UNIVERSITY OF TECHNOLOGY OF COMPIÈGNE

Floating Mobile Platform

Feasibility study

Alexandre Wilkinson, Brieuc Naveau, Vitor Honna, Mohamed Chedly Bchir , Lucas Ferreira Monteiro

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Identifying potential technical and economical obstacles to an innovative floating platform project

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II. INTRODUCTION

a) Floating mobile platform (FMP) project

The Floating mobile platform project is a joint effort to develop and create a floating platform that will be set up in Guanabara Bay (Rio de Janeiro, Brazil). The platform will be used for training, scientific research, environmental monitoring of the bay, as well as serve as a showroom for innovation. The University of Technology of Compiègne (UTC), the Federal University of Rio de Janeiro (UFRJ) and Saint-Gobain were the first partners who got together on the project, which is currently being supervised by Gilles Morel from UTC.

The increasing population in the world, especially around coastal regions, is creating stress on real estate, and the parts of the Earth covered in water are not exploited to their full potential. This platform will take advantage of this free space, as a mobile research lab to collect samples and data, process it, as well as analyze maritime conditions and air quality *in situ*. As a result, the platform should be mobile, in order to study various locations along the coast and inside the bay. The first version of this platform is not intended to have its own engine but will be towable instead.

On top of this, the stakes for sustainable development and renewable resources are ever increasing, and it is intended that the platform be eco-friendly. Resources on board (energy, water, heat…) are meant to be generated through sustainable means and exploited as much as possible thanks to a circular economy.

The platform will also serve as a meeting room, where training can be dispensed, and where coworkers can gather to confer on projects. The platform will provide space to live, sleep, and work, and a modular attachment system could allow users to choose which modules are needed for a mission (laboratory, dormitory, conference room…).

Boats will be able to moor to the platform, in order to resupply it if necessary (with food, for instance). The platform will also be equipped with various sensors and drones, through which data will be acquired and stored onboard in a database. This data will then be used to pursue scientific goals, thanks to the computers on the platform.

Finally, this project is meant to be carried out by numerous international partners, as well as students who will participate in its various stages, such as working on the BIM and the prototype, and helping with the building the platform.

b) Our mission: technical and economic feasibility

We are a group of five engineering students from UTC, Alexandre Wilkinson, Vitor Hona, Brieuc Naveau, Chedly Bchir, and Lucas Ferreira, and after contacting Gilles Morel in March 2019, we were assigned the task to identify the technical and economical obstacles the creation of the platform would have as it was then envisioned, as an early feasibility study. The result of our findings would allow to steer the project towards or away from certain solutions and desired characteristics. This document contains the result of our research.

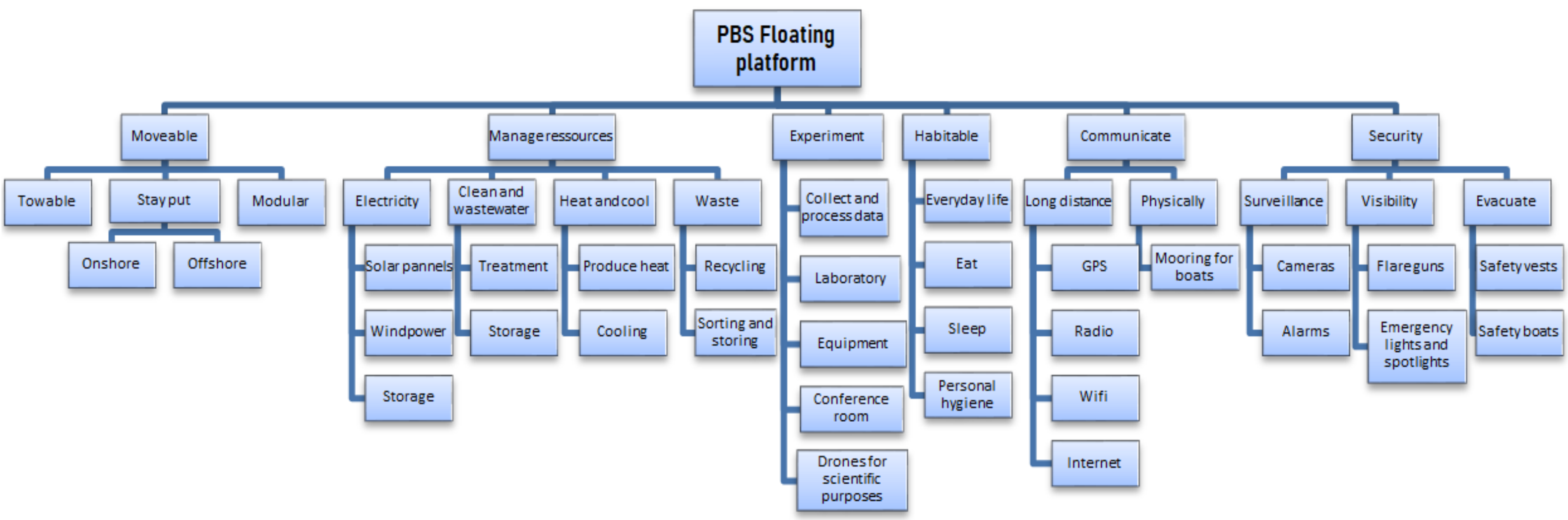
Moreover, our work was done in the context of a project management course, and as such we have clarified the organization of the project, as well as conducted a risk analysis, which we have included in this paper.

c) Organization of the project

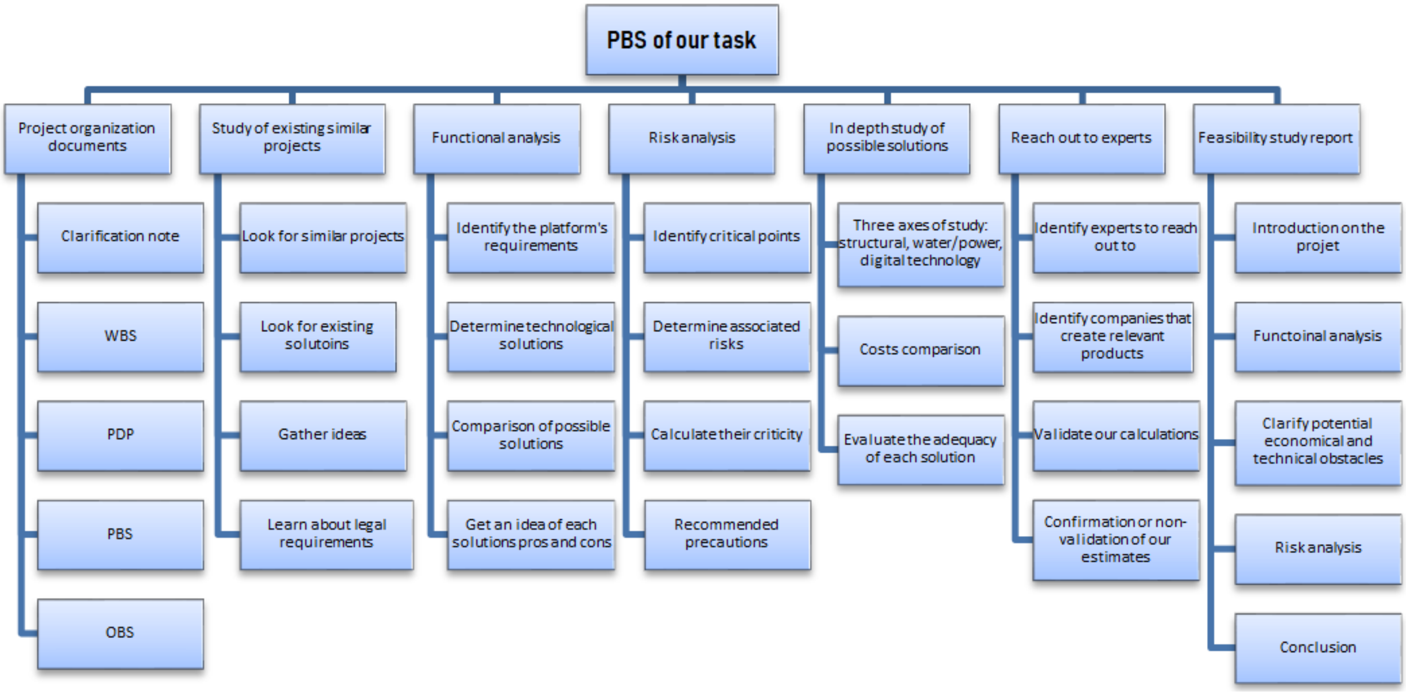
1) Product Breakdown Structure (PBS)

To begin with, we laid out the principal desired characteristics of the platform into their main categories: movement, resources, experimentation, everyday life, communication and security.

