University of Brighton

Group 13
P.R.A.D.S

Plastic Reclamation and Disposal System

XE500 Engineering Systems Presentation

University Of Brighton 2021/22

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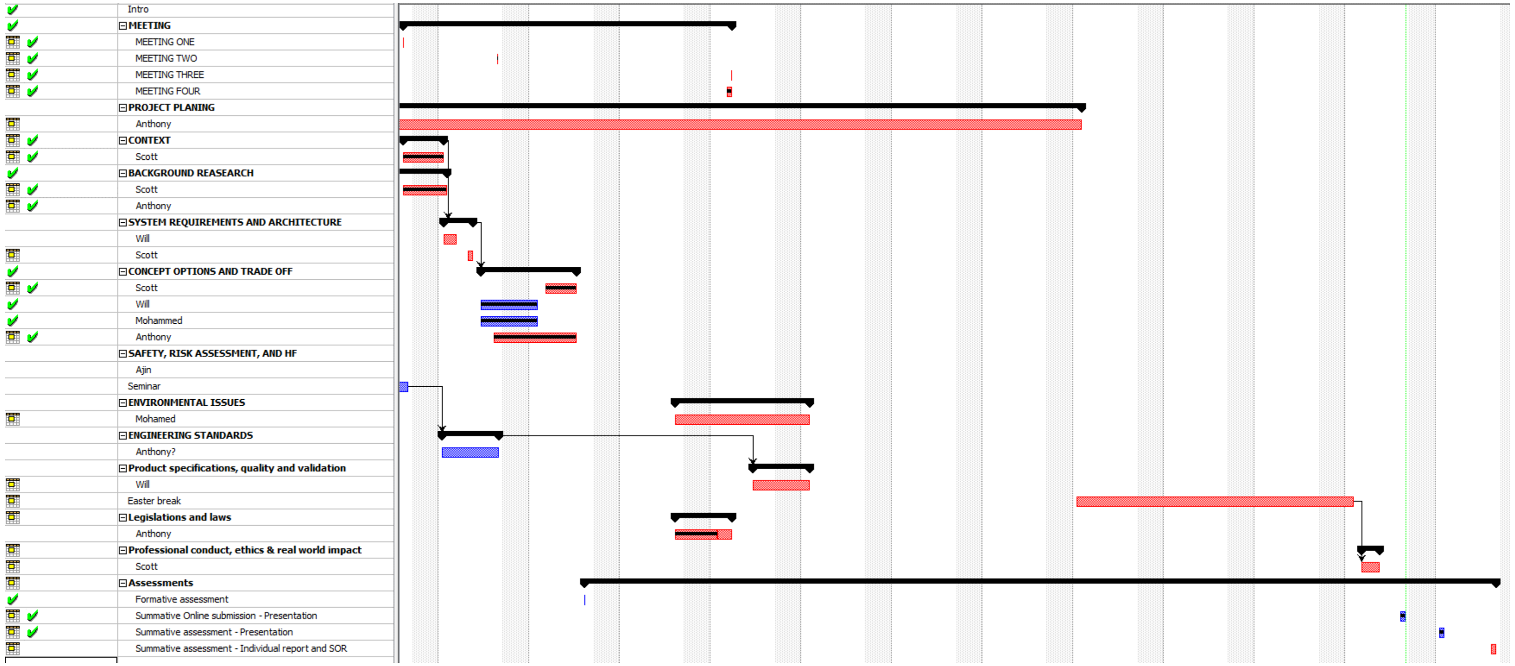
Project Planning and Meetings

<u>Meetings – A Rough Layout</u>

18/02/2022 – Background Research and Project Planning
25/02/2022 - User Requirements and System Requirements
04/03/2022 - Concepts, Health, and Safety
08/03/2022 – Justification of Subsystems and Architecture
11/03/2022 – Ethical Issues and Environmental Issues
15/03/2022 – Laws and Legislation
18/03/2022 – MoSCoW Deciding a Final Concept
25/03/2022 - Final Design Concept and CAD Modelling
02/05/2022 – Producing Presentation
06/05/2022 – Clean up



Context and Need

Need

- A system which efficiently collects plastics and other foreign materials from the surface of the ocean from the eastern side of the great pacific garbage patch

Geographical Area of Concern.

Great Pacific Garbage Patch – South Gyre

- - Largest collection of plastic debris present in our oceans
- - Covers an area of 1.6 million square kilometers (3 x the size of France)
- - Shape of patch is constantly in flux
- - Requires a lot of team/organizations to manage area.
- - Majority of Patch is made up of Floating (surface) Plastics.
- - Estimated 80,000 Tonnes of Plastic
- - Only predicted to increase in size
- - Off the coast of California

Source: The Ocean Clean Up

Background Research – Why is this system Important?

- **Issues and impacts on humans and wildlife:**
  - Ecosystems are harmed by dangerous microplastics formed when the larger fragments breakdown (macro-plastics). Due to degradation from the sun, marine
  - Bio-accumulation – from PBT chemicals (Persistent Bio-accumulative Toxic)
  - Where plastic travels through the food chain. Small marine animals feed on the plastic
  - Which, in turn, are fed larger animals, and then ends up in the human food chain.
  - The macro-plastic can blot the light from the surface -> Phytoplankton cannot photosynthesize, and this can impact the local ecosystem.
  - Entanglement of marine life -> swimming animals collide with the floating ghost nets, becoming trapped and cannot free themselves.
  - Ghost nets -> abandoned nets from fishing boats, often marine animals cannot escape them because they are invisible in dim light
  - Plastics can wash ashore and cause ecological/economical damage to a natural beach

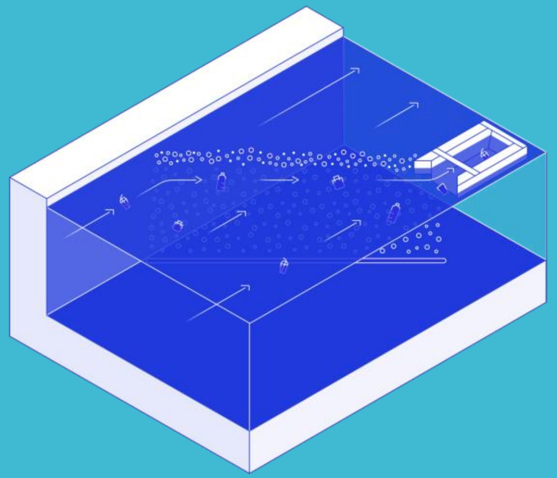
Concepts Already In Practise – 002 systems “Jenny”.

Ocean Clean Up Company (Jenny):

- 800m long netted barrier, 3m deep.
- -Fully open underneath, enables fish to vacate safely
- -Floatation devices to retain the nets form
- -Both ends of the barrier linked to separate tugboats.
- -1.5Knots (2mph) -> speed
- -Plastics is swept across the ‘wings’ into a central collector bin (retention zone)
- -When the bin is filled (approx. week), the tugboats move together
- -Jenny barrier is detached from one tug and reconnected to the other
- The free tug travels behind the barrier draws the plastic in from the retention zone to where it is sorted on dec
- Before, being offloaded at the nearby port

Source: The Ocean Clean Up

Concepts Already In Practise – Great Bubble Barrier.

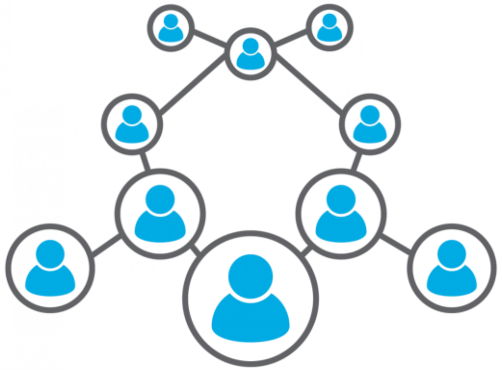


Source: The Great Bubble Barrier

The Great Bubble Barrier:

- Creates a non invasive barrier of bubbles that doesn't impact Lane traffic or Local wildlife
- Deployed on the bed of a river, has extensive reach, covering from water bed to surface.
- Directs the debris along a curtain of air, also making submerged plastics float.
- Directed Plastic is collected in a collection bin and scooped every few days.
- Increases the level of dissolved oxygen on the water Positively effecting the wildlife.
- Operates 27/7
- Versatile and can be deployed in a wide range of location with minimal effect to infrastructure.

Stakeholders and Main Functions



Stakeholders

- Environment body – ecosystems
- People operating the system
- People manufacturing the product
- Trainers (if the system is complex and requires you to be taught)
- Port officials and Life-guards
- On shore companies used where the plastic is being offloaded
- Local Port operations Impacted by Large ship Movements

Functions

- The system needs to collect plastic and foreign materials from the ocean
- The system needs to be able to hold plastic and foreign materials
- The system needs to be able to empty the waste and foreign materials

Ethical Issues of a system

- Those who operate boat/system require a place of rest if they are going to be out at sea for longer than a day
- Those who operate boat/system need training to control the system properly and with minimal risk
- Disposal of the collected plastics and foreign materials – if we dispose of them incorrectly then we could end up throwing them back into the ocean, furthermore, if we dispose of them incorrectly then we could be causing more damage.
- We need to make sure that we aren't harming marine life – we could break laws by harming them
- Boating laws need to be considered – again we could be breaking laws by sailing in certain areas
- World sailing code of ethics needs to be followed [Available @ https://www.sailing.org/tools/documents/2019CodeofEthicsPostMidYear-[25097].pdf]
- Safeguarding
- Lifeboats and other safety equipment are required on the boat to either prevent risks or to keep people safe when a hazard occurs
- Anyone manufacturing the system/device/boat should be trained to remain as safe as possible
- Anyone manufacturing should have safety equipment

Environmental Issues of a system

Craft design, manufacturing, and related environmental impact

- Manufacturing

  Building our design might involve a diverse mixture of materials and methods, aimed at producing durable, resistant and autonomous craft. Materials are to a significant extent fibre or glass-reinforced plastic (FRP or GRP) composites manufactured with a matrix resin and for some the use of structural foam. Most craft are still made of glass fibre and polyester resin.

