

Habitable Mars Ascent Vehicle (MAV) Concept

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Introduction

NASA's ultimate goal is the human exploration of Mars. Among the many difficult aspects of a trip to Mars is the return mission that would transport the astronauts from the Martian surface back into Mars orbit. One possible conceptual design to accomplish this task is a two-stage Mars Ascent Vehicle (MAV). In order to assess this design, a general layout and configuration for the spacecraft must be developed. The objective of my internship was to model an MAV example concept design to support NASA's latest human Mars mission architecture trade studies, technology prioritization decisions, and mass, cost, and schedule estimates.

Background

NASA's latest plans for the first three human missions to Mars is described in the Mars Design Reference Architecture (DRA) 5, published in 2009. DRA 5 proposes to first send the Mars Ascent Vehicle (MAV) and Surface Habitat (SHAB) before sending any astronauts. When at Mars, the MAV would autonomously land on the surface and begin producing propellant for the return trip, while the SHAB would remain in Mars orbit. About 2 years later, a crew of 6 would be sent to Mars on a fast-transit trajectory in the Mars Transfer Vehicle (MTV). Upon arrival, the crew would rendezvous with the SHAB, descend to the surface in it, and leave the MTV in Mars orbit. The crew would then have approximately 18 months for exploration before going into the MAV to ascend back into Mars orbit, rendezvous with the MTV, and head back to Earth. DRA 5 details a promising strategy, but many issues still need to be addressed before such a mission is possible.

