

Transport Group 3 EWB Report

Trusted Transport

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Background & Problem Definition

Introduction

This year's Engineering Without Borders Challenge is based in Peru. More specifically, we have been asked to focus on two Coastal communities in the Piura region called Lobitos and Piedritas. We decided to choose transportation as our topic since as a group, we are all eager to help the residents of Lobitos and Piedritas move around safely, efficiently and without unnecessary harm to the area's natural beauty. Our design brief stated that,

“Mobility and access to transport infrastructure allow people and goods to move around freely. Mobility plays a key role in making societies more inclusive through enabling access to key services and educational, economic and social opportunities. Transport infrastructure comes in many forms such as pedestrianised areas, cycling facilities, boats, public transport, shared-ownership transport, rented and hired transport and private transport.” (Engineering Without Borders Design Brief, 2021, p.19)

The design brief also states that we must be aware of, and follow the UN's Sustainable Development Goals. More specifically to the transportation section, goal numbers 11, 17 and 8.



Figure 1: The UN's sustainable development goals. (United Nations, 2018)

Key Background Points

The typical vehicles used in Lobitos and Piedritas are motorbikes, 3 wheeler mototaxis, cars and some larger capacity taxis. Many of the residents live in poverty, meaning they can't afford cars. The residents need to make an essential trip to the local city Talara for supplies and services like medicine and food, and during water shortages, it is critical for water to get delivered to the residents. Talara is 17km from Lobitos and the road there can flood during regular El Nino events. This is because the road to Talara is only partially paved, and thus gets washed away regularly. For the residents to get to Talara, they get a shared taxi. It costs S/4 per person (80p) to get to Talara on a weekday, whereas it is S/5 per person (£1.00) during the

weekend. Since the taxis are shared, the commuters have to wait for the taxi to be full, before it will leave for Talara. If a resident wanted to use a normal private taxi, it would cost between S/30-50 (£6-10) to get to and from Talara. This means only tourists use private taxis because in Lobitos 30% residents live below the poverty line, while in Piedritas, its 80% of residents. Currently there is a new project being developed called the La Costanera highway. It will travel through Lobitos, connecting the town to other coastal towns. However the La Costanera highway is far away from being complete at the moment and there is backlash from the local residents, who believe that the highway will cause damage to the environment. There is a huge lack of eco-friendly transport for tourists, meaning many have to walk, which can be dangerous during the middle of the day, since the temperature from December to March can easily reach 32°C.

(Background information taken from EWB design brief)

The Landscape

As part of our research, we collected a number of images from Google Maps to fully understand the geography of the area.

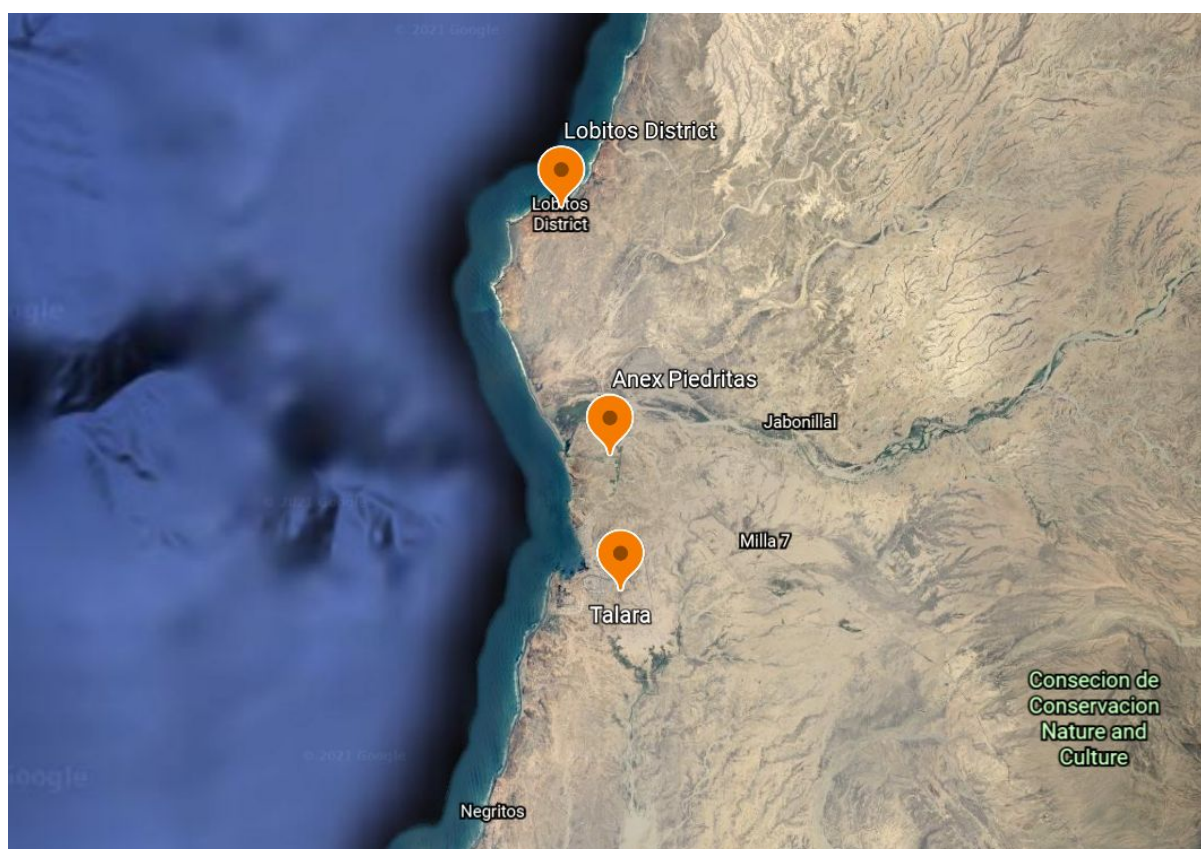


Figure 2: Map of Peru showing the location of Lobitos, Piedritas and Talara. (Google Earth, 2021)



Figure 3: Road between Lobitos and Piedritas. (Google Earth, 2021)



Figure 4: The road from Lobitos to Talara. (Google Earth, 2021)



Figure 5: Street View of Talara. (Google Earth, 2021)



Figure 6: The Pier in Lobitos. (Google Earth, 2021)



Figure 7: The road out of Lobitos. (Google Earth, 2021)



Figure 8: Road out of Piedritas. (Google Earth, 2021)

Problem Definition

We decided to focus on developing a solution for the lack of Environmentally-friendly affordable transport in Lobitos and Piedritas. We feel as a group that tackling this problem is very important, so that not only local residents can have a more affordable and convenient way to travel around, but also to attract more tourists to the local area by giving the option of environmentally responsible, affordable transportation on their stay.

Design Specification

Function

When designing anything no matter what it is, the single most important thing to consider is will this function how it is designed to and will it do it effectively. For us when designing a mode of transport between two villages, obviously it must be able to make the journey at the bare minimum and be able to call our project effective it must be an improvement on the current system. For our vehicle, we want it to function in a way that it can get from A to B without failing or needing any repairs or adjustments along the way and to easily travel through rough terrains while maintaining a high level of safety and comfort.

Customer

When designing any sort of vehicle or mode of transport, it is important to make sure you understand what type of people are going to be using it, what their financial and economic situation is and what sort of things are currently popular with people of the region. Doing this increases the chance of the solution becoming popular and widely used by the residents. A good way of finding out about what the customer would find appealing would be simply to ask people from the area in the form of a survey. You could ask residents what sort of things they would like to see in our product solution, what problems do they face on their trips and how much they would be willing to spend. This information would both aid the design process and make the finished product better catered to the people who will be using it.

Cost

When designing/manufacturing any product cost is one of the most important elements to consider. Ideally you want to have a reliable product whilst also not being too expensive or exceeding any budget you may have set. I believe this to be an important point when we consider the people of Lobitos and Piedritas because we want to provide a solution to the transport issues in the region without any large financial detriment on the residents as well as the manufacturers.

“Manufacturing costs fall into three broad categories of expenses: materials, labour, and overhead (Manufacturing overhead cost is the sum of all the indirect costs which are incurred while manufacturing a product.” (Beers, 2021)

Environmentally Responsible

“Eco- or environmentally friendly manufacturing protects the planet from exploitation and conserves natural resources. Products are made from sustainable materials, while waste is reduced through remanufacturing, reuse and recycling.”
(smallbusiness.chron.com, 2021)

As modern-day engineers we must also consider what we create is not harmful to the environment. It is important in our project in the towns of Lobitos and Piedritas we do not add anymore to the carbon footprint (in 2016 Peru was recorded to have produced 1.86 metric tons of CO2 emissions per capita). In short our product should be made of materials that can be recycled and still prove effective.

Safety

The product must be safe for the residents of Lobitos & Piedritas, as well as tourists. This means the product solution must be thoroughly tested before release. To make sure the user understands how to safely operate the product, clear and concise instructions must be able to be easily read on the product. Any safety gear such as helmets will need to be included for the user. The safety of the user must come before other issues like cost or aesthetics. Given the fact that the nearest hospital is in Talara, the product needs to be as risk free to the user as physically possible.

