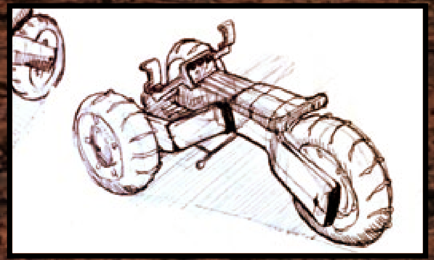
M.A.R.T.I.N [Mars Automobile Rover for Transportation and Investigatory Navigation]

Course: Stars Design 2012
Year: 2012
Length: 15 weeks

5/9 2012 - Project introduction

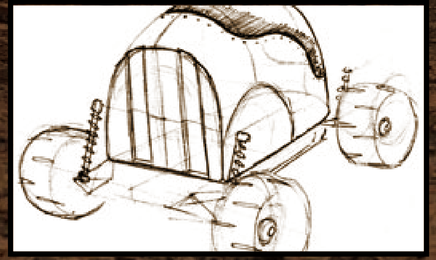
17/10 - Pre studies presentation LPI, Houston

24/10 - Idea presentation JSC, Houston

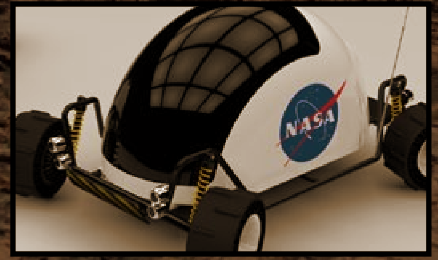


16/11 - New research finished

30/11 - Final design finished



12/12 - Final presentation



The school of Industrial Design at Lund University is annually doing a project in the second year of the Master program which is a collaboration with NASA. The course is about designing for extreme environments and the purpose is to learn how to step back and look at the very fundamentals of the design process - to be able to erase factors that are usually taken for granted when designing a product (e.g. gravitational force, access to water and breathable air, atmospheric pressure and perception of time).

The students of this course collected research on a collective blog on tumblr at the address starsdesign2012.tumblr.com. Since many were doing research in the same area, it was a more efficient way of working by sharing links and documents with information about other projects and experiments about space.

The initial idea for this project was to work with time perception in space to learn more about how the human mind is affected by the shifting hours of the days and years depending on which celestial body in space that is visited. In order for me to get a notion of what I was going to work with I decided to make an experiment. I was going to lock myself into a room with no windows so I wouldn't know if it was daytime or nighttime, no contact with other people to eliminate the risk of them revealing the time by mistake, no music and no technical devices that could in any way tell me the time. All I had was a camera to take photographs of my time estimations during the experiment, and afterwards (on a computer) compare the estimated time with the actual time the picture was taken. After 24 hours of isolation, the experiment resulted in a four hour difference between my estimations and the actual time. A more elaborate description of this experience is still available at lassing.tumblr.com.

After the pre studies of the project a two week field trip to Houston, TX was scheduled so feedback could be achieved directly from people who work in different areas at NASA. After the pre studies presentation of the project about time, the subject turned out to be a lot more complex, and in many aspects already solved, so the decision was made to change the subject to something that has a lot of information available, but does not have an existing solution yet.

At some point in the future, man will walk on planet Mars. There are several rovers and robots developed to explore the surface of the planet, and parts of the surface has already been photographed or analysed. But there are things that can not be caught on camera or discovered through samples of the materials from the surface. Also, if human beings build research stations or habitats in more than one location on the Martian surface, they need to be able to travel between the stations.

A new brief was written and it was to design a transportation system for astronauts on planet Mars. During the two weeks in Houston with field trips to the different departments of Johnson Space Center (JSC) studies were made on how astronauts traveled on the surface of the moon and also how the conditions differ between the Moon and Mars. At the Robotics Laboratory many interesting projects were found and the visit gave a good look of the existing technology in transportation on celestial bodies. In the early stages a compact and simple vehicle on two or three wheels was considered, but after feedback from the idea presentation at JSC a larger vehicle with an onboard life support system was encouraged. The larger size of such a vehicle could be motivated with parts of the vehicle being used in other applications like a lander or in a habitat.

Roving vehicle studies

In order to quickly get a good base of knowledge to stand on designing a roving vehicle it's a good thing to study existing rovers that already has been developed by experts. For this project there were three existing vehicles that had interesting aspects of development.

Lunar Roving Vehicle (LRV)
The lunar rover (Lunar Roving Vehicle) was studied because it is the only manned rover built that has also been tested in it's real environment, the surface of the Moon. Therefore there was a lot of relevant testing data available to be compared with a potential Mars mission. The LRV was also a relatively simple construction due to it beeing an open vehicle with no life support system.

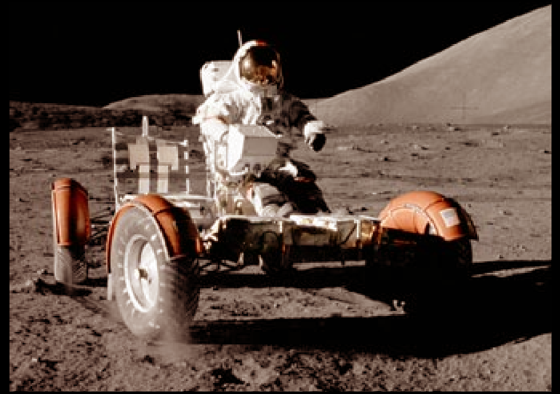
+ simple (unadvanced), lightweight, tested on site
- open vehicle (risks), not too versatile

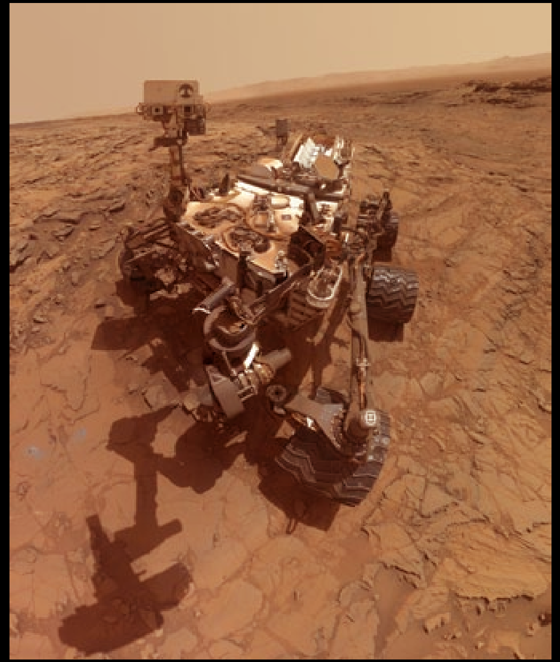
Chariot
Another roving vehicle that were studied was the new lunar rover called Chariot. It is a larger vehicle with a full cockpit with a life support system. This means that it can be driven without an EVA-suit. The interesting feature of this vehicle is that it has the life support system, which was recommended by experts at the presentation at Johnson Space Center to be utilised for a Mars roving vehicle because it would be safer than an open vehicle. Another important factor studying Chariot was that it was available at the Robotics Laboratory for both external and internal studies. Unfortunately this rover has never been on the lunar surface.

+ life support system (safe), suit air locks, works as a habitat
- large/heavy (for transit), never tested on site

Curiosity
The third roving vehicle investigated for this project was Curiosity, the roving vehicle taking samples and photographs on Mars. It is an unmanned vehicle, but the big interest here is in the fact that it is built to work in the environment of Mars.

