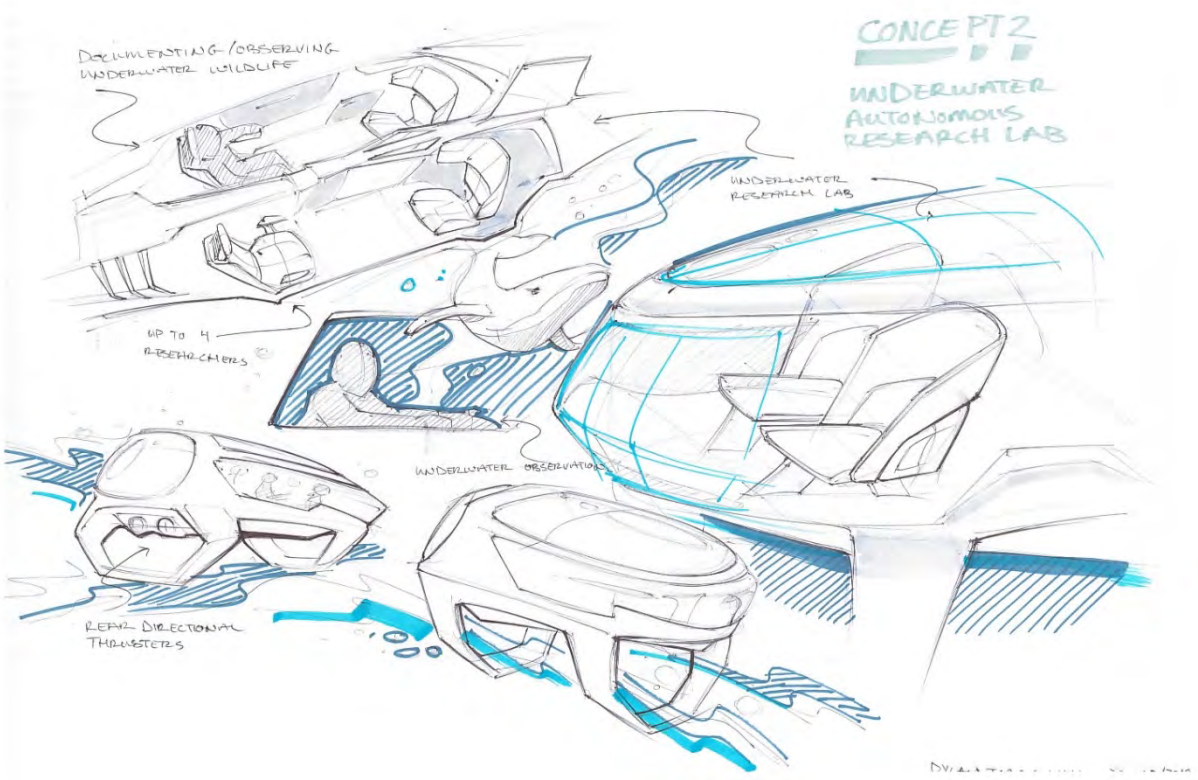


Figure 48 - Concept 2 - Direction 2

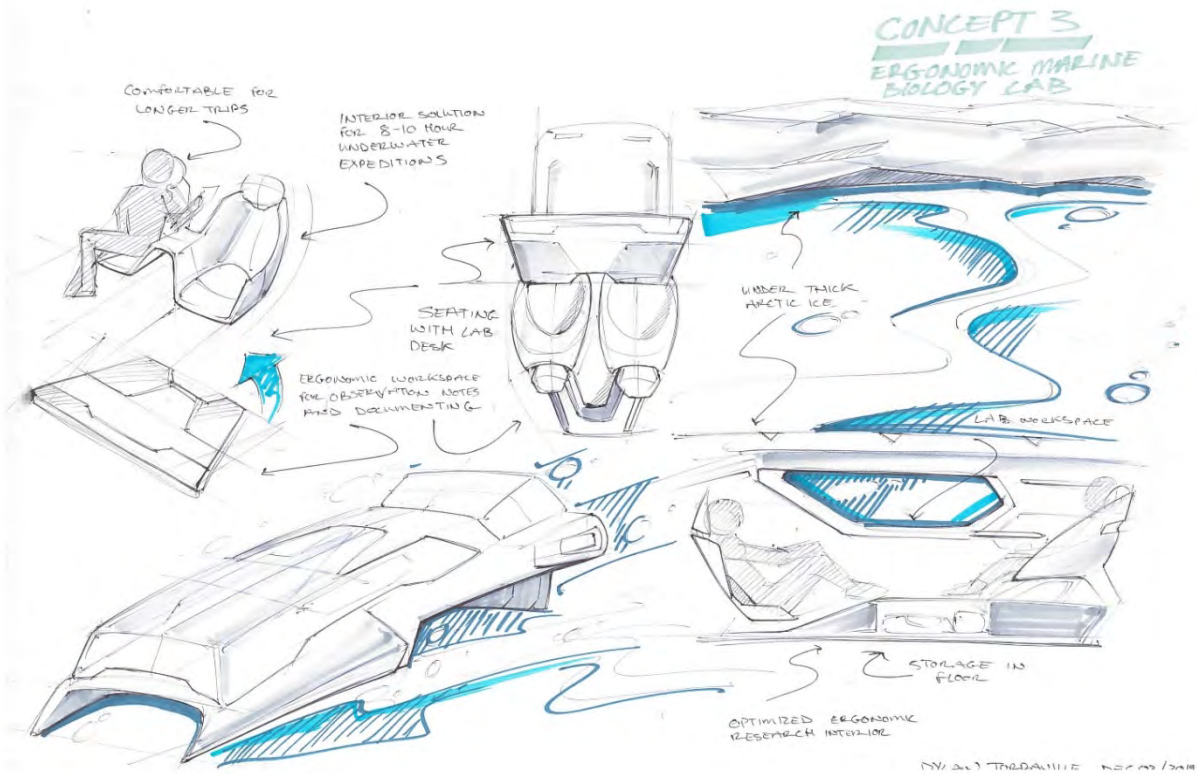


Figure 49 - Concept 2 - Direction 3

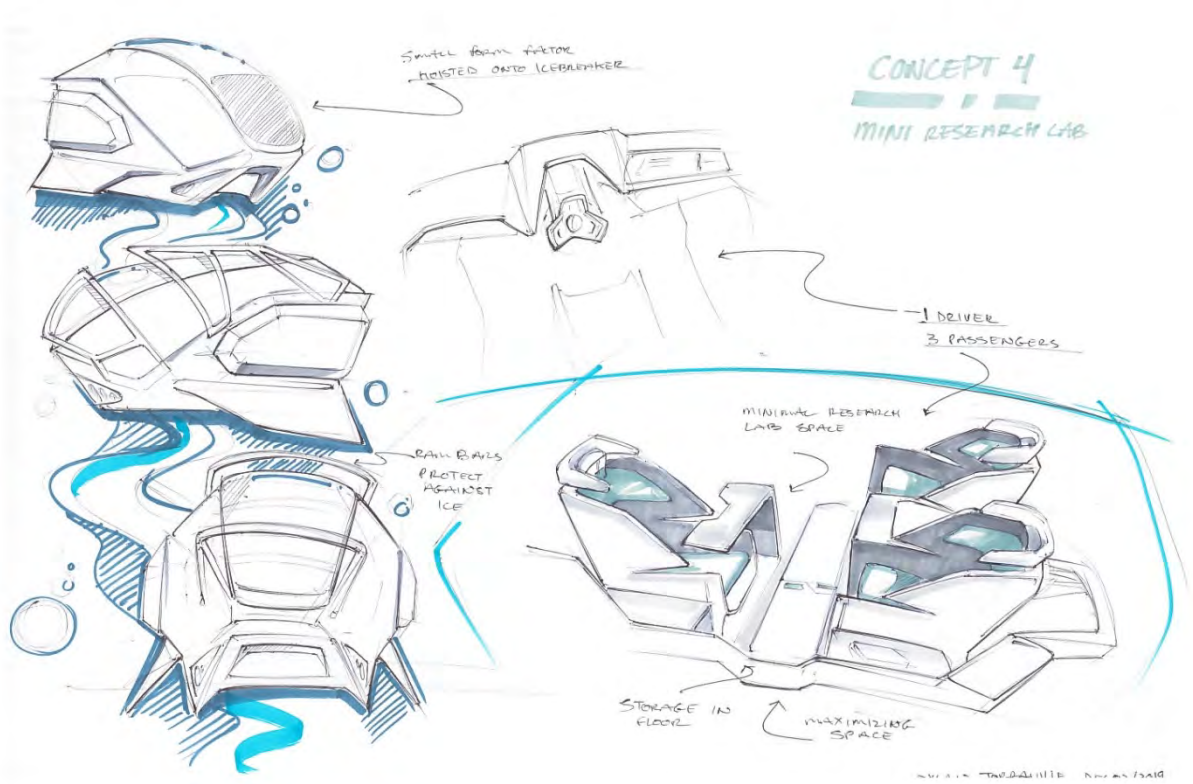


Figure 50 - Concept 2 - Direction 4

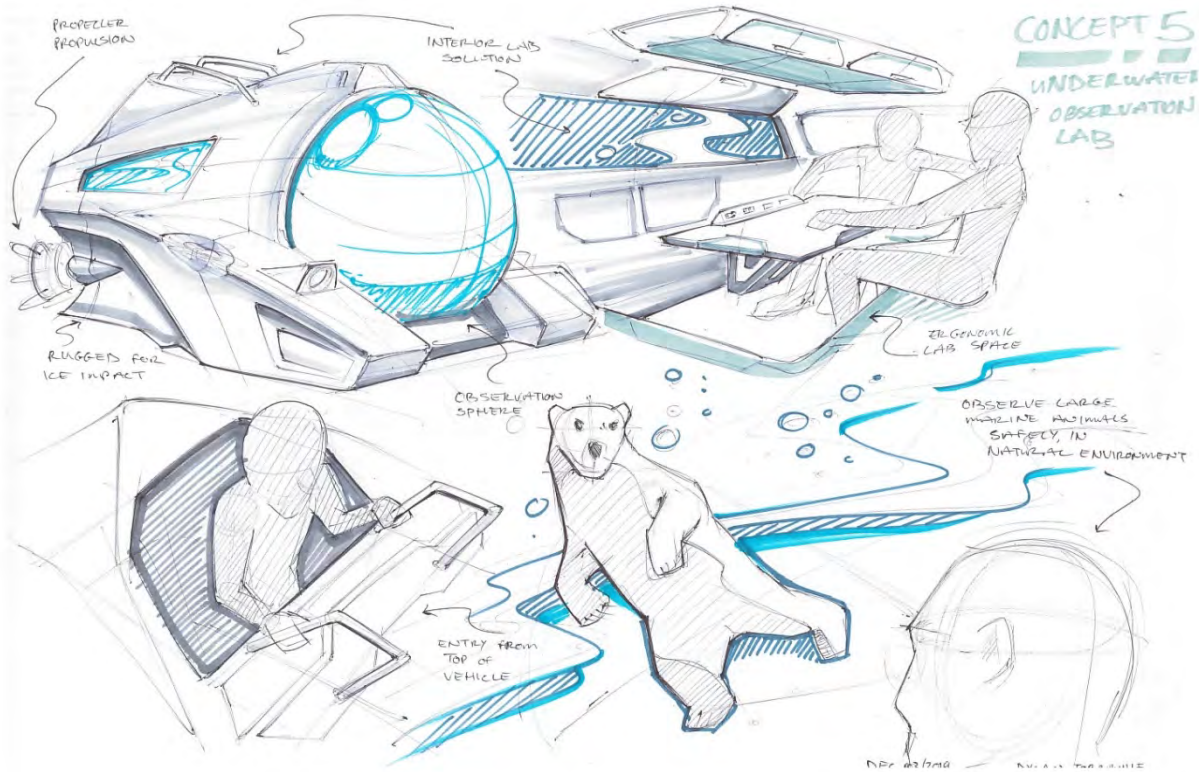


Figure 51 - Concept 2 - Direction 5

4.3 CONCEPT REFINEMENT

Concept refinement was done in a simple, 9”x12” sketch book, culminating over two dozen pages of detail work, loose sketches, refined perspective views and side profile exploration. This is a necessary step in the design phase, refining the concept. Refining the concept was a result of combining aesthetic and functional qualities from both different concept directions as seen in 4.2.