Reliability

The product solution needs to be reliable since it will have to withstand the daily wear and tear of use in the unforgiving road conditions in Lobitos & Piedritas. If the product does break down, it must be possible for it to be repaired with basic hand tools and affordable parts. Having to bring the product to Talara for repair would not be acceptable since it would leave residents and tourists with less options for transport. The transport of the product to Talara would also be expensive, and the local council may not be keen on funding it. Whichever materials are chosen must be able to cope with the high temperatures during the day.

Comfort

The product must be comfortable for the user. This means keeping the type of rough terrain the product may experience in mind and find the best way possible to overcome this. This also means taking into consideration the size and shape of the seat to make the product comfortable for everyone that uses it no matter their size or what they are wearing.

Aesthetics

The product must be aesthetically pleasing for the user in order to make them more desirable to be used. In order to achieve this the product must be designed with a modern concept in mind to optimise the looks and appeal of the product. Colour and material must also be taken into account when looking at the aesthetics as colour will obviously add to the appeal of the product and material is also an important aspect as if you choose the wrong material the product may rust over time directly affecting the aesthetics of the product.

Simplicity

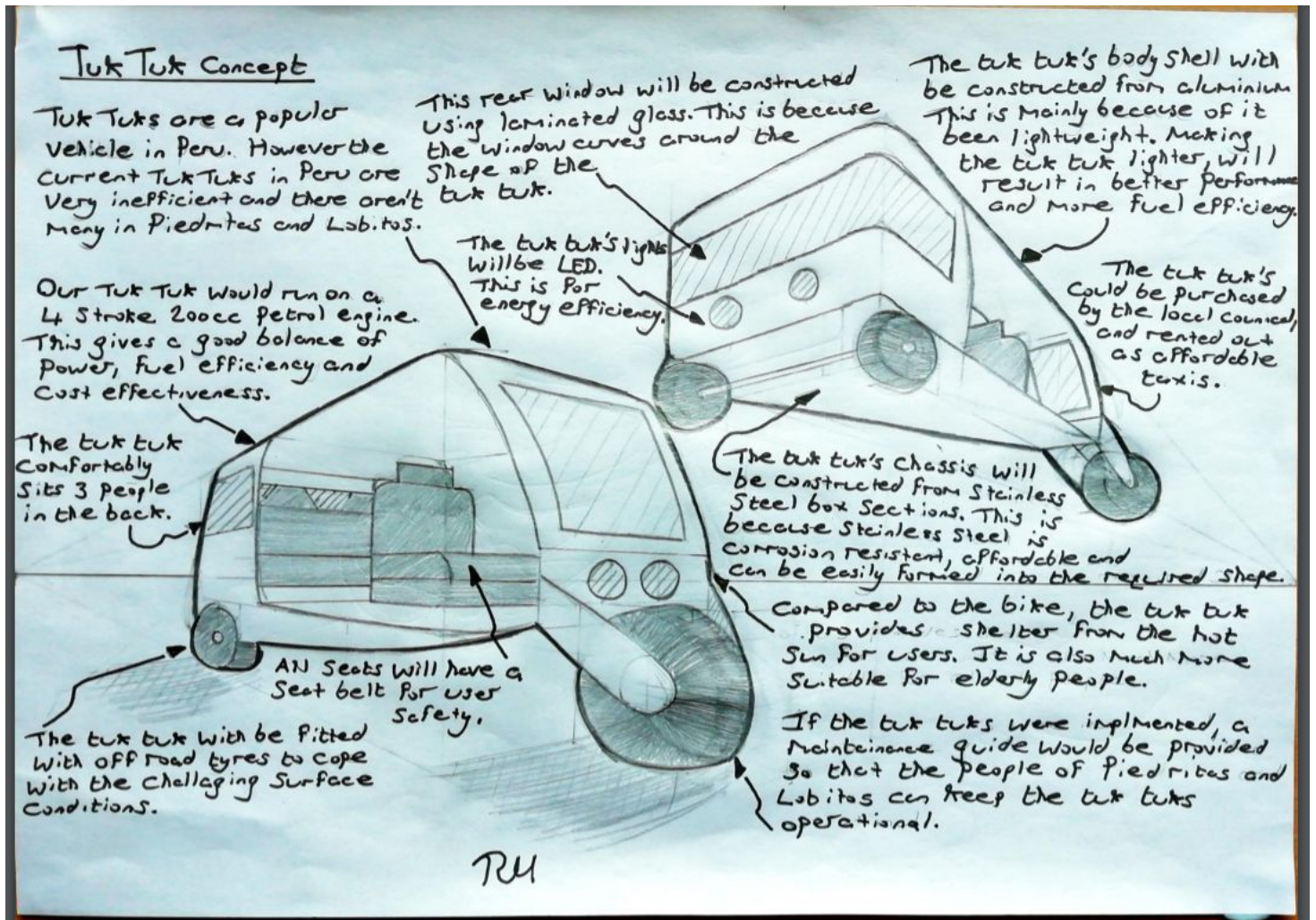
The mode of transport must be easy to use for any person inhabiting Lobitos and Piedritas to ensure that the system will work all of the time and can be maintained easily without complication, expense, or large amounts of physical effort. For example, if the solution for transport requires excessive amounts of training for all of the locals, then the solution would not be suitable compared to a more simple one that can be all inclusive and more affordable for the people living in the area. However, it must not be too simplistic otherwise this could deter tourists from travelling into these settlements.

Availability

The availability strongly ties in with the cost of the transport. For example, the method must be affordable for the people who require the transport regularly so that they can still obtain vital supplies from the nearby city of Talara. The mode of transport should also be easy to source within close proximity to Lobitos and Piedritas so that if an issue arises, it could be easily replaced or have the suitable requirements nearby to be maintained, for example, ease of access to parts and to people qualified to make repairs.

Concept Solutions

Concept 1 (Tuk Tuk)



Pros

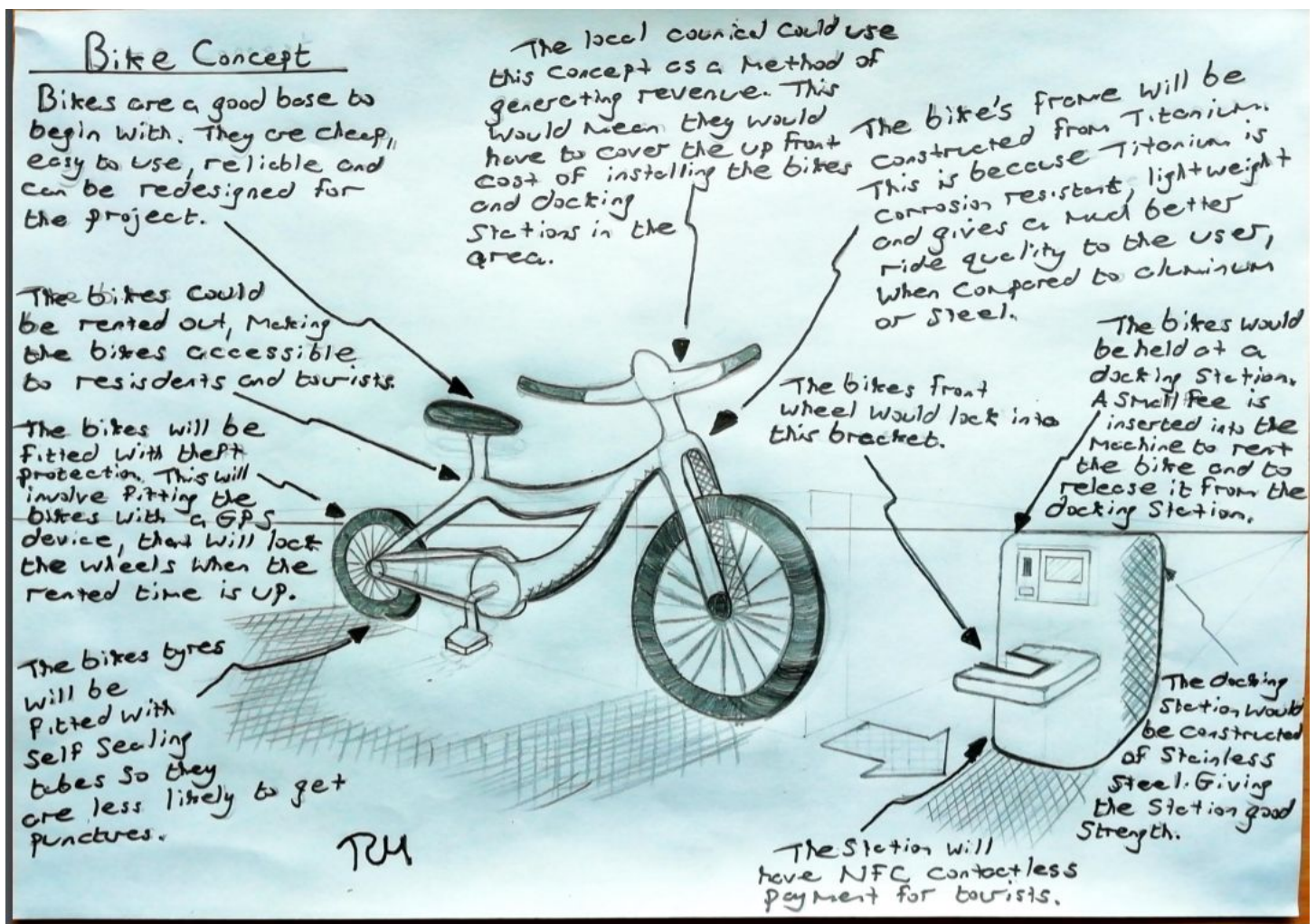
- The tuk tuk could be used by the local council to generate revenue. This could be done by purchasing the taxis, and then renting them out to residents or by providing a taxi service.
- The user is not exposed to elements when using a tuk tuk, meaning it can be comfortably used in all weathers.
- Generally tuk tucks are simple to work on, normally having 4 stroke engines and basic drivetrains.

