

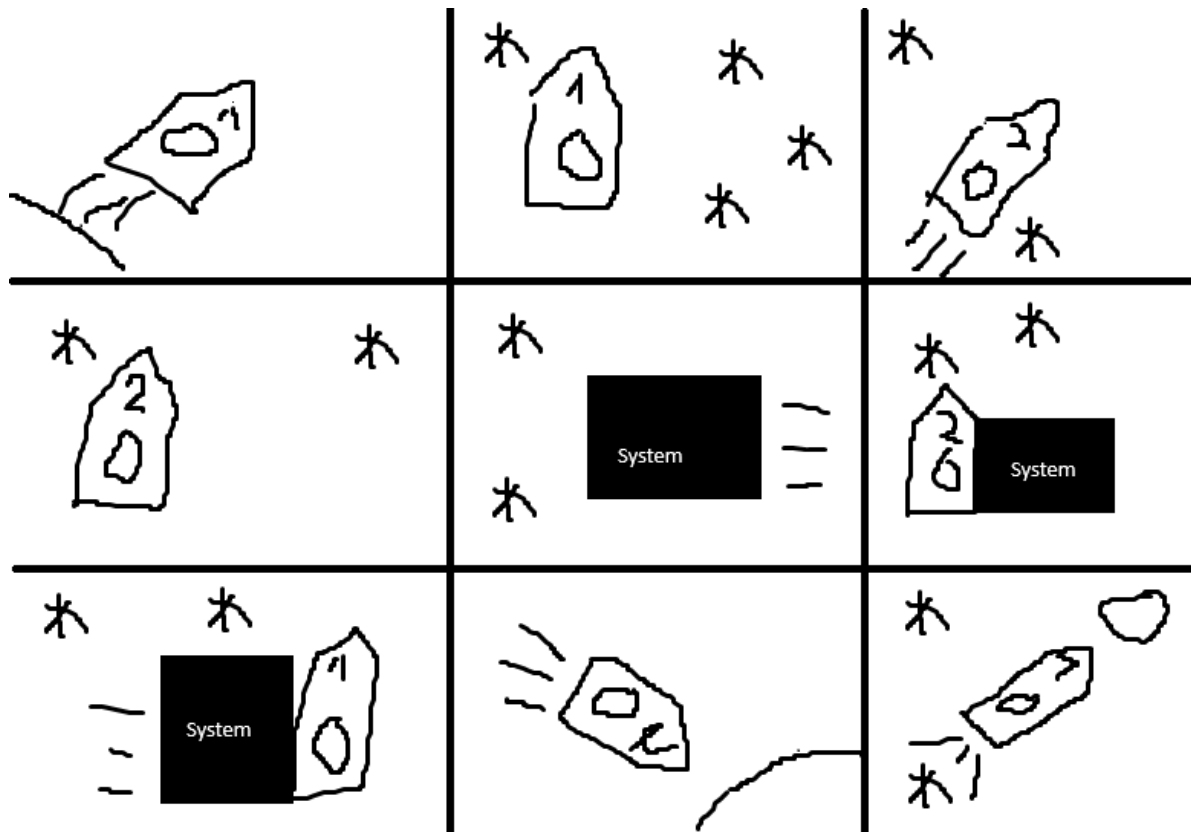
Definition of Autonomous System

To define an autonomous refueling system, for rockets traveling interplanetary, I have tried to look up three other definitions for automatic systems related to refueling and space stations. None of the "definitions" are actually any good definitions for automatic systems, as they aren't meant for it, but this was the best I could find. The first definition is for the Danish robot refueling station add-on and the definition is "Autofuel is a robotic refueling system - The automated link between car and energy". The second is for an automatic refueling station created by Swedish company Fuelmatics. "Fuelmatics 500 is the fifth generation of truly automated refueling units". The final definition is for the European Space Agency's Automated Transfer Vehicle. "The ATV was an uncrewed platform that operated with a high level of automation, such as its docking sequence". Now, none of these definitions are good for their systems, since none of them mention anything about what is automated and what is human controlled. For the most part these are all sales slogans, except the ESA ATV since it is merely a short description from a wiki. However, they do mention they are autonomous and some of their functions. Both fueling stations mention refueling, and the ATV mentions docking. For my system, automatic refueling space station, I have tried to use the nice parts of these three definitions while being clearer about its functions and challenges. Now my definition is "A human deployed refueling system, which, given identifying tags for rockets to interact with, can operate with a high level of autonomy". This definition points out the system was deployed by humans, given some info, and refuels rockets on its own.

