GNG 1103 – Project Deliverable D: Conceptual Design

Group A09 “Algae-gees”

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1.0 INTRODUCTION

Our design team has been tasked by our client, Growcer, with creating a device for cleaning the growing rafts used in their hydroponic farming units. Following the initial client meeting our team interpreted the client's statements into abstract needs that our solution must address. Those needs were summarized into the following succinct problem statement:

"Growcer requires a highly usable device that will allow their users to spend less labour cleaning the rafts for their hydroponic farm systems without compromising food safety."

Next, design criteria and metrics were developed to measure a potential solution's ability to address the client's needs, and after evaluating existing products using the design criteria, target specifications were set. Having thoroughly defined the problem, our team defined key subsystems of potential solutions, developed concepts for each of these subsystems, and after comparing and evaluating these concepts, created a conceptual design for our solution to Growcer's problem.

This report will document the subsystems created, subsystem concepts, and the final conceptual design, as well as the reasoning behind our design team's choices and two alternative conceptual designs.

2.0 SOLUTION SUBSYSTEMS

Based on the previously formulated interpreted client needs and design criteria, which can be found in appendices A and B, the following three key subsystems have been created to define a solution.

2.1 Cleaning System

This subsystem will be responsible for removing algae from the rafts, thus addressing one of the client's primary needs. This is an intentionally abstract definition so that a variety of cleaning methods can be compared.

2.2 User Interface

This subsystem will consist of the solution's controls and how a user operates and interacts with the system. Two of the client's primary needs will be addressed by this subsystem: having a highly usable solution, and reducing labour spent cleaning.

2.3 Raft Management System

This subsystem will encompass how the rafts are stored before cleaning, moved through the cleaning system, and stored after cleaning. This subsystem will address the same needs as the user interface system, as well as the compactness of the solution.

3.0 SUBSYSTEM CONCEPTS

Our team has created the following concepts, shown in table 1, for each of the three subsystems defined above. Similar concepts have been combined, and most have been abstracted to allow for simpler comparison; a detailed list of the original concepts can be found in appendix C.

Table 1: Subsystem concepts

Subsystem		
Cleaning System	**User Interface**	**Raft Management System**
High pressure water	Mechanically driven	Conveyor belt
Ultrasonic	Digital panel	Rollers
Chemical treatment	Hybrid	Slide
Friction based with sponges		Manual loading
Friction based with brushes		

4.0 CONCEPTUAL DESIGN

After comparing and evaluating subsystem concepts, our team has chosen the following elements to create a complete conceptual design for our solution.

4.1 Cleaning System Concept

Our team has chosen a high-pressure water based cleaning system in combination with a mild chemical pre-treatment because we believe this will be the most effective way to fully clean the rafts and require the least complex moving parts. Before entering the main cleaning system, the rafts will be left in a mild chemical treatment to begin removing algae, then a self-contained dishwasher-like device with high-pressure water jets will be used to clean the chemical treatment and remaining algae from the rafts. The pressurized water will also likely be heated.

This system should:

- Effectively remove algae from the rafts, including their contours, meeting one of the client's primary needs.
- Reduce labour spent cleaning the rafts, meeting another primary client need.
- Not damage the rafts, meeting a secondary client need.
- Clean multiple rafts at once, meeting another secondary client need.
- Increase the cleanliness of the cleaning process, meeting a tertiary ideal client need.

The possible downsides of this system are:

- High water usage.
- High electricity usage.
- Production of wastewater.
- Impact of chemical treatment on food safety.

4.2 User Interface Concept

Our team has chosen a hybrid digital with mechanical switches user interface which we believe will be the most accessible and usable system. Specifically, the device will have a panel with an on / off switch, a start button, an emergency stop button, a low / medium / high cleaning strength dial, as well as a visual indicator system to show when the device is in operation.

This system should:

- Be simple and highly usable, meeting a primary client need.
- Require very little time to operate, reducing labour spent cleaning, meeting another primary client need.
- Clearly indicate the system is in operation through tactile switches and a visual indicator system, meeting the primary client need of usability.