Cons

- The tuk tuk is powered by a petrol engine, meaning it is using a non-sustainable source of fuel. If there was a large intake of fossil fuel tuk tucks, then the air quality in Lobitos and Piedritas would be negatively affected.

- The local council would have to fund the upfront cost of purchasing the tuk tuk for the area which may be difficult.
- The design of tuk tuk would struggle on the more challenging off road surfaces in Lobitos and Piedritas. This is because it has no active drive in the front wheel.

Concept 2 (Bicycle)



Pros

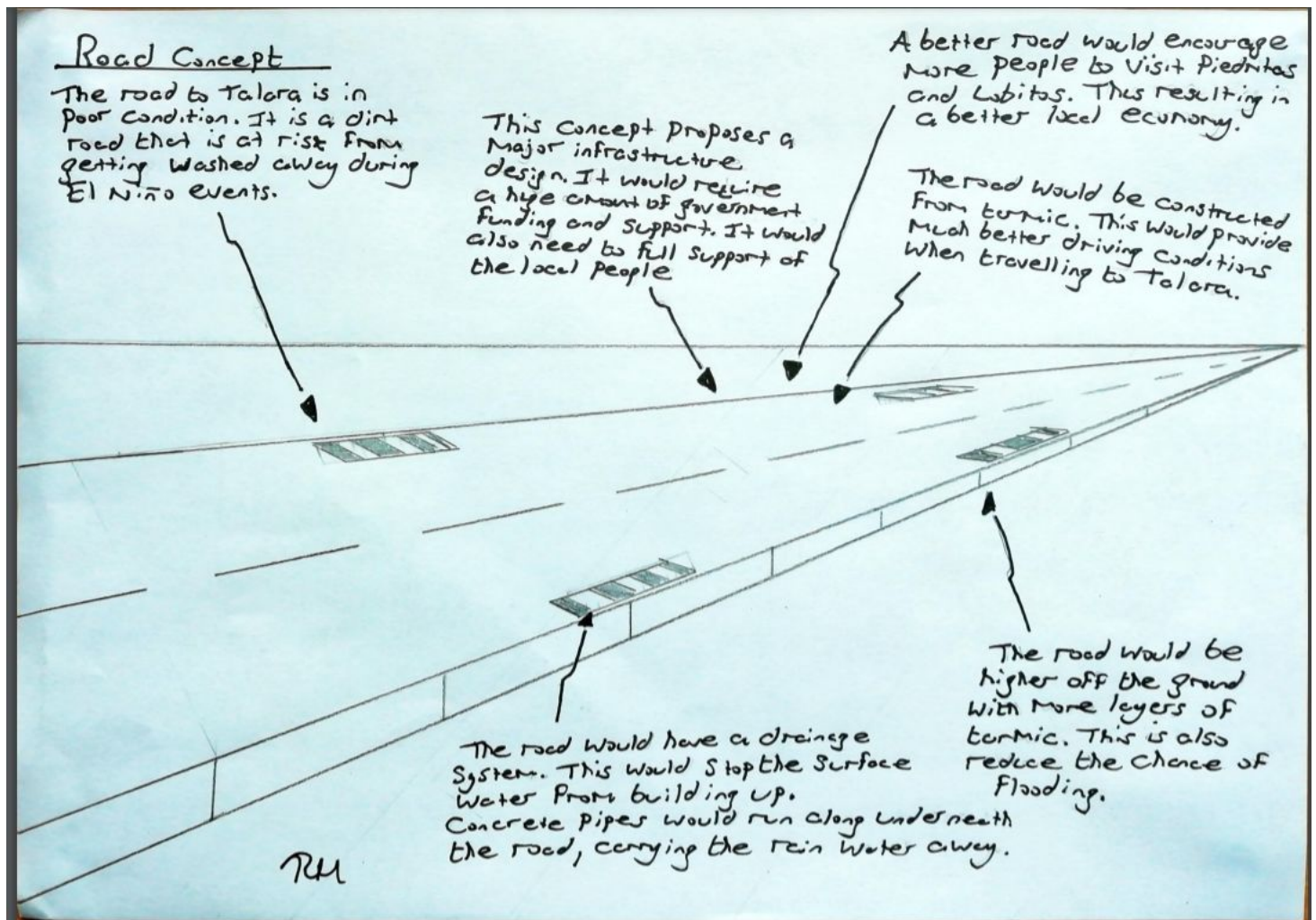
- Bikes are much more affordable to manufacture and distribute compared to larger vehicles. This means that some residents may be able to afford to privately buy their own bike.
- Having rentable bikes located around Lobitos and Piedritas would give tourists an affordable and environmentally friendly option to travel around the local area. The docking station with NFC contactless payment makes it quick and easy to rent a bike. This would of course also generate revenue for the local area.

- Bikes are very simple to work on and can be easily maintained.

Cons

- A pedal bike would not solve the issue of getting people to Talara. Since it is 17Km away from Lobitos, it would be unrealistic to expect anyone to cycle that distance. As well as this, the user would be exposed to the hot sun on a bike, making long distance travelling life threatening.
- The docking station may not be enough to protect the bikes from theft, and unfortunately from reading the design brief, theft is a real issue in Lobitos and Piedritas.
- The bikes may cause discrimination since elderly and disabled residents and tourists may not be able to use the bikes.

Concept 3 (Road)



Pros

- This would be a huge improvement for the road between Lobitos and Talara. Currently the road is only partly paved and regularly floods during El Niño events, cutting Lobitos and Piedritas from important supplies and services.
- This concept road would include a drainage system, meaning the road is very unlikely to flood, allowing people to continue to commute back and forth to Talara.
- Having a reliable safe road between Lobitos and Talara would give the local economy a huge boost, since more people will be encouraged to travel to Lobitos and Piedritas using the more accessible road.

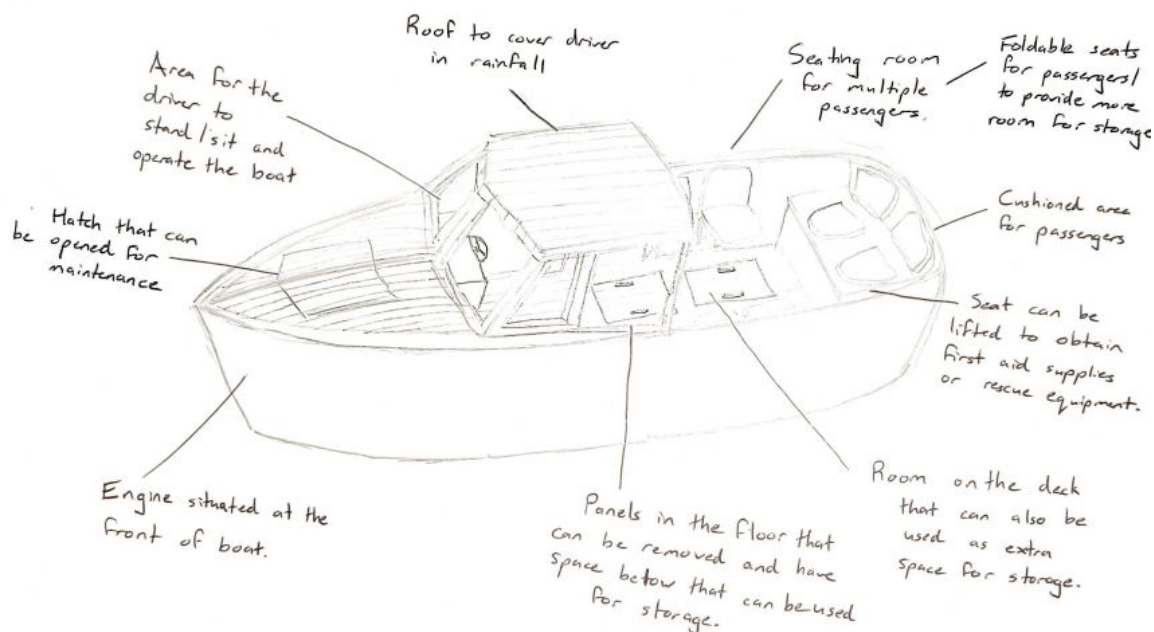
Cons

- This would be a multi-million pound project, requiring Peru's government's support and funding. It would require a huge workforce, large expensive equipment and materials.
- Time scale would also be another problem. It would possibly take years before the actual construction would begin, because of the issues mentioned above like generating funds and public support.