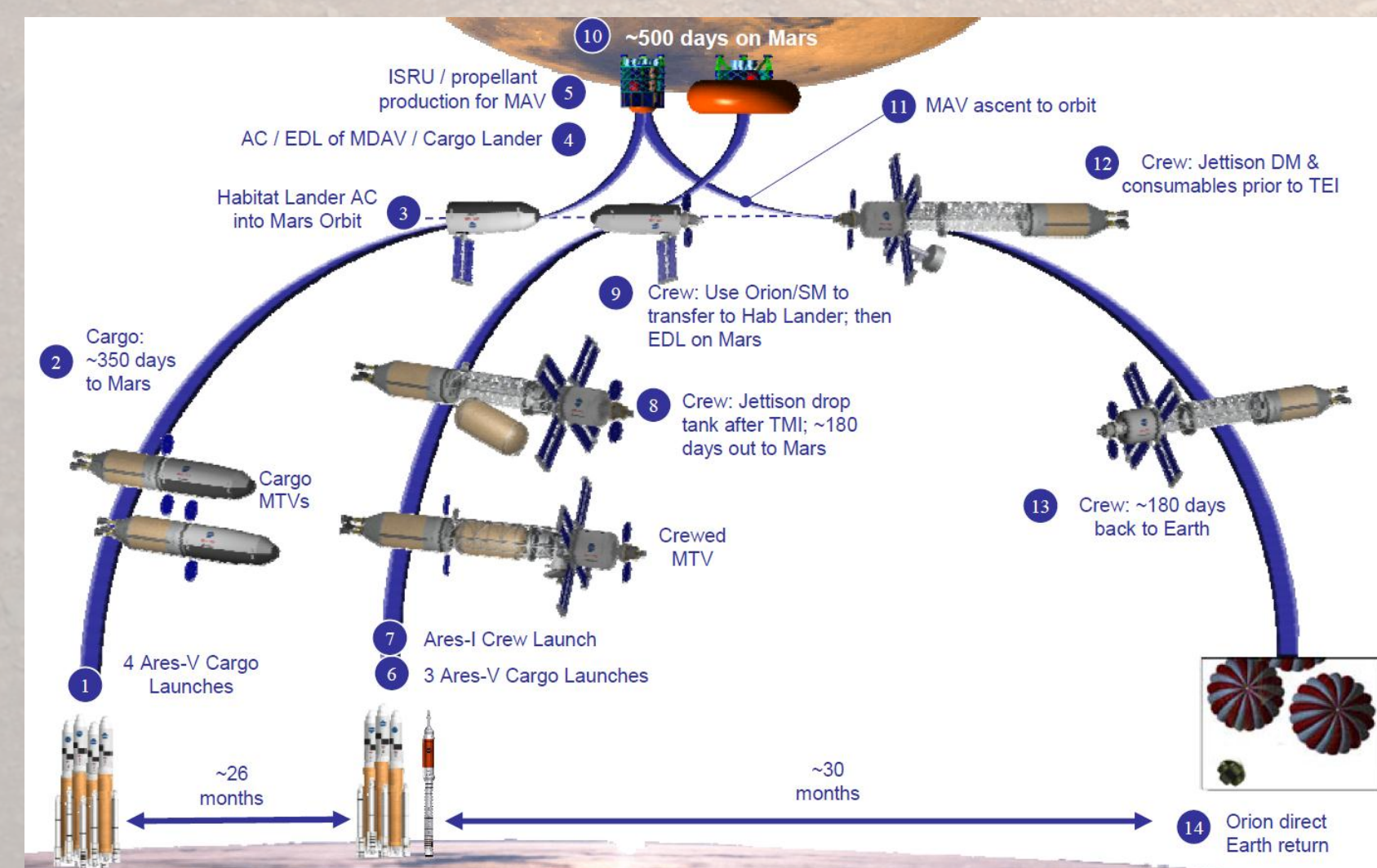


Fig. 1: Mars DRA 5 Mission Sequence Summary

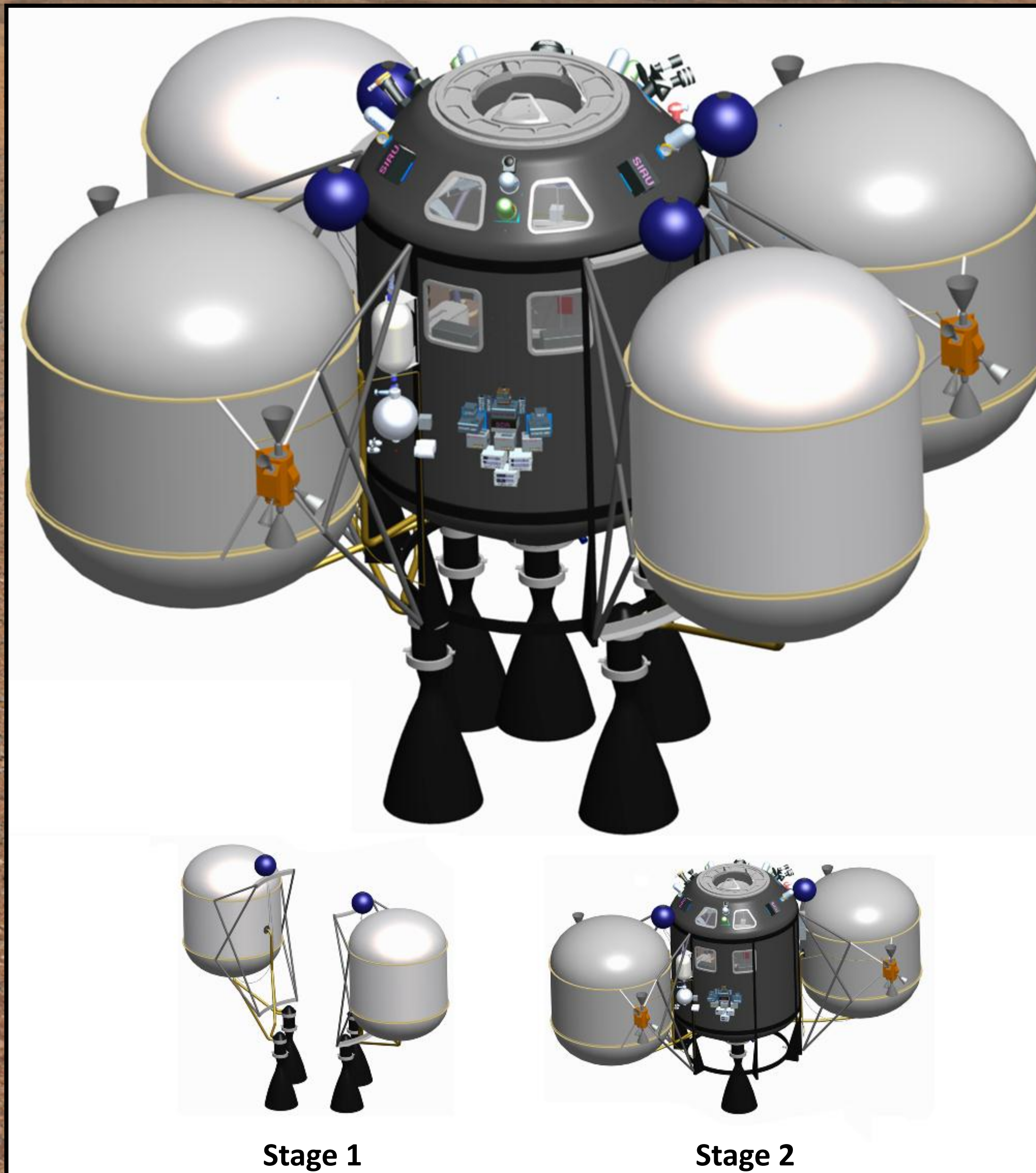


Fig. 2: Exterior View of the 2-stage Habitable Mars Ascent Vehicle

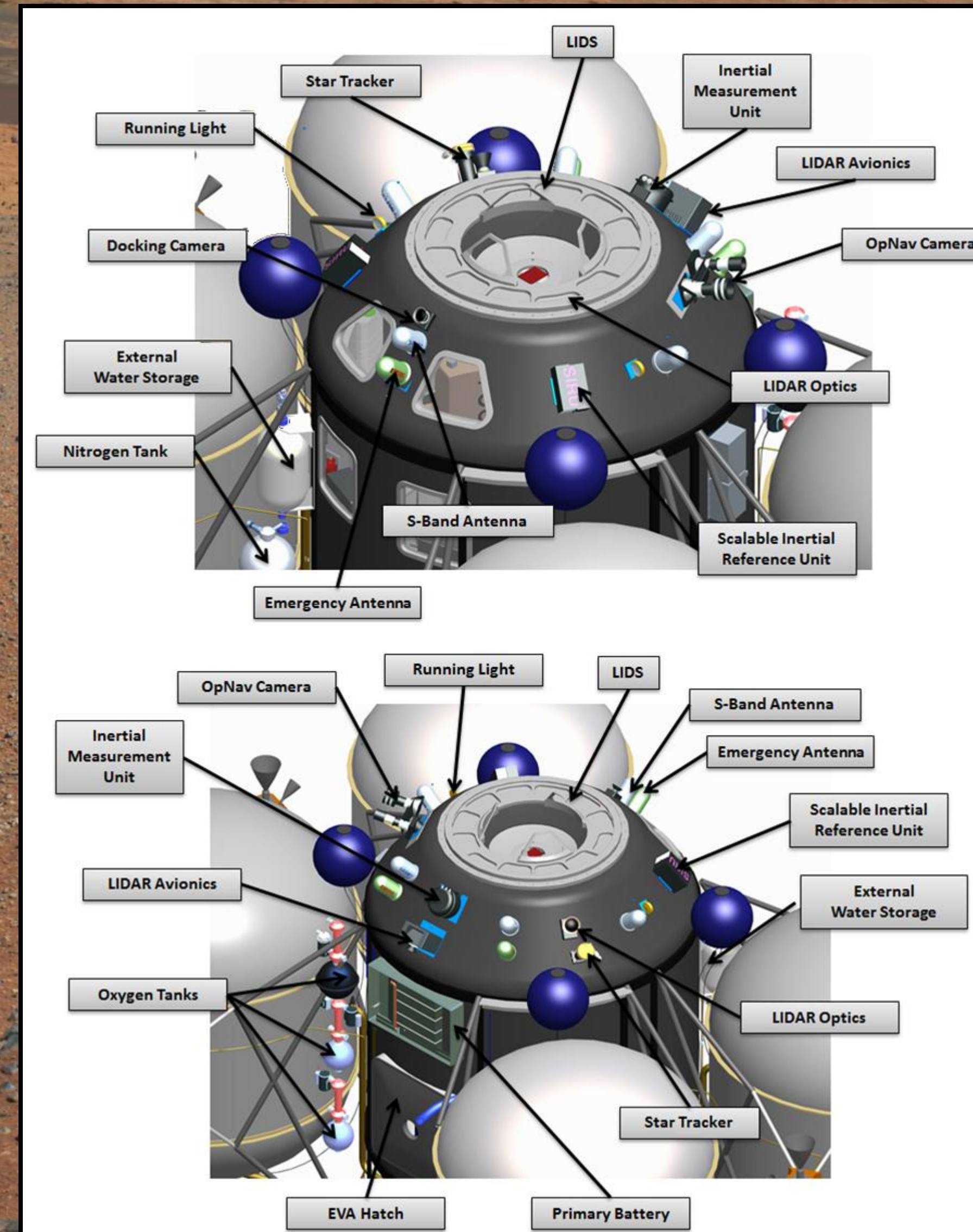


Fig. 3: Outfitting of Mars Ascent Vehicle

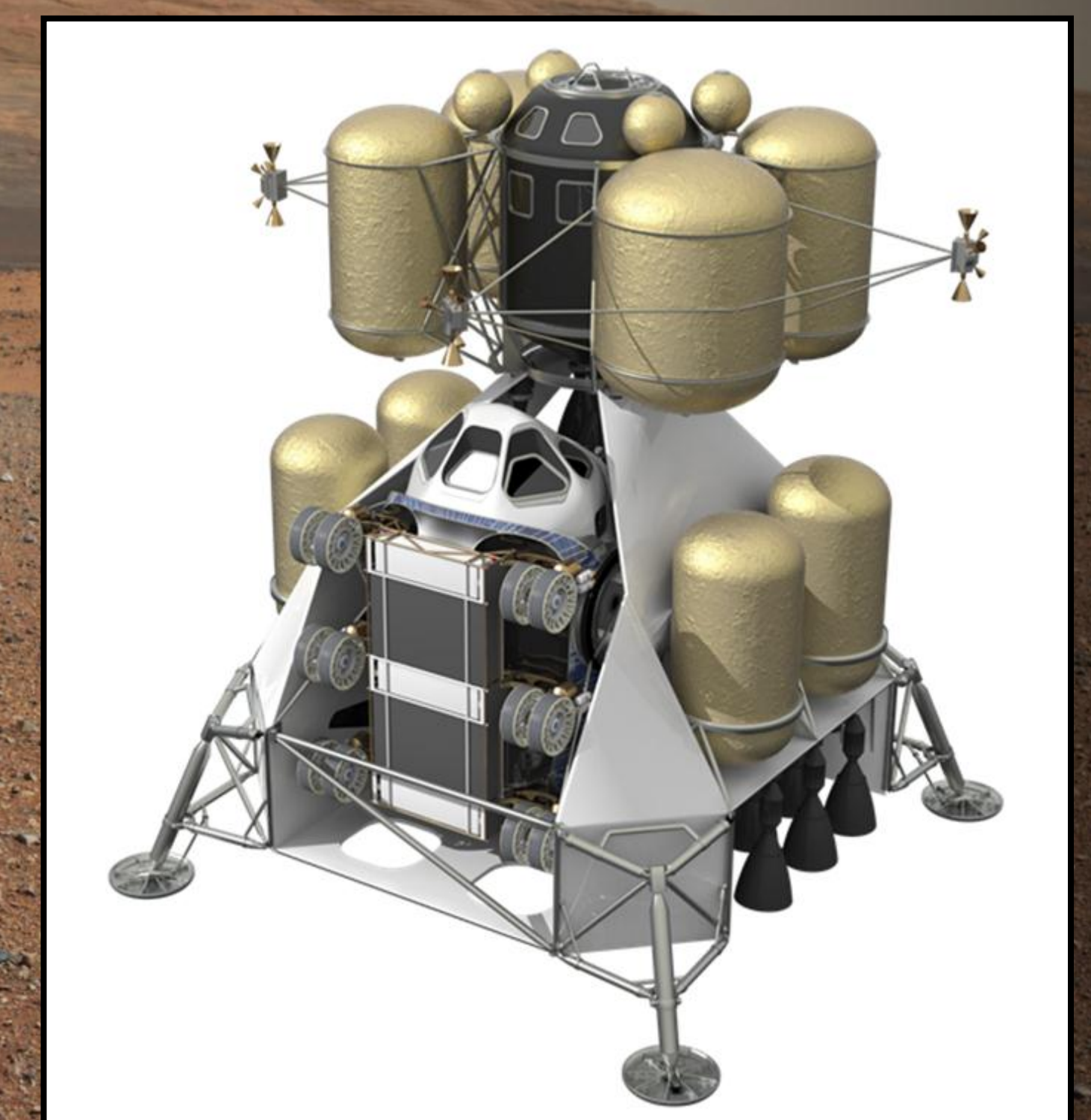


Fig. 4: MAV with the Descent Stage

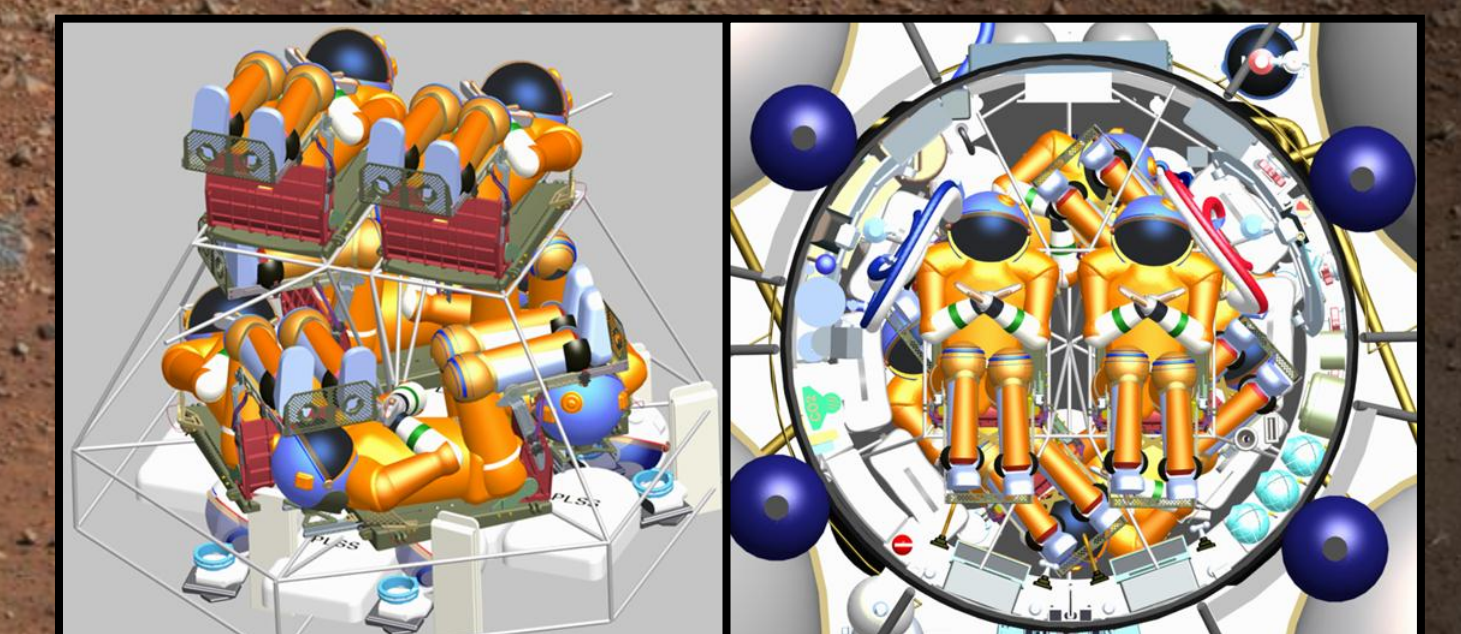


Fig. 5: Descent Configuration

Adding Habitability to the MAV

A significant drawback to DRA 5 is the MAV's long service life of 5 years. Almost 2 of those years are spent on the Martian surface without any human surveillance. If the MAV is damaged during this time, the crew could be stranded on Mars. A solution to this problem would be to convert the MAV into a habitable vehicle. Though it would be heavier, the habitable MAV could switch places with the SHAB in the DRA 5 plan and become a part of the crew lander. This way, it would only be on the surface of Mars while the crew is also on the surface.

The reason the MAV must be habitable for this to work is because the astronauts will need to spend about a week in the descent vehicle in order to acclimate to Mars' gravity after being in space for up to 225 days. Being habitable also allows the MAV to act as a secondary surface habitat instead of sitting idly during the 18 month surface expedition. Furthermore, this design would make the ascent trip (which could be up to 43 hours) much more comfortable.

Modeling the MAV

In order to visualize this example MAV concept, the layout and configuration was modeled in Creo Elements/Pro. The model includes more than 1500 components critical to the operation of the MAV. A model of a lunar lander concept called the Altair from NASA's Project Constellation facilitated the design. Physical specifications and dimensions were provided by a team from Marshall Space Flight Center. The MAV design needed to be compatible with their descent stage example concept design (shown in Figure 4).

The size of the propellant tanks, the close proximity of the 1st Stage to the rest of the vehicle, and the cramped descent configuration were the most obvious problems with the design. Adding habitability also increased the mass of the MAV, but it could potentially decrease mass of other mission elements, such as the surface habitat.