The following product breakdown structure displays the main desired characteristics the final platform should have:

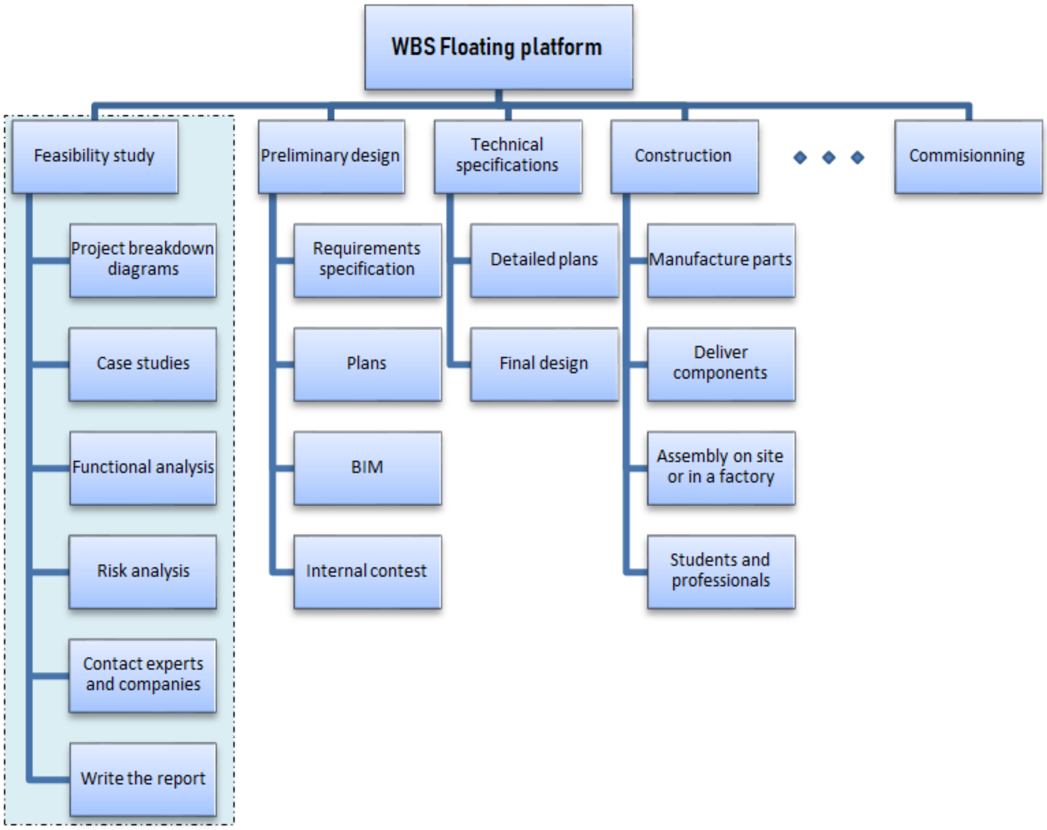


To further clarify what our task entails, we also created the product breakdown structure for our specific task within the project, which was the feasibility study:



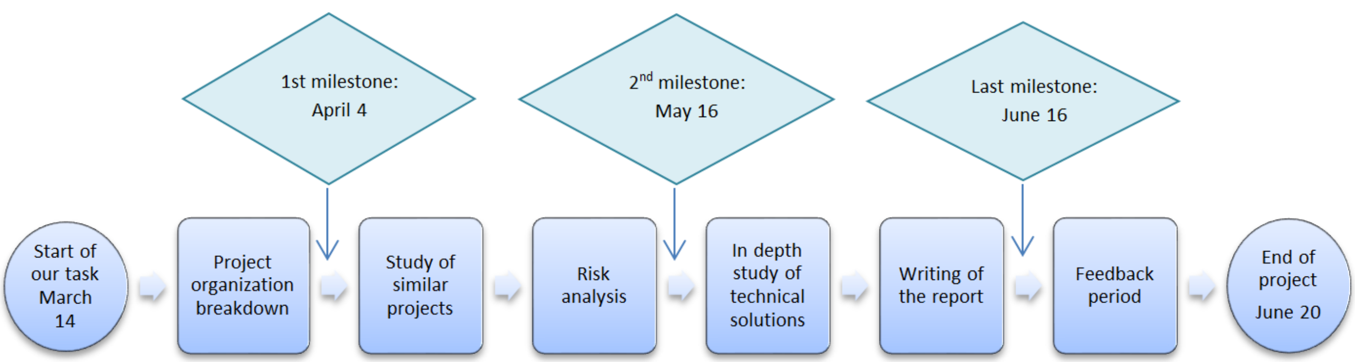
2) Work Breakdown Structure (WBS)

Next we put together the main phases of the project, starting with the feasibility study of the platform's initial conception, and ending with its commissioning. The following work breakdown structure displays the project's main phases:



3) Organization of our task

Regarding our task, which is the feasibility study, we operated according to the following chart:



III. BENCHMARKING

To begin with, we looked at similar projects to our floating mobile platform, which served as sources of inspiration for new ideas and to become familiar with existing technologies. Here are some of the projects that stood out and their most interesting characteristics.

1) The Makoko floating school

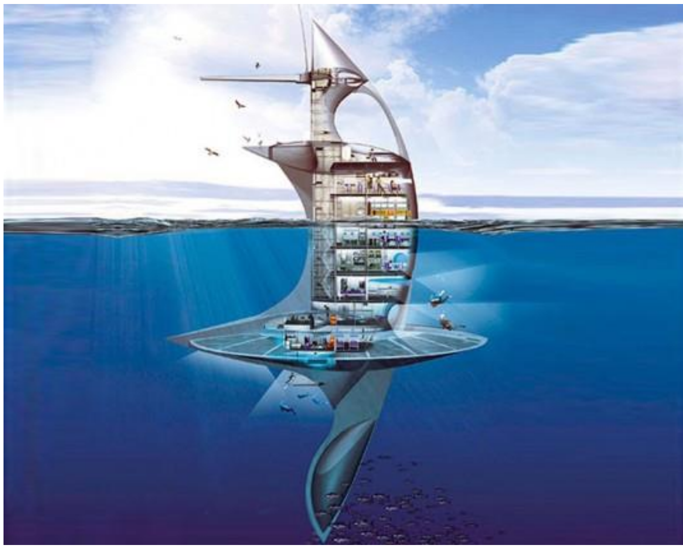
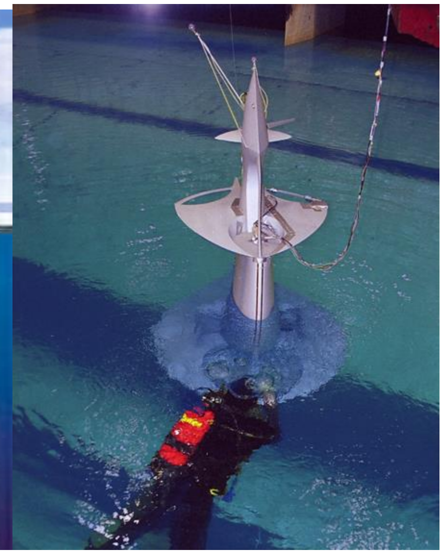
The Makoko floating school sparked the idea for the floating mobile platform. In the slums of Lagos, people build their own homes out of wood on the water, but these anchored structures face problems with the tides and powerful currents. Therefore, architect Kunlé Adeyemi looked for a solution to these problems and imagined a floating school. The school is buoyed on locally sourced wood and barrels, and was built by the local community. Several iterations of the Makoko floating school have been built since the first one.

This undertaking shows that the construction of a mobile floating platform is achievable with limited resources and workforce.

https://www.theguardian.com/cities/2015/jun/02/makoko-floating-school-lagos-waterworld-history-cities-50-buildings

2) The SeaOrbiter

The SeaOrbiter is a project by architect Jacques Rougerie to build a structure that will travel the seas, all the while enabling scientists to work in a maritime environment and see directly underwater through the windows. It will also have a diving zone to explore the waters. Furthermore, the SeaOrbiter will enable a better understanding of the oceans' functioning through educational programs and information for the public. The SeaOrbiter also has living quarters to allow people to go on extended expeditions far at sea.

The SeaOrbiter has the same objectives as our floating mobile platform, with scientific research and education at its core. At its current stage of development, a prototype to validate the shape's stability in water has been built and tested, and one of its components has been built. However the SeaOrbiter has not been completed and is still in development as of today (June 2019).

http://www.seaorbiter.com/

3) The Energy Observer

The Energy Observer is a ship that aims to optimize technologies on its onboard laboratory. One of its main goals is to be autonomous for its energy and its resources, making use of solar panels, vertical axis wind turbines, reverse osmosis cells for desalination, an electric engine, and a hydrogen fuel cell and an electrolyzer to charge the batteries.

The Energy Observer has been built and is being used today. Its technologies used to achieve autonomy heavily inspired the technologies considered for out floating platform.

http://www.energy-observer.org/en/

4) Amazon research center

The amazon research network is a project that combines anchored docking stations and mobile research units, that would move from docking station to docking station while taking advantage of the efficient river systems for mobility. The units can navigate the rivers for up to a week without refuelling, and the docking stations have large laboratories and living accommodations for scientists.

Like our own floating platform, this project will take advantage of mobile units to collect and analyze data *in situ*. However, this project has not been built yet.

https://www.designboom.com/architecture/estudio-arkiz-amazon-research-network/

5) Artificial floating islands

The SeaSteading Institute had planned to create modular artificial islands in French Polynesia. Their honeycomb-like shape would allow the modular plots to attach to one another and extend out into the sea. These artificial islands would be tethered to the ocean floor, and would comprise a multitude of applications: scientific research, school, gardens, office space, luxury units...

The honeycomb-like shape could serve as a basis for the modularity of our platform. Though these floating structures are modular, which is something we want for our mobile platform, they are not mobile. As a matter of fact, we were unable to find any mobile ***and*** modular floating structures.

The project was later abandoned when the government of French Polynesia pulled out of their unofficial deal with the SeaSteading Institute, in part due to the large investments required for its creation.

https://www.seasteading.org/the-story-of-floating-islands-in-french-polynesia/

6) AZ Island

Architect Jean-Philippe Zoppini partnered up with Alstom to envision a giant floating structure, resembling a mobile city. This structure was supposed to have gymnasiums, cycling paths, tennis courts, businesses, restaurants, and living spaces.

This project was however abandoned twice, due to its size, and the huge investments required to build it. This project serves as a reminder that in order to see ours through, it has to be designed within reasonable economic and technical limits.

http://www.cyberarchi.com/article/le-reve-fabuleux-de-l-architecte-zoppini-23-10-2002-405

7) Vincent Callebaut Architecture

Vincent Callebaut Architecture is an architecture firm that has imagined several floating structures, but that have not seen the light of day. One example of this would be the Physalia, a mobile garden to clean european waterways of pollution.

Even though many of this architecture firm's maritime projects have not been finalized, they have some interesting concepts that could inspire ideas for our floating platform.

http://vincent.callebaut.org/object/100104_physalia/physalia/projects/user

8) Floating city of modular pyramids

Wayaland is a project by designer Pierpaolo Lazzarini to create a floating city of modular pyramids. These pyramids will include living and entertainment facilities, such as hotels, shops, gyms, bars and cinemas. These pyramids are solar-powered, and small engines allows the modules to move into position. Once in place, the pyramids are anchored.

