Final Project: Next NASA Mars Rover

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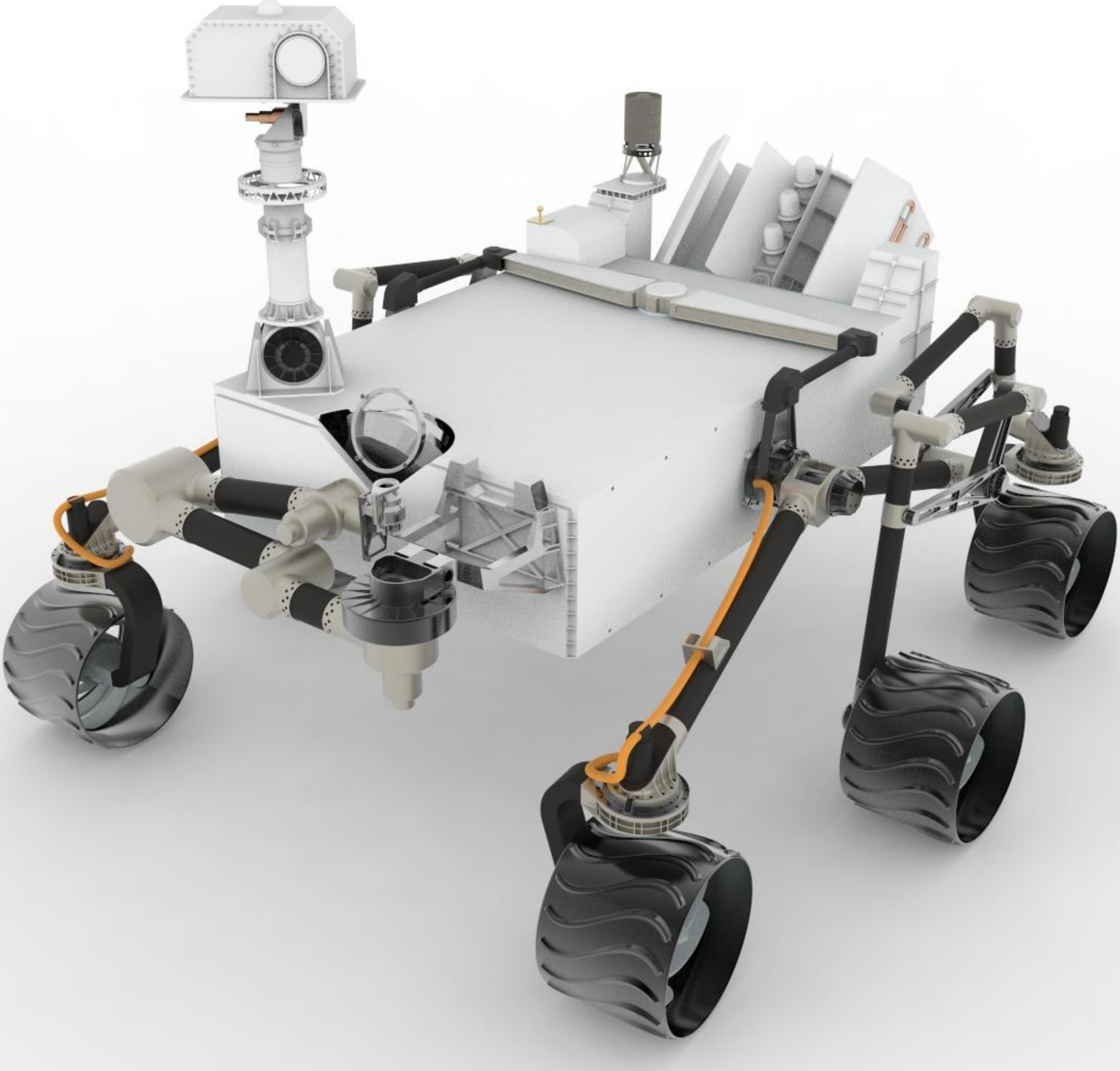


Abstract:

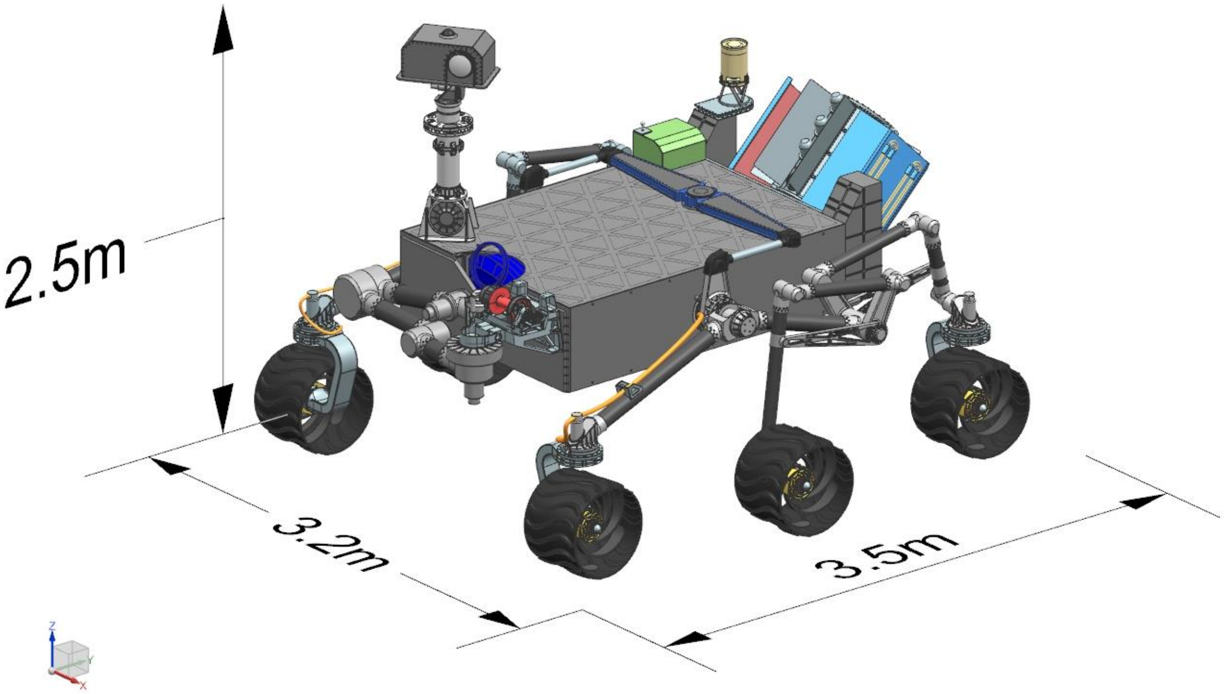
All known types of life have a single chemical commonality; Liquid water. Therefore, discovering liquid water on a planet like Mars is a primary objective in the search for extraterrestrial life. Due to the nature of the thin atmosphere on Mars, obtaining liquid water at the surface is not possible. However, drilling deep into the subsurface of the planet yields a higher probability of acquiring water in the form of hydrated perchlorates or saturated soil. To further investigate the possibility of life on Mars, a rover with the capability of subsurface scanning, deep drilling, and sample analysis is required. Utilizing a sub-surface scanner with ground penetrating radar will accurately guide the mission to a drill area with a higher probability of obtaining water. Following the scanning, the rover will deploy a self-assembling deep drill that will bore to the maximum depth of 1.5m. Directly after the drill cycle is complete the rover will retract the drill utilizing the deep drill “Kevlar tether” designed by the Planetary Society/Honeybee Robotics. Once retracted the drill sections will disassemble into sample containers and be processed onboard the rovers automated science lab for further analysis and data acquisition.