- Many would argue that building a road like this would ruin and damage the local area's natural beauty and charm. Also the machinery required e.g. trucks, steamroller, etc would produce a lot of noise and disruption to the local area.

Concept 4 (Boat)

BOAT



Pros

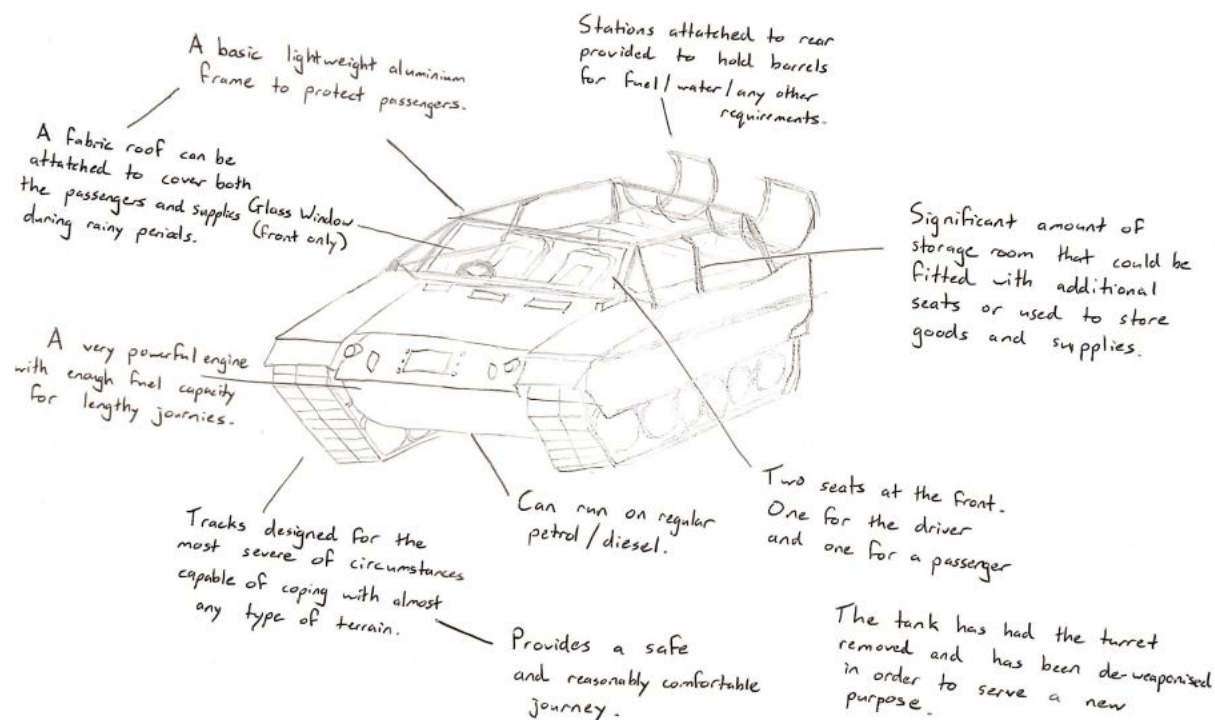
- Makes use of the geographical location of Lobitos by using the pier as a dock for the boats to stay in and the sea can be used as a simple method of transport to access Talara.
- A cost effective solution as it is cheaper than many other alternatives and could also be used for boat trips for tourists to be able to generate some revenue for the locals.
- Lots of locals already have experience in sailing and are accustomed to this method of transport, therefore most would be happy to use this method of transport to travel to Talara.

Cons

- The long term running cost of the boat could provide a continuous expense. This includes the wage of the sailor, the cost of fuel and any maintenance that could be required.
- If the boat breaks down or develops faults, it may require specialist attention which can be hard to come by in the region or expensive to obtain due to the complicated moving parts of the boat.
- During El Nino season, it could be dangerous to sail along the coastline therefore ruling out this method of transport during those stormy months.

Concept 5 (Tank)

TANK



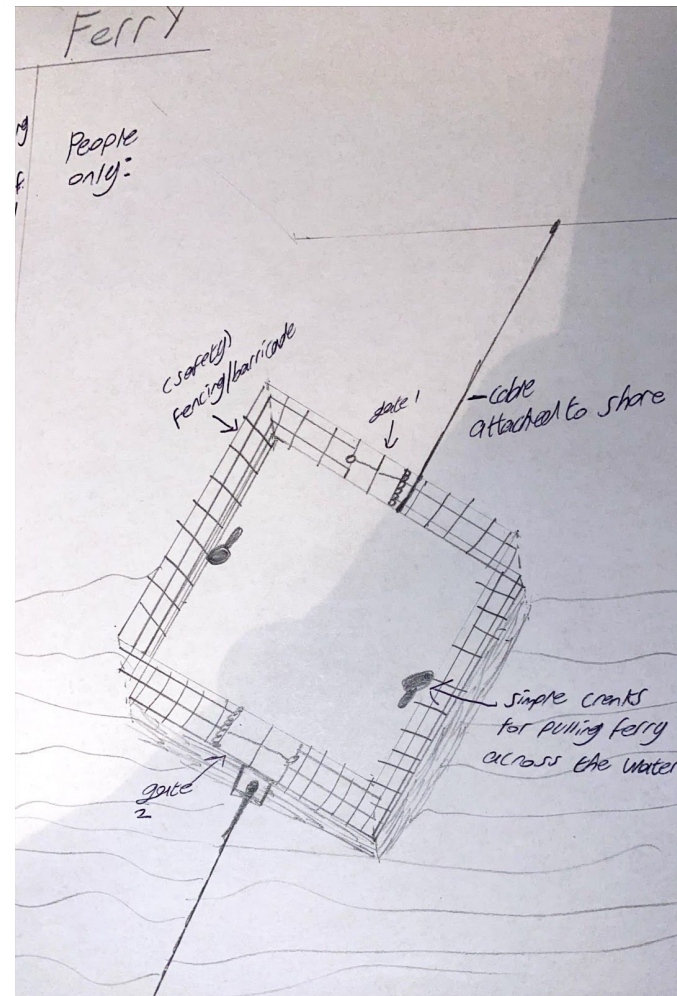
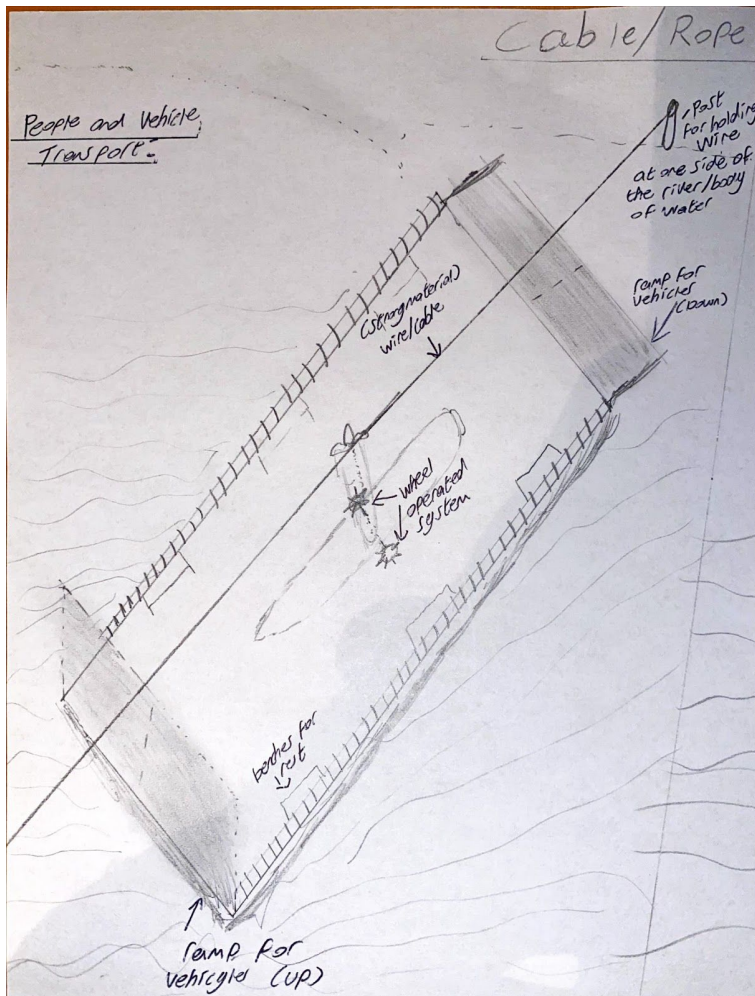
Pros

- The tank is a large vehicle, meaning it has a lot of storage capacity for passengers and supplies.
- The tank can cope with nearly all forms of terrain and weather conditions.
- It could be a good tourist attraction as everyone would love to drive a tank.