These modular and moveable pyramids resemble what we would like to achieve with the floating platform, but with less emphasis on scientific research and autonomy. This project has not been built yet.

https://www.designboom.com/architecture/floating-city-modular-eco-friendly-pyramids-pierpaolo-lazzarini-04-24-2018/

9) Ecological mobile homes

Finally, there are many examples of floating mobile homes that produce their own energy. Here are some of them:

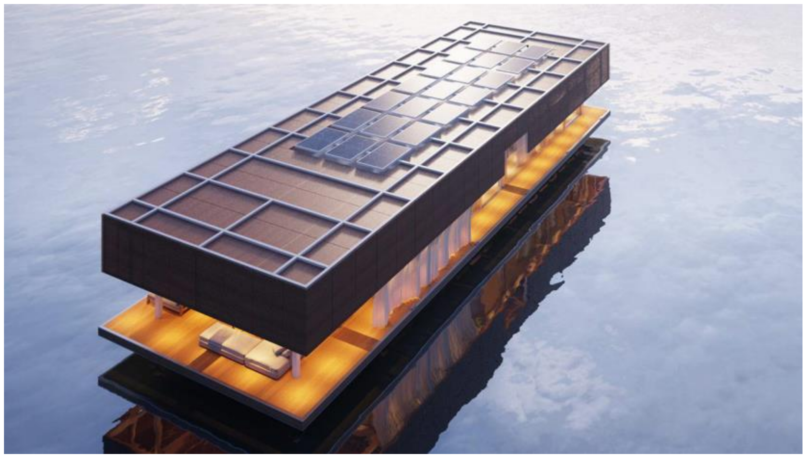
Modul GO houseboats:

https://www.designboom.com/design/modul-go-floating-customisable-living-unit-max-zhivov-03-26-2018/

Solar Wing, a solar powered home:

http://ilimelgo.com/en/projects/mobile-floating.html?lang=en

Waterlovt luxury houseboats:



https://www.designboom.com/architecture/waterlovt-houseboat-08-07-2016/

Houseboats that use renewable resources are common, and a lot of these projects have been built. This is similar to what we would like to achieve with the platform, even though we would like it to look less like a boat and more like a habitable scientific lab.

IV. CHARACTERISTICS OF THE PLATFORM

a) Objectives of the project

According to the initial vision of the floating platform, the following list encompasses its main characteristics:

- A floating, mobile and modular platform

A place for training and meetings, seminars, presentations, and expositions (with room for 20 seats and 10 people standing), an area of 35m², with tables, chairs, video, connections. This place will be used by researchers, students and professionals.

An exposition showroom, a living lab for innovation.

One or two laboratory rooms, for acquiring data, monitoring, data analysis, capable of studying water, air… Each lab has an area of 10m².

An equipment room.

- An autonomous and habitable structure

A kitchen fit to feed 20/30 people for a day (the food can be comparable to that in a plane), and for 4/5 people for several days.

Bedroom(s), toilet and bathroom, for 3/4 people for several days (2 small bedrooms).

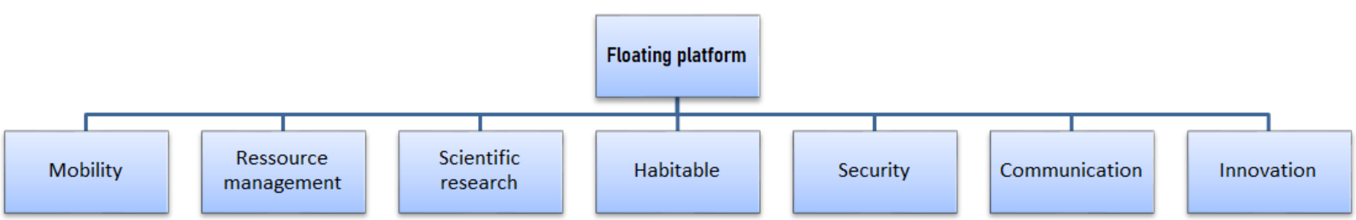
Water management (clean and used, production, storage, treatment), power management (production: solar panels, and storage: regular batteries or hydrogène, eventually make use of a smart grid to optimise power management), heat management and garbage (recyclable and non-recyclable).

- Platform equipped with communication systems (GPS, wifi, internet…) and entertainment
- Monitoring tools to make diagnoses thanks to sensors, data analysis and appropriate models
- Capable of resisting local weather conditions (corrosion, waves, wind, severe heat…)
- The platform is accessible from a fixed dock, and boats can dock on the platform
- Equipment: sensors for data acquisition (air and water quality, camera, weather station…), computers and software (database, models, data analysis), furniture adapted to a moving platform (held in place…)
- Secure platform: security cameras, proximity alarms, emergency lights and spotlights, evacuation kits (life vests, flare gun, lifeboat…)

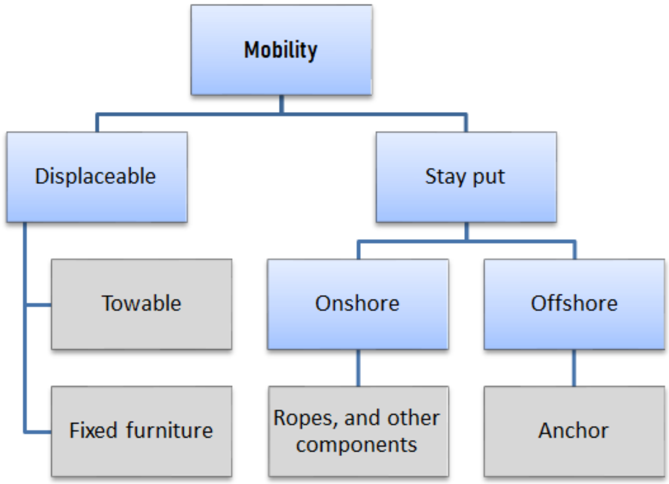
b) Functional analysis

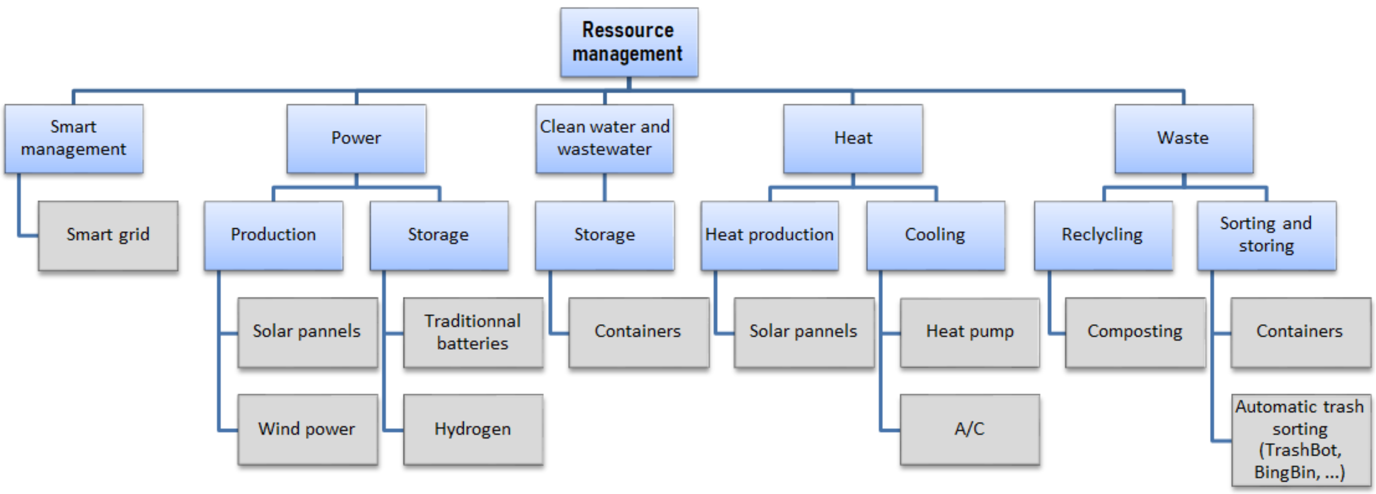
In order to further help us identify all the components the platform will need, we did a functional analysis using the previously defined characteristics. This functional analysis was performed with an emphasis on novelty and unvalidated technologies, as our objective is to identify possible blocking points in the project. As a consequence, solutions already largely employed on boats are less relevant to our case study. The following functional analysis is therefore not exhaustive, but contains the points of interest for our feasibility study.

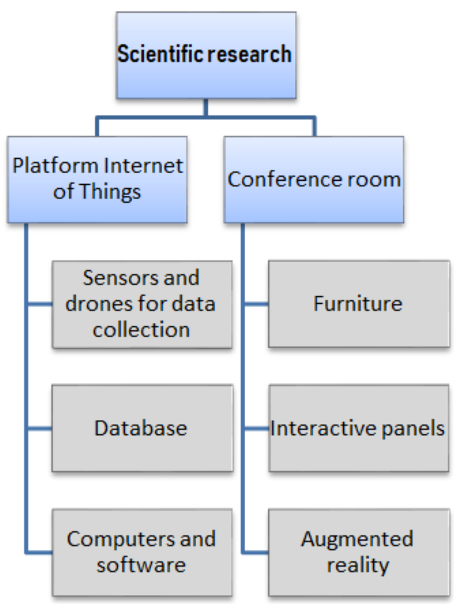
The main axes for the floating platform functional analysis are the following:



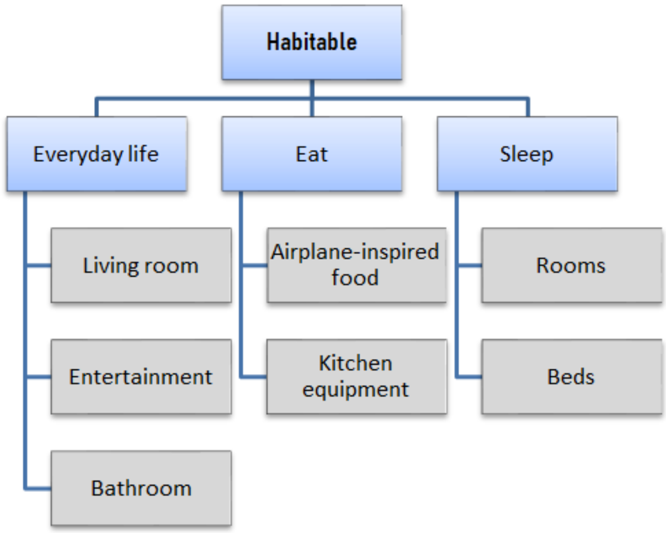
Each axis is detailed in the following diagrams, with grey boxes representing the platform's components.