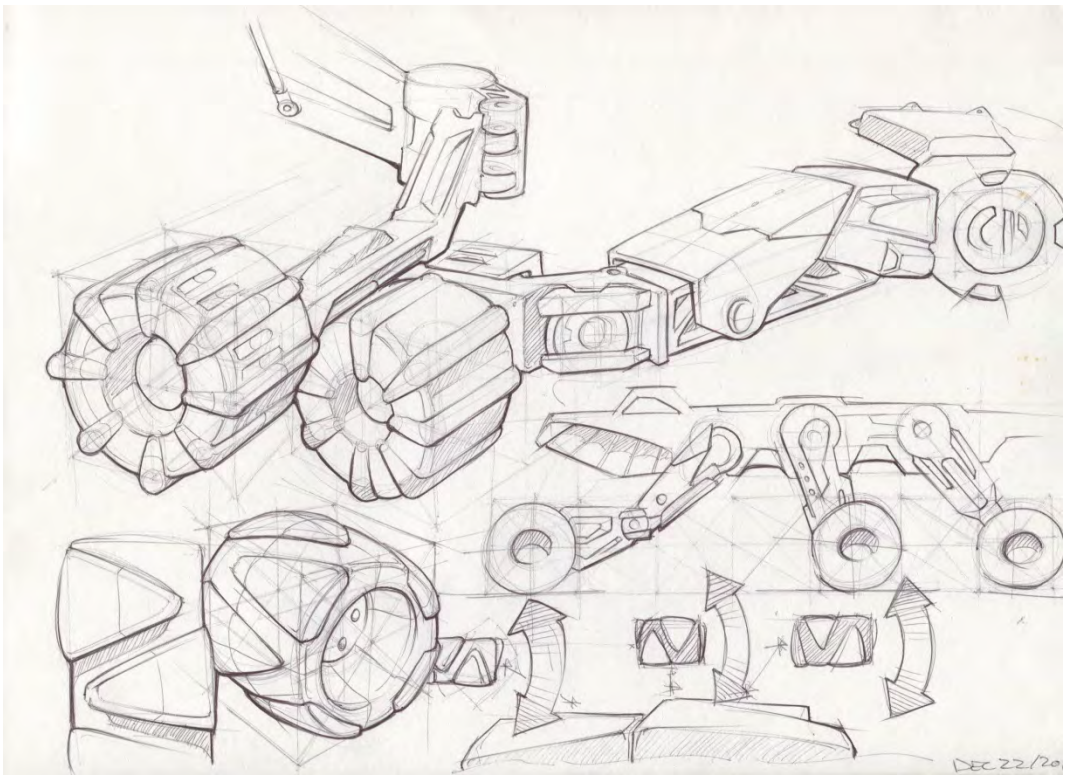


Figure 52 - Concept Refinement Sketches - Wheel Detailing

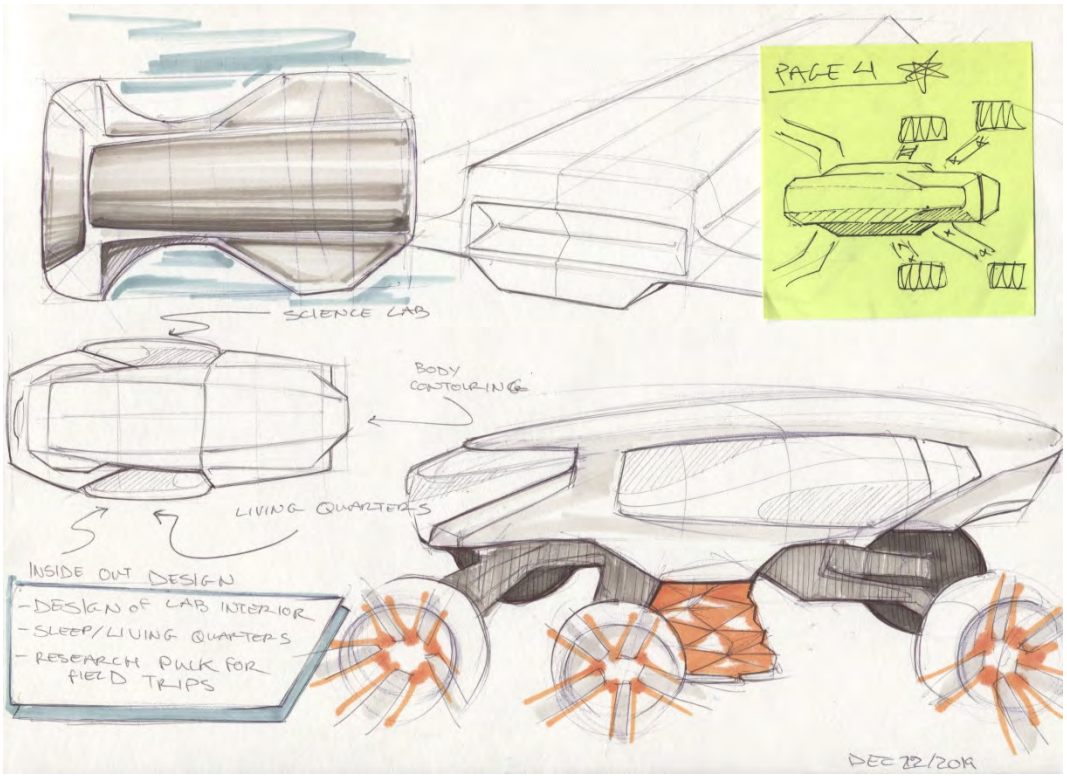


Figure 53 - Concept Refinement Sketches - Contour Detailing

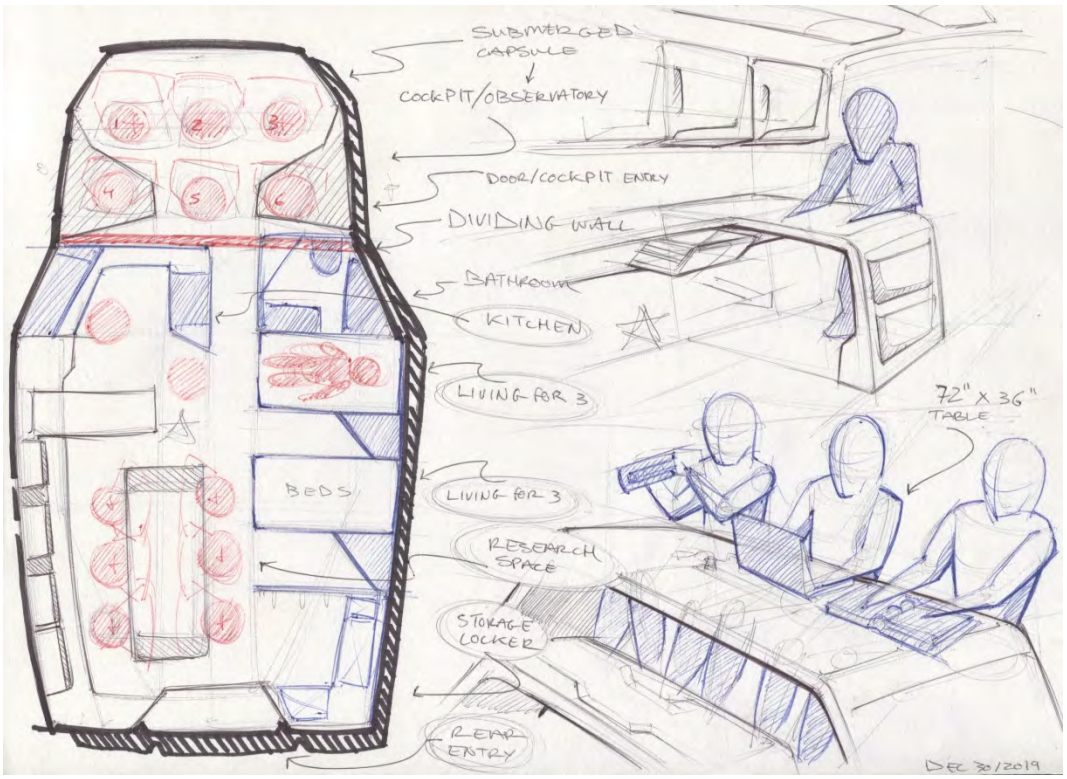


Figure 54 - Concept Refinement Sketches - Layout Detailing

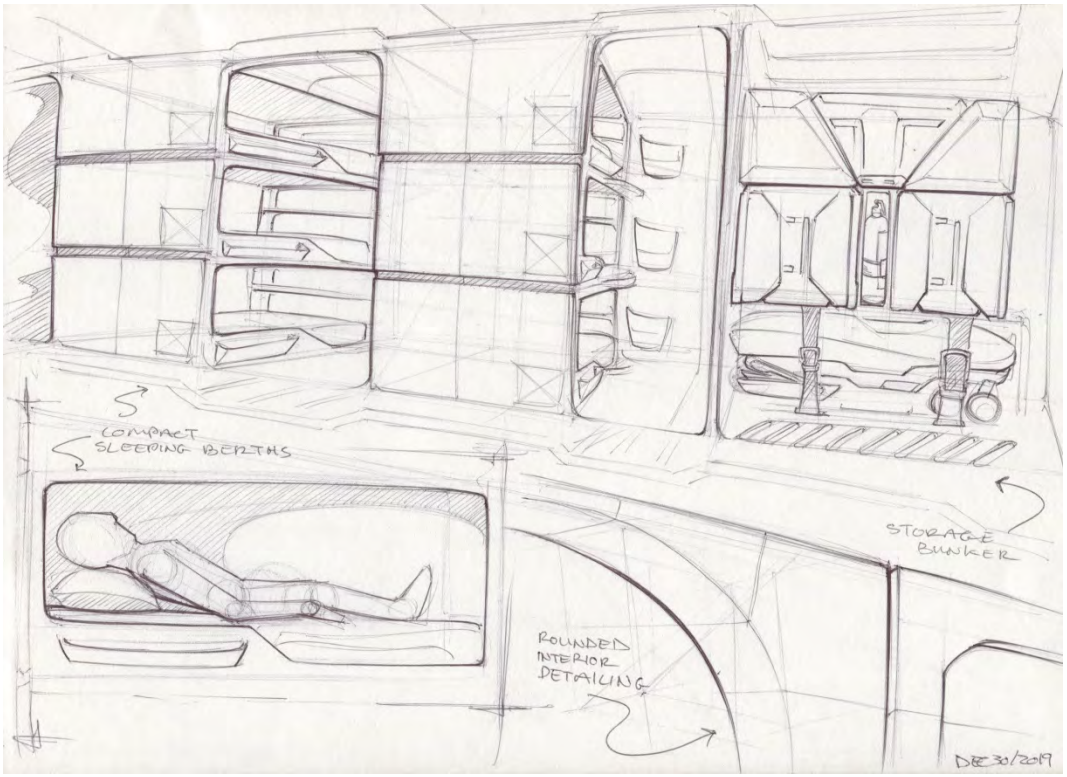


Figure 55 - Concept Refinement Sketches - Living Space Detailing

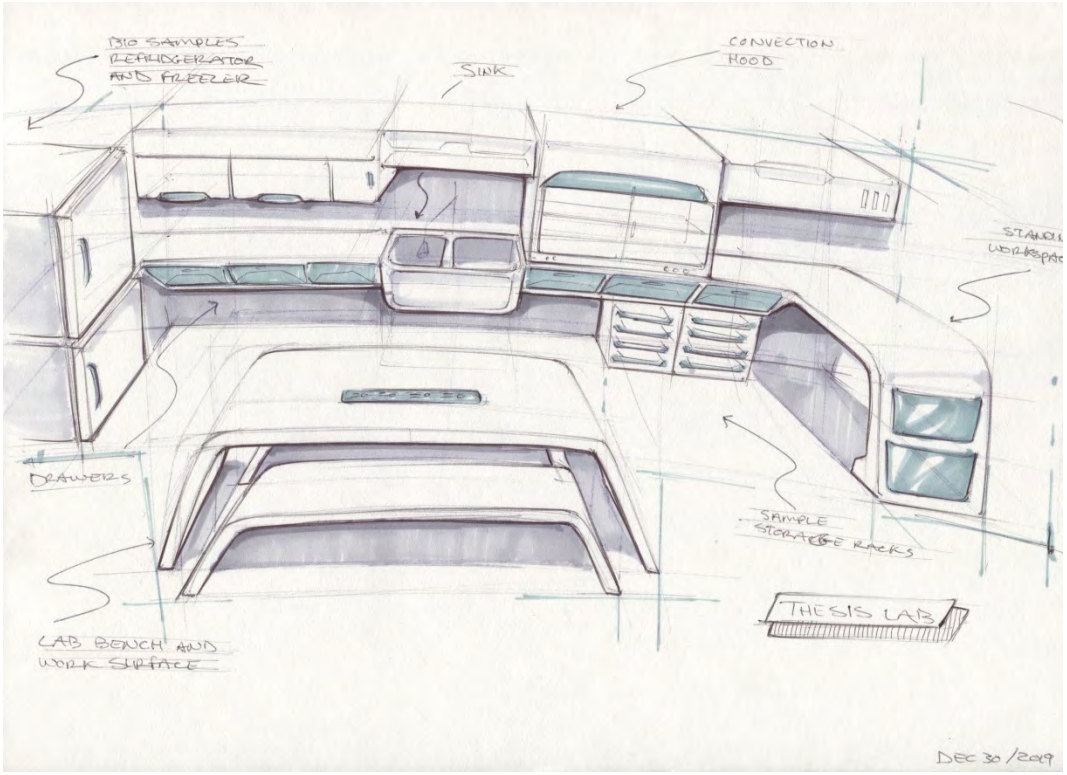


Figure 56 - Concept Refinement Sketches - Lab Detailing

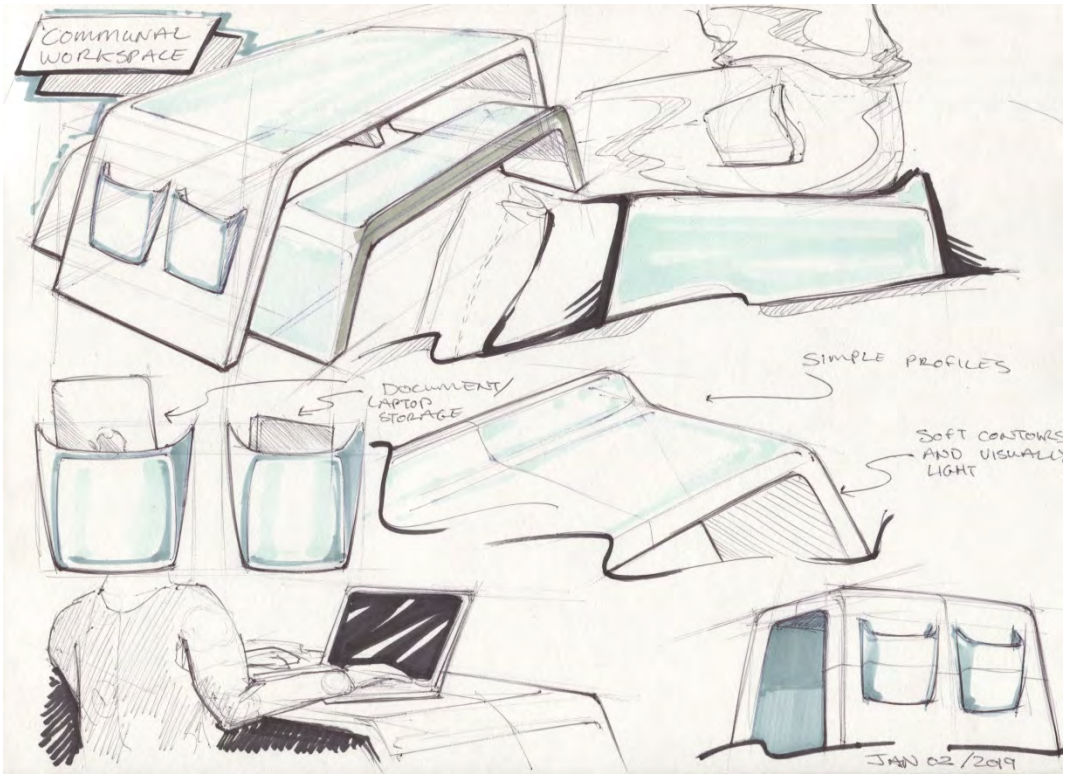


Figure 57 - Concept Refinement Sketches - Lab Desk Detailing

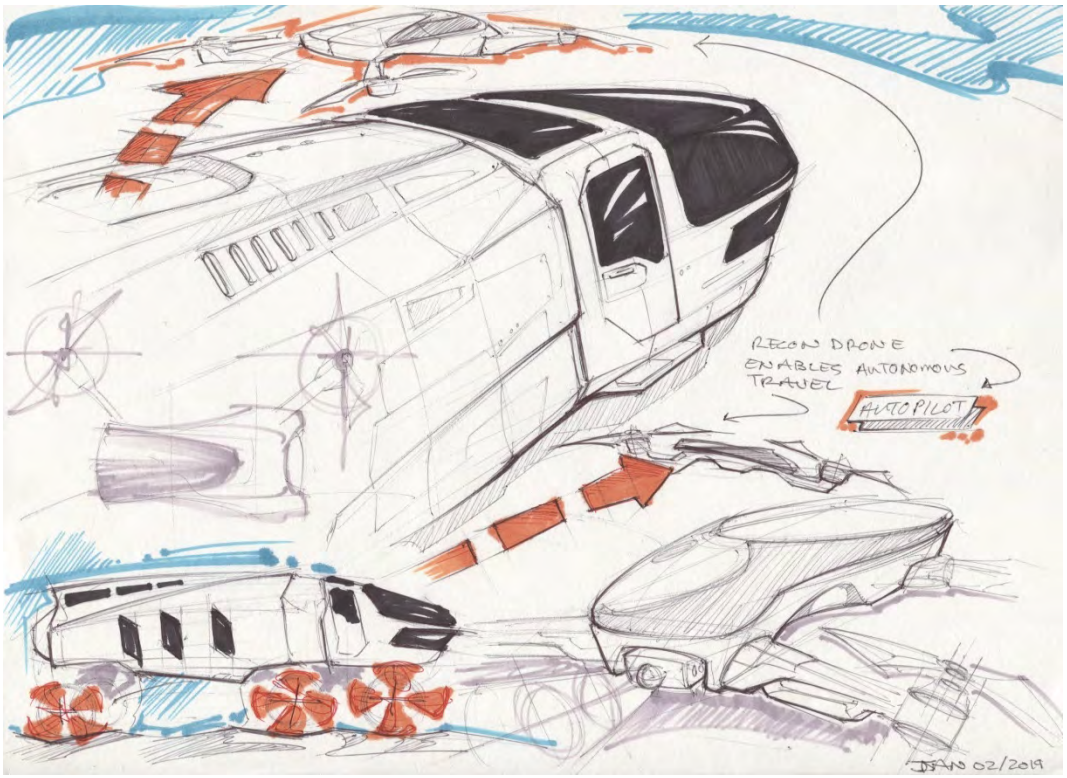


Figure 58 - Concept Refinement Sketches - Exterior Detailing

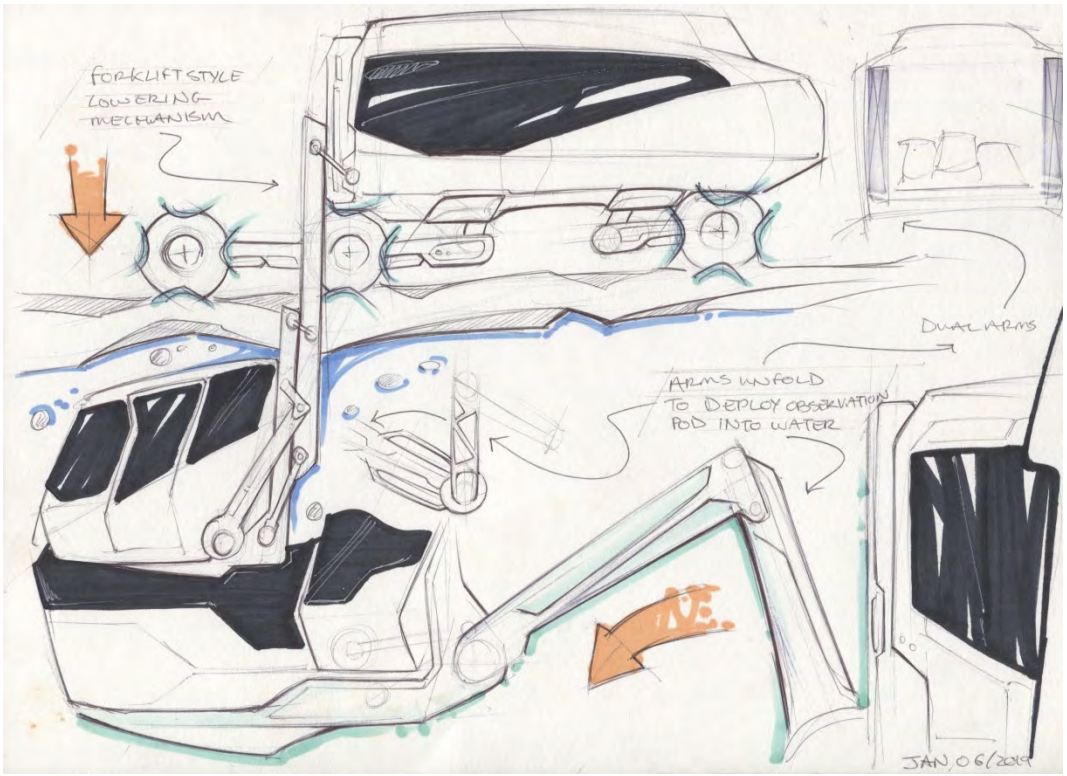


Figure 59 - Concept Refinement Sketches - Lowering Pod Detailing

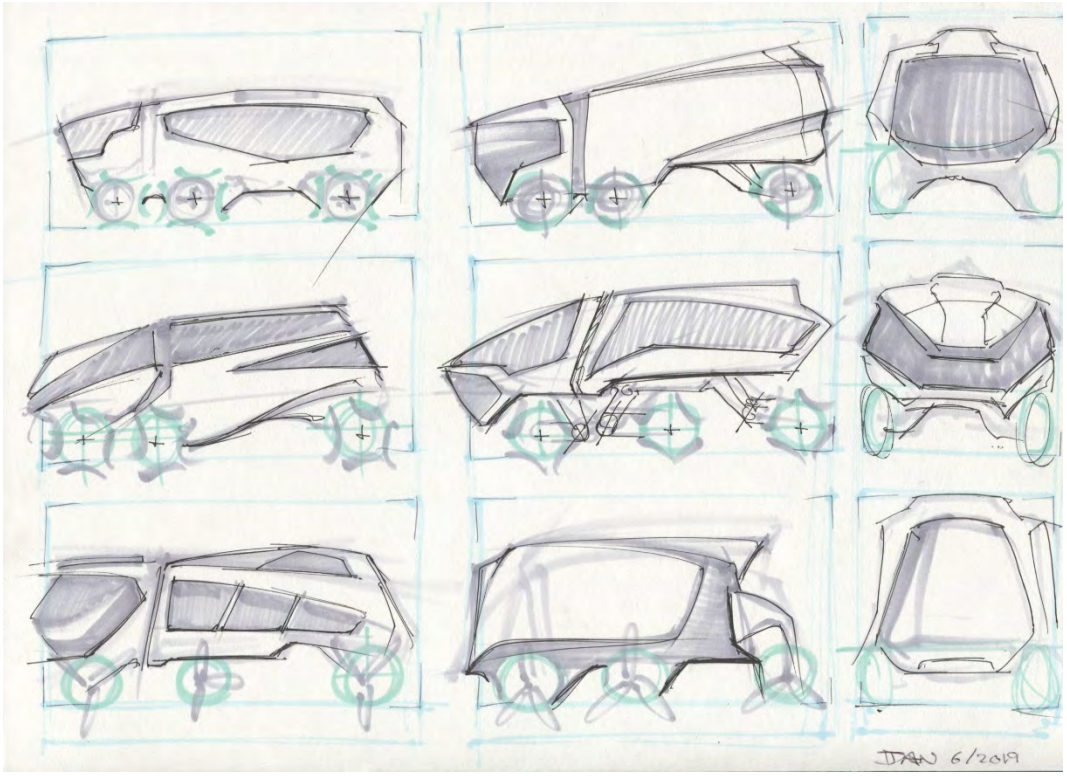


Figure 60 - Concept Refinement Sketches - Exterior Styling

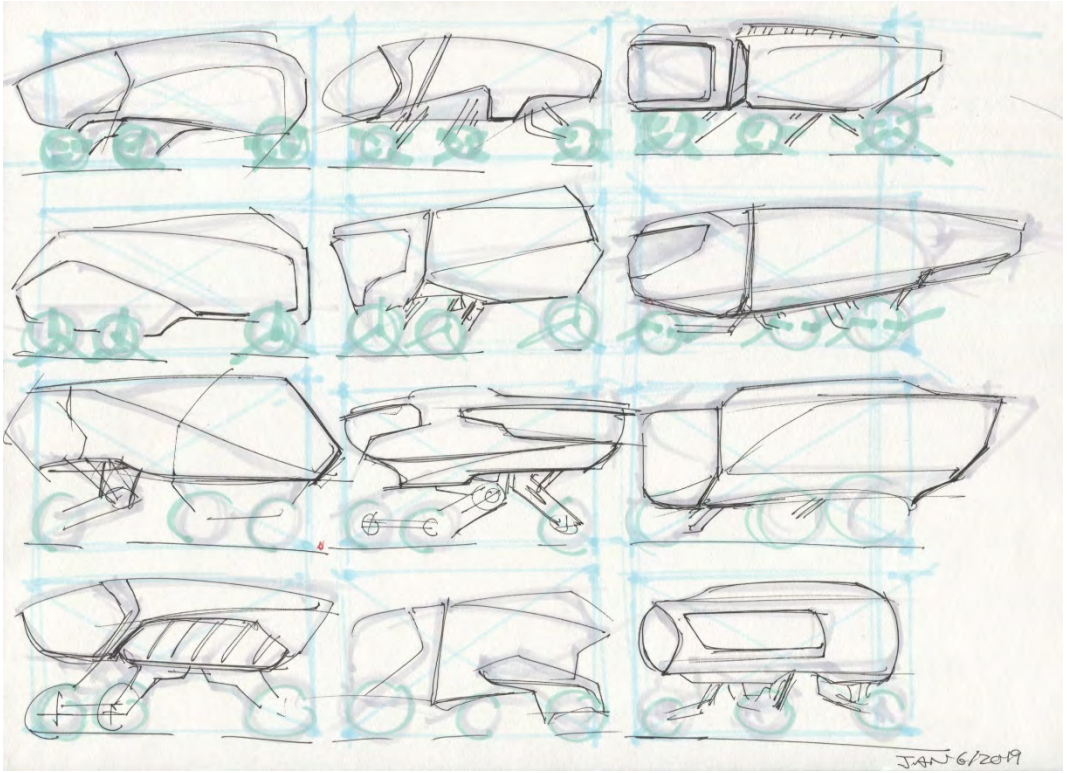


Figure 61 - Concept Refinement Sketches - Exterior Styling 2

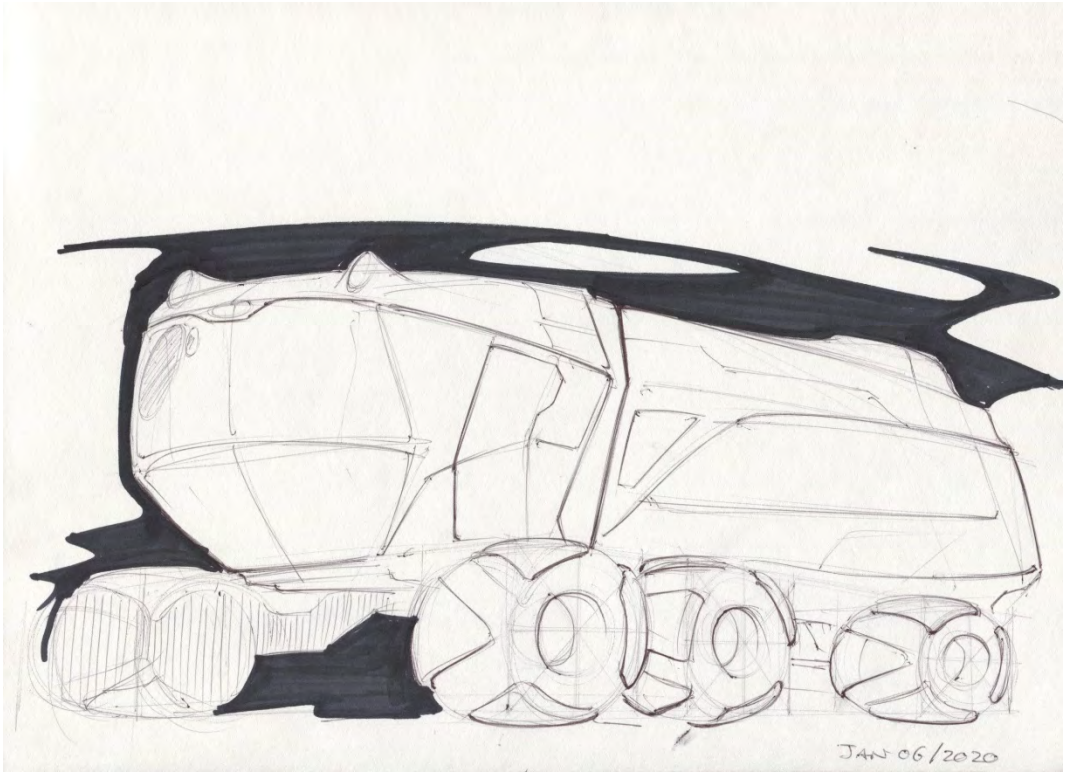


Figure 62 - Concept Refinement Sketches - Exterior Form Details

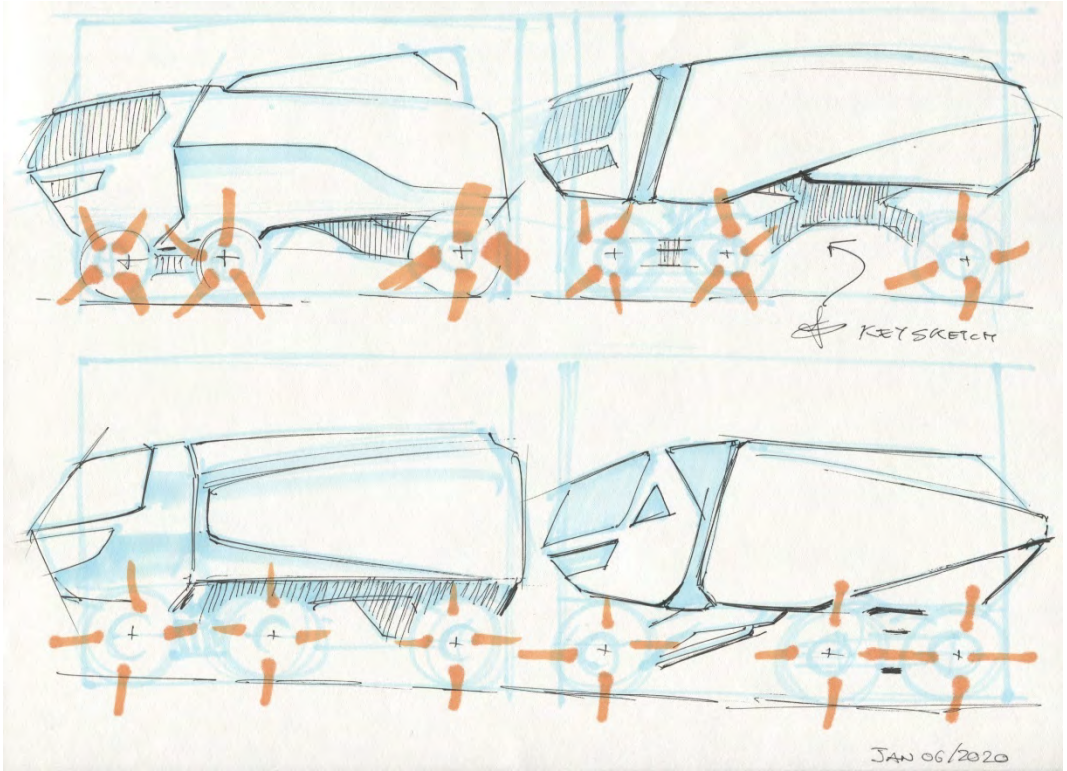


Figure 63 - Concept Refinement Sketches - Exterior Form Styling

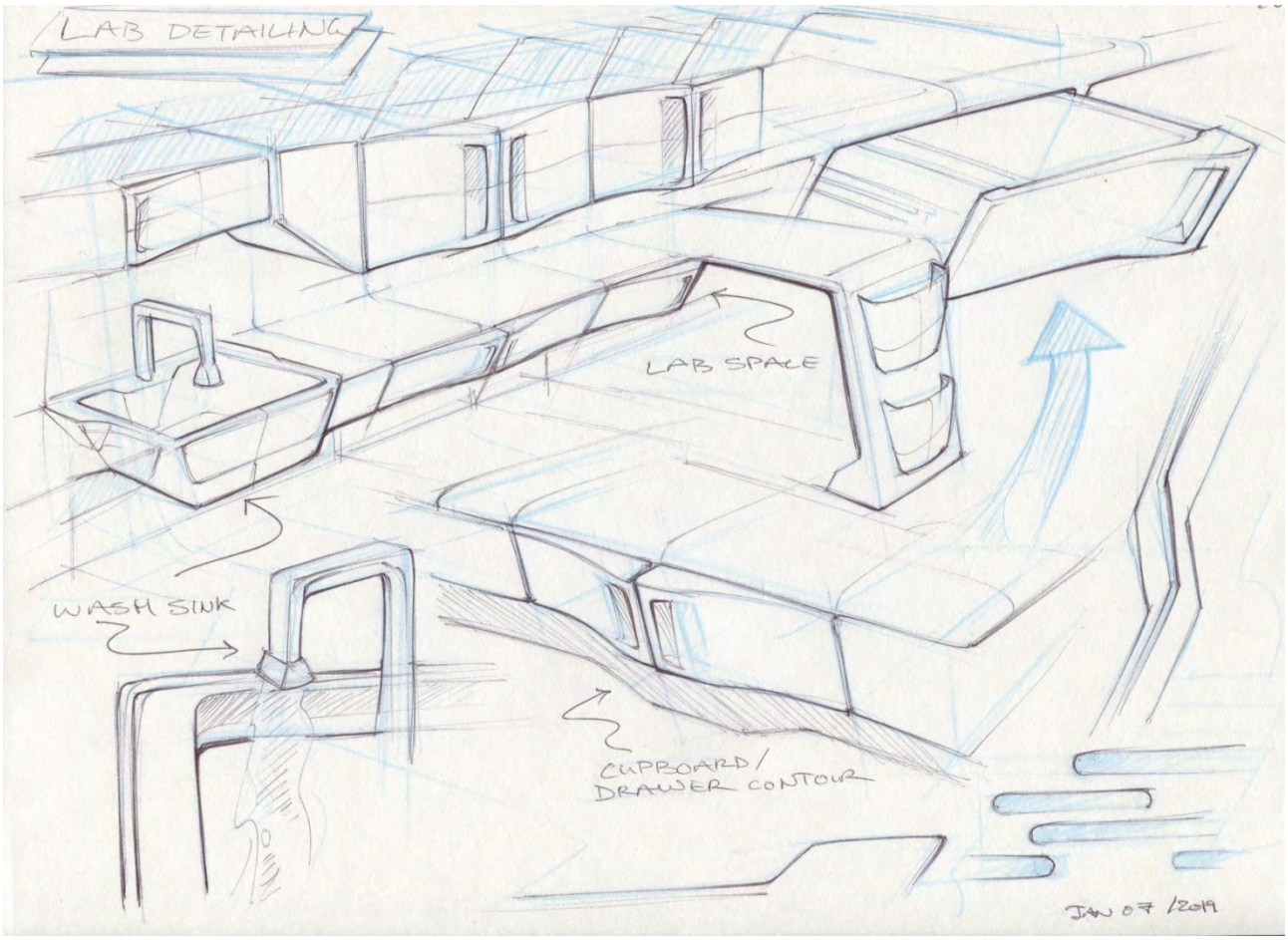


Figure 64 - Concept Refinement Sketches - Lab Desk and Bench Detailing

4.4 DETAIL RESOLUTION

Detail resolution focuses strongly on taking the final concept and massaging the characteristics which make it unique, ensuring a consistent and unified design. This detailing goes from exterior surface contour lines, to material finishes and even further to the interior of the solution, such as simple styling and part lines on the research desks. Straying from conventional detailing of Arctic vehicles and scientific research motifs was important to create a visual paradigm shift.

The detail resolution phase aided in sorting out more final styling decisions which ensure that the CAD process will be more efficient and organized.

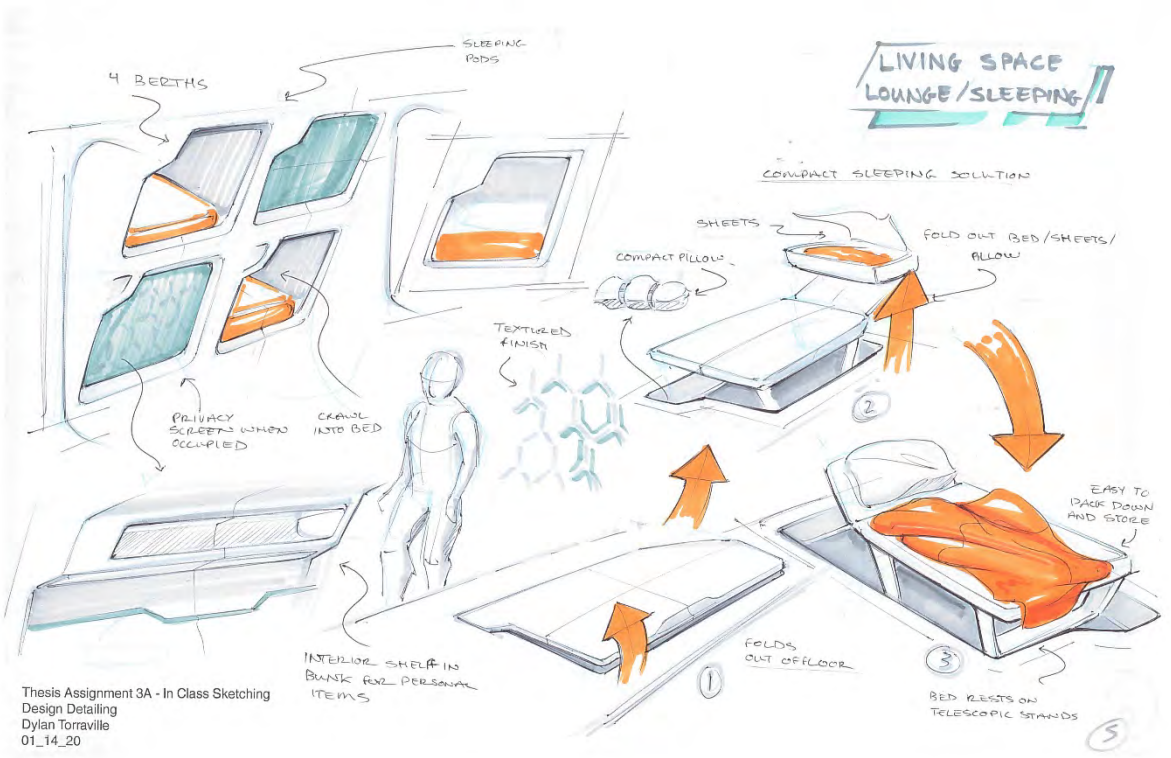


Figure 65 - Detailing Sketches - A

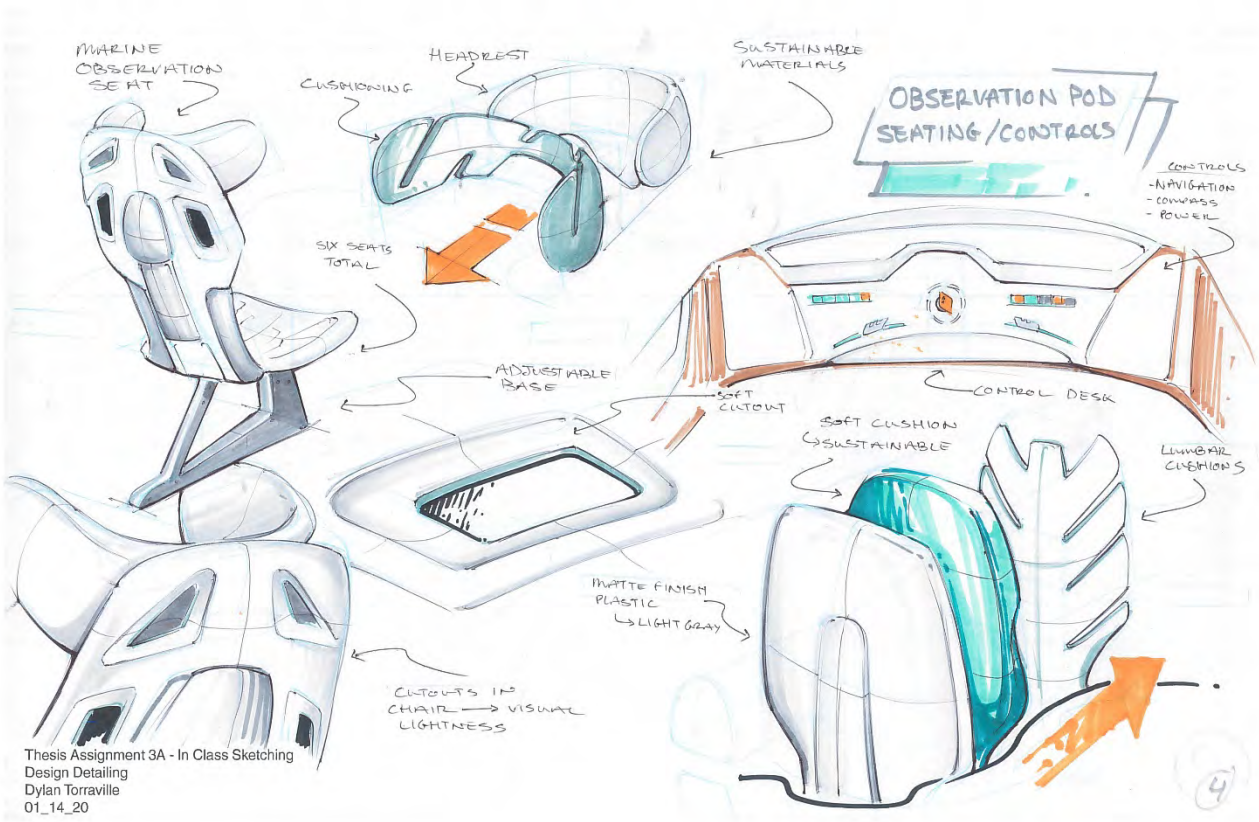


Figure 66 - Detailing Sketches - B

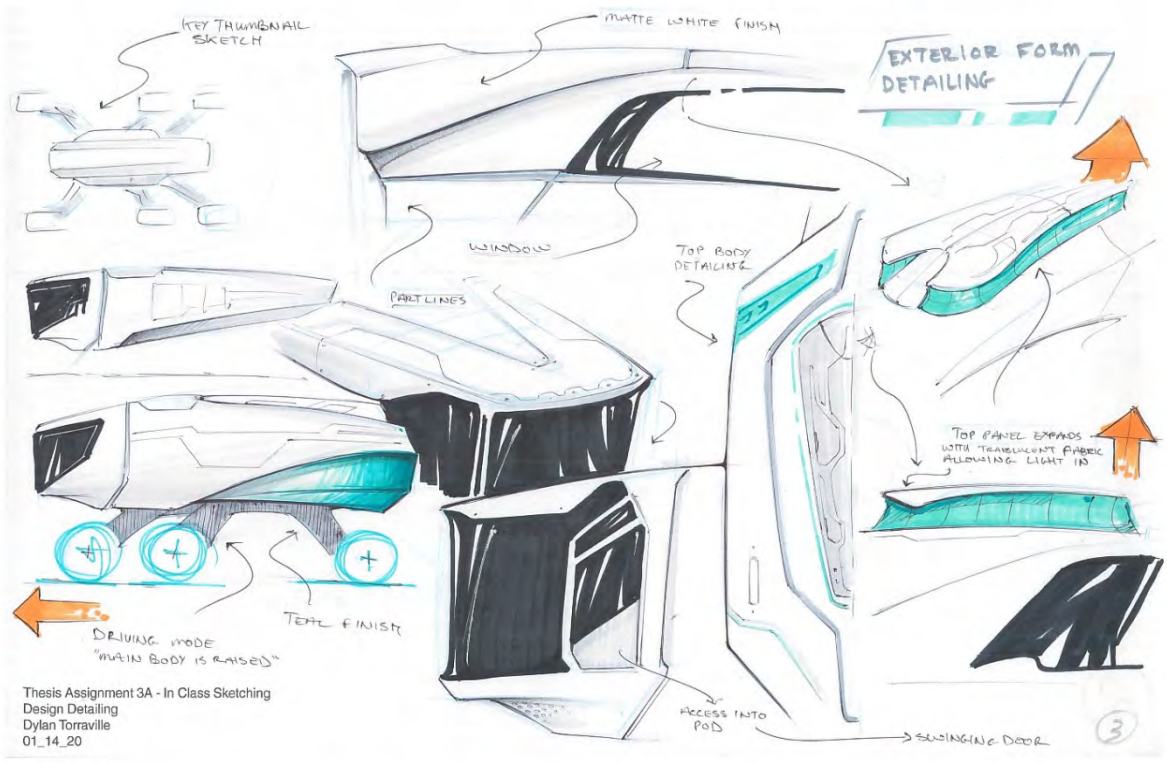


Figure 67 - Detailing Sketches - C

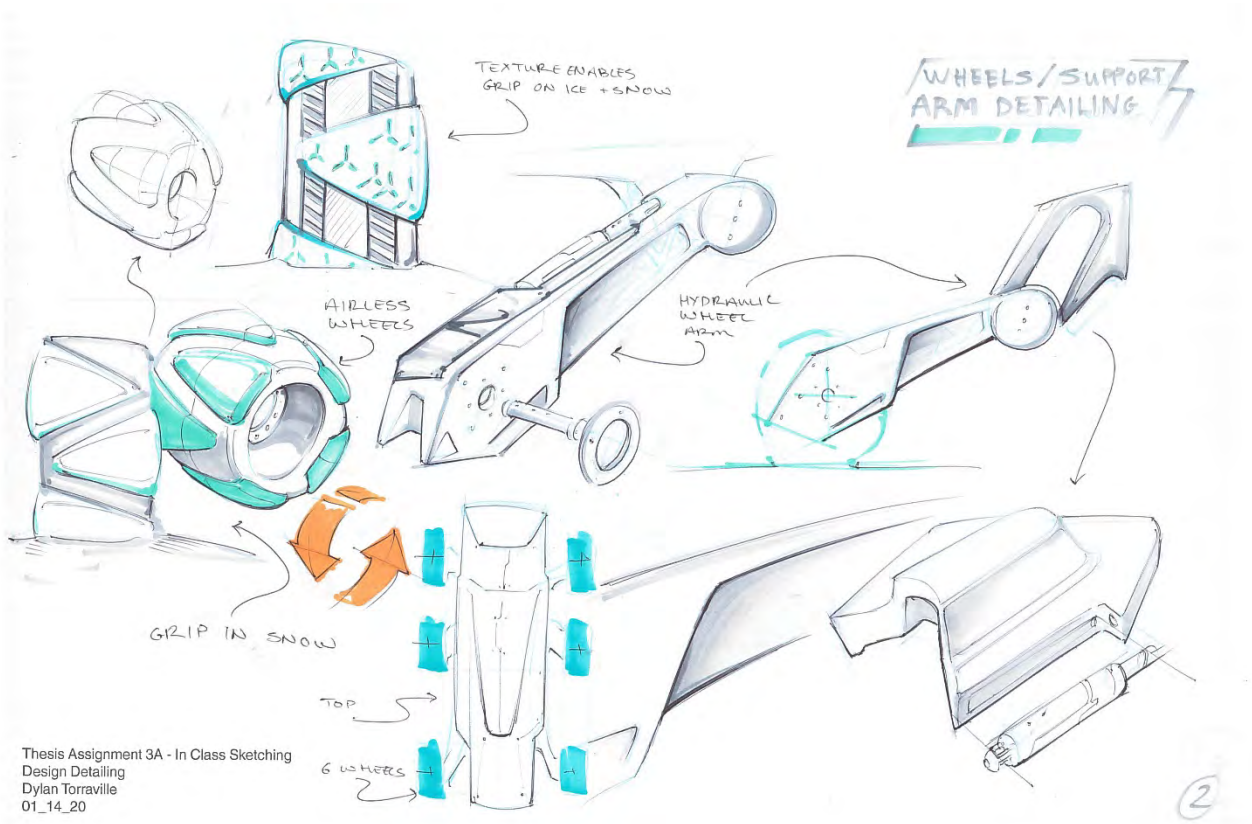


Figure 68 - Detailing Sketches - D

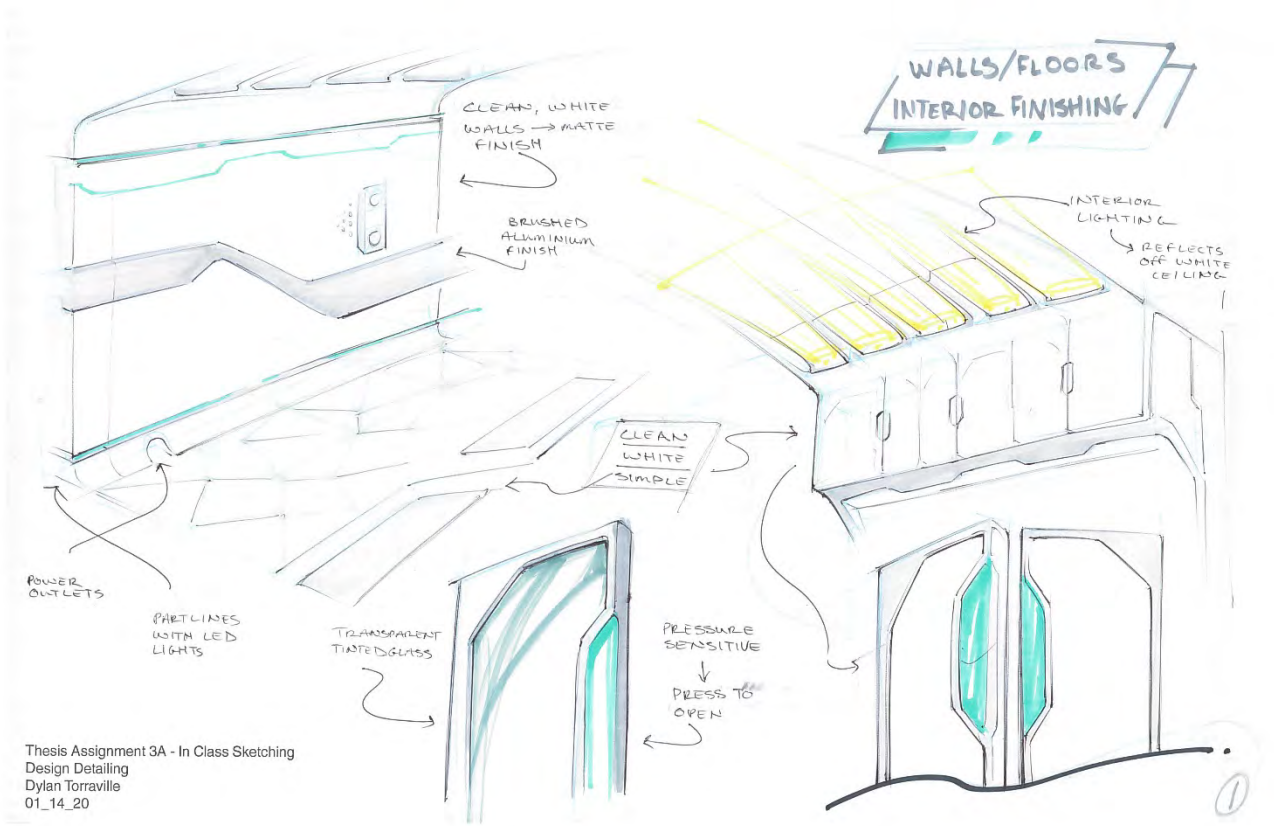


Figure 69 - Detailing Sketches - E

4.5 SKETCH MODELS

4.5.1 FUNCTIONALITY (USER OBSERVATION)

A sketch model was constructed at the anticipated scale of the final model (1:18th scale) to better understand the interior ergonomics and spatial layouts. Foam core, illustration board and Bristol vellum was used to construct the frame of the vehicle and the primary design features. Building a scaled sketch model also highlighted several areas that may pose a challenge when 3D printing as well as for the final concept, resulting in a few minor revisions.

