AQUASIST

TEAM 525: ASSISTING PARAPLEGICS WHILE SCUBA DIVING

DR 6

04-APR-19

TEAM INTRODUCTIONS

Kylie Halbert:
Material Selection Engineer
&
Project Manager

Ebony Luster:
Operations Engineer & Financial Delegator

Dominic Balistreri:
Design & Test Engineer

Kevin Nicholas:
Design & Test Engineer

SPONSOR AND ADVISOR

FAMU-FSU
College of Engineering

Project Sponsor

Michael Devine, Ph.D.

Entrepreneur in Residence & Professor

Academic & Engineering Advisor

Shayne McConomy, Ph.D.

Teaching Faculty I, Mechanical Engineering

KYLIE HALBERT

OBJECTIVE

THE OBJECTIVE OF THIS PROJECT IS TO CREATE A DEVICE THAT OFFERS PARAPLEGIC SCUBA DIVERS GREATER INDEPENDENCE WHILE IN THE WATER.

KYLIE HALBERT

MOTIVATION

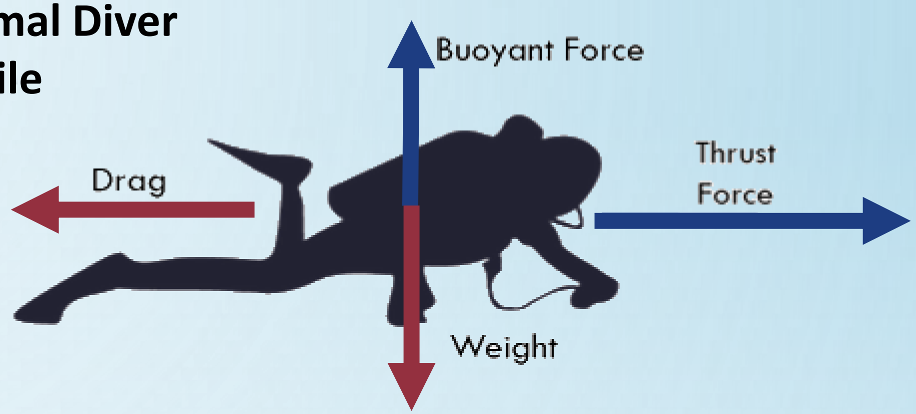
- WITH THE DEVELOPMENT IN TECHNOLOGY, PARAPLEGICS ARE ABLE TO PARTICIPATE IN NUMEROUS ACTIVITIES AND SPORTS
- INSPIRED BY WITNESSING PARAPLEGIC VETERANS STRUGGLE WHILE DIVING
- PARAPLEGICS ARE JUST AS ENTITLED TO HAVE FREEDOM WHILE IN THE WATER

KYLIE HALBERT

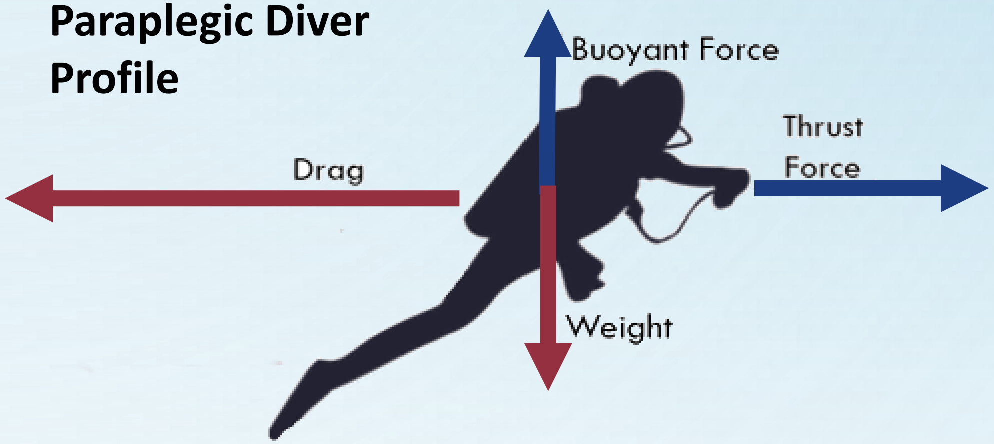
PROJECT BACKGROUND

- PARAPLEGICS EXPEND MORE ENERGY AND THUS MORE AIR AS COMPARED TO OTHER DIVERS
- A DEVICE THAT AIDS DIVERS IN CONTROLLING THEIR TRIM WOULD BE BENEFICIAL
- THE MARKET WILL INCLUDE PARAPLEGICS AS WELL AS DIVE CHARTERS, INSTRUCTORS, ETC.

Normal Diver Profile



Paraplegic Diver Profile



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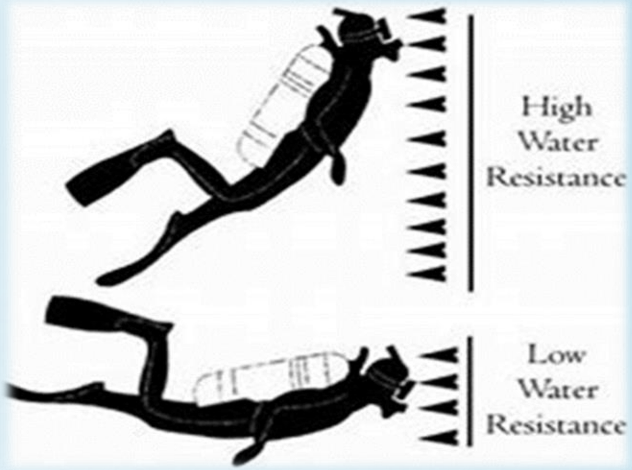
KEY GOALS

- ALLOW PARAPLEGICS TO INDEPENDENTLY CONTROL THEIR **BODY'S ORIENTATION** IN THE WATER
- ALLOW PARAPLEGIC SCUBA DIVERS TO HAVE CONTROL OF THEIR **LEG'S LOCATION**
- ALLOW PARAPLEGICS TO **ATTACH AND DETACH** DEVICE TO THEIR BODY WITHOUT AID FROM OTHERS
- ALLOW PARAPLEGIC SCUBA DIVERS TO **MOVE SAFELY** THROUGHOUT WATER WITHOUT INTERFERING WITH **PREEXISTING SCUBA DIVING EQUIPMENT**



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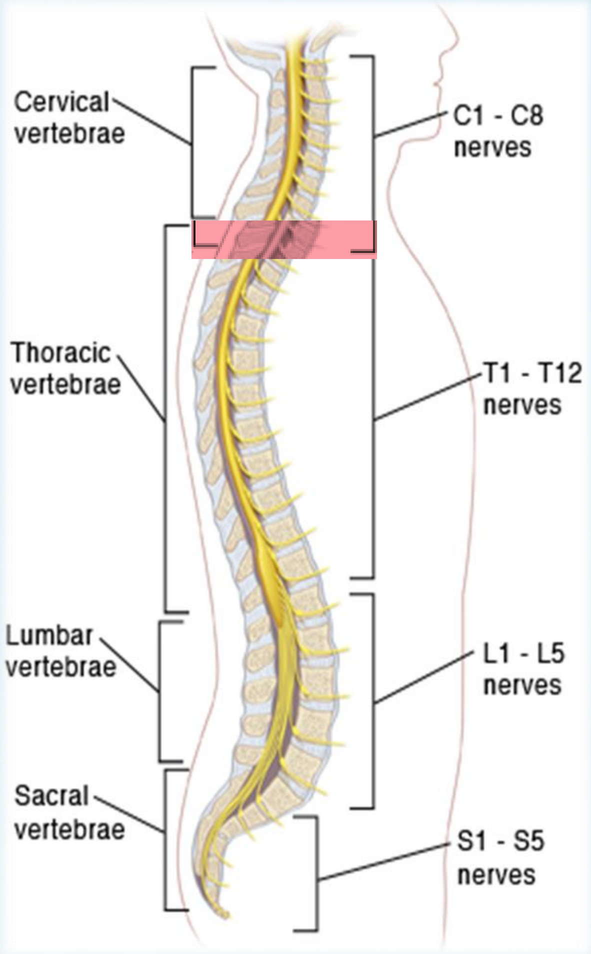
ASSUMPTIONS