Cons

- The tank would be very difficult and expensive to maintain.
- Despite second hand tanks being surprisingly affordable, modifications made to fulfill the tanks purpose could be expensive to perform.
- The production process will not be very environmentally friendly, nor will the running of the vehicle due to its weight and fuel requirements.

Concept 6 (Ferry)



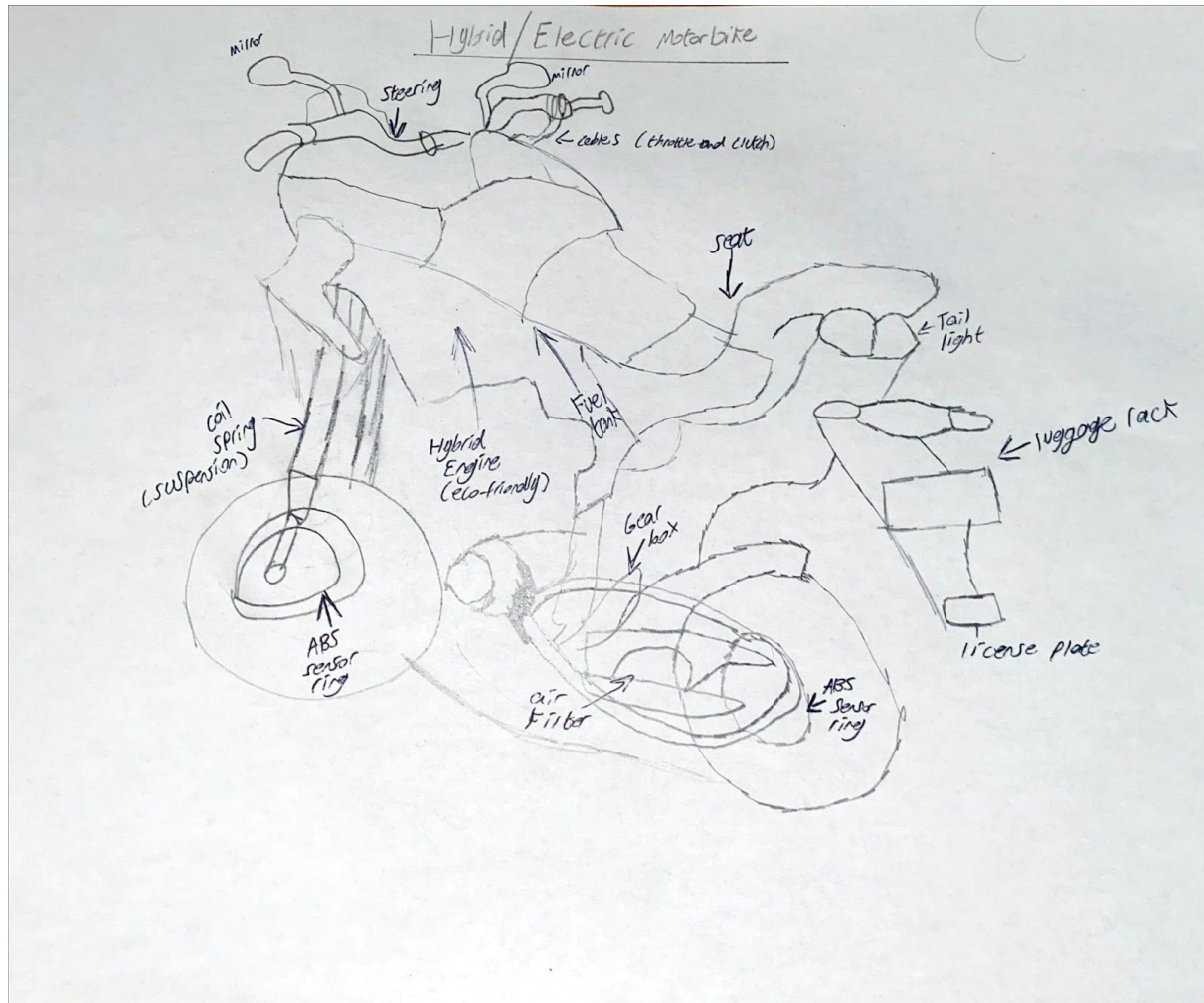
Pros:

- Eco-friendly
- Cheap
- Simple design
- Helps for crossing large bodies of water
- Good for transportation of goods/land vehicles over water

Cons:

- Exhausting (reliant on manpower)
- Argue a bridge is more practical
- Slow
- Limited use (restricted to water)
- In this region of Peru, water travel is not the biggest concern.

Concept 7 (Electric Motorbike)



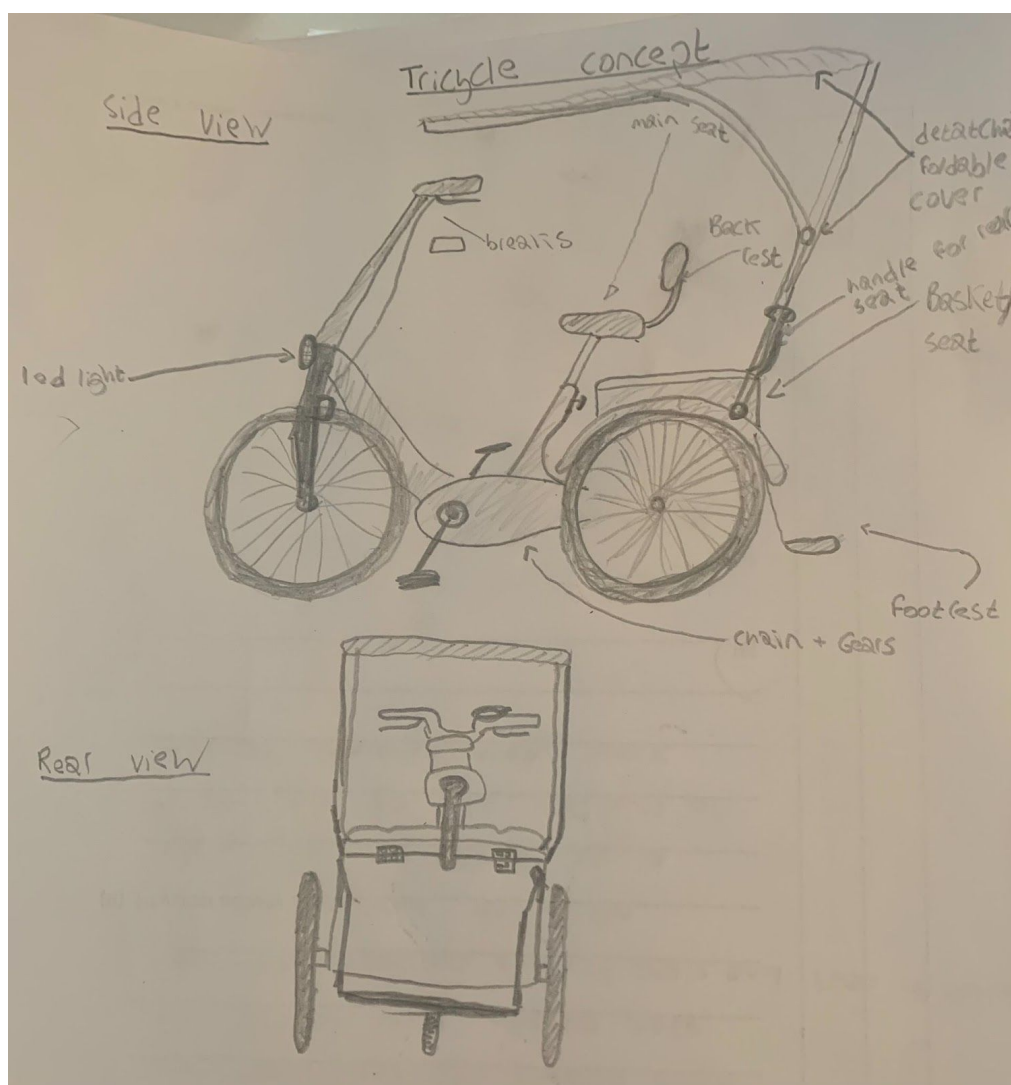
Pros:

- Quick transportation
- Eco friendly
- Usable on all roads
- Easy parking

Cons:

- Costly
- Dangerous
- Not practical to the locals or tourists
- Harder to get a license for a motorcycle

Concept 8 (Tricycle)



Pros:

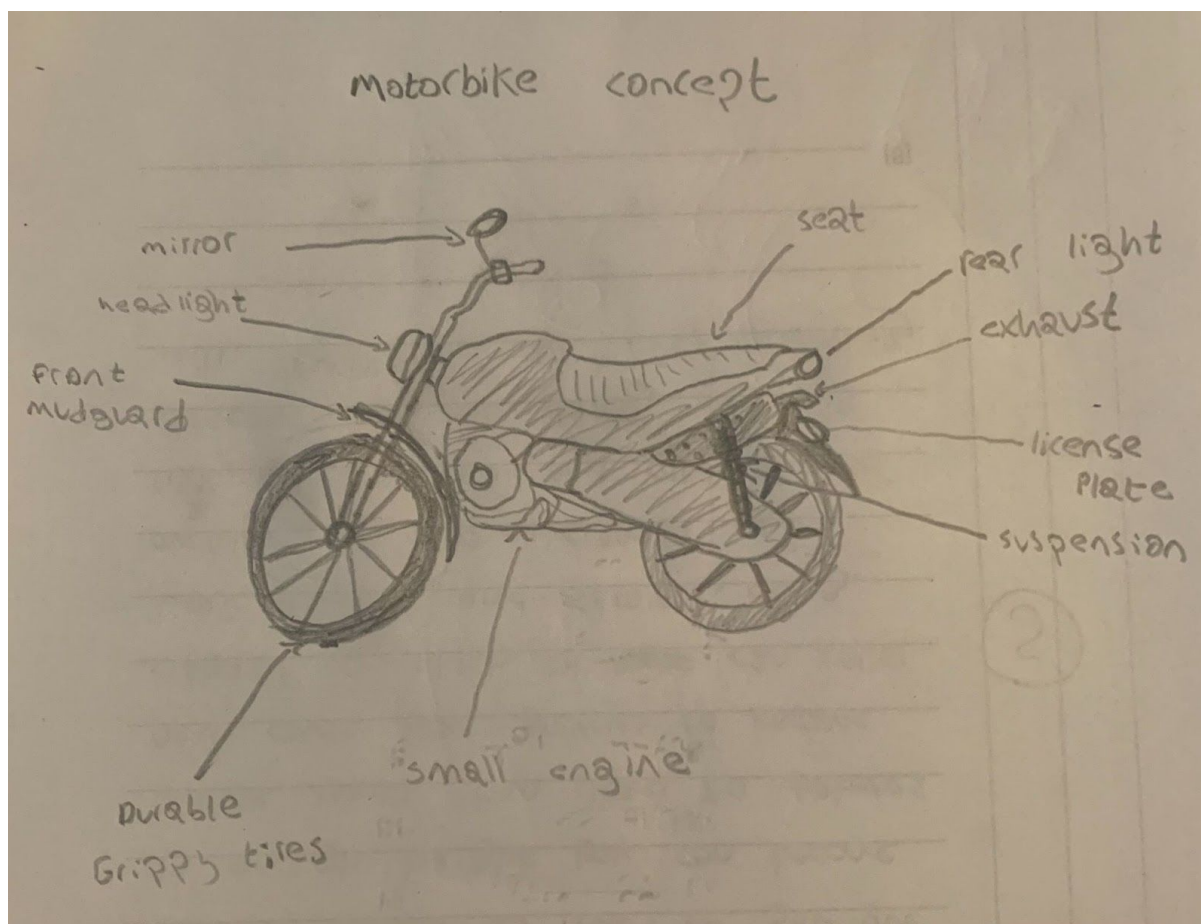
- Eco Friendly as a tricycle requires no fuel other than the energy exerted by the person using it so they have no emissions.
- Very cheap to produce and use as they don't need fuel which can be expensive and also don't require a great deal of expensive material to make.
- Can be fitted with a relatively large basket that can be used to carry groceries too and from the neighboring villages.
- Can be fitted with a comfortable seat.
- Small fold up tarp to protect from rain and harsh sun.

Cons:

- Requires a lot of endurance to travel a reasonable distance due to weight of the tricycle itself and the contents of the rear basket.
- Can only transport a maximum of two people and even then this would require the person riding the trike to be relatively strong.

- Can't carry very much compared to a larger motorised vehicle due to the fact that it's powered by pedal power.

Concept 9 (Motorbike)



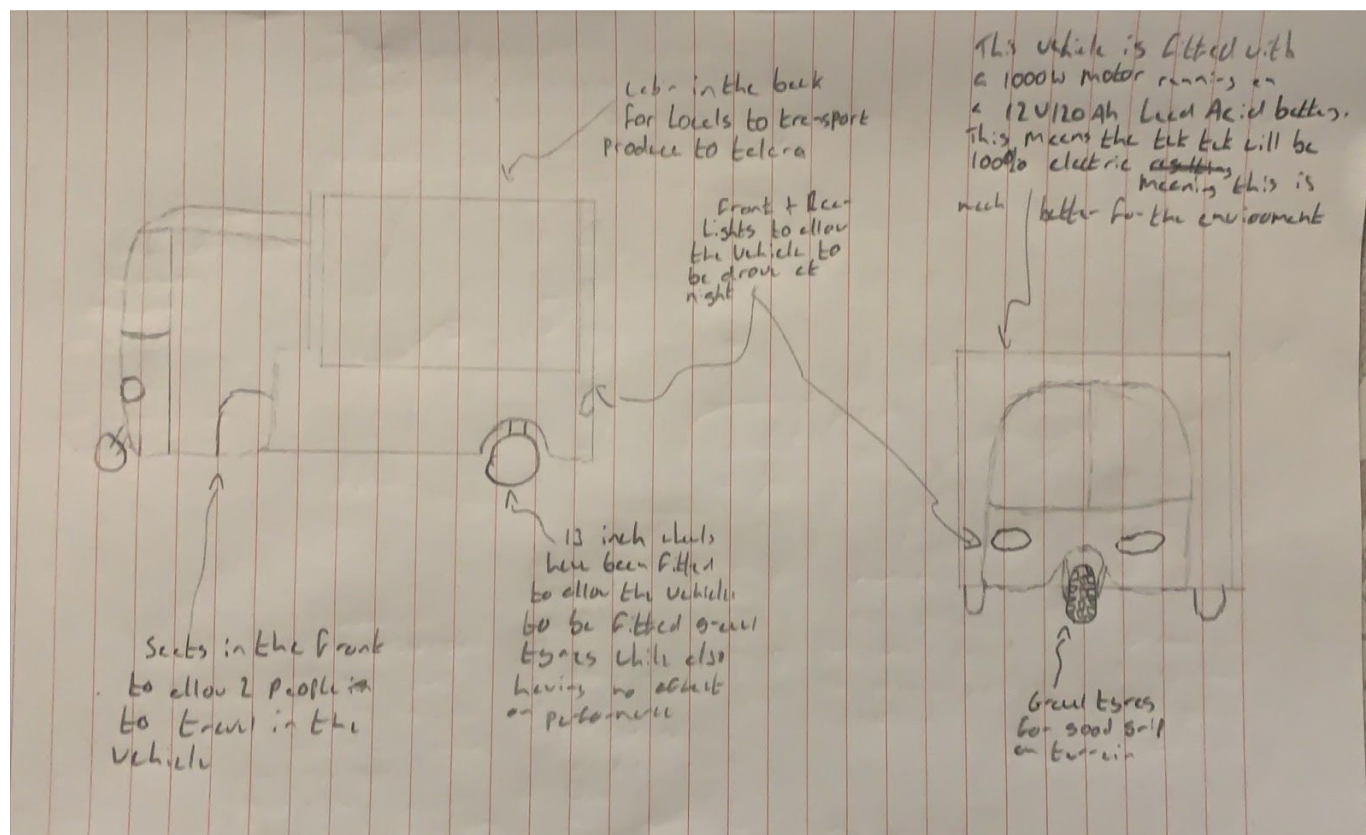
Pros:

- Motorbikes are a very fast form of transportation.
- A small container can be fitted to the back of the bike which can carry groceries and other belongings.
- The motorbike can travel off road easily.

Cons:

- Not very eco friendly as it runs on petrol or diesel which releases harmful gases to the environment.
- Can be dangerous as they can reach high speeds and there is little to no protection.
- There is no storage room for carrying supplies.
- Motorbikes aren't very cost effective since they are expensive to run and maintain.

