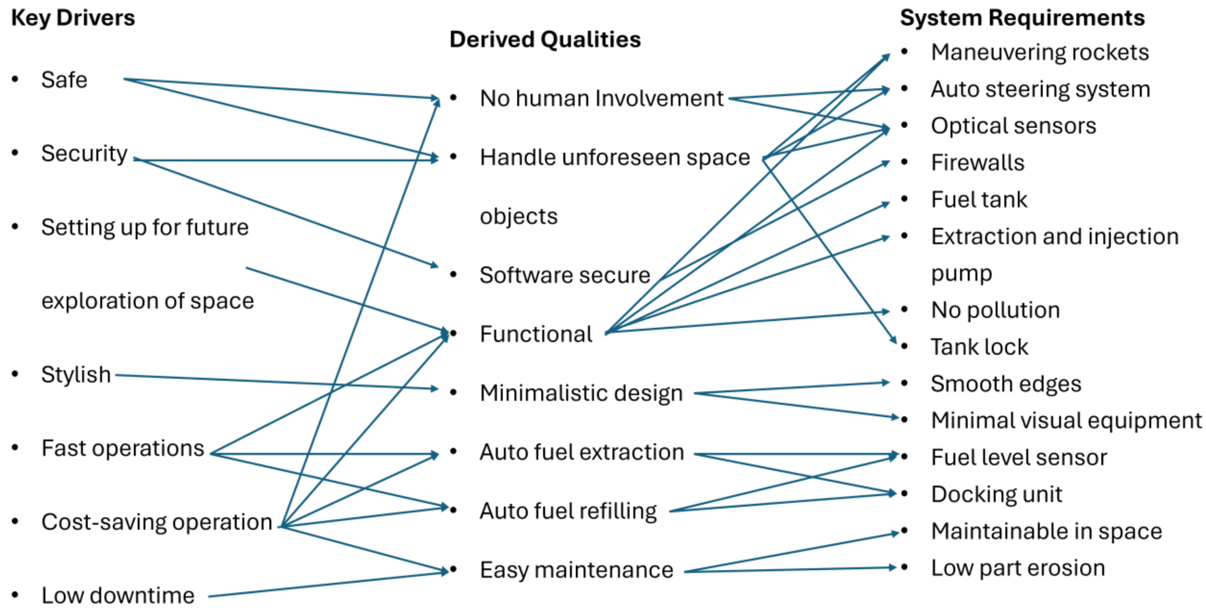
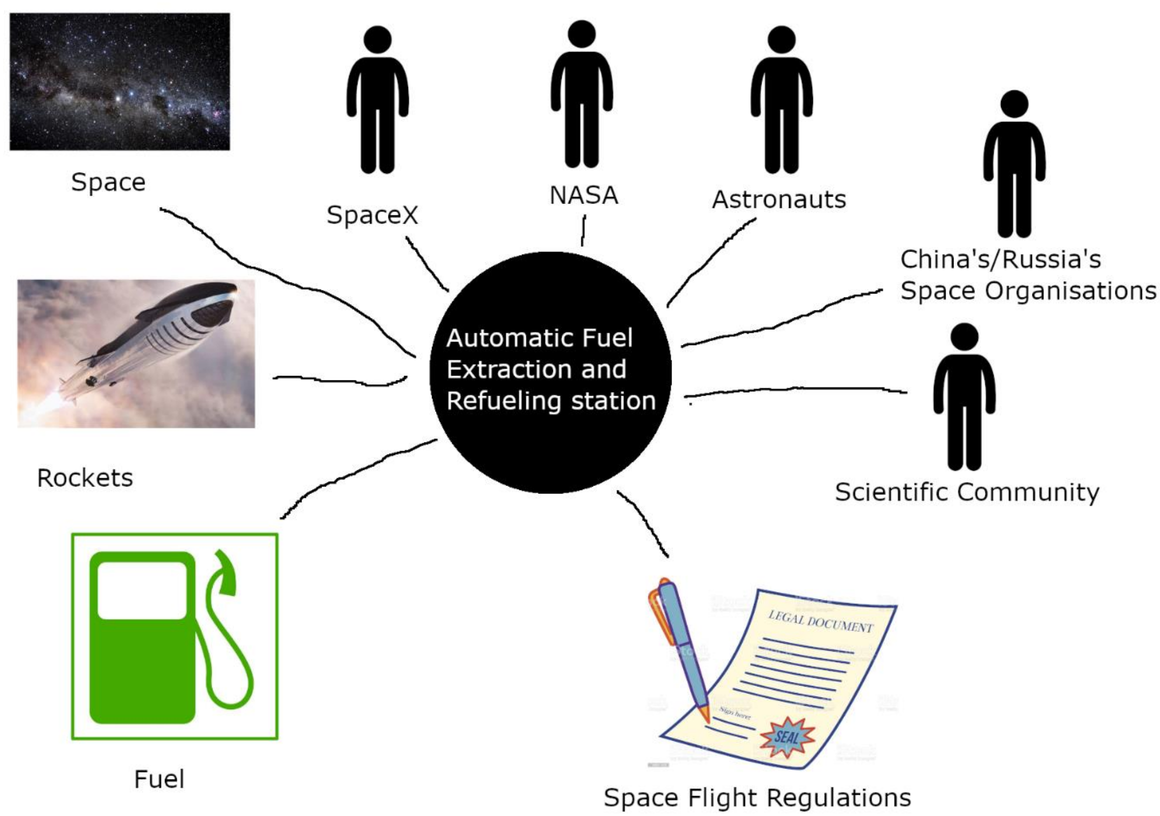
2.1 Key Drivers and Requirements