The potential downsides of this system are:

- Digital systems being less reliable than mechanical systems.

4.3 Raft Management System Concept

Given our choice of cleaning system, our team has chosen a simple manual loading raft management system. The dirty rafts will be stacked in the preparatory chemical treatment, then loaded into the cleaning device, then manually removed.

This system should:

- Be simple and highly usable, meeting a primary client need.
- Require no maintenance or replacement, meeting a secondary client need.

The potential downsides of this system are:

- Requiring manual labour to load the rafts.

Our design team believes that the combination of subsystems described above will most effectively meet the largest subset of the client's needs. Figure 1 shows a conceptual sketch of the design.

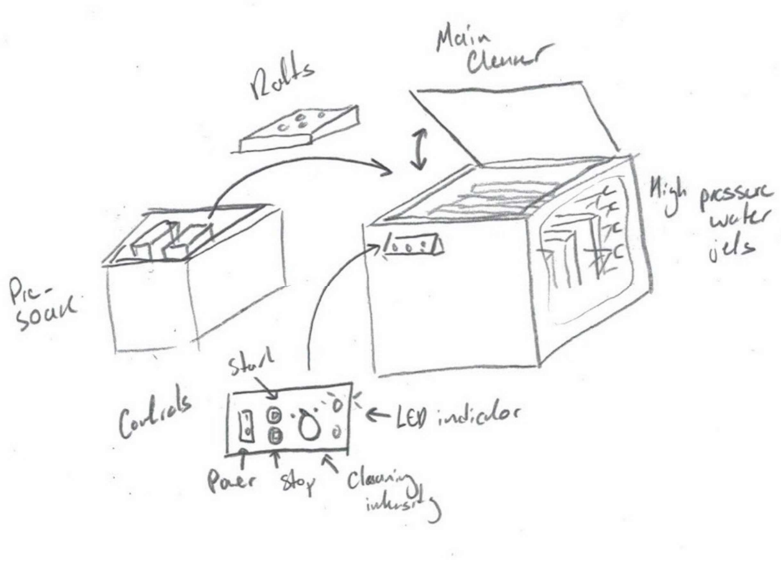

Figure 1: Conceptual design.

5.0 ALTERNATIVE DESIGNS

Should the previously described conceptual design prove ineffective or unfeasible, our design team has also created the following three alternative conceptual designs.

5.1 Conveyor Based High Pressure Water System

This design would be nearly identical to the chosen design, except that instead of a dishwasher style cleaning system, the rafts would be moved by conveyor belt through a car wash style high pressure water cleaning system. This design, shown in figure 2, would reduce the manual labour required to load the device, but increase the mechanical complexity of the system and would likely require a longer cleaning time.

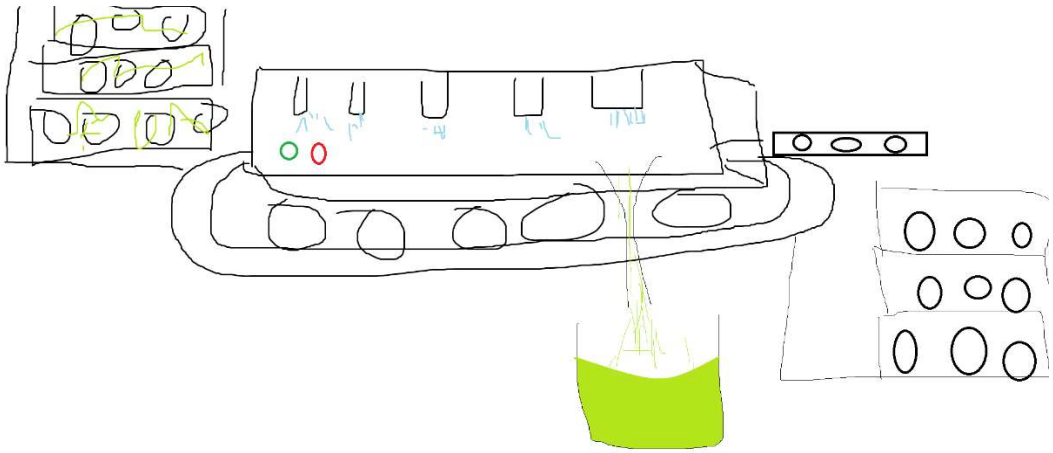

Figure 2: Conveyor based high pressure water system.