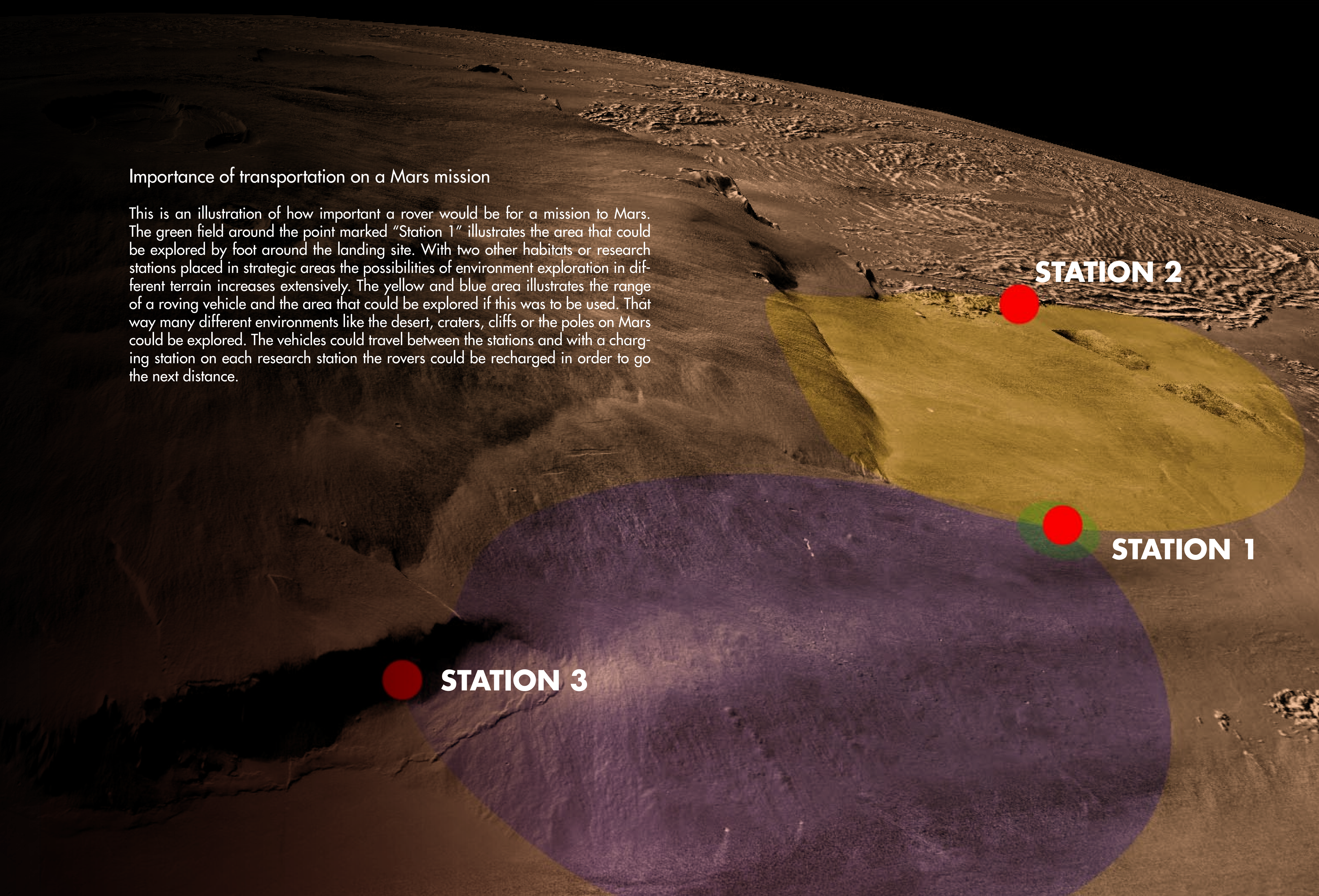
+ developed for Mars
- not for manned transportation

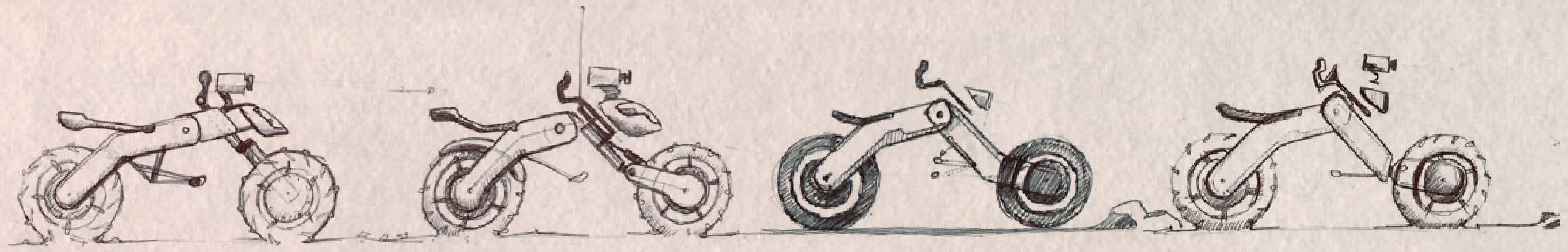


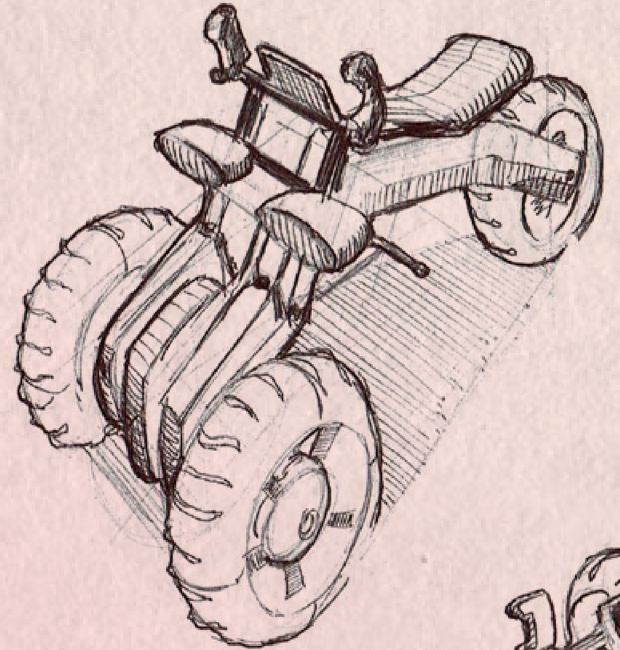


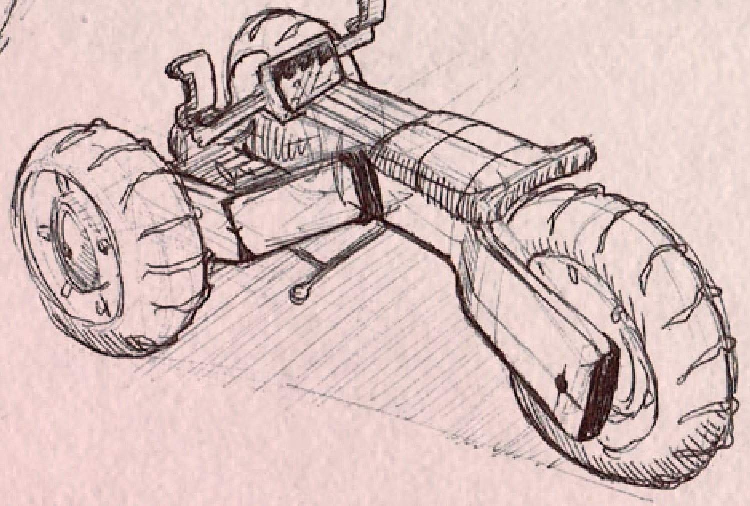
Importance of transportation on a Mars mission