2.2 Sustainability

A sustainable autonomous system is a system which either has positive or at least neutral impact on the world around it. There are many aspects relating to the systems that needs to be considered to make sure a system doesn't negatively affect its surroundings. The most common are perhaps the environmental and climate aspects, making sure the system doesn't release a lot of dangerous chemicals or use up natural resources we can't replace. Other common aspects are those related to communities, economic and work. Especially making sure autonomous systems allows for economic growth for a whole community while also not removing the jobs of people is important. However, what is also an important part of sustainability, where autonomous systems are very good, are the health and safety aspects. Many autonomous systems biggest selling points are actually health and safety of humans doing dangerous work.

For the autonomous fuel extraction and refilling system, safety to human astronauts and educational aspects are especially important key drivers when considering the UN sustainability goals. But the economic and societal aspects are also very important, especially since the ultimate goal for the Starship rocket is to allow for multiplanetary settlement and this will allow humans a more robust chance of surviving potential disasters. Finally, the climate aspect of this system is the hardest to consider, since all our rocket technology uses unrenewable resources for propulsion. However, in the future a solution like electromagnetic propulsion might be a possibility which could be explored.

2.3 Safety and Security 1

There are multiple safety aspects to consider with an autonomous refueling station in space. First of all, space as an environment is very dangerous and hostile to everything. Radiation from the Sun is especially high and can often cause large temperature fluctuations which could be problematic for the fueling tank or possibly for metal prone to stretching. Furthermore, small objects often zoom around at high speed while hitting our machinery. This is known to destroy equipment quickly if not considered. Finally, the fact that it is so hard to get up to space makes maintenance a very expensive and possibly unavailable option which must be taken into account. Still, even when not considering space, there are multiple more threats. The highly explosive rocket fuel must be protected properly from heat and sparks. Spillage of the fuel into space is also not wished for from an environmental aspect, so a properly sealed pumping system is important.

As for security, the most likely threat will be hacking. This means a strong firewall and proper encryption of communications is important. There has also been cases of espionage and satellites being captured physically by foreign enemies. This means the system should be able to protect itself in some way from capture or attempts to steal fuel or spy on its tech. Possible solutions to these problems are to simply run away when unidentified objects approach, or to mount some sort of defense system to the station. However, as space is considered neutral, it might not be a smart solution to bring weaponry to space, as this might be seen as an act of aggression. Simply making the system visually uninteresting, and making sure its docking station is locked and its location tracked could also be enough for the foreseeable future, as going to space is not an easy endeavor in itself.

2.4 Safety and Security 2

System element or activity	Hazard/ threat	No.	Hazardous event (what, where, when)	Cause (triggering event)	Consequence	Risk			Risk - reducing measure	Responsible	Comment
						Freq	Cons	RPN			
Docking	Mechanical fail	D1	Fuel leakage	Sensor fail Software fail Manufacturing fail Wear or degeneration	Fuel spill, larger expenses	2	2	4	Pressure sensors	Part manufacturers System developers	
Propulsion motor	Mechanical	P1	Loss of propulsion	Wear/tare, aging Manufacturing fail	Risk of other damage to system Possible lowering of defences	2	4	6	Redundant motors Extra manufacturing tests	Part manufacturers System developers	
		P2	Improper propulsion	Wear/tare, aging Manufacturing fail Fuel shortage	Risk of other damage to system Possible lowering of defences Risk of harming environment	1	3	4	Multiple propulsion steps Redundant motors Emergency fuel storage	Part manufacturers System developers	
Navigation system	Software	N1	Bad route calculation	Bad algorithm Sensor fail Sabotage	Higher risk of collisions Unnecessary use of fuel Lowered defences	3	2	5	Multiple route simulation Code revision	Software developer	
		N2	Soft locked route								
Battery	System fail	B1	Loss of power								
	Wear	B2	Acid spillage								

2.5 Business Cases

Stakeholders:

- SpaceX
- NASA
- Other Space Agencies

All of these are interested in interplanetary travel and will need this system if humans are included in these types of missions. As per now, there are no competitors so no one are hurt by this system other than in competitions related to first human on other planet etc.

Business Value Canvas

<table>
<tr>
<td colspan="2" rowspan="2">Key Partners

NASA

FAA

ESA?

Part manufacturers</td>
<td colspan="2">Key activities

Manufacturing

Maintenance

System surveillance</td>
<td colspan="2" rowspan="2">Value Propositions

Fast and efficient fuelling

Saving on personnel cost

Possibility of humans traveling interplanetary</td>
<td colspan="2">Customer relations

Inhouse communication

Future customer support</td>
<td colspan="2" rowspan="2">Customer Segments

SpaceX

NASA

Future space agencies wanting to explore the solar system</td>
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<tr>
<td colspan="2">Key resources

Reputation

Developers

Manufacturers</td>
<td colspan="2">Channels

Emergency phone number</td>
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<tr>
<td colspan="5">Cost structure

Manufacturing

Maintenance</td>
<td colspan="5">Revenue streams

One-time project contributions from government

Price per ride to Mars

Future rocket fuel prices per litre</td>
</tr>
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