- End-of-life boats: an environmentally responsible approach to disposal
- For metals and composites, produce less waste material at source, reuse a product at the end of life and recycle the material and Disposal in landfill (This option should only be taken when others are not feasible)
- Electric & Electronic, components must be disposed or recycle in proper way.

The environmental impact of operations

- Releases of hydrocarbons and other oil pollutants

From watercraft engine.

- Cooling Water

The primary pollutants expected to be present in the discharge, i.e., cooling water, and metals.

- Noise disturbances

Hull noise & mechanical noises form the ship and the drone.

- Sewage.

Sewage can pose the following environmental problems when massive quantities are discharged:

- It contains suspended solids
  Below the surface, which is "visual" pollution,

- It may cause eutrophication
  By introducing nutrients into the water which then stimulate the growth of algae, which is an environmental problem.

- It will reduce the amount of oxygen in the water.
  Where water volumes are limited, this can cause stagnation and the development of anaerobic bacteria leading to the production of unpleasant smells and gases.

- It may introduce pathogenic micro-organisms into the water,
  Which can cause disease, and which constitutes a health problem.

- Grey water

It is from all onboard washing and operations.

- Antifouling paints

During their use on maintenance (Copper oxide, which is the biocide commonly used in antifouling paints)

- Garbage and other waste

Generated onboard and to be disposed.
- Physical damage to the environment

- Such as bad anchorage or wave generation.

  Anchorages in areas where the seabed is sensitive, such as sea grass fields and reefs, can cause problems. The local authorities responsible for anchorages in these areas must provide sufficient buoys to guide visitors and prevent anchoring in sensitive areas. Such buoys need to be moored in a manner which avoids bottom scour possibly by means of elastic rather than chain-based moorings.

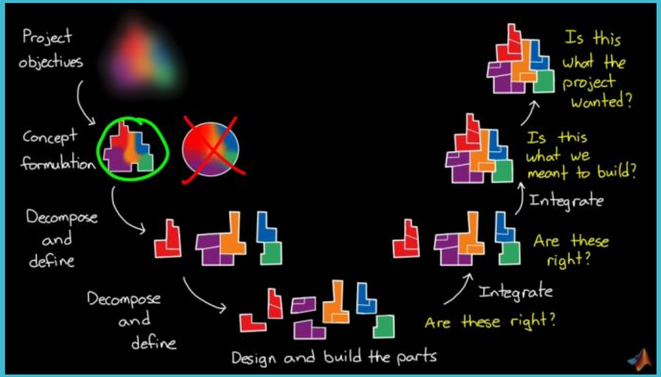
- Methods of removing plastic

  Some methods of using several instruments might damage the seabed and disturb ecosystems.

- Removing collected plastics from sea to land

- Introduction of non-indigenous species through voyages.

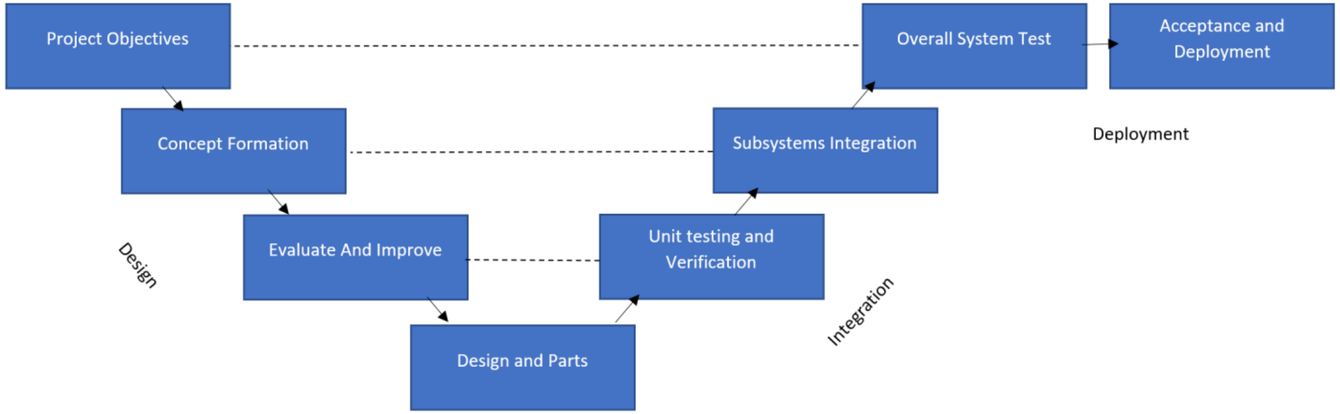
Systems Engineering V model Architecture



Source: MATLAB Systems Engineering

V-model Stages used:

- Project Objectives – Needs, Specifications and all defined limitations considered from the stakeholders and other shareholders.
- Concept formulation – What it says on the tin!
- Evaluate and Improve – Refining the Ideas and evaluating the solutions proposed down to a final solution.
- Design and Parts – Breaking down the solution into requires factors and researching costs and constructions.
- Unit testing and verification – Confirm it is right, adheres to needs
- Subsystems Integration – Evaluation of subsystems and testing of operation
- Overall Systems test – Penultimate testing and verification
- Acceptance and Deployment – Completion/Final approval for deployment.



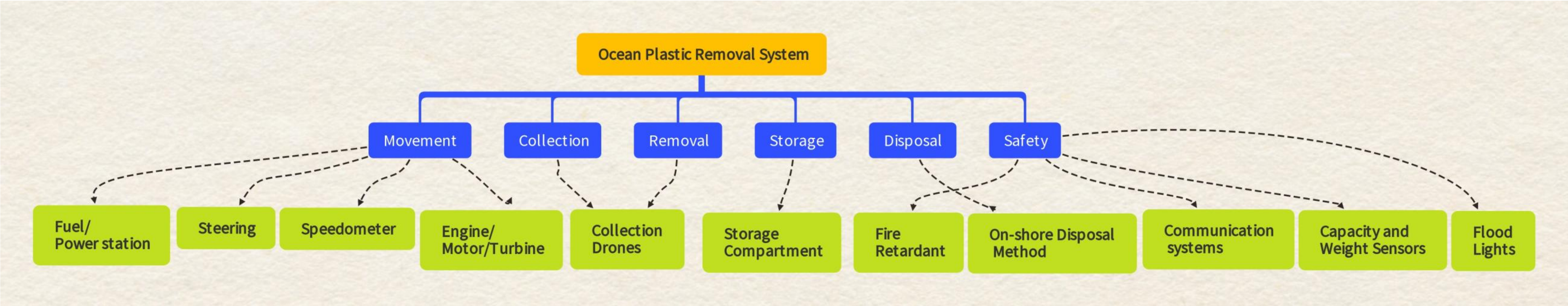
System Requirements (MUST)

System Requirements

- Cover a 10Km Area of earth's oceans
- Remove Micro Plastics at minimum
- Contain a defined amount of collected detritus back to mainland.
- Function in ALL defined operational weather conditions
- Autonomous or Semi-autonomous.
- Collect a minimum of 2 metric ton of material.
- Operate as much as possible on renewable Fuel source (e.g. Solar, wind, etc.)
- The system must be operating (battery life, fuel, etc.) for more than 1 hour
- The system needs an entry point that needs to be bigger than a 19.6-ounce bottle and no bigger than a 1-liter bottle
- The system must be able to collect and unload plastics and foreign materials
- The system needs to prevent water ingress

System Requirements (Should & Could)

- Minimise Environmental Impact for fabrication.
- Repurposing of large vessels e.g. Cargo ships
- Materials locally sourced
- Process Waste at sea
- Compress Plastics for more storage capacity
- Disposing waste appropriately at port
- Self-recycling on ship
- Adhere to all appropriate Californian recycling Legislation
- Energy Storage regulations - PC
- The system needs to move at a maximum speed of 15 knots
- MARPOL Annex V – Garbage management
- The system should have lights if it should be used at night, in dark areas or underwater
- The system should discourage animals from coming close to it
- Have fully developed Presentation prepared by 13 may
- Have completed all design related tasks by 13 may



Justification of Subsystems – Plastic Reclamation and Disposal System (PRADS)