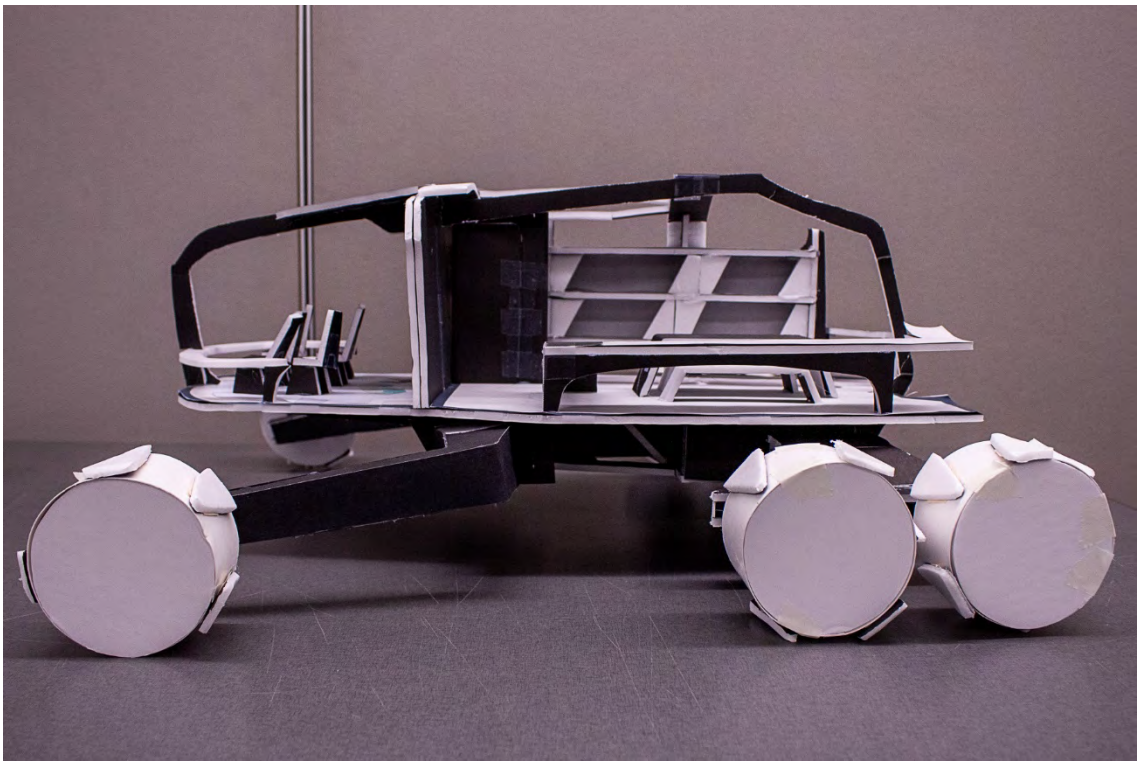


Figure 70 - Sketch Model Side View

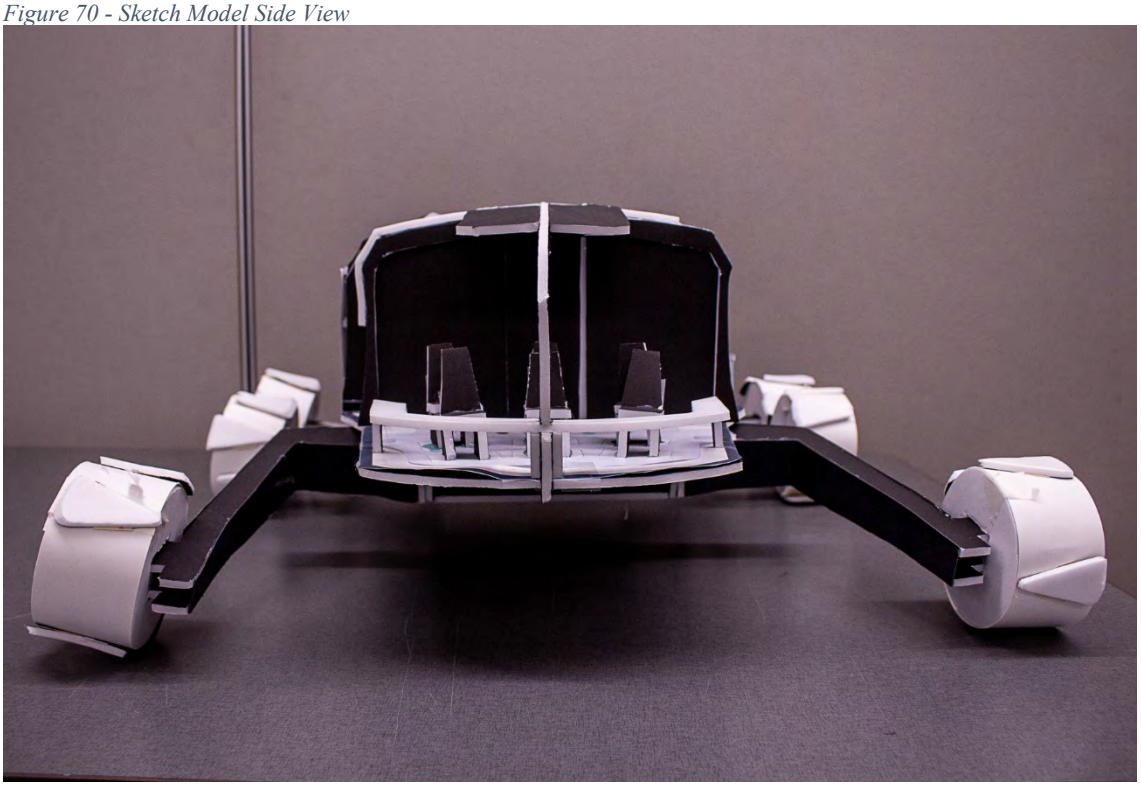


Figure 71 - Sketch Model Front View

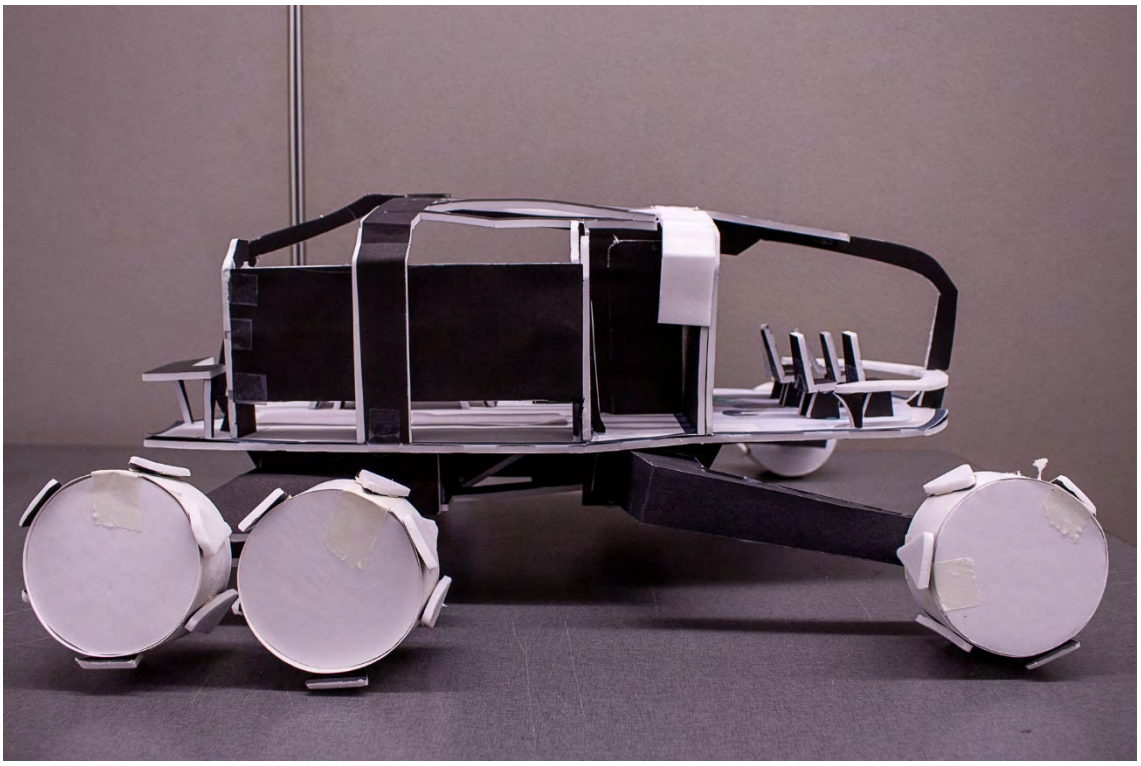


Figure 72 - Sketch Model Side View

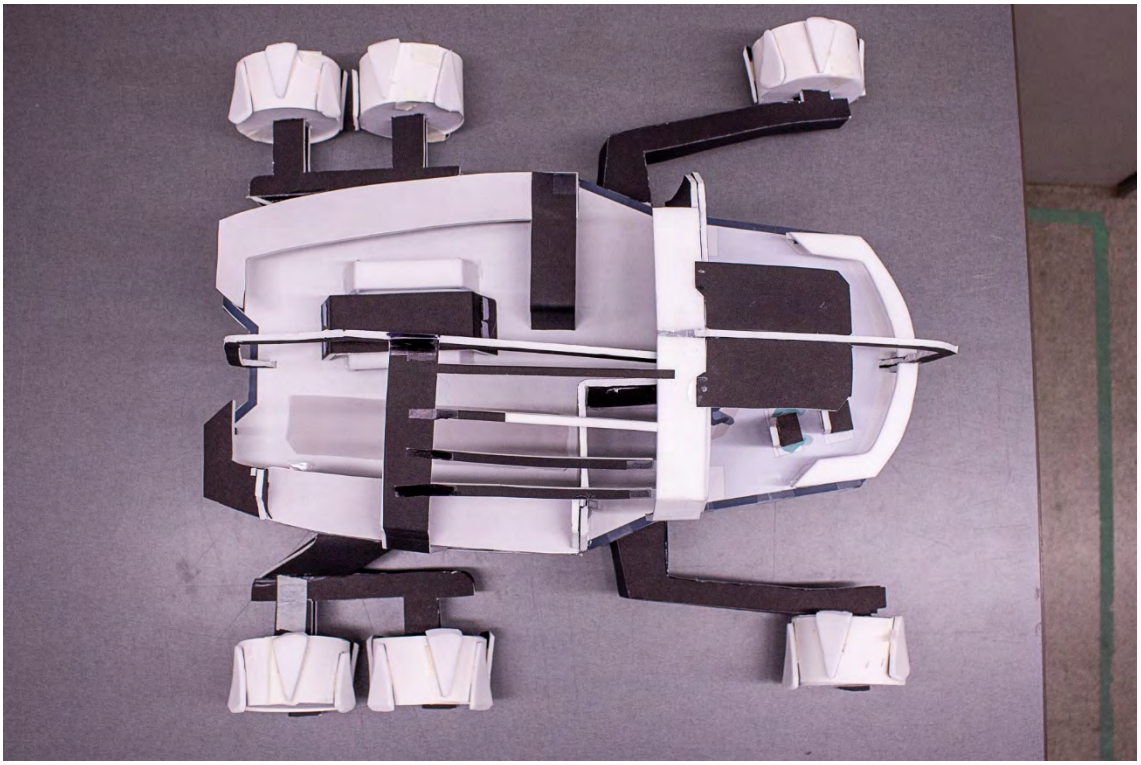


Figure 73 - Sketch Model Top View

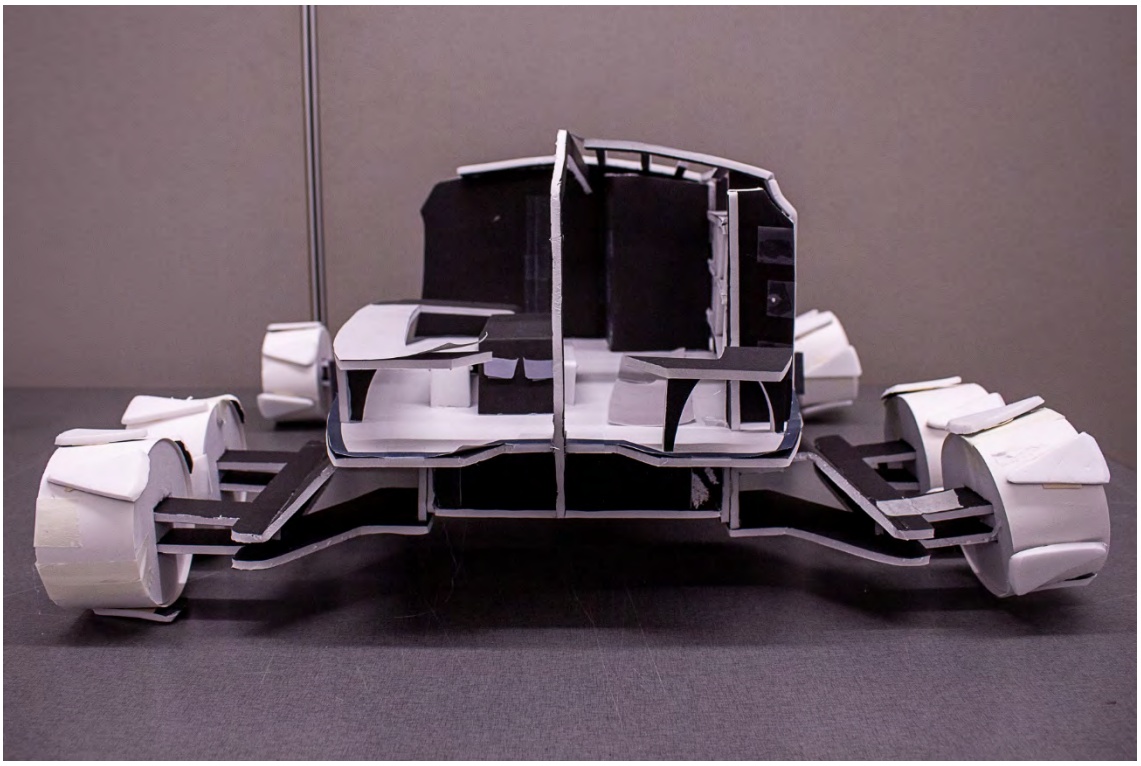


Figure 74 - Sketch Model Rear View

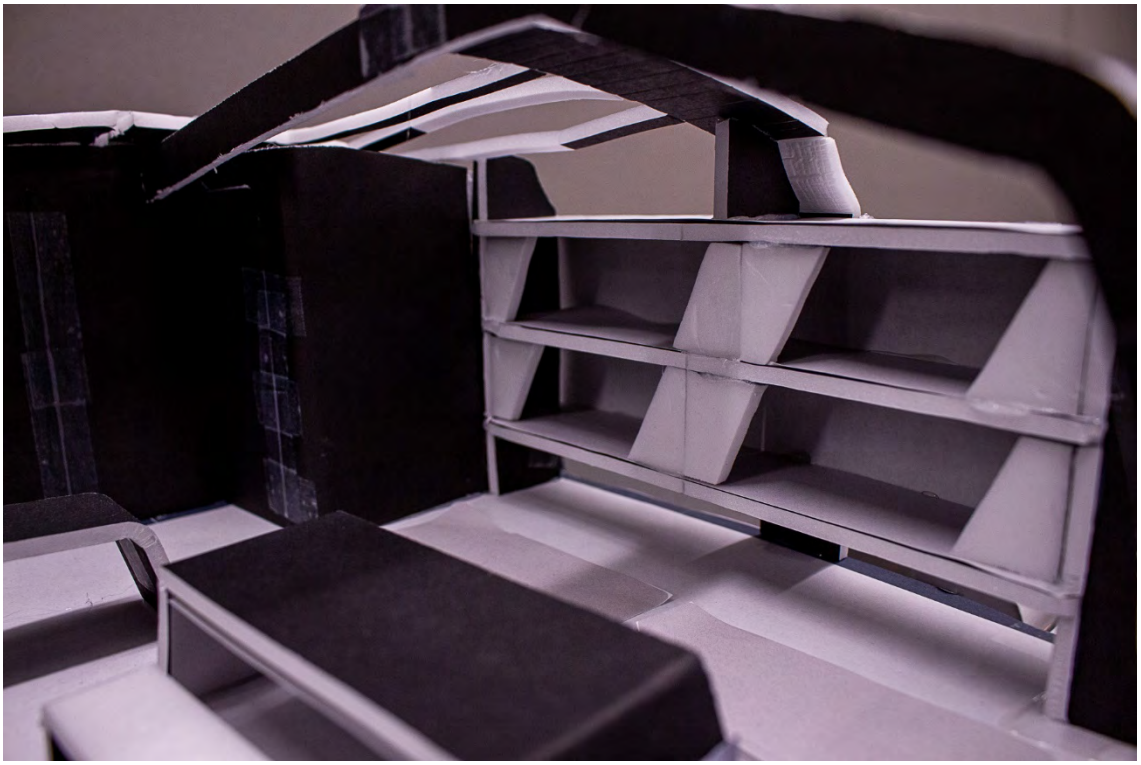


Figure 75 - Sketch Model Sleeping Berths

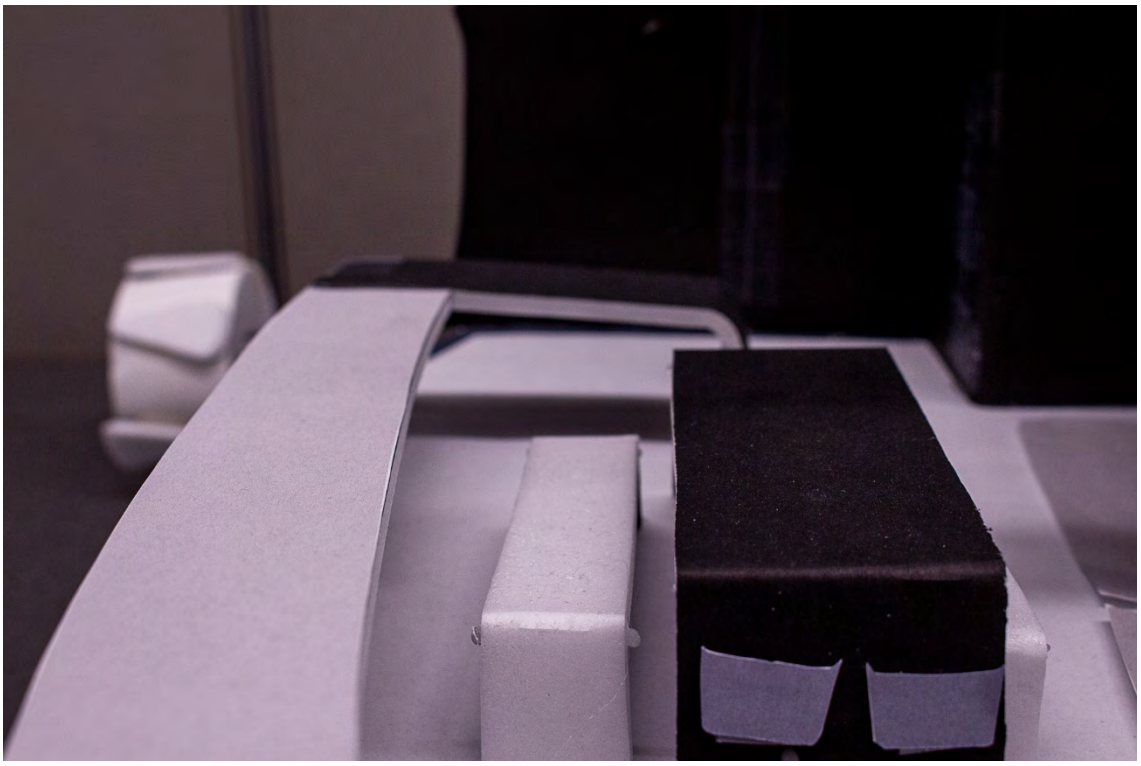


Figure 76 - Sketch Model Work Desk

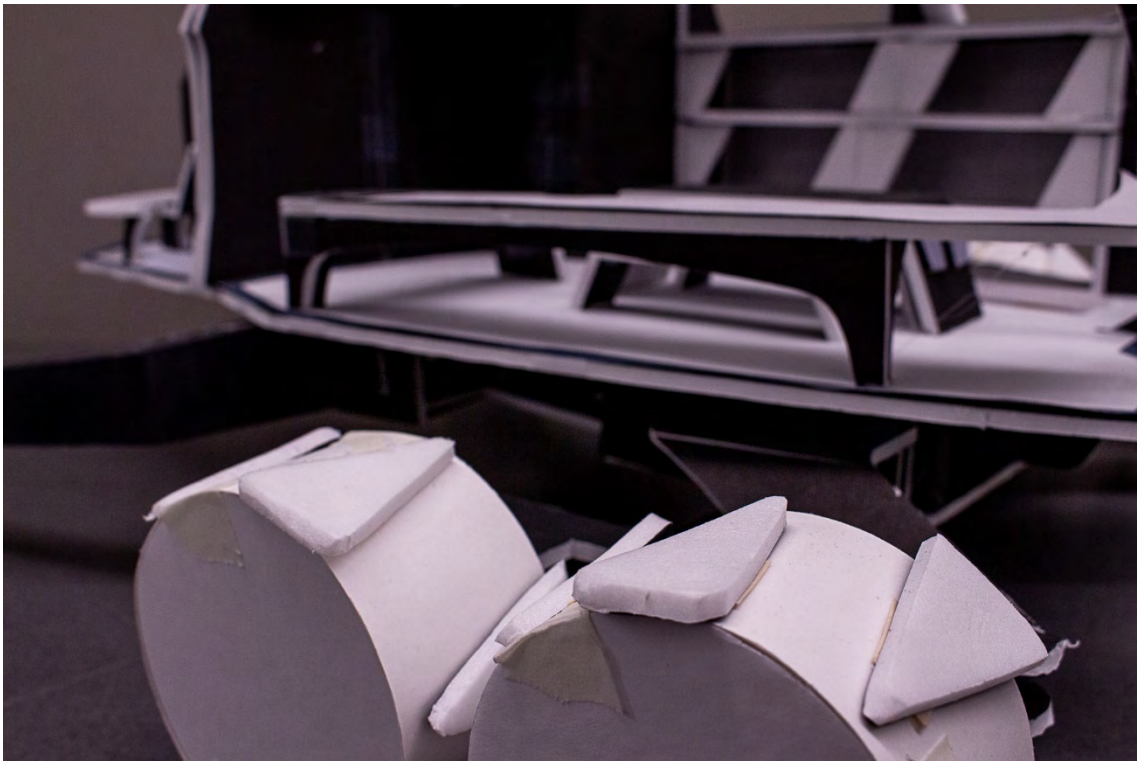


Figure 77 - Sketch Model Wheel Details

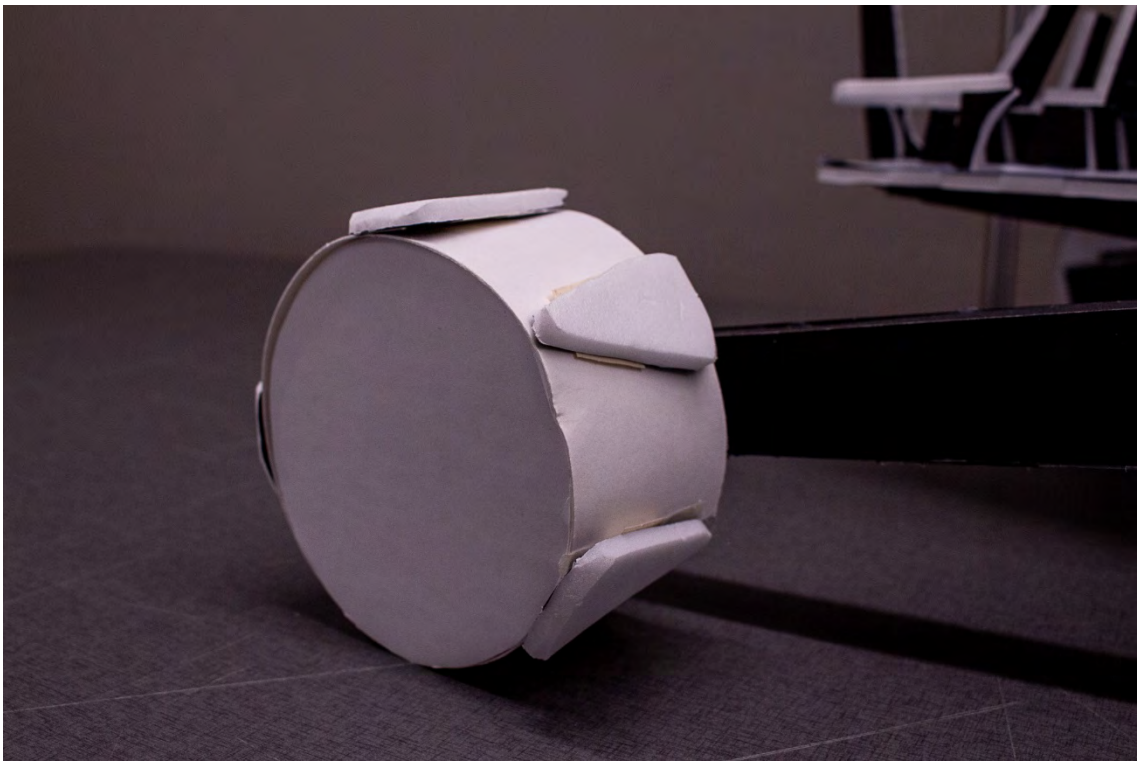


Figure 78 - Sketch Model Wheel Profile

Figure 79 - SKetch Model Observation Pod Side View

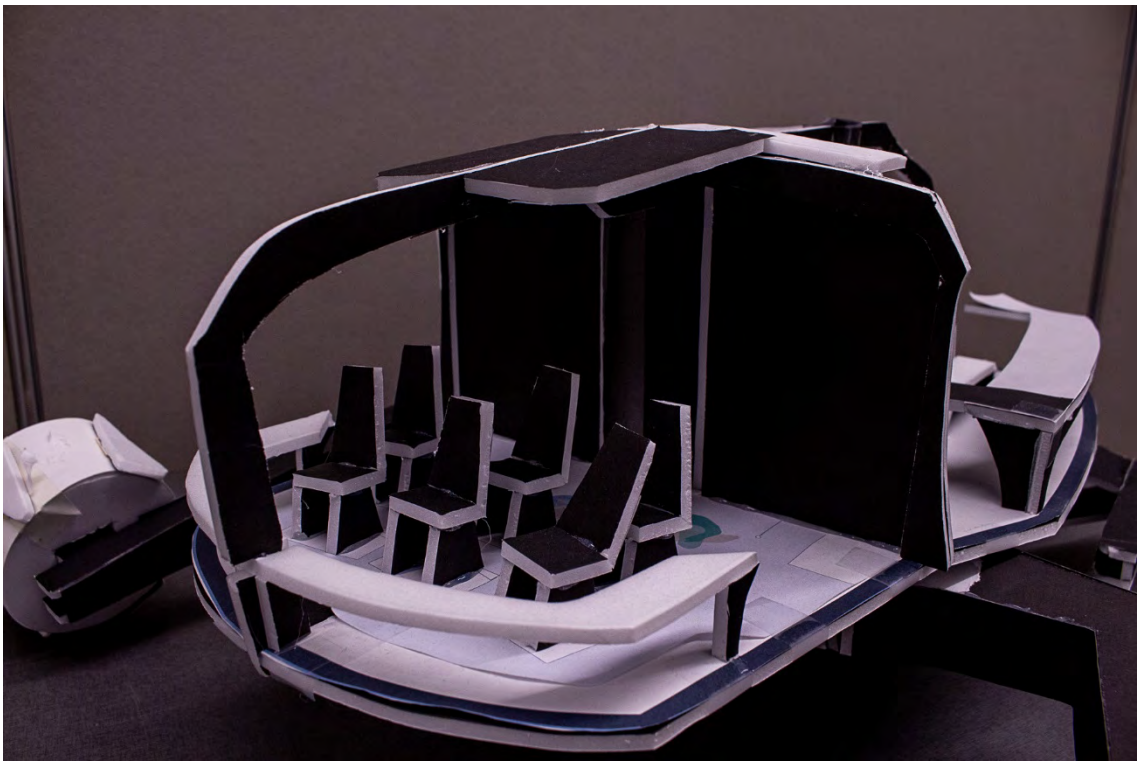


Figure 80 - Sketch Model Observation Pod Front 3/4

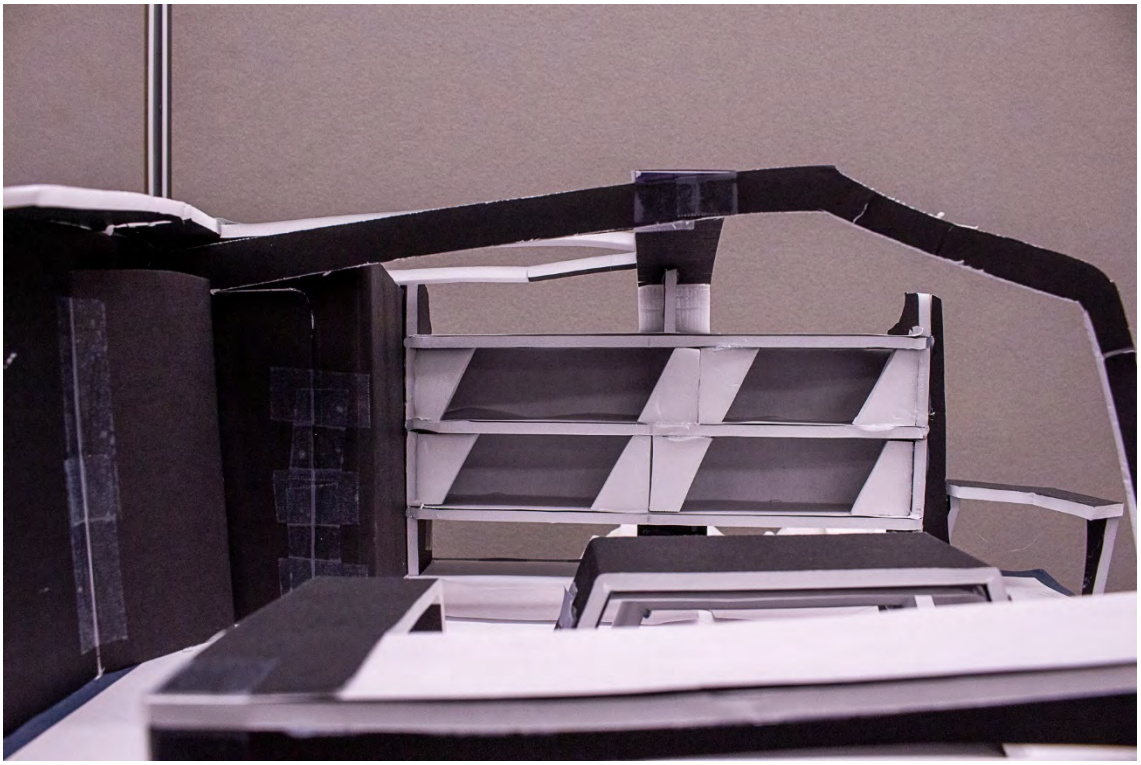


Figure 81 - Sketch Model Interior Shot

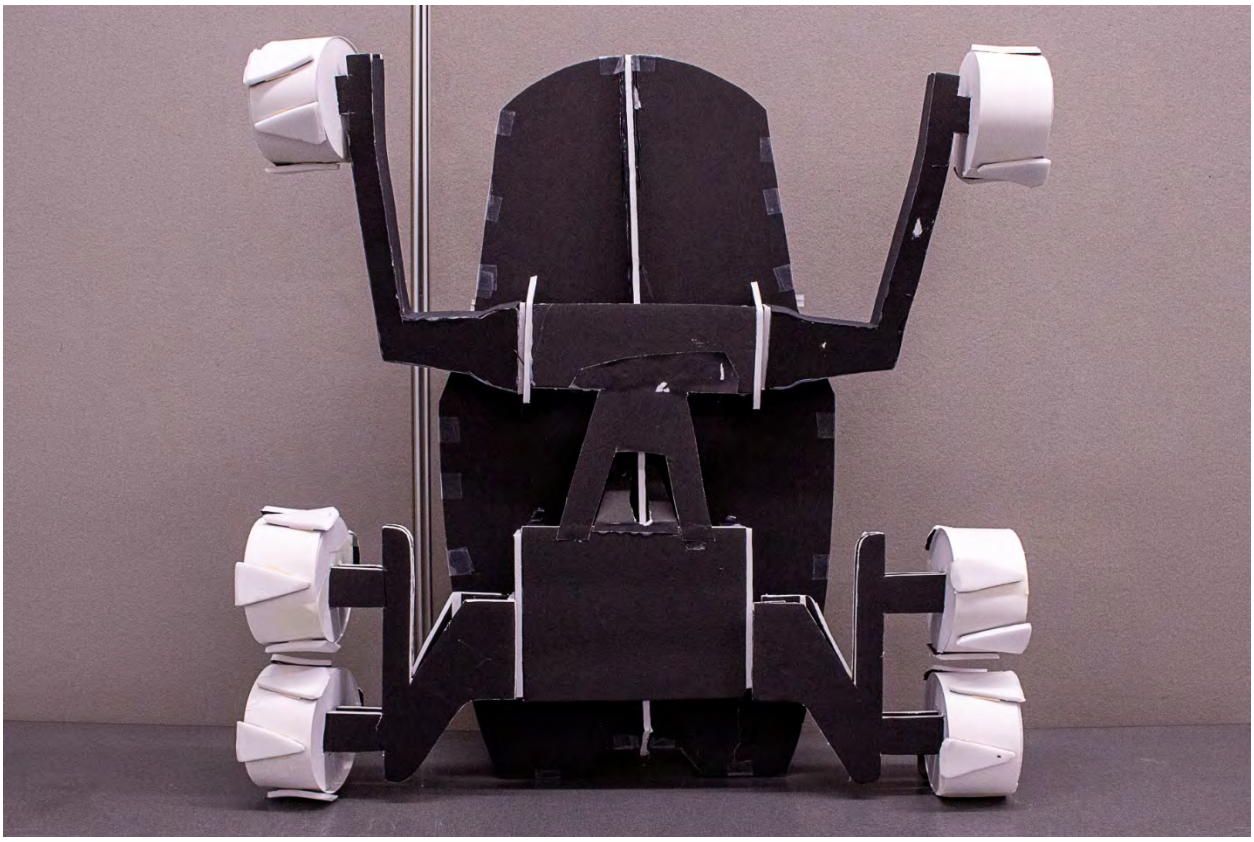


Figure 82 - Sketch Model Underside View

4.5.2 ERGONOMICS

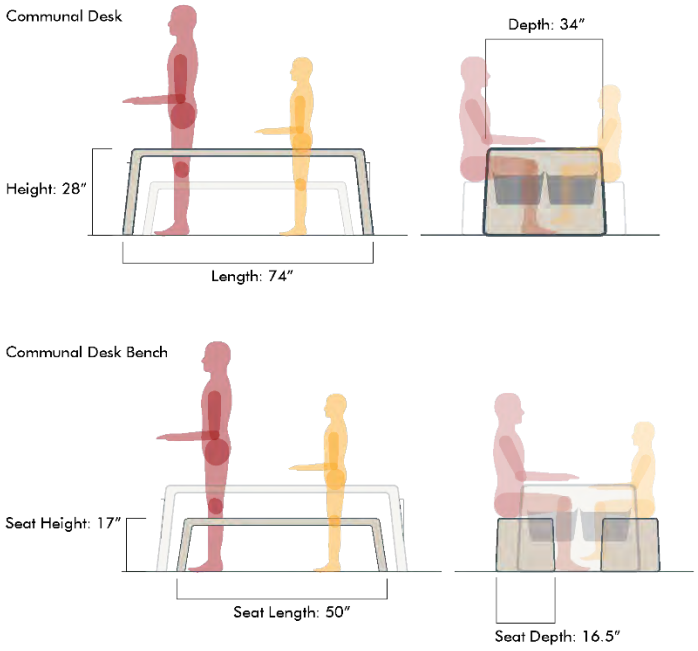


Figure 83 - Ergonomic Drawings 95th Percentile Male & 5th Percentile Female

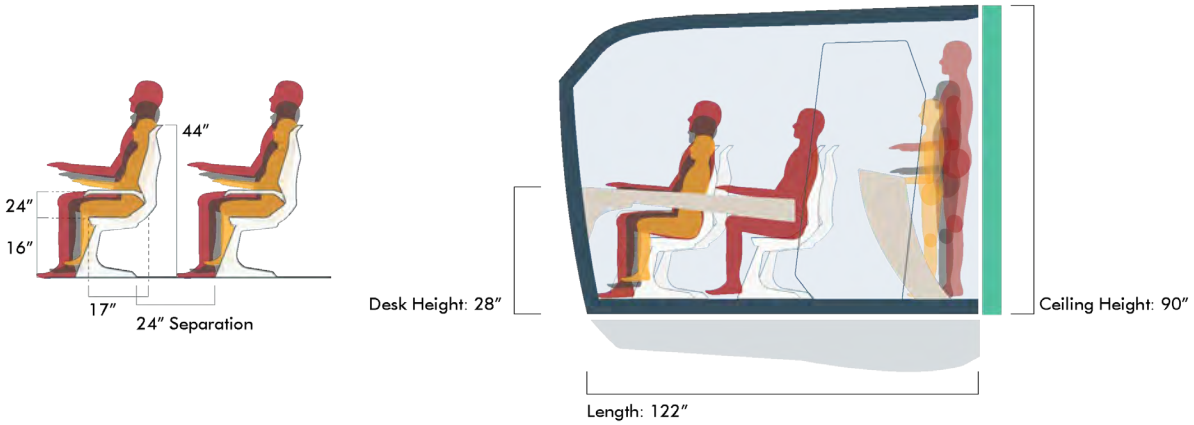


Figure 84 - Ergonomic Drawings Observation Pod

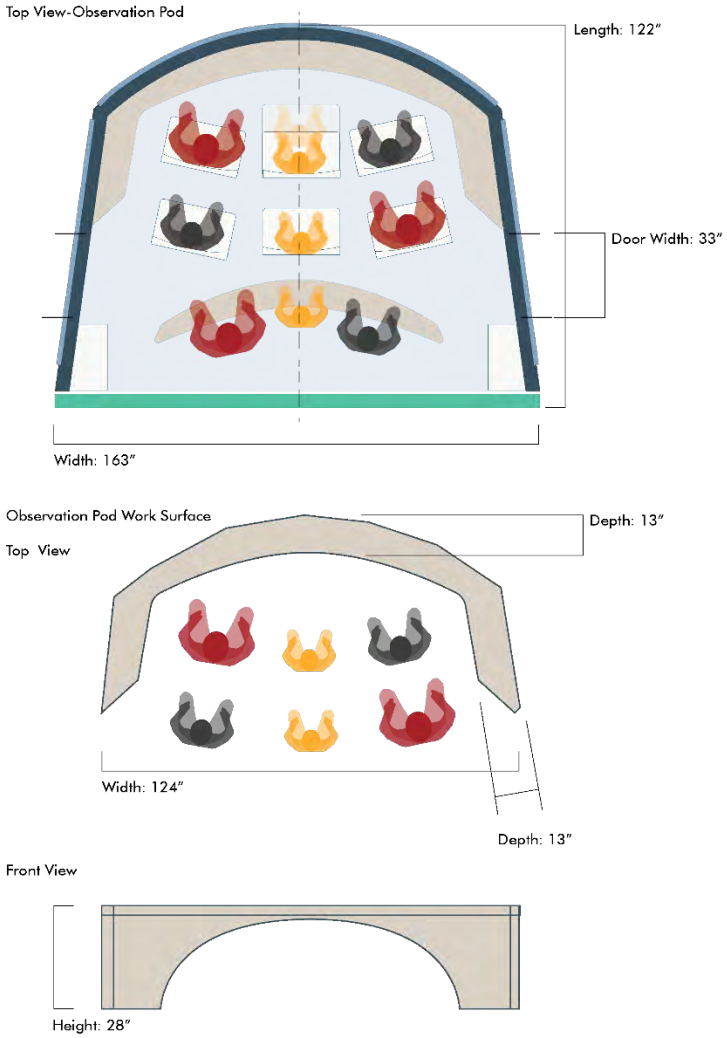


Figure 85 - Ergonomic Drawings Upper View of Observation Pod

The sketch model covers the primary ergonomic features of the research lab space on the interior of the vehicle as well as the observation pod space. These two areas in particular are the primary focus of this thesis as a majority of problems are resolved in these spaces.

4.6 FINAL DESIGN

This final sketch was produced as a culmination from the detailing work, ideation and concept development, as well as using the sketch model geometry to determine the final form. Doing a final sketch in proper perspective before CAD began allowed for a full understanding of the design in a physical sense, before jumping into the digital realm of CAD.

In this section, the final design is solidified, incorporating sustainability elements, ergonomic considerations and focusing on features and benefits for the user. This is the final design for the mobile research station, enabling underwater research and observation while also functioning as a mode of transport and micro living.