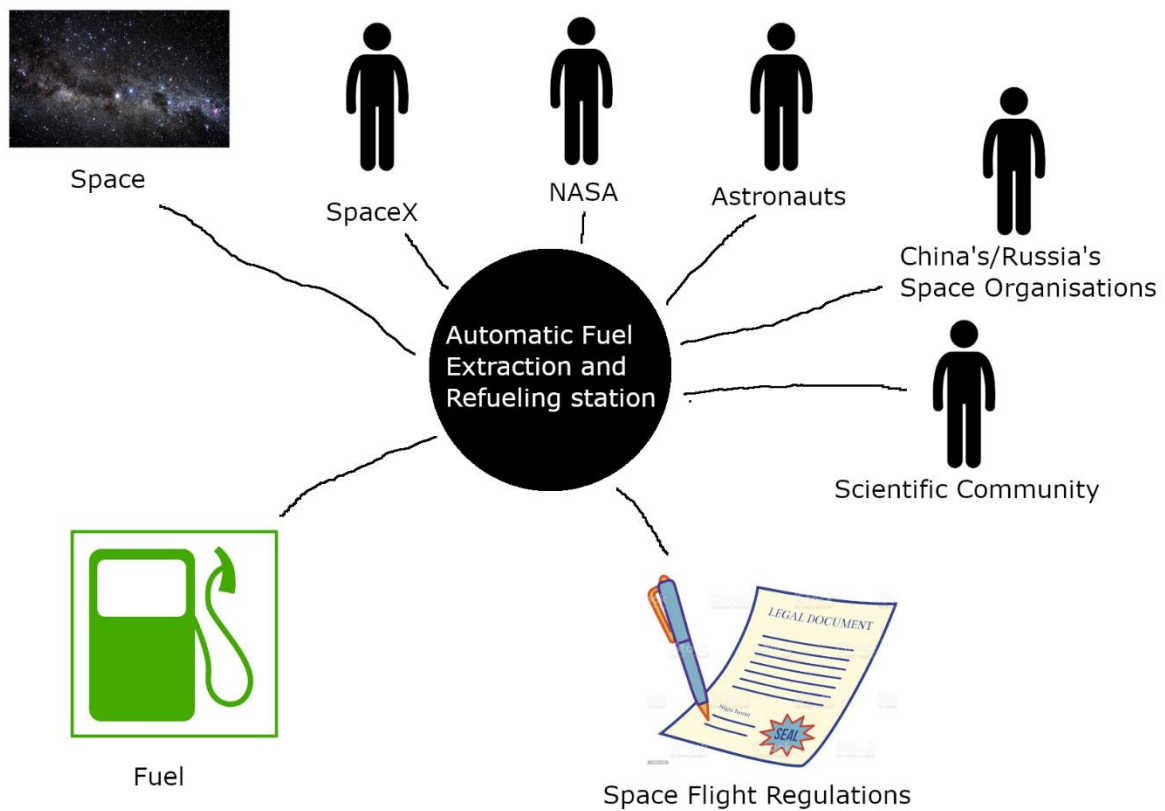
System Thinking

| TRIZ | Past | Present | Future |
|---------------------|--|---|---|
| Super System | Solid Fuel Rockets | Liquid Fuel Tanking on the Ground | Interplanetary Refueling stations. (Like any fueling stations for cars today) |
| System | Ground based fueling tower | Automatic refueling and extraction station for Starship | Automatic refueling and extraction station for all ships with a larger tank and handling more ships at the same time. |
| Sub System | Fuel types, Automatic docking, Heatshields | Pumping in vacuum, auto recognition of fuel delivery rockets and rockets to be refueled | Station security, Mult docking capabilities |

The TRIZ diagram's purpose is to help think about the context of the system in time, looking at future and past challenges.



