Deliverable C Group A1

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1. Introduction

The Growcers company demands a design that can effectively clean their boards from algae while decreasing the time of labour for that task. Indeed, in order to develop such a design, we need to determine some criteria that would satisfy our clients' needs. Due to the multiple needs that were presented to our team during the meeting, we will have the responsibility to determine these criteria by organizing and prioritizing them based on the level of importance of our clients' needs that we have mentioned in deliverable B. As a result, these criteria will then influence our decision while developing possible concepts for our client. However, before developing possible concepts, we will research different possible products that have a main function to clean and facilitate the job of a user. By researching many products, we will be able to benchmark which will allow us to develop some metrics which is an approach to measure our design criteria. As a result, we can then determine our target specifications which will give us an insight on some quantifiable marginal measurements that respects the design criteria. Hence, this procedure can enlighten our thoughts and ideas by reflecting on the decisions we have made until now such as the prioritization of our clients' needs.

2. Design Criteria:

First of all, we believe that an important design criterion that we must respect in our design should be the rate of error of cleanliness. As a matter of fact, we decided to establish this design criteria based on the client's needs which is the ability of the product to clean the boards. In order to determine these criteria, we decided to calculate the percent of algae on the board compared to the area of the board. As a result, this metric will determine how well the design can purify the boards from algae. Hence, to determine this percentage, we can use a "reflectance colorimeter" (CNET) which can show us the difference before and after the boards have been cleaned. A second design criteria that we have decided is time. Indeed, based on our client's needs, they want to reduce manual labour. We have then interpreted this need as the time spent on cleaning boards. Hence, the metric that we have chosen for this design criteria is the time in minutes spent to clean 1 board. A third design criteria would be the cost of the design. The need that relates to this criterion is that the design must be cheap. As a matter of fact, the client wanted the design to not cost too much in order to still have a reasonable ROI and that the design must have a good lifespan. Therefore, the design criteria of cost will be calculated through the metric of value over quality ($/quality). A fourth design criterion is the area and the volume of the design. This design criteria has been based upon the need of space efficiency. Indeed, our client does not have much table or wall space to place our product. Hence, they need a design that does not surpass the dimensions of (30" deep 96" wide 36" tall) for the table and (48" wide 72" high 36" outwards) for the walls. Therefore, the metrics to calculate this criterion would be in inches^2 for the area and inches^3 for the volume. A fifth design criteria that we have interpreted from the client's need of environmentally friendly is the reduction of water contamination. Our client's business is based on a hypotonic farm. Hence, in order to have a good environment, we interpreted that the design must not contaminate the water that is emptied in the environment or that is reused for the growth of the plants. A sixth criterion that we have decided to implement based on the need of being safe and simple to use is the quality of the product. We will determine metrics for the quality of the product by analyzing the reviews such as the number of stars on Google. To add, a seventh criteria based on the need of decreasing the amount of water would be the quantity of water in (L) used. In fact, the metric for this design criteria would be the % of the intake of water used to clean a board. An eighth criterion that we have established based on the Growcers'need of mass production is the quantity of boards cleaned. As a matter of fact, the metrics to evaluate this need would be the number of boards that can be cleaned per wash. Finally, the ninth and last criteria that we have decided to create based on the need of having a non-manual design would be the ability of being autonomous. The metric that will be used to determine this criterion will be a yes/no approach. The needs that have based the design criteria will have a specific requirement. Indeed, some of the needs will have a functional requirement and some will have a non-functional requirement. Nonetheless, the criteria mentioned will still have an attributed importance whether the need is a functional or non-functional requirement. **See Appendix for design criteria based on needs Table (Table I)**

2.1. Functional Requirements

The functional requirements are requirements that our design must be able to carry out. One of the functional requirements is the ability to clean the boards because the design must accomplish this task. Indeed, without the design being able to accomplish this function it would be useless for our client since the design would not respect the problem statement based on the needs of our client.