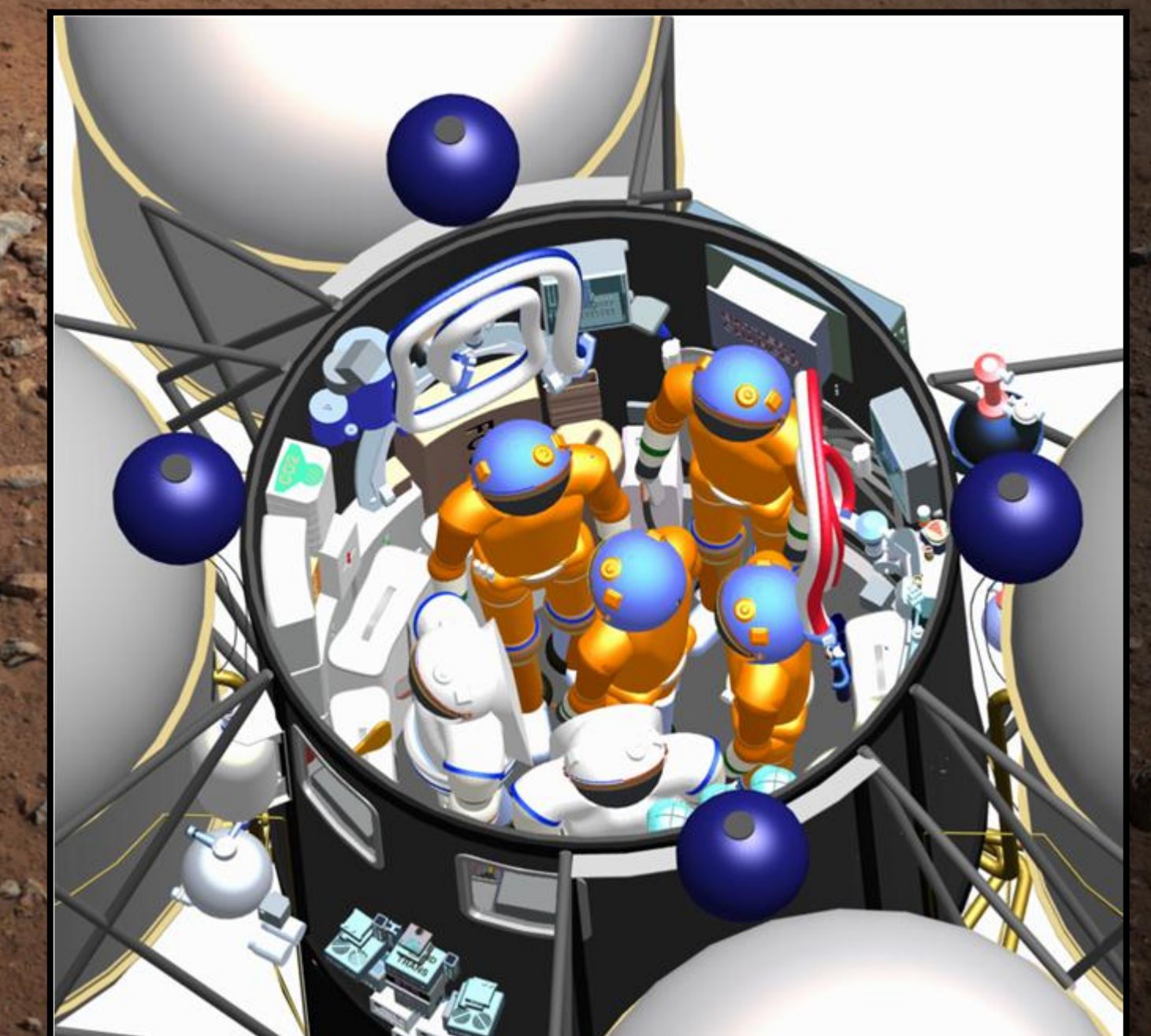


Fig. 6: Ascent Configuration

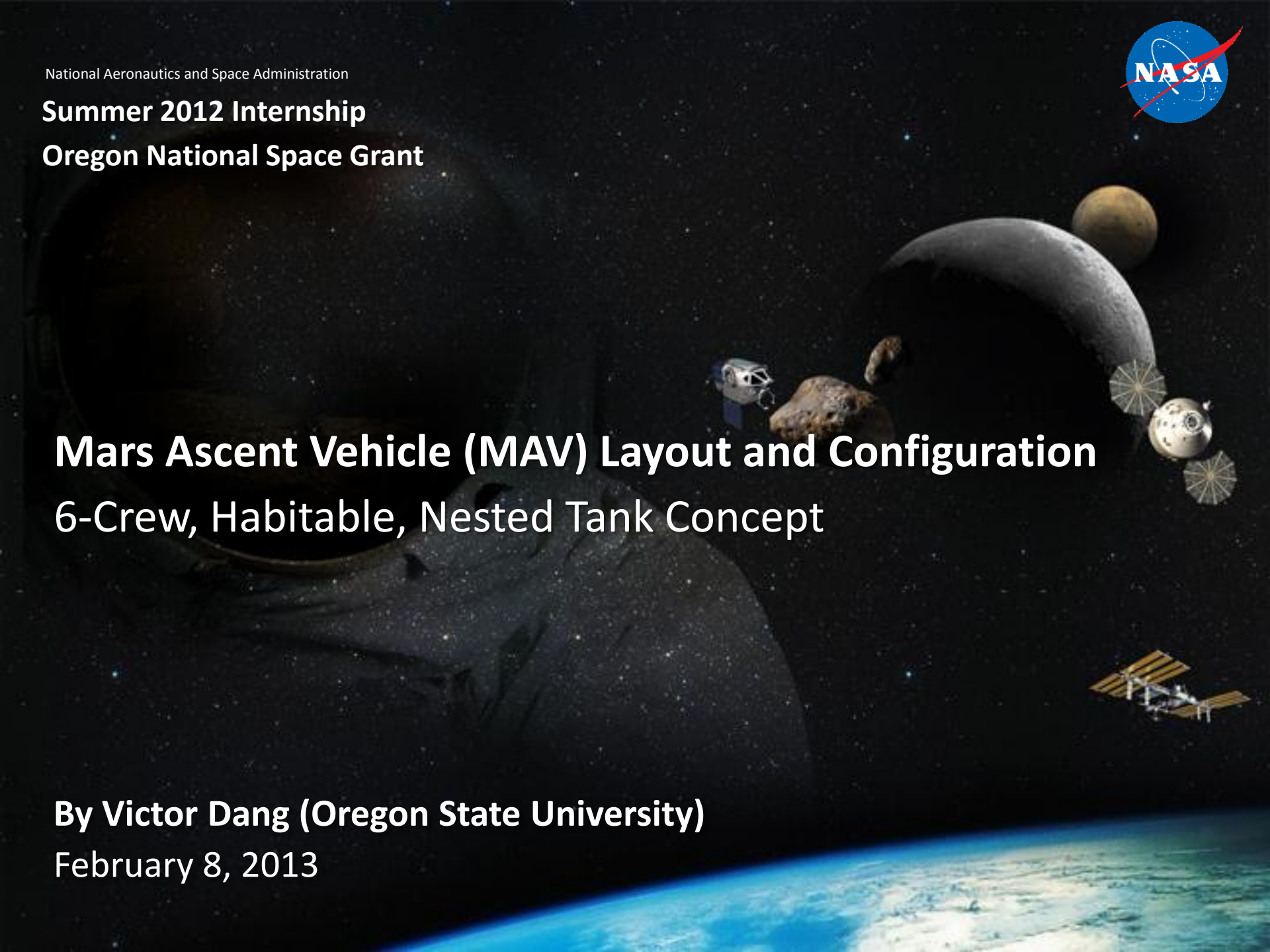
National Aeronautics and Space Administration