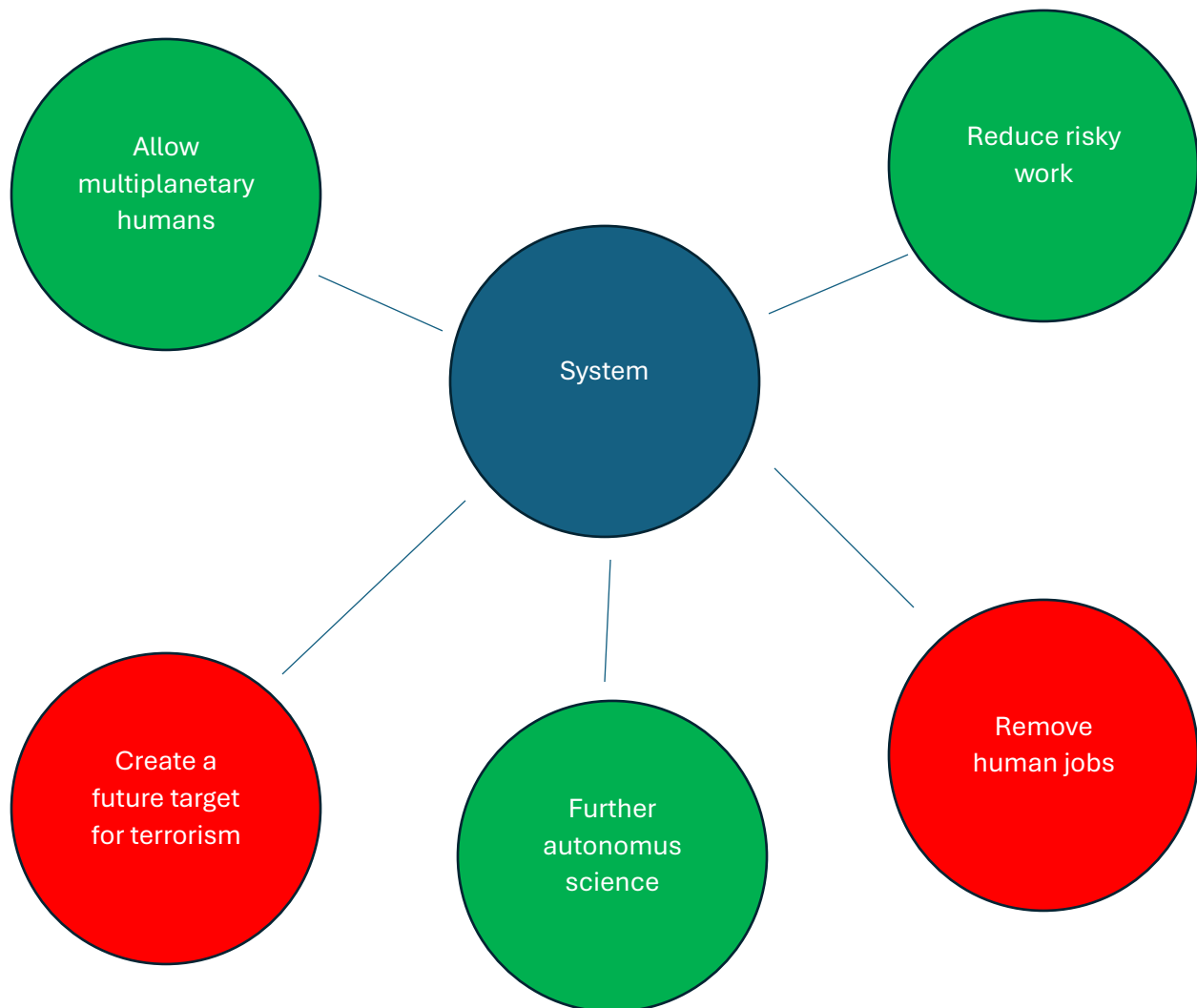
The ConOps diagram's purpose is to explain the systems function and potentially to make sure all needed functions are included.



The Context diagram is useful to organize the parts that will interact with the system, making sure all problem sources are accounted for.

Impact on Society

The automatic refueling and extraction station will first of all allow humans to travel to other planets, and potentially become multiplanetary if they settle there. Furthermore, the impact of the system on the job of the astronomers is to reduce the risky jobs they might have to do and allow them more time to perform science experiments. Now, as the station takes away a risky part of an astronaut's job, there is also possibly a need for fewer astronauts in the future, which will take away some people's potential jobs. However, it is not certain that these jobs are something we want or not, as they are based upon risking human lives. Another problem is that this station will collect a large amount of highly flammable liquid in a single place which could be attached to a rocket filled with potentially hundreds of people in a hard to control environment. This could make a very big target for future terrorists and escalate the use of weapons and warfare in space which is less than ideal. Finally, the station could help further the scientific field of autonomous robotics, allowing future projects to build upon the experiences in this project. This will be especially important in future space related applications, like automatic building of space station and setting up "Highways" for spaceships.



Legal and Ethical Aspects

There are not that many current legal and ethical problems with this solution, as space is mostly unrestricted space. The only regulations currently active for the space station is the restrictions on the rockets flying up to transport fuel, and restrictions on some orbital paths used for different satellites. However, in the future the station will interact with human transporting vehicles which could be in trouble. In these situations, allowing other rockets to refuel instead of drifting aimlessly through space could save lives. However, the creation of a large unsecured tank of highly flammable liquid could create a large target for thieves, terrorists or warring nations. There could also be future restrictions on the stations security if the station is taken into commercial use, which might lead to the station needing extra defences or not being a viable option at all. Finally, the obvious problem of autonomous systems replacing humans also will apply to this, as the future could have been filled with human run fuel stations also in space, but with the stations run autonomously, these jobs aren't available after all. Right now, fuel stations also often include kiosks or restaurants. If these inclusions are automated as well, by vending machines or similar, there would be absolutely no use for humans there.

Human Interaction

Since the system is supposed to be completely autonomous, operating at level 5 autonomy where no interaction with humans after deployment is needed, the interaction with humans will not be an intentional aspect. However, people with bad intentions will always be a problem. Any people wanting to hurt the owners of the product, any humans close by or simply to earn money by stealing the fuel will represent future challenges. The ethical problem of giving fuel to stranded spaceships drifting helplessly might also become an interaction challenge in the future, as humans will request help even though they are not the normal recipients of fuel. These interaction challenges need to be considered in some ways now, as there is equipment it could be useful to include already. The ability to receive, recognise and handle distress signals could be smart to include. Also, the development of defence systems to handle future threats could also be used to handle current threats of asteroids satellites and might only require small changes to handle all threats. Thus it would be cost effective to include these at the start rather than only after they are necessary.