- THE PARAPLEGIC SCUBA DIVER IS A **CERTIFIED SCUBA DIVER** (OR BECOMING CERTIFIED) AND THEY WILL NOT EXCEED THEIR DIVING CAPABILITIES AND DIVING CERTIFICATIONS
- THE PARAPLEGIC PERSON HAS A **C8 SPINAL INJURY OR LOWER**
- THE PARAPLEGIC DIVER WILL ALWAYS BE **ACCOMPANIED BY ANOTHER SCUBA DIVER**
- THE PARAPLEGIC DIVER WILL HAVE **ASSISTANCE FOR GETTING IN AND OUT OF THE WATER**



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TARGETS MARKETS

- TARGET USER
  - PARAPLEGIC SCUBA DIVERS
- TARGET MARKETS
  - PARAPLEGIC SCUBA DIVERS
  - DIVE CHARTERS
  - DIVE INSTRUCTORS
  - VETERAN ORGANIZATIONS
  - REHABILITATION CENTERS
  - NON-PROFIT ORGANIZATIONS

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CUSTOMER NEEDS

INTERVIEWS WITH POTENTIAL END USERS AND EXPERTS WERE CONDUCTED TO BETTER UNDERSTAND WHAT PROBLEMS PARAPLEGIC DIVERS FACE

15 PARAPLEGIC DIVERS

20 DIVE INSTRUCTORS

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CUSTOMER NEEDS

Question/Prompt	Customer Response	Interpreted Need
Where do you typically go diving?	I like to go to reefs and sometimes springs.	The assistive device can operate in fresh and salt water.
How do you normally get in and out of the water?	I either pull myself with my arms until I'm in deep enough water to swim or have someone help drag me off the boat.	The assistive device operates normally after repetitive dragging against boat deck or sand surfaces (under the weight of the scuba diver).
How deep do you normally dive?	I have my advanced diving certification, so I regularly reach depths of around 100ft deep.	The assistive device has a safety pressure relief valve (if pressurized gas is used) and can operate under pressure.
Do you maintain your dive equipment regularly?	I get my regulators services and buoyancy compensator serviced whenever the dive shop that fills my air recommends.	The assistive device requires no more maintenance than standard scuba diving equipment (once a year or twenty-five dives).
What is a task you struggle with when you dive?	Getting in and out of the water with all my gear on is always a challenge for me and whoever is assisting me.	The assistive device doesn't hinder the diver getting in and out of the water.
What are some difficulties you encounter when training paraplegic divers?	Many of students have different styles of buoyancy compensators so training each student to control their trim and buoyancy comes with different challenges.	The assistive device is compatible with most vest/jacket flotation, back flotation, and horse collar buoyancy compensators.
What is something you feel would make diving easier for you?	Putting on my wet suit has always been very difficult, and it can be embarrassing for me to ask for help getting dressed.	The assistive device provides a means for the scuba diver to put on their wet suit by themselves.
If you had a device that you had to control in the water how would you like to operate it?	I would have to control something with my hands. I would like the controls to not be confusing because my hands are also my only means for propulsion.	The assistive device can be operated with the diver's hands and doesn't interfere with other pre-existing controls.
Do you go diving on vacations and do you bring your own equipment with you?	I have been diving on vacation several times. I have brought my equipment with me but only about half of the time because my gear takes up too much space to travel with on planes.	The assistive device is compact and portable
What are some of the water temperatures that you dive in?	I have been in water as hot as 85 degrees and as low as 43 degrees.	The assistive device operates normally under various temperatures it is exposed to, in and out of the water.
As an instructor, what do you see paraplegic divers struggle with the most?	I feel that paraplegic divers are unable to control their trim properly and are constantly needing someone to keep hold of them.	The assistive device helps control a diver's trim without needing the assistance of another diver.
As an instructor, why do you feel it is necessary for paraplegic diver's to not need assistance while diving?	Diving is a very freeing experience and is the one place that a paraplegic can feel free again. They should not need someone to be constantly holding onto them because that defeats the purpose of feeling free.	The assistive device can be operated by just the single diver and not need any assistance while in the water.
What issues do you encounter when trying to control your trim?	I mainly have issues with my legs dragging.	This assistive device allows assistance in not letting the diver's legs drag.

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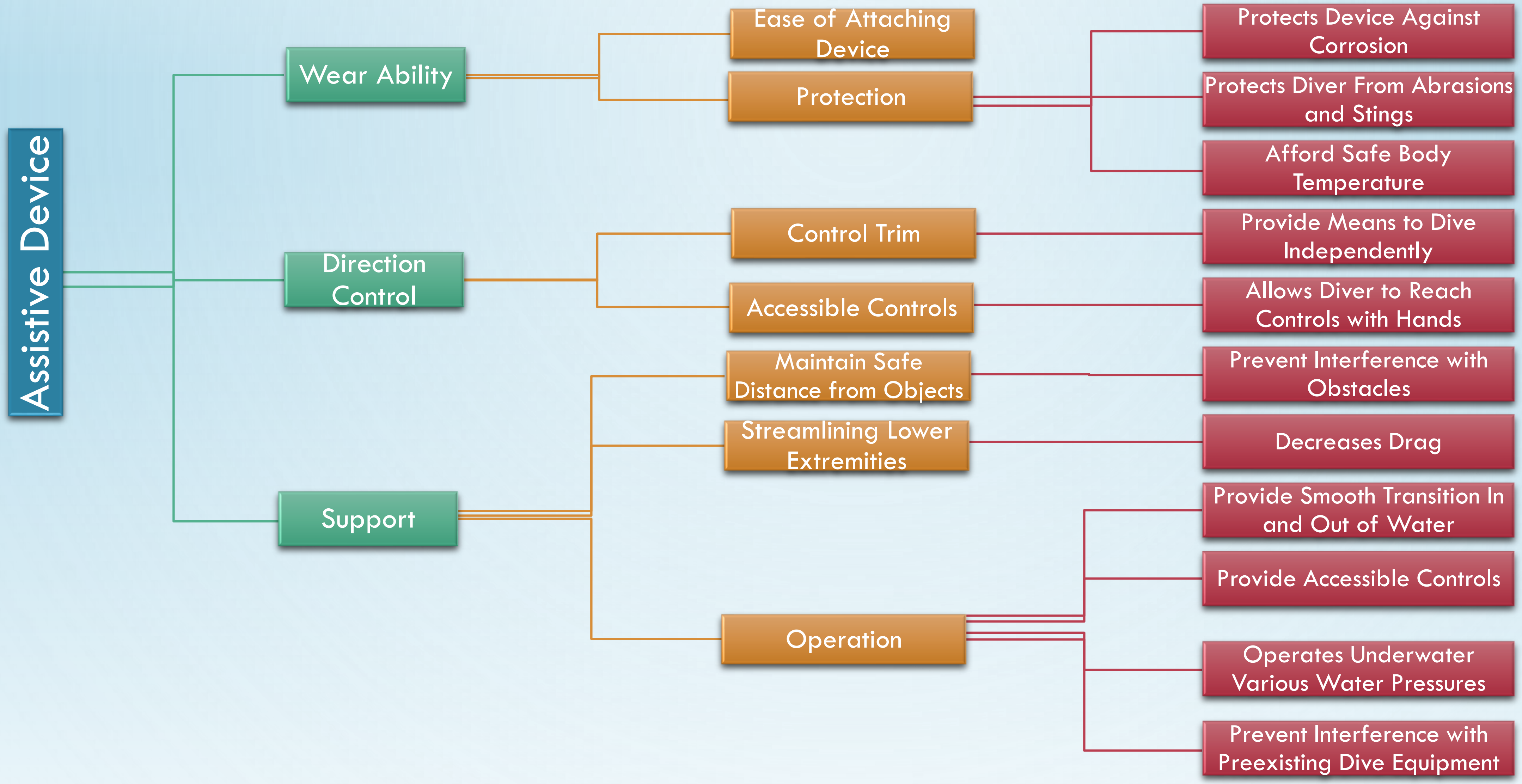
FUNCTIONAL DECOMPOSITION