Concepts

Mohamed's Proposed Final ideas

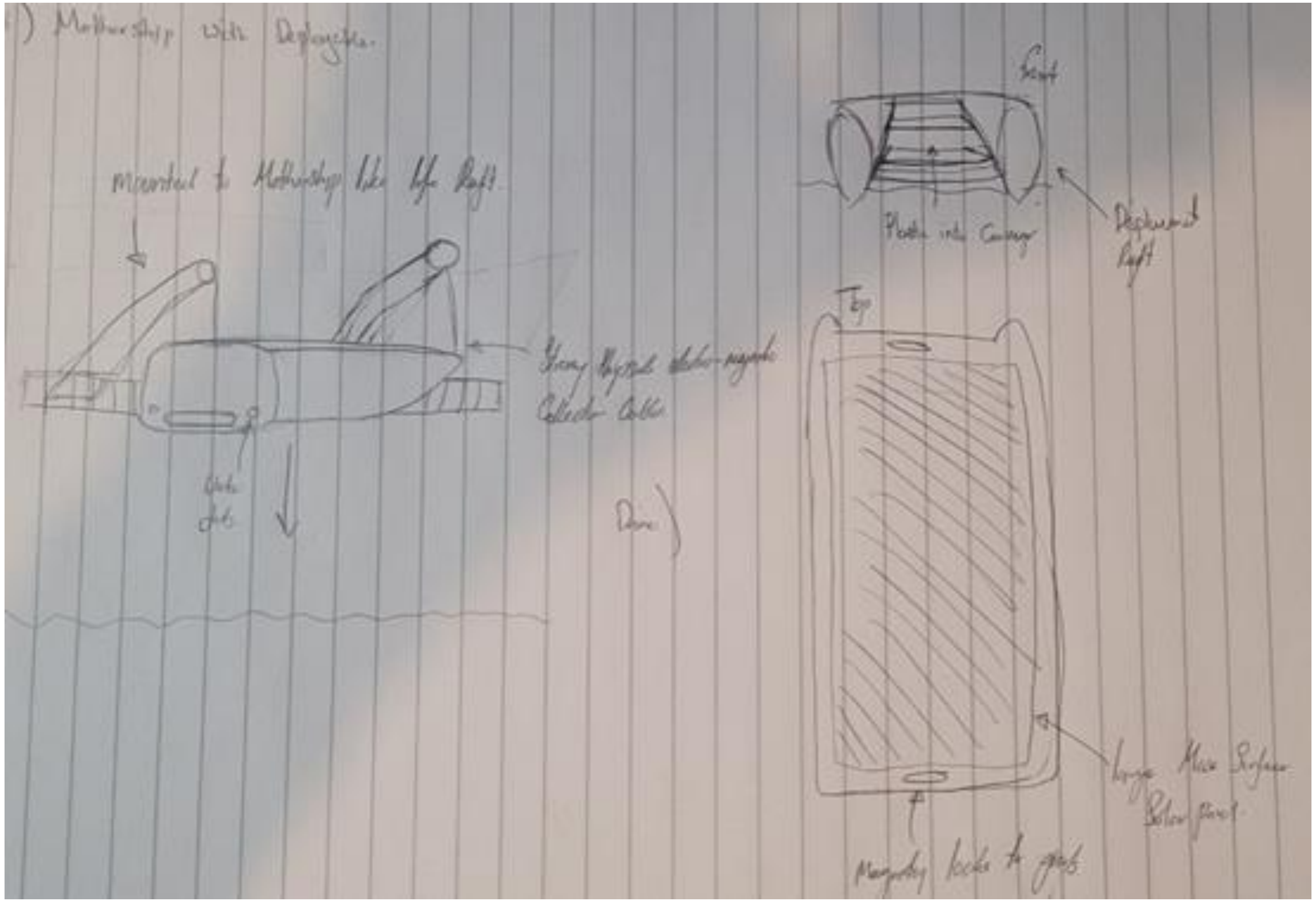
Concept Idea

- A floating machine which sucks the sea/river water though one end and collect the plastics push the water though the other end. It can be design in the shape of a tube placed in vertical. We can make multiple of these machines to float in the middle of the ocean.
- In addition, we can build a common storage once every machine collects and then it can store the storage.
- These machines and the system can be powered by floating solar panel.

Concepts

Will's Proposed Final Idea

Solar automatic collection drones, deployable from a "mother Ship”, The automatic collectors will collect surface to low surface plastic via a conveyor system. It'll carry a determined amount then return to the mother ship to offload and continue.



Concept

- A filter that is lowered vertically down from a ship hull via flexible, pressurized (extendable/retractable) pipe greater than 300 m
- Thruster (x4) arranged around the circumference of the intake, enables omnidirectional motion of the intake -> ROV?
- In the ship microplastic is stored in internal storage tanks filtered from the water
- Excess water exits through a port in the hull
- Ship is renewably powered via Solar panels could possibly also use electrolysis of seawater to make hydrogen such as the [2017 Energy Observer]

Anthony's Proposed Final Idea

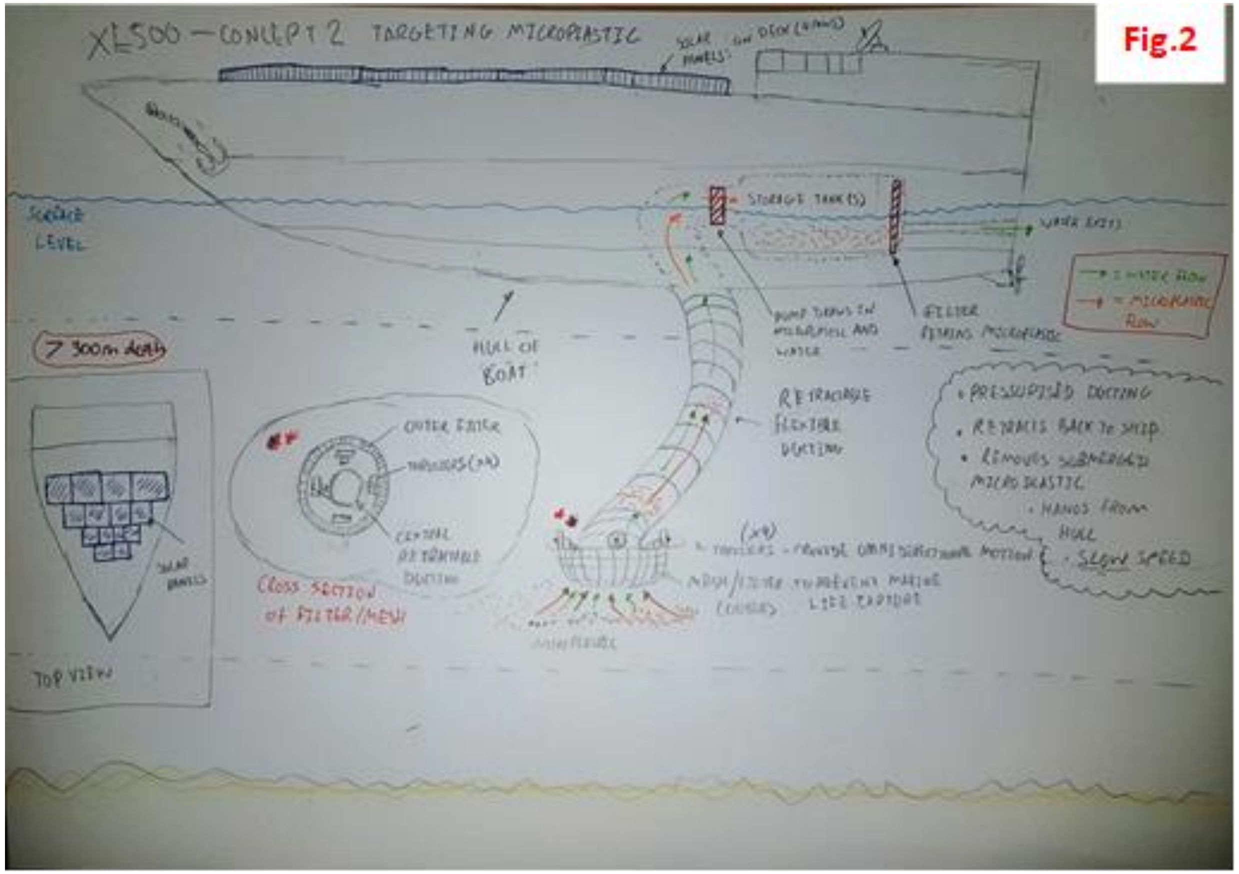
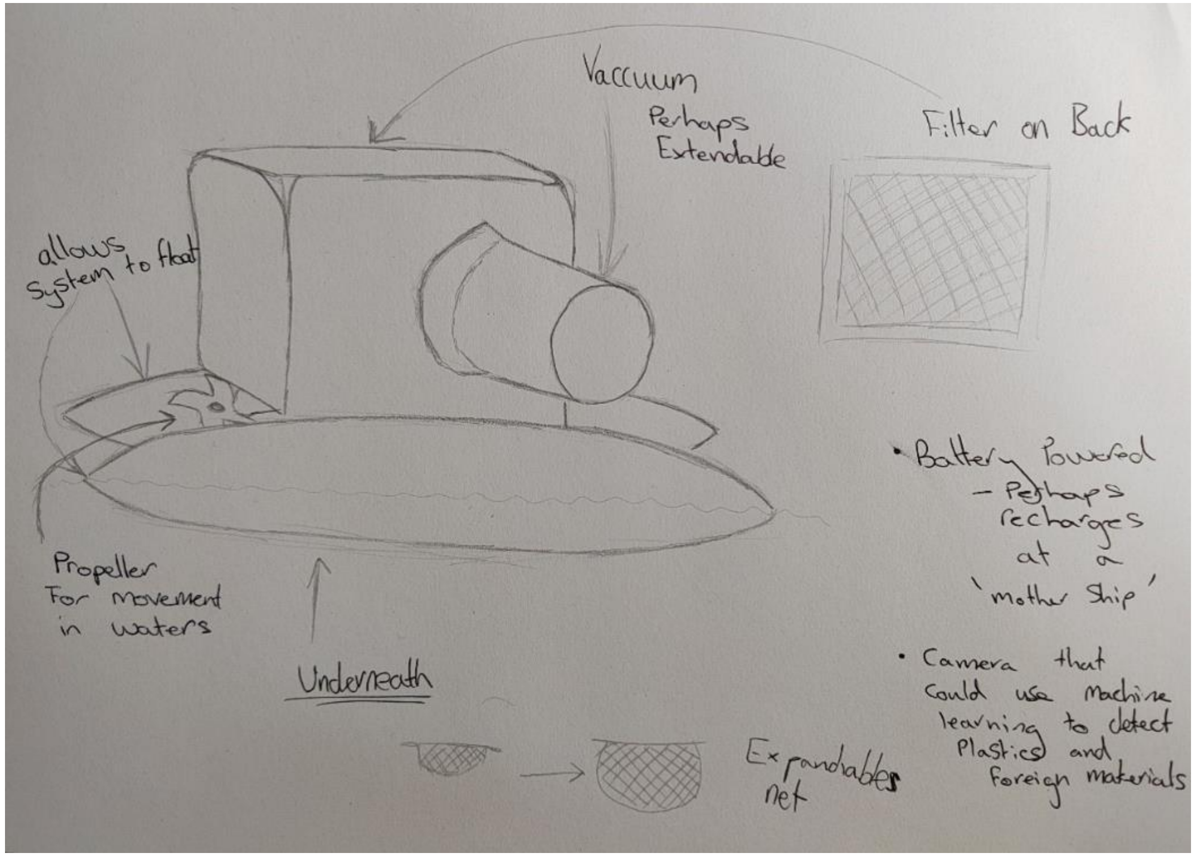