2.2. Non-Functional requirements

The non-functional requirements are requirements that define the design's characteristics as to what it should be. Indeed, the design criteria of simplicity and ease of use would be considered as a non-functional requirement because our design must be easily manipulated and manoeuvre for non-experienced workers. For example, if the design is mounted on the wall, the worker should easily manoeuvre it from the wall to the table. Another non-functional requirement we had was the audio and or visual cue for in progress as well as completion of the task. This is important to have so that the user can clearly know when the machine is in use, when the job is done, as well as know when it is safe to interact with. This could be anything from a small beeping like a microwave to a flashing light as seen on emergency vehicles. To add, another non-functional requirement is that our design must clean the board in a timely manner. If the boards do not get cleaned faster than it would take for them to just be washed by hand, then the farmer is losing out on valuable growing time rendering the design as redundant since the main purpose of the design is to save the workers time. To continue, another non-functional requirement is that our design should make efficient use of water. This is so that the farm can keep their hydro bill low which would maintain their good margins. If the product is very wasteful with its water, then it makes the product obsolete as the company's main goal is to make money. Furthermore, the design can be automatic and must be simple and safe for the workers and farmers. Finally, the design needs to be cheap and good for the environment in order to satisfy our clients' needs.

2.3. Constraints

Design constraints are given for a variety of reasons. Whether that be a lack of space or a lack of resources. With this design we have a plethora of design constraints to consider. For example, one design constraint that we have is the size of the board we are trying to clean. Since our board is 24" x 32" if we go with a dishwasher or carwash style design, we must ensure that the board is able to comfortably fit inside our device and get a proper cleaning. Moreover, another constraint that we need to respect while creating this design is that we need to respect the availability of space given by our client. Indeed, our client has restrictedly given us a maximum of (30" deep 96" wide 36" tall) as dimensions for the wall mounting our design and (48" wide 72" high 36" outwards) as table space. Finally, we have made a list below that englobes the constraints that our design must respect.

-Dimensions of the table space (30" deep 96" wide 36" tall)
-Dimensions of table space (48" wide 72" high 36" outwards)
-No pesticides/ harmful chemicals
-½" potable water line @ 30 PSI
-2 120V, 15 amp circuit MAX
-Board is 24"x32"
-2.6-3.4 rafts per hour (¼ of the rafts get cleaned a week, 82 rafts/4 = 20.5 rafts per week (6-8 hours), 20.5 / 6 = 3.4167, 20.5 / 8 = 2.5625. Therefore 2.6-3.4 rafts per hour)

3. Technical Benchmarking

Dishwasher:

most of the dishwashers that were benchmarked all had similar scores. The one that set itself apart from the rest was the dishwasher manufactured by Hobart. With its 40 cycles per hour it would be able to clean all of the farm's rafts in just over 2 hours compared to the closest competitor that would take over 150 hours. While the price

is quite steep compared to the rest, we believe that we will be able to adapt the technology and make a much cheaper version for Growcer's farms. **For more information see Table II in the Appendix.**

Algaecides:

The overall best algaecide out of the 4 products that are benchmarked would be the Kem-Tek KTK-50-0006. The reason for this being that despite the more elevated cost per litre of this product due to the ease of use. This product compared to the other one produces no foam if used in larger amounts. The other products if used incorrectly can cause irritation to eyes and skin and cause foaming which could clog certain systems. Yet this product will not do that. Furthermore, this product will not react with the salt residue on the boards.

Car wash:

Out of the 4 different car washing machines, we believe that the best one would be the X1.1 Automatic car wash equipment. As a matter of fact, all 4 car wash machines have similar characteristics. Indeed, most of them are the same price, they have the same lifespan, they are all automatic and they are all hugely large. However, the X1.1 Automatic car wash equipment is the best for our client since it takes less time to wash one car compared to the other washing machines. Also, it is the second least car washing machine that consumes water. Therefore, this car washing machine would be the best product out of the four car washing machines.