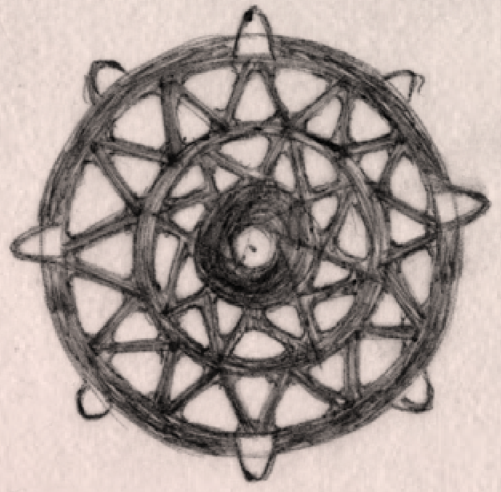
This is an illustration of how important a rover would be for a mission to Mars. The green field around the point marked "Station 1" illustrates the area that could be explored by foot around the landing site. With two other habitats or research stations placed in strategic areas the possibilities of environment exploration in different terrain increases extensively. The yellow and blue area illustrates the range of a roving vehicle and the area that could be explored if this was to be used. That way many different environments like the desert, craters, cliffs or the poles on Mars could be explored. The vehicles could travel between the stations and with a charging station on each research station the rovers could be recharged in order to go the next distance.



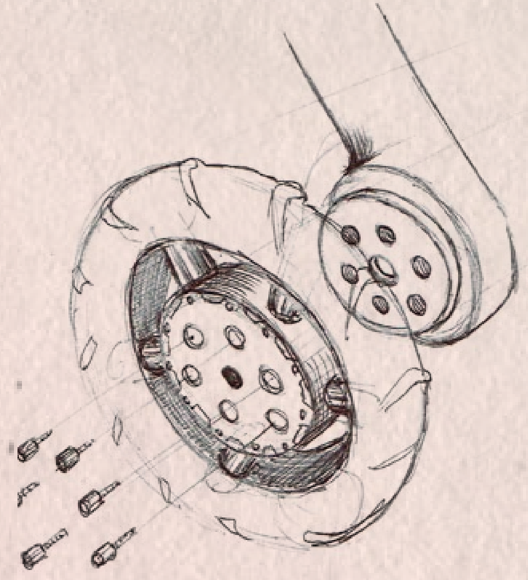


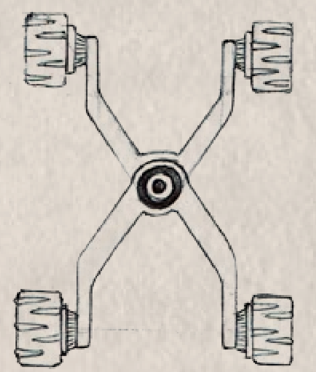




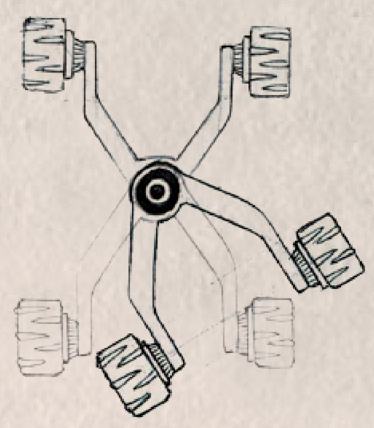


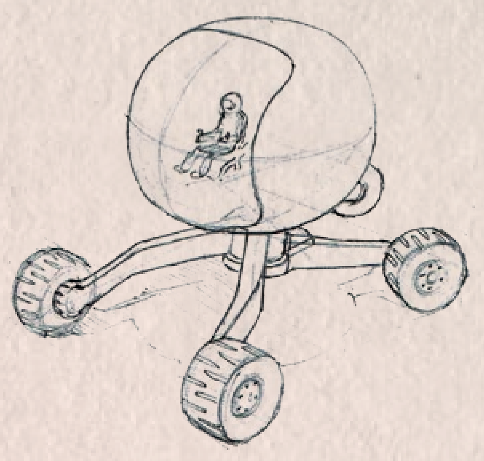
TWEEL ?