Scientific objectives:

Search for signs of life in Martian sub surface.

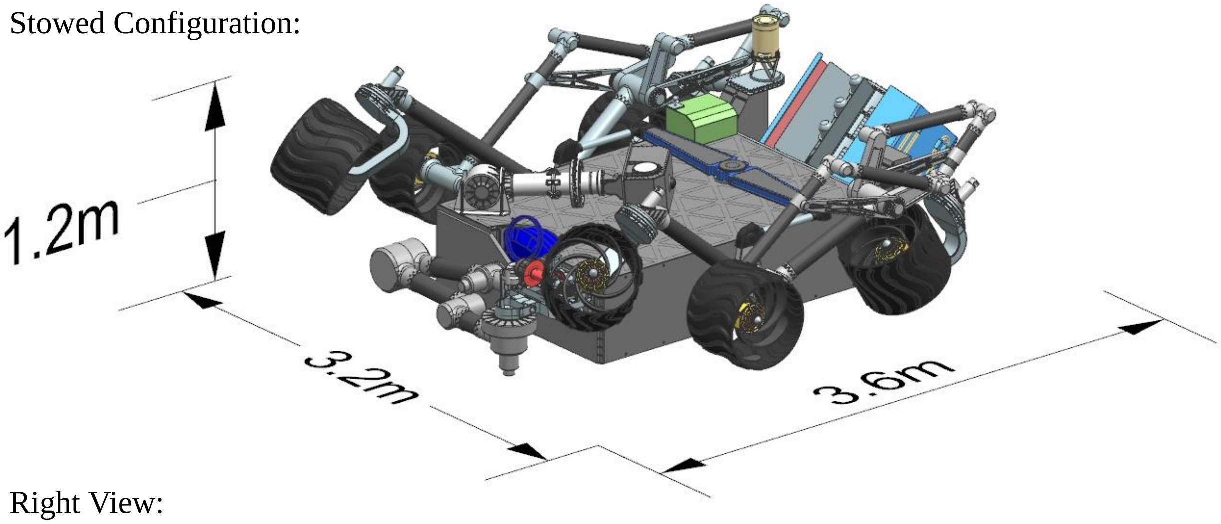
1. Ground penetrating radar scan In search of water
2. Deep drill for sample acquisition.
3. Sample analysis and data relay

Overall Dimensions:

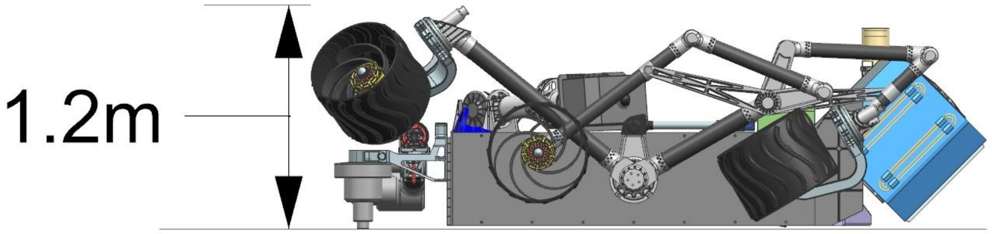


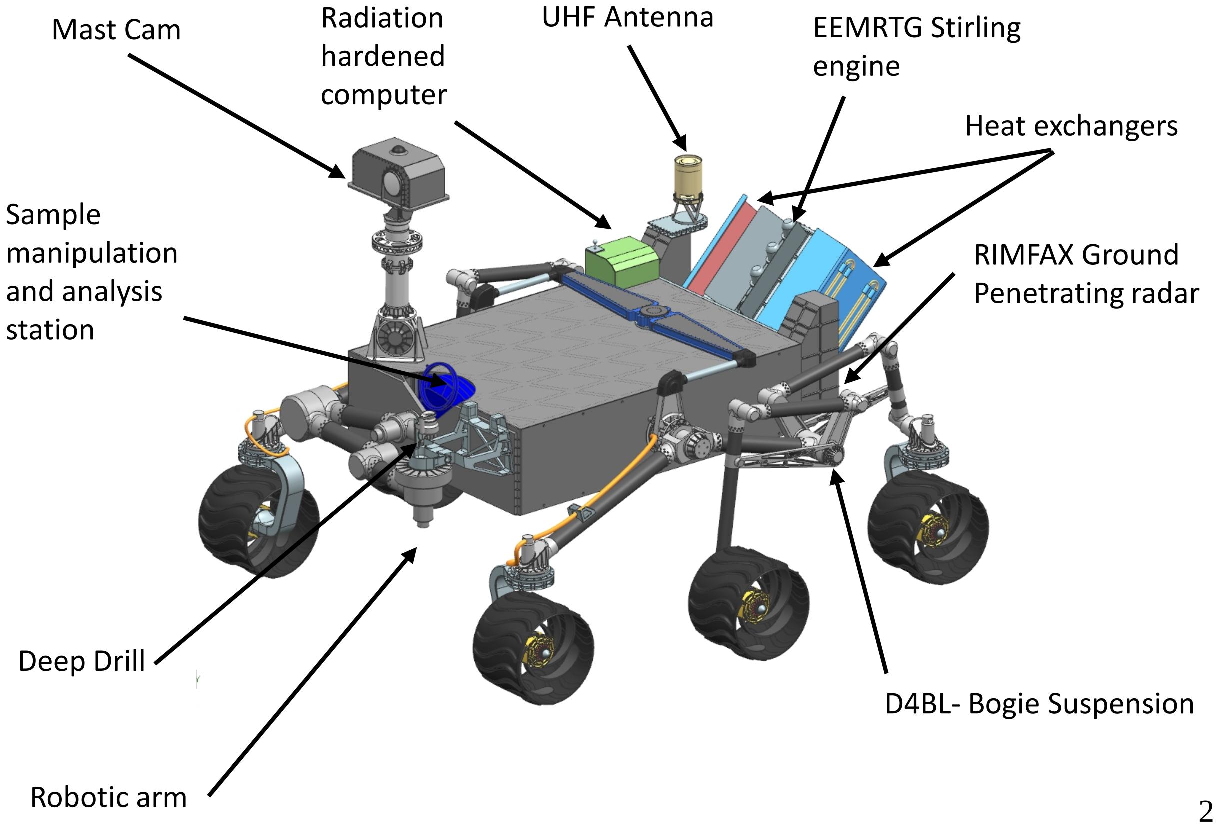
Overall Dimensions Continued:

Stowed Configuration:



Right View:





Design Ethos:

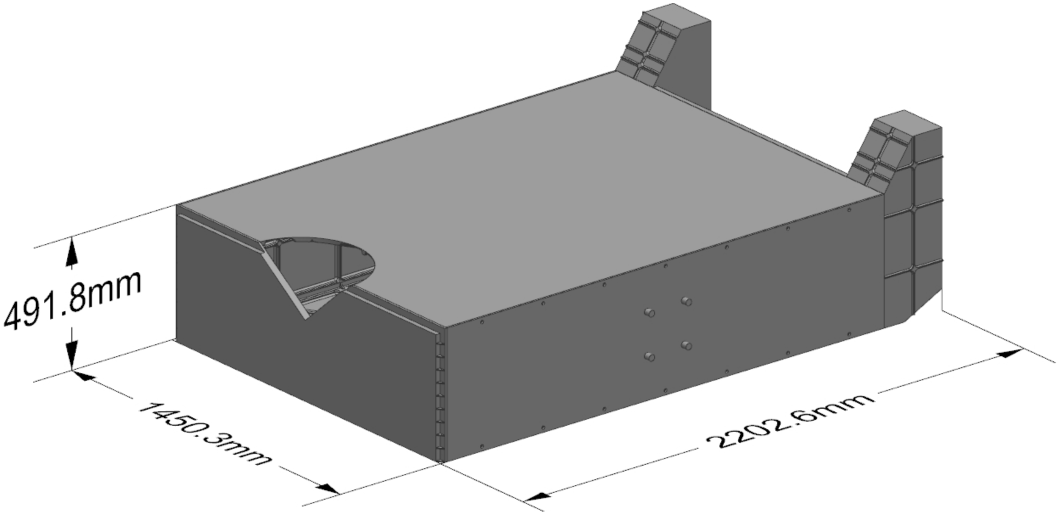
The design intent of this rover was to create all the components to utilize as much commonality as possible throughout the assembly. By having commonality of components, the manufacturing costs are reduced substantially. For example, the suspension system uses a total of 6 unique components, which are common between the robotic arm system. Therefore both systems can be manufactured using the same tooling and manufacturing process.

A majority of components are based off of the Mars Curiosity and Mars 2020 rover platforms. This was done in order to reduce the tooling costs associated with producing all new unproven componentry.

Chassis:

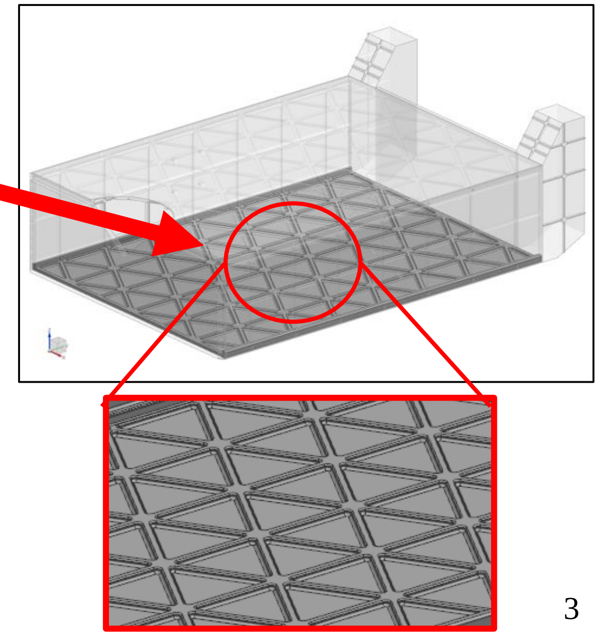
Chassis Body:

The body design is shaped in a simple rectangular prism. The purpose of this shape is to increase the surface area for instruments to be attached on the top of the body. In addition, a majority of the scientific instruments are made in a similar shape so that they can nest efficiently inside the body of the rover, utilizing all of the area inside the body.



The rover’s chassis panels are machined from 7075 T6 aluminum, with a triangular lattice pocket on the interior surface. This feature reduces the overall weight while retaining structural properties of the material.

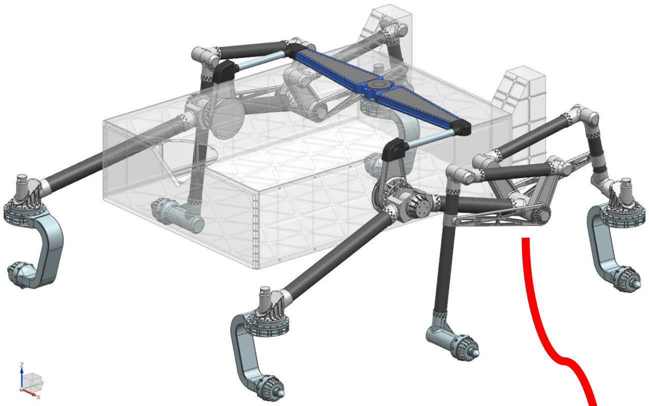
The interior of the chassis is finished by attaching carbon composite, Nomex core sandwich panels that are filled with Aerogel. This is done to thermally insulate the interior of the rover body.