EBONY LUSTER

BRINGING IT ALL TOGETHER

CUSTOMER NEEDS

FUNCTIONAL DECOMPOSTION

The Assistive Device Prevents Divers Legs From Unintentionally Contacting Objects

- Protects Diver From Abrasions and Stings
- Prevent Interference with Obstacles

EBONY LUSTER

ESTABLISHING TARGETS AND METRICS

Function	Targets	Metric
Protects Device Against Corrosion	Minimum Number of Dives Before Equipment Needs Servicing	1 Year or 25 Dives (Whichever Comes First)
	Minimum Life Expectancy of Device	5 Years
Provides a Mean to Dive Independently	Desired Angle of Diver at Surface	90°
	Desired Angle of Diver at Diving Depth	0°
Operates Under Various Water Pressures	Maximum Pressure Able to Withstand	220 kPa

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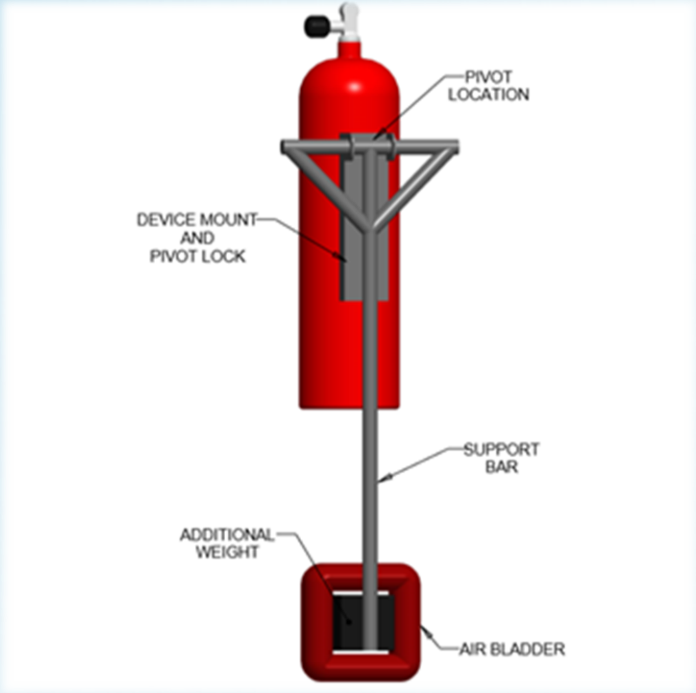
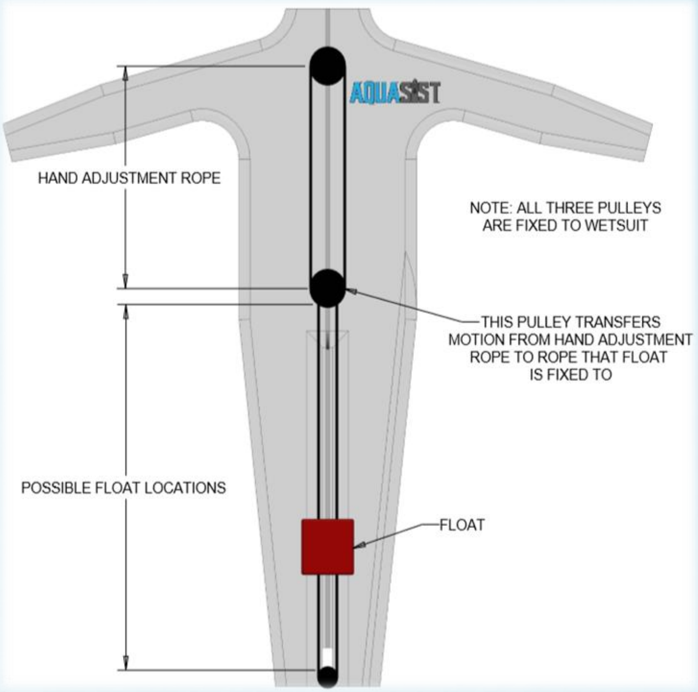
CONCEPT GENERATION



Secondary Buoyancy Compensator



Adjustable Float

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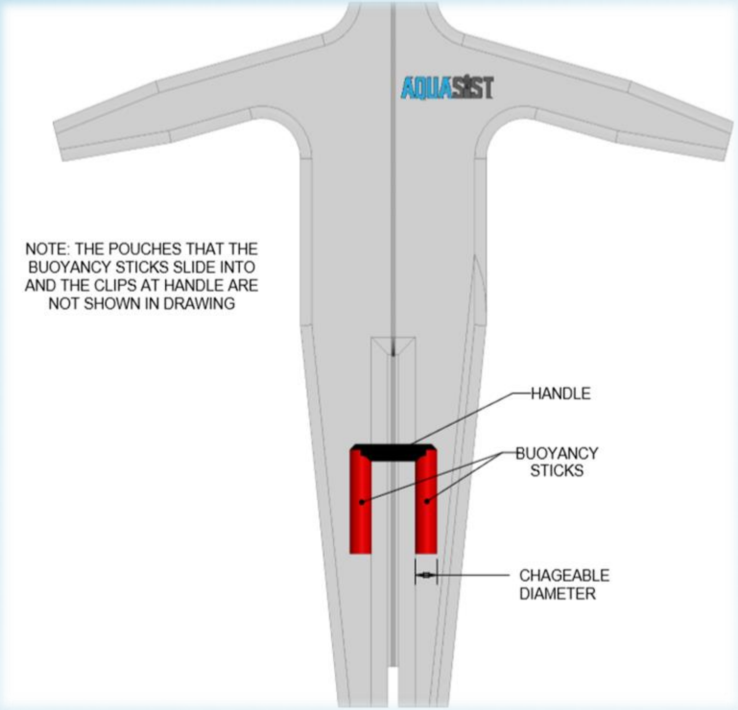
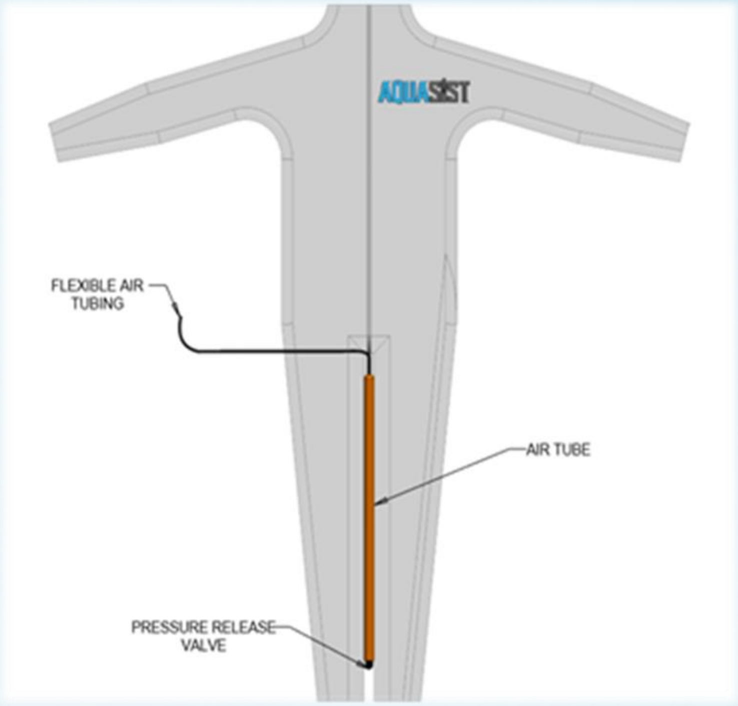
CONCEPT GENERATION