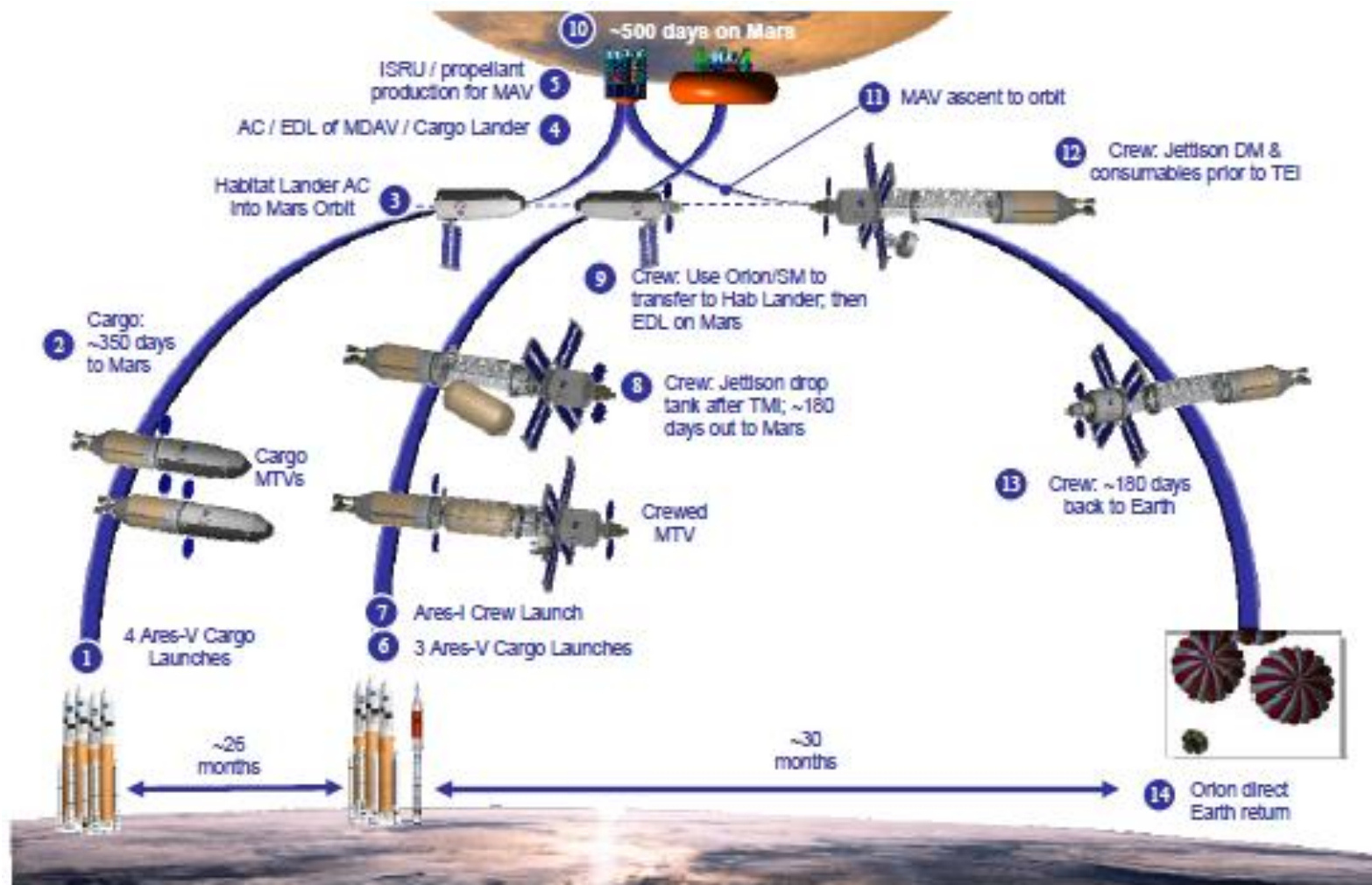
**Summer 2012 Internship
Oregon National Space Grant**

Mars Ascent Vehicle (MAV) Layout and Configuration **6-Crew, Habitable, Nested Tank Concept**

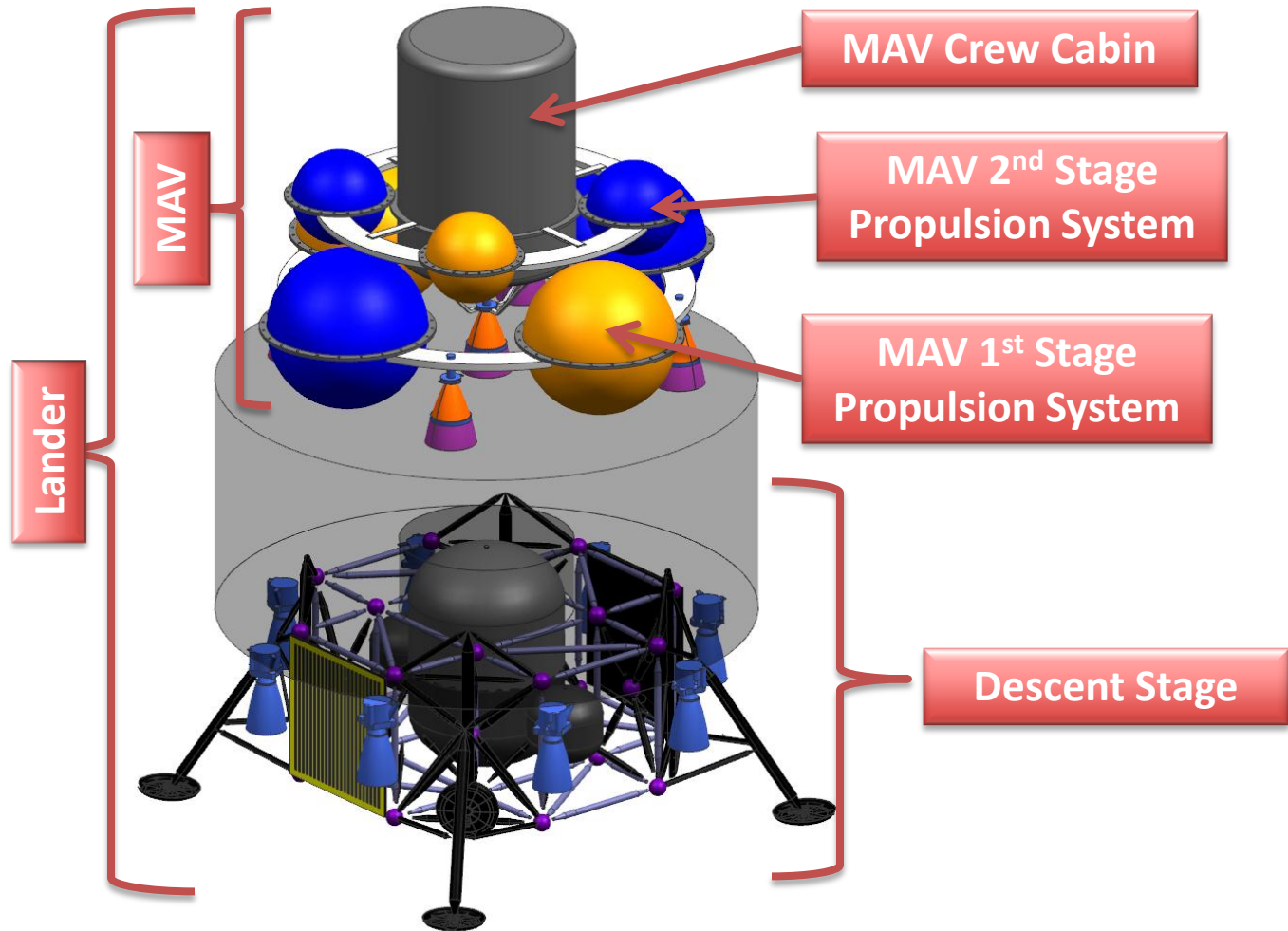
By Victor Dang (Oregon State University)
February 8, 2013