For more information on the benchmarking, See Appendix for benchmarking table (Table II)

4. Target specifications

Minimum time per board: In our final solution we will want a lower time per board. Current time spent on board using a manual brush is around 17min/board thus in our final solution we will have to reduce manual labour by at least half and have a minimum time/board of 6hrs. Seeing as we have a week to clean 21 boards, we will need to clean at least 1 board every 8 hours to meet our quota. However, due to not being in a reliable environment 2hrs of redundancy has been added per board, judging by the time per board of our benchmarked cleaning methods this should be realistic to meet demands.

8.5min/board manual

6hrs/board automatic

Autonomous: Does not need to be autonomous as long as it reduces manual cleaning manual labour time to at least 8.5min/board on average.

8.5min/board manual

Cleanliness percent: At least 50%, in questioning with clients they asked for visibility clean results. This is not a very accurate measure of how clean something is, however, if we're talking about microorganisms. A study done by WASH assessment of maternity units of Gujarat concluded that given visually clean surfaces, the actual level of cleanliness of said evaluated surfaces could range from anywhere from 50% to 18%. However based upon further research regarding the algae at hand(assumed to be green algae for the moment) and seeing how it is only detrimental to the plants in large quantities and could even be beneficial to some extent in small quantities we decided to go with the high end of visual cleanliness reported in the study of 50%.

50% Minimum Cleanliness

Using lettuce as a baseline for that is the most common plant, given they grow 600 mature lettuce heads per week on average at a profit margin of 40 cents per lettuce head we can assume an average profit margin of 240$ a week and 11520$ a year. Seeing as the profit margins for these farms are rather low we would want a return on investment as high as possible. Thus, setting a minimum of taking 4 months and generating at least 4x as much as the product costs over its lifespan.

4 months ROI

4x ROI

Seeing as the quantity of water used was very hard to judge and that it was a low priority need we have decided to not set a minimum value to reach.

For physically demanding taken into account that we want to make this process as user-friendly as possible we have chosen to set a maximum of 5, setting that 10 is the current method of manually brushing all the boards.

Maximum of 5

5. Important Solution Attributes

From our meeting with our client, we determined that there were three main attributes, key criteria required when determining the importance of our solutions. The first property is for the product to be safe for the environment. During our interview with the client, they had mentioned a few things that were implicit with such characteristic. The client mentioned that they do not use pesticides with their product in addition to limited resources like water and electricity. They also mentioned within their presentation some of the company's ethics like mentioning the company's reduced carbon footprint, benchmarking itself as being greener than other farms due to the farm-selling food locally, reducing the carbon consumption from transporting the food. Reduced resource consumption, anti pesticides and the company advertising its reduced carbon footprints all fell under the category of being environmentally safe. The second property is effective cleaning methods. The client mentioned many things from reducing the labour required to clean each board to the method being safe and simple to use, requiring no tutorials or explanations as to how to use a set item to the method being autonomous saying things like 'click of a button,' suggestive towards the method being able to clean the boards instantly and suggestive towards the method being potentially automated. Reduced labour and cleaning times, the method being simplistic and safe for the farmers and the method being potentially autonomous could all be grouped under the common theme of the cleaning method being effective whether regarding time management, the amount of physical labour required or the efficiency regarding the learning curve of set method. Finally, the third property was space efficiency. A major thing mentioned by the client was the dimensions of the farm. Due to the Growcer's micro farms being extremely compact units, the amount of free space required to store the cleaning method is very limited; Therefore, the Solution must be able to be stored in the limited compact space without exceeding the size of free space or else the cleaning method becomes obsolete. To conclude, the three main attributes that the solution must meet are for the solution to be safe for the environment, the solution is efficient regarding time and labour when cleaning the boards and the solution must be able to be stored within the micro farm without any issue.