Figure 86 - Final Design Sketch

4.7 CAD MODELS

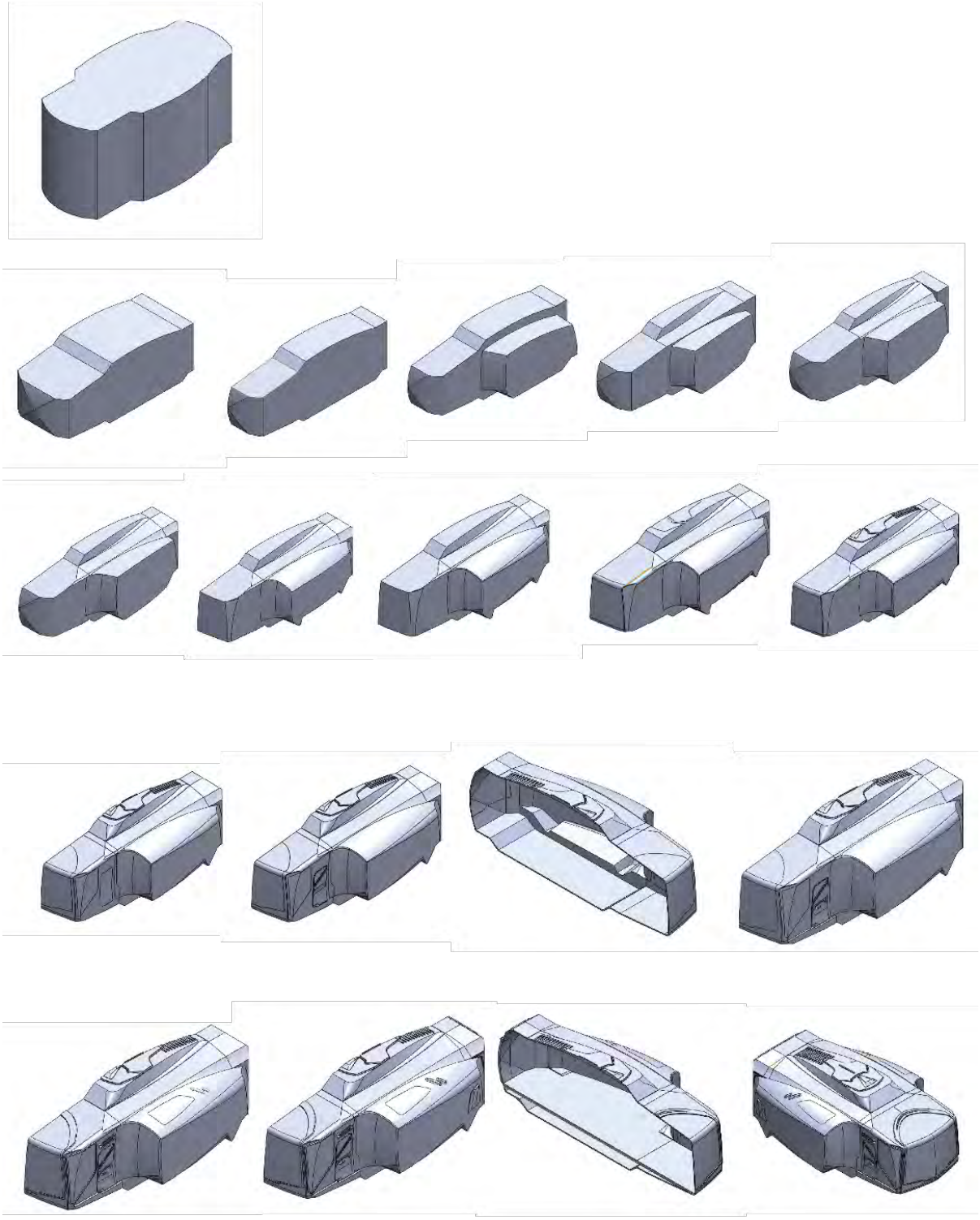


Figure 87 - CAD Process - Exterior

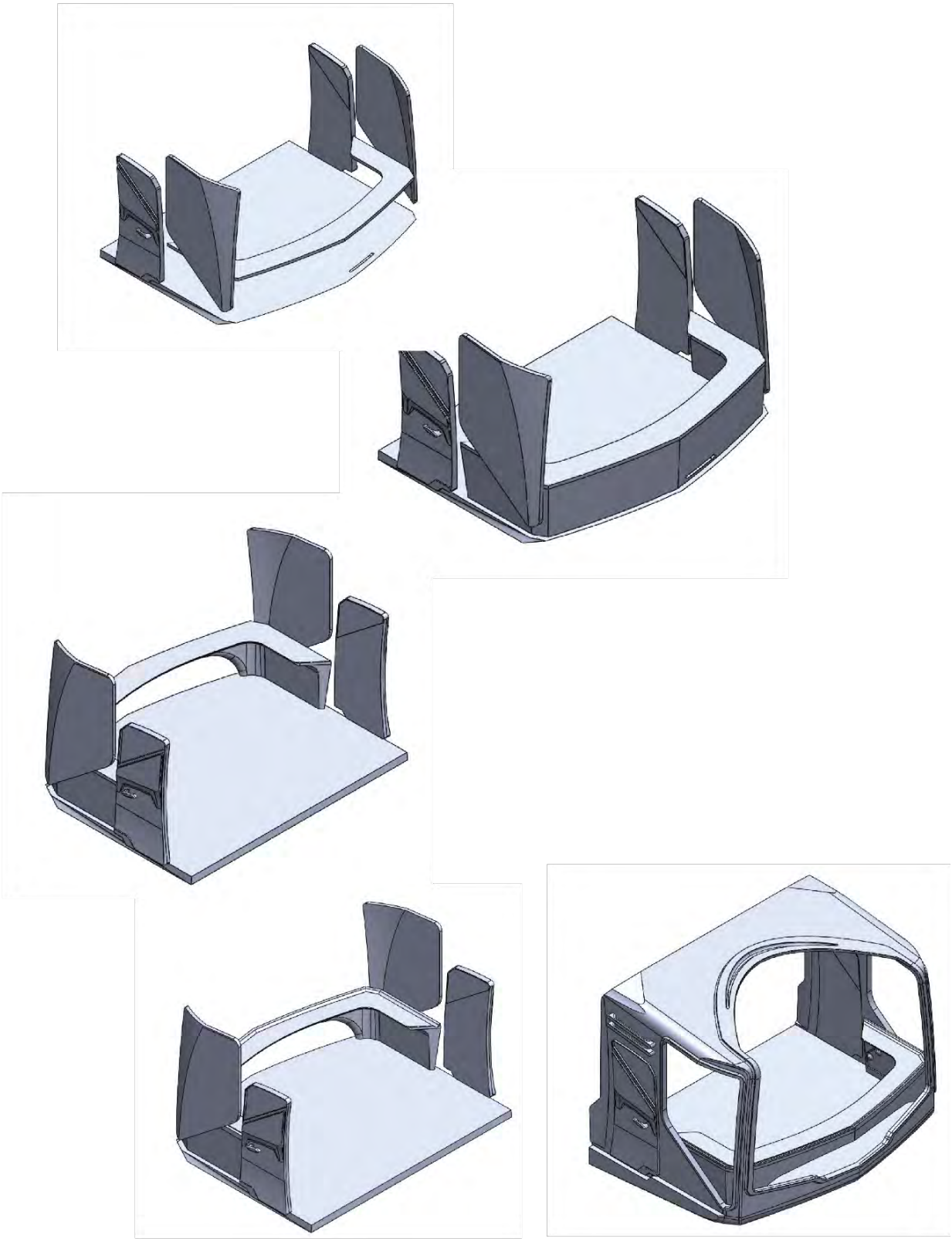


Figure 88 - CAD Process - Observation Pod

Figure 89 - CAD Process - Observation Pod Chairs

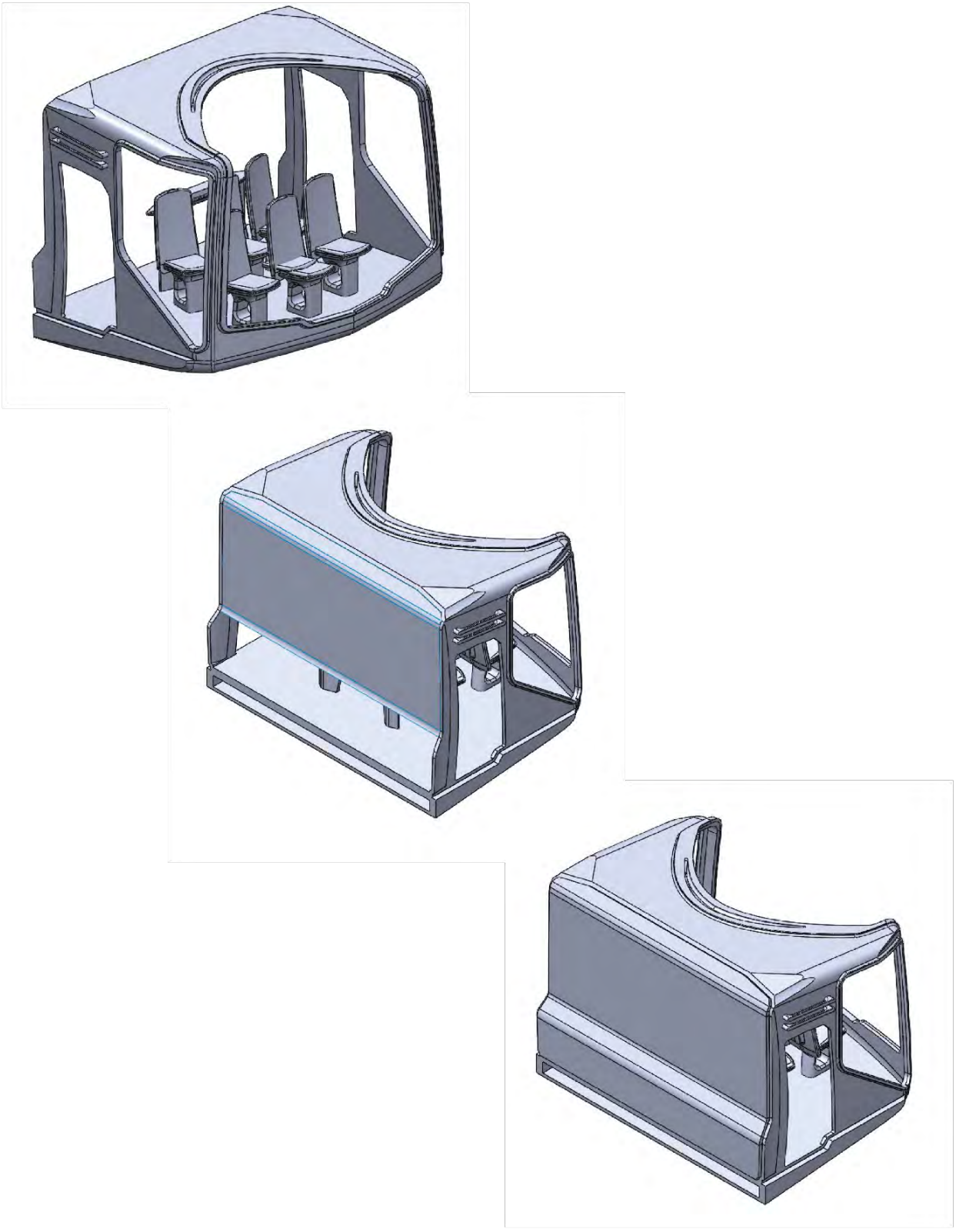


Figure 90 - CAD Process - Exterior Pod Walls

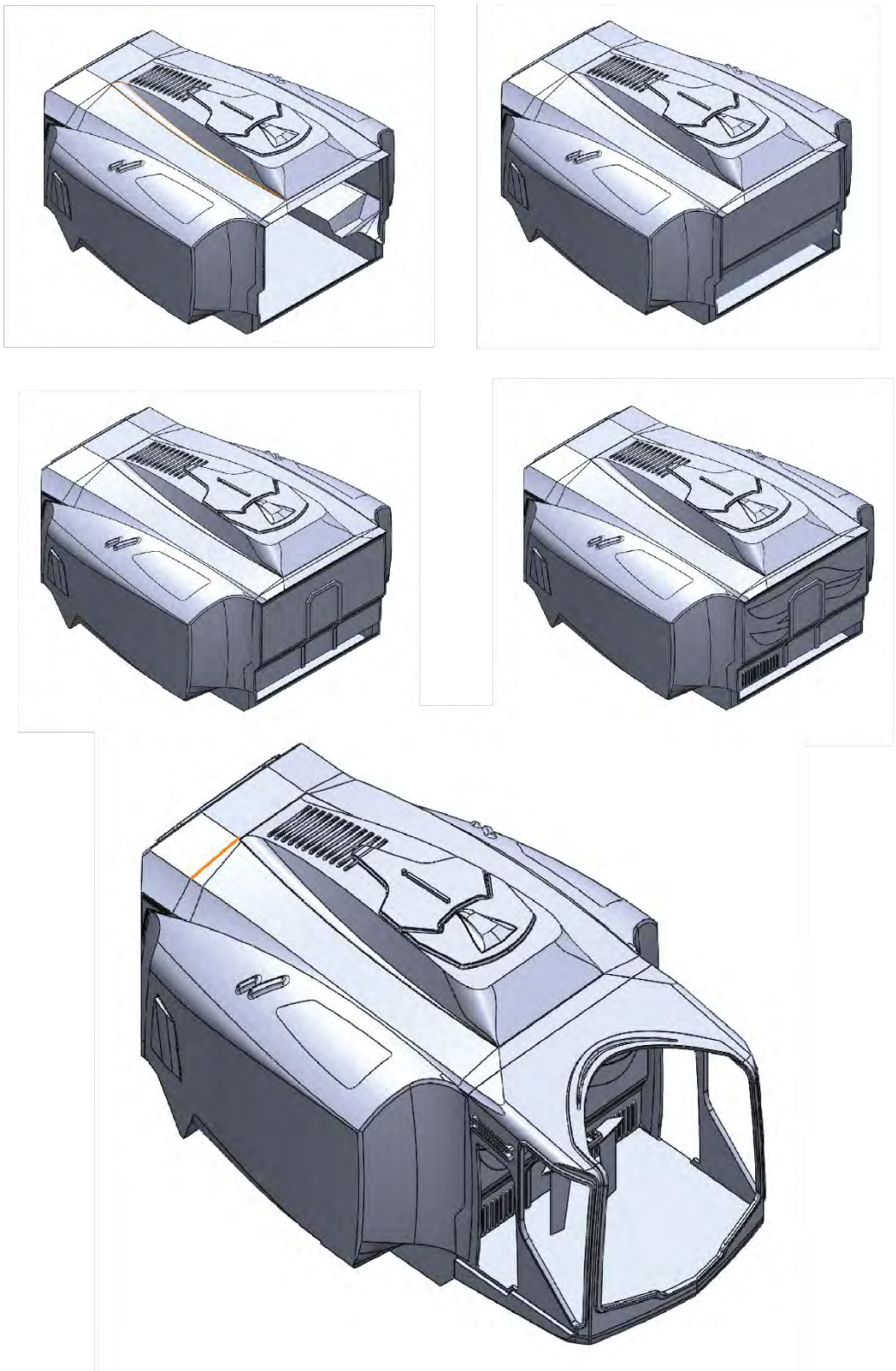


Figure 91 - CAD Process - Exterior Detailing

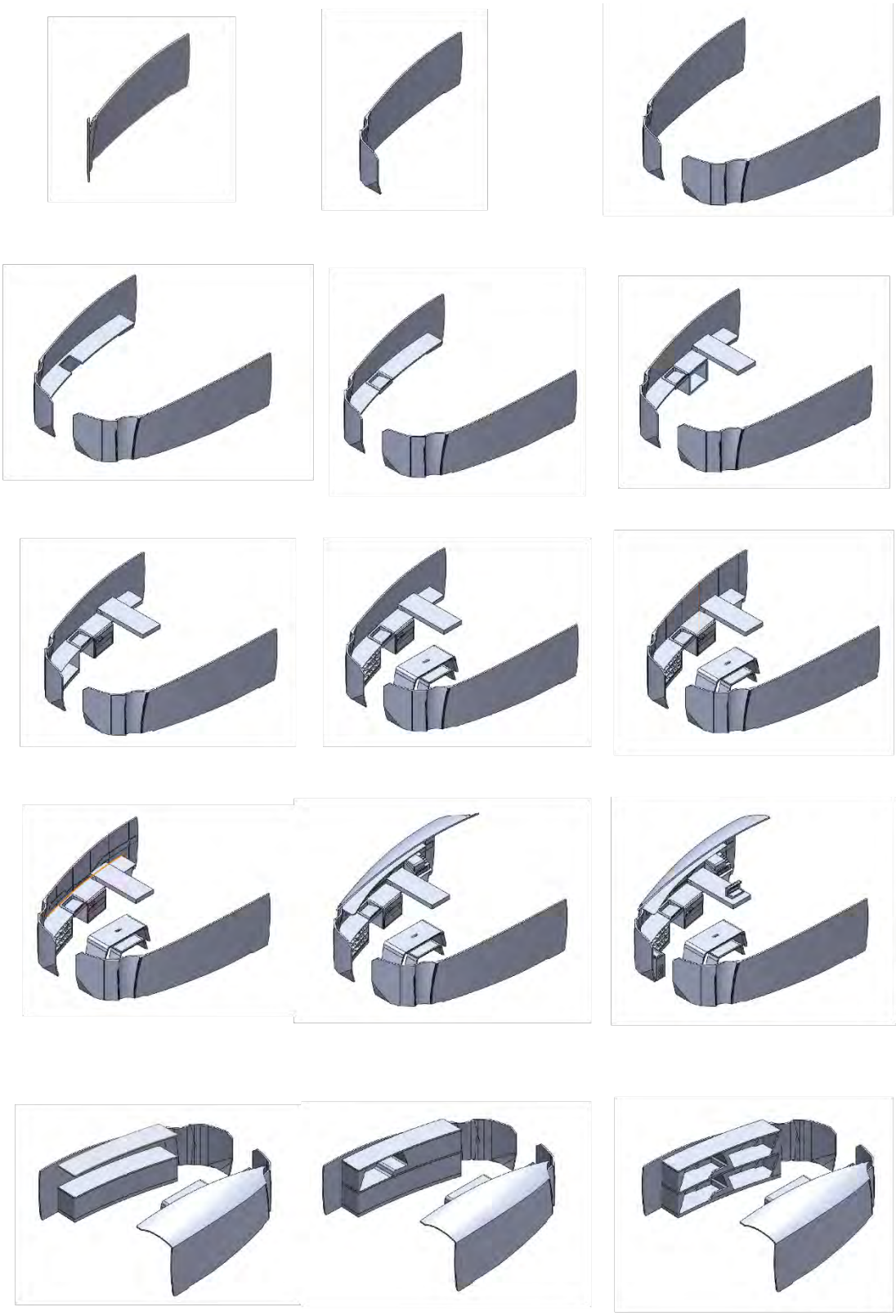


Figure 92 - CAD Process - Interior Spaces

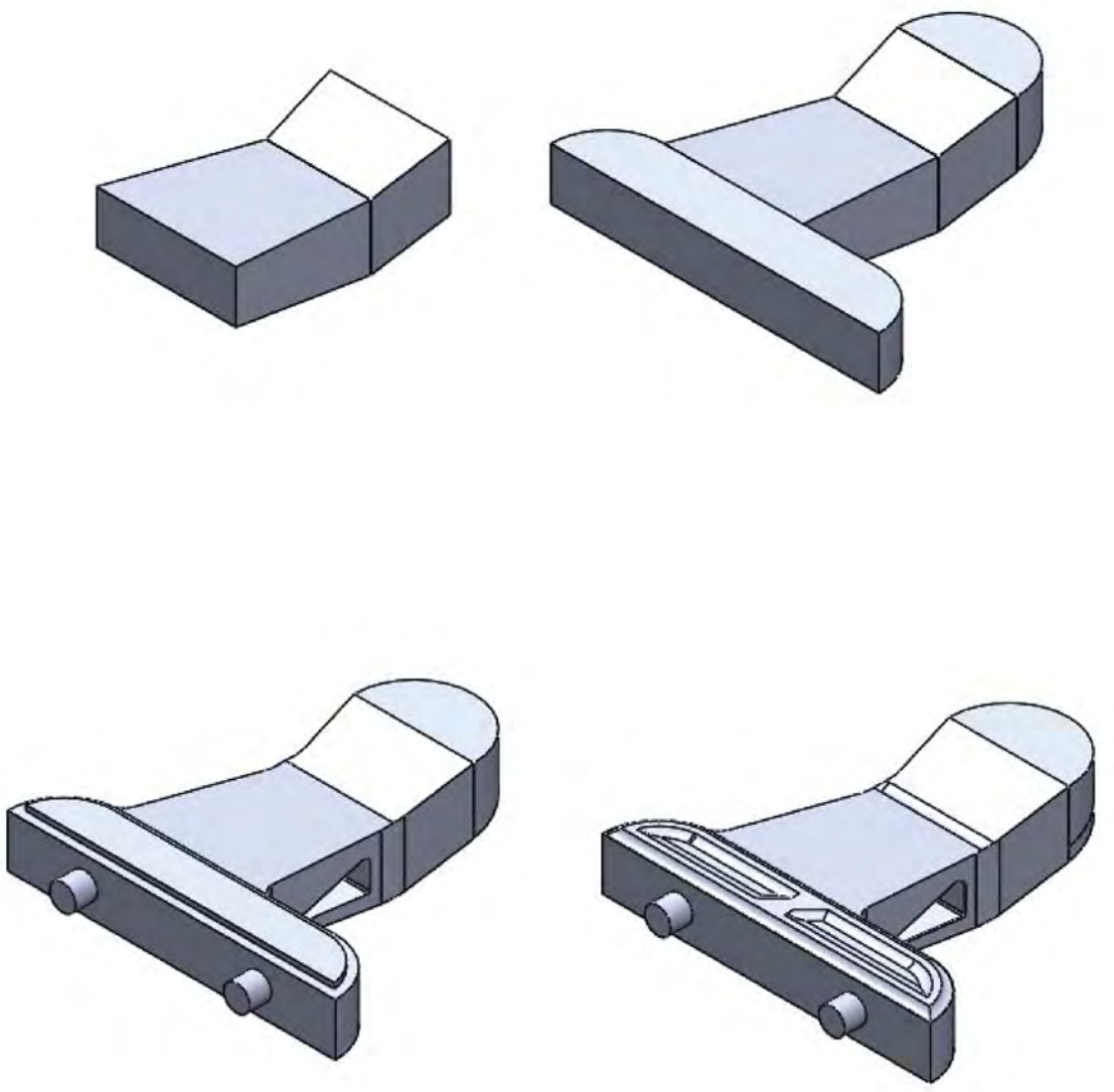


Figure 93 - CAD Process - Rear Wheel Arm

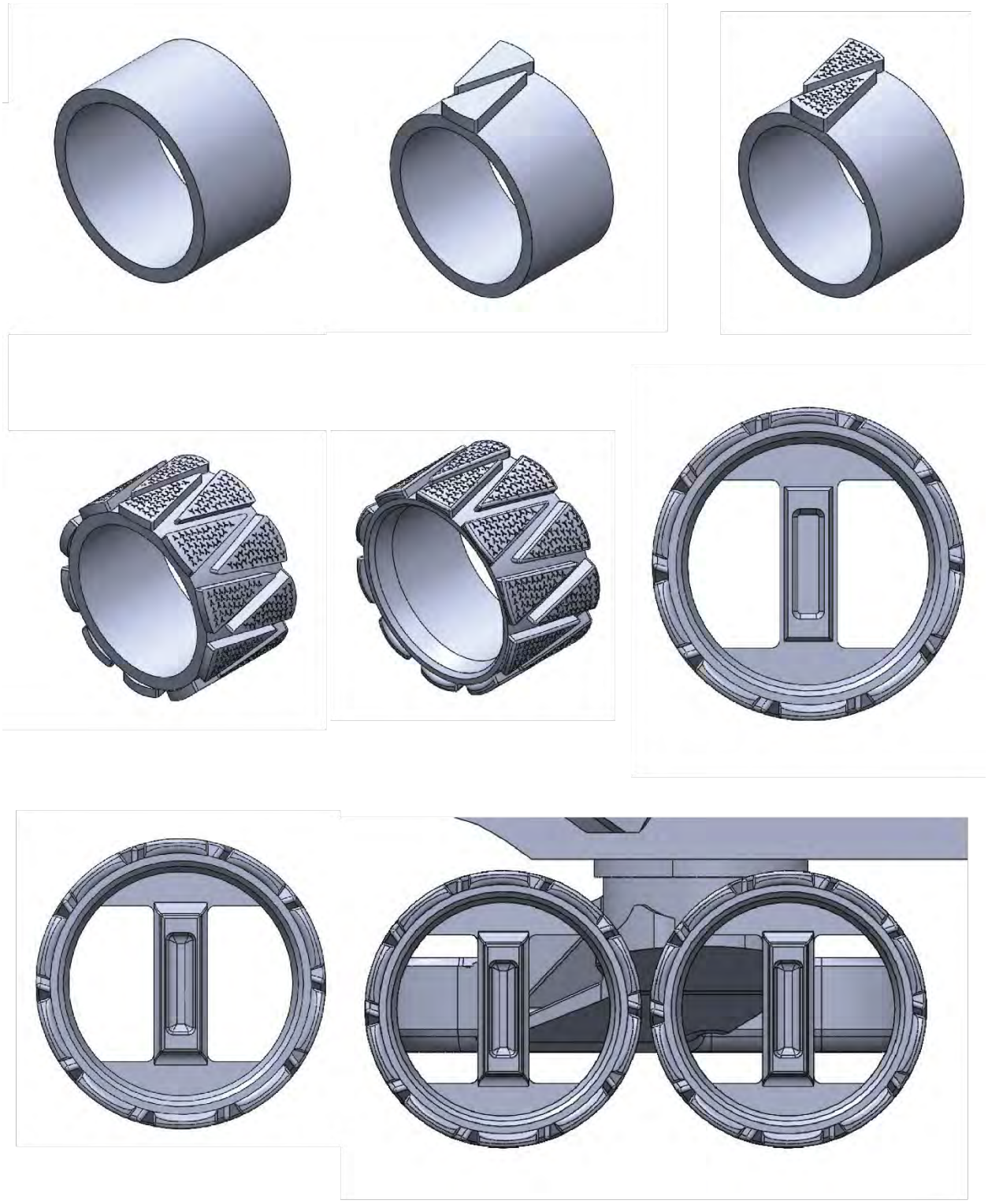


Figure 94 - CAD Process - Wheels

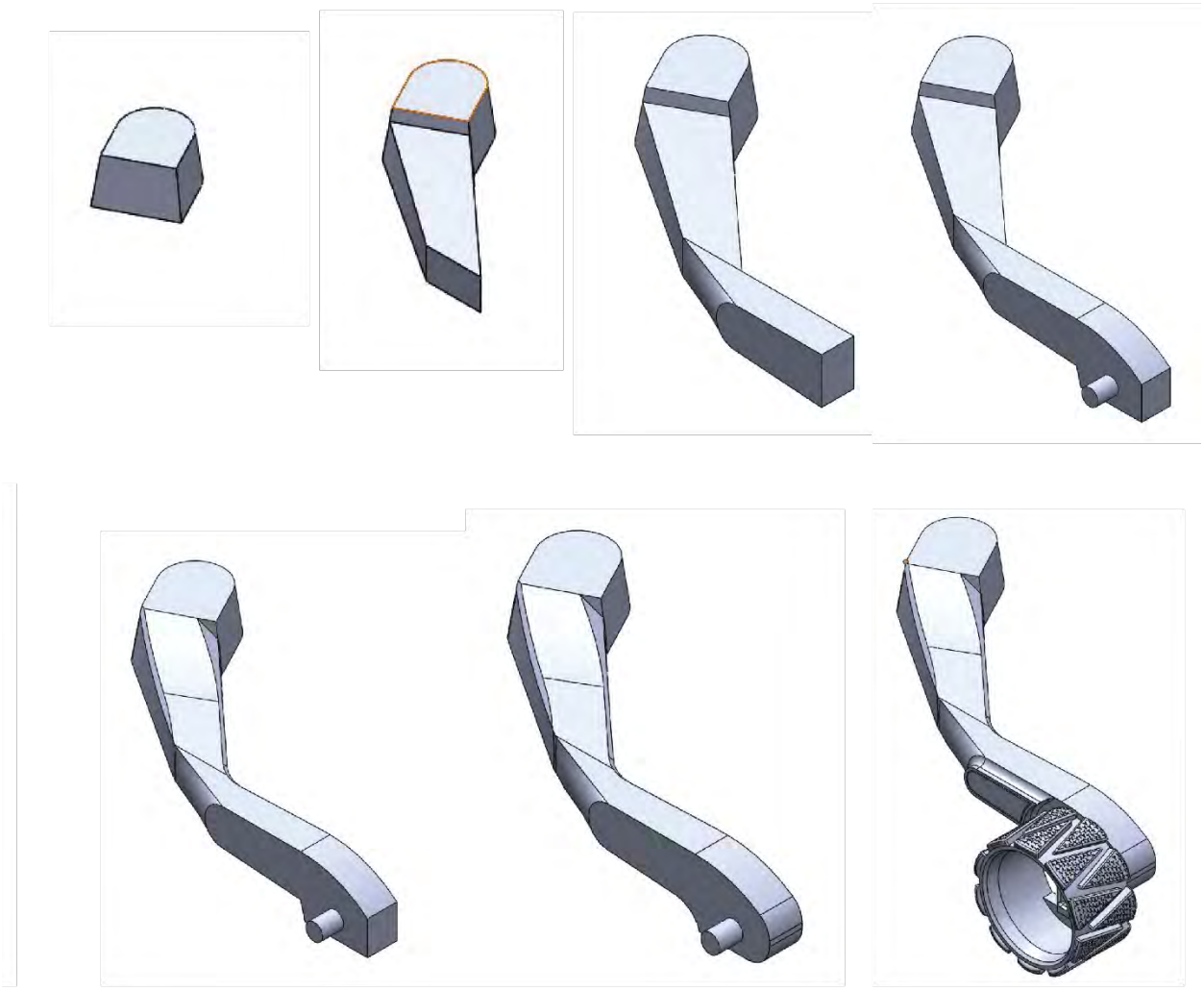


Figure 95 - CAD Process - Front Wheel Arms

The CAD modeling process took place over the course of several weeks, using the current version of Solidworks (2019-2020) to do so. Initial CAD was started and re-started four times before preliminary modeling issues were worked out. The entire design was constructed in a single part file, neglecting the use of 'Merge Results', which enabled the construction of dozens of separate parts inside one singular file. This process of CAD modeling can be inefficient in terms of file size and processing power required by the laptop, however in this case it was deemed to be the most efficient as there was a plethora of parts which required specific and accurate alignment. The file resulted in over 128 individual parts (more of which were split

up for 3D Printing), with over 700 individual features and 84 planes of reference. At a final size of 143 megabytes, the entire CAD modelling process took around 220 hours to complete, excluding rendering and material selection time.

4.8 HARD MODEL FABRICATION HISTORY

The final model of this thesis was constructed using 3D printed parts, laser cut components and a great deal of patience and Gorilla superglue. In an effort to save cost and reduce project waste, a translucent PLA filament was used in a Dremel 3D40 printer which was purchased a year earlier for $1000 CAD. The current model retails for $1700 CAD plus tax. The smaller print bed size required many larger components to be split into smaller parts which could be assembled after printing. This was a minor hurdle to overcome, but with some practical thinking, efficient fastening methods were developed to ensure a strong final model. 95% of components in the final model were either built by hand or printed at home on a budget level 3D printer and finished by hand with a myriad of sandpaper grits ranging from 80 grit up to 2000 grit.

Sandpaper Grit	Purpose
80 Grit	Removing initial surface blemishes on 3D printed parts. Light sanding to start off with for all PLA parts, careful not to apply too much pressure and gouge the plastic.
120 Grit	Cleans up marks from 80 grit while still removing considerable amount of material. Using a new piece / sheet of paper for each part to ensure efficiency.
150 Grit	Continues to smooth surface from 120 grit. Most significant surface blemishes are smoothed down and filament printer lines are minimal.
180 Grit	Continues to smooth surface from 150 grit, preparation for transitioning into wet sanding techniques.
220 Grit (Wet)	All parts are wet sanded at 220 to remove dust and debris from the surface from dry grit sandpapers. 220 ensures a good surface to apply initial primer coats, where the surface quality can be re-evaluated and bondo / body filler can be applied.

400 Grit (Wet)	Removes larger masses of bondo / body filler, continues to smooth surface.
600 Grit (Wet)	Continues to smooth surface from 600. Any surface imperfections are clearly visible as most of the surface is well smoothed.
1000 Grit (Wet)	Starting to get slightly overkill with surface sanding, but 1000 grit ensures a consistent, smooth surface. Ideal for removing surface texture in between primer or painting coats.
1500 Grit (Wet)	Removes surface texture between final paint coats. Ideal for sanding clear printed parts.
2000 Grit (Wet)	Final sanding before the final coat of paint, gives a high quality polish and finish to the surface. Any grit higher than this simply becomes redundant, wasted time.

Table 25 - Sand Paper Breakdown

Montana Gold spray paint was used for colored areas of the model, in combination with Rustoleum primer. Rustoleum has been notoriously tricky for industrial designers as it tends to develop a tacky finish, even days after painting. This was resolved using a kettle, boiling water and letting the can sit in hot water for 5 minutes before shaking and painting. Immediately following paint application, the paint was ‘baked’ using a hair dryer or a heat gun.

In total, the final model required four bottles of Gorilla Super Glue to complete.

3D printing and rapid prototype manufacturing began as early as possible, due to the grand scale of the final model (1:18). The first 3D printed parts were produced on February 15th. The last part to be 3D printed was finished on March 14th. It totaled up to 583 hours of printing.

In all, the final model of NANUK is comprised of 128 parts.

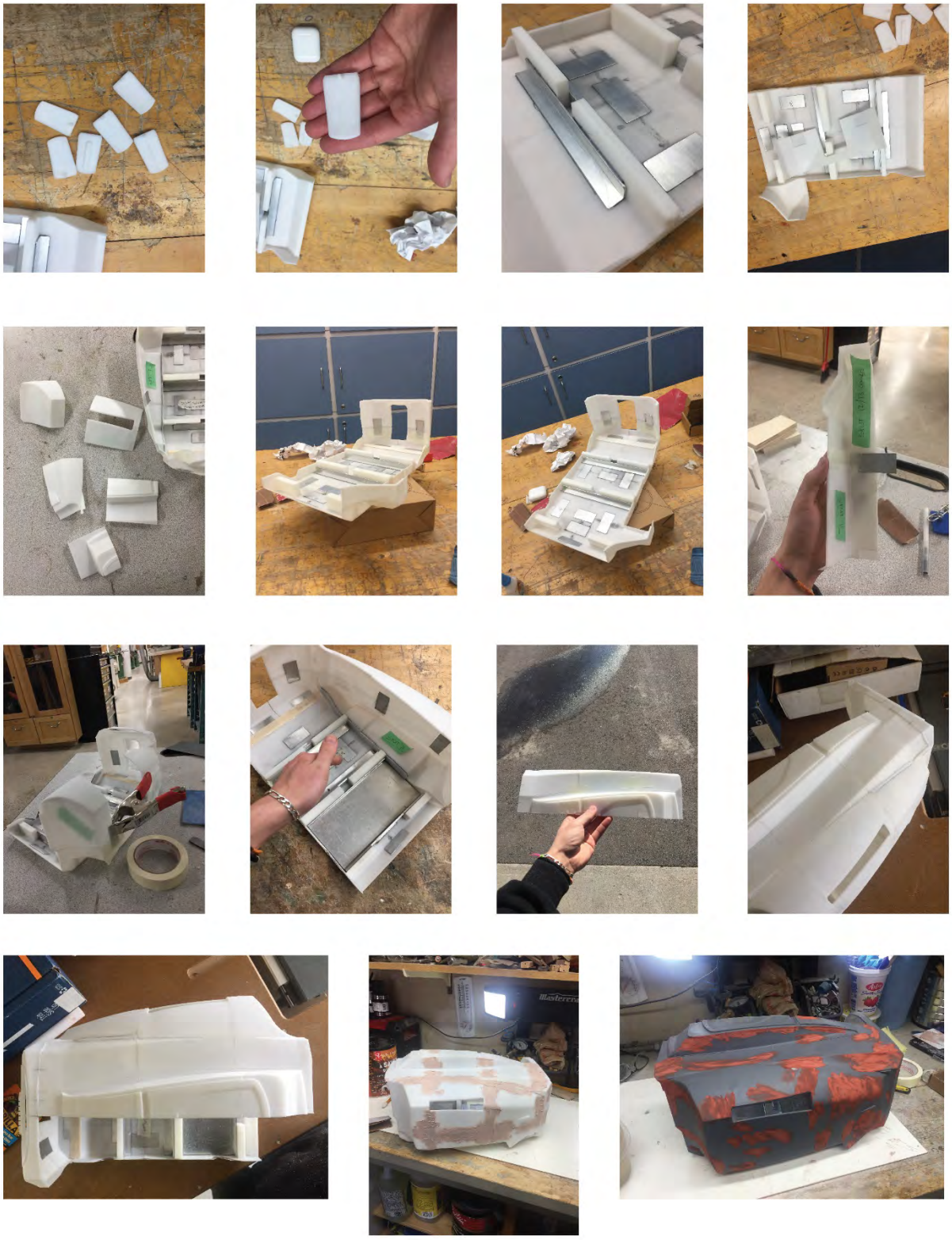


Figure 96 - Model Process Pictures

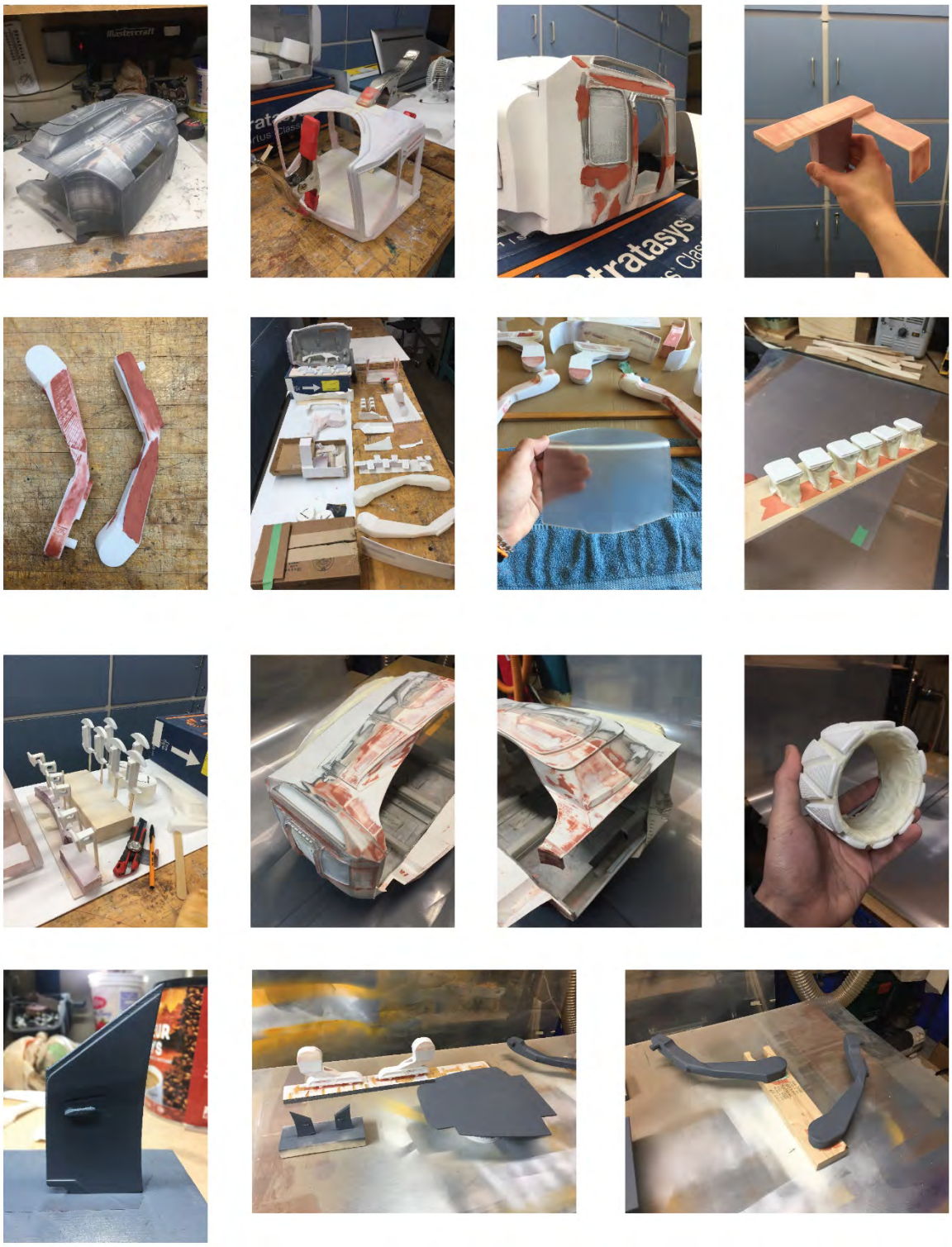


Figure 97 - Model Process Pictures 2

Figure 98 - Model Process Pictures 3

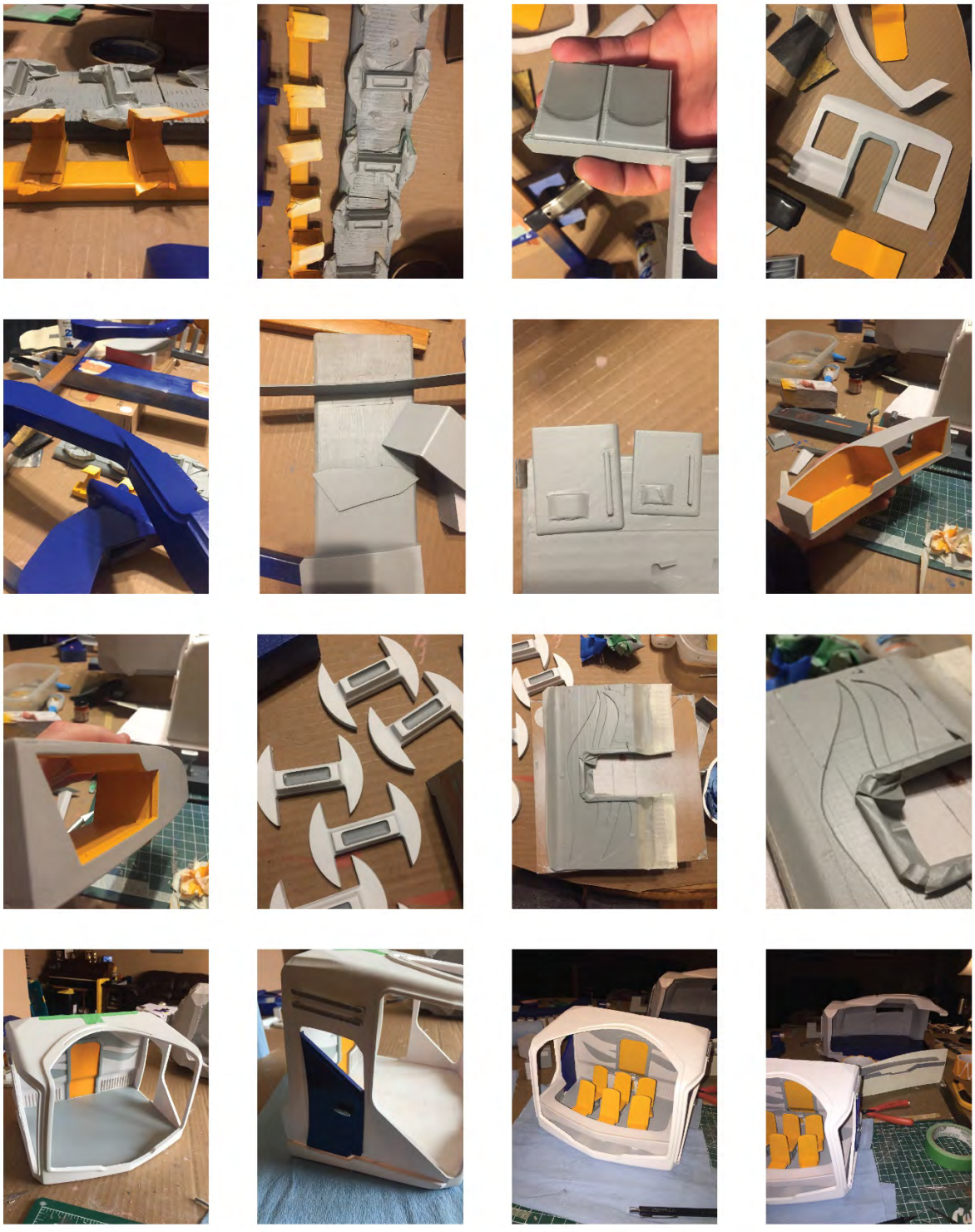


Figure 99 - Model Process Pictures 4

CHAPTER 5 FINAL DESIGN

Figure 100 - Retrieved from https://paulnicklen.com/stills/polar-bears/#!jig[1]/ML/2239

CHAPTER 5 FINAL DESIGN

5.1 SUMMARY

5.1.1 DESCRIPTION

NANUK is an amphibious Arctic research station, optimized for research conducted in cold environments, acting as a safe and comfortable place for resident researchers to conduct research both on land and in the water with minimal environmental risk and harm.