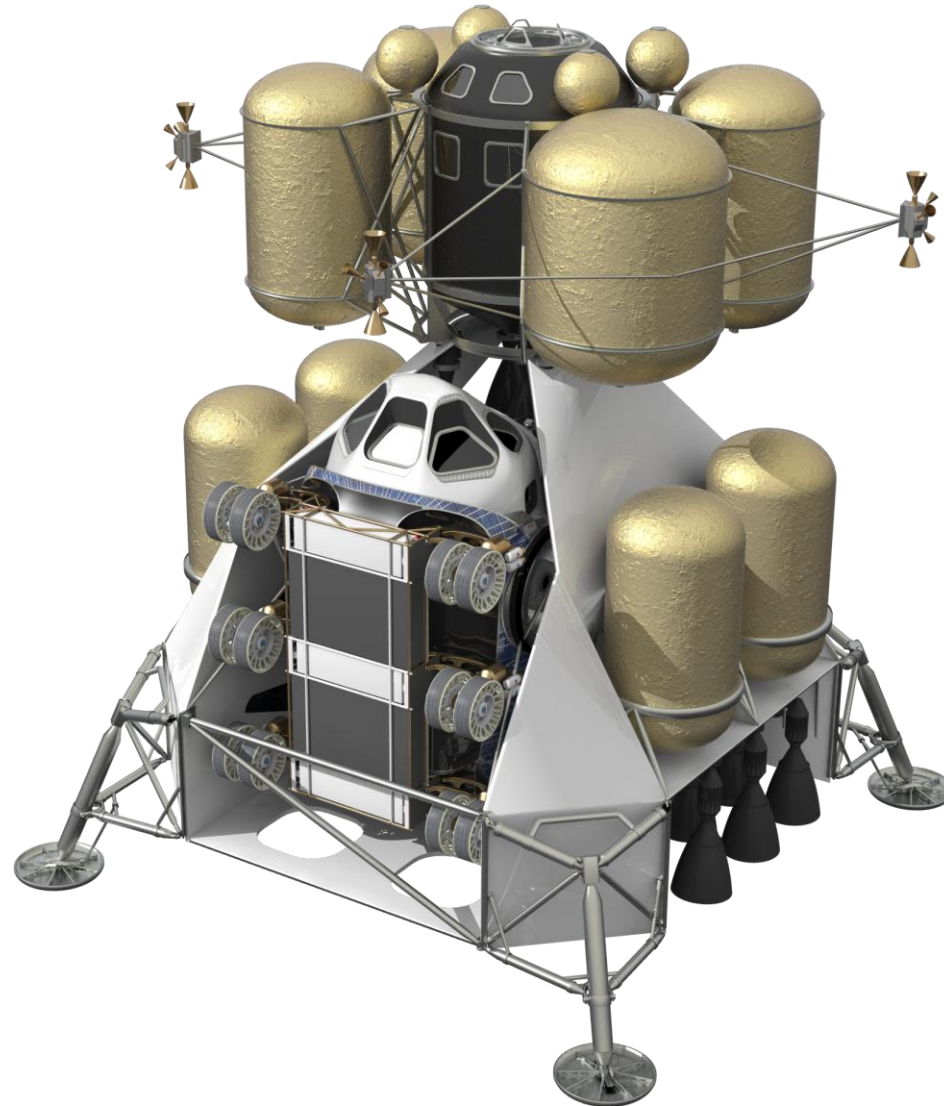
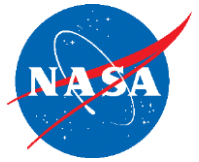
DRA-5 Mission Architecture



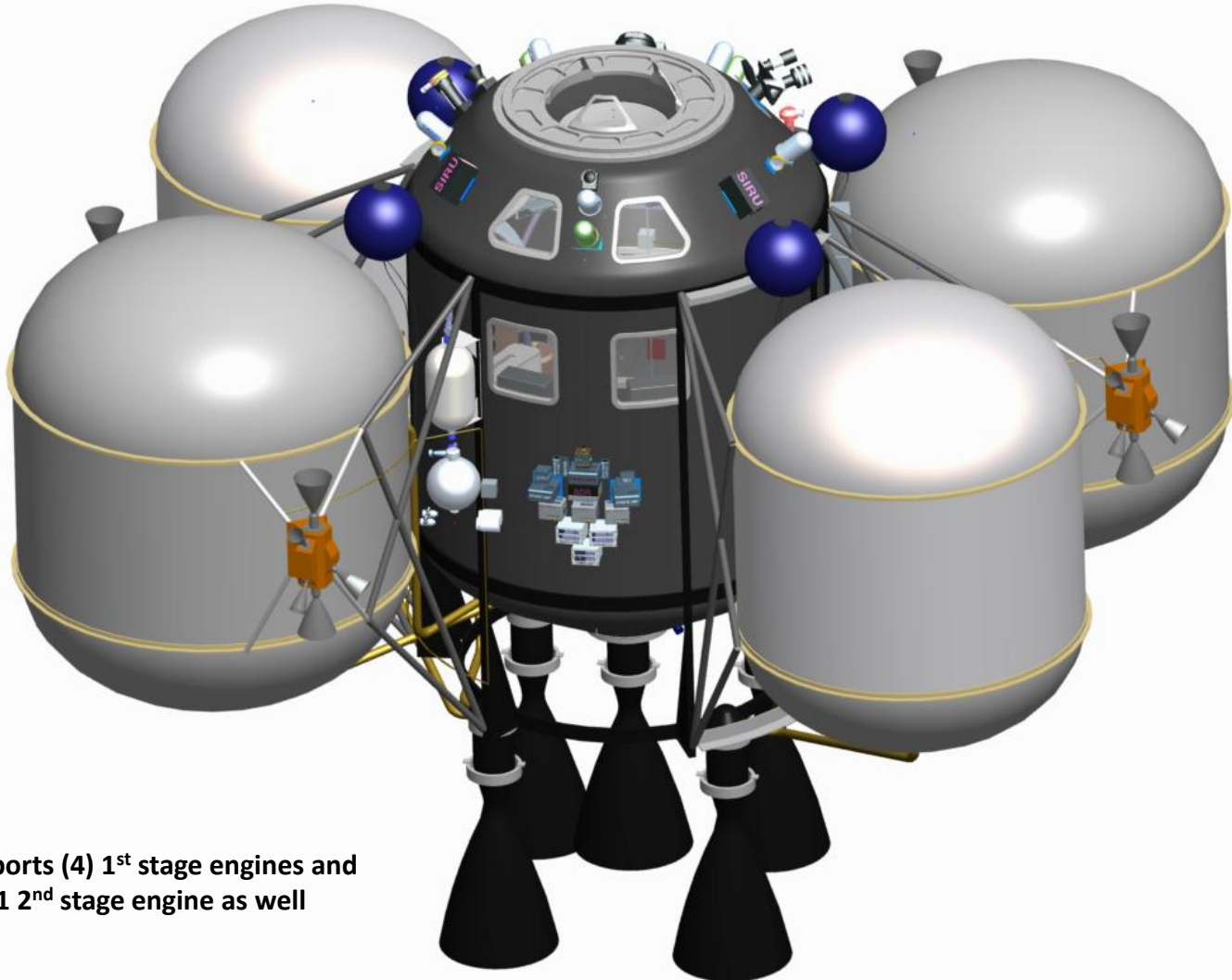
Mars Ascent Vehicle (MAV)



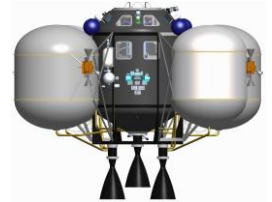
Mars Ascent Vehicle (MAV) Rendering



6 Crew Habitable MAV with Nested Tanks



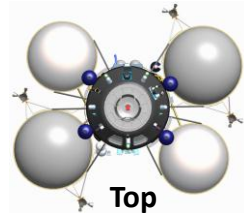
Supports (4) 1st stage engines and
1 2nd stage engine as well