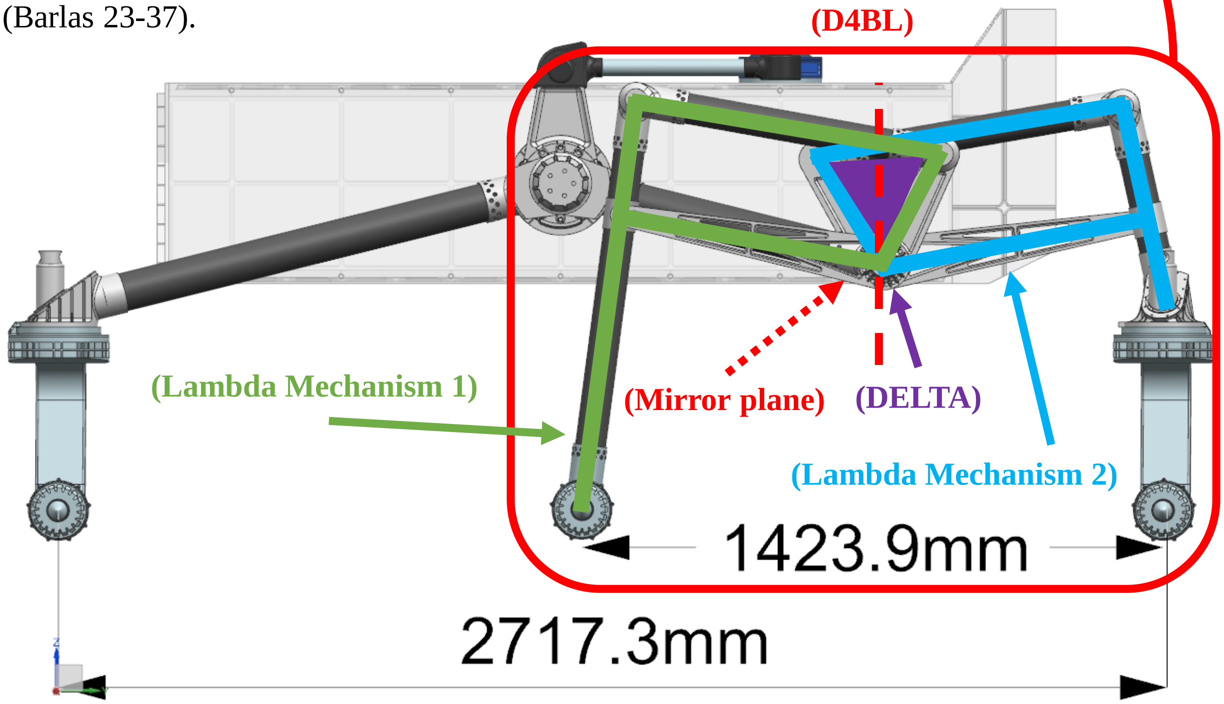


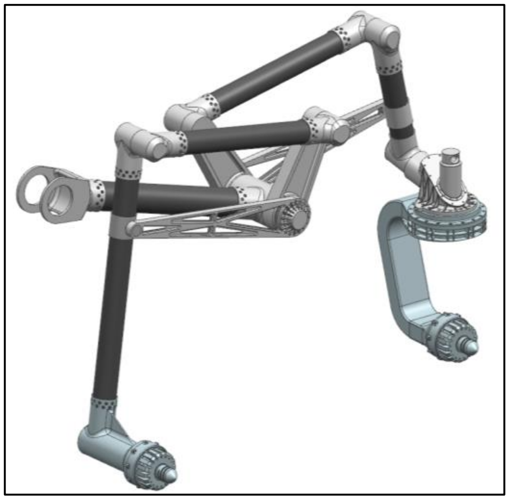
Mobility System:

Suspension:

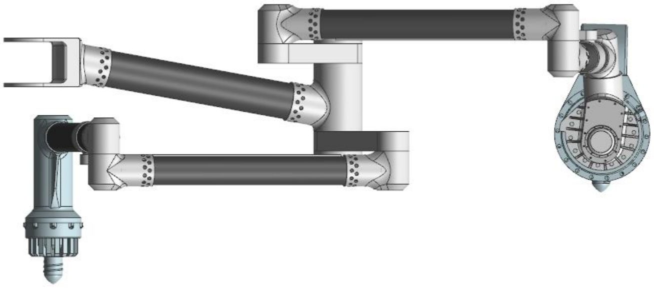
The Suspension system is a modified rocker bogie system with superior obstacle clearance due to the D4BL (Delta 4 Bar Link) bogie. The D4BL is a “Lambda Mechanism(4 bar link)” that is mirrored about the rear suspension boom arm creating a “Double Lambda mechanism” or “Double 4 bar link.". By connecting these two mechanisms a triangle is created in the center, hence the name (DELTA) (Barlas 23-37).







Top View



<u>Mobility System Continued:</u>

Suspension:

A study conducted in the *Journal of Astronomy and Space Sciences* (JASS) provides the data demonstrating the superior obstacle clearance of the D4BL bogie system. Figure 1 and 2 from the kinematic study display the data comparing the D4BL and the Rocker-Bogies obstacle clearance capability. In Figure 2 the diagram displays the kinematic model of the D4BL (Kim et al., 2012).

(Fig 1.)

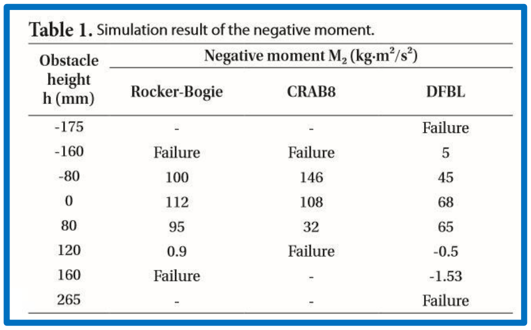
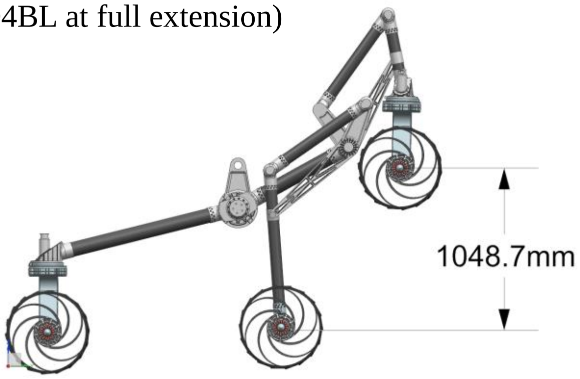


Table 1. Simulation result of the negative moment.

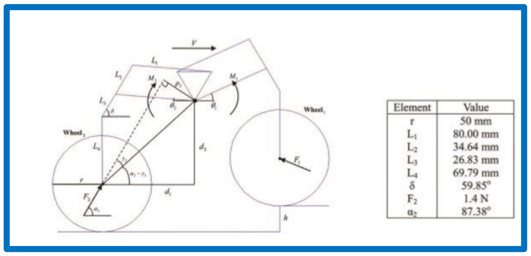
Obstacle height h (mm)	Negative moment M_2 (kg·m²/s²)		
	Rocker-Bogie	CRAB8	DFBL
-175	-	-	Failure
-160	Failure	Failure	5
-80	100	146	45
0	112	108	68
80	95	32	65
120	0.9	Failure	-0.5
160	Failure	-	-1.53
265	-	-	Failure

(Kim et al., pg.418)

(D4BL at full extension)



(Fig 2.)