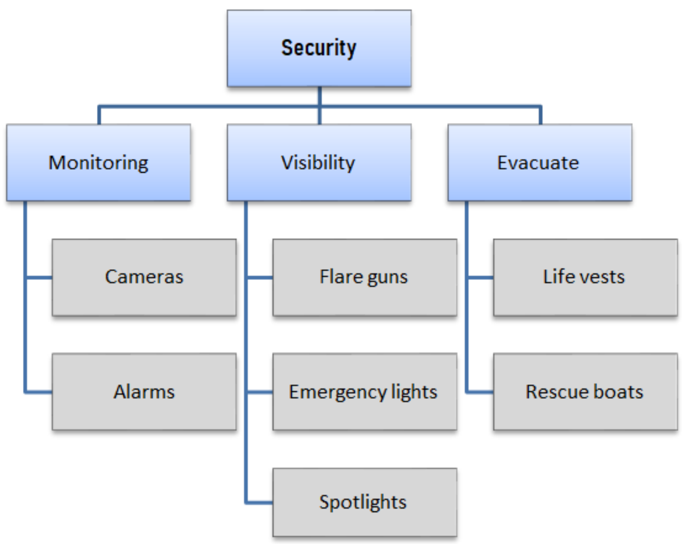

Mobility
Displaceable
Stay put
Towable
Onshore
Offshore
Fixed furniture
Ropes, and other components
Anchor

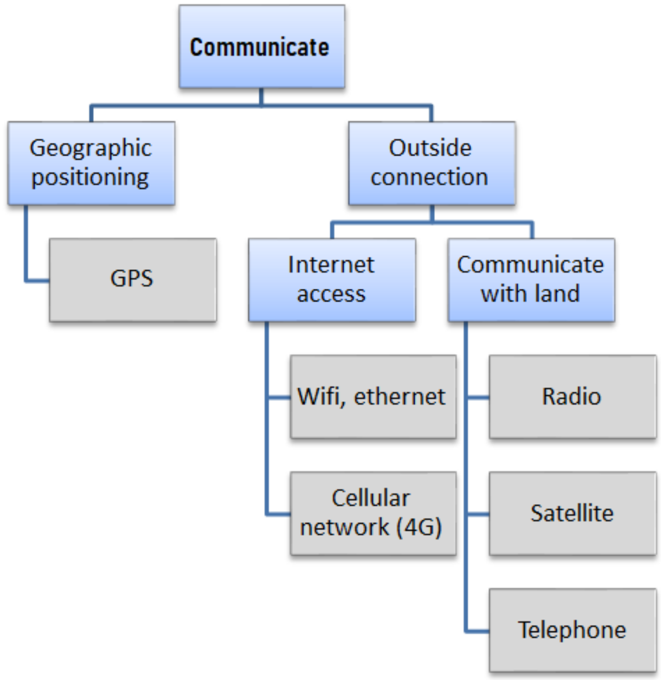

Ressource management
Smart management
Power
Clean water and wastewater
Heat
Waste
Smart grid
Production
Storage
Storage
Heat production
Cooling
Reclycling
Sorting and storing
Solar pannels
Traditionnal batteries
Containers
Solar pannels
Heat pump
Composting
Containers
Wind power
Hydrogen
A/C
Automatic trash sorting (TrashBot, BingBin, ...)

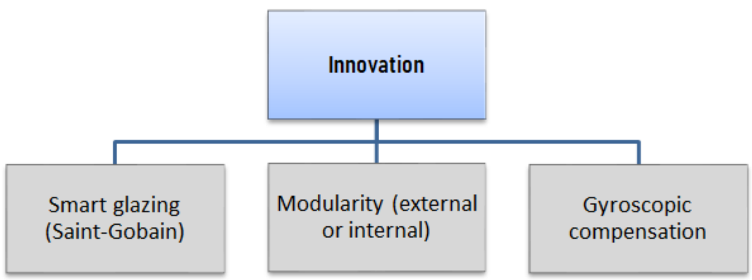

Scientific research
Platform Internet of Things
Conference room
Sensors and drones for data collection
Furniture
Database
Interactive panels
Computers and software
Augmented reality

Note: Augmented reality was included as a possibility for the conference room, as this technology (alongside virtual reality) is increasingly used to exchange and present information (for instance, CAD modelling).









V. TECHNICAL AND ECONOMICAL FEASIBILITY

a) Structure

1) Structural materials

There are five principal building materials to consider for the platform.

1) **Wood :**

The platform could be built out of wood, for instance with empty barrels allowing it to float. Using empty barrels to float rather than making a solid waterproof hull (like boats) will be easier, as it will not require as much skilled craftsmanship. The latest version of the Makoko floating school (called MFS IIIX3) is partially built with bamboo, which there is an abundance of in Brazil.

Pros	- Treated wood (with a sealant, for instance) will chemically resist the water - Resistance to waves will depend on the shape of the structure (for instance, alternating the direction of the beams to better resist the waves)
Cons	-The structure's vulnerability will depend on how it is built

A big advantage of a wooden structure is that the platform can be assembled locally by students.

2) **Steel :**

The platform could also be built out of a solid structure of steel.

Pros	- High strength, durability, resistance to abrasion, and relatively low cost -Produces very little constructional waste, and is completely recyclable
Cons	-In the wake of new composite materials, it is heavier and more expensive than its counterparts

3) **Aluminium:**

Pros	-Has good chemical and corrosion resistance, imperviousness to magnetism, has a tendency for plastic deformation, is lightweight (especially when compared to steel) -Aluminum boats are more stable and seaworthy and are easier to move around due to reduced weight -Entirely recyclable
Cons	-Aluminum is expensive -It is a soft metal and hence is more susceptible to abrasion

To create a boat out of aluminum, aluminum sheets are cut out to the desired shapes. Caulking is used to insure watertightness, and foam is placed on the inside of the hull in case it is pierced.

The manufacturing process of the aluminum sheets cannot be done outside of a factory, however they could be assembled on site by students.

4) **Polyethylene:**

Polyethylene is often used in the maritime industry, because of how versatile it is.

Pros	-High strength-to-density ratio, advanced chemical and impact resistance, low maintenance, and good buoyancy -Recyclable -Fuel consumption is reduced due to the lighter weight and lack of hull paint
Cons	-Not as structurally stiff as aluminum or fiberglass -Becomes brittle over time -Warps at high temperatures -Bonding agents like epoxy resins, adhesives, and vinyl cement do not adhere to polyethylene boats -Need a mold for manufacturing, adapted to the scale of the platform

Polyethylene boats are molded, and therefore can only be created inside a factory. The major problem with this production process is the size of the platform, which will require a mold to be built to scale, and only for a single use.

5) **Fiber-reinforced plastic (FRP):**

Fibre-reinforced plastic is one of the best options available, as most boats built today are made of fibre-reinforced plastic (which is a composite).

Pros	-The structure is light, speedy, strong, watertight, durable, and corrosion-free - FRP composites are completely recyclable and have no adverse effects on the marine ecosystem
Cons	-Though the material required for manufacturing these boats is moderately cheap, the process itself requires skilled labour and a knowledge of boat making principles -Need a mold for manufacturing, adapted to the scale of the platform

FRP boats are made with a mold (like polyethylene), which is covered in fiberglass and a binding agent. This production process therefore takes place inside a factory by skilled labor (to make sure every part of the mold is covered in the material, …)

2) Summary of possible structural materials:

A structure made of wood will be adapted to the assembly by students, and will also be adapted to maritime conditions, granted that it is properly treated and that the shape of the structure is conceived accordingly.

A structure made of aluminium can be assembled locally by students, but the individual parts and sheets will have to be preemptively cut out in a factory. The worksite might also be more complex than the worksite for a wooden structure: bigger heavier parts might have to be moved around, need for caulking, riveting…

A structure of fibre-reinforced plastic will have the best mechanical properties, but the manufacturing process is done entirely inside a factory, and will be all the more complicated the bigger the platform is, with the need for creating a large single use mold.

3) Glazing, interior design and modularity

With regard to glazing, Saint-Gobain's smart glass **SageGlass** can become more or less translucent throughout the day to reach optimal luminosity within a room.

https://www.saint-gobain.com/fr/sageglassr

Moreover, Saint-Gobain's subsidiary **VetroTech** creates glazing specifically adapted to ships.

https://www.vetrotech.com/fr-fr/marine

Furthermore, **Saint Gobain Marine Applications** is a subsidiary of Saint-Gobain, one of the project's partners, which focuses on creating products with marine applications: glazing, insulation, floor coating, piping, coating solutions and more.

It was originally intended for the floating platform to be modular, with modules that could be added or removed depending on what the platform was being used for: a laboratory for scientific research, bedrooms for extended excursions… We internally discussed ways to achieve this modularity, but kept bumping into problems. For instance, water pipes and electric cables have to connect the different modules, without hanging loose when there is no module attached. The modularity will also lead to weak spots in the structure where the modules are connected, which could be especially problematic on a mobile platform that will be subject to the water's drag in various directions.

As a potential alternative, we suggest contemplating the idea of an internal modularity for the platform, inspired by transforming apartments. By making use of movable partitions inside the platform, concealing beds, wardrobes, and more, the space could optimized, and relieve the platform of its need for numerous modules.

b) Digital technology

1) Internet

There are four possibilities for having internet access on a boat.

