4.5 Overall Capabilities

The Autonomous Extraction and Refueling Station will need sensors for creating a 3D map of the environment. This would ideally be one or multiple optical cameras which can identify objects of interest. These need to take pictures in multiple directions and communicate with some internal data processing software. The system also needs sensors for detecting confirmed docking. This could be a combination of proximity sensors and torque sensors on the station hull and inside the machinery performing the docking. Sensors for detecting fuel level or at least if the tank is full or empty are also required. Sensors detecting possible malfunction in actuators, or to measure the battery level is also required to plan accordingly.

As for actuators, the station needs some propulsion engine, running on the same fuel as it is transporting. The easiest solution would be to use at least three raptor engines, the same ones in use for Starship. Furthermore, actuators for docking with a starship, and then to push or pull fuel to or from the tank is needed. The docking mechanism must hold on to the rocket and seal off any holes to outer space, even while under stress from fuel being pushed or pulled through. The pulling or pushing mechanism would be a mechanical pump either creating vacuum in the station’s tank and sucking the fuel in or pushing the fuel out. Finally, depending on how the system should acquire electric power, actuators for folding or deploying solar panels should be present.

Regarding the human interactions of the system, in general it is not wished for humans to interact with the system during operation. However, maintenance must still be performed by humans, and for this there should be some way to anchor oneself to the station for astronauts. There should also be some sort of physical way of accessing the station’s machinery and possibly also a socket for accessing the software, to allow updates to be performed and machinery to be maintained.

The robotics framework is required to allow for communication between sensors, actuators and internal software as well as development and running of intelligent autonomous planning and decision-making software. It also needs to allow the storage, updating of and use of sets of data such as maps, movement history, maintenance times, statuses of interesting objects and possible laws and regulations applicable. This framework should also allow for encryption and secure storage of all internal communication and software, as to remove the risk of cyber-attacks from hostile actors. A solution is to use the version of ROS described by B. Dieber et al. in Security for the Robot Operating System, found here: <https://www.sciencedirect.com/science/article/abs/pii/S0921889017302762>

All these sensors, actuators, tools and software must be built to withstand the radiation of space, vacuum, low to no gravity and at least microscopic to small meteors hitting the station. Thus, the equipment must be built with extra care to durability and if liquid or gaseous components are included, they need to consider extra sealing measures. For actuators specifically, any mechanical parts prone to erosion due to moveable parts should be avoided, as to keep maintenance cycles as large as possible.