LUNATIC RANGERS

Human Systems Integration

Context, Objectives & Stakeholders

Context

The inevitable increasing world population, leads to an increase in the demand for natural resources (water, energy, minerals, wood) and habitable spaces. These demands put pressure on ecosystems and will increase in the years to come. The planet cannot sustain this continued growth: non-renewable natural resources are running out, the impacts of climate change are beginning to manifest themselves and species are threatened more than ever. What can humans do in order to improve that situation? Moon seems to be the right answer. Investigations carried out by certain space agencies, such as NASA, have made it possible to discover that the exploitable resources are not limited to the surface of the Moon. Indeed, the basement also has some resources such as iron and titanium. The Moon presents various exploitable resources such as regolith (moon dust), magnesium, calcium, silicon, etc. These raw materials would be a great use in the development of possible lunar bases. Not to mention their role in the development of long-time space missions. The Moon is highly attractive for its minerals and gas resources. For our project, we have decided to focus on the silicon extraction. Indeed, to have a little bit of data, the Moon has 21% of this material on its surface. On Earth, silicon represents 27,7% of its surface and it can be extracted from many natural resources (soil, sand, rocks, plants, etc.). Today, the world's most popular country for the production of silicon is China. The Lunatic Rangers would like to take the advantage and have the monopole in Europe to be the leader of silicon production.

Objectives

Silicon is particularly useful to produce microchips for any type of electronic devices (phone, computer, television, etc.). Today in Europe, semiconductor companies hold just over 8% of the world market, and have no major foundry capable of producing components of less than 22 nm. In association with NASA, Lunatic Rangers have a long-term and futuristic project. In the mini-projected conducted we have decided to design a revolutionary machine capable of extracting the silicons from the Moon. The objective of this project is to extract silicon on the Moon and to supply it on Earth and particularly to France in order to make it more independent vis-à-vis silicon shortages caused by wars, severe weather, pandemics and trade-wars.

" That's one small step for a man, one giant leap for mankind "

Neil Armstrong

Who are the stakeholders?

Stakeholders generally designate all of the actors and stakeholders who have an interest in a company. Stakeholders, on the other hand, have very variable interests which fundamentally diverge from one another depending on their position vis-à-vis the company. For our mini-project, we have distinguished some key stakeholders. Let's have a look below at our stakeholder analysis:

Stakeholders	Impact	Influence
Microchips producers	Medium	High
Lunatic Rangers	High	High
Solar cells producers	High	Low
Automotive industry	High	Low
NASA	High	High
Legislations	High	Low

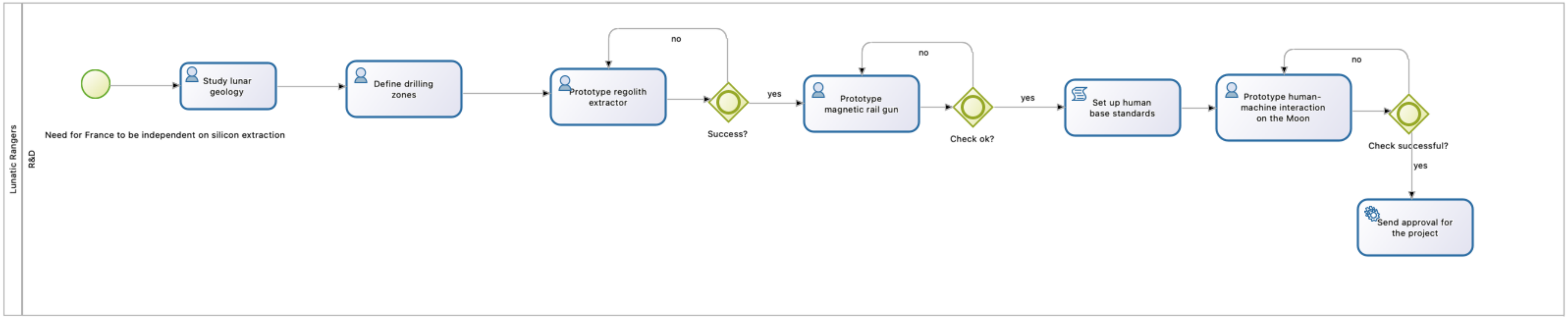
The above stakeholder analysis shows the impact and influence that all our stakeholders may have. As we can predict the most important stakeholder is NASA as indeed, we are partnered with them. Followed by Lunatics Rangers itself, as a matter of fact the project can have a huge impact on the future of the company. We also need to think about the possible legislation because we are a french company and our partner company NASA is american so we need to find a middle ground in order to respect both laws. Moreover, we also count three other parties as stakeholders, microchip producers, solar cells producers and the automotive industry, they overall have a high impact as the influence of the project.