Fig.2

Scott's Proposed Final Idea

Concept



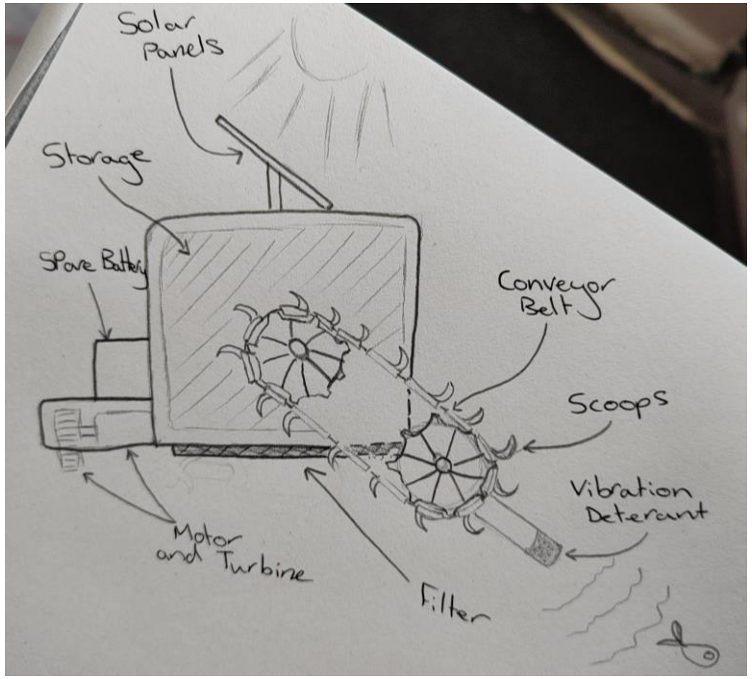
Deciding a Final Design (MoSCoW)

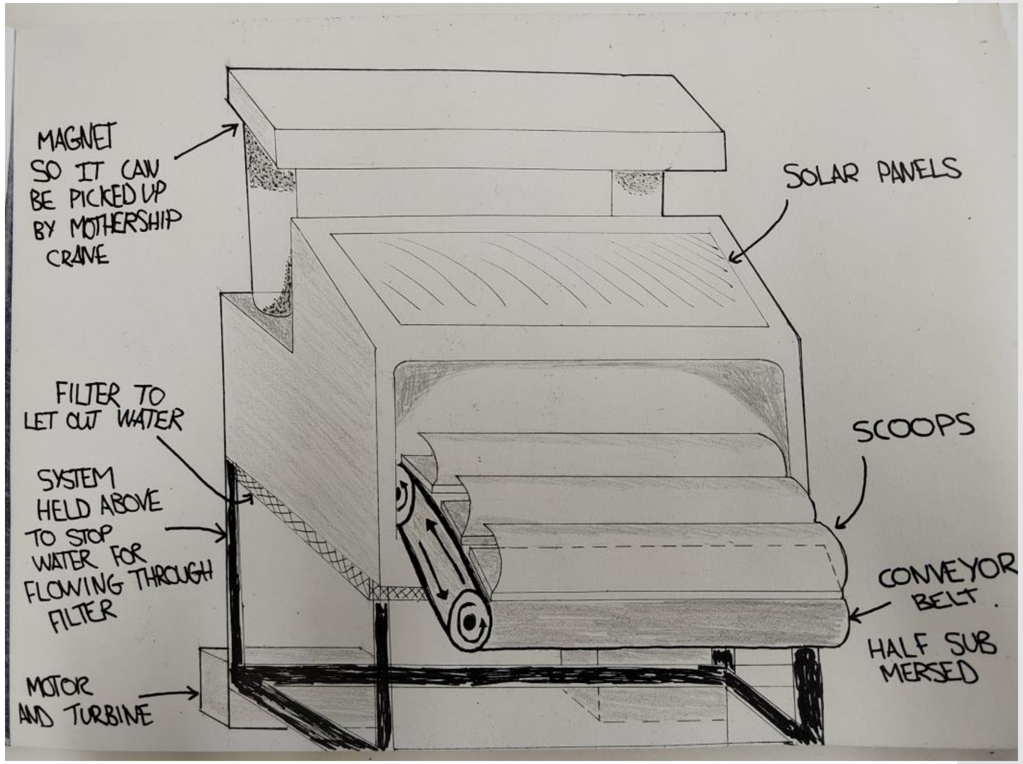
Specification Number	Category	System Requirements	Initial Priority Given (Must, Should or Could)	Priority Given After Reflection 1 (inconsequential) to 5 (majorly significant)
	Performance			
#1		Cover a 10Km Area of earth's oceans	Must	5
#2		Remove Micro Plastics at minimum	Must	5
#3		Contain a defined amount of collected detritus back to mainland.	Must	5
#4		Function in ALL defined operational weather conditions	Should	4
#5		Autonomous or Semi-autonomous.	Could	3
#6		Collect a minimum of 2 metric ton of material.	Should	5
#7		Operate on renewable Fuel source (e.g. Solar, wind, etc.)	Should	2
#8		The system must be operating (battery life, fuel, etc.) for more than 1 hour	Could	5
#9		The system needs an entry point that needs to be bigger than a 19.6 once bottle and no bigger than a 1-liter bottle	Should	3
#10		The system must be able to collect and unload plastics and foreign materials	Must	5
#11		The system needs to prevent water ingress	Must	5
	Manufacturing			
#12		Minimise Environmental Impact for fabrication.	Should	2
#13		Repurposing of large vessels e.g. Cargo ships	Should	2
#14		Materials locally sourced	Could	3
	Disposal			
#15		Process Waste at sea	Could	4
#16		Compress Plastics for more storage capacity	Would	2
#17		Disposing waste appropriately at port	Must	5
#18		Self-recycling on ship	Could	3
	Standards And Legislation			
#19		Adhere to all appropriate Californian recycling Legislation	Must	5
#20		Energy Storage regulations - PC	Must	5
#21		The system needs to move at a maximum speed of 15 knots	Should	2
#22		MARPOL Annex V – Garbage management	Must	5
	Desirables			
#23		The system should have lights if it should be used at night, in dark areas or underwater	Could	4
#24		The system should discourage animals from coming close to it	Could	4
#25		Hydrogen Fuel	Would	1
	Time Restrictions and Deadlines.			
#26		Have fully developed Presentation prepared by XX may	Must	5
#27		Have completed all design related tasks by XX may	Must	5

Deciding a Final Design - MoSCoW Specification Fulfillment

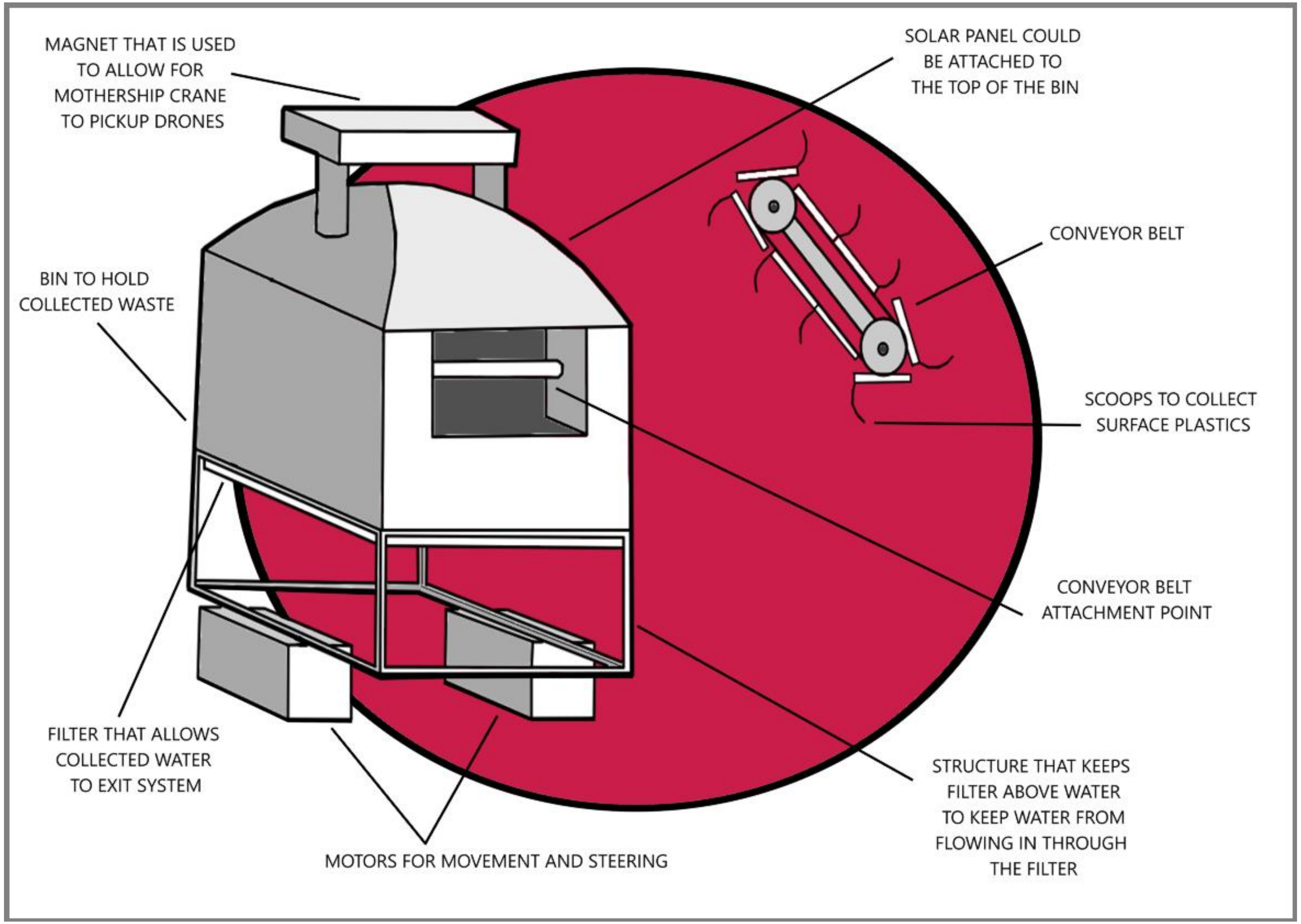
Will's Concept:				AI drone Mothership
Specification Number from MoSCoW				Is it predicted to be fulfilled?
Must	Should	Would	Could	
#1	-	-	-	YES
#2				YES
#3				YES
-	#4	-	-	YES
			#5	YES
-	#6	-	-	YES
-	#7	-	-	YES
-	-	-	#8	YES
#10	-	-	-	YES
#11	-	-	-	YES
-	#12	-	-	YES
-	#13	-	-	YES
-	-	-	#14	YES
-	-	-	#15	NO
-	-	#16	-	NO
#17	-	-	-	YES
-	-	-	#18	NO
#19	-	-	-	YES
#20	-	-	-	YES
	#21			YES
#22				YES
			#23	YES
			#24	NO
		#25		NO
#26				YES
#27				YES
How Many Fulfilled?				23 (All Must Fulfilled)