5.1.2 EXPLANATION

Current methods of conducting Arctic research, specifically those practices which aim to understand wildlife, are still primitive and underdeveloped. In fact, most of the research efforts conducted (while scientifically beneficial) are arduous, environmentally harmful and expensive. There are significant financial, environmental and physical costs incurred with Arctic research, specifically when studying marine wildlife such as *Ursus Maritimus,* the polar bear. Helicopters are expensive and obtrusive to the fragile ecosystem, where the frigid Arctic temperatures can wreak havoc on delicate modes of transport which leave users exposed (such as snowmobiles, sleds and primitive field stations). The goal of this thesis was to mitigate the challenges which face these polar bear biologists and to enable them to conduct the necessary research above *and* below the ice, while minimizing physical risks.

NANUK is a solution which addresses these issues, providing users with the necessary amenities and facilities to perform the broad range of jobs which they are required to perform as Arctic researchers, thus mitigating these challenges. The concept vehicle also incorporates unique technologies and functional features which enable safely enclosed, underwater observation wherever water is present and is deep enough. Ample space has been developed to allow researchers to analyze samples, conduct their field notes and catalogue data, while also

living in a simple, compact manner without the need for commuting between the field and their field station.

5.1.3 BENEFIT STATEMENT

NANUK is an Arctic Mobile Research Station solution which incorporates a dynamic lab environment with micro-living and underwater observation, all in a singular fuselage insulated from the exterior, with focus on sustainability and protecting the fragile Arctic ecosystem. This enables NANUK to mitigate challenges facing polar bear biologists, curating a productive research experience and rethinking ways in which Arctic research is conducted. NANUK eliminates the need for researchers to commute and travel to and from their field locations, enabling on-sight, mobile research to be conducted while minimizing the negative effects on the environment.

Figure 101 - Final Design

5.2 DESIGN CRITERIA MET

5.2.1 ERGONOMICS

NANUK is a mobile research solution which adopts a human-centre design approach to be more ergonomic and considerate for the users whilst in operation. The interior of the solution is designed to be ergonomic and practically laid out, offering optimal space for conducting and analyzing research data, ergonomic observation space and a compact yet effective living quarters. Likewise, the interior styling and color palette also take into consideration efforts to mitigate a claustrophobic environment, using natural light and pale tones to instill a sense of calm for the users.

Figure 102 - Interior Render, showcasing ergonomic considerations.

Observation Space

The underwater observation space was laid out with a larger, open ceiling and broad, high visibility windows to ensure as little observational area was lost during construction. This results in an observation space which makes it ideal for studying and monitoring marine wildlife at a safe distance from a secure enclosure without compromising visibility. Adjustable work chairs and a sloped work surface are designed to make note taking and writing as effective as possible without a great deal of neck strain.

Figure 103 - Observation Pod Interior View

Research Space

NANUK's interior research lab is equipped with the necessary equipment and facilities which are commonly used by Arctic biologists. This research lab incorporates a standing desk and a sit-down work desk which act as a visual divider between the research space and the living space. This desk accommodates users from a variety of percentiles, whilst giving them the choice to conduct their work from either a standing or seated position. Standing desks are becoming ever more prominent in workplaces and research labs, mitigating poor posture related injuries from sitting all day.

Figure 104 - Interior Research Space

Interior Concept Layout

The interior layout is designed to follow an open concept design language, maximizing internal space as much as possible. With an average ceiling height of 90”, rising to 103” in the middle of the vehicle, NANUK only utilizes walls and partitions where necessary, sealing the observation pod from the remainder of the research pod when deployed under water. To mitigate claustrophobic sensations during long research trips, the living space and research space are intentionally left open, as walls and space dividers often lend themselves to feelings of smallness and cramped sensations.

Figure 105 - Interior Concept Layout

5.2.2 MATERIALS, PROCESSES & TECHNOLOGIES

There were many materials investigated which aught to be included in the final design, if it was produced in a hypothetical fashion. In Section 2.2.4, a full breakdown of considered materials and material finishes are detailed in this section. In the table in Section 2.2.4, aluminum, plastics and various forms of synthetic insulation are considered as they are going to be the primary materials used in the build of this solution. Aluminum will be the material of choice for the exterior body panels, fastened to an insulated aluminum frame. Various materials will be utilized to produce the workstation surfaces, desks and floor treatments. These materials and parts can be sourced from third-party suppliers which currently support Canadian research initiatives and produce equipment used by Canadian research agencies. Likewise, functional systems such as plumbing, air filtration and lighting will also be outsourced to third party companies with efficiency and sustainability at the forefront of production.

Arctic research is an ever-growing field of science, especially with the rise of awareness around endangered wildlife and global warming. As a result, new and evolving technologies are constantly being tried, tested and implemented into research vehicles and current solutions. The technologies which are implemented into the final design include:

- Level 4 Autonomy
- Lithium Ion Batteries
- Drone reconnaissance and autonomy driving
- Retractable step ladders on exterior, controlled electronically
- Manual control and navigation when necessary
- Electronically monitored hydraulic wheel arms
- Air purification system
- Solar energy panel integration

5.2.3 MANUFACTURING COST REPORT

Manufacturing costs have proven to require a more focused approach during this project. As this solution is unlike any current Arctic research solutions seen on the market, cost reports have been near impossible to come by without making a great deal of speculation. With conceptual thinking, the design was modeled after similar products already on the market and use their associated costs of manufacturing to determine an estimate.

The table below demonstrates an estimate of the various components seen within this design, modeled after similar products in existing markets. While the aesthetic connections cannot be made between products on the market and the design, it is the principle of the product itself and the tasks it performs, as well as associated material and manufacturing cost which are taken into consideration.

HIGH COST ITEMS					
Concept Item	***Description***	***Estimated Cost / each***	***Similarly Produced Item***	***QTY***	***Material***
Lithium Ion Batteries	Multiple	$40,000	-	4	Sourced
Hubless Wheels	X6	$4400	-	6	Aluminum
Hydraulic arms	X8	$18,000	-	8	Aluminum
Computer	For autonomous travel	$6,000	-	1	Sourced
Body Panels	All body parts for exterior	$400,000	-	-	Aluminum
Exterior insulation	In between body panels and frame	$50,000	-	-	Synthetic Down
Custom windows	For observation pod	$150,000	-	8	Sourced
Air purification	All parts included	$25,000	-	1	Various
Heating system	All parts included	$20,000	-	1	Various

Plumbing system	All parts included	$15,000	-	1	Various
Water tight sealants	All parts included	$3000	-	-	Various
Labour	-	-	-	-	-
MEDIUM COST ITEMS					
Concept Item	***Description***	***Estimated Cost***	***Similarly Produced Item***	***QTY***	
Chair frames	X6	$1366	Marini Chair-Teknion	6	Various
Chair cushions	X12	$120	Marini Cushions-Teknion	12	Various
Kitchen microwave	X1	$229	Samsung MG14J3020C	1	Stainless steel
Kitchen sink	X1	$869	CLARK Double End Bowl	1	Stainless steel
Kitchen fridge	X1	$579	Danby 22”	1	Stainless steel
Lab fume hood	X1	$645	Whirlpool 30”	1	Stainless steel
Lab sample analyzer	X1	-	Purair LF Laminar Flow Cabinet	1	Various
Lab sample incubator	X1	-	Embryosafe 100	1	Various
Lab desk	X1	$3200	Height-Adjustable Bench Navigate	1	Various
Interior lights	X20	$129	Aperture Light	20	LED Light panel
Toilet	X1	$849	Kohler Veil Tankless	1	Stainless steel
Bathroom sink	X1	$869	CLARK Double End Bowl	1	Stainless steel
Bio waste tank	X2	$2185	Sun-Mar Centrex 3000-NE	2	Stainless steel
LOW COST ITEMS					
Concept Item	***Description***	***Estimated Cost***	***Similarly Produced Item***	***QTY***	
Levers	For manual navigation	$150	-	4	Various
Nuts	All included	$500	-	Numerous	Steel
Bolts	All included	$500	-	Numerous	Steel

Flooring	For research pod and observation pod	$3000	-	-	Synthetic
Door handles	X10	$200	-	1-	Aluminum
Wall outlets	X18	$200	-	18	Plastic
Outlet coverings	X20	$50	-	20	Plastic
Chair padding	X8	$600	-	8	Various
Sleeping covers	X7	$120	-	7	Bamboo fibre
Pillows	X7	$50	-	7	Bamboo fibre
Mattresses	X6	$100	-	6	Bamboo fibre
Miscellaneous	Miscellaneous	Miscellaneous	Miscellaneous	Miscellaneous	

Table 26 - Cost Breakdown

5.3 FINAL CAD RENDERINGS

Figure 106 - Side Profile

Figure 107 - Rear Profile

Figure 108 - Upper Profile

Figure 109 - Cutaway Render

Figure 110 - Frog View

Figure 111 - Observation Pod Deployed

Figure 107 - In Situ Render

Figure 108 - In Situ Observation Pod Deployed

5.4 HARD MODEL PHOTOGRAPHY

The hard model for this thesis was produced using a Dremel 3D40 printer, with some parts being outsourced to Agile Manufacturing in Uxbridge Ontario. These outsourced parts were used to create the transparent windshields of the underwater observation pod.