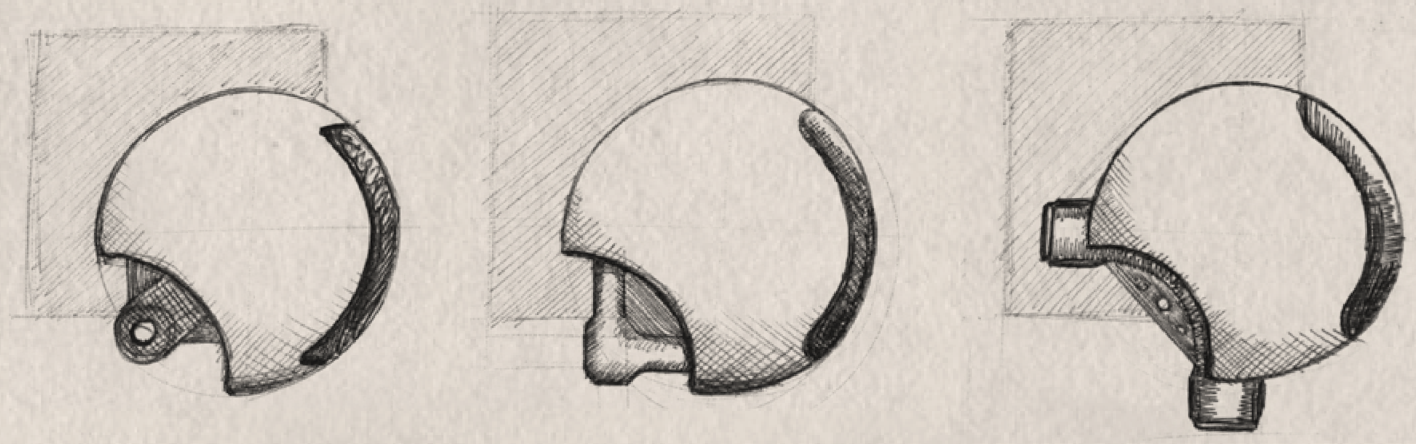


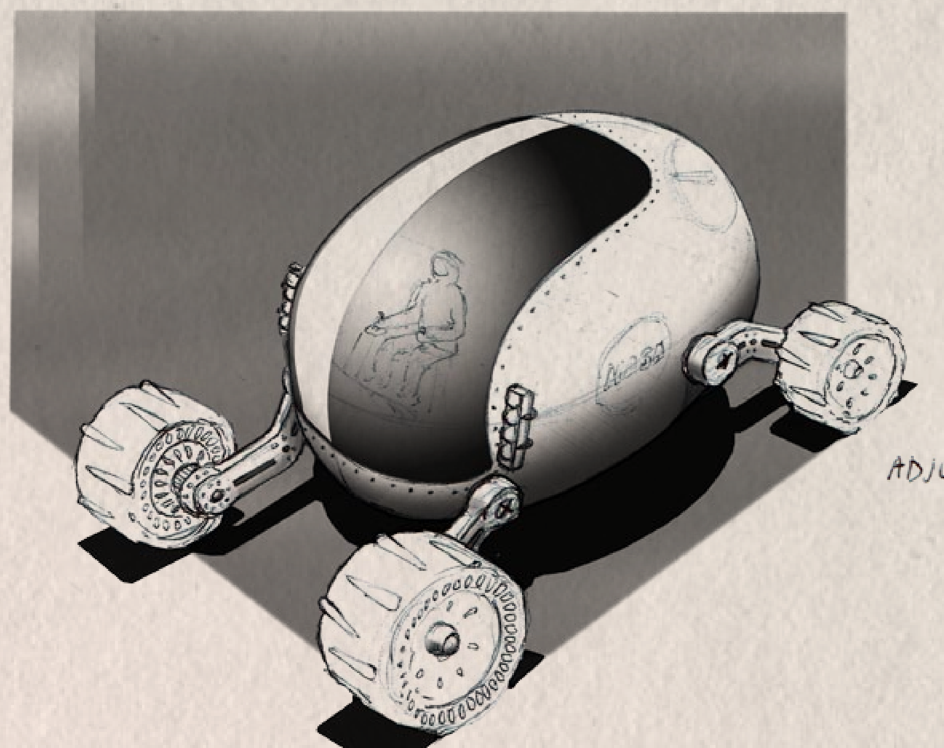


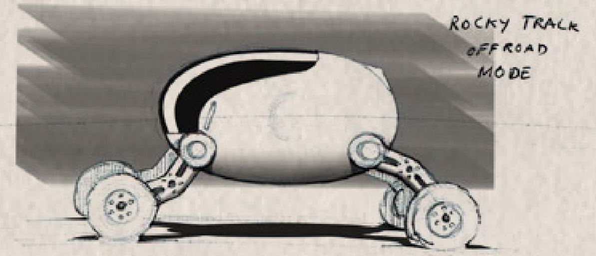
ARTICULATED STEERING?



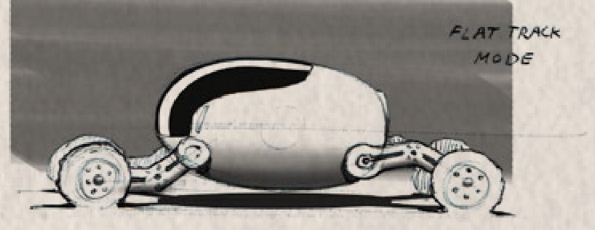






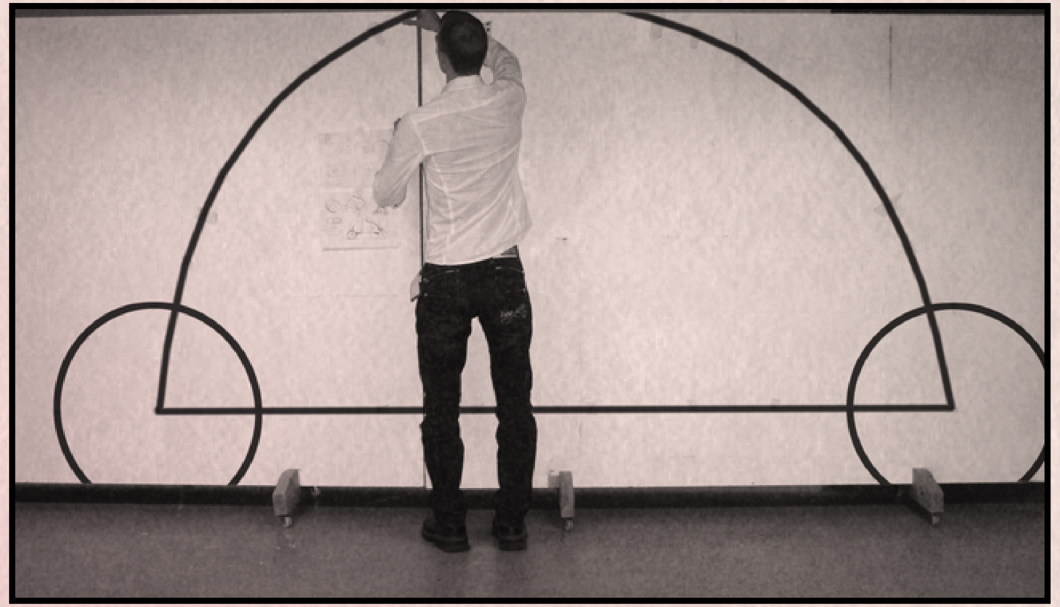


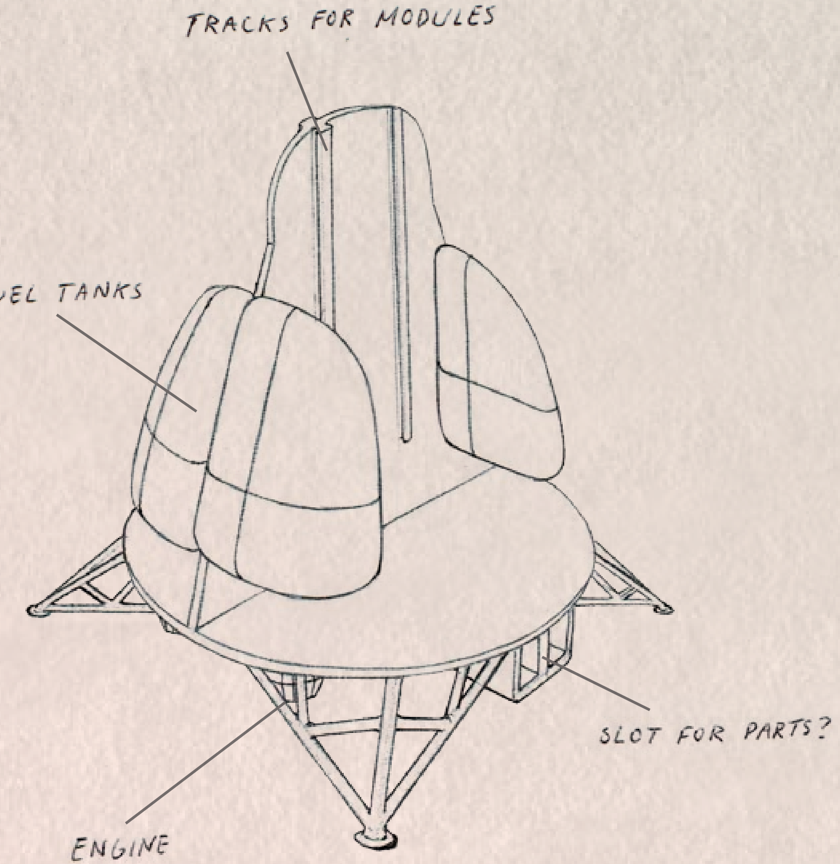
ADJUSTABLE GROUND CLEARANCE?