Final Concept Drawing

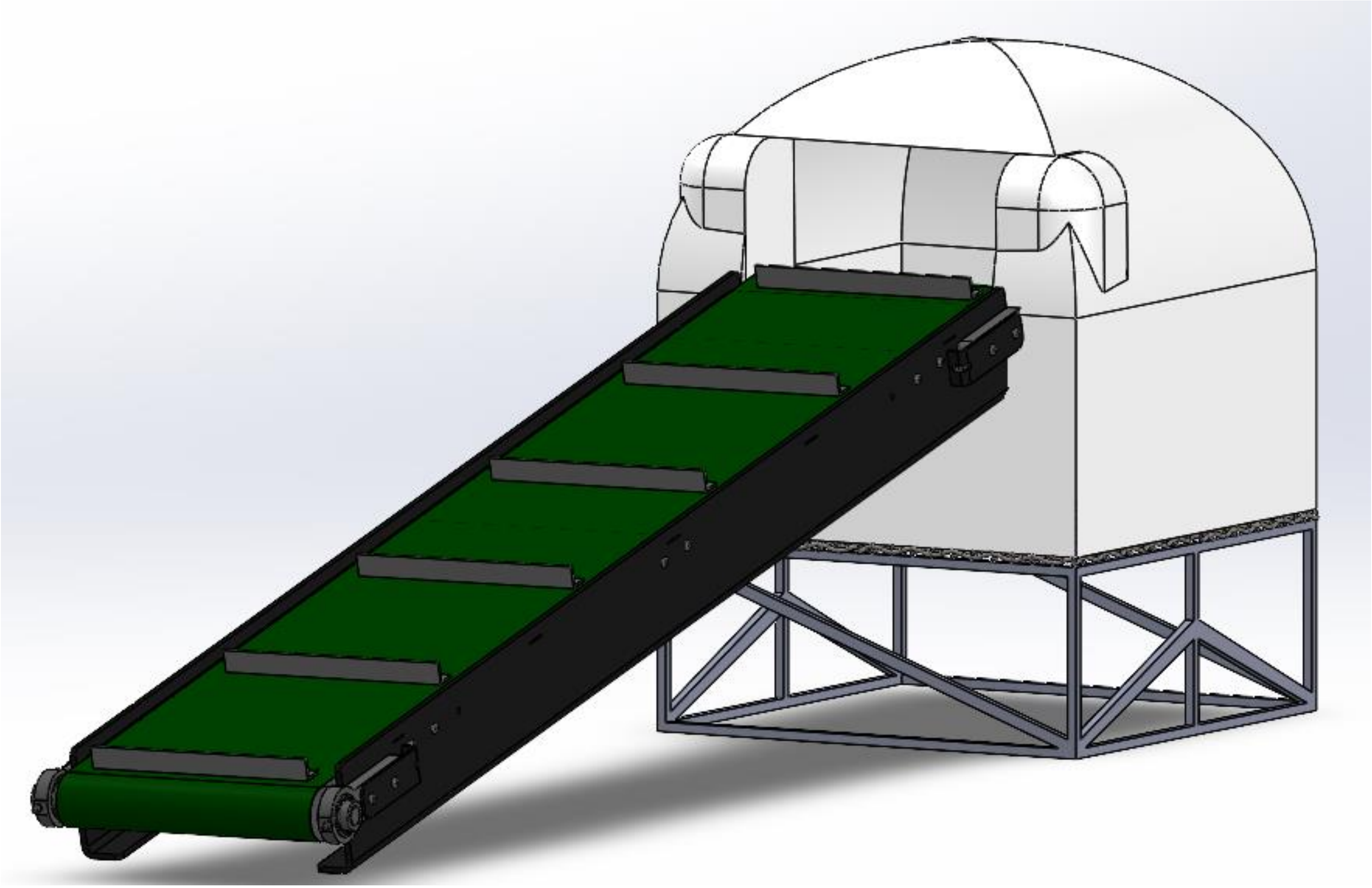




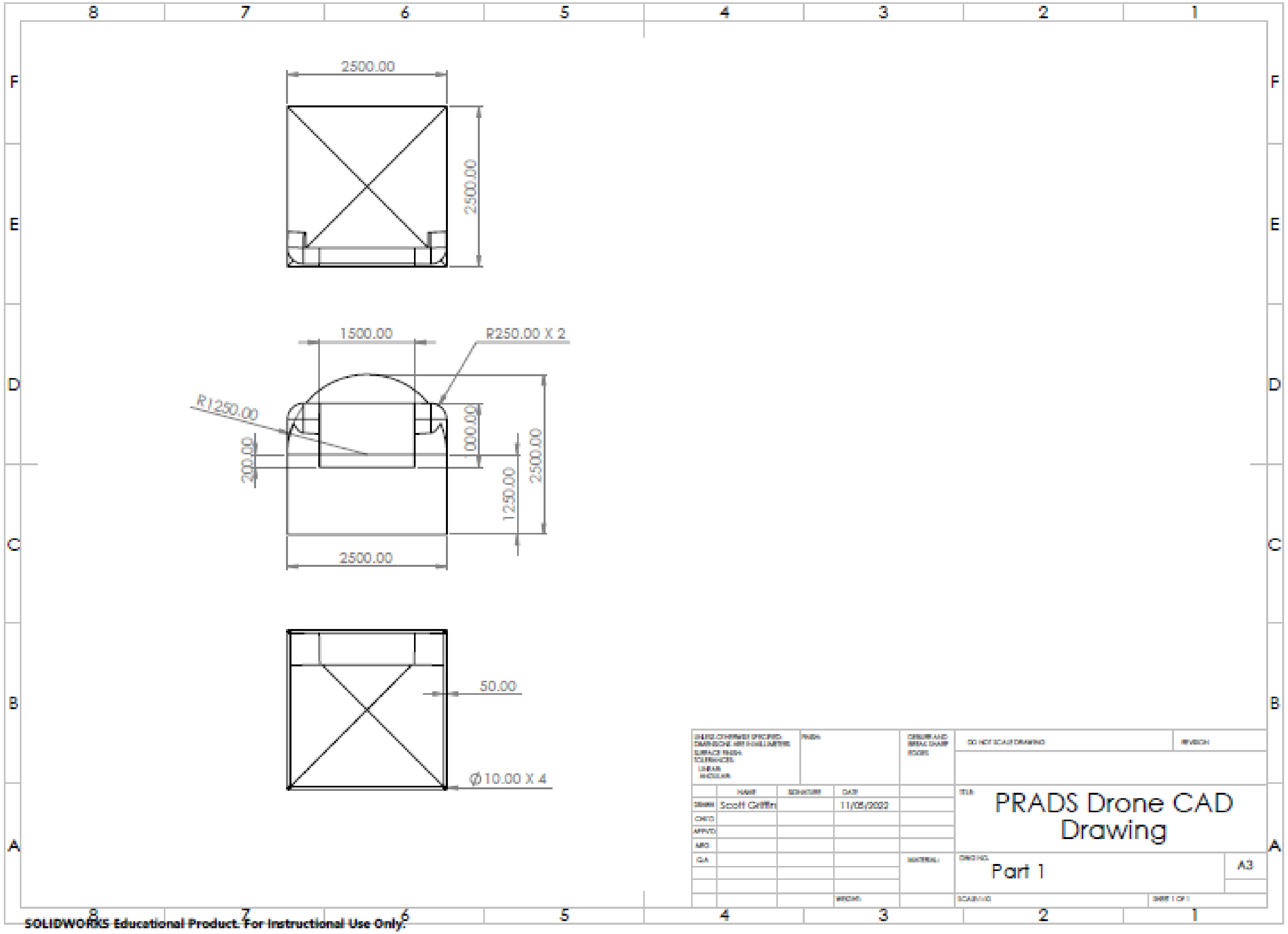
Digital Concept



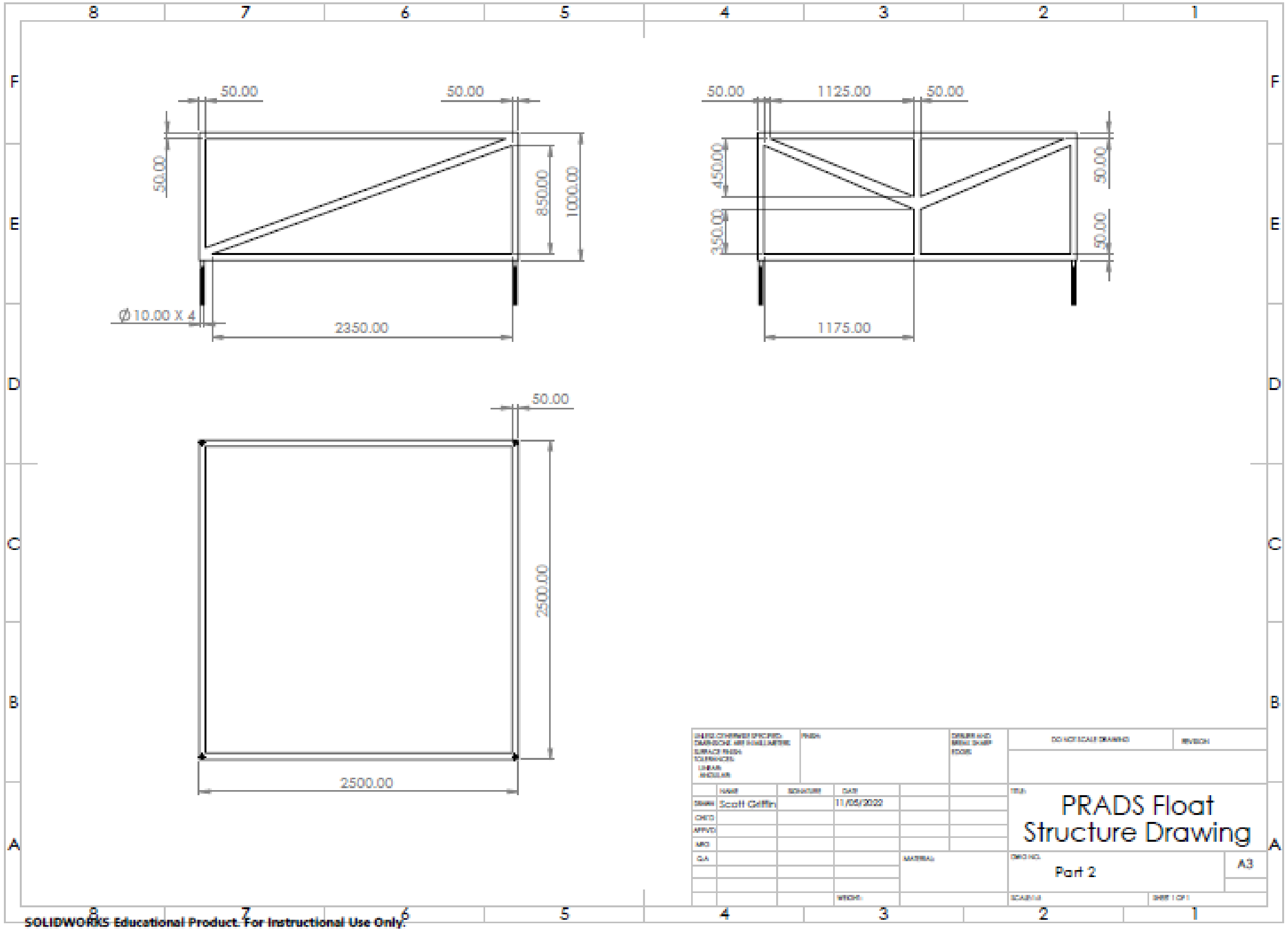
CAD Model



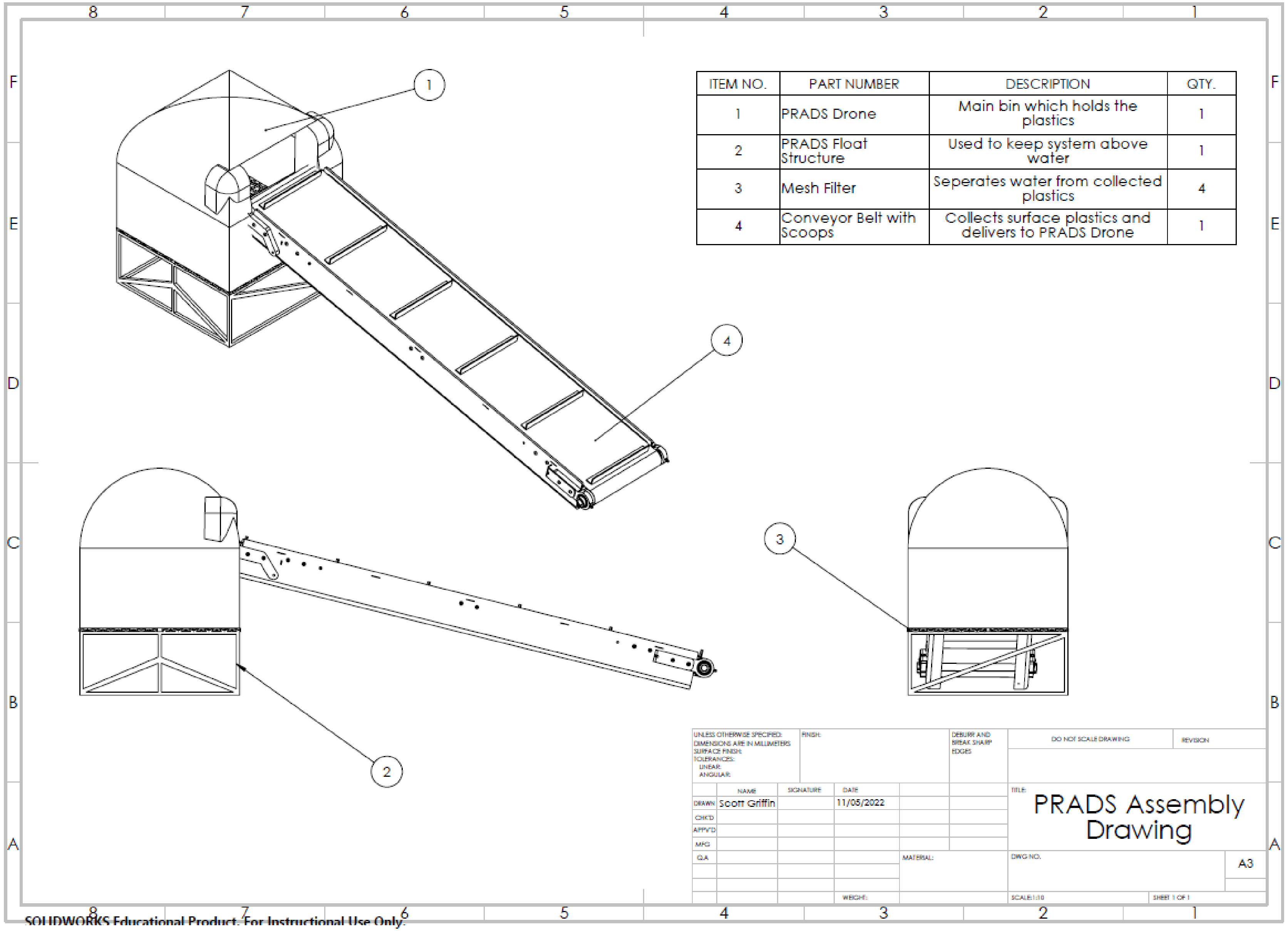
Engineering Drawing



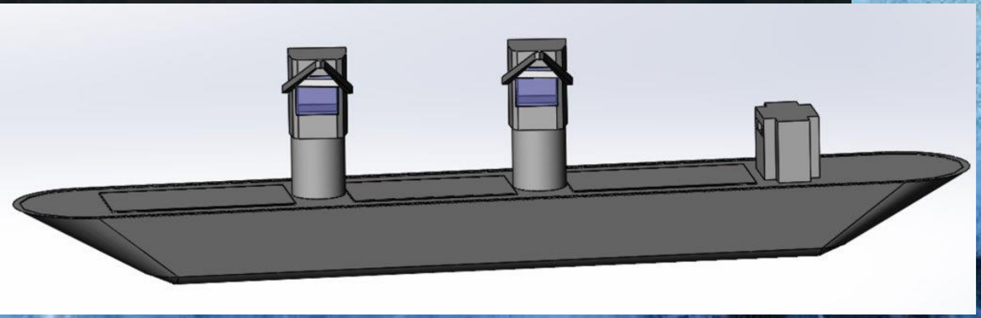
Engineering Drawing



Assembly Drawing



Chosen Ships Specifications



SHIPS SPECIFICATON	
Class Society	Nippon Kaiji Kyokai
LOA (length overall)	105.5 m
Beam	16.8m
Ship type	Balsa cargo ship
GRAND TOTAL(CAPACITY)	312112 cb.ft
HOLD 1	89735 cb.ft
HOLD 2	110888 cb.ft
HOLD 3	103755 cb.ft
DIMENSIONS	
HOLD 1	L: 24m W: 16.8/16.8m H: 7.6m
HOLD 2	L: 24.5 m W:16.8/16.8 H:7.6 m
HOLD 3	L:24.5 m W:16.8/10.6 m H: 7.6 m
Safest Cargo capacity	85 Metric Tonnes
ENGINE GENERATORS	Man B&W 5L35MC / 3800 HP 2794 kW 3* Yanmar S 165 (L) 240 kW
CRANES	2 sets Electro- Hydraulic driven SWL(Safe working Load): 15mtons