Observation Pod – Hard Model Photographs

Figure 112 - Observation Pod Hard Model

Figure 113 - Observation Pod Hard Model 2

Research Lab / Living Space – Hard Model Photographs

Figure 114 - Final Model Top View

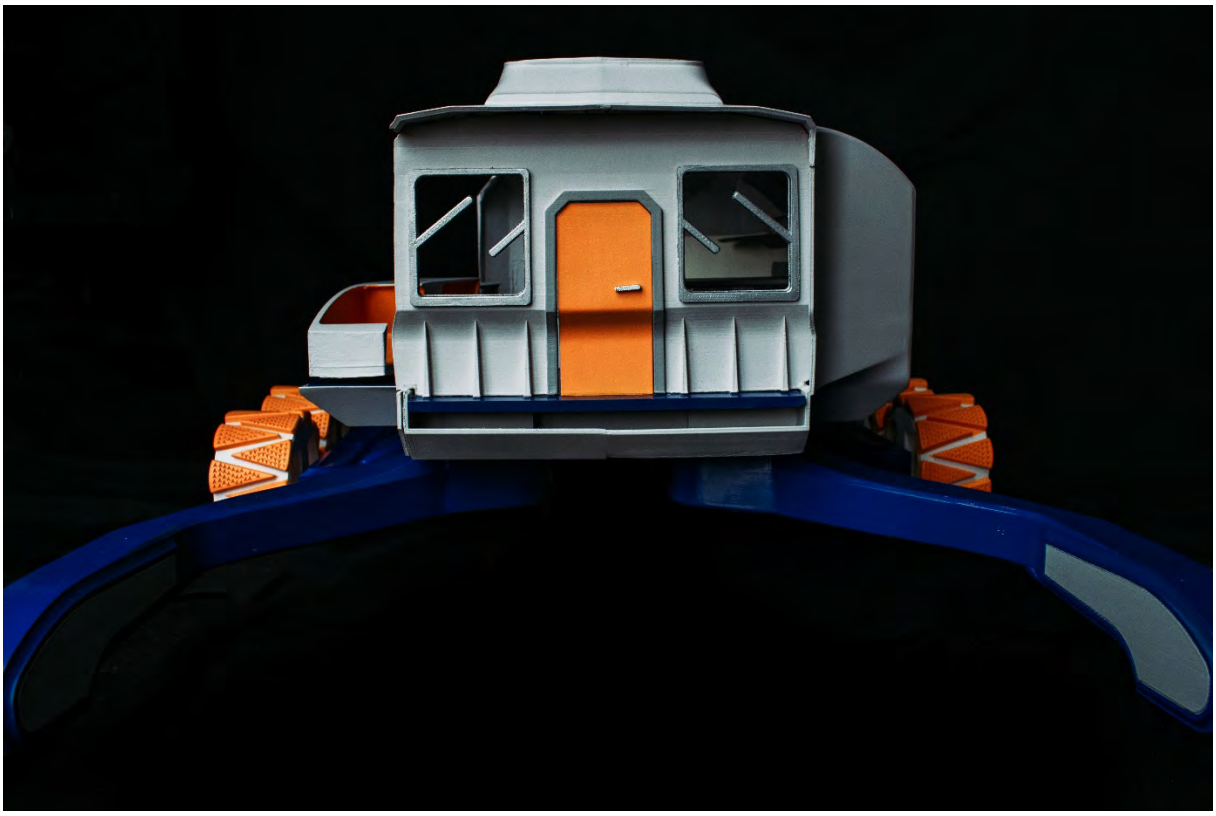


Figure 115 - Final Model Front View

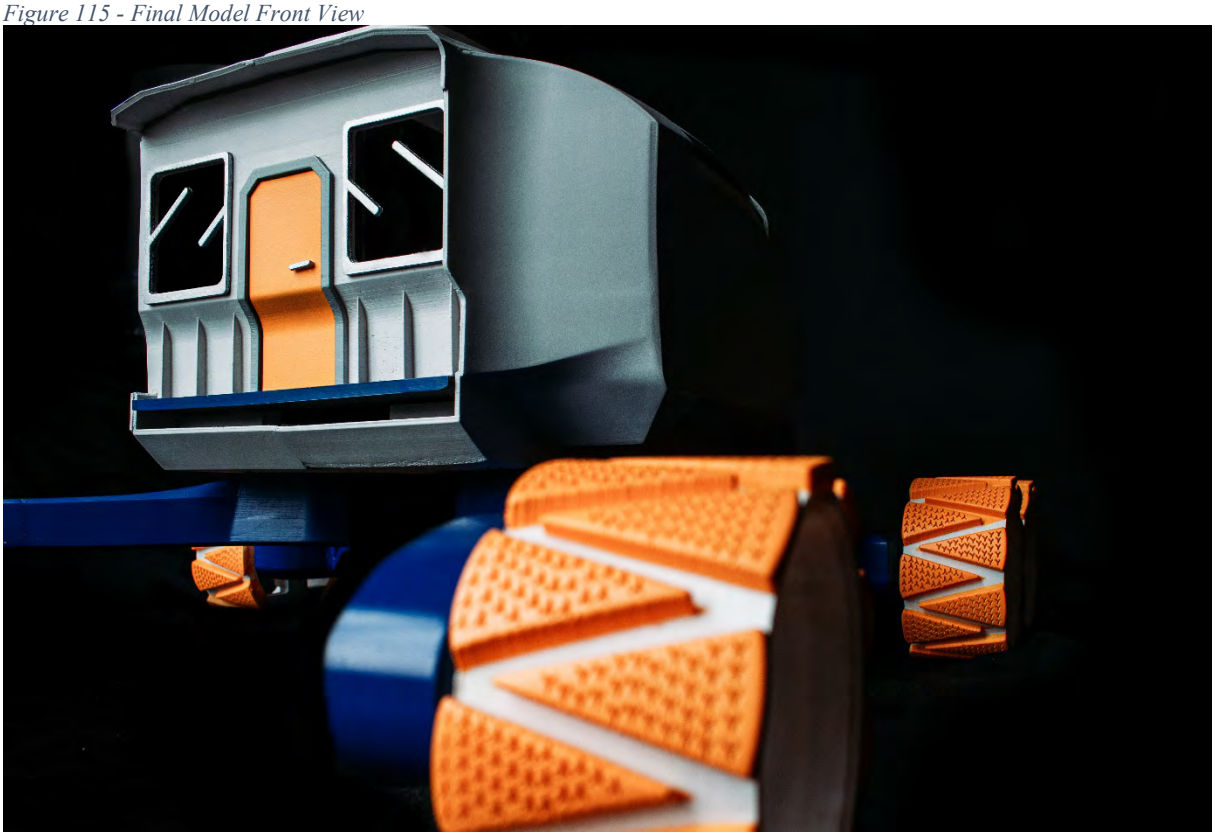


Figure 116 - Final Model - Lower 3/4

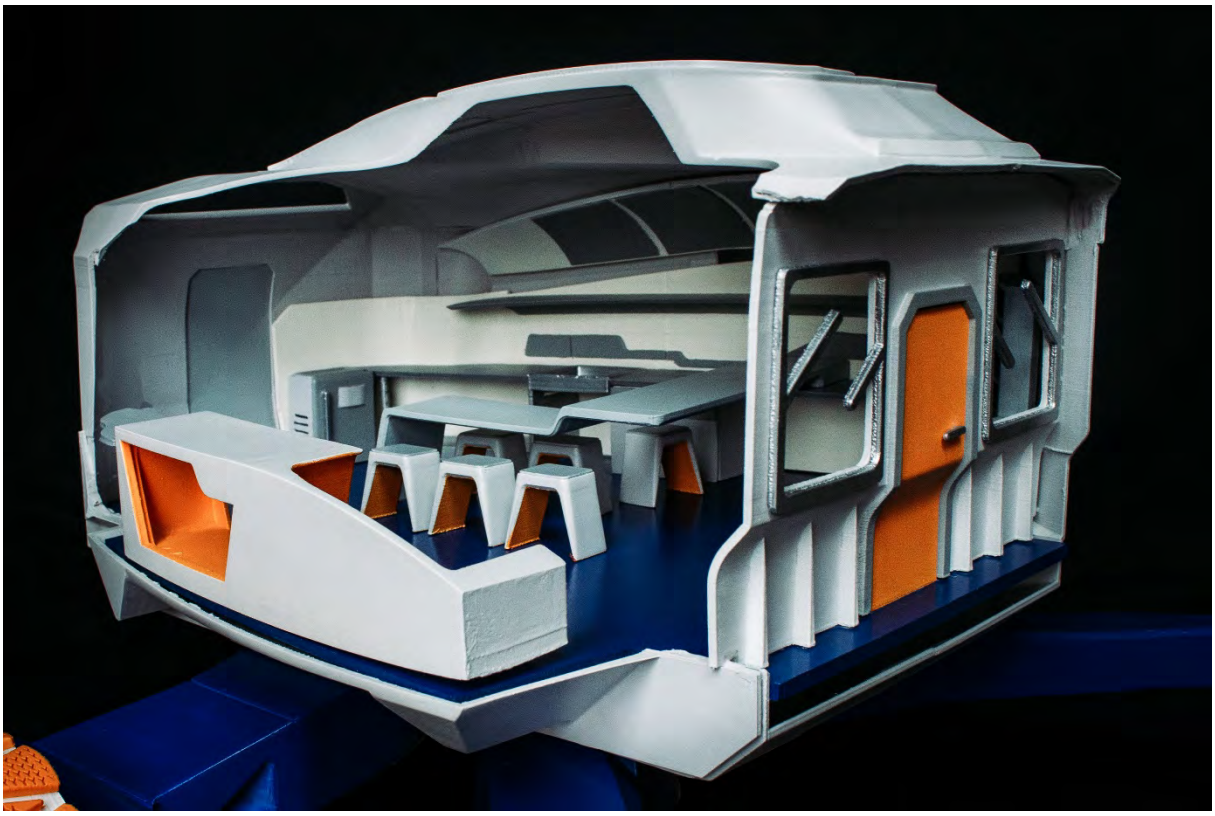


Figure 117 - Front 3/4

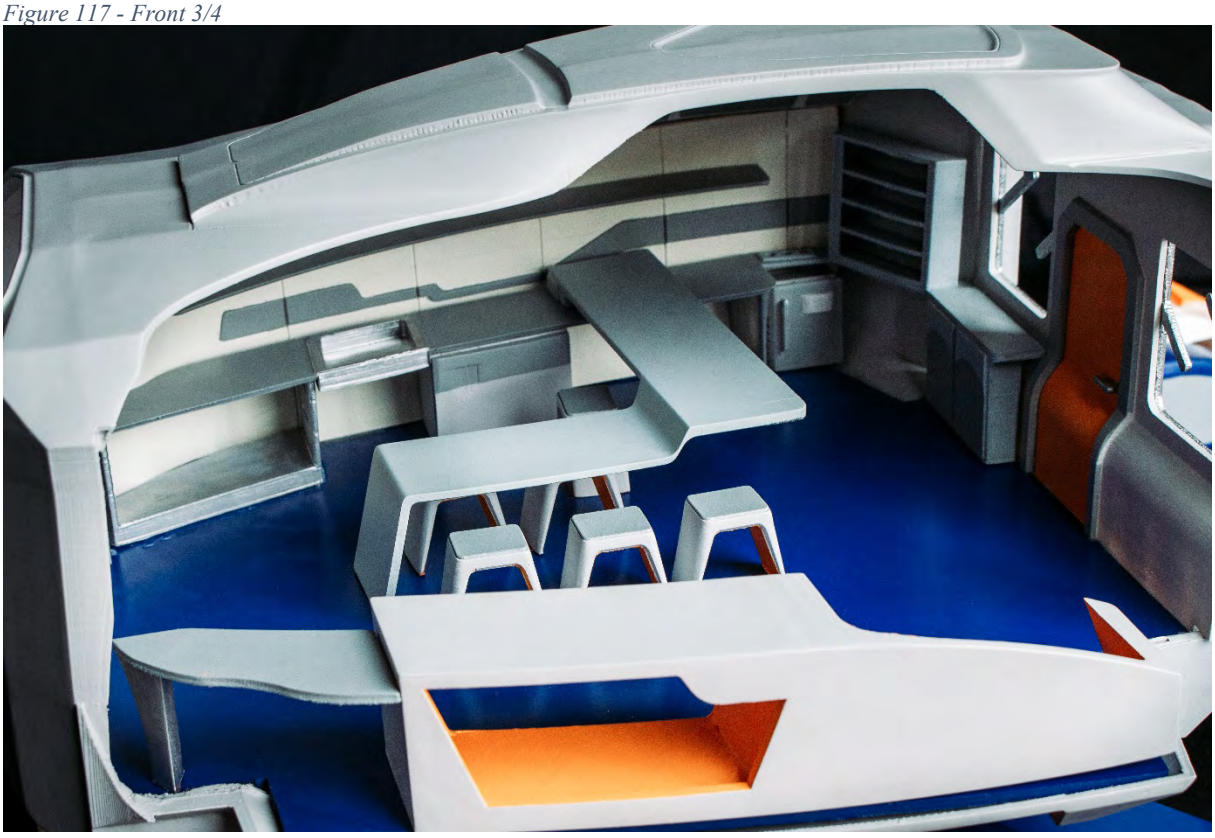


Figure 118 - Rear 3/4 Research Lab View

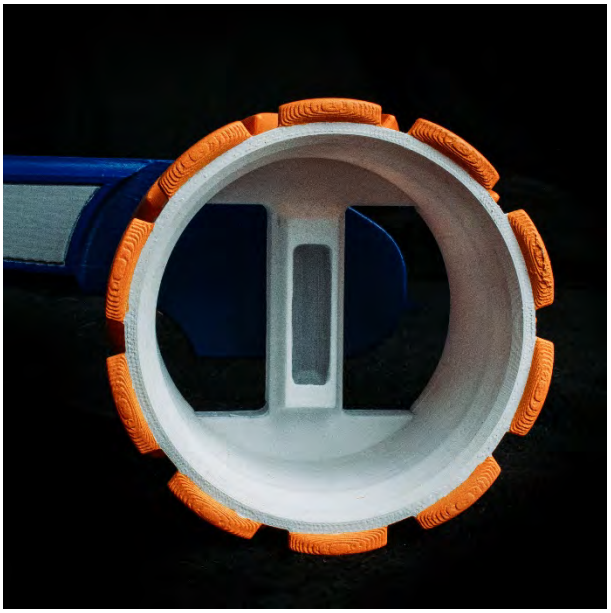


Figure 119 - Wheel Detail Photo

Figure 120 - Lower View

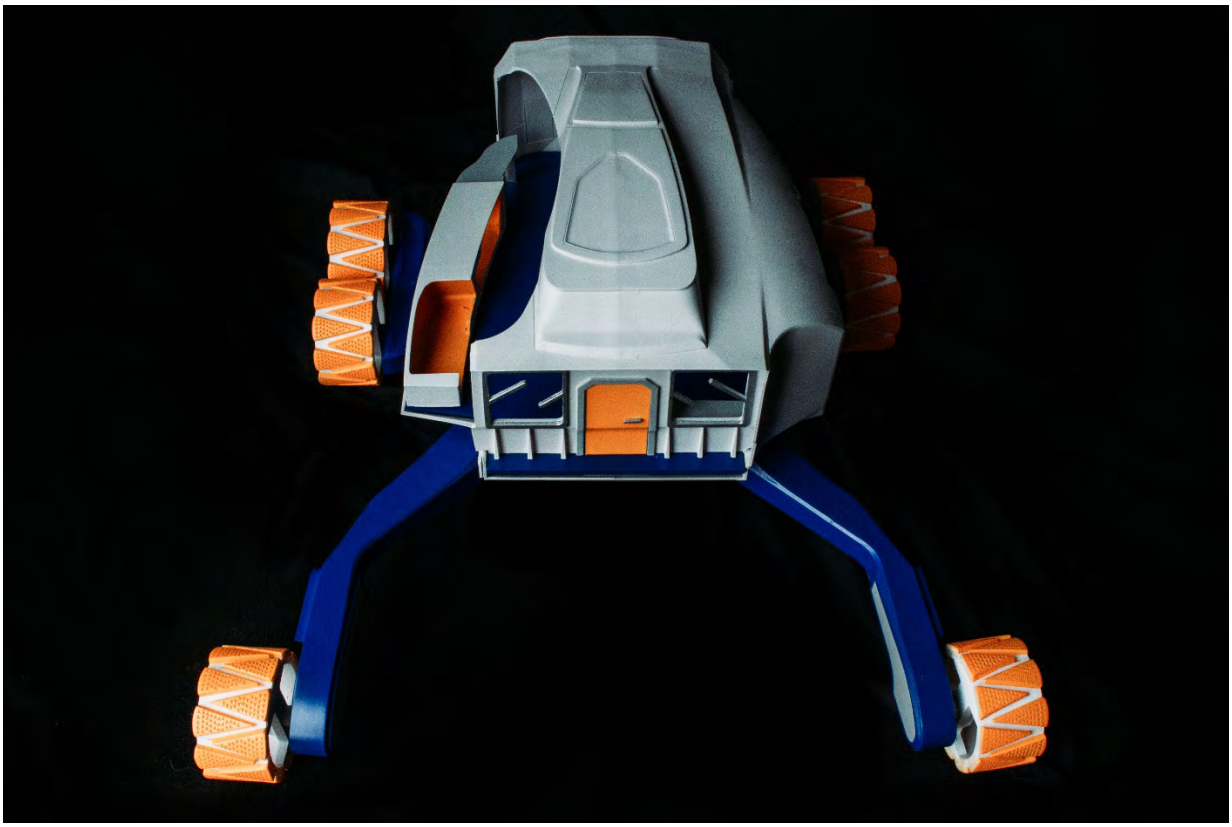


Figure 121 - Upper Perspective

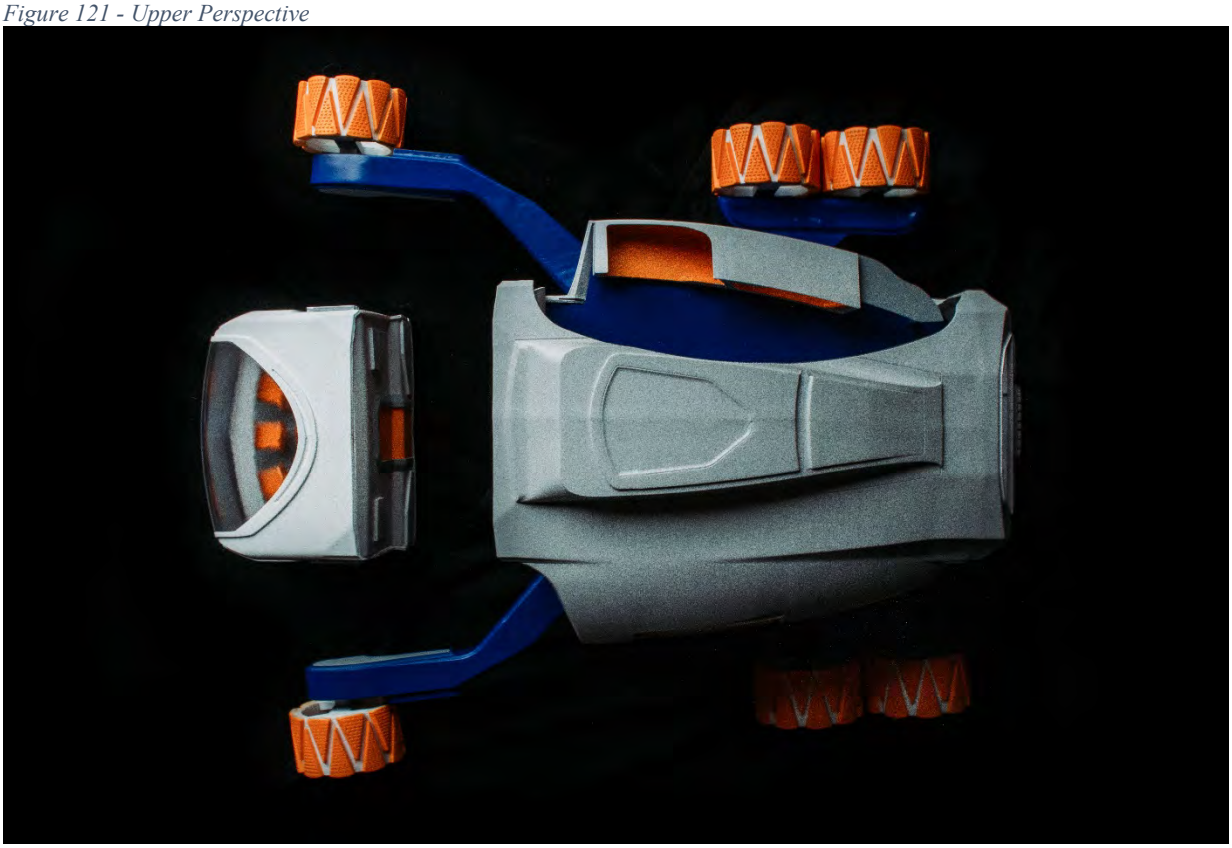
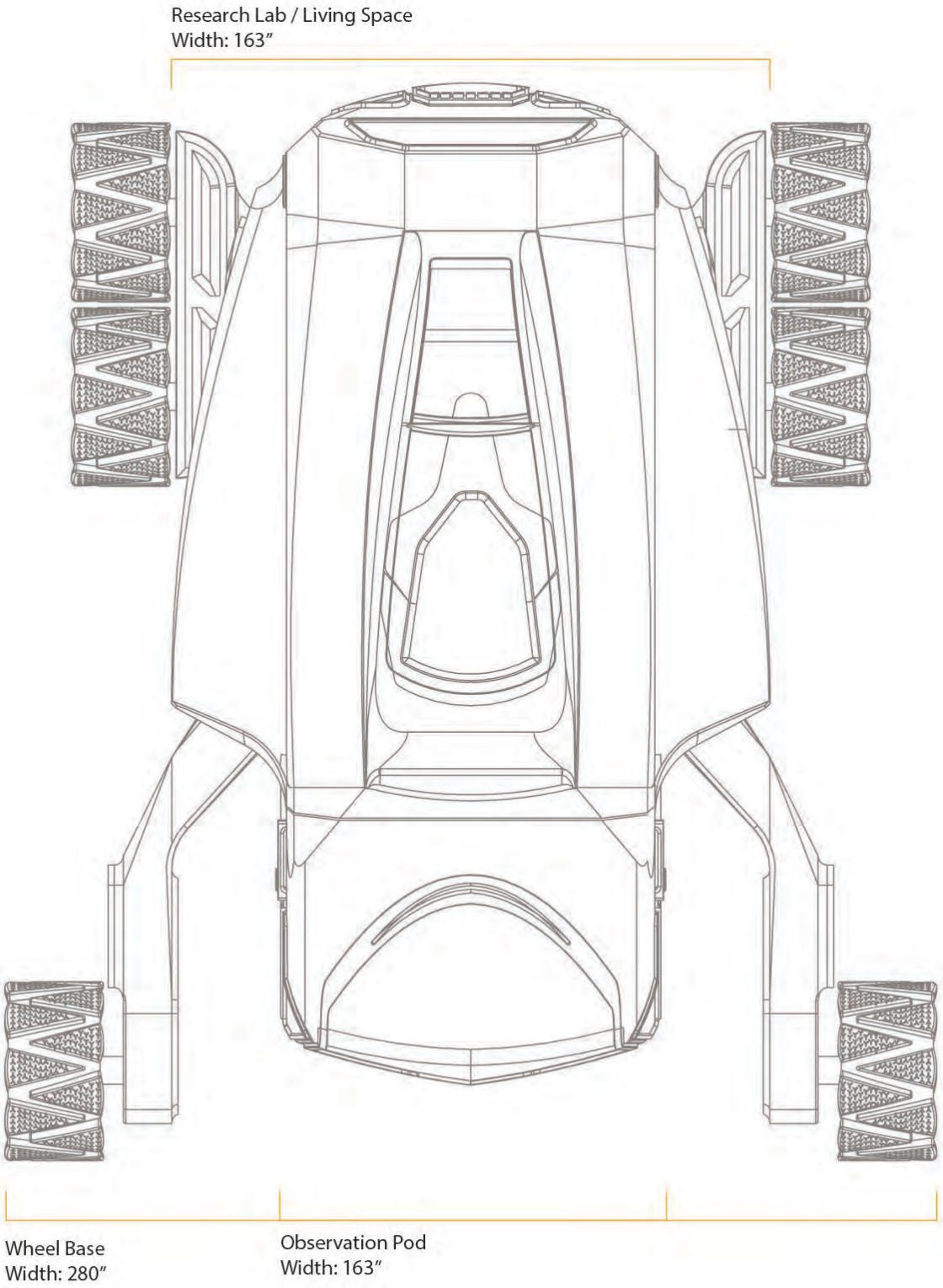
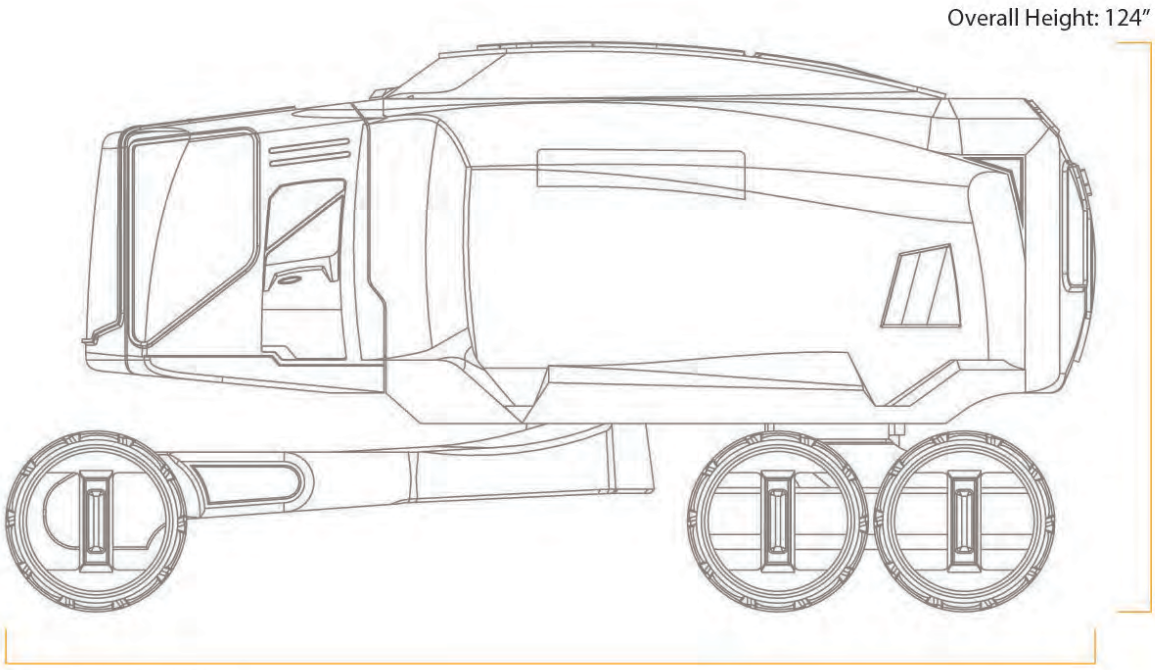
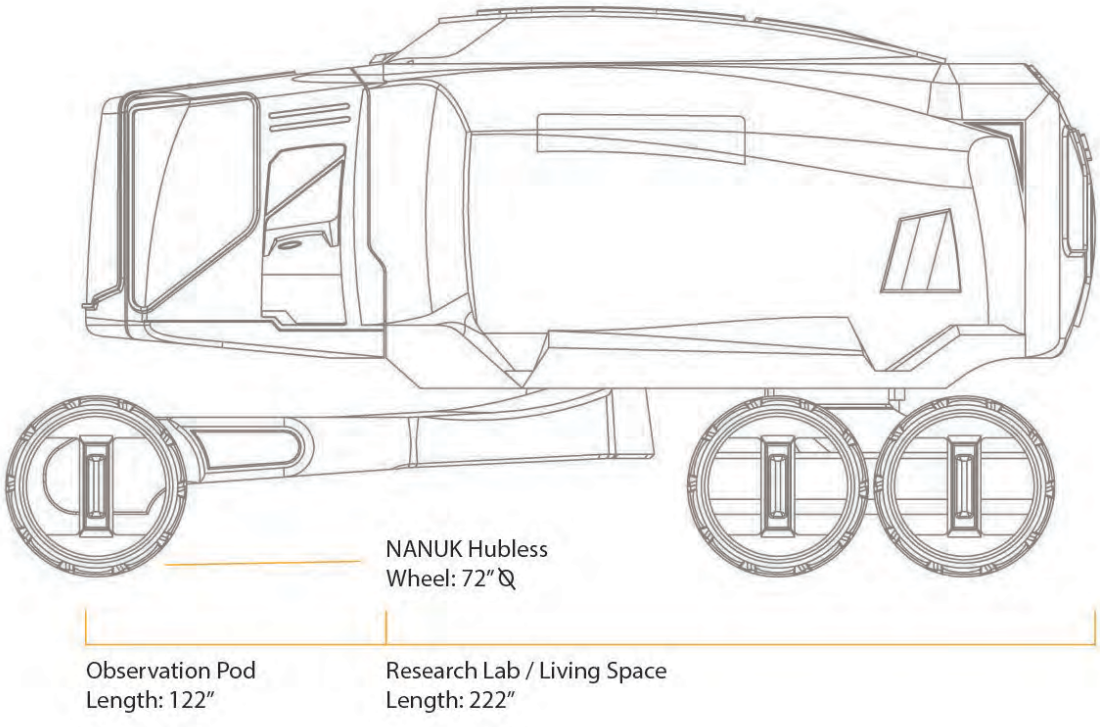


Figure 122 - Top View with observation pod

5.5TECHNICAL DRAWING




Overall Height: 124″
Overall Length: 344″


NANUK Hubless
Wheel: 72″
Observation Pod
Length: 122″
Research Lab / Living Space
Length: 222″

5.6 SUSTAINABILITY

Sustainability for the environment, materials, wildlife and humanity is crucial to the success of this thesis and the entire field of industrial design as it progresses. Without carefully considering sustainable design, the planet will become an empty well, void of resources. Within the context of this thesis, sustainability is a design element which eliminates the negative impact and gives back to the fragile ecosystem in which it operates. This design achieves that goal in every element of its design. From recycled / upcycled material use to its self sufficient ability to in its energy sources, this thesis also contributes to the understanding of Arctic marine species, particularly Polar Bears *(Ursus Maritimus)* which rely on the Arctic habitat for food, mating and their core existence.

The intent of this design is to enable productive and meaningful Arctic research, focused on preserving the fragile Arctic environment and the wildlife which call it home. Real life observation, sustainable use and a give-back environmental policy contributes to this sustainable success. As a marine biologist, their jobs are to observe and learn. Doing so in a way which is sustainable and productive is a win throughout the field.

NANUK makes use of electric batteries located at the bottom of the vehicle, allowing for optimal cooling from the environment around and through air intake vents. This natural cooling processes reduces the need for artificial coolants in the design. The use of electric power for transportation is what sets NANUK apart from other modes of Arctic transportation (helicopter, snowmobile, ice breaker) and eliminates the cost and need for maintenance of immobile field stations.

Floors, work surfaces and wall panels are produced interchangeably with the intent to upscale the design (allowing future vehicles to recycle and reuse older furniture components).

These surfaces are produced using a recycled HDPE material combined with Primaloft GOLD Insulation in the walls, where the desks use recycled HDPE from the automotive industry. The surface finish has small colored specks within it, a result of the combination of old recycled plastics used in the manufacturing process.

A solar panel is fixed to the top of the vehicle, capturing a percentage of the total power required to run the vehicle. This solar panel is able to provide power to items such as lighting, facilities in the kitchenette and bathroom as well as powering the research equipment used in the lab.

CHAPTER 6 CONCLUSION

Figure 123 - Retrieved from https://paulnicklen.com/stills/polar-bears/#!jig[1]/ML/2244

CHAPTER 6 CONCLUSION

Figure 124 - In Situ

Current Arctic marine biology research methods offer little benefit to improving the fragile nature of the Arctic environment. Effective marine biology research is inhibited by safe access to this habitat. Existing solutions provide numerous risks of damaging the environment through fuel and oil, noise pollution or incurring extreme costs of operation. NANUK is the appropriate solution to these challenges, taking advantage of a human centered approach to the design of Arctic field stations.

NANUK is a mobile research solution which adopts a human-centre design approach to be more ergonomic and considerate for the users whilst in operation. The interior of the solution is designed to be ergonomic and practically laid out, offering optimal space for conducting and

analyzing research data, ergonomic observation space and a compact yet effective living quarters.

NANUK is a solution which addresses issues of sustainability, providing users with the necessary amenities and facilities to perform the broad range of jobs which they are required to perform as Arctic researchers, thus mitigating these challenges. The concept vehicle also incorporates unique technologies and functional features which enable safely enclosed, underwater observation wherever water is present and is deep enough. Ample space has been developed to allow researchers to analyze samples, conduct their field notes and catalogue data, while also living in a simple, compact manner without the need for commuting between the field and their field station.

CHAPTER 7 REFERENCES

Figure 125 - Retrieved from https://paulnicklen.com/stills/polar-bears/#!jig[1]/ML/2246

CHAPTER 7 REFERENCES

Alvin R. Tilley, & Henry Dreyfus Associates. (2002). *The Measure of Man and Woman; Human Factors in Design* (Revised Ed). John Wiley and Sons, Inc.

[Animal Scholar]. (2018, April 8). *Arctic Research Haul – What I'm Taking Up North* [Video file]. Retrieved from https://www.youtube.com/watch?v=9a26moJZih0

Arizona State University. (2014, September 2). More than half of biology majors are women, yet gender gaps remain in science classrooms. Retrieved from https://www.sciencedaily.com/releases/2014/09/140902171429.htm

Belmonte, L. J., Ottosen, L. M., Kirkelund, G. M., Jensen, P. E., & Vestbø, A. P. (2018).

Canada, P. K. (2019, December 20). Government of Canada. Retrieved January 6, 2020, from https://www.canada.ca/en/polar-knowledge/main-research-building.html.

CareerExplorer, F. marine biologists on. (n.d.). Careers. Retrieved from https://www.careerexplorer.com/careers/marine-biologist/

Career profiles. (n.d.). Retrieved from https://www.eco.ca/career-profiles/marine-biologist/

Council of Canadian Academies. (2014). Ocean science in Canada: Meeting the challenge, seizing the opportunity.

[Eric Jorda]. (2016, May 18). *AB-202 Marine Arctic Biology Helmer Hanssen scientific cruise UNIS 2016* [Video file]. Retrieved from https://www.youtube.com/watch?v=QY4Q6wbv90E

Feng, L., Yan, Z., Shi, X., & Sultonzoda, F. (2018). Anti-icing/frosting and self-cleaning performance of superhydrophobic aluminum alloys. *Applied Physics A*, *124*(2). doi: 10.1007/s00339-017-1509-x

Gallone, T., & Zeni-Guido, A. (2019, March 1). Directory of Open Access Journals. Retrieved January 31, 2020, from https://doaj.org/article/e02e60c7062e4f3f8234f94404b4d846

Getting ready for science on ice. (2019, August 19). Retrieved from https://www.arm.gov/news/features/post/55857

HOIZ- Hobelspandämmung/ Wood Shavings Insulation. (n.d.). Retrieved January 31, 2020, from https://www.c2ccertified.org/products/scorecard/insulation-material-baufritz-gmbh-co-kg-seit-1896

How to Choose Fill Power. (n.d.). Retrieved January 31, 2020, from https://www.downandfeathercompany.com/pages/how-to-choose-fill-power

Kappen, D., Thomson, B., & Burke, P. (2018). Industrial Design Thesis Terminologies: Full-Bodied Human-Interaction Design. In *Industrial Design Thesis Terminologies* (pp. 1–3). Toronto.

Laidre, K. (2018, September 3). Marine Mammal Biologist Kristine Laidre: Video Transcript: Ocean Exploration Careers: NOAA Office of Ocean Exploration and Research. Retrieved from https://oceanexplorer.noaa.gov/edu/oceanage/06laidre/transcript.html

Lauren's Marine Biology Blog - internship in the Maldives. (2017, March 19). Retrieved from http://marinesavers.com/2015/12/laurens-marine-biology-blog/

Levinton, J. (2003, December 13). SOME COMMON QUESTIONS ABOUT A MARINE BIOLOGY CAREER. Retrieved from https://life.bio.sunysb.edu/marinebio/mycareer.html

L. Peichl, R.R. Dubielzig, A. Kübber–Heiss, C. Schubert, P.K. Ahnelt; Retinal Cone Types in Brown Bears and the Polar Bear Indicate Dichromatic Color Vision . *Invest. Ophthalmol. Vis. Sci.* 2005;46(13):4539. Retrieved January 31, 2020, doi: https://doi.org/.

Marine biologist. (n.d.). Retrieved from https://www.eco.ca/career-profiles/marine-biologist/

Marine Biology & Biological Oceonography. (n.d.). Retrieved from https://datausa.io/profile/cip/marine-biology-biological-oceonography

McDuff, R. (n.d.). Demographics of Ocean Science Graduate Programs Some Long Term Perspectives [PDF File]. Retrieved from http://oceanleadership.org/wp-content/uploads/Demographics-of-Ocean-Science-Graduate-Programs.pdf

[MercerReport]. (2009, March 10). *RMR: Bear Tagging* [Video file]. Retrieved from https://www.youtube.com/watch?v=vJRDpTUIrJI

Moana, K. K. (2019, August 12). Marine Biologist. Retrieved from https://www.careers.govt.nz/jobs-database/science/science/marine-biologist/

PrimaLoft® Insulation. (n.d.). Retrieved January 31, 2020, from https://www.patagonia.com/primaloft.html

Sciullo, L. (2017). John Wiley and Sons. Retrieved from https://yorkspace.library.yorku.ca/xmlui/bitstream/handle/10315/34473/Sciullo_Luana_2017_PhD.pdf?sequence=2&isAllowed=y

Sciullo, L. (2016, November 3). Researcher Luana is Finding Out What Arctic Sea Ice Loss Means for Polar Bears: Earth Rangers Wild Wire Blog. Retrieved from https://www.earthrangers.com/wildwire/take-action/researcher-luana-is-finding-out-what-arctic-sea-ice-loss-means-for-polar-bears/

Sciullo, L., Thiemann, G. W., Lunn, N. J., & Ferguson, S. H. (2017). Intraspecific and temporal variability in the diet composition of female polar bears in a seasonal sea ice regime. *Arctic Science*, 672–688. Retrieved January 31, 2020, doi: https://doi.org/10.1139/as-2017-0004

Screening of heavy metal containing waste types for use as raw material in arctic clay based bricks. *Environmental Science and Pollution Research International, 25*(33), 32831-32843. doi:http://dx.doi.org.ezproxy.humber.ca/10.1007/s11356-016-8040-z

Shmoop Editorial Team. (2008, November 11). Marine Biologist: Typical Day. Retrieved from https://www.shmoop.com/careers/marine-biologist/typical-day.html

Stewart, A., deYoung, B., Smit, M., Donaldson, K., Reedman, A., Bastien, A., Whoriskey, F. (2019). The development of a canadian integrated ocean observing system (CIOOS). Frontiers in Marine Science, doi:http://dx.doi.org.ezproxy.humber.ca/10.3389/fmars.2019.00431

Stirling, I., & Derocher, A. (1993). Possible Impacts of Climatic Warming on Polar Bears. *Arctic, 46*(3), 240-245. Retrieved February 3, 2020, from www.jstor.org/stable/40511411

Tang, W., Santare, M. H., & Advani, S. G. (2003, October 15). Melt processing and mechanical property characterization of multi-walled carbon nanotube/high density polyethylene (MWNT/HDPE) composite films. Retrieved January 31, 2020, from https://www.sciencedirect.com/science/article/abs/pii/S0008622303003877

Tarp. (n.d.). Vapex Wall Tent ~Traditional Arctic Grade Wall Tents. Retrieved January 31, 2020, from http://alaskatent.com/walltents/vapex.html

Teknion. (2017). *The True Measure Of A Space Is How It Makes Us Feel.* Toronto: Teknion.

[US Fish and Wildlife Service]. (2011, May 24). *Polar Bear Research on the Chukchi Sea.* [Video File]. Retrieved from https://www.youtube.com/watch?v=8iN7mC-aUpg

What is a Marine Biologist? (n.d.). Retrieved from https://www.environmentalscience.org/career/marine-biologist

Which Elastomer Offers The Best Low Temperature Flexibility? (n.d.). Retrieved January 31, 2020, from https://www.wcrp.uk.com/technical/material-selection/which-elastomer-offers-the-best-low-temperature-flexibility/

CHAPTER 8 APPENDIX

APPENDIX A – DISCOVERY

A key article for this topic was sourced and selected. Required article content (Abstract, Introduction, and Conclusion sections) was copied and highlighted.

Search Engine: Humber Library Discover

Keywords used in search: Oceanic Research Challenges Canada

Findings:

Citation: Stewart, A., deYoung, B., Smit, M., Donaldson, K., Reedman, A., Bastien, A., Whoriskey, F. (2019). The development of a canadian integrated ocean observing system (CIOOS). Frontiers in Marine Science, doi:http://dx.doi.org.ezproxy.humber.ca/10.3389/fmars.2019.00431

Key Content: is reproduced below.

Summary Statements:

1. Canada faces increasing demand for oceanographic data to support sustainable growth and address issues stemming from a changing ocean and needs a national data system to meet that demand.
2. Expert Panel on Canadian Ocean Science 2013 report that identified poor coordination as a current fundamental weakness of Canadian marine science and the need for national governance structures to integrate existing regional efforts.
3. Until now Canada has lacked a national vision and strategy for coordinated ocean observation, resulting in overlaps and gaps in our observation activities, from collection to sharing and interpreting data.
4. Aside from building comprehensive ocean observatories (Fisheries and Oceans Canada (DFO) et al. 2010), there is no easy mechanism to integrate the large amounts of data from the various sources or to explore interrelationships among variables, and no coordination and collaboration mechanism for the ocean community as a whole to generate an efficient system (Ocean Science and Technology Partnership (OSTP), for Fisheries and Oceans Canada (DFO) 2011).
5. Canada has the largest coastline of any nation in the world (244,000 km) along three ocean basins – Pacific, Arctic, and Atlantic. It has two major inland Seas, the Gulf of St. Lawrence, Hudson Bay, and the Laurentian Great Lakes. These waters are important to Canadians, serving as the backbone for the socio-economic well-being of Canada's coastal communities.
6. The world's oceans are a critical component of the Earth system. Sound knowledge and understanding of the ocean is essential to mitigate human impacts on the global environment and to promote the ocean's sustainable use. Effective ocean management depends on observations of the ocean, which are generated by existing national or regional ocean observing systems and networks.

Professional Interview-Luana Sciullo

The first interview for this thesis, in understanding and mitigating challenges faced by marine biologists in the Canadian Arctic, Luana Sciullo, PhD was contacted. Luana is experienced in Arctic and Sub-Arctic research methods, with experience studying polar bears in Western Hudson's Bay.

2019-20 Industrial Design Thesis Project

HUMBER

Informed Consent Form

Research Study Topic : Marine Biology Arctic Research Study
Investigator : Dylan Torraville
Course : iDSN 4002/iDSN 4502

I, __Luana Sciullo_____, have carefully read the Information Letter for the project ***Marine Biology Arctic Research Study***. A member of the research team has explained the project to me and has answered all of my questions about it.

I understand that if I have additional questions about the project, I can contact **Dylan** via email **djtaug@outlook.com** at any time during the project. I understand that this course has been approved by the Humber Research Ethics Board.

- ✓ I hereby give consent to have my voice recorded
- ✓ I hereby give consent to have photographs taken with the proviso that my identity will be blurred in reports and publications
- ✓ I hereby give consent to have videos taken with the proviso that my identity will be blurred in reports and publications

Consent for Publication: Add a (X) mark in one of the columns for each activity

Activity		Yes	No
Publication	I give consent for publication of data with privacy and confidentiality maintained in the Humber Digital Library which is an Open Access platform	X	☐
Review	I give consent for review by the Professor	X	☐

Withdrawal:

- ✓ I also understand that I may decline or withdraw from participation at any time without negative consequences.

Privacy:
All data gathered is stored anonymously and kept confidential. Only the researcher

Mr. Dylan Torraville and Prof. Catherine Chong may access and analyze the data. All published data will be coded, so that visual data is not identifiable. Pseudonyms will be used to quote a participant (subject) and data would be aggregated.

My signature below verifies that I have received a copy of the Information Letter, and that I agree to participate in the research project as it has been described in the Information Letter.

Signature : _____

Participants Name : Luana Sciullo

2019-20 Industrial Design Thesis Project

HUMBER

Verification of having read the informed consent form:

☑ I have read the informed consent letter

I, Luana Sciullo *(First Name, Last Name, Signature)*, have read this document and give consent to the use of the data from questionnaires and interviews in research reports, publications (if any) and presentations with the proviso that my identity will not be disclosed.

Signature : _____

Participants Name : Luana Sciullo

Humber Research Ethics Board

This course has been approved by the Humber Research Ethics Board.

If you have any questions about your rights as a research participant, please contact Dr. Darren Lawless, REB Chair, 416-675-6622 ext. 3226, darren.lawless@humber.ca.

Project Information

Thank you very much for your time and help in making this study possible. If you have any queries or wish to know more, please contact me at Ph: ***289-879-1334***, email: ***djtaug@outlook.com***

My supervisors are:

Prof. Catherine Chong, catherine.chong@humber.ca, 416 675 6622 xt. 4672

Name		Email	Basis of expertise
***Luana Sciullo*, PhD**		Luana.sciullo@humber.ca	Polar bear foraging ecology Environmental Science and Ecology

Method

Questions were prepared in advance to the interview. These questions are aimed towards gaining unique individual insight from personal experience working in Arctic environments, interacting with Arctic wildlife and conducting biological research. In the context of this interview, questions were specified towards the interviewee and her own unique work and background.

The questions are asked in a simple, conversation style between the interviewer and the interviewee, Luana Sciullo. In some instances, the exact phrasing of these interview questions was changed within the context of the situation, and additional questions were asked. In the following transcript, the questions are highlighted using green text, key takeaway points are highlighted using yellow text.

This transcript is not 100% accurate to actual words spoken during the interview. These minor variances are due to limits of the transcription software. This transcript was generated from the original .WAV file, processed using Adobe Audition and transcribed using Otter.ai.

Dylan Torraville 0:00
This is Dylan Torraville, industrial design student. The date is October 1 and I'm sitting with Lou on a scale though, to do an industrial design thesis project interview, and Luana, I would just like you to confirm that you're aware that this is being recorded.

Luana Sciullo 0:16
Yes, I am aware it's

Dylan Torraville 0:18
cool. Like I said before, I don't want it to be too interviewee like, I like to keep it more of a conversation.

I just think it's easier for for you and for myself, basically, just trying to understand stuff related to Arctic research, transportation, logistics, how you get out there and what exactly it is you're doing. So you taught environmental science, you taught me the elective last year, and I guess the fall semester of 20 2018. Yes. And I believe you had just finished your doctorate and I guess you would finish out the year before, right.

Yeah. And that was around polar bear forging ecology and Western Hudson.

Bay. If I'm correct, the first the first thing that I would kind of want to uncover is why you decided to pursue a career in environmental science or that realm in the first place.

Luana Sciullo 1:11
Environmental Science or ecology, I would say has been my background since undergrad. And I feel that probably in my teenage years, I don't even know how it came to be. But I was super fascinated with mammals like marine mammals, specifically, the top predator type of marine mammals that you see killer whales or will large body, marine species.

Most of the work before that was always ecology related, but it had been targeted to fresh water systems, just because that's what research was available in Ontario. And we did some in cottage country area. And then for my master's, it was less freshwater, more Marine, but I was still sort of at the bottom of the food web, we were studying in vertebrate communities, Holly moved between fossilized coral reefs. But originally I was I'm very much like a top predator, marine mammal, interested researcher. Just because I think in my undergrad learning more about how food webs are connected and how ecosystems are structured, there is a lot of power or influence on a top predator on the structure of the rest of the food web. So I found that to be like, pretty interesting, where how these top down effects happen with one apex predator, right, the PhD was, I feel like super serendipity how that worked, because my supervisor had just started at York, about a year or year and a half before that. So it's a brand new lab, and they were looking for students. So that was very much serendipity. Because you can imagine how difficult it is to get involved in research on polar bears today, when it's such a hot. It's a hot topic. Yeah. So that was just pure luck. I don't I don't know how that happened. And then that PhD lasted a few years. And we did like several fields seasons. But even more than just polar bear research, or it was it was a polar bear thesis, but it revolved around this very sensitive ecosystem, which was the Arctic, and how most of the things that we're seeing with the impacts of climate change were heightened in that environment versus other ones. It's evident everywhere. It was just in the Arctic, it's much more profound, the changes that we've seen at a rapid rate compared to other ecosystems, like tropical rainforest, for example.

Dylan Torraville 3:29
Why do you think that is? Maybe sensitive is the right word, as opposed to, say the Amazon.

Luana Sciullo 3:36
So a couple things. First, the food webs in the Arctic are not that complex. Like there, there are many species involved, but they're much more simplified than something like tropical rainforests where there's so many more species, the web is highly connected. So if there was a species affected, it would actually affect other things. But the shift wouldn't be as true Matic as if we had affected one species in a relatively simple unbranded food web from the Arctic. So there's fewer species, they're more reliant on predictable patterns of like, sea ice melt and freeze up snow cover. And most of their life history absolutely relies on those predictable patterns, like the sea ice to freeze in November. So by December, there has to be ice there for the bears to come out of the dens and like and go look for food. So they're much more particular on on small environmental shifts, and the food webs are less complex. So if there was something that suddenly decreased in abundance, in population size, something else would have to respond to that pretty dramatically.

Dylan Torraville 4:47
That makes sense. Because I guess you've got, say, tend to the nth number of species living in the Amazon. And like half of them, we don't even know what they are, because they haven't been discovered. But whereas the Arctic is more limited, per se,

Luana Sciullo 5:02
yeah, there's much fewer species in the like a tropical rainforest.

And there's a lot of very particular top level species like a high traffic levels, for example, like polar bears, some whales species seals that rely on the things at the bottom of this food web to be present when they need them. Rich populations.

Dylan Torraville 5:25
Yeah. Okay. Makes sense.

And you mentioned that you had done your, your thesis or your PhD revolved around polar bears, and in a, in a way, yeah, I remember the first day we had class, you were telling us how you were giving us kind of a background on yourself. And you showed us the photo of you holding a polar bear cub? Can you tell me how you ended up in that situation holding a polar bear cub? Like, what was that story that so

Luana Sciullo 5:54
So we have two fields, seasons, ones in the fall ones in the winter? We do, I guess like aerial surveys. So we're looking for where these individuals are in the fall versus the winter, if they're there in the father in a full fasting season, or females are pregnant, if in there in the winter, they're usually already heading out on the sea is mainly the males. The only ones left on land, or the females with cubs that have just come out of the maternity dens. So the Cubs would have been born, let's say December, maybe early January, or let's say December, because by the time they come out in February, there may be a couple months old, they wouldn't be able to survive before that period, they're just too, there's not much body fat, they're very dependent on more in the den. So when we see them in February, these are females who have just birthed cubs, and they're going on to the sea ice to forge. So in the same work that we do that we did in the fall, which is to look at polar bear body condition, diet, we do those the females in the winter, so we still dark them. And we collect like more for metric measurements like lengthen girth, and mass, we take the fat sample of the females to look at diet composition. And we do this and we measure more for metrics on the comes, we don't take the fat sample, because they're too small at that point. But we just measure sort of weight and girth. And we keep track of these individuals in like a huge database that monitors that your tags we place on them.v If we've caught her like last year did she have comes last year? So we're sort of keeping track of the same individuals many years in a row and see sort of how they change over time? Like has their diet changed as their body condition changed? Did they have comes two years ago or not? And that sort of thing.

Dylan Torraville 7:46
So the fast samples and the darting you call that? Is that? Is that done through like an air rifle? The gardening aspect of things?

Luana Sciullo 7:53
Yeah, so our supervisor did that. At environment, Canada, it's a sedative. It's called TELUS all that is administered from the air based on like her size or his size and mass, which is done like from years of experience at using that particular tranquilizer. The students don't do that. It's sort of just the supervisor doing it. And then once we have her, she's just sort of sleeping for about half an hour to 40 minutes. And we take all those measurements in that time spend and that sort of wait to see her get up and then we keep looking.

Dylan Torraville 8:34
And then fat samples. How do you how do you go about collecting a fat sample from a polar bear?

Luana Sciullo 8:38
Yeah, so it's a small biopsy punch that you take from the rump, the rump generally has the largest layer of severe subcutaneous fat, flat surface fat just under the skin. It's, I think it's like a six millimeter sample. And it would give you the call, like just a, like a shallow column of the superficial fat layer, then that's what you took to the lab and looked at fatty acid analysis to model diet from

Dylan Torraville 9:05
right. And then the lab that you take that too is that where's that lab located? Is that close to you guys? Or

Luana Sciullo 9:11
so the lab? Will we actually officially process and extract that little bit of fatty acids that's at the university? In the time that we're doing field research, we're just storing those in the freezer,

Dylan Torraville 9:22
right? Just keep them as cold as possible. And then nothing, nothing changes from there.

Luana Sciullo 9:27
Yeah, yeah, exactly.

Dylan Torraville 9:28
You guys ever looked at blood from large mammals like that, like take blood samples?

Luana Sciullo 9:32
Right? There has been other studies, I can't recall exactly when I believe it would be for things like contaminants, but they also use skin and hair for contaminant samples. I've never done any research into that or take taking blood samples that usually use a

veterinarian to take the blood sample in the field, which is a bit more tricky. But I'm not working with blood in the sense of like contaminants or anything, right?

Dylan Torraville 9:58
That's right. And when you're doing this, when you're going out, you're flying around trying to find these polar bears, what is at least in your experience, what's the the main issue that you've had, like the the main roadblock or point of resistance, something that's maybe caused a delay or,

Luana Sciullo 10:15
and I would say whether Yeah, because especially this fall is actually lovely, it's can be 20 degrees, 22 degrees, it's beautiful, it's dry, and you could go anywhere you want in the winter, especially if it's February, every day is up in the air if it's too late, sometimes fog or snowfall, so whatever would reduce visibility, if it's not a safe situation, and we have a very rigid range, we don't like to gamble too much with weather will go out that day. So that means a lot of the time or good chunk of the time in the in the winter, is sitting around waiting for a nice day that it's not super cold, the visibility is good, because even if it's too cold, sometimes with the Windchill, like minus 40 degrees, we don't even want to do work on bears in that environment. Because the other Arctic species, but they are like just as especially cancer as easily at risk of that kind of temperatures where

Dylan Torraville 11:17
Yeah, and you don't want to be putting putting them asleep in that.

Luana Sciullo 11:20
Yeah, exactly. Those kinds of conditions.

Dylan Torraville 11:21
Yeah, say it's a stretch of bad weather for three or four days. And you can't leave wherever you are, what do you what are you doing in that? That time period.

Luana Sciullo 11:31
Um, so it's a great field to station that we were at, but it's just, you know, you had you just hang around, I didn't usually worked on my own thesis. There's tons of volunteers there as well as other researchers. So sometimes you're helping other people out or just socializing. But it's really sometimes hunkering down in really bad weather for a couple of days in a row and just waiting it out. Yeah, but it's a phenomenal Field Station. It was like, five star field station compared to some more remote periods that are have like less space.

Dylan Torraville 12:04
Yeah, yeah. So where was was this? The Field Station? Was that in Churchill? Yeah.

Okay. So you weren't? You weren't too far away? Was that still sub-arctic? Technically? Yeah.

Luana Sciullo 12:15
Okay.

Dylan Torraville 12:17
So go building off that, because that's, that's kind of interesting how you're like in bad weather. You're just in there, just waiting for good weather to happen. Yeah, on a good day, when you're able to go out and you're able to say, okay, we're going to go it's like perfect weather ideal conditions. What does a day in the life of, say, an Arctic, an arctic researcher, what does that kind of look like from, say, you went visit waking up at a particular time, or like everybody getting up?

Luana Sciullo 12:47
well, it started probably started, our supervisor in the field was the first person and he's constantly checking the forecasts, like, the night before and the day before monitoring, and he makes the call in the morning, whether it's a good day or not, on average, I think, the whoever was going, and there's only a handful of people, because the helicopters can't see that many. So it's probably four of us at time, maybe five, I think usually for we all just sort of get up in the morning regular, like 730 or so have breakfast meet at breakfast, to discuss, what are the kinds of things he sees in the forecast, if it's a day that we should go out. And if it's looking great, within the hour, we're just sort of packed up in the gears already set the night before, I mean, every time at the end of the day, when we come back, it was a sort of like a clean up reset of like materials that you need. So it was prep for whatever that next day was, whether it's tomorrow or two days from now. So the Get ready is only maybe like an hour or so. And then we the he calls into the pilot who's not at the Field Station is just in the town. He comes over with helicopter and then we head in and

head out. And most of the time in the air is finding individually in the fall, it's a lot easier because they're all on shore. In the winter, it's more tricky because Well, for one, they're white and this landscapes all white, and it's only females that were looking for. So there's obviously not as many available right in plain sight. So you're searching for a bit longer than you would in the fall.

Dylan Torraville 14:19
Right. And how long How long is a trip like a you say take a helicopter? How long is the trip from leaving the field station to finding or getting in range of where a polar bear might be?

Luana Sciullo 14:34
It's not a far flight, I would say maybe like half an hour, right, is that the Study Center is right on the cusp of will plus National Park. So and that's where we search. So it's not like we're flying hours and hours to get to their habitat. That's exactly where they are. So we're not very far down to maybe half of them.

Dylan Torraville 14:54
Okay. And then does the helicopter just kind of wait somewhere farther away? Well, you guys get off go do whatever it is you have to do if you find a bear.

Luana Sciullo 15:04
Yeah. So when the helicopter land, it's close enough that we could run over and walk over to the bear. And that's where the helicopter hangs out until we're done. And then we head back and we just kind of wait to see them wake up from there. And then we can hit back Go.

Dylan Torraville 15:18
Right. And are you are you waiting in like how close of a proximity Are you guys waiting to awaking polar bear?

Luana Sciullo 15:26
Ah, I think very long, maybe like 10 to 15 minutes? Well, we can see like the heads up and then they start going on their front paws. They're just looking at that's the kind of wake up now we're looking for that it was sort of like the smooth transition out of sleep

Dylan Torraville 15:41
coming kind of back to consciousness is aware of what's going on? Yes, yeah. Yeah.

Dylan Torraville 15:45
Are you guys close? Are you guys like, say 20 feet apart? Or a bit more distance

Luana Sciullo 15:51
to maybe like

I'm trying to gauge in terms of feet, which I'm not very good at?

Dylan Torraville 16:00
Yeah, maybe I just do 20 feet.

Luana Sciullo 16:02
I'm trying to think if it's like hallway to hallway, maybe like two hallways long.

Dylan Torraville 16:07
Okay. So a considerable distance. Yeah.

Luana Sciullo 16:10
Yeah, we could see. But we're, we're sitting in the helicopter at that time. Yeah. So it's not that there's any kind of risk for us hanging?

Dylan Torraville 16:18
Right. Have you ever been in a situation near a polar bear, where you've been scared?

Luana Sciullo 16:24

No, no, no, no, there's such a I feel like there's such a tremendous safety buffer that there that we always ensure exist so that there isn't ever been like, Oh, my God, this is too close now.