Concept 10 (Electric Tuk Tuk)



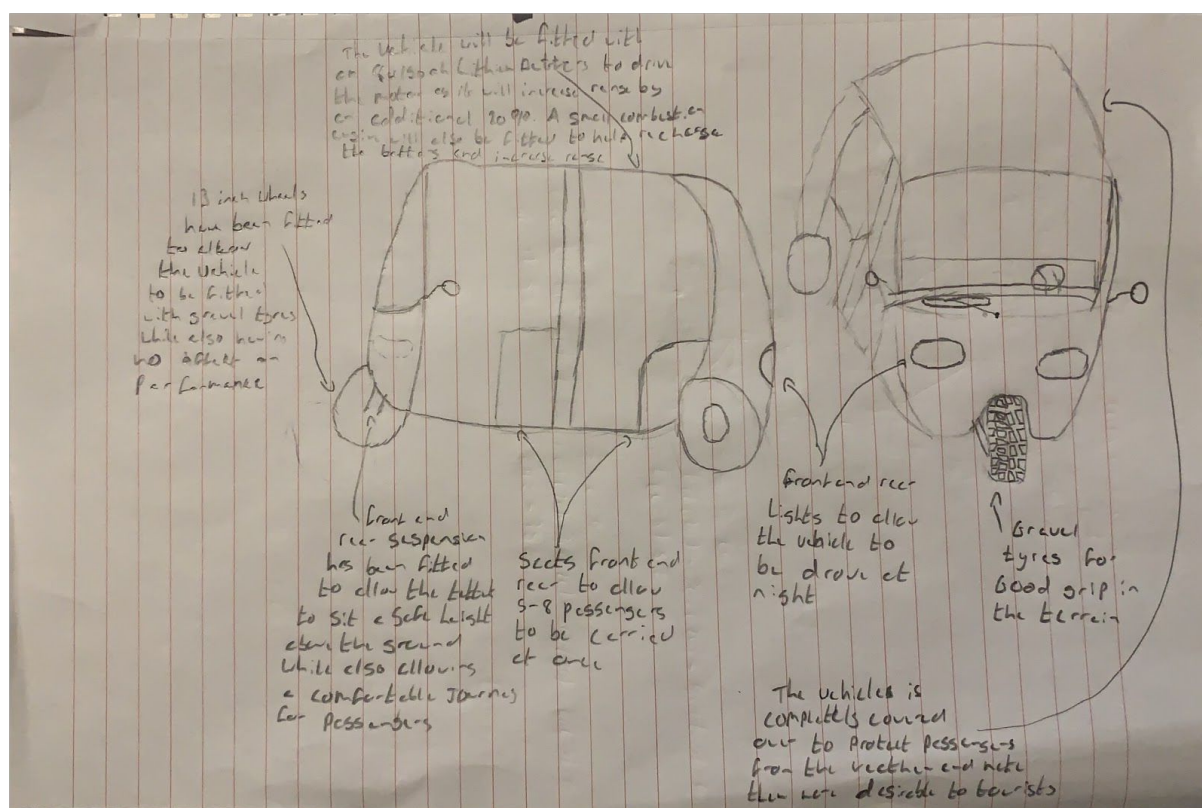
Pros

- I Believe the Electric TukTuk is quite a good design mainly for its environmental benefits. This TukTuk is 100% electric resulting in 0% emissions which makes the TukTuk very sustainable.
- Another positive with this TukTuk is the fact it has the ability to carry produce in the back. This is especially important for the locals as they need to transport supplies from Talara.
- The upgraded suspension and tyres are also a big benefit as most of the roads they will be travelling on are mostly gravel or sand meaning its harder to have grip on.

Cons

- One of the biggest Cons is initial set up cost, it will require a lot of money from the government or private funding to set this up and there will also need to be a charging station set up to charge the tuktuk which requires more funding meaning that this could be a very costly project which may not be sustainable.
- Another disadvantage to this tuk tuk is the fact it can only transport 2 people at a time so this doesn't solve the public transport problem between piedritas or lobitos.

Concept 11 (Hybrid Tuk Tuk)



Pros

- With a seat in the front and rear of the tuk tuk this means it can carry 5-8 people in it and if there were many of these available to the community it would completely solve the transport issue for Piedritas and Lobitos.
- Another big Pro to the Hybrid Tuk tuk is its long range, with addition of the small combustion engine to keep recharging the battery this tuk tuk can travel up to 300km on one charge.
- This Tuk tuk is completely covered over meaning that none of the passengers will be exposed to the weather and may make the Tuk tuk more desirable to tourists.

Cons

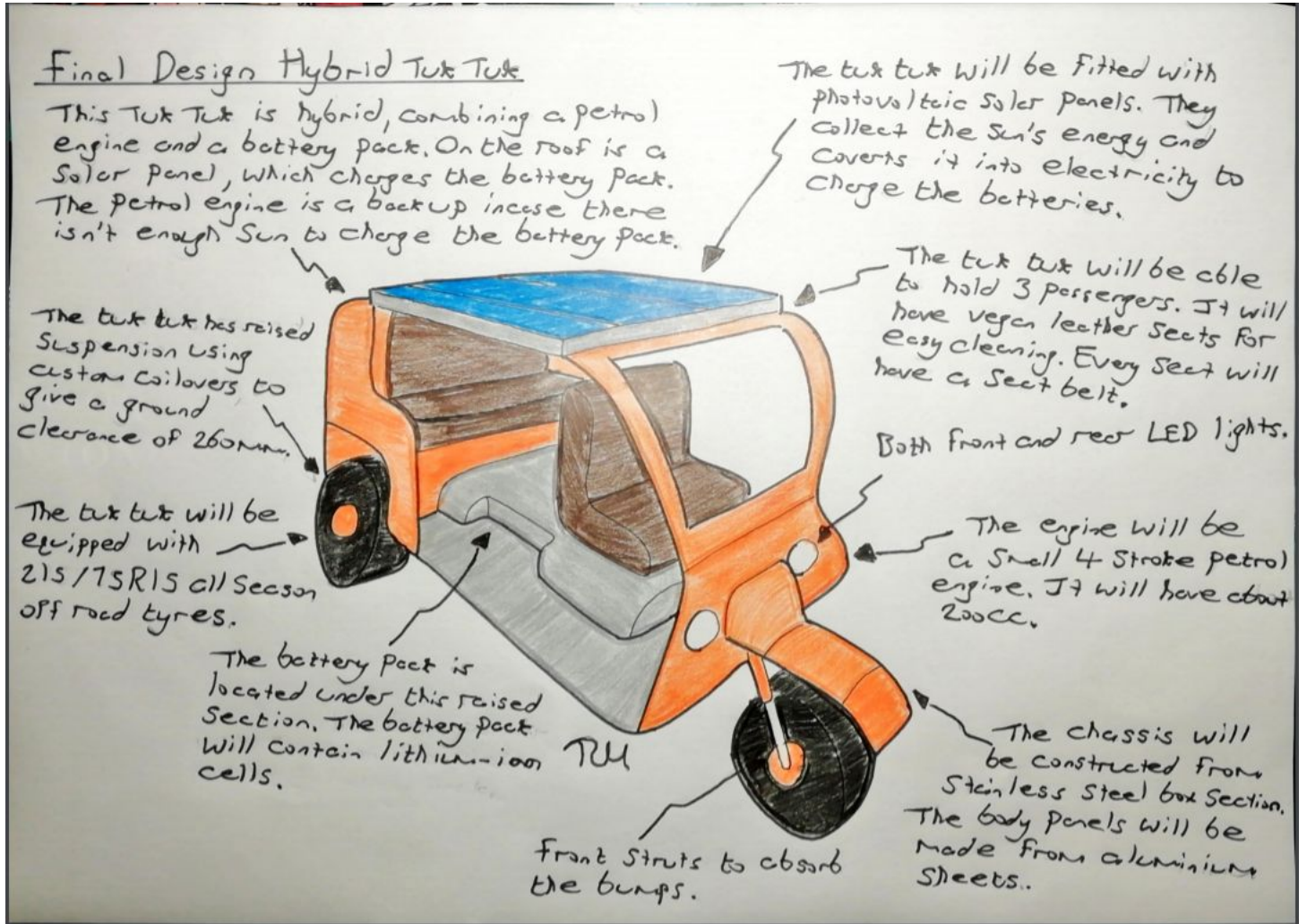
- Just like the Electric Tuk tuk the biggest con for the hybrid is the initial set up cost, Purchasing these could prove very costly at the start and if the locals don't deem them a suitable form of transport that could be millions of pounds worth of government or private funding down the drain.
- Another Con is the fact that this Tuk tuk can only carry passengers meaning that it may not be suitable for people travelling to Talara to sell their products or bringing back products from Talara.

Decision Matrix

Concept	Function	Customer	Cost	Eco Friendly	Safety	Reliability	Comfort	Aesthetics	Simplicity	Availability	TOTAL SCORE
Tuk Tuk	9	8	7	5	9	7	9	8	6	9	77
Bicycle	4	9	10	10	3	8	4	6	10	10	74
Roads	9	9	1	3	5	7	9	5	6	5	59
Ferry	7	6	3	10	7	9	5	5	8	7	67
Boat	9	9	7	5	7	7	6	8	8	8	74
Tricycle	6	9	9	10	5	7	5	6	10	8	75
Tank	10	4	2	3	6	10	5	10	4	2	56
Motorbike	5	6	8	5	5	7	6	8	7	7	64
Electric Bike	5	9	9	10	3	7	5	6	10	5	69
Electric Tuk Tuk	7	8	6	8	9	8	9	8	8	5	76
Hybrid Tuk Tuk	9	8	7	7	9	7	9	8	7	6	77

After putting all our concepts into the decision matrix and ranking them on their ability we concluded that the Hybrid Tuk tuk was the best form of transport. It does everything we need it to do while also being very environmentally friendly. The hybrid Tuk tuk is also very appealing to both locals and tourists and it can transport many people from Piedritas or Lobitos to Talara at a very low cost. The upgraded tyres and suspension mean that it can travel along any terrain with ease which will also be appealing to the customer as the local terrain is very rough. The hybrid Tuk tuk is also very simple which means maintenance cost will be low. The initial set up cost for these can be expensive but by charging a small fee for use, the local community should make its money back.