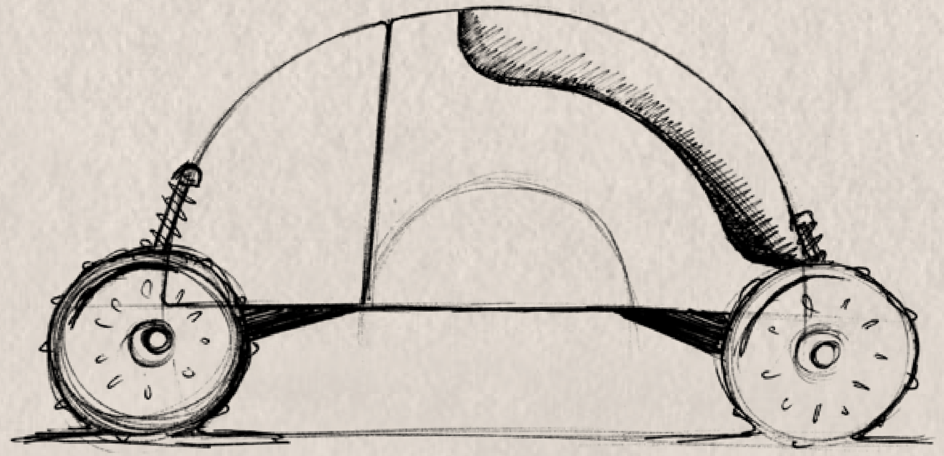


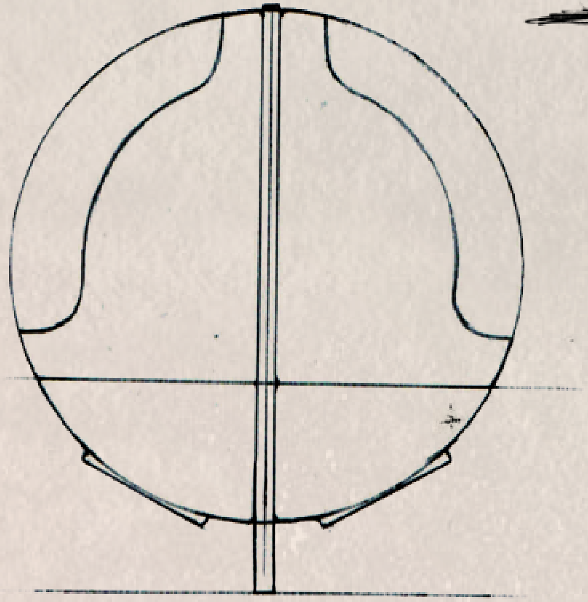
Full scale test

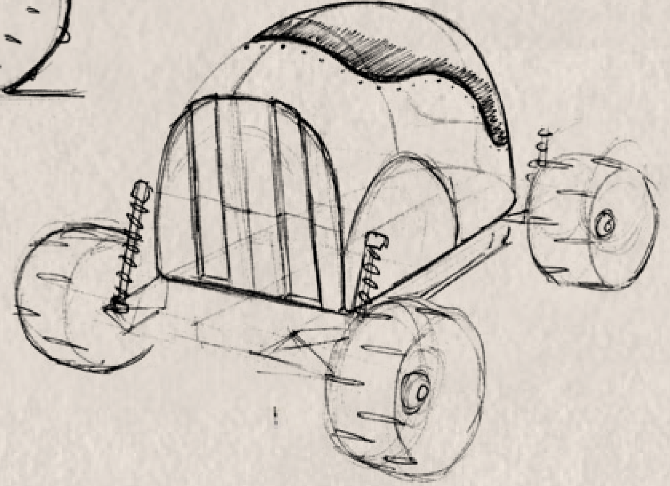
In order to get realistic measurements I had to build 1:1 scale models parallel with the sketch process and 3d-modelling. This way I could try out different situations, reducing errors, and improving my estimations. I made models for the suit lock, the exterior shell (image below), the wheelbase and width of the vehicle, and the measurements of the interior. The methodology I used was to sketch the ideas by hand, then build it in 3d-software, and try it out in a 1:1 model. If the idea didn't work I started over. This is a useful design technique when you are designing large objects like cars and motorcycles.