Dylan Torraville 16:35
Yeah. Okay, that's fair. So, you've got the Day in the Life thing sorted out? Do you do the research? How many? How many bears? Would you do in a day? If possible? Is it kind of as many as you can locate?

Luana Sciullo 16:49
Yeah, I will say as many as we could locate within, like, reasonable conditions, nice weather, especially the fall.

Luana Sciullo 16:57
My goodness, I can't recall, maybe

Luana Sciullo 17:01
maybe less than 10 individuals or 10 individuals in a day.

I think it just depends on where we are, if you're at the shore, near the shore, that's where most individuals are like, a lot of the males hang out there. So it's much easier to find them as opposed to if we go inland, where we find females, there be they'd be much more spaced out. So we'll be flying

Dylan Torraville 17:23
longer looking right. So any reason why a female would tend to be more inland than male on the shore?

Luana Sciullo 17:29
Yeah, so she's going inland, in theory to den, so she uses maternity dens that are made out of like piles of dirt that she then borrows in. So she moves inland to do that. And also they like to if they did have come such they will be much bigger by the fall. They like to move away from the shoreline because that's where the males tend to congregate. And they don't mean the males are not involved in rearing and come so there it would be to minimize conflict. And ha like a female male comes right?

Dylan Torraville 18:02
Yeah, I've seen like all the planet or some the Arctic tail. I know it's not a great dynamic between the cubs and the grown male. Yeah, this is this is an interesting question that I'm kind of excited to just to get your opinion on a first relation to the thesis, but be because it's something that I'm quite interested in general. And I'd like rewrite it a bunch of times to figure out the best wording. But how would you best describe the importance of Arctic research?

Luana Sciullo 18:38
I would, I would say, Arctic research is probably important on a global level, like with respect to global ecosystems, as well as global climate because a lot of climate moderation. And what's happening in terms of precipitation and humidity and temperature elsewhere on Earth, especially in the ocean, is influenced by what's happening in the Arctic, like ocean currents and salinity and temperatures. And this huge sort of flux of cold water, warm water is moderate what's happening in the Arctic. So aside from the species, which are tremendously important in terms of how climate in Arctic ecosystem, regulates, global climate, is extremely important. We studied one species in the Arctic, that is an entire ecosystem that influences ecosystems everywhere on Earth, especially oceans and climate.

Dylan Torraville 19:35
Yeah. Because we I was in I was in Newfoundland, like northern Finland. This is going on 12, maybe 13 years ago, and where it's on an island in Newfoundland called fuego Island. And right at the top, talk most like the northernmost point of the island, it's only like 40 kilometers across. We're up there because my dad grew up there. And we're on the top of this little mountain ridge that's maybe 75 meters above sea level. And you look at we're looking at right onto the ocean and the next closest land is here. So the Greenland after that. And just humpback whales was all swimming, swimming through and then we've been back there about five times since and haven't seen a single one. Which is it's I think it's kind of testament to how things are changing.

Luana Sciullo 20:30
Yeah. There's like the North Atlantic right well, and it gets super endangered I remember I did a field field isn't I took a field course there in my undergrad was called marine mammals and seabirds in out of, again, super serendipity. We were on a boat looking at seals, because there was a lot of them. And there was like four or five, right whales, not breaching they were just certain like breaking the water. But that was super rare, because those are like a handful of individuals left in the North Atlantic. I hadn't been. I haven't been. I have been back to the Maritimes. But we haven't been sorted out on the water, like almost whale

watching boats or anything. But at the time, this was well over a decade ago of maybe 15 years. That was a very endangered, like endangered species that was very unlikely to see multiple individuals in one spot. But I imagine that kind of event doesn't happen super often. Yeah.
Was there any times where you felt say homesick or frustrated at the weather? Because you're here you're trying to do your PhD, you want to get out? Do productive research, you want to contribute? But you can't because it's snowing too much outside? What was what was dealing with that like?

Luana Sciullo 28:09
yeah, maybe in the world, the winter, we call it like the spring season, but the winter is when maybe the most time was sitting around. I felt like I was a student. And the thing was with me I was I had fixed seal field seasons I would attend before I had to cut off the year of collection so that you could analyze all that data and right, because if I kept doing filters until the very end, it would give me enough time to do all full analysis and then write the thesis. So I knew that I would be doing filters. And to a certain point. Ideally, I wanted as much data as I could put into that pool. And it was a little bit frustrating probably when we you know, it's it's research that you know, is surely important to do you want to get more information, but you're only limited to what the weather is allowing you to do. So that's always frustrating, because it's completely out of your control. It's not that I didn't have enough funding, or there's not enough fuel we had all of those things it was waiting for the weather to clear out is completely out of your hands. Like what are you going to do? You could just sit there and grumble about it. Yeah. But there's there wasn't much other than that. So there, it was a little bit annoying. But for me, it was like it was completely out of any of our hands. It wasn't that someone didn't do the things that they were supposed to do. And that's why we're not going out. And homesick on average. No, I never really felt that because the there was like fantastic people, students, volunteers, researchers at the fields station, it was always a very great environment to even just hang out and even if you were doing any your work or research or maybe if it was someplace that was more remote for me and maybe there's only like four of us and it's only as four and nobody's around for miles that probably would have been difficult for the way my personal Alan naturist but the field season it was start Field Station, it was always like, there was field courses going on, there was like a Northern Lights course, there would be I we, I could sit in on those classes. And just learn about like astronomy and the Northern Lights, or they go out at night when the actual Northern Lights would be going on. And everyone would have these huge like cameras with these lenses. And everyone was it was freezing, like minus 35 degrees. But everybody was out there. And they're like whole parka with their cameras, like taking shots in the northern lights. And then one year there was like a solar flare or something that made more colors come out of the lights, then on an average year. So I feel just like very lucky to be in that environment at all, like first of all to be doing that research, which is like a handful of people were able to have that opportunity. Mine was super random luck. And then just to be around people who are just keen to learn about, yeah, you know, Northern Lights, or astronomy or the Arctic, you know what I mean? So it was like a super nice environment, even if it was just having to sit around for a few days, waiting for it to stop, like you're almost,

Dylan Torraville 31:14
you're almost more grateful that you have the opportunity to be there.

Luana Sciullo 31:17
Yeah, that was more than anything with the PhD was, for me was difficult sometimes to analyze data and run samples, those are always like the tougher things that take very long, you're sitting there for hours trying to finish your understand what the data means. The field work for me is was always sort of like some of the greatest times there because you're seeing this amazing environment that, you know, I don't know, when I'd get a chance again, to go the Arctic. And then working with these people who have like such a passion to learn and know more, it was super fun. I really enjoyed that.

Dylan Torraville 31:52
So would you would you say then feel like field work is where you would rather spend most of your time?

Luana Sciullo 32:00
Well, in terms of like whether it had to be field work or data analysis. was never amazing at that analysis. The lab bench work was something you just kind of get through. For me the best parts were the field season. And then once the data was analyzed and understood, I really enjoyed writing the story, what was happening with the information or these trying to piece it together? Based on what other people understood or collected or talking about in their papers. The analysis was always a huge hurdle for me. Yes, in my genetic makeup

Dylan Torraville 32:37
wasn't in your wheelhouse. Yeah, you keep mentioning that the term field field season, how long? Two questions, how long is a field season, typically? And then what what defines a field season? Is that like, may spring, summer, fall kind of a thing?

Luana Sciullo 32:56
Yeah. So with the bear research in Churchill was two seasons. One was called spring, but it was the dead of winter. It was in February. Still not even sure what to call it a spring field season. But that's the word in the literature. It happens in February. In the which is you know, when it's very, very cold, those who are looking for a females coming out of the dens with the comes. And then the second was in the fall, that's around most of September. And that's where we're looking for anybody on shore. At the time. We're not just female, like males, some adults anything. And the fall season. The Fall, I remember because at the time, I was always teaching while doing the field work, so I couldn't totally dip out of like, regular school responsibility. So I was in the fall season for about two or so weeks. And in the spring season about three weeks. Okay. The supervisor and the other team members could have been there a week before and then maybe two weeks after in the fall. And then maybe a week later in the spring. It totally fluctuated on. What's weather doing, like How's it looking? What's been happening day by day terms of right, we're finding,

Dylan Torraville 34:12
right? And how many people are you up there with spending the time at the field station? On average?

Luana Sciullo 34:19
Two mean, just for the people in our research study? Oh, yeah. You know, research study was probably two, three, maybe five at a time, if anything.

It's always difficult because there's only so many seats in the helicopter. Yeah, there's always just, you know, who were the students who would do this data analysis after and always the head researcher was there.

And then the pilot? Yeah. So maybe I would say,

four to five of us, right.

In the spring, the helicopter was a bit bigger, because we took more of a load with us. Snowshoes and stuff that right? There was an extra seat in that, but it was still always usually for people flying at a time. And is a helicopter The only way that you can kind of get out to see the polar bears.

Luana Sciullo 35:12
It was in the sense of the distance that we wanted to cover in the time that we had, it was the best way to scan like, several hundred kilometers, and find as much as we could if it was sort of maybe closer habitat that we could take a snowmobile, but it would still be difficult to Dart with a snowmobile helicopter, I think is the most efficient in terms of time use.

Dylan Torraville 35:38
That makes sense. Have you ever, ever had any experience using like a Zodiac boat or anything like that?

Luana Sciullo 35:48
There was some students in our lab who did sea ice research, who used those boats. think I've seen them in movies. It was never a time that we went on the water. Right? It was just went on the shoreline or England. So no, I've never used those know,

Dylan Torraville 36:05
figured figured out. Yeah, I mean, they look the wicked fast. But what I've because I've been watching, trying to do like visual observations off stuff from YouTube, or, like National Geographic has a bunch of great video resources and stuff. And it's like, I see these people in a Zodiac boat, going in between ice flows and stuff. And then they're trying to find this polar bear. But then I'm thinking, well, if you get the polar bear, and you're, you're on the ice, you can't, you can't darn it because it's going to fall asleep and it's going to drown. So

Luana Sciullo 36:44
wait, what was there with it? was their research they were doing? Or

Dylan Torraville 36:48
I think so it didn't fully explain it. Or if it did, I didn't catch that, that part of it. But they were trying to follow this this guy through the ice flows. And he kept talking up and then that rerouting everything is

Luana Sciullo 37:01

swimming,

Dylan Torraville 37:02
swimming, yes swimming through like from kind of from ice cold ice floe, hop up, see the Zodiac bow coming and then go back onto the water. pretty wild, pretty wild. I've got I've, you've painted a really good picture of kind of like a day in the life, what you were doing, and how you would go about doing it. What I what I want to know, because I haven't been able to find a whole lot of like almost any information on it at all, in terms of logistics of say, preparing for a research expedition. Like there's one that's underway right now. called Mosaic, I think, which is they've got this German icebreaker. And there's people from like, 60, like, there's 300 scientists on board this vessel, they're going to sail up into the Arctic, and they're going to just let the boat get stuck. And then they're going to be there until I think March. Wow. And then they're just going to drift back down. And they're going stay there for the entire time.

Luana Sciullo 38:01
This is gonna happen recently, I think

Dylan Torraville 38:03
I think they left port on Friday, from, I guess, Germany or Normandy around there. And then I'm going up, I guess, past Greenland and Iceland around there. But even even for that something that's happening now, I couldn't find anything on say, specific types of equipment that they would be using. They talk about their objectives, understand impact of climate change, understand cis and how that's changing relation to like ecology and whatnot. But no specifics on say they've planned for, or they're trying, they're anticipating this anticipating XYZ. In New York, like in your experience with polar bears, what were you involved, particularly in, say, planning, say, we need this much of this type of equipment for Say, say the fat samples,

Luana Sciullo 38:57
know that it was always sort of like that our head researcher, who was sort of keeping the inventory of equipment that we needed to replenish and you always order it as well? I know, I mean, even the biopsy samples, which would have been the samples that I actually used, like, how many punches we needed, what sizes we needed, they always sort of for involved in ordering those things and stocking them. So it really just came with myself.

Dylan Torraville 39:27
Yeah, you just show up?

Luana Sciullo 39:29
Yeah, no parka. And, yeah, it was almost like having some extra hands in the field. And it gave the student this field experience, which I think is more students, like, most exciting part. Yeah. So that we can actually see the thing that we're going to write 400 pages on later. And, you know, training people in this field if they should happen to stay in this research area later. But it was always sort of mainly one or two individuals who are heading can't get more involved in stocking. So the head researcher and his technician,

Dylan Torraville 40:04
right. So you're just you're basically you're going out as an extra pair of hands, and other brain to learn. You don't have to worry about the technical aspect of stuff really? No, right? Was there anything you would bring with you on a trip, or it was kind of as minimal as possible?

Luana Sciullo 40:23
usually, just a small little pack that had maybe like something I took from the kitchen like an apple or banana. We did pack lunch with us, because we ate lunch out there. So that was in one bag, and like I've seen tea or something. But that's all that I needed. When I went out in the field. For me personally, I did have my camera. That's it. And then in the spring, when it was much colder and bring these little pockets that you break open, and they release heat, okay, sometimes, like put my shoe or my pockets. But that's it, it was sort of like the less less you have is better, because it was all stuff loaded on the helicopter. Right that I didn't want to sort of bring, you know, I wasn't going to do reading, you know? Yeah. actively looking. So less was always better.

Dylan Torraville 41:08
Right? And would say the gear that you have unpacked is that or in your case, was that Captain say? like a like a pelican case or something, something that was insulated? Because I guess you guys would need some kind of an insulation vessel for whatever samples you're going to take. Right?

Luana Sciullo 41:26

Yeah, so we always brought this mini little cooler, which is where we stored biopsies where we had this black would look like a doctor's bag, where we stored like measuring tape and things to measure like jaw size and skull length. So those were always two things that we carried with us we had the big sort of book of all the bears previously cotton their tag numbers, we can easily look it up and figure out how the bear was and all that. In the I can't recall anything being in like a specific Dr. A, because almost things were well sealed things like even the doctors day. And just actually my clipboard of papers where I was recording certain things for myself. I kept in my mini backpack when that wasn't even really little waterproof bag. Because we didn't go near water much the only time it would be what is if it was snow, and I like just drop my papers on the floor. Yeah, definitely. Yeah. The time on out of the helicopter was like super efficient, quick bursts of time. Yeah. So that you don't dilly dally too much. And you're losing paper, this comes out like a really well oiled machine, especially once we knew each other. And without the hang of it. After a couple of times, it became like everyone knew what they were going to do. Every time we had a bear

Dylan Torraville 42:48
everyone. Everyone was clear on what their role was streamlined. Yes. As best as it possibly can. Yeah, yeah. Are there any times where it didn't go as planned? With a bear?

Luana Sciullo 43:02
No, I can't remember a time when I thought.

No, I can't remember that this isn't going right. I'm concerned note and ever. It was always very, as a student, I felt so like it was just, it was work like you were actively working. But it was, for me, especially just as a, as a student. In the beginning, it was very enjoyable, kind of like learning experience as opposed to worrying. Like, did I bring enough equipment that I did this, like we had our checklist that we had every night that we may ensure replenish, like, vials or whatever biopsies that we needed. But it was never sort of like a stressful situation where I had to make sure I had all these things, right, that that research had been undergoing for like two decades, right? So it had it had already. It's sort of events, very well planned out. And whoever was knew would learn them quickly,

Dylan Torraville 44:05
right? You kind of already answered this one about the technical year and stuff and how it's stored. And I guess was there was there were you guys, you guys said you were working off like a checklist to make sure that you have a minimum of like XYZ kind of a thing. Yeah. I guess probably just from a just a clean work workflow point of view. That was that was something everybody was across, or was it more or less just like your you and other students

Luana Sciullo 44:34
know, because the person who people are now doctors, the pilot, who would go back with the helicopter, then it would be the supervisor and probably two students. And it was always sort of get back, go to the lab, empty from the doctor's bag, or the cooler what was used, like the dirty vials are dirty biopsy punch, disposable are put the samples in the freezer after they were labeled, and then just replenish what was in there. It just became like, I don't know how it worked. It just we didn't even have to remind each other It was just once you did it the first time or I learned the first time or then the other new student learned. That was the thing that you did the next day became very much like the step by step mechanical way of doing it so that there wasn't anything missing. Like oh, my goodness, I forgot to restart this. It was just something that you automatically did when you came back.

Dylan Torraville 45:29
Yeah, everyone, everyone understood,

Luana Sciullo 45:31
yeah, their role. And it was great, because it's a small group, it's not like you're in a 20% field season where something might get lost, you thought someone took it started, then they forgot, you know, to me, in a group of four, and three of them were like the students plus the researcher would be difficult to like lose parts of something, or miss something, because there's only a couple of us involved, right?

Dylan Torraville 45:56
I mean, it makes it makes sense for something that so technically or a, it's like, if you mess up, you don't get another chance at night. With because you mentioned, say the fat samples and you keep those in the freezer until you're able to get back to the university to properly analyze those. Is there anything in the way of like electronic data that you guys are capturing out there are like backing stuff up in any way. Like is there is there like a Microsoft Excel polar bear kind of a thing,

Luana Sciullo 46:34

there is our supervisor recorded every day at the end in his massive excel sheet, the bears that were

captured, like their tag number,

what their measurements were, so their morphological measurements was a male, female. And this is the same information to get it that big book that we care, which was the print version of those rights, we could take it in the field, but he would every night, based on our data sheet that we recorded, put all that upload that in this Excel sheet, then I would receive that Excel sheet after we get back from the field, because those would be the barriers that would match up with the biopsy samples that we had. Right. So then I would know later on much later after that, that samples analyzed. The diet of this bear that turned out was you know, 14 years old female to cop or something like that gentlemen, sort of I have the whole background. The other thing I guess that was, I guess, knowledge you thing was we recorded the GPS coordinates of everyone that we tagged or located. Okay. Even the times that we didn't do anything with the various we just were let's let's take searching or roaming and seeing who was out, we would always record where we saw them. Okay, yeah, for maybe the next day case, we saw something similar, right in that same area.

Dylan Torraville 47:54
So I guess say over say, a five to seven year time span, you could say for specific polar bear, you could look at the specific GPS coordinates. And yeah, basically build a visual map of where you found them insane. 2010. And then where they're where they are notes, doesn't it know where they moved?

Luana Sciullo 48:13
Yeah, yeah, absolutely. And some people do that sort of, I didn't work on anything with the GPS coordinates in my research, but there's been students who've looked at individual barriers and where they move within a field season, within couple seasons, like from fall to winter, where they are on the sea is like we can keep track of certain coordinates for some individuals, right? We could sometimes get general ideas of, you know, range size or distribution of like males, females,

Dylan Torraville 48:43
because I've seen that on Shark Week, I guess, when you discovered tracking great whites. And then like they started Johannesburg, South Africa, and then they're like, all the way over there. And then they pop back up, and then they're all the way back over there. I guess you're probably like a similar, you could do a similar thing. Hypothetically.

Luana Sciullo 49:04
Yeah. Like you could look at how, how largest an individual's range? Is there a difference between like a male Ranger as a female range and adult versus a sub adult? So how do they use the landscape or the space, right, you wouldn't really know exactly what they're doing the whole time, you don't have camera on them or anything. So we don't know, if they're forging it's one area versus some other where you can sort of make generalizations on how they use the space of populate the sub population that they're in.

Dylan Torraville 49:32
Has anyone ever put a camera on a polar bear, like a tracking camera?

Luana Sciullo 49:36
like, I remember seeing something, I don't remember if it was in the news, or something online. And now I'm not recalling if it was on the bear or sort of in the den. It wasn't something that was done on a large scale. As far as I remember, it was one individual. But I don't remember reading any actual papers on that it might have been something that I saw on the news at one point, that's fair.

Dylan Torraville 50:01
This, this might be interesting, just especially from you, having Arctic experience as a student, the way I've written it out here is trying to understand the effects that a human presence has on the Arctic or the Arctic ecosystem. Because obviously, if you're at a base, say, like, like a research base, that base has been constructed. And that base has, at some point in time, then built by people and machines and stuff. And obviously, the helicopters and other thing, the physical presence of human beings is another thing, probably not so impactful in Churchill, because it's still, it's sub-arctic. But I could imagine the farther north you go, they're not like in a bear sees you. And it's, it doesn't recognize you necessarily as a human being. What do you think, in your experience, could be a potential solution for mitigating? Like the physical impact of human being presence in such like a remote and sensitive, sensitive ecosystem?

Luana Sciullo 51:16
Um, do you mean their human presence with respect to research specific? Yeah.

Dylan Torraville 51:20
So flying a helicopter of each day and flying around? Because I was reading papers on noise pollution in the ocean, in regards to boats, right? I wonder if there's any relation with the Arctic.

Luana Sciullo 51:34
Yeah, I'm not sure in the sense of the High Arctic bears because they are more remote. But there are communities that live in those areas that move with like a snow machine, for example, with some of the sub populations that are in the south, some of them run adjacent to towns or communities, and are probably more, I guess, I'll do an air quotes use to certain noises. I didn't like when we're flying. I, you know, they look and they, they see you. But that's the extent of in terms of, like, simplest explanation of behavior was just a recognition of it, as opposed to something that seemed alarmed or anything, right. Like stress wise. And especially the sub-arctic Southern population. So you've been doing research series since about the 70s or so. So it's not a it's not like a super remote area that hasn't been explored in terms of human presence and wildlife, right? Just from like, what I what I recall, it was sort of flying around, they see us there, they recognize us, but there's never recognize what's happening in their in their own mind. But they, they see that there is something but it was always just sort of like a look up and a wonder and there wasn't anything to suggest some like sense of alarm, like in terms of running or anything, right. I don't know why I don't know about more High Arctic. Individuals, if those encounters are less frequent, so maybe it would be something more of a surprise for them. The thing is, the research doesn't happen sort of every day, all year round. So there are sort of limited spurts of them. And keeping, I feel like the value of keeping track of a population over several decades, has helped us to identify some of the changes that are happening, like in body condition and died, that we wouldn't otherwise know. Had we not explore this environment more. So be so sort of sort of doing things in sort of the most safest way Yeah, with the least amount of risk to us. And then there's always the best way. And there, there's still value to be there and get as much information

Dylan Torraville 53:49
as you can definitely.

Luana Sciullo 53:51
But don't be extra invasive,

Dylan Torraville 53:53
right? And is the point to not be extra invasive, is that the reason you're only there for a 2, 3, 4 or five weeks?

Luana Sciullo 54:02
Yeah, even five weeks is like we've never stayed that long, I would say in the fall, maybe two to three, and in the spring three to four. It's not that we need to sample every single individual, whatever works with, you know, climate, environment, temperature, the time and what we see. But we will never sort of, you know, stale to my phone. Because we we just want more bears, like whatever we can find and add to the database is still valuable. Doesn't have to be like 25 bears. That was five that's great to something is better than not being there at all. I think we're not collecting any information.

Dylan Torraville 54:40
Yeah, one's better than none.

Luana Sciullo 54:42
Yeah, okay. Even just that one, if it was a barely saw last year, or three years ago, maybe we didn't see her for like five years or something, something may have changed in five years that we wouldn't be able to identify how we not

Dylan Torraville 54:54
found her again. Right. Okay, back to the research again. Because you mentioned the reason like the research lab is in the university. Is there anything other than, say, pure economics and cost that prevents that lab facility from being located in Churchill, Manitoba, or whatever? location? Like is there a reason why it's spread out?

Luana Sciullo 55:20
all the the supervisor works at the university. So that would be where the research, or the research lab would be where all your funding would go towards the field stations, house researchers for certain amounts of time, however, they needed to collect the data, it does have a research lab, like it had lab benches that you could do or gone. But it's to us, you know, it's remote enough that we couldn't spend, you know, months and months and years, versus, you know, at the institution or like an academic institution, I could work there, I could do lab bench warfare could do data analysis, so many other parts that, I don't know, if the field season, certainly field stations could support for a long period of time in years. In that sense. Also, the field stations are just

using sort of turnover points for researchers to come stay big collect what they need, and then leave, right. Um, most of the funding would be to wherever the supervisors like working out of in terms of teaching and research, which happens to more often than not be at the university or at the government. Right.

Dylan Torraville 56:32
Right. And what's involved in a research lab, because when I think of a research lab and thrown back to like grade 10, in high school doing chemistry, with like, microscopes and the little beaker,

Luana Sciullo 56:45
yeah,

Dylan Torraville 56:46
how would say how would like an Arctic research lab, differentiate itself from, say anything else, like another type of research?

Luana Sciullo 56:56
so the lab room itself looks exactly the same in that way, it has a bench, it has sort of the funnels coming out where you could attach gas, say, for example, it has a fume hood, where you would do stuff with solvents. Like it has an IR station as a fire extinguisher, those things are the same, probably most laps, the materials that we have, which are the solvents that we use to extract the fatty acids and a little bit from the samples. Those are probably more specific to whatever the work is being done in that lab. So some labs may not use certain solvents over others. We have more refrigerators, probably than an average, like chemistry lab, when I mentioned they don't have any, because we have all the samples, and that's where we store them. But the basic parts, which are you know, that whole very traditional view of a bench, those are all the same, right? I think in most labs, right?

Dylan Torraville 57:53
What happens with the samples after your done? So you've taken the samples from the bear, you've brought them back across the country to say Toronto, now you've analyzed them you've done what you need with them are they kept on file anywhere.

Luana Sciullo 58:09
The sample starts off as the biopsy, it becomes then a liquid extraction, which we keep in store. The third part of that sample becomes fatty acid samples will fatty acid metal, US esters are called that we had to send out to another institution where they finished the process of the fatty acid analysis because we didn't have that kind of equipment in our lab, there was a specialized lab at another school that did all the fatty acid work for us and for other institutions. So that sample was sent out to them. And then it gets used in in the gas chromatography machine. So that samples gone the liquid samples, sort of what we keep in our refrigerator, we could go back to it if we need to most mostly it's stored there after the fact. Right? For I don't know, like until they run out of space. Yeah, refrigerator space. But technically, once the limit is extracted, we know how much fat was in it. That's the information we record. So we wouldn't really need that sample. Again. We do keep it on, like in the freezers. Yeah, in case we do, but I've never had to go back to one. So

Dylan Torraville 59:21
no. And are these say standard freezers you would see, like a grocery store, like those big industrial freezers that are kept at a solid temperature, or they specific, like specific for biological.

Luana Sciullo 59:38
We had a couple one was regular freezer, that it looked like a refrigerator, but the whole thing was a freezer.

So instead of like the top part of your fridge being a freezer, the whole thing was that's where we kept most stuff, some samples, which were like, from harvest, for example. Some other samples that I didn't work on, we kept in a minus 80. freezer. So it's just a much colder thing that can hold it for longer periods of time if, if they were going to be analyzed right away.

Dylan Torraville 1:00:10
I think that's all I've got. That's all that I can think of right now.

Yeah, I mean, as far as I'm concerned, I have no more questions. Do you have questions for me in terms of this?

Luana Sciullo 1:00:22
No. So you'll do other interviews with other individuals sort of in this field. Ideally,

Dylan Torraville 1:00:27
we've got we've got a two week window to do interviews for report, supposed to do like a minimum of two, whether that's in person on the phone via email, to at least kick off a preliminary research thing. You know, people have posted questions on forums before and then gotten just 60 responses based off of whatever their topic is.

Transcribed by https://otter.ai

PANEL ON RESEARCH ETHICS
Navigating the ethics of human research

TCPS 2: CORE

Certificate of Completion

This document certifies that

Dylan Torraville

has completed the Tri-Council Policy Statement:
Ethical Conduct for Research Involving Humans
Course on Research Ethics (TCPS 2: CORE)

Date of Issue: 3 September, 2019

APPENDIX B – USER RESEARCH

User Profile

Primary User	**Marine Biologist, Zoologist, Scientist**
Secondary User	Volunteers, Research Assistants
Tertiary User	Animals subject to study

Findings

Demographics		**Use Behavior**		**Personality**		**Cognitive Aspect**	
Age	30-45 Years old	**Frequency of use**	Working in labs, working in the field.	**Locus of control**	↑	**Technical skill**	↑
Gender	Mostly female (60% F)	**Duration**	Field work: 12-15 hrs Lab work: 8-10 hrs	**Self-efficacy**	↑	**Pre-req. content knowledge**	↑↑↑
Culture/Ethnicity	White	**Hobbies**	Mountain biking. Photography. Outdoor activities.	**Changeability**	↑		
Income	Middle Tier ($40K-$70K)	**Level of focus**	High	**Uncertain avoidance**	↑		
Education	Bachelors, Masters, Doctorate	**Location**	Marine environment. The Arctic.				

Demographics

Overall, marine biologists tend to be middle aged females and white.

The demographic distribution sits between 30 years old and 45 years old. Most marine biologist volunteers are under 23 as they are still in school, using volunteer experience to generate industry contacts.

User Behavior

The frequency of use, as well as the context of the activity, indicates that this is a high profile and technically oriented field.

The average working day corresponds to two main types of work: laboratory work and field work. Lab work typically operates for 8-10 hours a day whereas field work can be more intensive, sometimes operating for 12-15 hours daily. Marine biologists often operate in a team setting, working with at least one other individual.

On research expeditions, which can last anywhere from a week up to 3 months, marine researchers are often stuck in remote locations with limited access. These expeditions are often research intensive, with groups of researchers from multiple countries and varying marine backgrounds.

An extensive education is involved for marine biologists. A master's degree is seen as the minimum requirement for conducting field research and analyzing data. Marine biologists often pursue a doctorate degree after a few years in the industry, typically focusing on a specific animal species or aquatic environment.

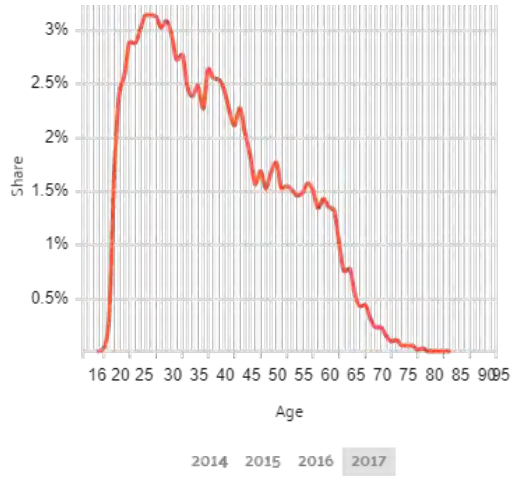
During their personal downtime off the job or outside of the lab, many marine biologists participate in outdoor activities, photography, yoga and meditation. These activities may be due to a subliminal connection to the environment as a result of their education and attachment to animals.

Marine biologists have a mid-level income, as it is a career which does not pay traditionally well. Most marine biologists will earn between $40,000-$70,000 per year. There is the potential to earn more working for Universities or government agencies. This suggests that the intent of the career is not necessarily money, but rather the environmental benefit, an element of social exclusivity.

Persona

A marine biologist persona is developed, a fictitious person, who fits the demographic, motivation and background based off demographic research. The use of the persona aims to refocus the design intent from the product, to the user.

Age & Gender



This chart shows distribution of ages for employees with a degree in biology. Retrieved from https://datausa.io/profile/cip/marine-biology-biological-oceonography

"The average age of a person in the workforce with a degree in biology is 41.6…The most common ages of employees with this major (biology) are 28 and 29 years old, which represent 3.14% and 3.14% of the population, respectively." (Marine Biology & Biological Oceanography).

"Science, technology and engineering and mathematics (STEM) fields are traditionally heavily dominated by males, which is of great concern to universities as they try to improve student retention and achievement. Once exception to that trend is in the field of biology. Of undergraduate biology majors,

more than 60 percent are female and about half of biosciences graduate students are women." (Arizona State University, 2014).

The subsection relating to Education & Income contains viable information as well as it relates to gender for degree recipients. See Tables 4-6. These tables break down information on ethnicity as well as gender division.

Ethnicity & Culture

Program Population: Ethnicity	
Ethnicity	*Fraction of Graduate Students*
Caucasian	88
Hispanic	4
Asian American	5
Native American	1
African American	2

This table shows the ethnic fraction of graduate students from The School of Oceanography, University of Washington.

(McDuff , Slide 16) Note how a majority of graduate students are Caucasian. There is no information on the gender of these students available.

Education & Income

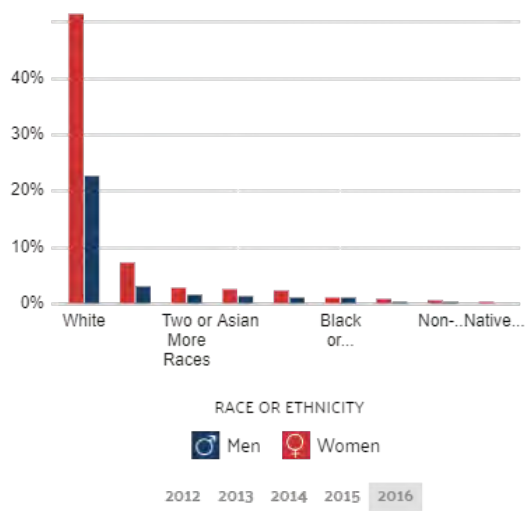
"To become a marine biologist you usually need to have a Masters or Doctorate in marine biology, marine ecology, marine conservation, zoology or a related science." (Moana, 2019).

Marine Biologist earnings by seniority:		
Top Level (90th percentile)	$34.40/hr	$71,561/year
Senior Level (75th percentile)	$21.52/hr	$44,755/year
Mid Level (50th percentile)	$15.46/hr	$32,159/year
Junior Level (25th percentile)	$12.68/hr	$26,377/year
Starting level (10th percentile)	$11.62/hr	$24,166/year

This table reresents the average earnings of marine biologists by seniority (in USD). Retrieved from https://www.careerexplorer.com/careers/marine-biologist/salary/

Note that the above values and wages are sourced from a United States website, and as a result the numbers are paid in US dollars. No specific information in Canadian salary or wages were available. "A marine biologist in an entry level position will make an average of $44,000 per year in Canada. Marine biologists with several years of experience and education will make between $64,000 and $78,000 per year." (Marine Biologist).

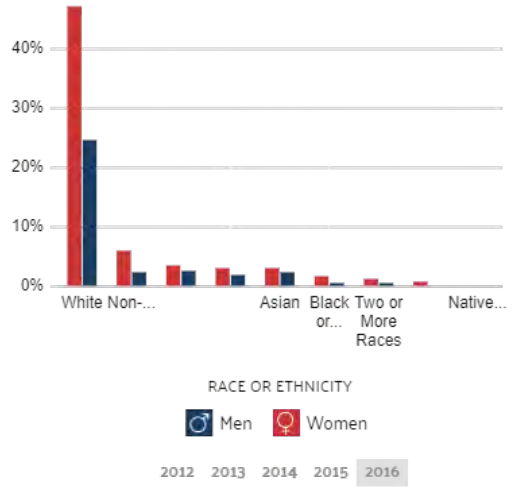
Bachelors Degree recipients in Marine Biology and Biological Oceanography	
White Female	698 degrees awarded



White Male	305 degrees awarded
Hispanic or Latino Female	99 degrees awarded

This chart illustrates the differences by gender for each race and ethnicity of Bachelors Degree recipients in Marine Biology and Biological Oceanography. Retrieved from https://datausa.io/profile/cip/marine-biology-biological-oceonography

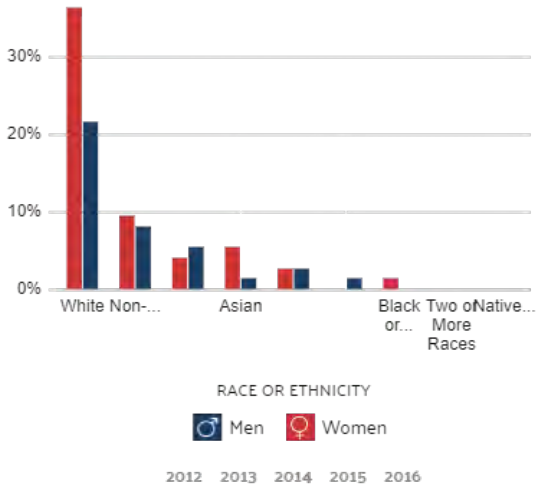
Note how white female students appear as the most common combination of ethnicity and gender, earning the highest number of degrees in the marine biology and oceanography field.



Masters Degree recipients in Marine Biology and Biological Oceanography	
White Female	127 degrees awarded
White Male	66 degrees awarded
Non-resident Alien Female	16 degrees awarded

This chart illustrates the differences by gender for each race and ethnicity of Masters Degree recipients in Marine Biology and Biological Oceanography. Retrieved from https://datausa.io/profile/cip/marine-biology-biological-oceonography

Note how even amongst Masters Degree recipients, white females are still the dominant gender and ethnic profile, with white males the second most dominant.



Research Doctorate recipients in Marine Biology and Biological Oceanography	
White Female	27 degrees awarded
White Male	16 degrees awarded
Non-resident Alien Female	7 degrees awarded

This chart illustrates the differences by gender for each race and ethnicity of Research Doctorate recipients in Marine Biology and Biological Oceanography. Retrieved from https://datausa.io/profile/cip/marine-biology-biological-oceonography

Individual Context

“Marine biologists may work for:

Government agencies and departments.