Fully Designed Solution & Implementation Plan



Hybrid Tuk Tuk Technical Specification

The vehicle will be marketed as the "TT Hybrid 200 Solar"

Length x Width x Height	3500 x 1510 x 2060mm
Tyre Size	215/75R15
Ground Clearance	260mm
Weight	1100 kg
Engine	4 Stroke Petrol
Drivetrain	Electronic (Simple Forward + Reverse)

Battery Pack Type	Lithium-ion
Battery kWh	62kWh
Battery Weight	107 Kg
Solar Panel Type	Thin Film
Max Speed	35 MPH
Passenger Capacity	4 (Including driver)
Body Shell Material	Aluminium Sheet Grade 6082
Chassis Material	Stainless Steel Grade 430
Purchase Cost	£1500
Extra Features	<ul style="list-style-type: none"> ● Front + Rear LED lights ● Seatbelts ● Glossy Paint Finish ● All terrain tyres ● Windscreen Wipers ● Fully Functional Dashboard ● Parking Brake ● Key Ignition

Engine Information

The engine we have chosen is the Honda IGXV700 4 stroke petrol engine. It is rated at 22.1hp and produces 48.3Mn of torque. This is suitable for the tuk tuk since the engine will only be needed if the battery runs out of charge as a backup. This engine features electronic fuel injection and variable ignition timing, allowing quick and easy starting. This prevents any long stops between switching from battery to engine mode. Honda also claims that the engine is extremely quiet and produces low emissions.

Battery + Drivetrain Information

We plan to source the battery packs and drivetrain from Nissan, who have made dramatic developments with their Leaf model. Since 2010, Nissan have continued to refine their battery so that currently it is more compact and efficient than ever. This is because they have been able to fit a higher density of lithium ions into the battery, and thus allowing the battery to last for more miles. Using this battery technology in our Tuk Tuk design will allow users to travel and make many trips to Talara on a single charge. The battery pack will be paired with Nissan's electric e-Powertrain, because it features an inverter which works by,

“Utilizing the motor it converts direct-current electricity to alternate current when driving, and then recovers energy by converting alternate current to direct current during deceleration (regeneration).” (NISSAN MOTOR Co., Ltd, 2019)

This means the battery pack will get a small charge every time the Tuk Tuk decelerations, making the vehicle last longer between charges.

Solar Panel

For this design, we decided that a lightweight, thin and flexible solar panel would be required. After some research we discovered a Swiss company called Flisom, who specializes in developing flexible photovoltaic solar panels. Their panel called the eFlex is manufactured from CIGS (Copper Indium Gallium Selenide) cells, allowing the panels to be very lightweight and thin, meaning that they can adhere to curved surfaces. Their largest panel is 250W, which will keep the Tuk Tuk’s battery pack topped up, stopping it from ever getting critically low on charge.

Material Analysis

The chassis of the Tuk Tuk will be stainless steel. When choosing the grade of stainless steel, a big factor is how the chosen grade copes with welding, since the chassis will be made up of welded box sections. Picking the incorrect grade of stainless steel would result in the metal cracking. The types of stainless steel that supports welding are the austenitic grades 304L and 347, and the ferritic grades 430 and 439.

<u>Grade</u>	<u>Proof Stress</u>	<u>Tensile Strength</u>	<u>Elongation (A50 mm)</u>	<u>Modulus Of Elasticity</u>
304L	200 Min MPa	500 - 700 MPa	45 Min %	193 GPa
347	205 Min MPa	515 Min MPa	40 Min %	193 GPa
430	260 Min MPa	450 - 600 MPa	20 Min %	200 GPa
439	230 Min MPa	420 - 600 MPa	23 Min %	220 GPa

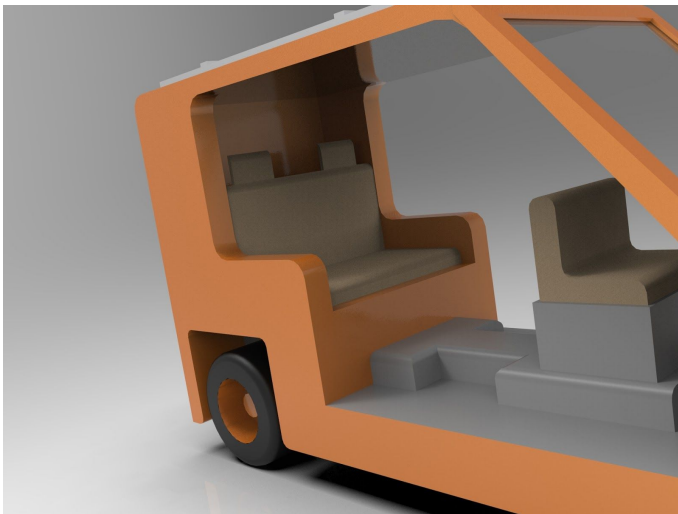
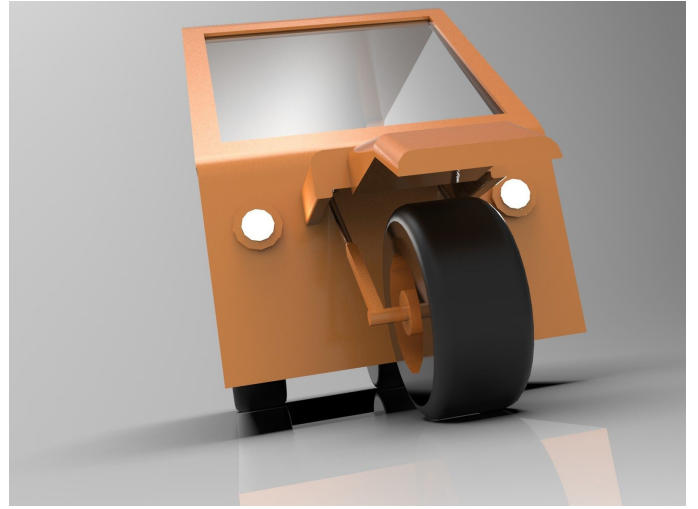
Date gathered from (www.aalco.co.uk, 2021)

The most suitable grade of stainless steel is the 430. This is because it has a high tensile strength, meaning it is able to support the weight of the tuk tuk without failing. It also has a good modulus of elasticity rating, meaning the stainless steel is quite stiff and will absorb the heavy loads during travel.

CAD Model

This model was created in the Siemens SolidEdge CAD package.



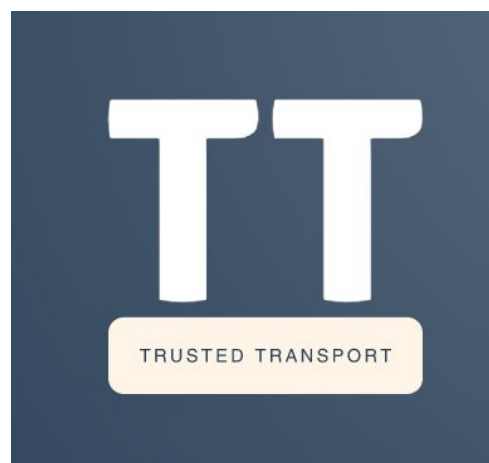


Implementation Plan

Our implementation plan for the hybrid tuk tuk is for the local council in Lobitos, and the community leaders in Piedritas to fund the cost of the tuk tuk. The plan would be for the council to buy multiple tuk tuks, so that they can start running an affordable taxi service for the local people. We would also set up an online fundraising campaign to help the tuk tuks be purchased. Partnering with Tuk Tuk UK would also be explored, since their knowledge and resources in developing and distributing these vehicles around the world would greatly help our project. Once the area has the tuk tuks, the local council can start to earn revenue from taxi fares, and for another stream of revenue, the tuk tuks could be rented out. This would be particularly appealing to tourists who want a simple, environmentally friendly transportation option while staying in Lobitos and Piedritas. It is our hope and aim that the revenue generated by this project can go on and be used to fund more projects to better help this deserving area of Peru.

Conclusion

After going through detailed research and creating 11 concepts, we have developed our solution for an environmentally friendly affordable transportation solution. Looking back at the product specification, our final solution successfully meets all our points and we believe with the appropriate funding, our solution can be successfully implemented into Lobitos and Piedritas. We believe the TT hybrid 200 solar will in the long term be a great source of revenue for the local area and a worthwhile investment.



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