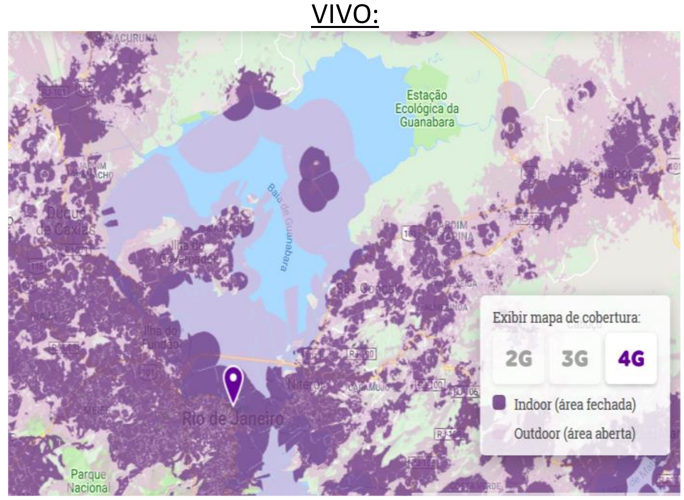
1. Wifi: by using a long range wifi booster, it is possible to connect to the marina's wifi, or other sources of internet on land (a restaurant along the coast for instance)

2. Cellular network: using a SIM card, it is possible to connect to a cellular network (4G…), granted that an internet provider covers the area.

We have found two examples of providers that provide internet over Guanabara Bay. TIM is a provider that covers the entire bay, and VIVO is a provider that partially covers the bay. The following maps show the areas covered by these providers:

TIM:

VIVO:



These first two solutions work to up to about 8km (or 5 miles) from the coast. In the deepest parts of the bay, there might not be a strong connection to the marina's wifi. However a cellular network should allow for a good internet connection everywhere across the bay.

In order to leave the bay and explore further away from the harbor while maintaining a constant internet connection, the two following solutions should be considered.

3. Radio: an SSB radio can be used to exchange small quantities of information (email, weather reports…)
4. Satellite: it is the most effective solution in the deep sea, however it is also the most expensive.

We also looked at the possibility of using Zigbee for data transfer, however its limited range (100 meters maximum) and medium bitrate make it unsuitable for use in open waters.

In conclusion, one of the suggested solutions can be prioritized depending on whether an internet access is only required while within Guanabara Bay or also while deeper at sea.

2) Computers and database

There are computers built specifically for maritime environment to go onto boats (for instance, they come without fans, are resistant vibrations, shocks…) Therefore it is possible to have computers on board, used for navigation and also for scientific purposes, as well as have an onboard database.

Here are some examples of computers built for boats that can be found on the internet:

http://www.seatronic.fr/64-unites-centrales

https://www.romarrange.com/12-ordinateurs-fixes

http://www.nauticexpo.com/boat-manufacturer/ship-server-26818.html

These computers are still vulnerable to water however, and they should be kept away from splashing water.

3) Drones

It is possible to launch and land drones on boats, but this is much more complicated when the boat is moving or when the waves make the boat roll. It is therefore recommended that the drones be used only when the platform is anchored.

4) Collaborative work

Naval Group, a potential partner of this project, uses augmented reality (3D glasses, tablets, and direct projection) on their submarines.

https://www.naval-group.com/en/innovation/successes/resources/

There are other companies that offer collaborative tools. For example, **Ubikey** is a startup company from UTC that creates digital interfaces for collaboration.

http://ubikey.fr/notre-histoire/

c) Water and energy

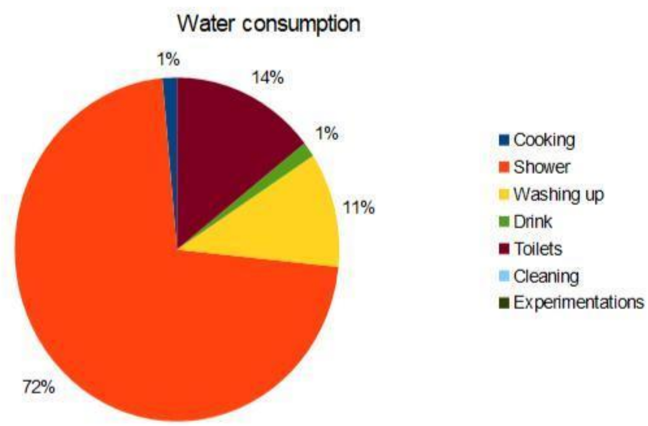
1) Desalination and storage of water

It is possible to desalinate water using a small scale reverse osmosis installation. This process kills bacteria; however manufacturers do not recommend using it in polluted or silted water. The water in Guanabara Bay is very polluted, and therefore creating water *in situ* by extracting it from the environment is an option we have ruled out. Collecting rainwater is another option, but rainfall can be inconsistent and large water tank might be required as a consequence.

Thus, it would be necessary to stock up on clean water when the platform is docked and store it in a tank.

Using the following analysis, we can estimate that the tank will have to be approximately 5m^3 for 5 people for a week, which is the objective for this platform. It should be kept in mind that this does represent 5 metric tons added to the platform.

Water consumption for one person for one week (L) :	
Cooking	2
Showering	100
Washing up	15
Drinking	2
Toilets	20



We considered that cleaning will be done when the platform is docked at a port (no water consumption for cleaning), and we did not take into consideration the water requirements for scientific experiments, which could vary greatly depending on what type of experiments are carried out on the platform.

As can be seen on the pie chart, the biggest source of water consumption is the showers (72%), which is why it is important to try and reduce the showers' water consumption.

Here are some ideas for solutions to reduce shower water consumption:

-Hydrao, pedagogical and connected shower head: the shower head's color changes depending on the water consumed to encourage users to reduce their shower time.

-Hansgrohe: it is an air powered shower head. The air added to the water creates an impression of high flow while actually reducing it.

-Ecovéa by Jedo: it is an intelligent shower column that sorts the water. Clean water is reused and soapy water is discarded.

Of course, setting a rule to take shorter, and perhaps less frequent, showers will help a lot in reducing water consumption.

2) Wastewater treatment

According to the annex IV of MARPOL (an international convention which Brazil has signed), wastewater can only be released into the sea more than four nautical miles from the coast if the wastewater has been treated beforehand. If the wastewater has not been treated, it can only be released over twelve nautical miles away from the coast. In any case, the water from the platform cannot be released into Guanabara Bay.

As a consequence, it would be necessary to store wastewater on the platform, and get rid of it at a pumpout station, just like boats do.

3) Power production

Several solutions are possible for producing power, two of which we will study in depth:

-solar panels

-wind turbines

We have initially ruled out tidal energy for this project, since most existing technology surrounding this subject is anchored and heavy. More research into this subject could shed light on the exploitation of tidal energy for a mobile platform in a bay. On top of this, the maximum depth of the bay is only 17 meters, which eliminates the possibility of exploiting the temperature gradient of the water to produce energy.

Groupe Muller, a partner of UTC, makes products for the entirety of the power system: power generation (heat pumps, solar panels…), storage (fuel cells), heating (boilers), cooling (A/C), and management (connected products).

Saint Gobain, one of the project's partners, also make products for the energy aspect of the platform: solar cells, wind turbines, hydrogen fuel cells…

https://www.films.saint-gobain.com/industries/energy

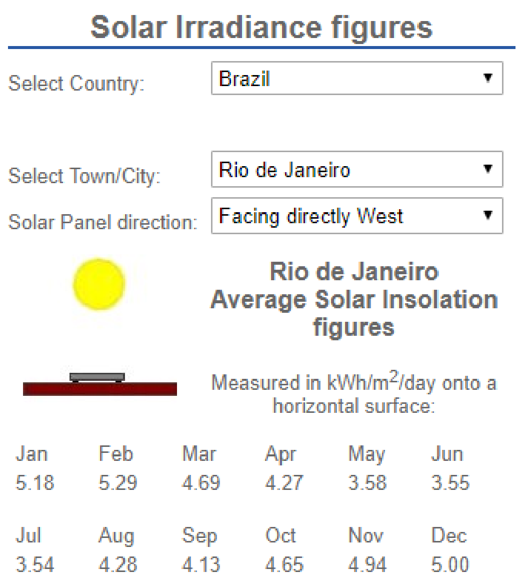
In the following section, we make an estimate of the order of magnitude of the power production possible on the platform, which will then be compared to the estimated power consumption. For a precise estimate, the situation would have to be modelled using specific software.

Specifically, the power production of solar panels depends on many factors, including orientation (which will vary because the platform is mobile), the presence of clouds, the time of day… Moreover, it is very difficult to calculate how much energy a wind turbine will produce, even by making modelling the situation. As a consequence, the following study will give an idea of the order of magnitude of the possible power production, but a more in depth study will be required for more accurate results.

Solar Energy

To estimate the power production of solar panels, we used data from the "Solar Electricity Handbook", which has gathered information over 22 years to have monthly average insolation figures.

http://www.solarelectricityhandbook.com/solar-irradiance.html



The following table contains the data for the solar irradiance in Rio de Janeiro over a year:

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5,18	5,29	4,69	4,27	3,58	3,55	3,54	4,28	4,13	4,65	4,94	5,00

The data for Rio de Janeiro shows an average of **4,43 kWh/m^2/day** of solar irradiance over a year, which we will use for our prediction of power production by solar panels.

The solar panel we chose for our estimation is the PW2450F by PhotoWatt. In standard test conditions (**1000W/m^2**), it can produce **280W**, which seems like a representative value for the solar panels we looked at.