Crown research institutes such as the National Institute of Water and Atmospheric Research.

The Cawthorn Institute – an independent science organization

Regional and city councils

Universities

Museums”

(Moana, 2019).

“What are some examples of equipment used by marine biologists?’

‘Field collecting equipment: plankton nets for sampling the plankton, bottom corers for sampling sediment in the seabed, bottom grabs for sampling the bottom for bottom creatures.” (Levinton, 2003).

“Oceanography centers, laboratories, aquariums, research boats and vessels are some of the possibilities for field workplaces. It would not be unusual to find a marine biology graduate working in a tide pool, a swamp a mangrove forest, a coral reef, or any place on earth that supports marine life.” (CareerExplorer).

Note that there are a broad range of working environments and contexts for marine biologist. Marine biologists in the Arctic would most likely operate in similar contexts such as laboratories, research boats and in the field.

Conclusions

Through analyzing image search and literature search demographics, the following content can be interpreted.

The primary, secondary and tertiary users are listed in the below table. These users are inferred from the data collected from image sources and literature searches.

Primary User	**Marine Biologist** **Zoologist** **Marine Oceanographer** **Oceanic Scientist**
Secondary User	Research Assistants Student volunteers
Tertiary User	Animals subject to study Research Supervisor SCUBA Certified Personnel

Demographics of Marine Biologists		**Reference**
Age	30-45 years old	https://datausa.io/profile/cip/marine-biology-biological-oceonography
Gender	Mostly female (60% F)	https://datausa.io/profile/cip/marine-biology-biological-oceonography
Culture / Ethnicity	White	https://datausa.io/profile/cip/marine-biology-biological-oceonography
Income	Middle Tier ($40K-$70K)	https://datausa.io/profile/cip/marine-biology-biological-oceonography
Education	Bachelors, Masters, Doctorate	https://datausa.io/profile/cip/marine-biology-biological-oceonography
Working Context	Laboratory, Field work	https://datausa.io/profile/cip/marine-biology-biological-oceonography

Overall, marine biologists tend to be middle aged (between ages of 30-45), female, and white, with a high level of education in their field. From demographic research, the majority of marine biologists have completed at least a Bachelor of Marine Biology or similar degree, and a Masters in a similar field. A lesser amount pursues a doctorate in their specific field, which is often done to enhance and further their specific and focused research. This research often focuses on a specified species or challenge. Marine biologists tend to work either in a laboratory setting, analyzing data, samples and findings or in the field, collecting data, samples and findings.

User Observation: Video Analysis

For the chronology of observation, screenshots from the video shown to the polar bear experts will be shown, along with the adjoining comments from the individual.

Chronology of Observation

Preparing for field expedition.

Notes	User Insight Notes
Marine biologist leaves a simple looking work station.	This is typically all that's needed for a polar bear expedition. Good to keep gear to a minimum, reduces hassle on longer days.
Holds a long pole, duffel bag and small cooler in his hands.	
Dressed in a thick jacket, pants, hat, no gloves.	

Packing helicopter.

Notes	User Insight Notes
Packing the gear into helicopters.	Travelling in helicopters can be tricky and cramped at times.
Minimal amounts of gear means that packing is simpler, less hassle.	Not much elbow room, you just look out the window, trying to spot a bear.
Helicopters still have limited space.	When entering a helicopter, you need to be careful not to knock any instruments or items loose that you've packed in.

Locating wildlife (in this instance Polar Bears).

Notes	User Insight Notes
Traveling by helicopter is a common and efficient way of traveling in the Arctic.	Traveling in a helicopter can be really fun the first time around, but it can grow into a long day when you're all cramped up.
Limited to good weather conditions.	Finding bears can be easy, depending on the season or time of day, or it can be impossible.

Covers a vast area quickly, easier to spot bears from the air.	You could go a full day without finding any bears.

Wildlife is located (a Polar Bear is spotted).

Notes	User Insight Notes
The Polar Bear is located from the air, using the helicopter.	Finding a bear is always exhilarating, such an exciting thing to see.
Difficult to spot in mid-winter (white bear on white snow).	It creates a buzz of energy in the helicopter and now its go time, everyone has to focus, you don't want to lose the bear.

Polar Bear is darted (shot with tranquilizer) from the air.

Notes	User Insight Notes
Individual is leaning out of a window, holding a rifle in preparation to darting the bear.	Darting a bear is a dangerous and technical process.
Helicopter moving, bear running, hard to aim.	The person darting the bear has had years of experience and training to do so safely and effectively.

Unpacking the helicopter.

Notes	User Insight Notes
Once bear has been darted, helicopter lands and the researchers disembark and unpack their gear.	Typically you can't land until the bear has fallen over from the sedative, this leaves you with roughly 15 to 20 minutes of waiting in the air.
	I recall feeling achy and sore getting out of helicopter, from such a cramped space.

Removing the dart from the bear.

Notes	User Insight Notes
Crucial to the bear's health and safety, removing the dart from the skin of the bear.	It looks a lot messier than it is, the dart doesn't hurt the animal at all.
	The sedatives gives you anywhere from 20-30 minutes of working time with the animal. 20 is safe. 30 is pushing it.

Preparing for documentation.

Notes	User Insight Notes
Preparing the field site for measurements. Lots of bending over, picking up and putting down as gear is set up.	Always important, keep your gear close. You don't want to be wasting time walking back and forth because this is all time that the bear is processing the sedative. Efficiency when the bear is asleep is crucial.
Unpacking gear from the helicopter and preparing for measurements and biological samples.	

Taking data and tagging the bear.

Notes	User Insight Notes
This tagging method is done using a tattoo on the inside of its gums to identify it if the same animal is caught in the future.	Tattoos are a rather non-invasive way to document the animal, although you can't track them like a GPS collar. The dye stains inside of the gums, is a cheaper, low-budget method of tracking bears.

Taking biological measurements of the animal.

Notes	User Insight Notes
Measurements such as overall length, width, girth are taken. Working with gloves is challenging for dexterity, often gloves are taken off to increase efficiency.	Bio-measurements are crucial, as they dictate how much the bear is eating and its diet, its health and the rate at which it is growing.
The jaw, head and skull are all measured, as well as the side of the paws.	We always document these in an analog way when in the field, using simple tools, no fancy gear needed. Just a tape measure, pencil and a notebook.

Measuring weight of the animal.

Notes	User Insight Notes
A mobile scale is set up, unpacked from the gear bags.	Measuring the weight of the animal isn't always done, depends on what researchers are going for.

Animal is rolled into a sling and suspended above the snow.	Measuring weight is tricky, you risk alerting the animal from its sleep, which is why the blanket is placed over its eyes, keeps the animal calm if it ever wakes up mid-test.
Weight is taken, measured in kilograms, again leading to insight into the diet and overall health of the bear, indicative of age.	
Rolling the bear is challenging, must be done quickly and is limited to manpower. Sitting on knees and pushing with hands in the snow to roll bear into sling.	

Packing up research site and preparing for evacuation.

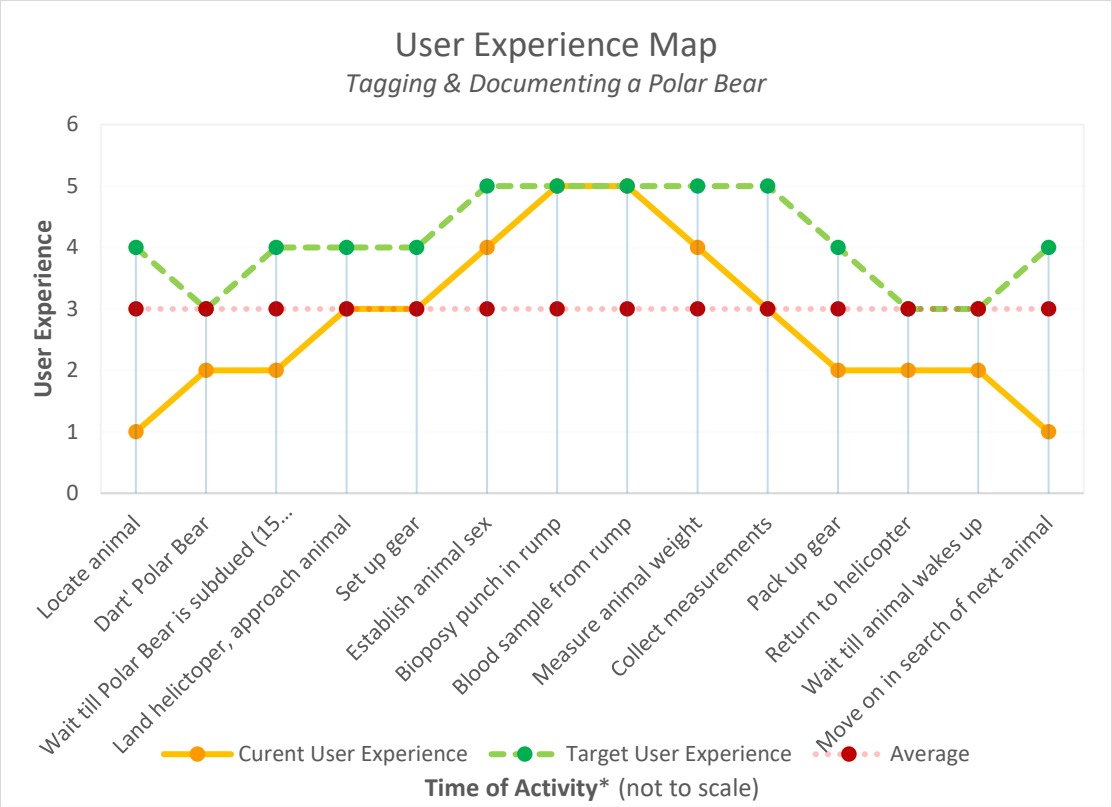
Notes	User Insight Notes
Pack up is done as quickly as possible once all samples and data are taken from the animal.	Take-down is always quick, but not really hectic. Everyone knows their own role and what they're responsible for.
Lots of bustling around in the snow, working in close proximity to the animal.	This is when the bear starts waking up and typically your fingers and face start to go numb, so you better go quick.
Gear is carried back to the helicopter as quick as possible.	

Bear recovers and researchers continue on.

Notes	User Insight Notes
The bear wakes up and walks off.	Just because one bear is found in a day, doesn't mean there will be another. You can spend the rest of the day looking for bears and find nothing. All day in a cramped helicopter is no fun for your back or neck.
Researchers return to the helicopter and take off, in search of another animal.	

Screenshots are all retrieved from the following cited video: [US Fish and Wildlife Service]. (2 011, May 24). *Polar Bear Research on the Chukchi Sea.* [Video File]. Retrieved from https://www.youtube.com/watch?v=8iN7mC-aUpg

4.1 User Experience Map



1 (Very Poor -ve), 2 (Poor -ve), 3 (Average), 4 (Good +ve), 5 (Very Good +ve)

The user experience map is ranked on a scale of 1-5 in terms of positive or negative experience. With a value of 3 being neutral, values of 1 and 2 are negative experiences, with values of 4 and 5 ranked as positive experiences.

Potential User Experience Improvement Chart

In the following table, a quick analysis of the activities and potential improvements to the various steps and processes within documenting and tagging a polar bear have been further listed.

	Steps / Process	Base User Experience	Potential for Improvement
Preparing for research expedition	-Gear is packed up into bags to be loaded onto helicopter -Helicopter is loaded with gear and organized, as researchers and pilot board	-carrying bags from lab/research station to the helicopter -climbing up into helicopter, cramped interior due to gear bags	-Refined interiors (more space, relaxing) -Efficient way to load gear (lower down to reduce stress of lifting)

Locating animal	-Animal is located, typically by air, using a helicopter -animal is 'darted' using a tranquilizer shot from a rifle -Researchers must then hover and wait until the sedative takes effect	-Lots of waiting, aimless searching -Difficult to dart bear from the air (lots of training) -Travel time with potential for no bears	-Improved location / wildlife finding (using Sonar, Radar, infrared imaging) -Easier darting techniques
Documenting animal	-Researchers approach the animal, bringing their gear and equipment -gear is set up / unpacked -the polar bear's sex is established -fat samples, blood samples and other biological samples are taken -bodily measurements are taken -stats are documented and cross-referenced	-Quick, streamlined process -limited time due to effects of tranquilizer -animals can be unpredictable, even when sedated -conducting delicate tests in cold temperatures	-easier method of transporting gear -more safe working time with animal (safe for humans and the bear) -tools designed for dexterity, use with gloves (for colder days)
Pack-up & departure	-gear is packed up in a timely manner -all researchers retreat back to helicopter (mode of transport) -wait safely until animal wakes up and moves on -researchers move on in search of next bear to study	-many steps and items to pack up -must be done before animal wakes up -requires team members to bring back gear back to helicopter / transport by hand	-easy set up / takedown of equipment -reduction of time spent setting up / taking down gear

Overall Analysis

Key Observations to inform design solutions

There were many observations through video and further conversations which have the strong ability to inform the design solution for this thesis in a positive way. Many pre-conceived notions were disproven through this process, which can ensure a solid design solution. Of the many observations that were noted, there are four which stand out above all others. They are listed below as follows:

Key Observation	Potential improvements
Loading bags of gear and equipment into helicopter (or similar mode of transport)	-Streamlined method of moving gear around -Packing and unpacking workflow, easier for researcher
Animal is darted / sedated from a moving helicopter as it runs away	-Refined method of darting animal -Safer for researcher and animal, eliminating margin for error
Packing up, unpacking, set up, re-packing of gear at research site	-what if there was no need to unpack gear or research equipment?
Traveling in search of wildlife (cramped environment)	-developing more accurate ways of locating wildlife -what if the wildlife came to the researchers?

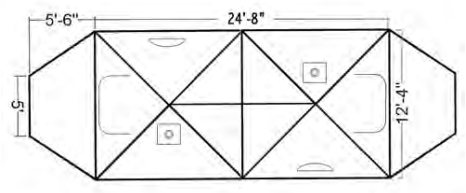
APPENDIX C – PRODUCT RESEARCH

Product benchmarking enabled a comprehensive understanding of the existing product market, analyzing product semantics, interactive abilities and room for improvements and innovation upon current designs. Current, existing products will be benchmarked in the form of several X-Y graphs measuring various design elements. Key benefits and features will also be analyzed and a frequency table will be generated to inform a clearer description. Ultimately this report will aid in determining features and benefits for the final thesis solution and to draw conclusions which will later inform the design direction.

This product was selected for benchmarking, as it is the current leading Dry-suit for Arctic diving. A dry-suit such as this currently allows users to safely dive in freezing temperatures which is a possible job activity of marine biologists working in the Canadian Arctic.

Product Image	**Product Name**	HDC Tech Dry Drysuit
	Description	Our most durable suit ever, the HDC Tech Dry is for the serious recreational diver who need an exceptionally tough technical suit. Features a FULL CORDURA® body, RipStop reinforced lower sleeves, shoulders and crotch/seat and KEPROTEC® (made with Kevlar™) knee pads.
	Specifications	• Anatomically shaped torso, arms and legs eliminates excess bulk and improves aqua dynamics • 3mm neoprene comfort-fit neck seal • 360 degree swivel inflator valve (default placement on the center of the chest) • Adjustable low-profile exhaust valve (default valve placement on upper left arm) • Includes suspenders • HD Bottleneck latex wrist seals with talc bag • 2-needle “felled seam” construction and reinforced “critical-wear” seam points • KEPROTEC® by SCHOELLER knee protection is an extremely abrasion and tear resistant fabric. Incorporates Kevlar™ for the highest degree of protection from unwanted punctures and tears • Your choice of HD vulcanized 4mm compressed density neoprene BARE boot, or compression-resistant Soft Boot • Delivered with backpack, LP Hose and zipper wax • Includes heavy-duty duffel bag • Available in custom MADE-TO-MEASURE size
	URL Link	https://www.baresports.com/en/dive/products/mens-drysuits/trilaminate-drysuits/hdc-tech-dry/mens/

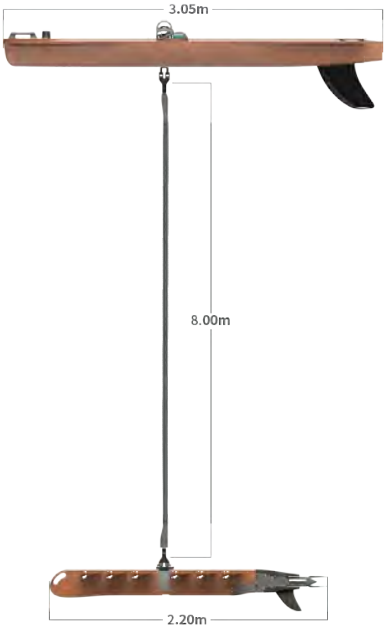
The Arctic Oven 12x24 tent was selected for benchmarking as it is a current leading product in tents and shelters for Arctic environments. The Arctic Oven is a good way of demonstrating how mobile Arctic shelters and living environments can be packaged and laid out for researchers on the move, or setting up camp away from a larger vessel.

Product Image	**Product Name**	Arctic Oven 12x24 (with Vestibules)
 	Description	An Arctic Oven tent so large, you might as well call it a lodge. That's what we have nicknamed the Arctic Oven 12x24 with dual Vestibules! The 304 square feet of livable space inside of the tent, along with the 90 square feet of storage space in the vestibules, makes for the perfect size base camp for larger groups, crews or families. The Arctic Oven 12x24 with Vestibules is unsurpassed in performance and design! As with all Arctic Oven tents, the Arctic Oven 12x24 with Vestibules is in a league of its own. With multiple configuration options, you can use this tent for sleeping quarters, communal area, cook shack, multi-room living space (with optional divider), meeting area, research center, and SO MUCH MORE! Break with tradition. Start your own… in an Arctic Oven 12x24 with Vestibules!

Specifications	SEASONS Four-season tent SLEEPS Thirteen to fifteen person tent according to industry standards. If sleeping on cots and utilizing a stove, this tent will comfortably sleep nine to ten people. WEIGHT 179 lbs packed weight including tent and poles FLOOR SIZE 24'8" x 12'4" VESTIBULE Two vestibules that are 5' x 5'6" AREA 304 square feet of livable space with steep side walls. Vestibules provides 46 square feet of storage space each. PEAK HEIGHT 7'2" peak PACK SIZE ~ 44" tall x 38" wide x 38" deep - stored in multiple bags VENTS Adjustable high and low tubular vents WINDOWS Screen windows in both doors and one window on each side wall FRAME Anodized aluminum tubing poles with durable steel hub fittings
URL Link	https://arcticoventent.com/tents/all-tents/arctic-oven-12x24-with-vestibules/

This product was selected for benchmarking as it provides an accurate and extreme size depiction of some of the equipment that is taken along by marine biologists during their field expeditions. This product can demonstrate some of the larger size restrictions that researchers may face when in the field.

Product Image	**Product Name**	Liquid Robotics Wave Glider
	Description	The Wave Glider is designed to support a wide range of sensors and payloads. The modular and adaptable payload design, coupled with a powerful solar energy system and on-board compute environment, allows our partners to develop and deliver unique solutions to customers. More importantly, it allows customers to scale a proven application across many Wave Gliders quickly.



Specifications	• Water Speed: Typical 1.3kts • Endurance: Up to 1 year (varies based on operating conditions and location) • Operating Water Depth: > 15m • Station Keeping: 30m radius • Payload Capacity: 7 modular bays (93L) • Tow Capability: 500kg (drag dependent) • Average Continuous Power: 5W – 20W • Max Solar Collection: 192W (nominal) • Battery Capacity: 0.9kWh – 6.8kWh rechargeable • Communications: Satellite, Cell, Wi-Fi
URL Link	https://www.liquid-robotics.com/wave-glider/how-it-works/

The Bell 412 was selected for benchmarking, as it helps lead towards a possible solution and is a popular method of transport for current marine biologists, researchers, environmentalists and other scientific individuals in the Arctic. It offers a customizable interior which is unique and can be an added benefit to the future design.

Product Image	**Product Name**	Bell 412 Helicopter
	Description	When your missions take you into extreme environments, the Bell 412 will always have your back. With the cabin you need for passengers and cargo, nothing and no one will get left behind.
	Specifications	Bell BasiX Pro™ Integrated Avionic System • Helicopter Terrain Avoidance Warning System (H-TAWS) Capability • Power Situation Indicator (single indicator for quick pilot monitoring) • Automatic Dependent Surveillance-Broadcast (NextGen, Standard ADS-B out, Optional ADS-B in) • LED cockpit lighting and panels

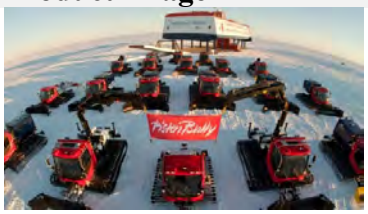
	Maximum Seating 1 + 14 • Cabin Volume 220 ft³ / 6.2 m³ • Aft (Baggage) Compartment Volume 28 ft³ / 0.8³
URL Link	https://www.bellflight.com/products/bell-412

This product was selected for benchmarking due to its ability and unique capability as a reliable mode of Arctic transport. Vehicles such as this and similar were depicted in many references images during the initial phases of research for this thesis and offer current features which can be expanded upon into a truly innovative solution.

Product Image	**Product Name**	Hagglunds BV2016 – Arctic Tracks
	Description	Hagglunds BV206 all-terrain vehicles are used in forestry, transmission line work, pipeline construction and maintenance, construction work on remote sites, forest firefighting, rescue and relief work, ambulance duty, crew transport and tourism.
	Specifications	* Driver 70 kg (154 lbs) included in payload. **Maximum 200 kg (44l lbs) of the payload can be carried on the roof rack. Maximum trailer weight 2500 kg (5500 lbs). Specific ground pressure Front/Rear car 11.6/13.6 kPa (1.68/1.97 PSI) 0.2/0.05 m sinkage Performance: Max. speed, on roads 55 km/h (34 mph) in water 3 km/h (2 mph). Range on roads 300 km (186 miles) Tracks: Moulded rubber with cord. Width 620 mm (24.4 in). Four track drive Bodies: Glassfibre reinforced plastic with PVC foam insulation
	URL Link	http://www.arctictracks.com/hagglunds-bv206/

The PistenBilly 300 Polar Antarctic was selected for benchmarking as it offered similar features and benefits as the Hagglunds BV2016, however it had the perceived look of a high-

end product, simply based on the marketing material associated with it. It was also clearly depicted in many photographs and articles pertaining to Arctic and Antarctic research.

Product Image	**Product Name**	PistenBully 300 Polar Antarctic
 	Description	At PistenBully we've been operating in Antarctica since the 1980's. This means we've had time to work with our clients, refining our vehicles to be the best for polar work. We've become real polar all-rounders, and the pinnacle of this is the PistenBully 300 Polar. The PistenBully 300 Polar is built to cope with the extreme conditions of the eternal ice. We focussed our design on outstanding performance, long-life and low operating costs that are all priorities in the ice shelf regions. And with its low ground pressure it reduces risk during unloading on the sea ice. Combine this with complete reliability and a truly versatile set-up and you can see why this machine is fast becoming a must have for research teams based in the Antarctic regions.
	Specifications	**Technical Specification PistenBully 300 *Polar***

Engine		
Engine Type		Mercedes Benz, OM 460 LA
Cylinders		6-cylinder in-line engine with turbocharger and charge-air intercooler, with electronically controlled pump-injector fuel supply and thermostatic fan clutch
Power output (ECE)		335 kW (455 hp), EUROMOT III A and EPA TIER 3
Max. torque		2,000 Nm at 1,200 rpm
Displacement		12.8 l / 12,800 cm^3
Fuel consumption		from 22 l / h
Fuel tank capacity		370 l with 2 auxiliary fuel tanks each with 80 l volume
Dimensions		
Width	without tracks:	2,600 mm (102.5")
	over steel tracks:	4,260 mm (168")
Height with cab tilted		3,385 mm (133")
Overall height		2,930 mm (115")
Length with All-Way-Blade		8,400 mm (214")
Ground clearance		350 mm (14")
Load area		2,230 x 1,920 mm/4.3 m^2 (88" x 75.5"/5yd^2)
Weight		
Tare weight with steel tracks		8,400 kg (18,518 lbs.)
Gross weight limit incl. attachments		12,000 kg (26,455 lbs.)
Payload on platform without attchments		2,500 kg (5,510 lbs.)

URL Link	https://www.pistenbully.com/usa/en/vehicles/antarctic/300-polar-antarctic.html

This product was selected for benchmarking because it demonstrated a simple and well tested method of transport for individuals working in snowy environments, such as the Arctic.

Product Image	**Product Name**	2020 Expedition SE Snowmobile
	Description	The 2020 Expedition SE is where luxurious comfort and rugged capability meet with perfect chemistry. Based on the REV Gen4 platform, full of cozy features paired with work-oriented components to offer a remarkably capable sled both on- and off-trail.

Specifications	• Rotax® 600R E-TEC®, 900 ACE™ Turbo and 900 ACE™ engines • pDrive™ clutch • REV® Gen4 platform with wide-design bodywork • 20-in. wide Multi-LinQ plate with 125 lb / 56.7 kg cargo capacity • SC™-5U articulating rear suspension with locking mechanism on one side (no tool required) • Air Control Suspension (ACS) • 20 x 154 track choices: 1.5 in. Silent Cobra WT or Silent Ice Cobra WT or 1.8 in. Cobra WT • Air radiator with fan • RF D.E.S.S.™ key • Easy Shift transmission (H-L-N) with RER™ electronic reverse (600R E-TEC) / electro-mechanical reverse (ACE™ engines) • Removable passenger seat and with heated grips • Ultra large LinQ utility cargo box with 135 L / 35.7 US gal of storage • Hitch receiver with 1,500 lb / 680 kg towing capacity when equiped with an HD rear bumper. (1,200 lb / 544 kg std.) • High capacity battery • Forward Adjustable Riser • 7.2-in. wide digital display • 26.5-in. Ultra-high windshield with side deflectors • Pivoting mirrors • Deep snow running boards with large openings • Heated driver's visor power outlet
URL Link	https://www.ski-doo.com/en/ski-doo/expedition/expedition-se.html

This product was selected for benchmarking in this report as it appeared to be a valuable adative to a current design and could have its current features and benefits expanded upon, or implemented thoroughly into a final design solution. This product also has the potential to serve multiple purposes and become a smaller piece as part of a larger design solution.

Product Image	**Product Name**	Paris PULK
	Description	This system uses the Paris 960 Expedition™ sled. The Paris sled is vacuum molded from 1/8″ high density polyethylene. Its signature orange color is easy to find in a white out. Its wide rims provide torsional rigidity and its design has proven to be effective in hundreds of expeditions and trips from the South Pole to the Canadian Rockies. This sled glides and floats in powder very well. It is durable enough to last several long trips while being about 4 pounds lighter than other more durable pulk sleds.
	Specifications	Size: 59″ long x 20″ wide x 6″ high Weight: 4lbs (sled only) Details: • ERAPro Paris 960 Pro Expedition sled • Vacuum molded/thermo formed from 1/8″ high density polyethylene • Optional stow away fins
	URL Link	https://www.skipulk.com/product/paris-pulk/

This product was selected for benchmarking because, much like the Paris PULK pictured above, it can act as an element of a larger design. Additionally, its intent for athletic movements in 8,000 meter environments of extreme cold make it ideal for use in freezing environments such as the Arctic. The athletic design intent can further transfer into a better user experience and overall comfort.

Product Image	**Product Name**	Mens Himalayan Suit
	Description	Designed for athletes aiming for the top of the world, the Himalayan Suit is the pinnacle down suit for climbing 8,000 meter peaks.
	Specifications	Fabric: Lining: 20D 35 G/M² 100% Nylon Fabric: Body: 30D 56 G/M² (1.65 Oz/Yd²) Pertex® Endurance—100% Nylon Ripstop Fabric: Seat, Lower-Leg, Inner-Leg And Cuff Abrasion: 40D 100 G/M² (2.95 Oz/Yd²) DryVent™ 2L— 100% Nylon Faille Weave Fabric: Down Insulation: 800 Fill Goose Down Throughout The Body; 700 Fill Goose Down In Sleeves; All Down Certified To The Responsible Down Standard (RDS) By Control Union Fabric: Synthetic Insulation: 133 G/M² PrimaLoft® Gold Insulation In Lower Leg; 80 G/M² PrimaLoft® Silver Insulation In Waistband, Shoulder And Back
	URL Link	https://www.thenorthface.com/shop/mens-himalayan-suit-2-en-ca

This product was selected because it is a piece of scientific equipment which can be used in day to day research usage for a marine biologist. Its size, capabilities and sensitivities are also good features to include and consider as it can determine certain interior size limitations.

Product Image	**Product Name**	SEAMOR ROV
	Description	The Steelhead inspection-class ROV is a portable, lightweight and stable underwater system that is easily operated through intuitive flight controls. Its small profile allows this vehicle to inspect confined spaces and be easily stowed.

Specifications	The compact Steelhead is easily deployed and recovered from small vessels and docks – no need for hoists or cranes. A standard definition NTSC/PAL camera, optimized for lowlight conditions provides the ROV operator with quality video. “Out of the box” features include an integrated controller and LCD monitor module with auto depth, auto heading, a digital video recorder and much more. • Intuitive controller • Broadcast-quality colour, zoom camera • Variable speed & directional ROV control • Integrated controller with LCD monitor • Digital Video Recorder (DVR) • Manual & automatic camera focus control • Depth-rated to 300 m (1000 ft) • Auto depth, auto heading functions • Four (4) powerful thrusters • Leak detection warning system • Tether-launchable
URL Link	https://seamor.com/products/seamor-steelhead/

Below, the key benefits have been grouped into three columns. All benefits from promotional literature have been gathered in the column titled BENEFITS. In the middle column, ‘Sort #1’ the Data is color coordinated into various categories. In the third column on the right, ‘Sort #2’ these benefits are sorted into their appropriate categories and given a category name to make identifying the general scope of these benefits easier for future reference.

BENEFITS **From Promotional Material**	**Sort #1** **DATA [On Menu Bar] →**	**Sort #2** **Groups like categories**
Condensation free	abundant reflectivity	***comfort*** ***16***
usable interior space	articulated steering	compression resistance
warm interior	compression resistance	Condensation free
Extremely breathable	Condensation free	drop-seat configuration
Water repellent	countryside and snow	eliminates cold spots

easy to set up
livable space
off-road ability
little maintenance
works in all terrain
fully amphibious
excellent heating and ventilation
excellent traction
excellent hill-climbing ability
easy to find
glides and floats
lighter and durable
Superior warmth
compression resistance
eliminates cold spots
durable water-repellent finish
drop-seat configuration
integral suspender system,
reliable warmth
finest alpine equipment
abundant reflectivity
seals cold out
payload
articulated steering
four-track drive
countryside and snow
rubber tracks
vestibules
sleeping quarters
Fire retardent

drop-seat configuration
drop-seat confguration
durable water-repellent finish
easy to find
easy to find
easy to set up
eliminates cold spots
excellent heating and ventilation
excellent hill-climbing ability
excellent traction
Extremely breathable
finest alpine equipment
Fire retardant
four-track drive
fully amphibious
glides and floats
integral suspender system
lighter and durable
little maintenance
livable space
livable space
off-road ability
payload
payload
reliable warmth
rubber tracks
seals cold out
sleeping quarters
Superior warmth
usable interior space
vestibules
warm interior
Water repellent

excellent heating and ventilation
Extremely breathable
lighter and durable
livable space
reliable warmth
seals cold out
sleeping quarters
Superior warmth
usable interior space
vestibules
warm interior
Water repellent

Style	***2***
Liveable space	
Easy to Find	

efficiency	***14***
articulated steering	
countryside and snow	
drop-seat configuration	
durable water-repellent finish	
easy to set up	
excellent hill-climbing ability	
excellent traction	
finest alpine equipment	
four-track drive	
fully amphibious	
little maintenance	
off-road ability	
payload	
rubber tracks	

Safety	***6***
abundant reflectivity	

		easy to find
		glides and floats
		integral suspender system
		payload
		Fire retardant

Below, the key benefits have been grouped into three columns. All benefits from promotional literature have been gathered in the column titled BENEFITS. In the middle column, 'Sort #1' the Data is color coordinated into various categories. In the third column on the right, 'Sort #2' these benefits are sorted into their appropriate categories and given a category name to make identifying the general scope of these benefits easier for future reference.

FEATURES		**Sort #1**	**Sort #2**
From Promotional Material	**Re-order: NOUN first**	**DATA [On Menu Bar] →**	**Group like categories**
Heavy duty	Heavy duty	8000 meter peaks	
Urethane coated nylon	Urethane coated nylon	10.000 km track-life	**Transportation**
Vapex	Vapex	13-15 people	10.000 km track-life
Storage Spaces	Storage Spaces	304 square feet storage	glides and floats
Anodized aluminum	Anodized aluminum	6 passengers	Max speed - 50 km/hr
Arctic-grade bungee cords	Arctic-grade bungee cords	800 Fill goose down	Nylon cord reinforced tracks
Auto-motive grade plastic	Auto-motive grade plastic	Anodized aluminum	Turning radius
304 square feet storage	304 square feet storage	Adjustable hood	
Four seasons	Four seasons	Arctic-grade bungee cords	**Storage**
13-15 people	13-15 people	Auto-motive grade plastic	304 square feet storage
Vestibule storage	Vestibule storage	carried on roof or rear unit	Adjustable hood
Adjustable	Adjustable	Four season living	carried on roof or rear unit
Screen windows	Screen windows	glides and floats	Heavy duty
Turning radius	Turning radius	Heavy duty	Load capacity over 2 tons
Load capacity over 2 tons	Load capacity over 2 tons	High density polyethylene	Storage Spaces
10.000 km track-life	10.000 km track-life	Load capacity over 2 tons	torsional rigidty
Max speed	Max speed	Max speed - 50 km/hr	Up to 200kg of gear
			Vestibule storage

High density polyethylene	High density polyethylene
800 Fill goose down	800 Fill goose down
zero cold spots	zero cold spots
PrimaLoft Gold Insulation	PrimaLoft Gold Insulation
Adjustable hood	Adjustable hood
8000 meter peaks	8000 meter peaks
vacuum molded	vacuum molded
glides and floats	glides and floats
torsional rigidty	torsional rigidty
6 passengers	6 passengers
Sleeps 9-11 people	Sleeps 9-11 people
Up to 200kg of gear	Up to 200kg of gear
carried on roof or rear unit	carried on roof or rear unit
Nylon cord reinforced tracks	Nylon cord reinforced tracks

Nylon cord reinforced tracks
PrimaLoft Gold Insulation
Screen windows
Sleeps 9-11 people
Storage Spaces
torsional rigidty
Turning radius
Up to 200kg of gear
Urethane coated nylon
vacuum molded
Vapex
Vestibule storage

zero cold spots

Accomodations
13-15 people
6 passengers
Four season living
Sleeps 9-11 people

Materials
800 Fill goose down
Anodized aluminum
Auto-motive grade plastic
Arctic-grade bungee cords
High density polyethylene
PrimaLoft Gold Insulation
Urethane coated nylon
vacuum molded
Vapex

Other
8000 meter peaks
Screen windows
zero cold spots

APPENDIX D – NEEDS ANALYSIS

Statement of Need

Marine biology in the Arctic is a purposeful and scientifically valuable practice built on ease of using and transporting research equipment (gear) (control, mastery), and comfort for the research / marine biology team in the cold environment (comfort and security).

Arctic marine biology research is also a practice focused on efficiency and ease of use, since most research trips are time and condition dependent, enabling users to interact freely (freedom, autonomy) is important.

Durability can be afforded through material choice and structural design.

A transportation / storage apparatus for marine biologists which enables the transport of research equipment and gear in a comfortable living environment in the Canadian Arctic.

Specific needs include:

- Living comfort in the Arctic, dealing with cold climates
- Security of the load being carried, balanced and protected (delicate equipment)
- Convenience and ease of use in challenging situations (severe cold weather)
- Durability in freezing temperatures
- Comfort for Arctic marine biologists / researchers / crew members

Four key activities	Purpose / Relation to thesis
The act of carrying / transport of research equipment	Observing how marine biologists and Arctic researchers can use their scientific instruments in the field will be vital to ergonomic considerations in the design solution.
Accessing wildlife habitat, traveling to and from the field site	Observing the methods of accessing wildlife habitat and traveling to field research sites can highlight areas of improvement for more efficient transport or relocation.
Tracking devices are attached to wildlife (radio collars, satellite tags)	Observing how tracking devices are attached to marine wildlife can highlight various ergonomic considerations as humans interact with wildlife.
Safe interaction with wildlife	Observing safe interaction with wildlife can inform particular design considerations for the design solution, ensuring the safety of the human and the animal.