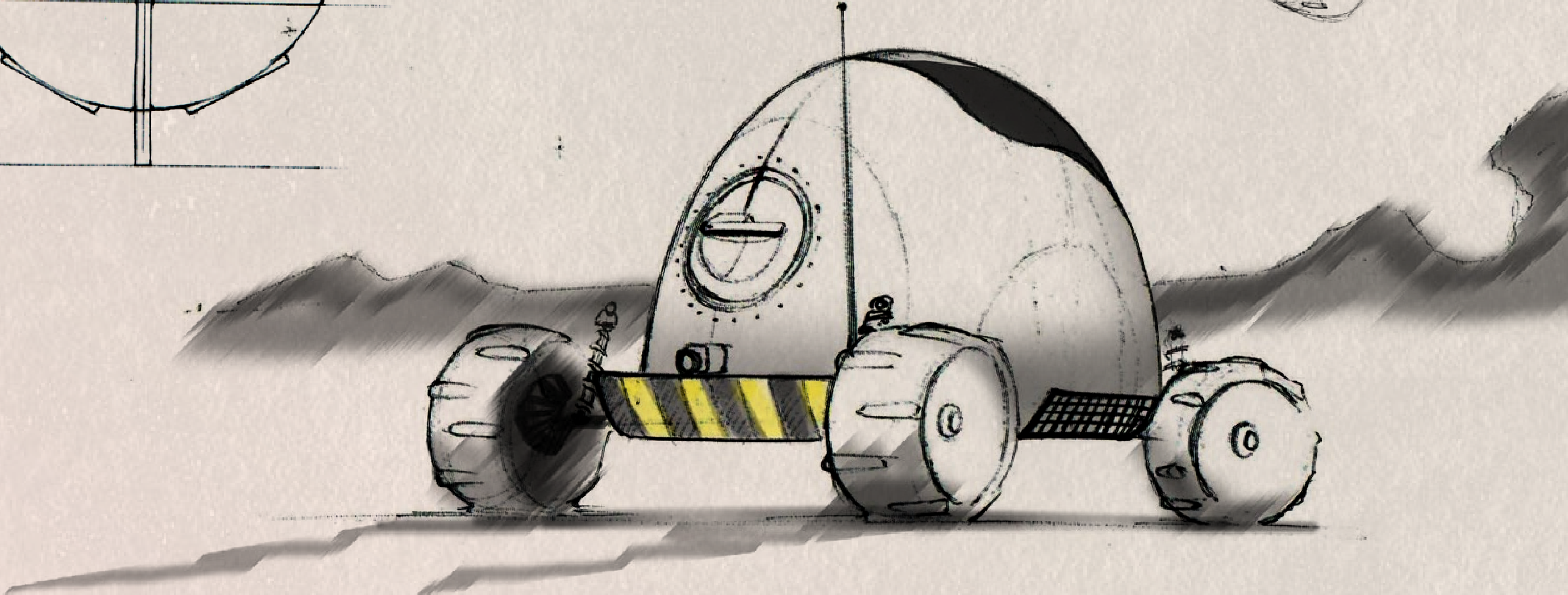


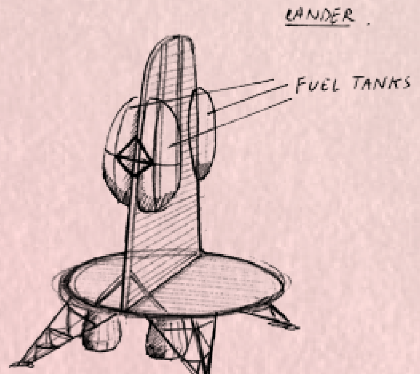


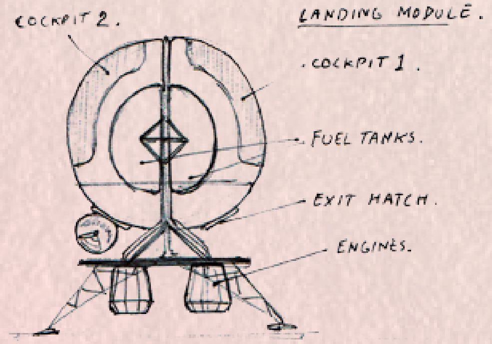


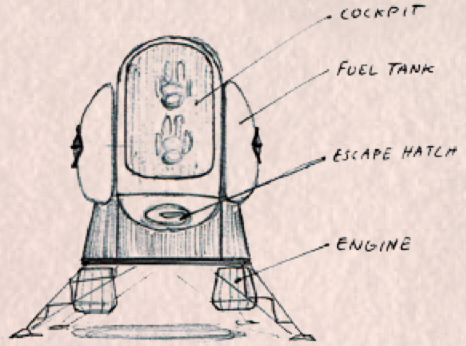


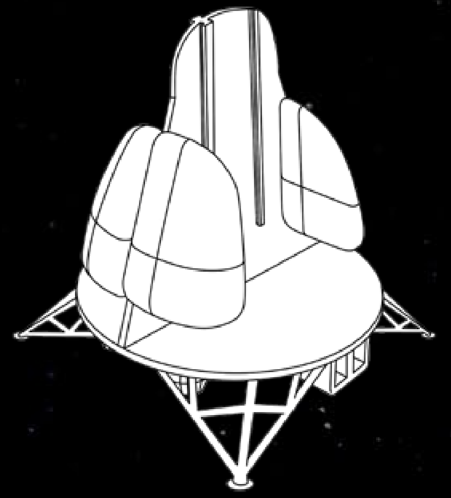




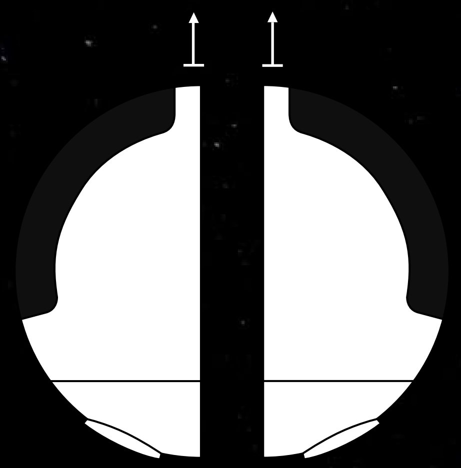




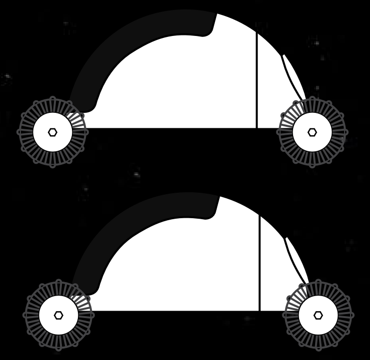




This is a 3d-view of the landing module without the rovers. The idea is that the two capsules are mounted on a lander which creates the module that takes the astronauts down to the Martian surface from the transit spacecraft orbiting the planet. During this project I used a lander that resembles the lander from the Apollo-missions for illustrative purposes in order to present the concept. The lander to the left was designed after the end of the project and is a more refined solution to this sort of mission.



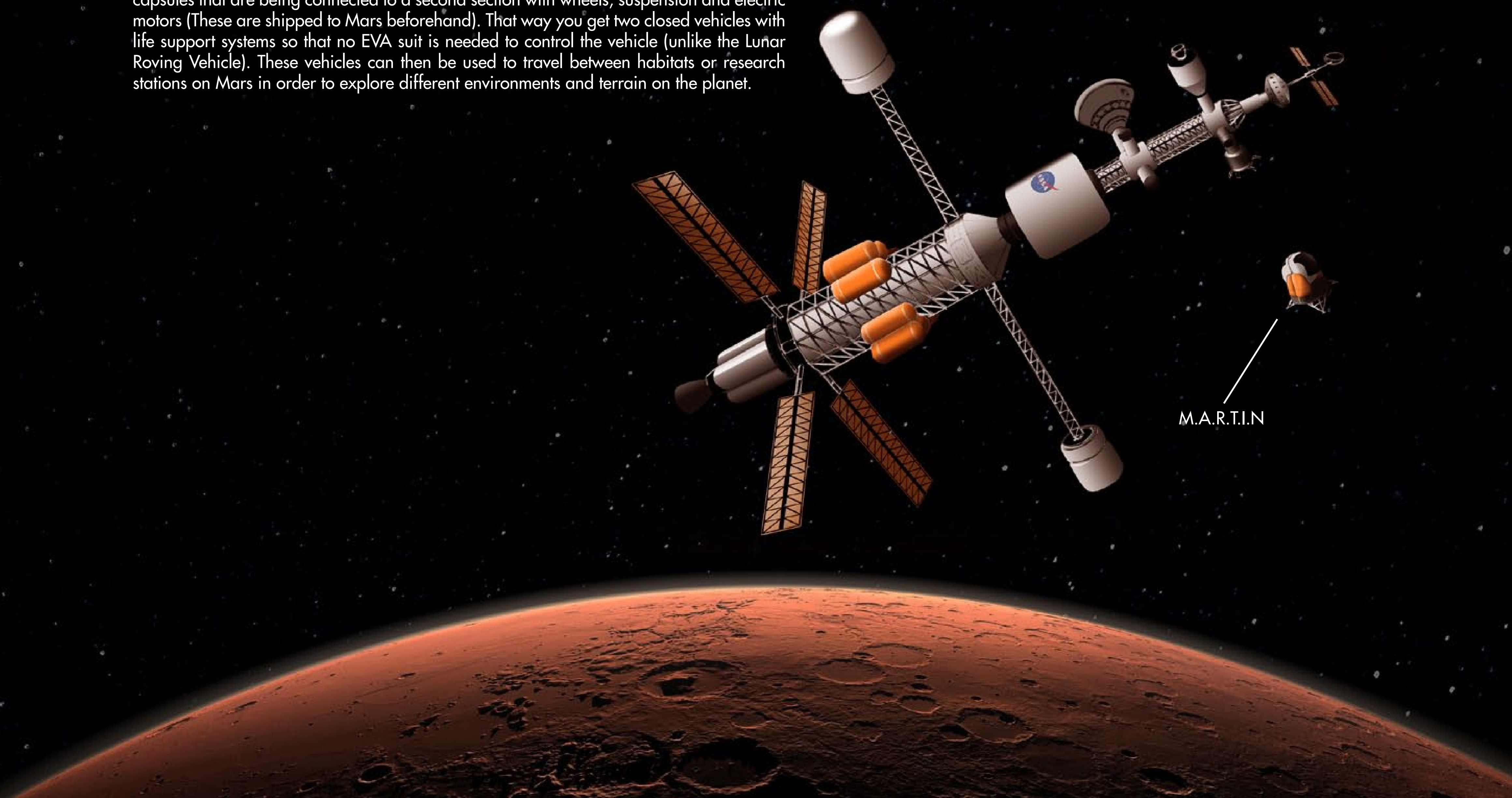
This is a side view of the two capsules. When landed on the planet the two capsules are separated from the lander by sliding them upwards and off their slots. This gives us two identical halves.