PW2450F

Photowatt

MECHANICAL CHARACTERISTICS

Cell type	Multicrystalline
Module size	1685 x 993 x 40 mm
Cell size	156 x 156 mm (± 1%)
Cells number	60 (6x10)
Module weight	20 kg
Front cover	3.2 mm anti-reflected tempered glass
Back cover	With Tedlar®
Frame material	Anodized aluminum alloy
J-BOX	IP 65
Solar cables	UV resistant, 4.0 mm^2, 1100mm
Connector type	MC4 or MC4 compatible

TECHNICAL CHARACTERISTICS (STC*)

Typical power	W	280	275	270	265	260
Power tolerance	W	0/+5	0/+5	0/+5	0/+5	0/+5
Voltage at typical power	V	31.3	31.1	30.9	30.7	30.5
Current at typical power	A	9.00	8.90	8.75	8.68	8.61
Open circuit voltage	V	38.5	38.4	38.2	38.1	37.9
Short circuit current	A	9.50	9.40	9.29	9.21	9.16
Module conversion efficiency	%	16.9	16.6	16.3	16.0	15.7

*Under Standard Test Conditions : STC
(1000 W/m^2 ; spectrum AM 1,5 ; cell temperature 25°C)

The average irradiance in a day in Rio de Janeiro is 4,425 kWh/m^2, which is 15 930kJ/m^2. This represents **510W/m^2.** In these conditions, one solar panel can produce 142,8W**,** which means that over the course of a day, one solar panel can produce **3427,2Wh.**

Wind power

It is difficult to estimate wind energy production, because we have to consider not only the wind velocity but also its direction and the gusts. So to have at least an estimation of the potential wind power production, we made an approximation by considering only the wind velocity. We used the data provided by **WindFinder**, which is specialised in observations and forecasts of wind, wave, tide and wind related weather conditions.

https://www.windfinder.com/windstatistics/guanabara_boia_niteroi

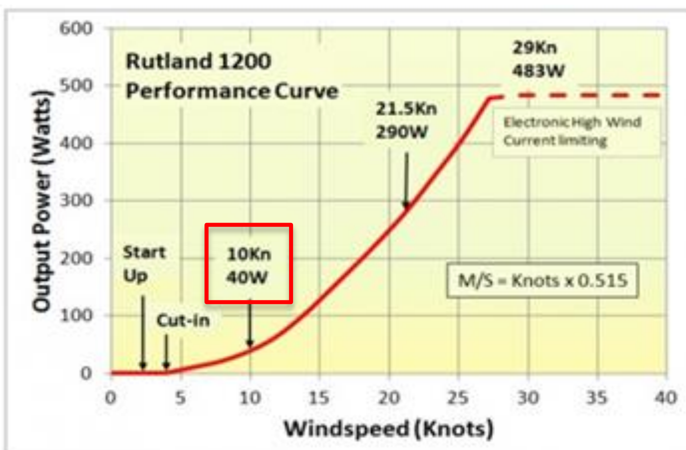
The following table shows the wind velocity throughout the year in Rio de Janeiro:

Month of year	Jan 01	Feb 02	Mar 03	Apr 04	May 05	Jun 06	Jul 07	Aug 08	Sep 09	Oct 10	Nov 11	Dec 12	Year 1-12
Average Wind speed (kts)	9	11	11	9	12	8	8	9	10	12	13	8	10

So, using a similar process to solar energy production, we used the average of the wind velocity over a year, which is **10 knots**.

Here is an example of a wind turbine that could be used on the platform, the Rutland 1200:

It is a wind turbine that is adapted to marine applications and is used on boats. Its curve of efficiency is used to calculate how much power it can output thanks to the air velocity:



So, by using a "Rutland 1200" wind turbine, it could be possible to produce around 40W, which represents **960 Wh** per day. We can see that at 10 knots, the wind turbine is not very efficient. Its efficiency increases with the wind's velocity. In reality, the wind will come in bursts, so the true yield of the wind turbine will be higher than what we have calculated using the wind's average velocity.

4) Energy consumption

In the following section, we make an estimate of the daily power consumption of the platform. For the energy consumption calculation, some hypotheses were made:

- Heating (for food and water) will be done by gas burning appliances since electric heating elements (ovens, burners, etc.) consume a very high amount of energy, which would make it much harder to make sure that more energy is produced than is consumed;
- The energy consumption on the platform is similar and comparable to that on a boat (reference data for consumption on boats were used and adapted, links are below).
- Most of the water will be stored, not produced, on the platform (therefore no energy for water production was taken into account).
- For a later version of the platform (in which it would have engines for its own displacement), the engines of the platform would run on fuel, not on the electrical energy produced onboard. The power consumption needed to start the engine was therefore considered in the calculations (although it represents a very small amount of energy : 0.02%).

In order to calculate this initial energy consumption, the following references were used :

http://www.save-marine.com/fr/electricite-a-bord-voilier

http://www.energy-online.fr/news/bien-ga-rer-son-a-lectricita-a-bord-de-son-bateau-ou-sa-pa-niche--127.html

http://seme.cer.free.fr/plaisance/gestion-electricite-a-bord.php

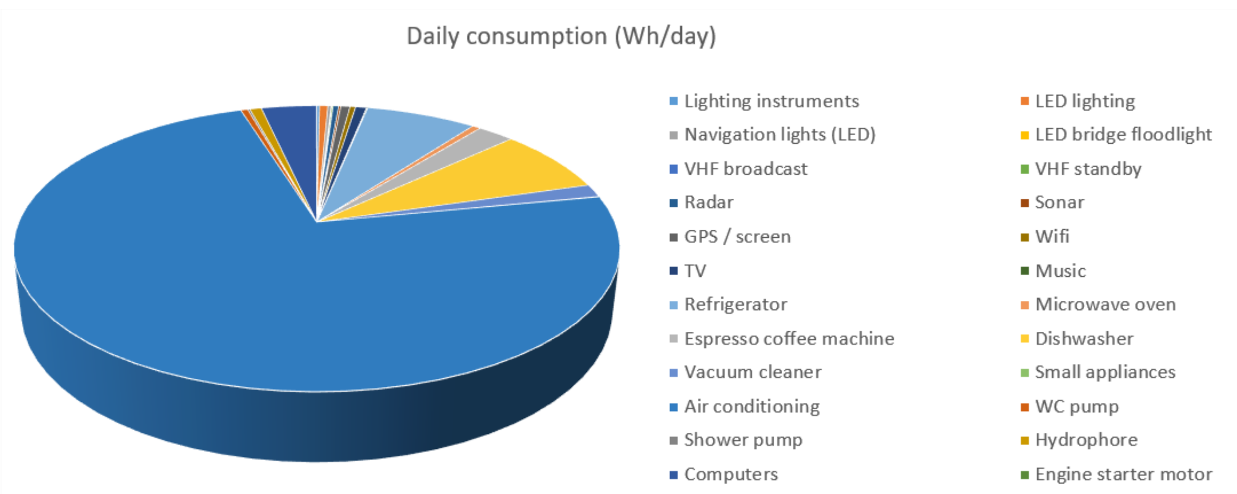
http://blog.seatronic.fr/fiches-pratiques/energie/electricite/bilan-denergie/

For a more precise estimation, the appliances makers should be contacted in order to have a more accurate idea of the platform consumption.

-Energy consumption per appliance:

Category	Appliance	Power (per unit)	Number of appliances powered at the same time	Number of hours of usage per day	Daily consumption	Percentage
Unit	-	(W)	un.	(h / day)	(Wh / day)	
Lighting	Lighting instruments	10	1	6	60	0.18%
Lighting	LED lighting	3	10	6	180	0.53%
Lighting	Navigation lights (LED)	3	4	6	72	0.21%
Lighting	LED bridge floodlight	11	1	0.25	2.75	0.01%
Communication	VHF broadcast	48	1	0.25	12	0.04%
Communication	VHF standby	1.2	1	24	28.8	0.08%
Communication	Radar	24	1	5	120	0.35%
Communication	Sonar	12	1	4	48	0.14%
Communication	GPS / screen	40	1	5	200	0.59%
Communication	Wifi	10	1	12	120	0.35%
Leisure	TV	60	1	4	240	0.70%
Leisure	Music	12	1	2	24	0.07%
Kitchen	**Refrigerator**	**100**	**1**	**24**	**2400**	**7.02%**
Kitchen	Microwave oven	1800	1	0.1	180	0.53%
Kitchen	Espresso coffee machine	1600	1	0.5	800	2.34%
Kitchen	**Dishwasher**	**2500**	**1**	**1**	**2500**	**7.32%**
Cleaning	Vacuum cleaner	2000	1	0.25	500	1.46%
Cleaning	Small appliances	120	1	0.17	20	0.06%
Infrastructure	**Air conditioning**	**2500**	**1**	**10**	**25000**	**73.17%**
Infrastructure	WC pump	150	1	1	150	0.44%
Infrastructure	Shower pump	50	1	1	50	0.15%
Laboratory	Hydrophore	250	1	1	250	0.73%
Laboratory	**Computers**	**48**	**5**	**5**	**1200**	**3.51%**
Motor	Engine starter motor	360	1	0.02	7.2	0.02%
TOTAL					34164.75	100.00%

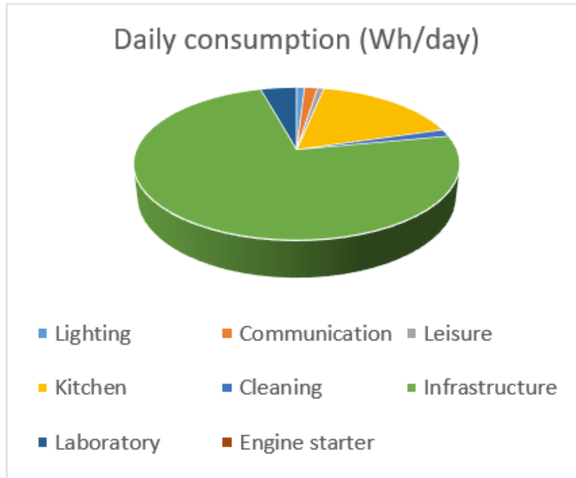
The following pie chart shows a detailed division of the energy consumption :



We organised the energy consumption into 8 categories: Lighting, Communication, Leisure, Kitchen, Cleaning, Infrastructure, Laboratory and Motor. In order to get a better understanding of the energy consumption, we created the following table and a pie chart showing the total daily consumption for each category:

-Energy consumption per category:

Category	Daily consumption	Percentage
Unit	(Wh / day)	
Lighting	314.75	0.92%
Communication	528.8	1.55%
Leisure	264	0.77%
Kitchen	**5880**	**17.21%**
Cleaning	520	1.52%
Infrastructure	**25200**	**73.76%**
Laboratory	1450	4.24%
Engine starter	7.2	0.02%
TOTAL	34164.75	100.00%



We noticed that the total energy consumption, 34.16 kWh/day, is fairly high. The highest source of energy consumption, as seen on the pie charts, is the air conditioning system, followed by the dishwasher, the refrigerator and the computers.