- **Environmentally safe**
  - **No Pesticides**
  - **Reduced Water Consumption**
  - **Reduced Energy Consumption or off the grid**
  - **The Company's Environmental Ethics**
- **Effective cleaning methods**
  - **Reduced Labour Time**
  - **Autonomy**
  - **Safe and simple to use**
  - **Space Efficient**

6. Reflection

Our client meeting happened before deliverable B was due. This being said we did have some ideas coming out of our meeting for deliverable A that we were able to tweak or rule out. One of the things we mostly ruled out was any use of a pesticide/ insecticide or algaecide. Although this would likely have been the most effective way of getting rid of any unwanted growth of algae on the board with minimal risks of damaging the board, this would go against a lot of Growcer's current clients as well as deter a lot of potentially new clients. In the client meeting, we found that a lot of Growcer's current clients do not like to use and are quite proud of their ability to remain pesticide free. In Canada about 7.4% of all farms are certified organic as of 2019 by the Canadian Census of Agriculture, this number is up to a total of 1.2% from the information gathered in 2016 (Government of Canada, 2020). This number will only keep growing as more people become more self and environmentally conscious over the coming years. One major thing that we had to tweak from our original plan was the usage needs. An example of this is that one of our ideas was to design something similar to a car wash or dishwasher. These designs are both still valid; however, they will have to be scaled down quite a bit in terms of wasted water, power consumption and the ability to run on a backup battery in the event of a power outage. Since the farms are located in such rural areas, in the event of a power outage a lot of farms are likely to be last on the list of restoring power. Water conservation was another thing that was talked about but not stressed. The biggest concern with water usage is that our design does not consume so much water that it makes the farm not profitable due to hydro bills. This being said, Growcer would like the design to be environmentally conscious but this was given a number 3 on the priorities list.

7. Conclusion

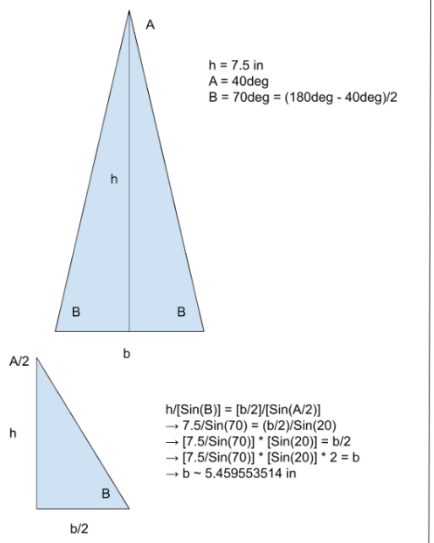
In conclusion, this deliverable allowed us to determine our design criteria by utilizing the needs of our client. As a result, we were able to prioritize these criteria by level of importance and we were able to determine the functional requirements, the non-functional requirements and the constraints for our design concept. Nonetheless, this information was very important for our benchmarking research. Hence, with the design criteria, we created some metrics in order to determine the data of a multitude of products and machines that are related to the cleaning industry. Thus, we were able to identify and define the necessary target specifications that we believe will satisfy our clients' needs. Overall, we were able to complete all the required steps found in the define stage of the design process. Yet, with the information gathered, we will still need to think of a way to implement everything by creating concepts of possible designs that will satisfy the Growcer company.

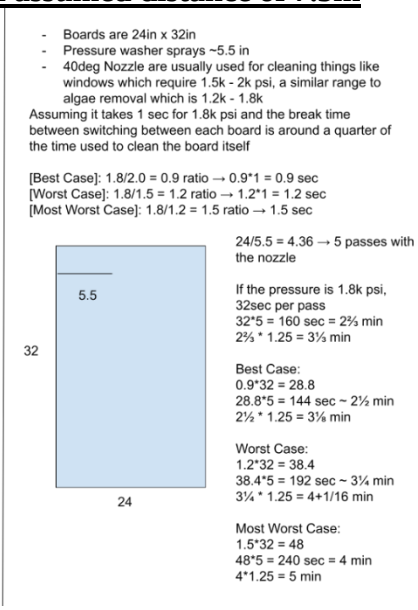
8. Gantt Chart snapshot link

https://www.wrike.com/frontend/ganttchart/index.html?snapshotId=w5ArLrRXMrXN4MPW3Y4HUxwGq7YV1J0c%7CIE2DSNZVHA2DELSTGIYA

9. Appendix

A1: Calculations used to find the cleaning rate of a pressure washer that uses the White Nozzle, 40degree spray range at an assumed distance of 7.5in