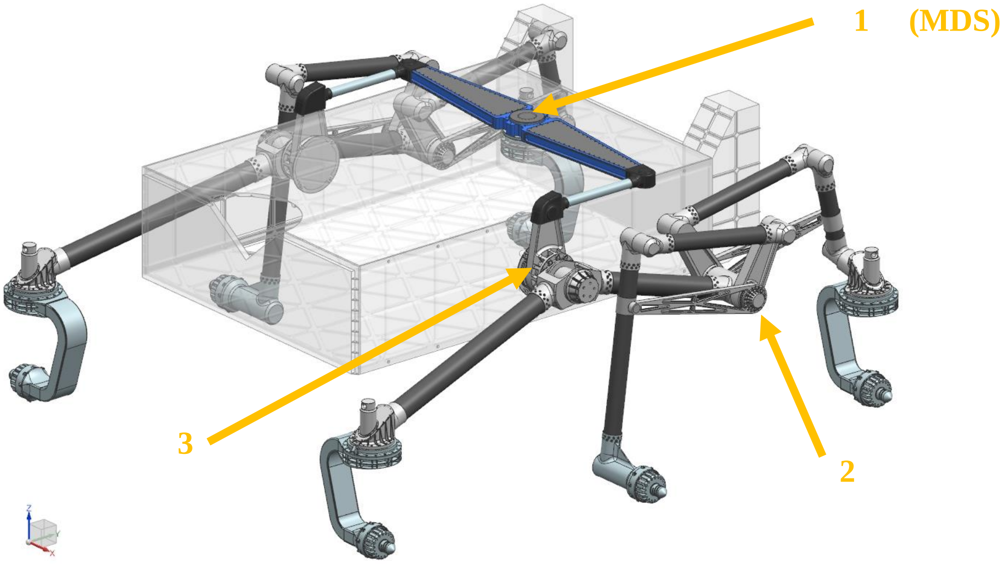


Element	Value
r	50 mm
L_1	80.00 mm
L_2	34.64 mm
L_3	26.83 mm
L_4	69.79 mm
δ	59.85°
F_2	1.4 N
α_2	87.38°

(Kim et al., pg.418)

Magnetic Dampening System (MDS) :

Due to the extreme operating environment and the inability to perform maintenance, using traditional dampeners on a mars rover is not possible. Therefore this rover utilizes a natural physical phenomenon known as eddy currents or (magnetic braking) to dampen the suspension. The electro magnetic dampening system is positioned at the center pivot of each joint and at the differential between the right and left suspension systems. Finally, all dampeners are connected to a central traction control system that automatically increases or decreases the electromagnetic field, which increases or decrease dampening dependent on the situation.



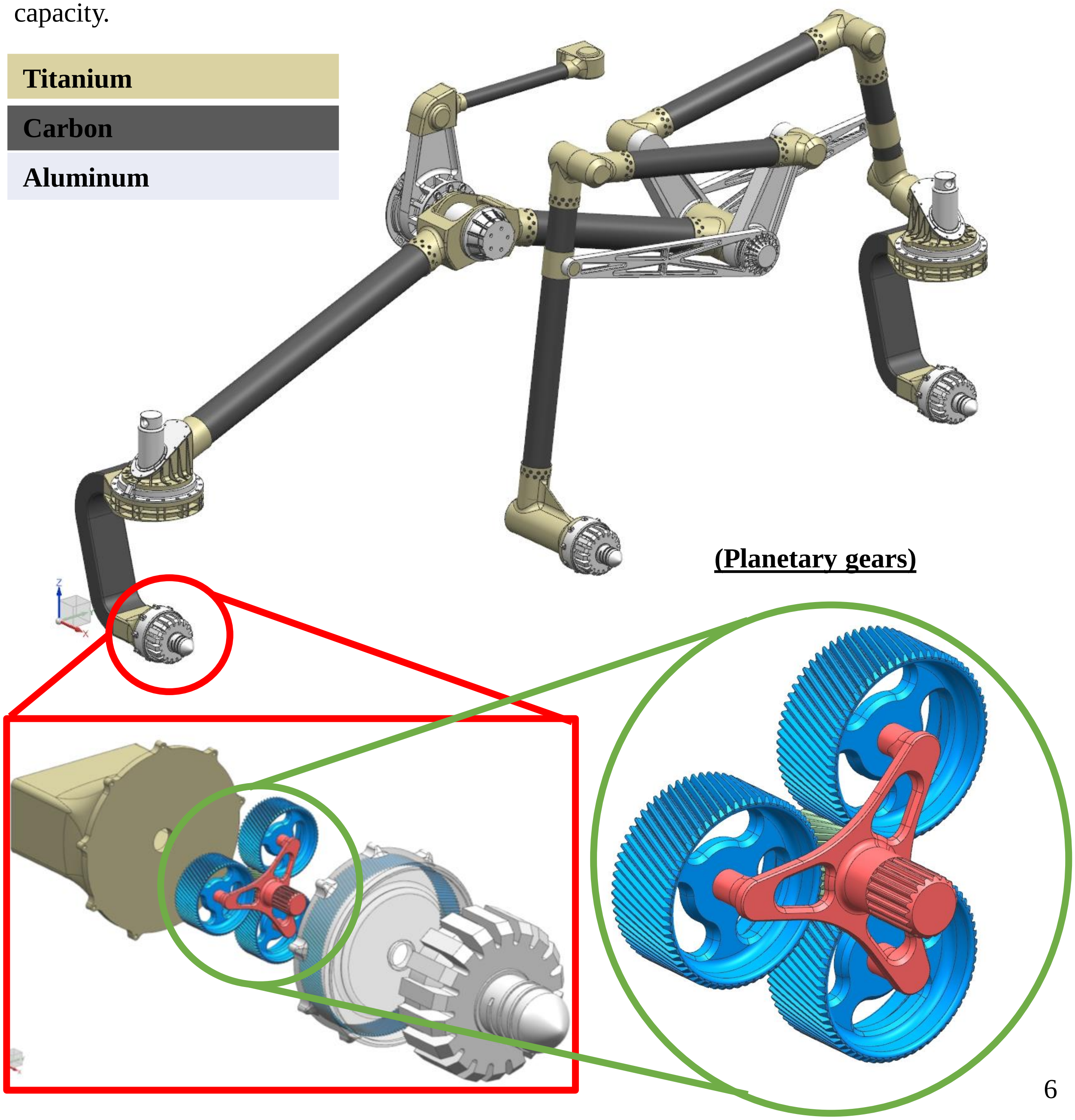
Mobility System Continued:

Suspension construction:

The suspension system is constructed from filament wound carbon booms bonded and riveted to machined titanium joints and payouts. Carbon and titanium were chosen because of their high strength to weight ratio. By reducing the weight of the rover there is a reduction in rocket fuel costs. Titanium was specifically chosen to reduce the chance of galvanic corrosion that occurs when metals are bonded to carbon. The vertical “knuckles” of the suspension are also made from carbon graphite composite. By using carbon in the suspension system small vibrations are absorbed and further contribute to overall dampening.