Therefore, it could be useful to cut the energy consumption due to the air conditioning system. Considering the year-round heat in Rio de Janeiro, we are more concerned with cooling the platform than heating it. The abundance of water can be exploited with a heat pump, that could produce both heat (for the kitchen and showers, for instance) and cold (for cooling the rooms). Heat pumps have a very low power consumption, and could therefore limit the energy required to run the air conditioning. The way the heat pumps should be used could be pursued further in a more specific study. One possibility is to use an air to water heat pump, that would cool down a volume of water (which could then be used for cooling).

Other high energy consuming appliances, such as the dishwasher, could be removed from the platform. However, it would probably increase the amount of water to be stored on the platform. So a choice would have to be made in order to find a balance between the energy produced/consumed and the amount of water that the platform could carry.

5) Comparing power consumption and production

By comparing power production and consumption, we can determine whether the platform can be energetically autonomous, as well as get an idea of the battery storage needed.

The energy consumption is estimated to be around **34 kWh** per day.

We have found that a single solar panel can produce around **3,4 kWh** per day. This model of solar panel has a surface area of 1.67m². To be energetically autonomous, the platform would therefore need at least **10 solar panels**, for a surface area of **17m²**. This is a reasonable surface area for the floating platform, which was initially projected to have a main room with around 35m² of surface area. These power production estimations were done by considering the solar panel's standard test conditions efficiency, so in reality the solar panel's yield could be lower. Its production will depend on the presence of shade, of clouds, the solar panels' cleanliness and orientation, as well as the time of day and year. Therefore, this is more of a minimum value for how many solar panels to equip the platform with.

We have also found that a single wind turbine can produce **0,96kWh** per day. This means that around **36 wind turbines** would be needed to produce enough energy for the platform. In reality, the wind turbines could produce more than that because the wind will come in bursts. Their power production also depends on their orientation and the location of the platform within the bay, so these values are approximate.

In conclusion, a combination of both solar panels and wind turbines should therefore be able to provide the energy required on the platform. The combination of both solar panels and wind turbines will have a smoothing effect on the production of electricity (for instance, solar panels are less efficient in winter and at night).

The next step would be to size the battery so that enough energy is available during periods of minimal energy production (for instance, at night in winter). It should be sized in regards to both the energy production over a period of time (in kWh) and power consumption spike (in kW). A more in depth study of the energy consumption and production on the platform will be more effective in narrowing down a realistic scenario.

6) Energy Management

Regarding energy management, a smart grid is probably too complex to be used for the platform. If a smart grid is wanted, companies such as **Vinci Energie** and **Engie Ineo** create smart grids, though they are mostly applied to factories, buildings and street blocks.

Nevertheless, it is possible to control the power distribution for the platform's components (lights, ventilation, security system…). For instance, **Empirbus** creates interfaces to regulate the electricity distribution on boats, and is therefore adapted to the challenges of a maritime environment. This power management system is also programmable, so power management can be automated, much like a smart grid.

This system could therefore optimize power distribution on the platform, as well as be the object of a student research project on how to configure the system and manage the power onboard.

https://www.empirbus.com/

VI. RISK ANALYSIS

We performed a risk analysis on the project to identify risk sources, as well as recommended precautions. The detailed process through which we evaluated different risks' criticality can be found in Annexe 2 - Risk analysis. The following paragraphs summarize our risk study's conclusion.

We identified a number of the project's critical points and their associated risks, which require the project's participants' attention.

In particular, if some of the technological solutions that are wanted by the project owners do not fit the budget, the platform will not fulfil its requirements. To avoid having to redesign the platform and delay the project, we recommend adapted components be chosen early on, during the project's conception, and to consider several technological solutions at the same time.

The project is specific and requires some expert knowledge in some fields. Therefore, it is important to make sure that there are companies with this expertise available, and for specialists to regularly check up on the work done by participating students and companies.

The platform's modularity is a wanted functionality for which there is no precedent on any other floating platform. Therefore it might be difficult or impossible to achieve, and either a solution for the modularity should be found early on, or the project owners should settle on a compromise.

This project is highly dependent on its numerous international partners. Therefore, it is preferable to approach the most important partners as early as possible, as well as find reliable and invested partners.

The floating platform is meant to be innovative, and will use new technologies that have not yet been proven. This could reduce the platform's reliability and structural integrity, as well as cause legal problems or unpredictable cost variations if the technologies used do not work as expected. To be quick to react, it will be very helpful to have considered multiple technological solutions during the platform's conception.

Moreover, the expression of the project owners' vision could induce mistakes, so it will be important for them to detail and clarify their vision, as well as plan regular meetings to make sure the project is going along according to their plan.

Finally, the project owners of this project are numerous and international, so to prevent a separation in the middle of the project, it will be helpful to agree on the projects primary and critical objectives early on in the project.

VII. CONCLUSION

Over the course of our study, we were able to identify potential obstacles and solutions the floating platform could have, according to the project owners' initial vision. After breaking down the platform into the different functions it had to perform (functional analysis), we identified applicable technological solutions and some companies that supplied them.

Firstly, we do not foresee any major difficulties in the digital technology onboard (computers, internet…), as it is something that boats are already capable of.

Next, in regards to water management, we have ruled out the possibility of desalinating water from the bay due to its pollution levels, and tanks will be used for clean water and wastewater, that will be emptied and filled at shore. A shared effort should be made to limit water consumption via showers. As for the energy production, complete autonomy should be possible to achieve for the equipment onboard required for everyday life. The combined use of solar panels and wind power should feed enough power to the hydrogen fuel cell to keep the platform operational for long enough.

Finally, there are several possible materials that the platform could be built out of, each with pros and cons, and the three that stand out the most are wood, aluminum, and fiber-reinforced plastic.

Following our work, the next step of the project would be a study of multiple scenarios of design choices. Some examples of companies that make components needed on the platform are named in this report, and there are three architects specialized in floating structures (Gérard Ronzatti, Jacques Rougerie and Vincent Callebaut). The project owners can subsequently reach out to these actors, in the hope of a future partnership. Considering that we were unable to come up with a solution for the modularity of the platform, and suggested in its place an internal modularity inspired by transforming apartments, it could be interesting to pursue and design a complete solution for this modularity. Moreover, we did not consider tidal energy as a means of power production, but there could be ways to explore tidal energy on a mobile platform. Furthermore, the way in which the heat pumps could be used should be clarified. And finally, a more accurate estimation of energy production and consumption on the platform, using a selection of components, will allow for a more accurate design of the power system on the platform.

We hope that our findings will prove useful to steer the project towards certain directions in its early phases, to one day see it built to completion.

VIII. APPENDICES

1) Appendix 1 - Clarification Note

This clarification note regroups the information surrounding the project's context and objectives, before we started our feasibility study task.

Historical context

Partnership between UTC and UFRJ

Create a « showroom for innovation » at Guanabara Bay (Rio de Janeiro)

Create an autonomous floating platform at a realistic cost

Take advantage of the free space offered by the seas

Have a project on which international students could work for the design (BIM…) and building phases

Inspiration taken from: boat and airplane equipment and design, "ISS of the sea", floating houses and other similar platforms, smart building concept

Scope, phases, purpose

2019 : defining the project and its partners

Our task: feasibility study (technical and economic difficulties)

July-August: Gilles Morel's mission

September-October: Leonardo Melo's project

2020: technical specifications, design, BIM, small-scale model and perhaps 3D printing by international students studying in different fields

2020: preparation for international cooperation

Next: building the platform (construction and assembling by students and/or experts)

Input information

Financial opportunity: UTC, ANR international

Existing similar projects and floating structures: Makoko floating schoo, SeaOrbiter, floating housing by the Seasteding Institure, AZ Island, the Venus Project, Waterstudio, etc.

Specialized architects: Gerard Ronzatti (Seine Design), Jacques Rougerie (Sea Orbiter), Vincent Callebaut (Vincent Callebaut Architectures)

Objectives, constraints

<u>For our task :</u>

Find solutions without much performance and cost constraints

Identify the project's principal technical components

Identify obstacles during the project's various phases (technical, financial, construction, legal problems…)

<u>For the project :</u>

Build a floating platform of realistic proportions

Phases' deliverables

Project's framework

Feasibility study report (experts/skills needed, technological difficulties, means needed for the specification, conception, modelling, construction and functioning phases, potential partners, identification of the fields of knowledge needed to see the platform come to fruition, identification of the platform's innovative functionalities

Requirements specification (Autumn 2019)

BIM and plans (internal student contest) (Spring 2020)

Detailed technical project

Legal certifications, insurances, etc.

Built platform

Project's final product

A floating, mobile and modular platform

-A place for training and meetings, seminars, presentations, and expositions (with room for 20 seats and 10 people standing), an area of 35m², with tables, chairs, video, connections. This place will be used by researchers, students and professionals

-An exposition showroom, a living lab for innovation

-One or two laboratory rooms, for acquiring data, monitoring, data analysis, capable of studying water, air… Each lab has an area of 10m²

-An equipment room

An autonomous and habitable structure

-A kitchen fit to feed 20/30 people for a day (the food can be comparable to that in a plane), and for 4/5 people for several days

-Bedroom(s), toilet and bathroom, for 3/4 people for several days (2 small bedrooms)

-Water management (clean and used, production, storage, treatment), power management (production: solar panels, and storage: regular batteries or hydrogène, eventually make use of a smart grid to optimise power management), heat management and garbage (recyclable and non-recyclable)

Platform equipped with communication systems (GPS, wifi, internet…) and entertainment

Monitoring tools to make diagnoses thanks to sensors, data analysis and appropriate models

Capable of resisting local weather conditions (corrosion, waves, wind…)

The platform is accessible from a fixed dock, and boats can dock on the platform

Equipment: sensors for data acquisition (air and water quality, camera, weather station…), computers and software (database, models, data analysis), furniture adapted to a moving platform (held in place…)

Secure platform: security cameras, proximity alarms, emergency lights and spotlights, evacuation kits (life vests, flare gun, lifeboat…)

Communication systems

Ubikey, email

Input information and document organization : Google Drive

Actors, stakeholders

Project owners:

UFRJ (Universidade Federal do Rio de Janeiro) : Parque Technologico, COPPE (LabFuzzy), POLI/PEU, represented by : Leonardo Melo

UTC (University of Technology of Compiègne) : represented by : Gilles Morel (urban engineering department)

Contractors:

For the feasibility study (our task) : Alexandre Wilkinson, Brieuc Naveau, Mohamed Bchir, Vitor Honna, Lucas Ferreira

For the design and modelling: international students

For the platform's building: students, architects specialized in floating structures, manufacturors for the platform's components, manufacturers for the laboratory's equipment, etc.