Boards per Hour

60 / 3⅓ = 18 Boards per Hour

Best Case: 60 / 3⅛ = 19 Boards per Hour

Worst Case: 60 / 4+1/16 = Boards per Hour

Most Worst Case: 60 / 5 = 12 Boards per Hour

Table I: Design Criteria based off of needs:

Needs	Design criteria	Mertics	Units	Ranking
Non-manual	Autonomous	YES/NO	N/A	3
Cleans the boards	Rate of error of cleanliness	The % of algae over the area of the boards (%algae/area)	%	5
Reduce manual labour	Time	Time spend on 1 board (board/hour)	n/hour	5
Cheap	Cost	The cost over the quality of the product ($/quality)	($/quality)	3
Space efficiency	Area and Volume	in^2 and in^3	in^2 and in^3	4
Environmentally safe	Reduction of water contamination	%contamination of water	%	4
Safe and simple to use	Quality of product	Reviews on google	*(stars)	5
Low water consumption	Quantity of water	% intake of water in litres per board (%L/board)	(%L/board)	3
Mass production	Quantity of boards cleaned	#boards per wash	n/w	3

Table II: Technical Benchmarkable:

Type of cleaning products	Name of Benchmarked Product	Hours per raft to clean (rafts / hour)	Autonomous (yes or no)	Rate of error (clean %)	Physically demanding (1-10)	Life expectancy (years)	Cost ($)	Quality (Review stars)	Dimensions (in)	Quantity of water (L/ 1 cycle)
What Growcer is currently doing	Brushes	2.6 - 3.4	no	N/A	8	N/A	Labour cost	N/A	N/A	Unknown
1 Dishwasher	Hobart	40 (1-6 min per cycle)	Yes	99.999	3 (once every 800 washes clean the pump)	10	8,716	4	18 x 26 x 27	3.04
	LG (Front Control, QuadWash, 24”)	0.4	Yes	99.999	2	12	648	4.5	23 ¾ x 33 ⅝ x 24 ⅝	10.85
	Bosch (100 series 24”)	0.44 - 0.5	Yes	99.999	2	10	650	4.4	33 ⅞ x 23 ½ x 22 ½	12.11
	Samsung (Stormwash)	0.357 - 0.588	Yes	99.999	2	10	950	3.9	23 ⅞ x 33 ⅞ x 24 ¾	13.25

Type of cleaning products	**Name of Benchmarked Product**	**Hours per raft to clean (rafts / hour)**	**Autonomous (yes or no)**	**Rate of error (clean %)**	**Physically demanding (1-10)**	**Life expectancy (years)**	**Cost ($)**	**Quality (Review stars)**	**Dimensions (in)**	**Quantity of water (L/ 1 cycle)**
2 pressure washer [assuming the use of a 40deg head at a 7.5in distance)	Rock and Rocker (Electric Pressure Washer Von 3.2)	12 to 18 Boards per hour	No	N/A	8	5 to 10	209.98	unavailable	unavailable	0.5L soap tank
	Sun Joe (SPX 3000)	12 to 18 Boards per hour	No	N/A	8	5 to 10	229.00	4.4	15.6x13.5x33.9	Two 0.9L detergent tanks (therefore 1.8L total)
	Westinghouse (WPX3400)	12 to 18 Boards per hour	No	N/A	8	5 to 10	379.00	4.6	21x19.5x23.6	1.6L detergent tank
	Simpson (MSH3125 MegaShot)	12 to 18 Boards per hour	No	N/A	8	5 to 10	749.00	4.5	21x24x34	unavailable
3 disposable coats	Duvet Cover	Range of times	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Type of cleaning products	**Name of Benchmarked Product**	**Hours per raft to clean (rafts / hour)**	**Autonomous (yes or no)**	**Rate of error (clean %)**	**Physically demanding (1-10)**	**Life expectancy (years)**	**Cost ($)**	**Quality (Review stars)**	**Dimensions (in)**	**Quantity of water (L/ 1 cycle)**
		from #1								
	Car cover	Range of times from #1	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Table cloth	Range of times from #1	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4 Algaecides	Lo-Chlor tropiclear algaecide (copper based)	Takes 1-2 hours per few boards	No	N/A	5	N/A	13.5/2.5L	5 stars/ 1 review	none	2.5L/50000L of water
	Polyquat In the swim algaecide	Takes 1-2 hours per few boards	No	N/A	5	N/A	25.9/L	4.8 stars/ 413 reviews	none	N/A
	HTH Super algae guard	Takes 1-2 hours per few boards	No	N/A	5	N/A	42/L	4.5 stars /9300 reviews	none	N/A