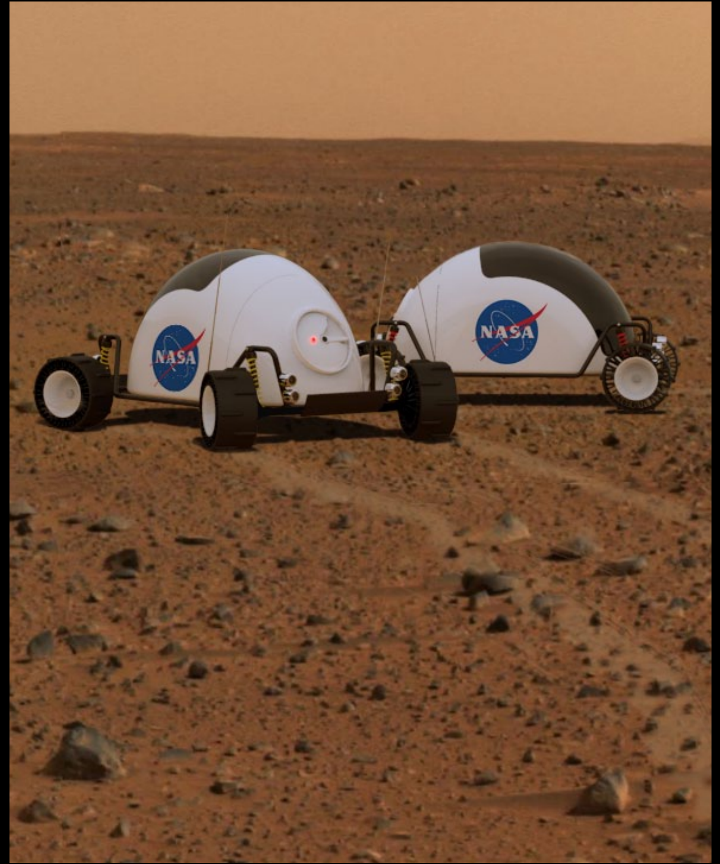


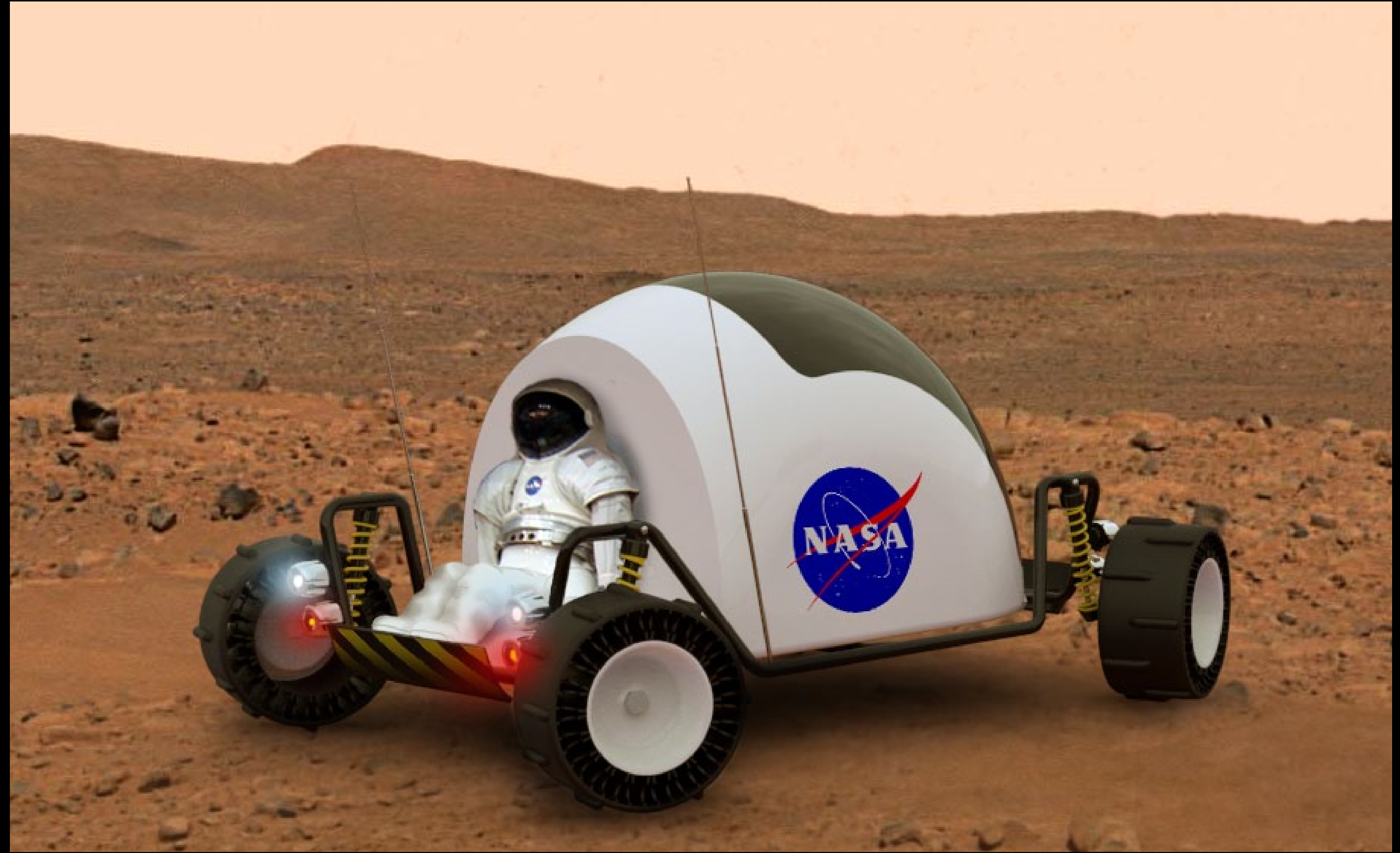
An assembly of chassi, suspension, batteries, wheels with motors, and other neccesary equipment are then fitted to each half which creates two roving vehicles to travel on Mars.