Buoyancy Sticks



Secondary Air Tube

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CONCEPT SELECTION PROCESS

BPwC → HoQ → Pugh → AHP → Concept Selection

- Compares customer requirements against each other
- Generates “Importance Weight Factors” used in house of quality

DOMINIC BALISTRERI

CONCEPT SELECTION PROCESS

- Compares customer requirements against each other
- Generates "Importance Weight Factors" used in house of quality

Customer Requirements \ Design Requirements	Importance
Operates in Fresh and Salt Water	6
Can Handle Repetitive Dragging	4
Pressure Relief Valve if Compressed Gas is Used	9
Maintenance Schedule	1
Does Not Hinder Transferring Diver In and Out of Water	3
Compatible With Pre-existing Dive Equipment	9
Diver Can Put on Wetsuit By Themselves	4
Device is Operated by Hands	11
Compact Device	2
Operates at Various Temperatures	4
Controls Diver's Trim	12
Does Not Need Assistance While Attaching Device	4
Prevents Diver's Legs From Dragging	9

DOMINIC BALISTRERI

CONCEPT SELECTION PROCESS

BPwC → HoQ → Pugh → AHP → Concept Selection

- Infuses voice of customer throughout the concept selection process
- Compares the customer requirements to the engineering characteristics
- Returns the importance ranking of the engineering characteristics based on the customer requirements

DOMINIC BALISTRERI

Improvement Direction		↓	↑	↑	-	↓	↑	-	↓	↓	↓	↓	↓	↑	↑	↑	↓
Units of EC's		Minutes	Years/Dives	Years	mm	cm^2	Hours	Degrees	mm	mm	m^2	kg	cm	kPa	cm	%	Dollars ($)
Design Requirements / **Customer Requirements**	**Importance**	Time to Attach Device	Time Before Equipment Needs Servicing	Life Expectancy	Thickness of Wetsuit	Amount of Exposed Skin in Lower Extremities	Time in Water	Angle of Diver at Depth and Surface	Distance to Controls	Protective Perimeter Around Diver	Surface Area That Would Affect Diver's Drag	Weight of Equipment	Length Equipment Extends	Pressure Device is Able to Withstand	Allowable Distance Controls Can Be From Pre-existing Scuba Controls	Works With Different Body Compositions	Cost of the Device
Operates in Fresh and Salt Water	6		3	9										1			
Can Handle Repetitive Dragging	4		1	3	1	3				3		1	3			1	3
Pressure Relief Valve if Compressed Gas is Used	9							3	3					3	1		9
Maintenance Schedule	1		9	3									1				9
Does Not Hinder Transferring Diver In and Out of Water	3	1					1	9		3		9	9		1	1	
Compatible With Pre-existing Dive Equipment	9							1	9	9	1	1	3		9	3	
Diver Can Put on Wetsuit By Themselves	4	9			3								1			1	1
Device is Operated by Hands	11							9	9						3	3	
Compact Device	2								1		9	3	3		1		1
Operates at Various Temperatures	4				9	9	1							3			1
Controls Diver's Trim	12				3		9	9	3	3	9	3		3		9	
Does Not Need Assistance While Attaching Device	4	9							1			1	1		1	3	
Prevents Diver's Legs From Dragging	9				3	3	1	9	3	9	9	1				9	
Raw Score (2238)		75	31	69	115	75	124	351	276	147	216	95	81	81	130	272	112
Relative Weight %		3.33	1.38	3.07	5.11	3.33	5.51	15.60	12.27	6.53	9.60	4.22	3.60	3.60	5.78	12.09	4.98
Rank		12	14	13	8	12	7	1	2	5	4	10	11	11	6	3	9

DOMINIC BALISTRERI

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Does Not Hinder Transferring Diver In and Out of Water	3	1					1	9		3		9	9		1	1	
Compatible With Pre-existing Dive Equipment	9							1	9	9	1	1	3		9	3	
Diver Can Put on Wetsuit By Themselves	4	9			3								1			1	1
Device is Operated by Hands	11							9	9						3	3	
Compact Device	2								1		9	3	3		1		1
Operates at Various Temperatures	4				9	9	1							3			1
Controls Diver's Trim	12				3		9	9	3	3	9	3		3		9	
Does Not Need Assistance While Attaching Device	4	9							1			1	1		1	3	
Prevents Diver's Legs From Dragging	9				3	3	1	9	3	9	9	1				9	
Raw Score (2238)		75	31	69	115	75	124	351	276	147	216	95	81	81	130	272	112
Relative Weight %		3.33	1.38	3.07	5.11	3.33	5.51	15.60	12.27	6.53	9.60	4.22	3.60	3.60	5.78	12.09	4.98
Rank		12	14	13	8	12	7	1	2	5	4	10	11	11	6	3	9