Concept of operations

As said, our goal is to mine silicon from the lunar surface. To do so, we should first study the lunar geology to identify the best zones to set-up our mining infrastructure. Then, thanks to our partnership with NASA, we are going to prototype and build a regolith extractor that will melt lunar regolith at high temperatures (above 1600°C) and extract silicon from it. Achieving a very high silicon purity is more difficult in the lunar environment than on Earth so an important R&D and prototyping phase with a regolith simulant must be conducted. We plan to have a four-person human base on the Moon in order to monitor the drilling infrastructure and to be in charge of the maintenance of the machines. Safety standards and training will be a priority before launching the mission. It will be necessary to satisfy basic needs of the crew in terms of food, water and oxygen. In the first period, we can plan to supply those needs from Earth but at a more advanced stage of the project (for instance after 2 or 3 years of operation), we can expect to produce them locally on the Moon. By doing so, we would be able to limit the travels between the Earth and the Moon solely to the crew rotation. To be more specific, by following the same principles of International Space Station (ISS) expeditions, one crew lunar mission will last 6 months before being replaced by another crew.

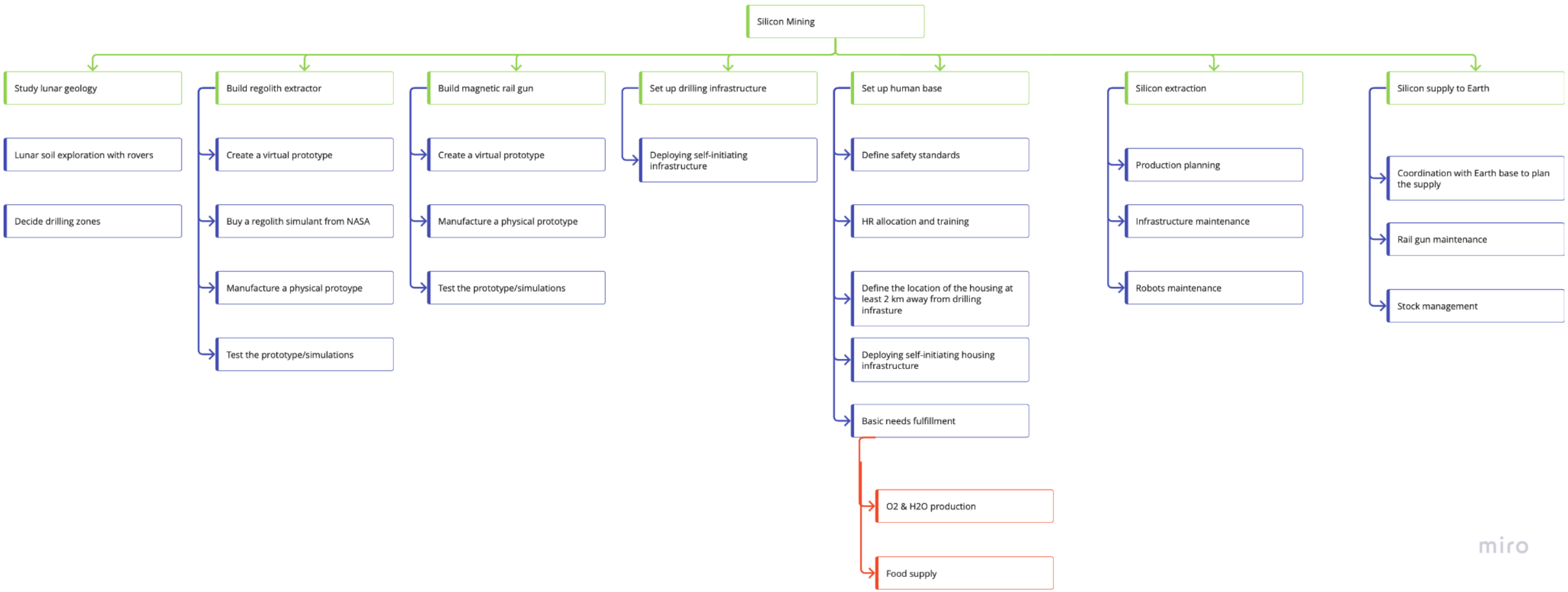
Concerning the supply of silicon to Earth, establishing a rocket roundtrip may require a high fuel consumption. Typically, only one SpaceX's Falcon 9 launch will require nearly 410 000 kg of fuel. That is why we are going to invest in the R&D for an electromagnetic rail gun for the supply of silicon. In order to escape from the gravitational influence of the Moon, it will be necessary to reach an escape velocity of 8530 km/h. This is not too much faster compared to the speed reached by the electromagnetic rail gun prototype that the US Navy is working on (7242 km/h). Since the Technology Readiness Level (TRL) of electromagnetic rail guns is still in the R&D phase, an important engineering and prototyping phase needs to be done.