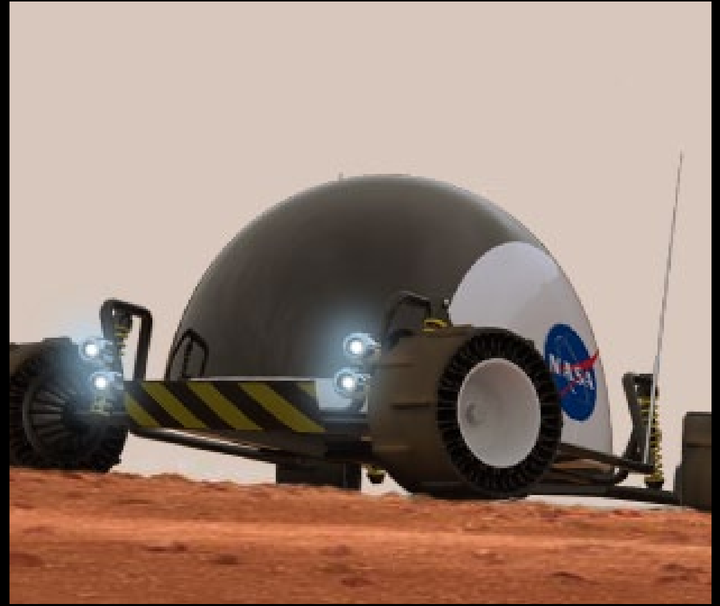
Results

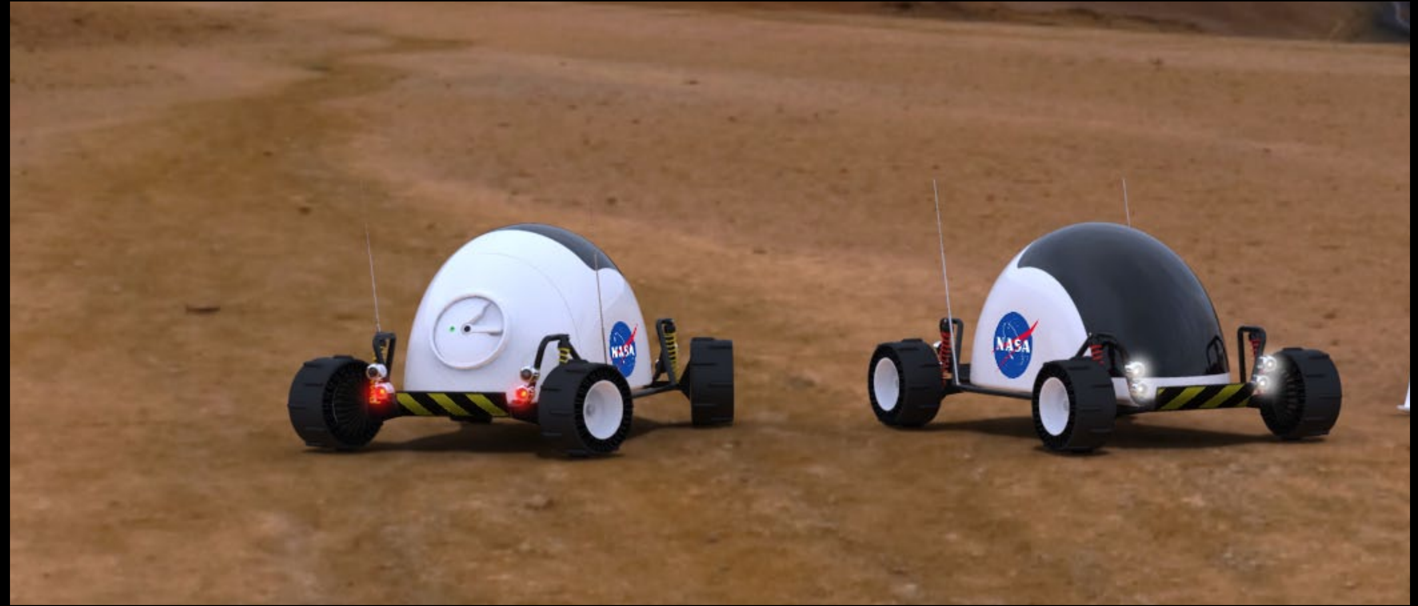
This concept is based on the idea of having a transit spacecraft that, when it arrives to Mars, starts orbiting the planet while a separate landing module takes the astronauts down to the surface. The same thing was done during the Apollo-missions to the Moon. The difference with this concept compared to the lunar module that landed on the moon is that when this module has landed on the surface it splits in half and you get two separate capsules that are being connected to a second section with wheels, suspension and electric motors (These are shipped to Mars beforehand). That way you get two closed vehicles with life support systems so that no EVA suit is needed to control the vehicle (unlike the Lunar Roving Vehicle). These vehicles can then be used to travel between habitats or research stations on Mars in order to explore different environments and terrain on the planet.

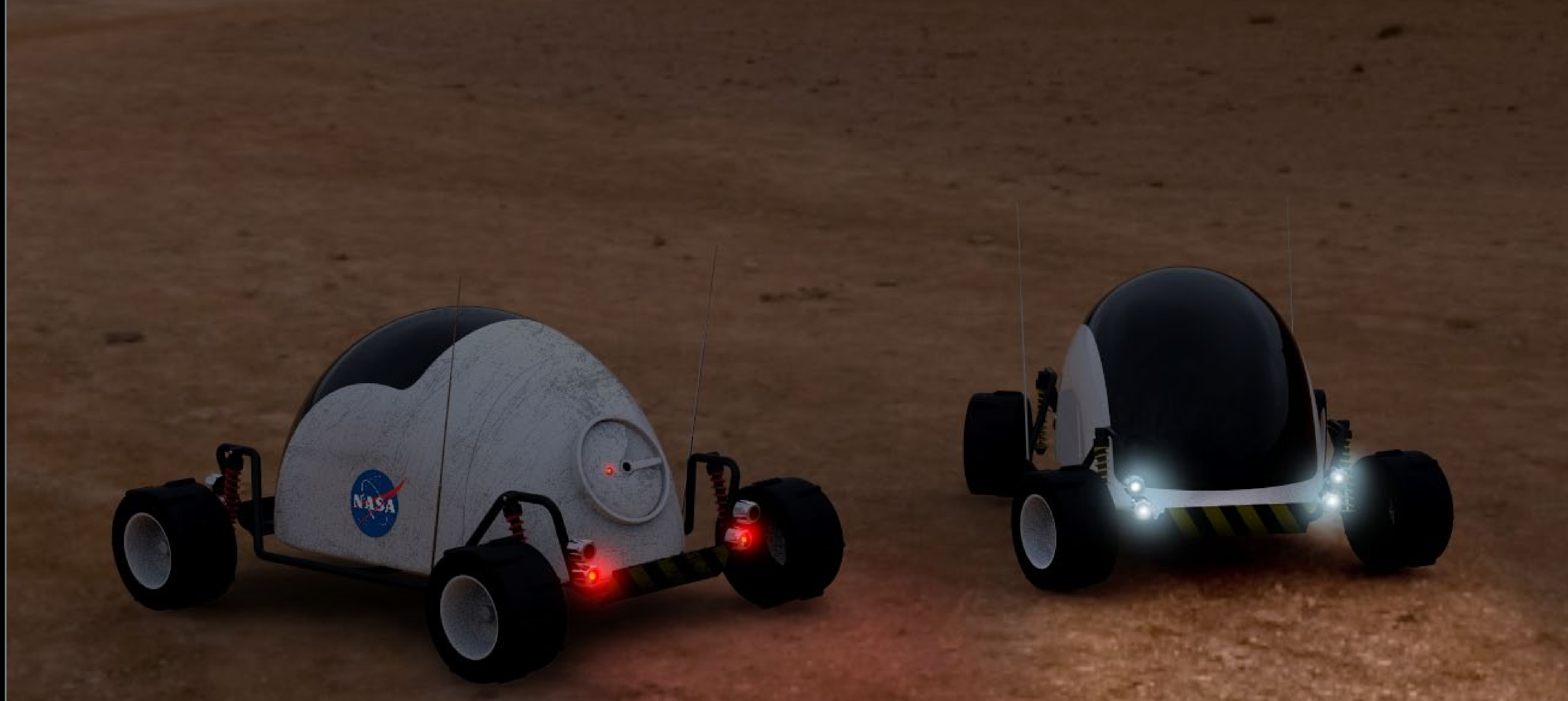












M.A.R.T.I.N

M.A.R.T.I.N is a four wheel drive rover propelled by electric hubmotors, since an internal combustion engine won't work in the Mars environment (lack of oxygen). It has a four-wheel independent steering system which means each wheel can be turned separately for manouvering in any terrain. The tires on the wheels are called tweels and uses rubber spokes instead of air to lift the rover off the ground. These are used in order to prevent punture. In order to save as much energy as possible to get a longer travel range all light-sources on the rover uses LED-technology.

In the back of the rover is a hatch where the rover can dock with a habitat in order to be able to enter and exit the vehicle. On the hatch is a light that indicates with red or green light if the inner hatch of the air lock is open or closed. The whole air lock can also be removed in order to fit a suit air lock to the back instead which can be used for EVA. With the suit set in a sitting position it gets easier for astronauts to get inside the suit.