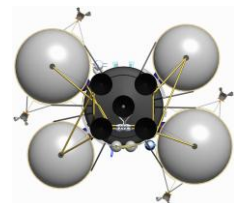
Front



Side

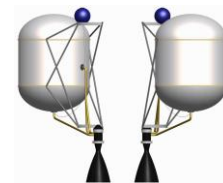
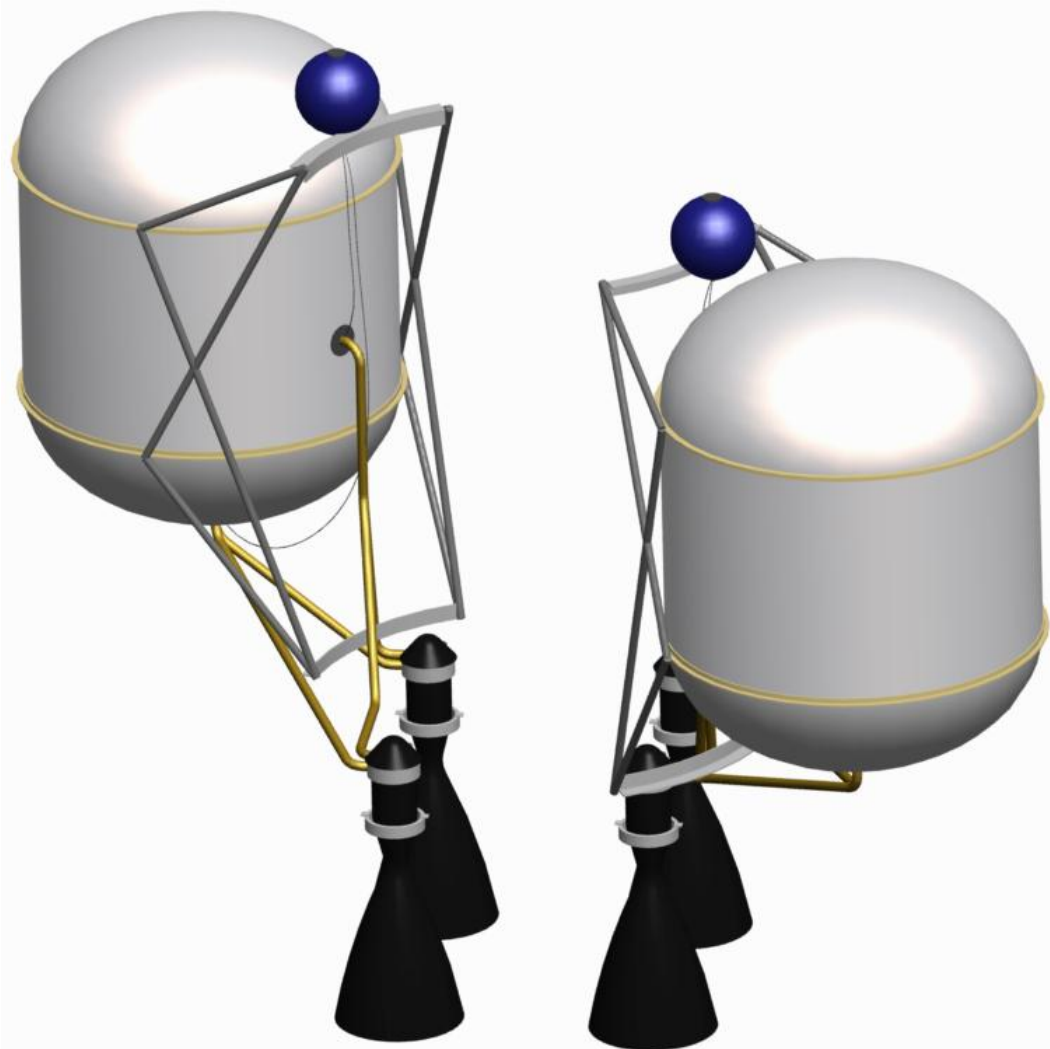


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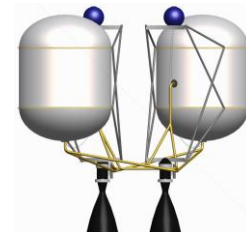


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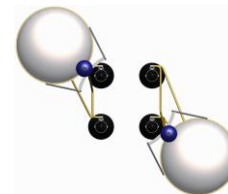
1st Stage Only (2nd Stage Blanked Out)



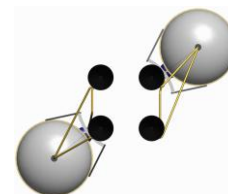
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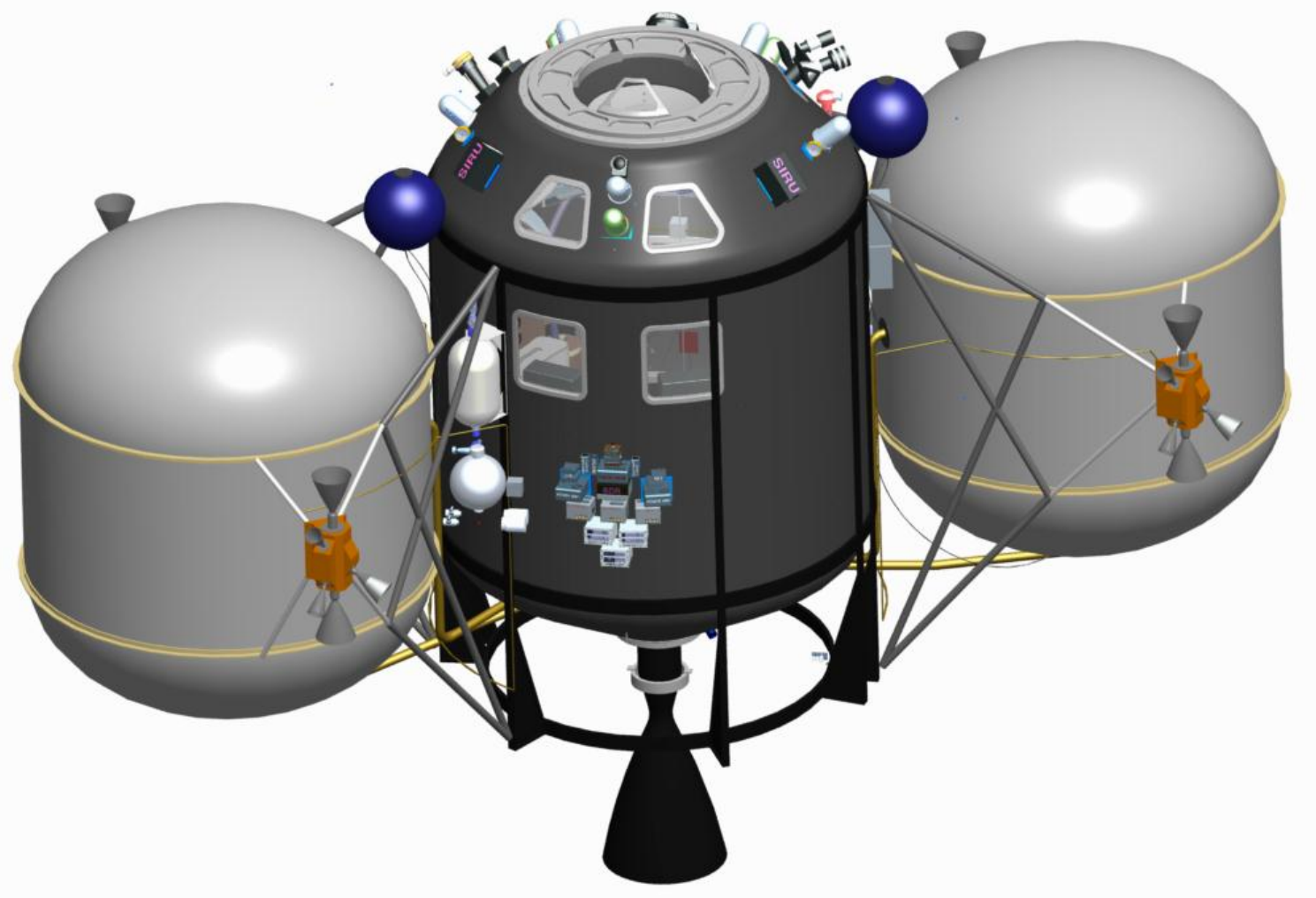


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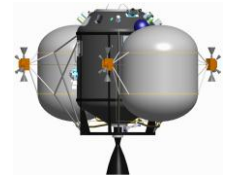


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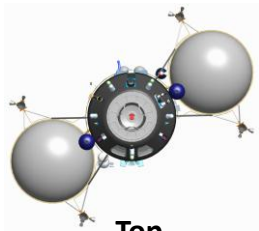
2nd Stage Only (1st Stage Jettisoned)



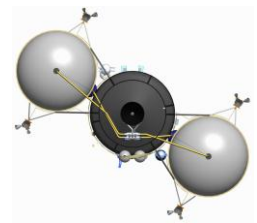
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Side