BPMN for the R&D phase



The R&D phase is a crucial step in order to assess the feasibility of our project. We plan to build several prototypes, both virtual and physical, for the regolith extractor and the magnetic rail gun. Furthermore, it will be necessary to define safety standards for the human base in terms of location of the housing infrastructure (distant enough from the mining facility), basic needs fulfillment (food, water and oxygen) and the human-machine interaction. It will be necessary to perform various simulations before submitting the project for the approval. A task analysis also including the production steps can be found in the following page.

Task analysis



Cost estimation of the project

We will need to take into account three types of cost: the cost for constructing and maintaining a human lunar base, the cost for extracting the silicon on the Moon and the cost for supplying the Earth through the magnetic rail gun.

First of all, let's analyze the cost of a lunar base. According to a report published by the Center for Strategic and International Studies (CSIS), the cost of a four-people lunar base has two components: a development cost and an operating cost. The development cost includes landers, habitation and support modules, deploying launchers and a safety margin. It can be estimated at a total of $35 billion. Regarding the annual operating cost, we will consider two four-people crew rotations per year and 15 medium launches for cargo needs. With this estimation we obtain an operating annual cost of $7,35 billion.

For what concerns the silicon manufacturing cost, to simplify the calculation we are going to consider the cost of a silica sand processing plant on Earth and apply it to the lunar environment. Let's take the example of a VRX Silica Ltd plant in Australia able to process 2 million tonnes of sand per year, which has an installation cost of nearly $12 million ($AUD 18 million).

Finally, regarding the magnetic rail gun we can estimate the R&D cost by looking at the experimentations carried out by the US Navy. Since the beginning of the program that aims at developing an electromagnetic rail gun capable of liquefying targets at up to 100 nautical miles away with a solid metal slug that travels at speeds up to 4,500 mph (7242 km/h), the budget allocated to the R&D of the project is more than $500 million. Considering that our ambition is to replicate a similar technology to travel from the Moon to the Earth, we should definitely consider allocating a much higher budget for our cannon.

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