https://www.alibaba.com/product-detail/Permanent-magnetic-lifter-Steel-Scrap-Circular_62362833817.html

Magnet

We are using the 1400mm Diameter Magnet

Model	MW1-70	MW1-80	MW1-90	MW1-110	MW1-120	MW1-130	MW1-140	MW1-150	MW1-165	MW1-180	MW1-210	MW1-220	MW1-240
Outer Diameter(D)	Φ700	Φ800	Φ900	Φ1100	Φ1200	Φ1300	Φ1400	Φ1500	Φ1650	Φ1800	Φ2100	Φ2200	Φ2400
Overall Height (H)	1055	1060	1025	1265	1345	1300	1370	1490	1540	1863	1845	1990	1958
Power (kw)	3.5	4.1	5.8	7.8	8.9	12.7	14.8	15.6	16.5	22	28.6	32	34.1
Weight (kg)	490	630	760	1250	1580	1890	2310	2820	3450	4350	6690	7480	8780

Drone Power and Considerations

- *After exploring the power capabilities, it came to light that a small change to the system would be more efficient and cost effective.*

Established Solar Options:

- Monocrystalline Silicon cells – Highly efficient cells, very costly.
- Polycrystalline cells – Cost effective, but less efficient
- Thin film – Low Power, Low cost, Bendable to surfaces.