DOMINIC BALISTRERI

Improvement Direction		↓	↑	↑	-	↓	↑	-	↓	↓	↓	↓	↓	↑	↑	↑	↓
Units of EC's		Minutes	Years/Dives	Years	mm	cm^2	Hours	Degrees	mm	mm	m^2	kg	cm	kPa	cm	%	Dollars ($)
Design Requirements / Customer Requirements	Importance	Time to Attach Device	Time Before Equipment Needs Servicing	Life Expectancy	Thickness of Wetsuit	Amount of Exposed Skin in Lower Extremities	Time in Water	Angle of Diver at Depth and Surface	Distance to Controls	Protective Perimeter Around Diver	Surface Area That Would Affect Diver's Drag	Weight of Equipment	Length Equipment Extends	Pressure Device is Able to Withstand	Allowable Distance Controls Can Be From Pre-existing Scuba Controls	Works With Different Body Compositions	Cost of the Device
Operates in Fresh and Salt Water	6		3	9										1			
Can Handle Repetitive Dragging	4		1	3	1	3				3		1	3			1	3
Pressure Relief Valve if Compressed Gas is Used	9							3	3					3	1		9
Maintenance Schedule	1		9	3									1				9
Does Not Hinder Transferring Diver In and Out of Water	3	1					1	9		3		9	9		1	1	
Compatible With Pre-existing Dive Equipment	9							1	9	9	1	1	3		9	3	
Diver Can Put on Wetsuit By Themselves	4	9			3								1			1	1
Device is Operated by Hands	11							9	9						3	3	
Compact Device	2								1		9	3	3		1		1
Operates at Various Temperatures	4				9	9	1							3			1
Controls Diver's Trim	12				3		9	9	3	3	9	3		3		9	
Does Not Need Assistance While Attaching Device	4	9							1			1	1		1	3	
Prevents Diver's Legs From Dragging	9				3	3	1	9	3	9	9	1				9	
Raw Score (2238)		75	31	69	115	75	124	351	276	147	216	95	81	81	130	272	112
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Rank		12	14	13	8	12	7	1	2	5	4	10	11	11	6	3	9

DOMINIC BALISTRERI

CONCEPT SELECTION PROCESS

BPwC

HoQ

Pugh

AHP

Concept Selection

- Method used to identify the most promising design concepts among alternatives
- Compares each concept to a “Datum concept” for each of the engineering criteria
- Allows for efficient elimination of multiple designs leaving only the strongest

DOMINIC BALISTRERI

PUGH MATRIX

		Concepts						
Selection Criteria	Datum	Secondary Buoyancy Compensator	Buoyancy Sticks	Air Tube	Adjustable Lift Location	Weighted Shoulder Pads	Customizable Leg Floats	Rigid Exoskeleton
Angle of Diver at Depth and Surface	MacGyver Style	+	+	+	+	S	-	S
Distance to Controls		S	+	+	+	+	+	-
Works With Different Body Compositions		+	+	+	+	S	-	-
Surface Area That Would Affect Diver's Drag		+	+	+	+	-	+	S
Protective Perimeter Around Diver		-	+	+	+	S	S	+
Number of Pluses	-	3	5	5	5	1	2	1
Number of Minuses	-	1	0	0	0	1	2	2

DOMINIC BALISTRERI

PUGH MATRIX

		Concepts						
Selection Criteria	Datum	Secondary Buoyancy Compensator	Buoyancy Sticks	Air Tube	Adjustable Lift Location	Weighted Shoulder Pads	Customizable Leg Floats	Rigid Exoskeleton
Angle of Diver at Depth and Surface	MacGyver Style	+	+	+	+	S	-	S
Distance to Controls		S	+	+	+	+	+	-
Works With Different Body Compositions		+	+	+	+	S	-	-
Surface Area That Would Affect Diver's Drag		+	+	+	+	-	+	S
Protective Perimeter Around Diver		-	+	+	+	S	S	+
Number of Pluses	-	3	5	5	5	1	2	1
Number of Minuses	-	1	0	0	0	1	2	2

DOMINIC BALISTRERI

PUGH MATRIX

		Concepts						
Selection Criteria	Datum	Secondary Buoyancy Compensator	Buoyancy Sticks	Air Tube	Adjustable Lift Location	Weighted Shoulder Pads	Customizable Leg Floats	Rigid Exoskeleton
Angle of Diver at Depth and Surface	MacGyver Style	+	+	+	+	S	-	S
Distance to Controls		S	+	+	+	+	+	-
Works With Different Body Compositions		+	+	+	+	S	-	-
Surface Area That Would Affect Diver's Drag		+	+	+	+	-	+	S
Protective Perimeter Around Diver		-	+	+	+	S	S	+
Number of Pluses	-	3	5	5	5	1	2	1
Number of Minuses	-	1	0	0	0	1	2	2

DOMINIC BALISTRERI

PUGH MATRIX

		Concepts						
Selection Criteria	Datum	Secondary Buoyancy Compensator	Buoyancy Sticks	Air Tube	Adjustable Lift Location	Weighted Shoulder Pads	Customizable Leg Floats	Rigid Exoskeleton
Angle of Diver at Depth and Surface	MacGyver Style	+	+	+	+	S	-	S
Distance to Controls		S	+	+	+	+	+	-
Works With Different Body Compositions		+	+	+	+	S	-	-
Surface Area That Would Affect Diver's Drag		+	+	+	+	-	+	S
Protective Perimeter Around Diver		-	+	+	+	S	S	+
Number of Pluses	-	3	5	5	5	1	2	1
Number of Minuses	-	1	0	0	0	1	2	2

DOMINIC BALISTRERI

CONCEPT SELECTION PROCESS

BPwC → HoQ → Pugh → AHP → Concept Selection

- "A really **Mathy** way to make a decision"
- Compares the results of the Pugh matrix to each engineering characteristic separately to determine which concept is most effective
- Ensures no bias is present in concept selection

DOMINIC BALISTRERI

CONCEPT SELECTION PROCESS

BPwC

HoQ

Pugh

AHP

Concept Selection

- Using the results from the Pugh Matrix and the AHP, a final concept was selected

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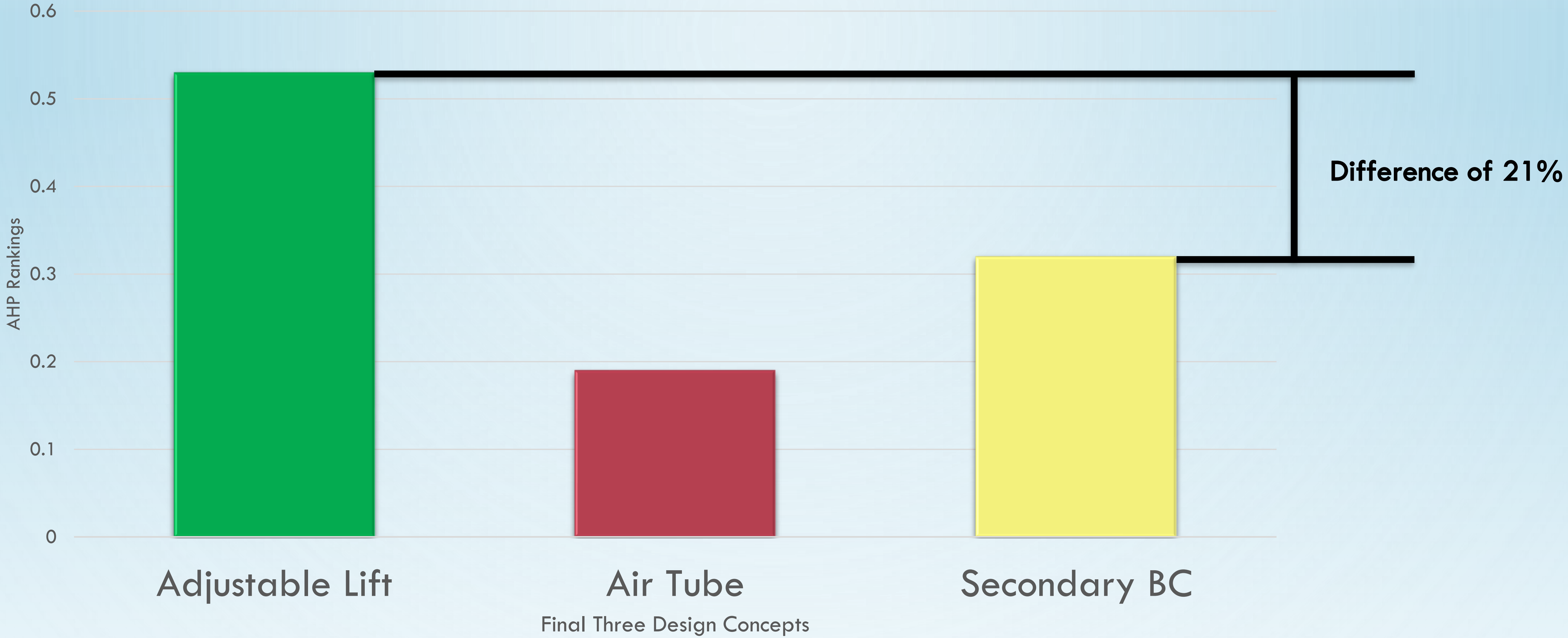
FINAL CONCEPT SELECTION