Gearing:

In-hub epicyclic gearing (planetary gears) are used to provide adequate torque and torque capacity.

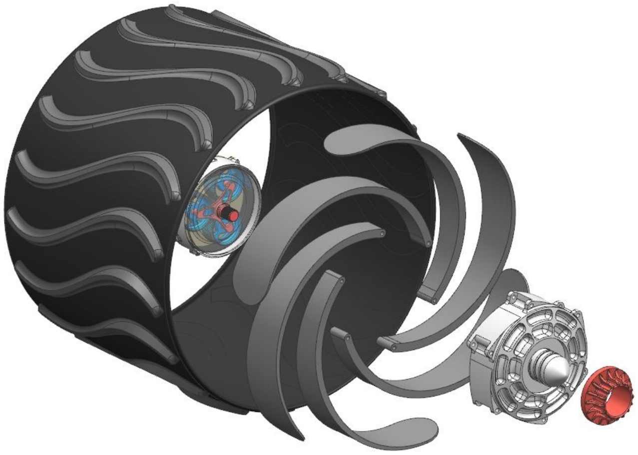


(Planetary gears)

Mobility System Continued:

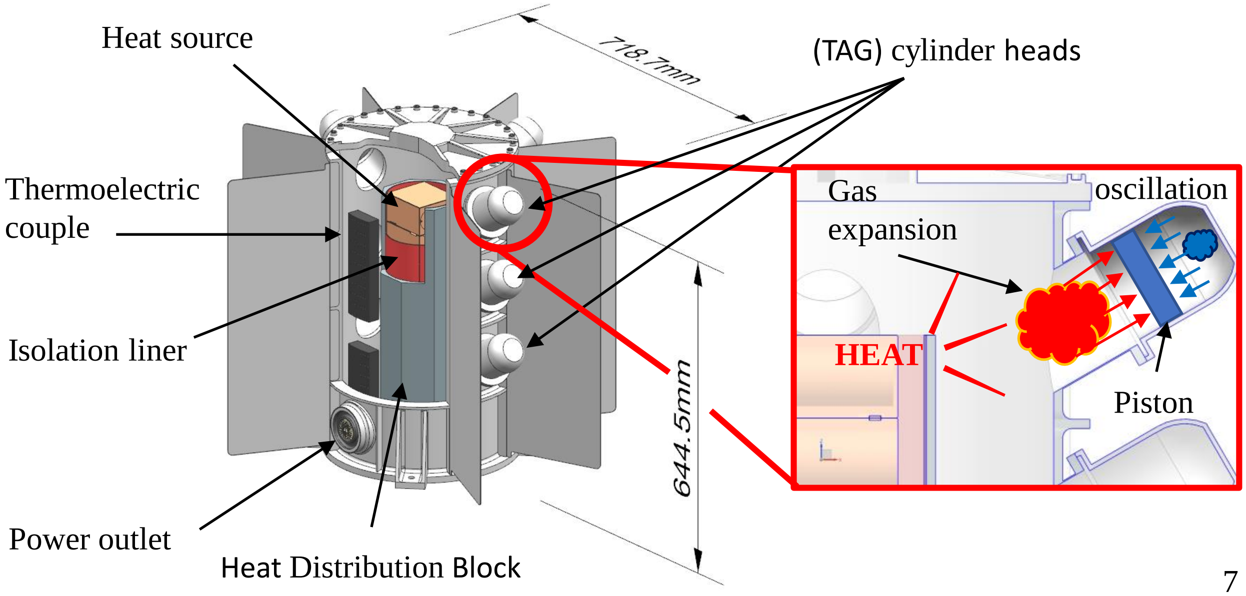
Wheels and Hub:

The exterior of the wheels are machined from 6061 T6 aluminum. The tread on the wheel is machined to use a “dual scoop” pattern so that the tires scoop material in clockwise and counter clockwise directions. Inside of the wheel are 6 flexure shaped carbon fiber leaf spring spokes which provide wheel support and in-wheel suspension. The wheels are fastened using a high pitch thread and a center axel nut. This method is utilized in formula 1 racing for quick detach and attachment. This design was chosen for the rover in hopes of future repair missions by additional rovers that would perform in-situ wheel replacement. Having systems designed for easy repair will allow us to resurrect past missions and increase our automated presence on Mars.



Power Source:

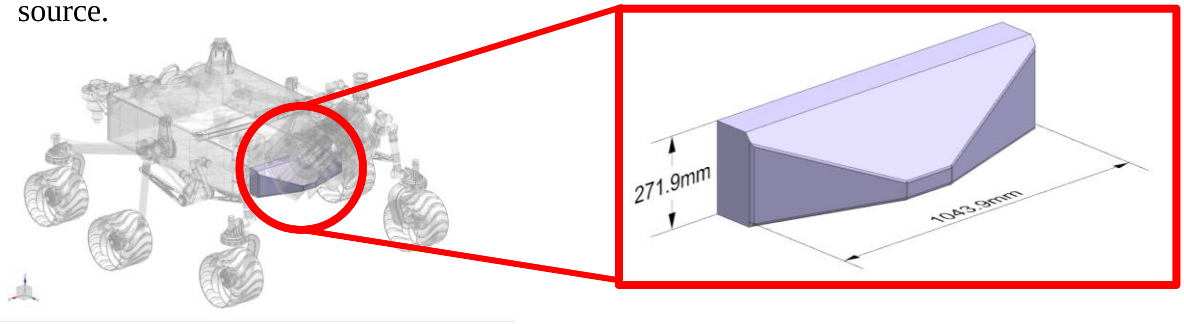
The power source selected for the rover is the Enhanced Multi-Mission Radioisotope Thermoelectric Generator (EMMRTG), created by the United States Department Of Energy. This system has been slightly modified for increased efficiency by the addition of 12 thermo acoustic electric generators (TAG). The generators utilize pistons that oscillate across a linear alternator transferring motion to electric current (Alary, Didier, et al.,pg.1).