Type of cleaning products	**Name of Benchmarked Product**	**Hours per raft to clean (rafts / hour)**	**Autonomous (yes or no)**	**Rate of error (clean %)**	**Physically demanding (1-10)**	**Life expectancy (years)**	**Cost ($)**	**Quality (Review stars)**	**Dimensions (in)**	**Quantity of water (L/ 1 cycle)**
	Kem-Tek KTK-50-0006 Pool and Spa 60-Percent Concentrated Algaecide	Takes 1-2 hours per few boards	No	N/A	5	N/A	40/L	4.9 stars/1300 reviews	none	N/A
5 Car wash	X2 Automatic car wash system	1 car / 5-7min	Yes	NONE	1	indefinitely	150000-200000	4.9	228.3x82.6x90.5	60 L/min
	X1.1 Automatic car wash equipment	Standard time (4-5min)	Yes	NONE	1	indefinitely	150000-200000	4.9	228.3x82.6x90.5	60 L/min
	KKE wave touchless car wash equipment	Standard time (4-5min)	Yes	NONE	2	indefinitely	150000-200000	None	90x105x90	106 L/min
	KKE SpeedoClean: Automatic car wash equipment	1 car/ 6-8min	Yes	NONE	1	indefinitely	150000-200000	None	196x82x118	40 L/min

Type of cleaning products	**Name of Benchmarked Product**	**Hours per raft to clean (rafts / hour)**	**Autonomous (yes or no)**	**Rate of error (clean %)**	**Physically demanding (1-10)**	**Life expectancy (years)**	**Cost ($)**	**Quality (Review stars)**	**Dimensions (in)**	**Quantity of water (L/ 1 cycle)**
6 UV Sterilisation	Emperor Aquatics / Pentair 25 Watt SMART UV LITE (reference 1)	360 gallons per hour (good for a 1600 gallon tank)	Yes	99.9%	1	13 months per lamp bulb of continuous use	825.99	N/A	30 x 2.5 x 2.5	N/A
	GKM24 W (reference 2)	120 gallons per hour (good for a 100 gallon tank)	Yes	99.9%	1	6 to 9 months per bulb	119.99	N/A	4x4x17	N/A
	Coospider Sun JUP-01	210 gallons per hour (good for a 80 gallon tank)	Yes	99.9%	1	N/A	49.99	N/A	12x3.3x3.75	N/A
	Advantage 2000+ UV 15-Watt Barb x Barb Unit	280 gallons per hour (good for a 300 gallon tank)	Yes	99.9%	1	14 month lamp life	274.00	N/A	12.5x2.75x4	N/A

Type of cleaning products	**Name of Benchmarked Product**	**Hours per raft to clean (rafts / hour)**	**Autonomous (yes or no)**	**Rate of error (clean %)**	**Physically demanding (1-10)**	**Life expectancy (years)**	**Cost ($)**	**Quality (Review stars)**	**Dimensions (in)**	**Quantity of water (L/ 1 cycle)**
Criteria	N/A	Lower	N/A	Higher	Lower	Lower		Higher	Lower	Lower
Target Specifications	**N/A**	< 1.7/hr Manual <0.16/hr Automatic		> 50%	< 5	Profitable in < 4 months ROI = 4x (over lifetime)		>4	≤ 30”x96”x36” or 48”x72”x36”	N/A

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Bosch - 2-2.25 hours/ cycle - meets NSF requirements - clean sensors every couple months for best results - 5 year warranty - 650 from best buy
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