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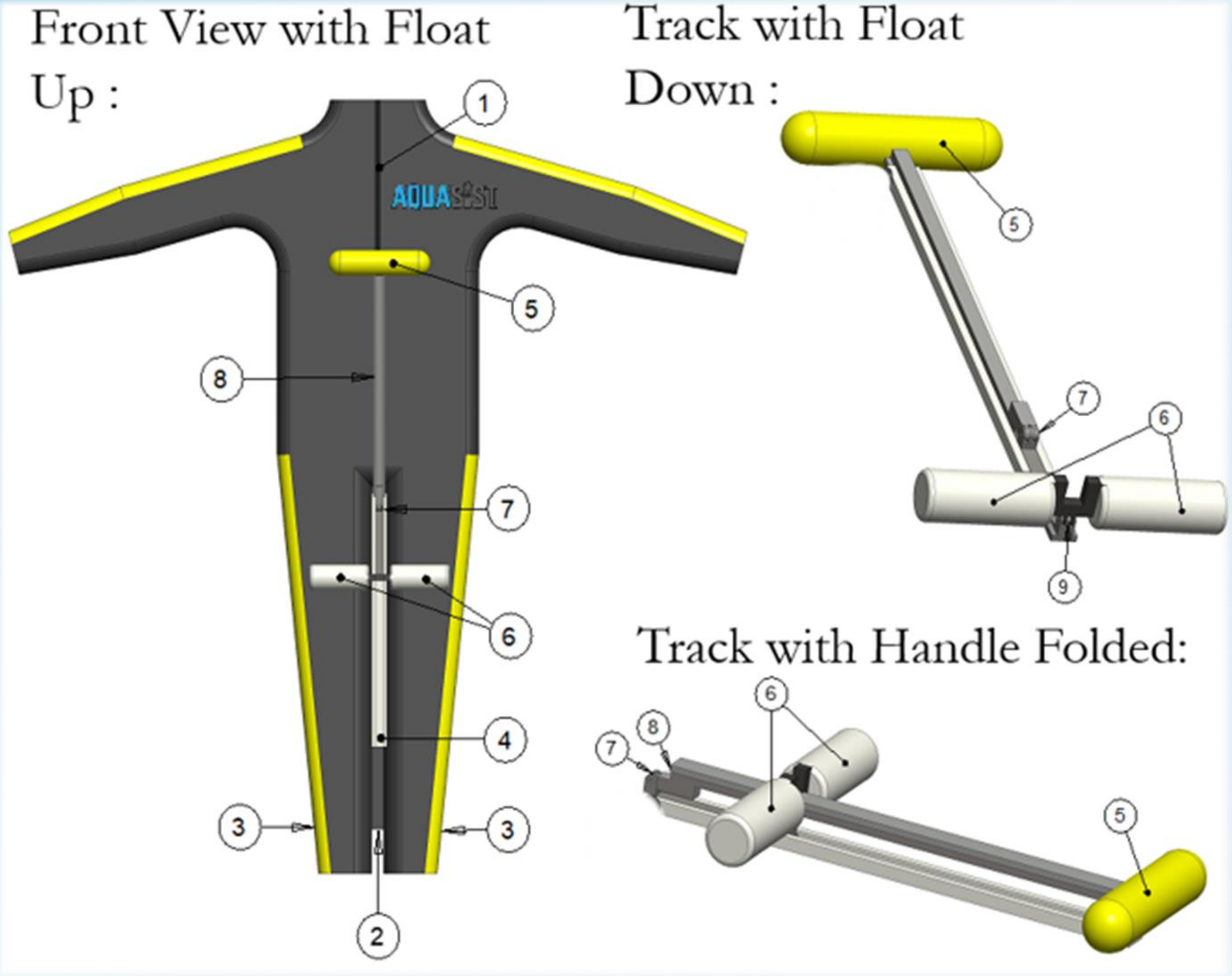
FINAL CONCEPT



1. **FRONT ZIPPER**: PROVIDES EASY ACCESSIBILITY FOR DIVER
2. **SECURES LEGS TOGETHER**: CONTROLS LOCATION OF DIVER'S LEGS
3. **ZIPPER ALONG LEGS**: ALLOWS DIVER TO DRESS THEMSELVES
4. **FLOAT TRACK**: LIMITS FLOAT TO ONE DEGREE OF FREEDOM
5. **HANDLE**: MOVES THE FLOAT'S LOCATION WITH HANDS\
6. **FLOAT**: ADJUSTS TRIM AND TWO-PIECE DESIGN ALLOWS HANDLE TO FOLD FLAT
7. **HANDLES PIVOT**: ALLOWS DIVER TO STORE HANDLE ALONG LEGS
8. **HAND KEY-WAY**: LOCKS HANDLE INTO FLOAT TRACK