New Solar Breakthroughs:

- Perovskites (New Thin Film) - 100 times the power to weight capabilities of conventional Solar cells (Silicone cells). Printable, and surface paintable. Current market contender for mainstream development.

Health and Safety

Likelihood of occurrence

1. Remote (almost never)
2. Unlikely (occurs rarely)
3. Possible (could occur, but uncommon)
4. Likely (recurrent but not frequent)
5. very likely (occurs frequently)

Hazard severity

1 – Trivial (e.g. discomfort, minor bruising, self-help recovery)

2 – Minor (e.g. small cut, abrasion, basic first aid need)

3 -moderate (e.g. strain, sprain, incapacitation > 3days)

4 – serious (e.g. fracture hospitalisation >24 hours, incapacitation >4 weeks

- 5 – Fatal (single or multiple)

Hazard	Description	How do you mitigate the risks?	Hazard Severity (1-5)	Likelihood of occurrence (1-5)	Risk Rating
Risk of being crushed (e.g. by heavy machinery, from offloading plastic netting at port)	Safety guards , belts and pulley	Regularly maintaining and checking machinery	4	4	16
Drowning – in rough sea	Falling overboard	Lifejackets, Lifebuoy rings etc.	4	3	12
Corrosion of metal components at sea	Damage to supporting decks e.g. Galvanic corrosion (occurs between dissimilar metals, electro chemical	Apply coatings on hull part Using sacrificial anodes	3	5	15
Fire	Short circuit overheating engine ,fuel leak	Flame detectors , Heat detectors , Smoke detectors	3	4	12
Turbulent seas	Violent storms, strange changes in ocean topography make vessel navigation unstable	Real time data access, Transparency measures , Responsive balancing	3	4	12

Risk Assessment

Failure to Follow Procedures:

1. Medication
   If the crew members in the ship use medication can have disastrous consequences. They should consult professionals before taking those medicines before taking charge of the vessel.

2. Time to Time Inspection:
   The vessels undergo regular time to time inspection to ensure safety and for better performance.

3. Misjudging Weather Threats:
   Underestimating high water currents can make the situation dangerous for mariners and can lead to accidents. The dangers must be assessed properly to reduce the danger

Risks in Ocean Shipping:

- Potential Weather Threats:

How to Protect Against these Weather Threats:

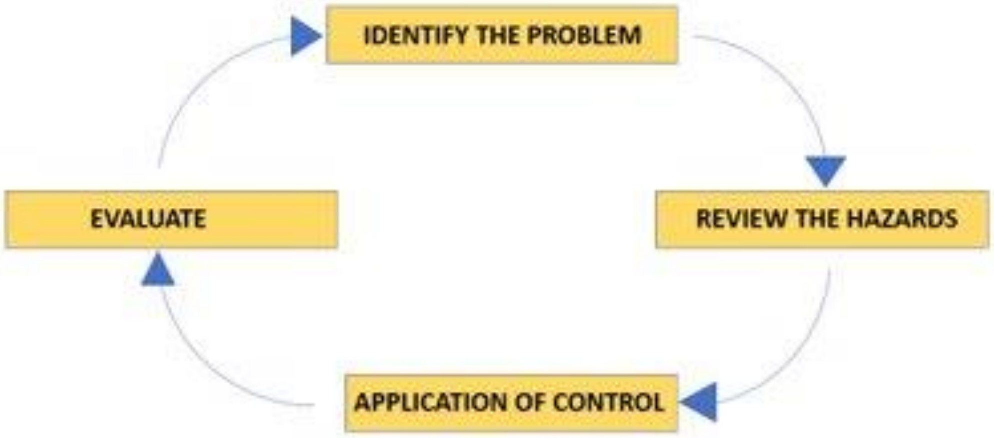
- 2. Weather Prediction
- Risks in Land Transportation
- Hazardous Driving
- Long periods of Service Compliance
- Driver Fitness
- Controlled Substances/Alcohol
- Unsafe Material Compliance
- Crash Indicator

Steps to Avoid Delays Due to Risks:

- Identification of hazards
- Assessment of the risks concerned
- Application of controls to reduce the risks
- Monitoring of the effectiveness of the controls

Risk factors in transportation

- Geographical threat
- Technical Shortcomings
- Reasons for Potential Risk
- Exhaustion

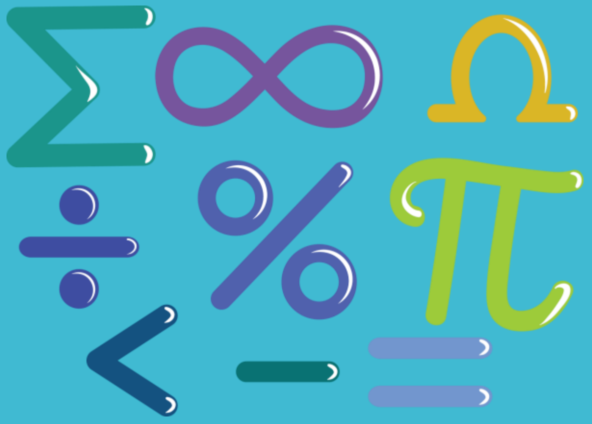


Risk Assessment

MARINE RISK ASSESSMENT

WHAT ARE THE HAZARDS ?	RISK OR HAZARD DESCRIPTION	RESOURCES IMPACTED	EXISTING CONTROL MEASURES	RISK PROBABILITY	RISK IMPACT	RISK RATING	PREVENTION MEASURES	WHO NEEDS TO CARRY OUT THE ACTION?	WHEN IS THE ACTION NEEDED BY?
SHIP									
Machinery	structural problems,engine issues,navigational equipment fail	Machinery	keep equipment up to date,inspect ship before journey	Likely	Medium	Medium	Failure to perform preventive maintenance	Engineers	in 24hrs
Mooring Operation	Fatal accident or Collition	Person	ensure the safety of who conducting the operation.	Very Unlikely	Low	Low	make sure all safety measures taken at start of operation	Mooring crews	in 24hrs
Explosion	crankcase explosions, boiler blasts	Machinery	Inspect ship before journey	Unlikely	High	High	safety features provided to detect the causes of explosion.	Maintanance Engineers	in an hour
Maintanance	working alone,lighting,slips and falls	Person	checking on your safety and always notify officer	Very Unlikely	Low	Low	make sure all safety measures taken at start of operation	Deck officer	in 24hrs
Environment									
Oil Spills	Beaches,Fragile Aquatic Ecosystems,kills marine mammals	Wildlife Habitat	fittings,Don't overfill fuel	Unlikely	Low	Low	Use oil absorbent pads,Recycle used oil and filters.		in months
Greenhouse Gas Pollutants	earth,rapid changes on	Human life,Wildlife habitat	Slow Streaming,Mostly short term	Likely	Medium	Medium	to lower carbon fuel for		in months
Ballast Water	Environmental imbalance	Human life,Wildlife habitat	manage water level in certain standard	Unlikely	Low	Low	check vessel quality in every year		in months
Wildlife pollution	Pollute air and water with toxic chemicals and waste	Wildlife Habitat	slowing vessel speeds	Unlikely	Low	Low	Ensuring mariners are aware		in months
Atmospheric pollution	Affects human health and make climate change	Human life,Wildlife habitat	Slowing down the speed	Likely	Medium	Medium	Utizing battery storage,Renewable energy		in months
Transportation Industry									
Geographical threats	Harm vessels,risky to navigate	Person,Machinery	Plan and navigate with extreme caution	Very Unlikely	Extreme	Extreme	Use GPS	Captain	in 24hrs
Technological shortcomings	engine issues, navigational equipment failure	Person,Machinery	Inspection of Equipment	Very Unlikely	High	Medium	Keep Equipment up to date	Captain	in 24hrs
Exhaustion	Failure to follow steps	Person,Machinery	Maintaining ship	Very Unlikely	High	High	Inspect ship and equipments before trip		in 24hrs
Human safety									
Search and Rescue	live electrical wires, broken natural gas lines	Person	communication,	Likely	Medium	Medium	Supporting proper trained rescue team	Fire and Safety officer	in 24hrs
Injured	Loss of life	Person	ensure all the safety measures done before trip	Unlikely	Low	Low	Supporting more medical team	Medical Officer	in 24hrs
Fatality	Failure to provide and enforce the use of safety equipment	Person	Placing well trained employers	Very Unlikely	Low	Low	Placing experienced employers in specific sites	Safety Manager	in 24hrs
Falls,Slips and Trips	Unwanted Injuries	Person	measures done before start	Likely	Low	Low	First Aid, Fire Prevention and Manual Handling	Safety Manager	in 24hrs
Waterway									
AtoN Trouble	Fail to reach Destination	Vessel	Inspect systems before Start Trip	Very Unlikely	Low	Low	Improve Security Protocols	Captain	in 24hrs
Geographic survey	Hull damage ,Vessel Damage	Vessel	Plan and navigate with extreme caution	Very Unlikely	Low	Low	Keep Navigation systems up to date	Captain	in 24hrs
Heavy Storms	Vessel Dmage	Vessel	Check weather before start trip	Unlikely	Medium	Medium	Collect weather Data before trip	Captain	in 24hrs
Others									
Major accidents	Ship collision,crash,loss of vessel	Vessel	Plan and navigate with extreme caution	Very Unlikely	Extreme	Low	Keep Navigation systems up to date and GPS	Ship Owner	in 24hrs
Ship external property	Disasters,Floods and Pandamic	Person/Machinery	Insurance	Very Unlikely	Extreme	Extreme	renew insurance every year	Ship Owner	in years

Mathematics – Crunching some numbers.