Partners

Saint-Gobain

Potential partners : Sorbonne Universities, French ecology Ministry, as well as partner universities (University of Rhode Island, University of Tokyo, Nanyang Technological University, National University of Singapore), and more.

Consequences

Development of a multi-purpose floating platform

Testing water and air quality

Promote innovation, education and training

Experiment with new technologies (autonomy, etc.)

Multidisciplinary research and training

Possibility to go for an outing for several days (seminar…)

First application: environmental study of a coast

2) Appendix 2 - Risk analysis

1) Participants in this risk analysis

This risk analysis, using a “critical aspects” method, was conducted by the five students who participated in this project: Chedly Bchir, Lucas Fereira, Vitor Honna, Brieuc Naveau et Alexandre Wilkinson. These five students are mechanical engineering students, with knowledge of the floating platform project, but without any particular expertise in this field.

2) Identifying critical points

The following list contains the critical points we have found, and the associated risks are written in the indented text.

Actors

Project owners

Disagreement among the multi-facetted and international clients

Desires and expectations for the project are poorly expressed to suppliers and partners (due to the innovative nature of the platform)

Contractors

The project is specific and requires experts in some fields

Contractors fulfil their promises

Poor task distribution (people are over or underworked)

Suppliers

Cooperation between suppliers and contractors

Manufacturing mistake by a non-specialized company

Lack of local suppliers for specific needs

Partners

Project’s dependence on partners (financial dependence…)

Users of the platform

Lack of scientists or users to make use of the platform’s equipment

Control authorities

Getting the proper authorizations

Technical aspects

Initial conception and requirement definition

- The modularity aspect proves too difficult to create
- Innovative technologies not proven yet (new materials…)

Conception approval

- None of the suggested small scale models satisfy the clients (during the contest phase)

Requirement definition / creation

- International standards vary and diverge (Brazil, France…)

Economical aspects

Budget

The desired solutions do not fit in the limited budget

Operational costs

- There is no stable income source to keep the platform operating

Financing

- Absence of partners to finance the project

External factors

Climate

- Tropical weather (storms, rain…) which jeopardizes the platform
- The maritime environment is corrosive to the equipment onboard

Economic environment

- Economic crisis

Legal environment and regulations

- Uncertain legal standing of the platform (is it registered as a boat?...)
- Authorization to fly drones and study the environment

Authorization to moor the platform at the port

Laws concerning boats: necessity to have safety vests, safety barriers…

Authorization for scientists leaving on potentially dangerous enterprises

Contracts

Clients

The project is abandoned

Partners

A partner does not respect his contract

Suppliers

A supplier does not supply the purchased products

Export contracts

Economic environment

Change conversion rates artificially bump up the project’s costs

Political and legal environment

Visas for international scientific staff

3) Weighted vote

We carried out a weighted to determine the aspects considered to be the most critical by the work group (where letters A to E represent to participants’ votes).

Weighted vote	A	B	C	D	E	Weighted sum
Budget	2		3	5	3	52
Partners	1		5		4	30
Initial conception and requirement definition			4	4	2	30
Project owners	5	5				20
Contractors		2	1		5	24
Contracts	4		2			12
Financing		1		3		8
Conception approval		4				4
Requirement definition / creation		3				3
Legal environment	3					3
Suppliers				2		2
Economic environment				1		1
Climate					1	1

Therefore, the most critical aspects for the projects and their associated risks are:

-Project owners

-Expectations for the project are poorly expressed to suppliers and partners (due to the innovative nature of the platform) (1)

-Disagreement among the multi-facetted and international project owners (2)

-Contractors

-Contractors fulfil their promises

-Poor task distribution (people are over or underworked)

-The project is specific and requires experts in some fields (3)

-Partners

-Not enough financial partners (4)

-Budget

- The desired solutions do not fit in the limited budget (5)

-The platform cannot meet the project owners' wishes

- Initial conception and requirement definition

-The modularity aspect proves too difficult to create (6)

-Innovative technologies not proven yet (new materials…) (7)

In the following section, we will study the numbered risks (i).

<u>Calculating the criticality of the risks</u>

For this phase, the members of the group discussed to come to a consensus and the criticality of each risk.

The criticality C is the gravity G multiplied by the probability P of the risk.

We associated numbers to each degree of probability and gravity:

		Gravity			
		Negligible - 1	Small - 2	Critical - 3	Catastrophic - 4
Probability	Very likely -	Tolerable with mitigation	Tolerable with mitigation	Unacceptable	Unacceptable
	Likely - 4	Tolerable with mitigation	Tolerable with mitigation	Unacceptable	Unacceptable
	Possible - 3	Tolerable	Tolerable with mitigation	Tolerable with mitigation	Unacceptable
	Rare - 2	Tolerable	Tolerable with mitigation	Tolerable with mitigation	Tolerable with mitigation
	Unlikely - 1	Tolerable	Tolerable with mitigation	Tolerable with mitigation	Tolerable with mitigation

Gravity categories:

4 - Catastrophic: Important damage to equipment, the platform cannot be finished

3 - Critical: Significant damage to equipment, the platform is unusable due to structural instability, the project has to be reconsidered

2 - Small: Minor equipment damage, some of the project's elements have to be reconsidered

1 - Negligible: Minor disruption of the platform's activity

Probability categories :

5 – Very likely: Will probably happen at least once during the project

4 - Likely: Likely to happen once during the project

3 - Possible: Could happen once during the project

2 - Rare: Not very likely to happen, but still possible

1 - Unlikely: The probability is so low that we can consider that the event will not occur

The following table shows the criticality of the studied risks :

Risk	Probability	Gravity	Criticality
The desired solutions do not fit in the limited budget	4	3	12
The project is specific and requires experts in some fields	4	3	12
The modularity aspect proves too difficult to create	5	2	10
Innovative technologies not proven yet	2	4	8
Not enough partners	3	2	6
Expectations for the project are poorly expressed to suppliers and partners	1	3	3
Disagreement among the multi-facetted and international project owners	1	3	3

Please note that we did not take into consideration the probability of non-detection for the criticality, because we considered ourselves to be at too early a stage in the project to determine accurately the value of the probability of non-detection.

4) Determinating causes, consequences and actions to take

For every risk retained, we listed its causes and consequences. Next we looked at preemptive and reactive actions to take.

Risk	The desired solutions do not fit in the limited budget
Cricality	12
Cause	The chosen technological solution is not adapted. There are no cheaper alternatives available. The project owners were initially too ambitious. Limited budget.
Consequence	Project completion delayed. End of the project.
Preemptive actions	Chose adapted components early on. Have an appropriate budget. Propose several technological solutions (see functional analysis)
Reactive actions	Revise conception. Seek further funding.
Risk	The project is specific and requires experts in some fields
Cricality	12
Cause	Students to work on project are not specialized / still learning. Companies lack expertise in the project's innovative aspects.
Consequence	Project is delayed or canceled. Project costs increase. Experts are adde to the conception and development phase.
Preemptive actions	Check all of the actors' fields of expertise: Organizational Breakdown Structure (OBS), table of competences...Get approval of decisions by specialists or experts.
Reactive actions	Increase the amount of specalized staff. Look for consultants and subcontractors, or turn towards knowledgeable partners. Rethink the design.
Risk	The modularity aspect proves too difficult to create
Cricality	10
Cause	The project owners' objectives are too complicated to make true. There is no techology or expert company available.
Consequence	The platform is not modular, which does not meet the project owners' vision. Ineffecient modular system, that jeoperdizes the platform. Project is delayed.
Preemptive actions	Think of a solution for modularity early on. Chose not to make the platform modular and let the project owners' know. Offer alternative solutions (partial modularity, with an easily changeable layout...)
Reactive actions	Commit more resources to looking for a solutions for the platform's modularity.
Risk	Innovative technologies not proven yet
Cricality	8
Cause	There are no existing solutions for certain required funcitonnalities. Technologies exist but they are new and untested, or uncommercialized.
Consequence	Platform is unreliable and unstable. Legal problems. Costs fluctuations.
Preemptive actions	Make extensive research into all possible solutions and alternatives for the same functionnality, to increase reactivity in case of problem.
Reactive actions	Rethink design.
Risk	Not enough partners
Cricality	6
Cause	The project owners do not have much funding, and do not have large financial and human resources. Need for multiple actors who each bring something important to the project.
Consequence	Budget and technological solutions are limited by which entites are a part of the project. Project is cancelled or delayed if partners leave.
Preemptive actions	Gather enough partners. Have reliable and invested partners (historical partners, linked by an organization (Sorbonne Université)...)
Reactive actions	Look for more partners. Seek extra funding to purchases what is required. Convince partners to participate in the project until the end.
Risk	Expectations for the project are poorly expressed to suppliers and partners
Cricality	3
Cause	Poor communication from the project owners. Contractors do not insist enough to better grasp the project's dimensions. Lack of details.
Consequence	Project is delayed. The constructed platform does not meet the project owners' requirement.
Preemptive actions	Focus on making detailed requirement specifications. Regular meetings between the project owners and the contractors to make sure the project is moving along in the right direction.
Reactive actions	Project owners can reclarifiy their requirements to the contractors. Rethink the design. More resources are invested into modifying the project en route.
Risk	Disagreement among the multi-facetted and international project owners
Cricality	3
Cause	Each partner has different goals for the project. Need to find a compromise on the projects funding. Cultural, political and economic aspects.
Consequence	Project is delayed or canceled. The project owners part ways.
Preemptive actions	Good communication and agreement amongst the project owner's on the project's priorities (its most important / critical / interesting aspects).
Reactive actions	Clarification meetings.

To conclude, we would like to point out that this risk analysis was conducted early in the project's life cycle by the students working in the project's technical and economic feasibility. As a consequence, it would be wise to regularly revise the risks and actions identified as the project progresses.