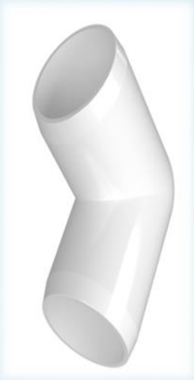
DOMINIC BALISTRERI

BUDGET REPORT

$ 1000.00 **Budget**

— $ 773.74 **Expenditures**

$ **226.26** **Remaining Balance**



EBONY LUSTER

FABRICATION PROCESS










KEVIN NICHOLAS

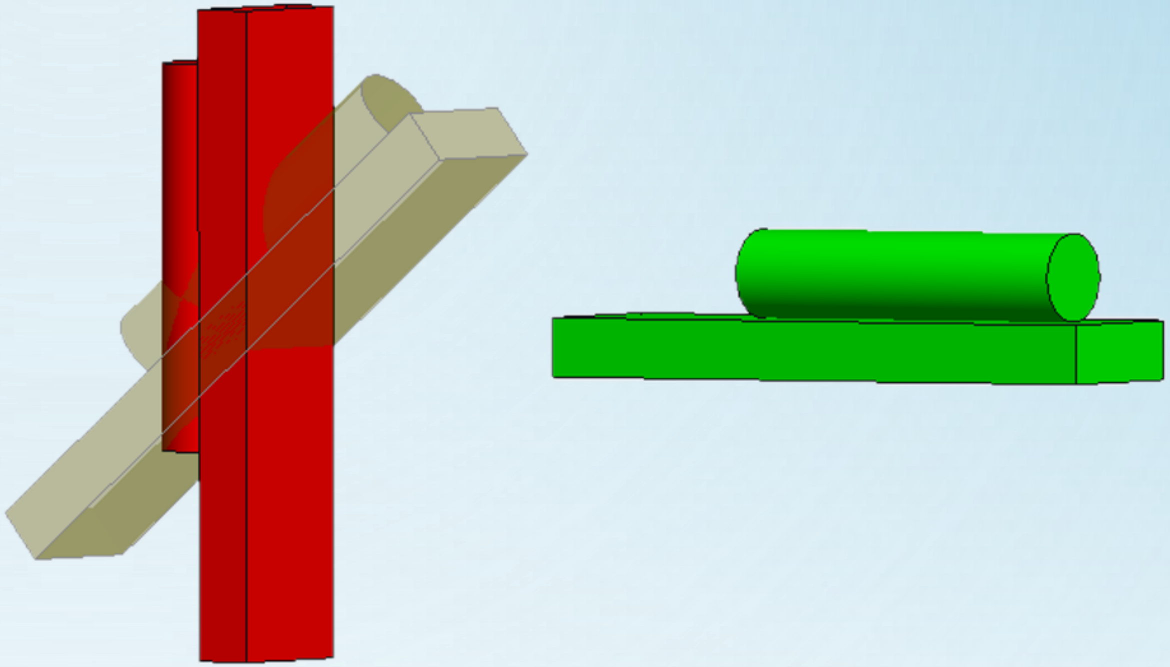
DRAG REDUCTION

- "THE AVERAGE EFFECT OF INCIDENCE IS TO INCREASE THE DRAG COEFFICIENT BY 0.013/DEGREE OR AN INCREASE OF DRAG OF 50% AT 15 DEGREES."

$$D = \frac{1}{2} C_d \rho V^2 A$$

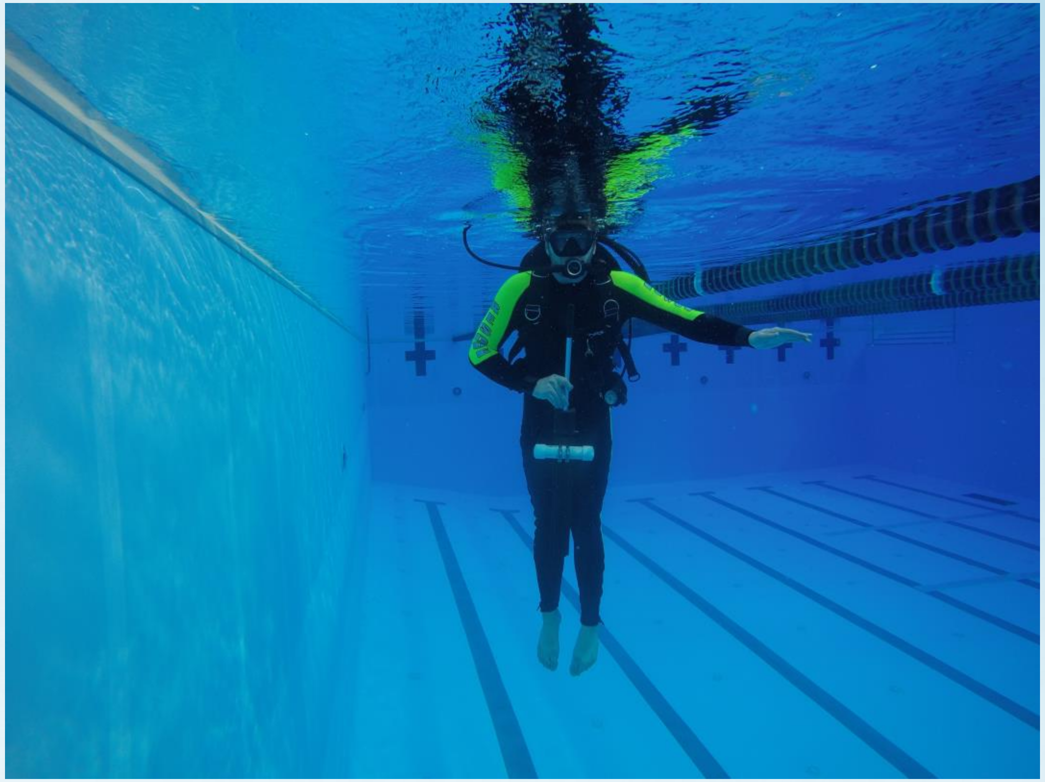
$$P_{in} = \frac{\rho A C_d U^3}{2\eta}$$

$$O_2(Consumption) = BMR + 0.002826P_{in}$$



KEVIN NICHOLAS

TESTING



KEVIN NICHOLAS

TESTING

KEVIN NICHOLAS

TARGET AND METRIC VALIDATION

Target	Metric	Prototype Preformance
Minimum Life Expectancy of Device	5 Years	8 Years
Maximum Dry Weight of Device Outside of Water	4.5 kg	4.3 kg
Operates Under Various Water Pressures	400 kPa	2585 kPa

KEVIN NICHOLAS

FUTURE MODIFICATIONS

- ADD ADDITIONAL LOCKING LOCATIONS FOR HANDLE.
- ADD WEBBING STRAP AT THE ANKLES.
- INCREASE THE BUOYANT FORCE BY INCREASING THE FLOAT'S DIAMETER.

$$F_b = V_{sub} * \rho_{H_2O} * g$$

KEVIN NICHOLAS

AWARDS AND ACCOMPLISHMENTS

- $4,000 MOST VIABLE – INNOLEVATION CHALLENGE
- FINALISTS – ENGINEERING SHARK TANK
- SEMI FINALISTS – REEF FLORIDA GOVERNOR'S CUP
- PATENT PENDING

KYLIE HALBERT

STAY LIMITLESS

"…definitely nothing like this on the market."

Susan DeVore, Executive Director of Dive Pirates Foundation

" …a highly functional device … would be great to have and use."

Dan Anderson Founder of

Veterans Dive Locker

"This is a priceless solution!"

Harry, Master Dive Instructor

Contact Aquasist at:
AquasistUSA@gmail.com

REFERENCES

- PASSMORE, M., & RICKERS, G. (2002). DRAG LEVELS AND ENERGY REQUIREMENTS ON A SCUBA DIVER. *JOURNAL OF SPORTS ENGINEERING*, 173-182.
- HTTPS://WWW.FACEBOOK.COM/HANDICAPPEDSCUBAASSOCIATION/
- COMBAT WOUNDED VETERANS PROJECT
- HTTPS://WWW.PVCFITTINGSONLINE.COM/RESOURCE-CENTER/STRENGTH-OF-PVC-PIPE-WITH-STRENGTH-CHART/