Finding the maximum mass

(The size of the bin is 2500mm (l) x 2500mm (w) x 1250mm (h) approx.,

Average density of floating plastic -> $980kg/m^3$)

$$\boldsymbol{V = lwh = 2.5m \times 2.5m \times 1.25m \approx 7.813m^3 (Volume\ of\ bin)}$$

$$\boldsymbol{max.mass\ of\ plastic = \rho V = 980 \times\ 7.813 \approx 7.657kg}$$

Average density from here

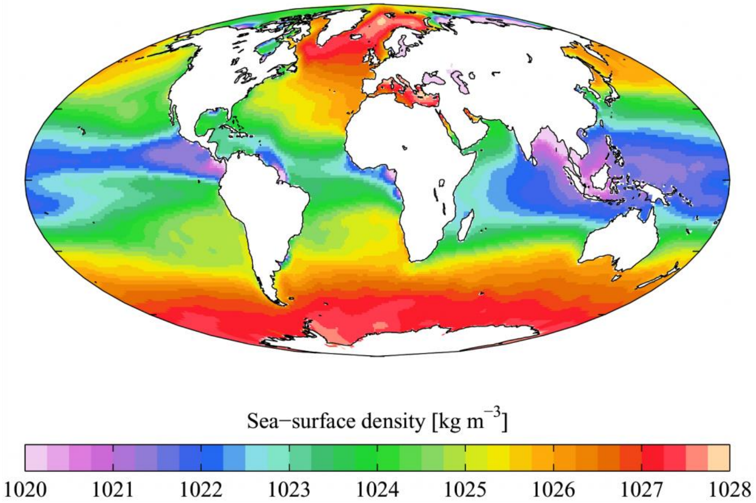


Image located here

$$\underline{\boldsymbol{Buoyancy\ force\ (F_b)}}$$

$$\rho = (density\ of\ sea\ water\ within\ region, see\ graph) = \boldsymbol{1026kg/m^3}$$

$$V\ =\ \boldsymbol{0.0875m^3}.$$

$$g\ =\ gravity\ =\ \boldsymbol{9.81\ m/s^2}$$

$$\boldsymbol{F_b = \rho V g = 1026 \times 0.0875 \times 9.81\ =\ 854.93N}$$

Formula from here

Conveyor Belt Speed

$$V = \frac{pi}{2} \times D \times \frac{RPM}{60}$$

conveyor belt **diameter = 60mm -> 0.06m or 2.36 inches**, **pi = 3.14**, average conveyor belt speed = **65 feet per minute**

$$\boldsymbol{RPM = FPM \times \left(\frac{1}{C}\right)}$$

$$\boldsymbol{C = circumference = 2 \times \pi \times r = 2 \times 3.14 \times (1.18\ inches) = 7.41}$$

$$\boldsymbol{RPM = 65 \times \left(\frac{1}{7.41}\right) = 8.77}$$

$$\boldsymbol{V = \frac{3.14}{2} \times 0.06 \times 8.77/60}$$

$$\boldsymbol{V = 1.57 \times 0.06 \times 0.15}$$

$$\boldsymbol{V = 0.014\ m/s^2}$$

Mass of plastic?

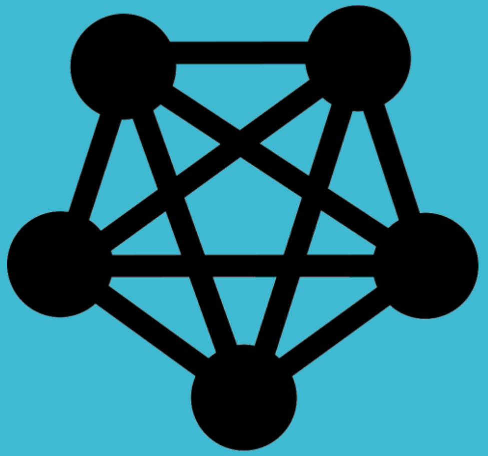
(Approx. mass is 80,000 tonnes, area is 1.2 million sq. km,

- weight over area average, times our projected working area 10 sq km, and a working depth of 1 metre to find density for mass)

$$\boldsymbol{\frac{80,000}{1,200,000} = 0.0667\ tonnes\ per\ sqkm.}$$

$$\boldsymbol{0.0667 \times 10 = 0.667\ tonnes\ in\ 10\ sq\ km}$$

Ergonomics of the Drones



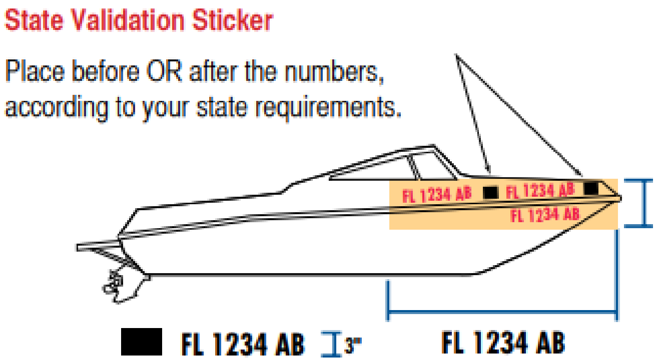
- Each hold will be divided in half for drone storage and plastic accumulation
- Overall Volume of the drone plus clearance from the sides:
- $V = a^3 = 2.5^3 = 15.63m^3$
- Hold volume:

> - Hold 1 $\rightarrow \mathrm{V} = \mathrm{lwh} = 5.8 \times 24.5 \times 7.6 \approx 1080m^3$
> - Hold 2 $\rightarrow \mathrm{V} = \mathrm{lwh} = 16.8 \times 24.5 \times 7.6 \approx 3{,}128m^3$
> - Hold 3 $\rightarrow \mathrm{V} = \mathrm{lwh} = 10.6 \times 24.5 \times 7.6 \approx 1974m^3$
> - If using half the space max no. drones that can be added respectively is:
>
> - $\left(\frac{1080}{2}\right) \div 15.63 \approx 34\ Drones$
> - $\left(\frac{3128}{2}\right) \div 15.63 \approx 100\ Drones$
> - $\left(\frac{1974}{2}\right) \div 15.63 \approx 63\ Drones$

Who will Validate our System?

How and who will validate/verify this is a safe system?

USA – CFR (Council of Foreign Relations)



Ventilation (33 CFR 175/183, 46 CFR 25)

Fire Extinguishers (46 CFR 25)

Visual Distress Signals (33 CFR 175.101) - You need approved distress signals by US coast guard. Electric distress light and orange flag required.

Life Jackets (33 CFR 175)

Registration (33 CFR 173) and Documentation (46 CFR 67) - All undocumented vessels equipped with propulsion machinery must be registered in the state of principal use

https://www.uscgboating.org/images/420.PDF

Legal Issues, Legislations and Standards

- **Maritime Labour Convention 2006 (MLC)** - To ensure the ship provides the necessary amount of PPE (Personal Protective Equipment)

- **ASME** – American Society of Mechanical Engineers
- **ASME B.30.20-3**– Specifies when operator is allowed to manually position or guide the magnet during relocation
- **ASME B.30.20-4 –** resolving compliance issues and precautions before operation

- **EMC – Electro-Magnetic Compliance**
- IEEE/ANSI C63.4 – “American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment”
- Range 9kHz – 40GHz

Legal Issue, Legislations and Standards

- IEEE/ANSI C63.10 -
- Electronic Equipment
- FCC part 15 - > radio frequency devices emission standard (e.g. this would apply to the drones themselves)
- EMC standards -> e.g. induction motors -> EMP
- MARPOL: Prevention of Pollution by Sewage from Ships ANNEX IV – circa. 27 September 2003 (link to page) – In accordance, as the part is made later on
- **United States Ship Registry Requirements**
- Prevention of Pollution by garbage from ships – circa 31 December 1988
- Prevention of Air Pollution from ships – circa 19 May 2005

- International Safety Management Code [ISM]Code for Ships
- ISO 8402:1995 / BS 4778 define risk management, which includes maritime risk assessment as: “The process whereby decisions are made to accept a known or assessed risk and/or the implementation of actions to reduce the consequences or probability of occurrence

IMO

Steps Going Forward; What's left to do?

- On Shore Offloading Method (From cargo to transport, from transport to post collection solution)
- Rapid Prototyping of Drone design to develop it to a working prototype
- Testing of electrical systems and Actual power requirements.
- Comparison of Canadian and USA shipping regulations to identify most cost effective and Complient mooring port.
- Costing and expenditure evaluation.
- Development of S.O.P (Standard Operating Procedures)
- Power requirements of propulsion method need to move fully Laiden Drone.
- Power storage methods and recovery methods on power out.

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Thank you for Listening!

Are there any Questions?