5.2 Conveyor Based Friction Cleaning System

This design would be similar to the previous alternative design, except that instead of a high-pressure water cleaning system, a friction-based cleaning system with sponges would be used. The benefits and trade-offs of this system would also be similar to previous design, reducing the manual labour spent loading rafts, but significantly increasing the complexity of the device. This design, shown in figure 3, would also reduce the water usage of the device.

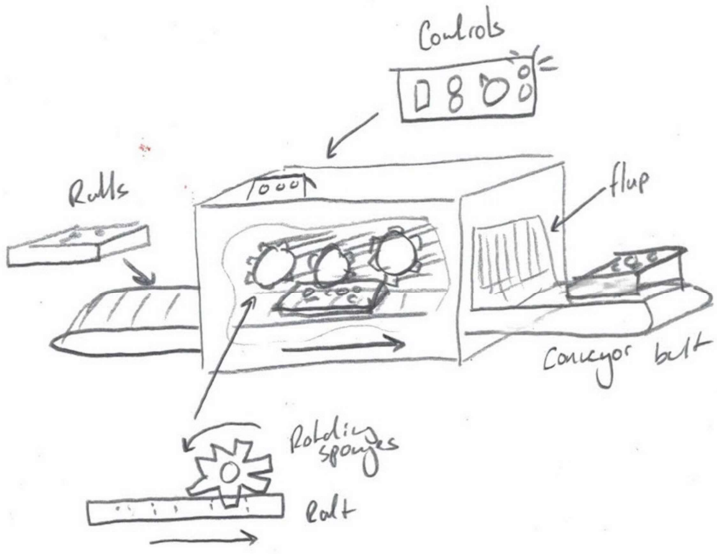

Figure 3: Conveyor based friction cleaning system.

5.3 Chemical Treatment System

This design would consist solely of using a chemical treatment on the rafts. This system would have no mechanical complexity, making it highly durable and maintainable, as well as only requiring the labour of placing the rafts in a bath; however, the food safety concerns associated with using a solely chemical treatment would be significant. This design would likely also require a secondary system to remove any chemical residue from the rafts.

6.0 CONCLUSION

Our design team has interpreted our client's needs, created design criteria, benchmarked existing solutions, and used this information to develop a conceptual design for our solution to the client's problem. This design consists of a mild chemical treatment followed by a high-pressure water based cleaning system in a self-contained device with a simple user interface. We believe that this design will effectively clean the rafts, reduce the labour spent on cleaning, be highly usable, and be food safe, meeting all of the client's primary needs, as well as many of the client's secondary and tertiary needs. Our team will now develop, test, and refine this design to effectively solve the client's problem.

APPENDIX A: CLIENT NEEDS

Our design team interpreted the following client needs, shown in table 2.

Table 2: Interpreted client needs.

	Interpreted Need
Primary Needs	Clean rafts well
	Reduce labour spent cleaning
	Be highly usable
	Be food safe
Secondary Needs	Be non-destructive
	Clean multiple rafts
	Be compact
	Be maintanable
	Be cost effective
Tertiary Needs	Low water usage
	Produce few disposables
	Be cleaner
	Clean quickly

APPENDIX B: DESIGN CRITERIA

Our design team developed the following design criteria and metrics, shown in table 3.

Table 3: Design criteria and metrics.