BACKUP SLIDES

Question/Prompt	Customer Responses	Interpreted Need
Where do you typically go diving?	I like to go to reefs and sometimes springs.	The assistive device can operate in fresh and salt water.
How do you normally get in and out of the water?	I either pull myself with my arms until I'm in deep enough water to swim or have someone help drag me off the boat.	The assistive device operates normally after repetitive dragging against boat deck or sand surfaces (under the weight of the scuba diver).
How deep do you normally dive?	I have my advanced diving certification, so I regularly reach depths of around 100ft deep.	The assistive device has a safety pressure relief valve (if pressurized gas is used) and can operate under pressure.
Do you maintain your dive equipment regularly?	I get my regulators services and buoyancy compensator serviced whenever the dive shop that fills my air recommends.	The assistive device requires no more maintenance than standard scuba diving equipment (once a year or twenty-five dives).
What is a task you struggle with when you dive?	Getting in and out of the water with all my gear on is always a challenge for me and whoever is assisting me.	The assistive device doesn't hinder the diver getting in and out of the water.
What are some difficulties you encounter when training paraplegic divers?	Many of students have different styles of buoyancy compensators so training each student to control their trim and buoyancy comes with different challenges.	The assistive device is compatible with most vest/jacket flotation, back flotation, and horse collar buoyancy compensators.
What is something you feel would make diving easier for you?	Putting on my wet suit has always been very difficult, and it can be embarrassing for me to ask for help getting dressed.	The assistive device provides a means for the scuba diver to put on their wet suit by themselves.
If you had a device that you had to control in the water how would you like to operate it?	I would have to control something with my hands. I would like the controls to not be confusing because my hands are also my only means for propulsion.	The assistive device can be operated with the diver's hands and doesn't interfere with other pre-existing controls.
Do you go diving on vacations and do you bring your own equipment with you?	I have been diving on vacation several times. I have brought my equipment with me but only about half of the time because my gear takes up too much space to travel with on planes.	The assistive device is compact and portable
What are some of the water temperatures that you dive in?	I have been in water as hot as 85 degrees and as low as 43 degrees.	The assistive device operates normally under various temperatures it is exposed to, in and out of the water.
As an instructor, what do you see paraplegic divers struggle with the most?	I feel that paraplegic divers are unable to control their trim properly and are constantly needing someone to keep hold of them.	The assistive device helps control a diver's trim without needing the assistance of another diver.
As an instructor, why do you feel it is necessary for paraplegic diver's to not need assistance while diving?	Diving is a very freeing experience and is the one place that a paraplegic can feel free again. They should not need someone to be constantly holding onto them because that defeats the purpose of feeling free.	The assistive device can be operated by just the single diver and not need any assistance while in the water.
What issues do you encounter when trying to control your trim?	I mainly have issues with my legs dragging.	This assistive device allows assistance in not letting the diver's legs drag.

FUNCTIONAL DECOMP BACKUP

- Ease of Attaching Device
- Protection
  - Protect from Abrasions and Stings
  - Afford Safe Body Temperature
- Control Trim
  - Provide Means for Diver to be Able to Dive Independently
- Accessible Controls
- Operation
  - Prevent Interference With Pre-existing Dive Equipment
  - Provide Accessible Controls
  - Provide Smooth Transition in and out of Water
- Streamline Lower Extremities
  - Decrease Drag
- Maintain Safe Distance From Different Objects
  - Prevent Interference With Obstacles

TARGETS AND METRICS

Function	Targets	Metric
Protects Device Against Corrosion	Minimum Number of Dives Before Equipment Needs Servicing	1 year or 25 dives whichever comes first
	Minimum Life Expectancy of Device	5 years
Provide Means to Dive Independently	Minimum Angle of Diver at Surface	90°
	Maximum Angle of Diver at Desired Diving Depth	0°
Allows Diver to Reach Controls with Hands	Distance to Controls Must Not Exceed	672 mm

CONCEPT SELECTION BACKUP

CONCEPT SELECTION PROCESS

House of Quality

Infuse voice of customer

Pugh Matrices

Narrow down concepts

Analytical Hierarchy Process

Consistency check

Final Concept Selection

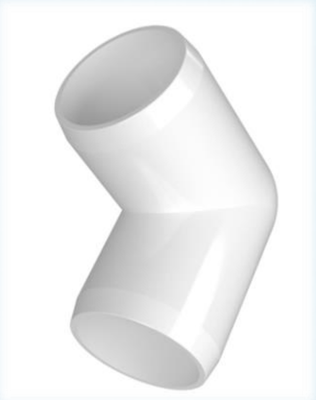
HOUSE OF QUALITY

DETAILED MATH BACKUP

Improvement Direction		↓	↑	↑	-	↓	↑	-	↓	↓	↓	↓	↓	↑	↑	↑	↓
Units of EC's		Minutes	Years/Dives	Years	mm	cm^2	Hours	Degrees	mm	mm	m^2	kg	cm	kPa	cm	%	Dollars ($)
Design Requirements / Customer Requirements	Importance	Time to Attach Device	Time Before Equipment Needs Servicing	Life Expectancy	Thickness of Wetsuit	Amount of Exposed Skin in Lower Extremities	Time in Water	Angle of Diver at Depth and Surface	Distance to Controls	Protective Perimeter Around Diver	Surface Area That Would Affect Diver's Drag	Weight of Equipment	Length Equipment Extends	Pressure Device is Able to Withstand	Allowable Distance Controls Can Be From Pre-existing Scuba Controls	Works With Different Body Compositions	Cost of the Device
Operates in Fresh and Salt Water	6		3	9										1			
Can Handle Repetitive Dragging	4		1	3	1	3				3		1	3			1	3
Pressure Relief Valve if Compressed Gas is Used	9							3	3					3	1		9
Maintenance Schedule	1		9	3									1				9
Does Not Hinder Transferring Diver In and Out of Water	3	1					1	9		3		9	9		1	1	
Compatible With Pre-existing Dive Equipment	9							1	9	9	1	1	3		9	3	
Diver Can Put on Wetsuit By Themselves	4	9			3								1			1	1
Device is Operated by Hands	11							9	9						3	3	
Compact Device	2								1		9	3	3		1		1
Operates at Various Temperatures	4				9	9	1							3			1
Controls Diver's Trim	12				3		9	9	3	3	9	3		3		9	
Does Not Need Assistance While Attaching Device	4	9							1			1	1		1	3	
Prevents Diver's Legs From Dragging	9				3	3	1	9	3	9	9	1				9	
Raw Score (2238)		75	31	69	115	75	124	351	276	147	216	95	81	81	130	272	112
Relative Weight %		3.33	1.38	3.07	5.11	3.33	5.51	15.60	12.27	6.53	9.60	4.22	3.60	3.60	5.78	12.09	4.98
Rank		12	14	13	8	12	7	1	2	5	4	10	11	11	6	3	9

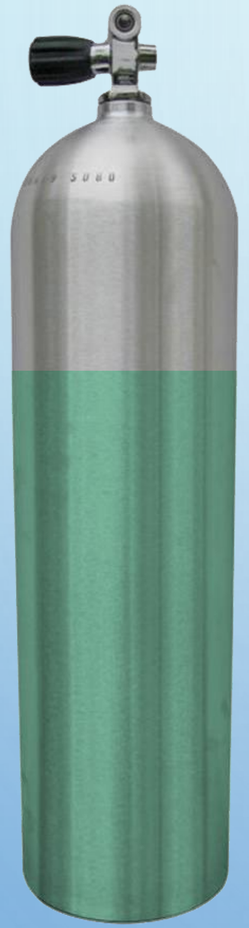
PARTS

- WEBBING
- FLOAT/ ACCESSORIES
- BUCKLE CLIPS
- HANDLE
- ZIPPERS
- TRACK/SLIDER
- WETSUIT


DOMINIC BALISTRERI

BUDGET REPORT



	\$ 1000.00	**Budget**
—	\$ 661.74	**Expenditures**
	\$ **338.26**	**Remaining Balance**

- Wetsuit
- Float Track Material
- Piping & Accessories
- Zippers
- Sewing Accessories
- Sewing Services
- Router Bit

DOMINIC BALISTRERI