Instrument Package:

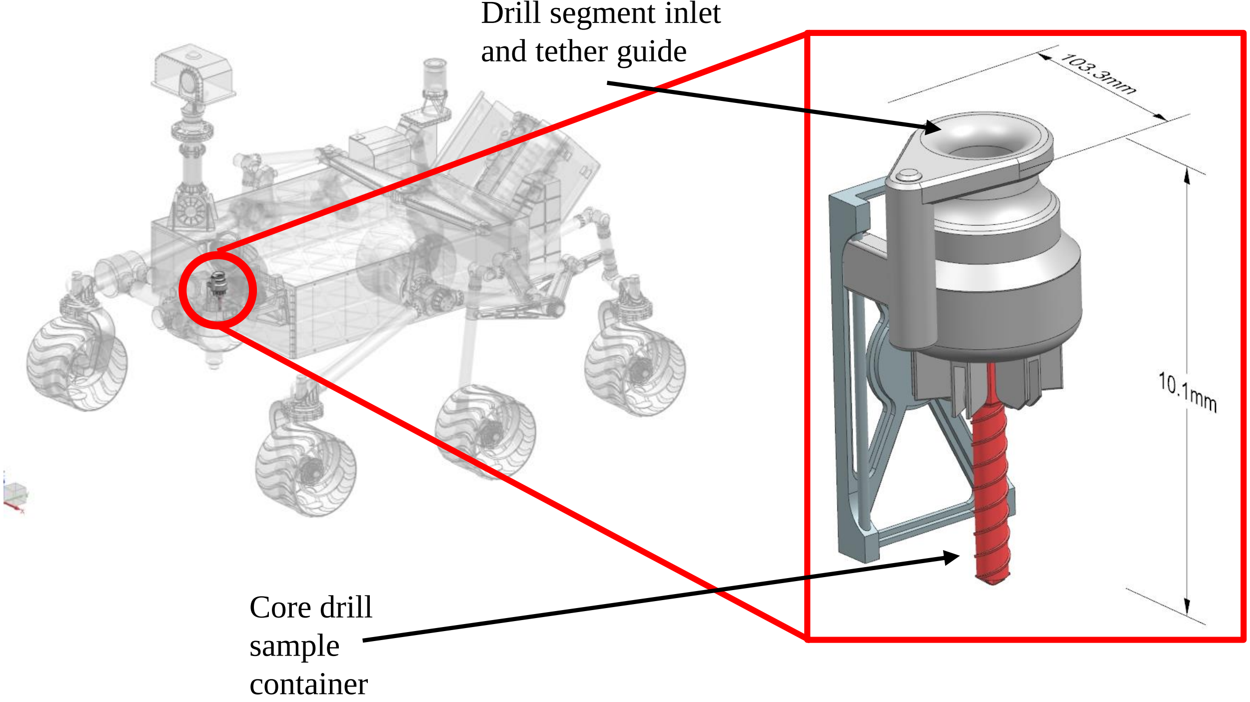
RIMFAX:

RIMFAX is a ground penetrating radar component that is used on the Mars 2020 rover. This component was chosen because its function directly supports this rovers primary objective of finding sub surface moisture. The RIMFAX radar can detect water and ice up to 30 meters, depending on the material it is scanning through. The data provided by this piece of equipment will also guide the mission to the most promising deep drill location where quality samples can be obtained. The radar is located at the AFT of the vehicle under the power source.



Deep Drill:

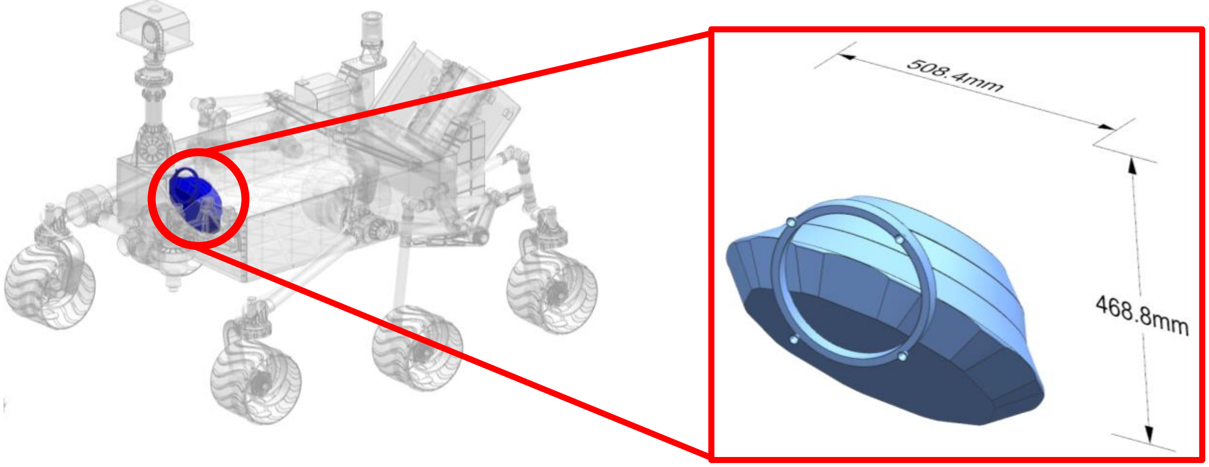
A Deep drill system, inspired by Honeybee Robotics/Planetary Society, is utilized at the end effector of the rovers robotic arm mechanism. The Deep drill is comprised of multiple drill sections that are assembled as the drill bores further into the Martian sub-surface. Once the drill cycle is complete, the drill is retracted using a winch and the Planetary society's Kevlar tether. Each drill segment is its own sample container. These sample containers are hermitically sealed to preserve any moisture that may be in the soil sample (“Planetary Deep Drill.” *Honeybee Robotics).*



Instrument Package continued:

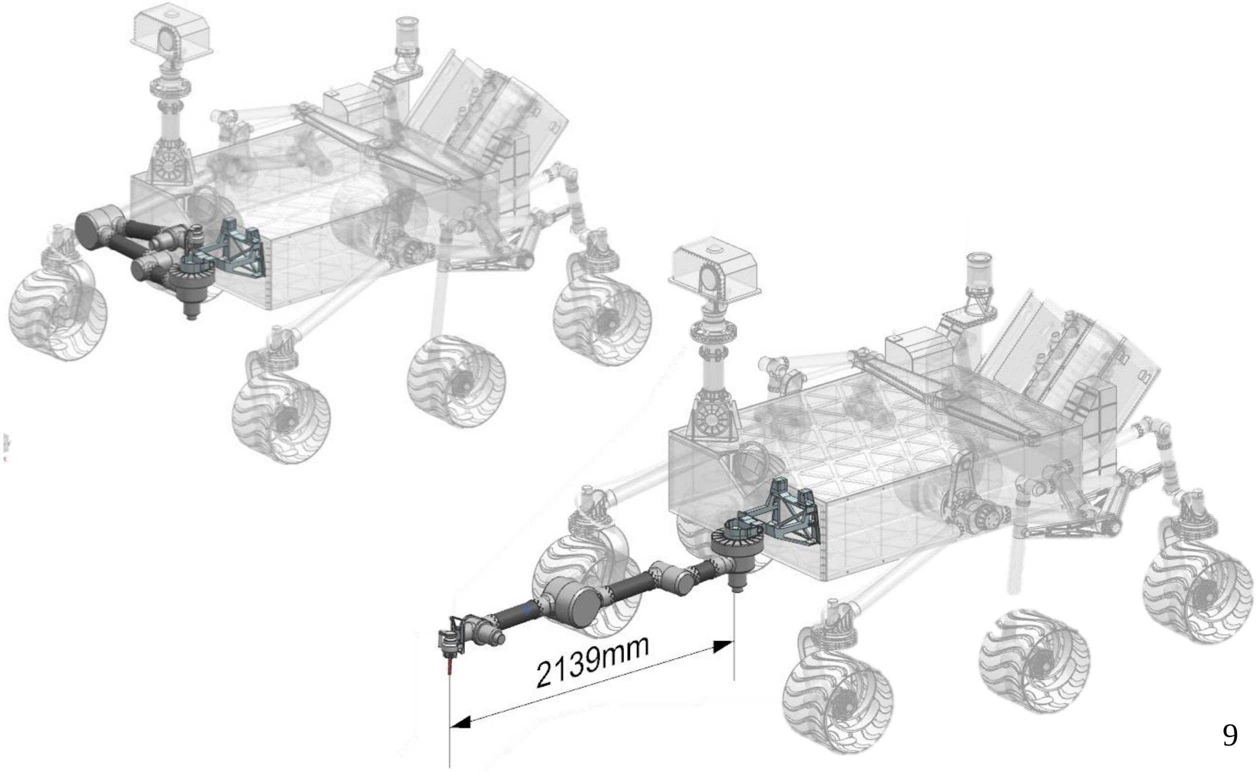
Sample manipulation and analysis station :

The sample manipulation and analysis station is located in the FWD section of the rover and is partially inside of the body. The station's carousel extends outside of the body for the robotic arm to access and dispense drill section/sample containers. Inside the body of the rover each sample container is cached along with a control sample for accurate data analysis. All data from the scientific analysis is logged and saved on the rovers internal memory.



Robotic Arm:

The robotic arm is a 6 degree of freedom heavy lift robotic arm mounted on the FWD face panel of the rover chassis. Its primary function is to assist the deep drill process and deliver samples back to the sample analysis station.



Computer Hardware:

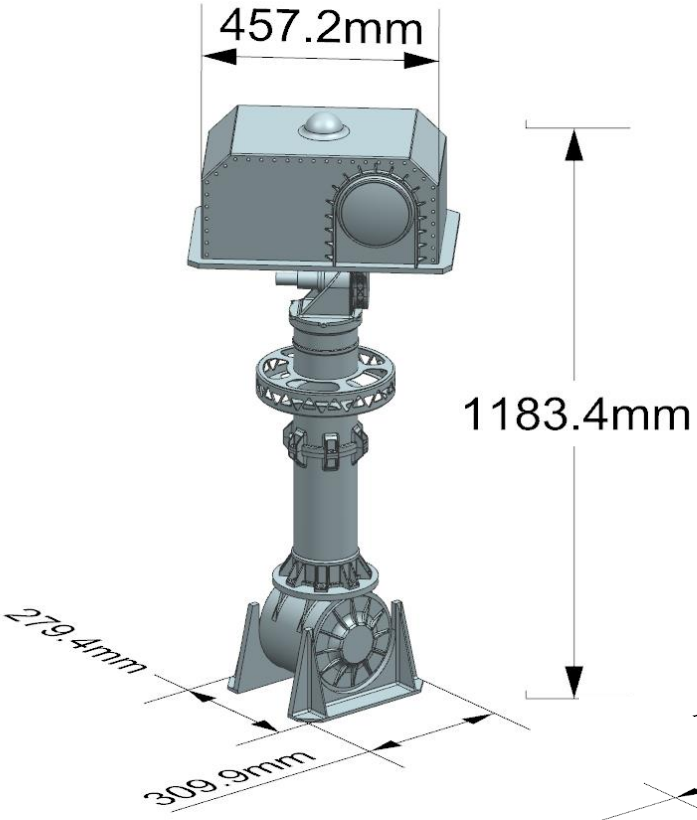
The rovers computer is a radiation hardened computer that runs a Linux operating system. The computer is the central unit where all the data is processed. All of the systems the rover has are controlled by the central computer, from its traction control system and motor operations, to its scientific instruments.

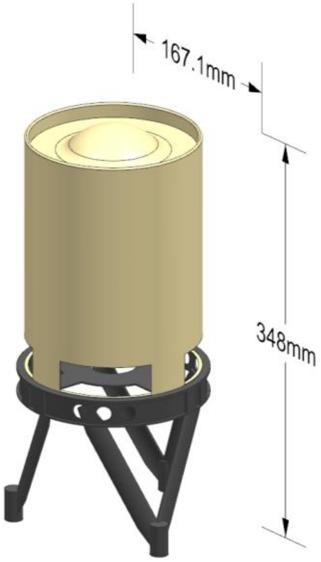
Communication and Navigation hardware:

The main form of communication is a ultra high frequency antenna(UHF) located on the top AFT panel of the craft. The UHF is in direct connection with the Mars orbital support satellites, which relay communications from earth to the rover and back. The rovers navigation instruments are all located on the mast in the form of a 360 camera and a Mastcam-Z, which was used on the mars 2020 rover. The 360 camera provides an over head or “birds eye view” so that rover operators can navigate the craft in third person view. All of the visual data is then processed by the onboard computer and analyzed so that the rover can navigate autonomously.

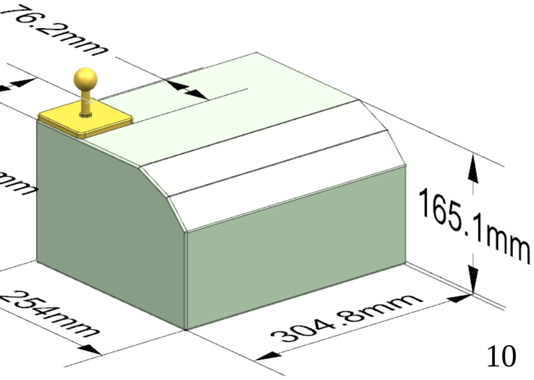
UHF

Mast Cam





Radiation hardened computer



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“We have seen further, by standing upon the shoulders of giants“ ~ Isaac Newton