Characteristic	Metric	Criteria	Constraint	Target
Cleaning ability	Percentage of dirty test area clean after one cleaning cycle	Higher	≥	80
Time on task	Time required to operate device for one cleaning cycle in minutes	Lower	≤	10
Simplicity	Number of steps to operate device	Lower	≤	3
Food safety	Yes or no whether device leaves residue on objects cleaned	N/A	=	N
Cleaning capacity	Volume of cleaning area in cubic cm	Higher	≥	$38x10^3$ (2 rafts at once)
Non-destructivity	Difference in weight of objects before and after cleaning in mg	Lower	≤	$1x10^5$
Compactness	Volume of device in cubic cm	Lower	≤	$20x10^6$ (Maximum space available)
Durability	Number of high stress or moving parts	Lower	≤	10
Maintainability	Number of parts	Lower	≤	100
Cost	Aggregate cost of materials in dollars	Lower	≤	1000
Water use	Water used per cleaning cycle in mL	Lower	≤	$6x10^3$
Cleaning speed	Time required for one cleaning cycle in minutes	Lower	≤	360
Waste Production	Weight of waste product produced per cleaning cycle in mg	Lower	≤	$6x10^3$
Cleanliness	Area around device likely to get dirty in square centimeters	Lower	≤	100

APPENDIX C: ORIGINAL SUBSYSTEM CONCEPTS

A comprehensive list of the subsystem concepts created by our design team, without any combination or abstraction and sorted by team member, follows.

Figure 4 shows Ankit Kapoor's concepts:

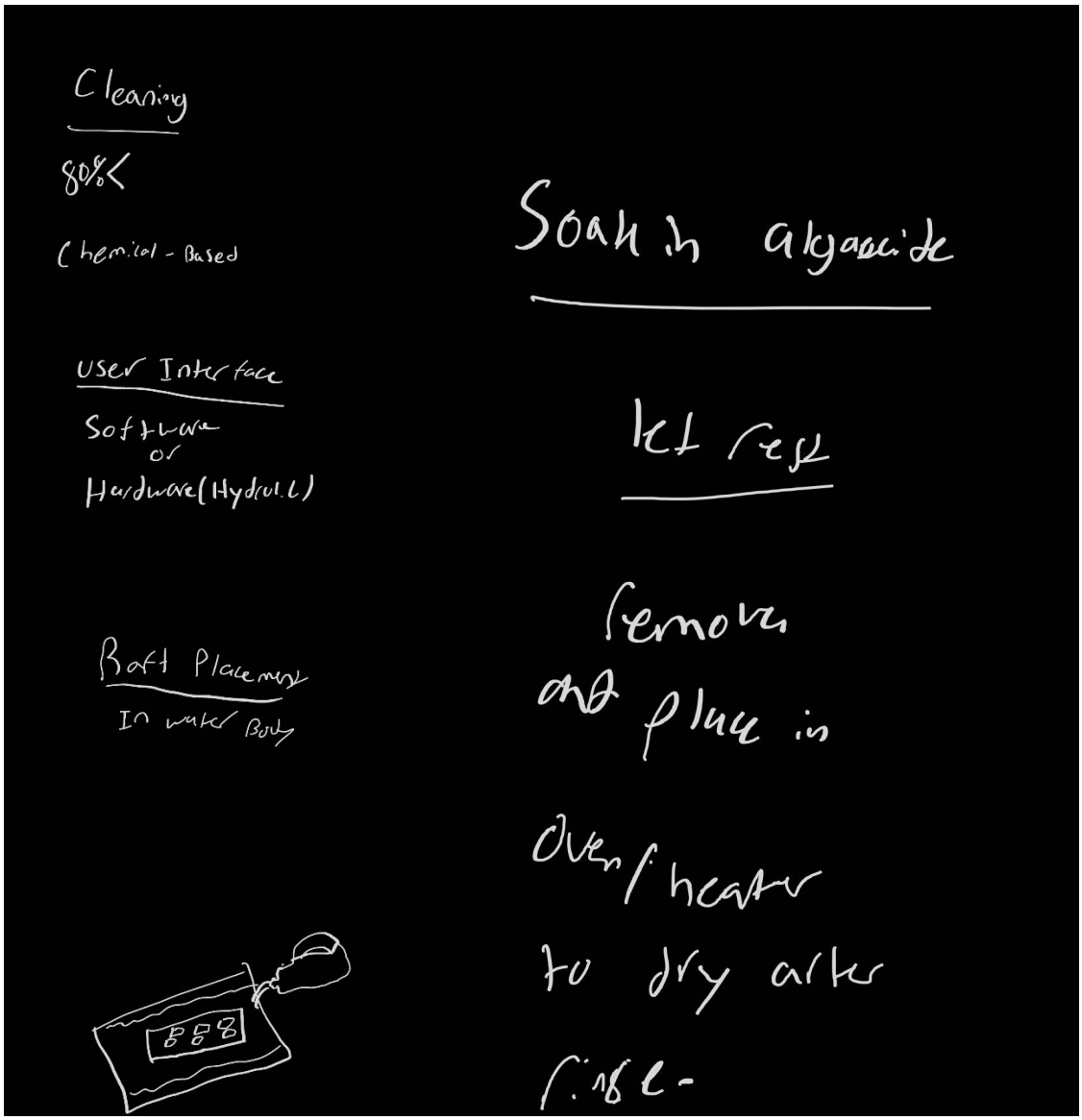

Figure 4: Ankit Kapoor subsystem concepts.

Figure 5 shows Ryan Gorodezky's subsystem concepts:

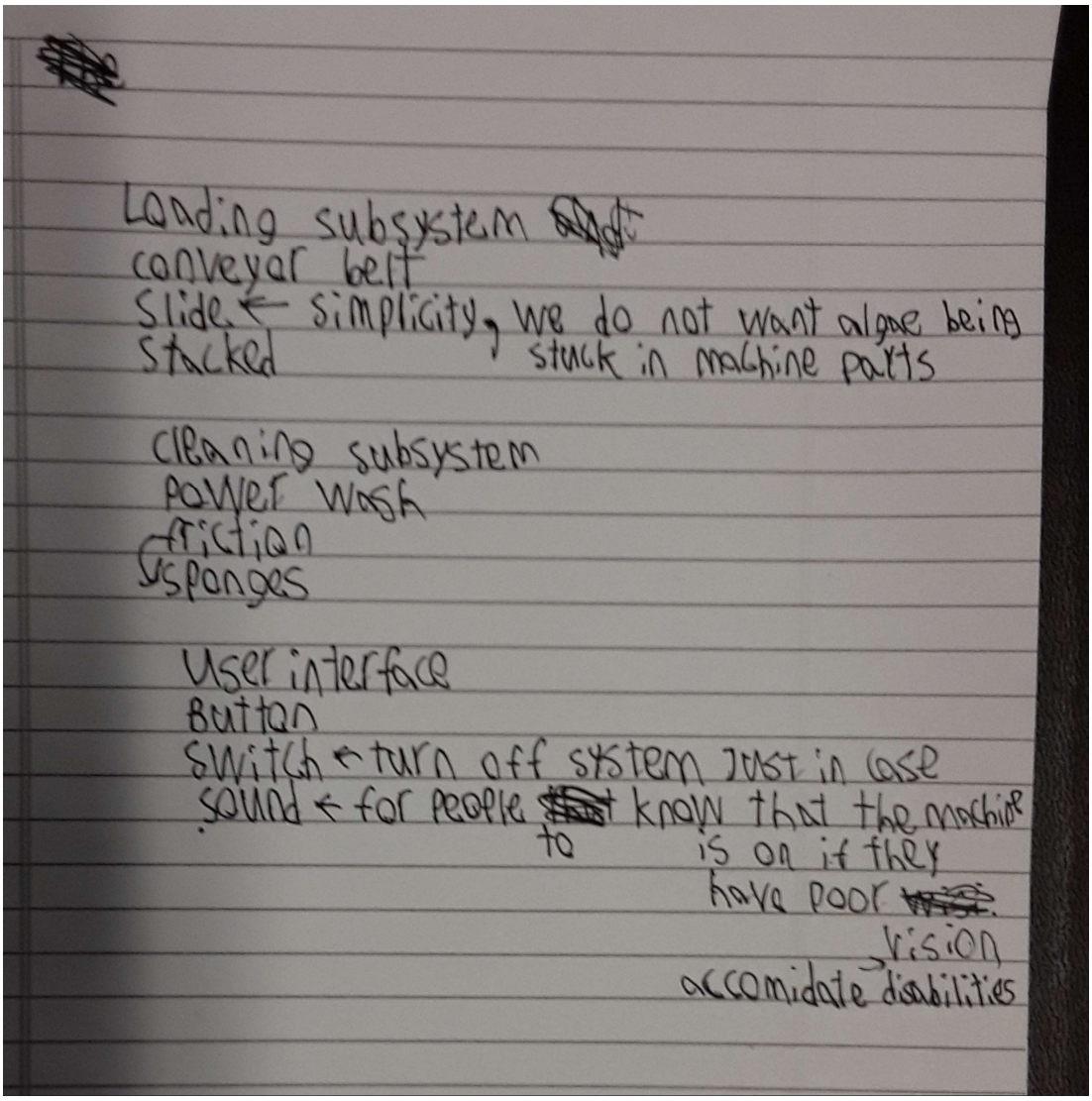

Figure 5: Ryan Gorodezky subsystem concepts.

Figure 6 shows Owen Duncan's subsystem concepts:

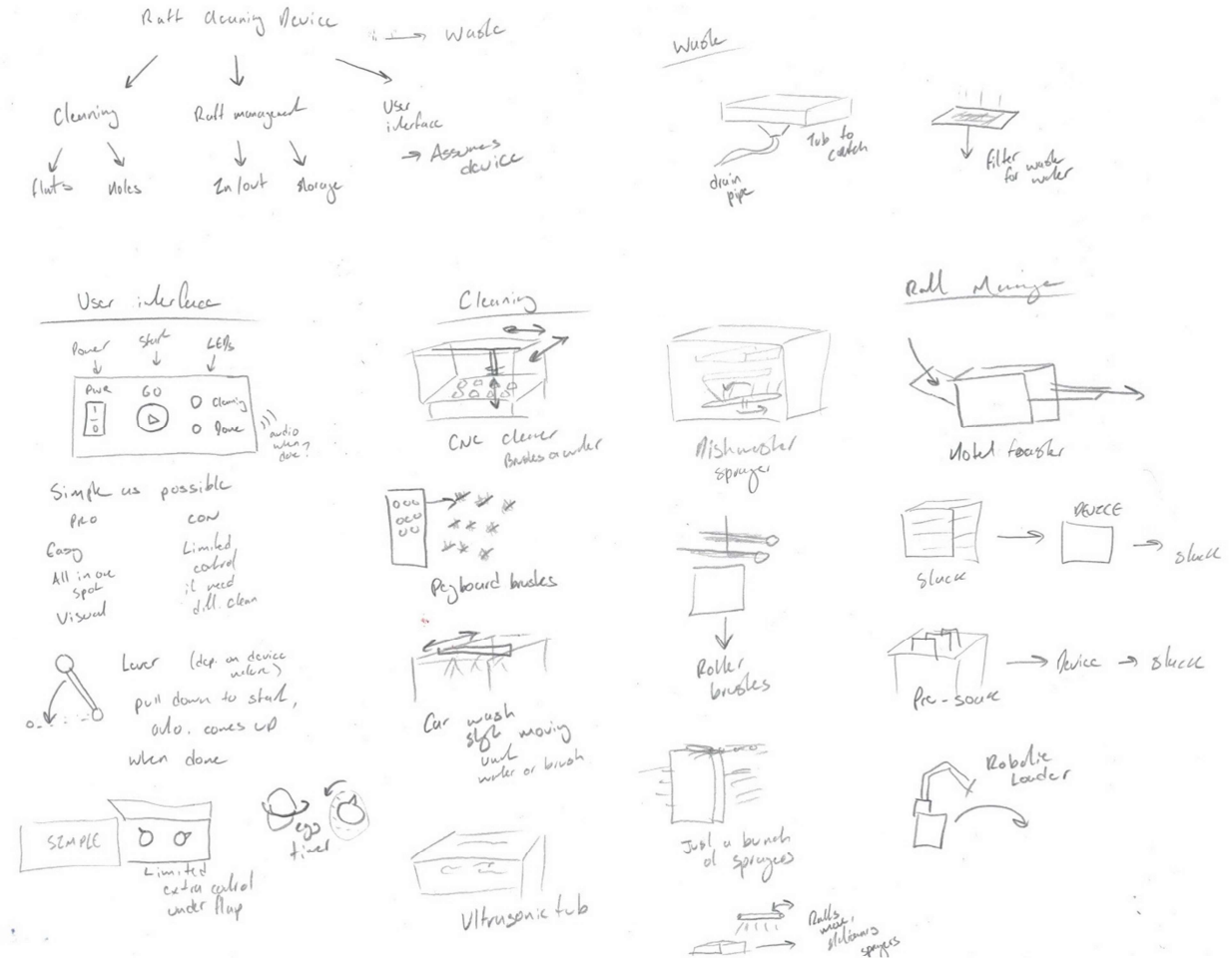

Figure 6: Owen Duncan subsystem concepts.

Figure 7 shows Zachary Chaloux's subsystem concepts:

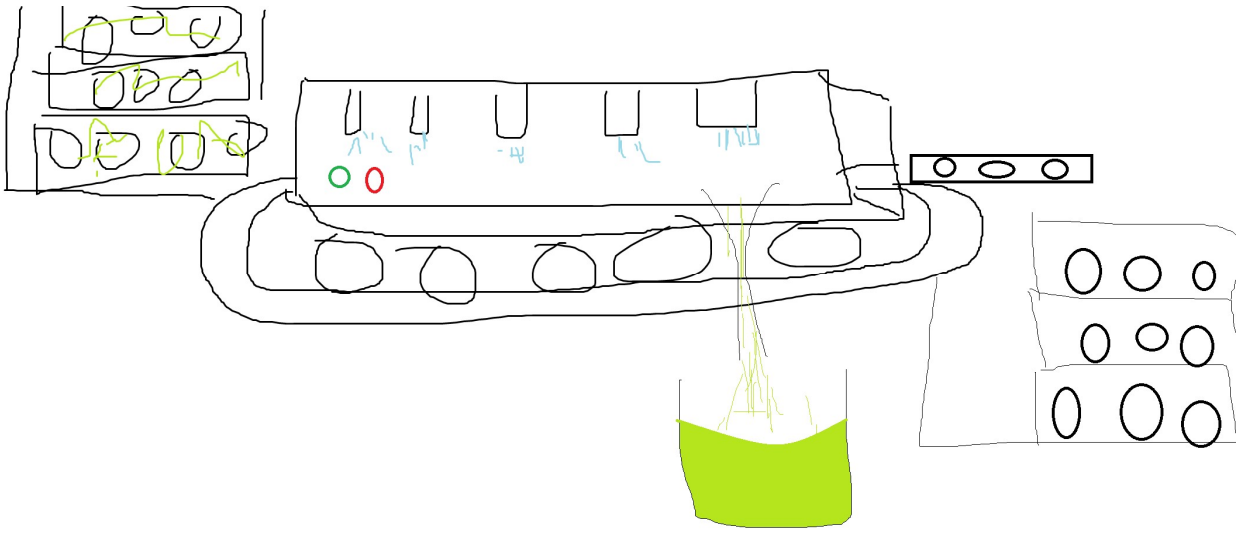

Figure 7: Zachary Chaloux subsystem concepts.