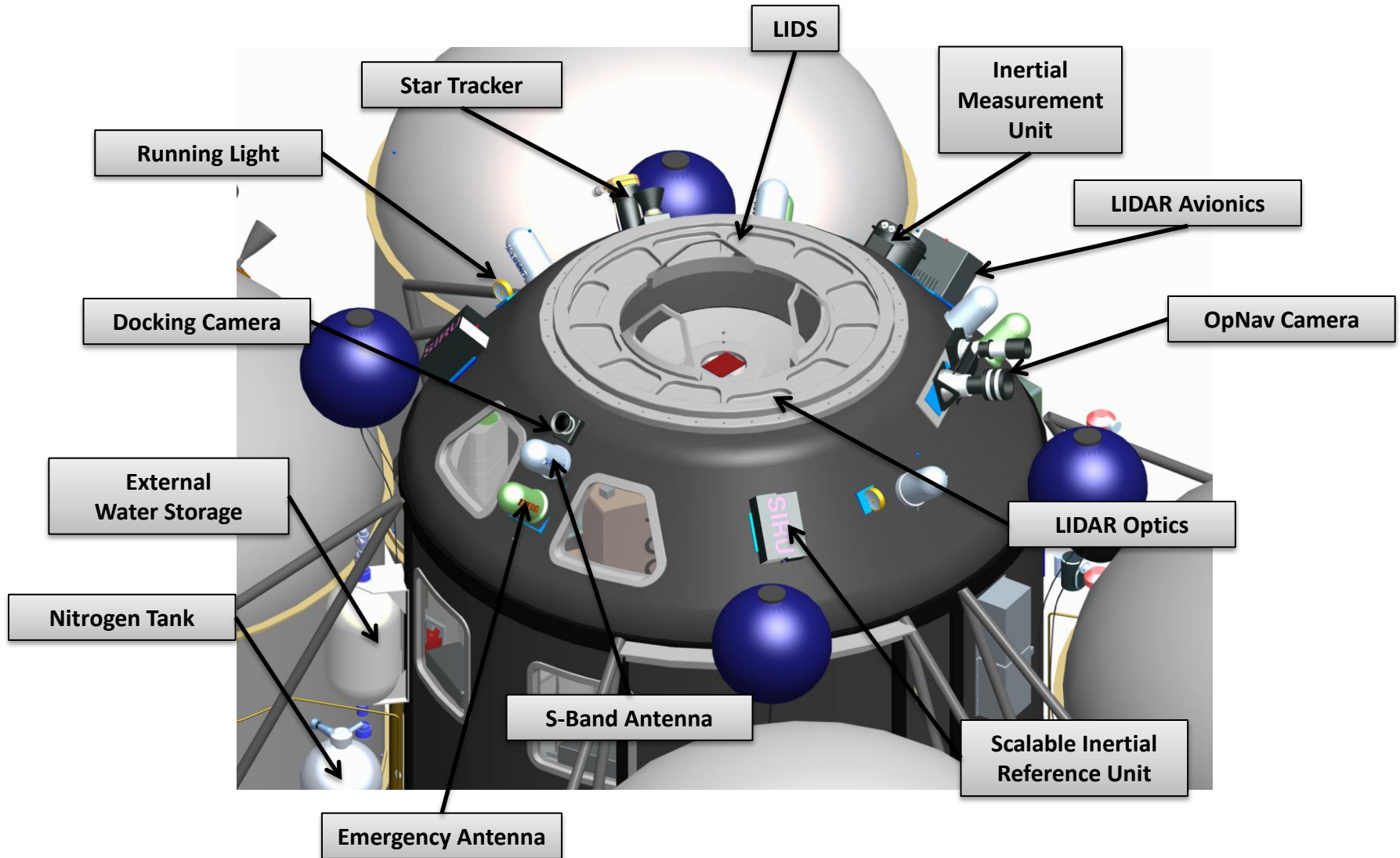


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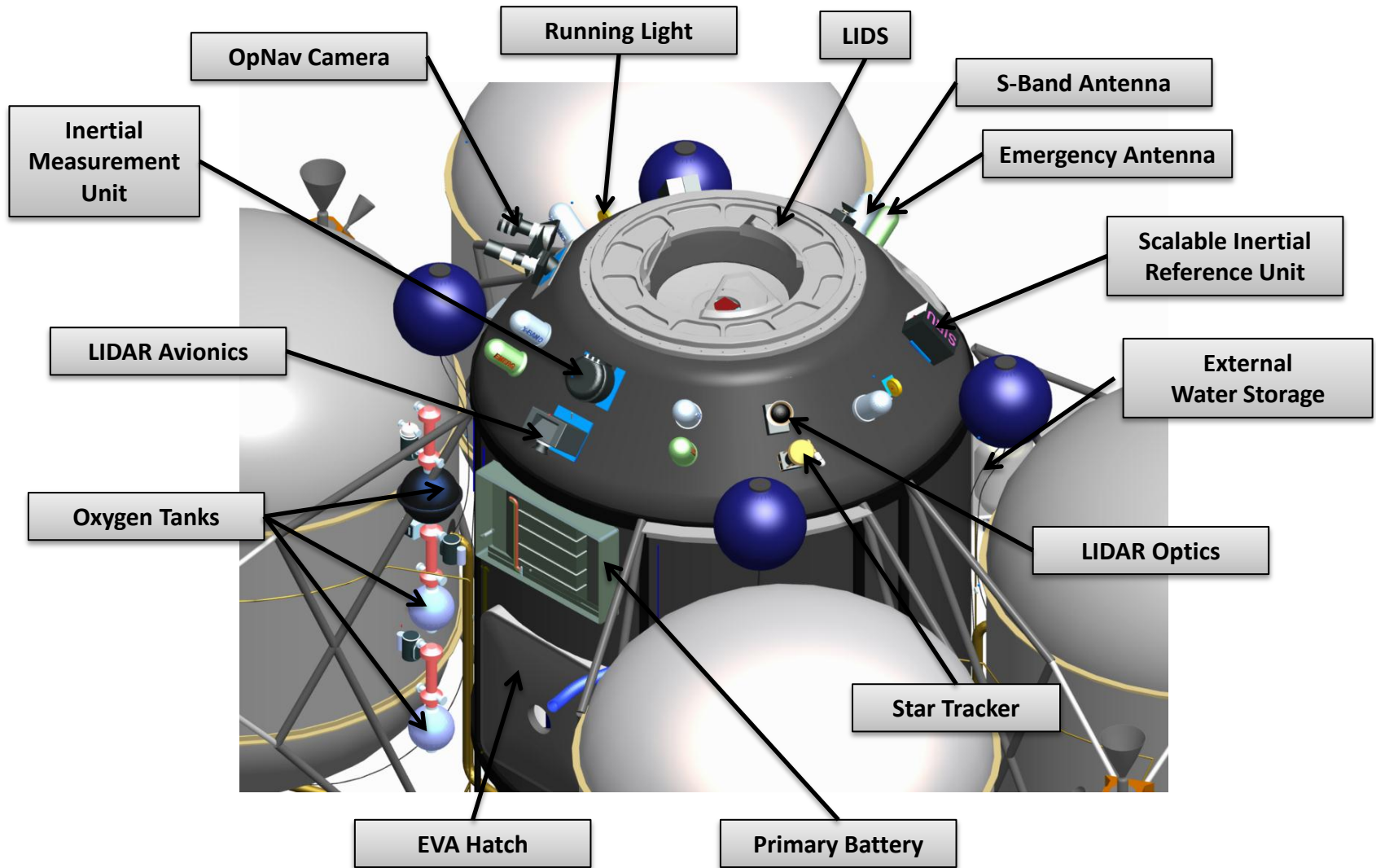


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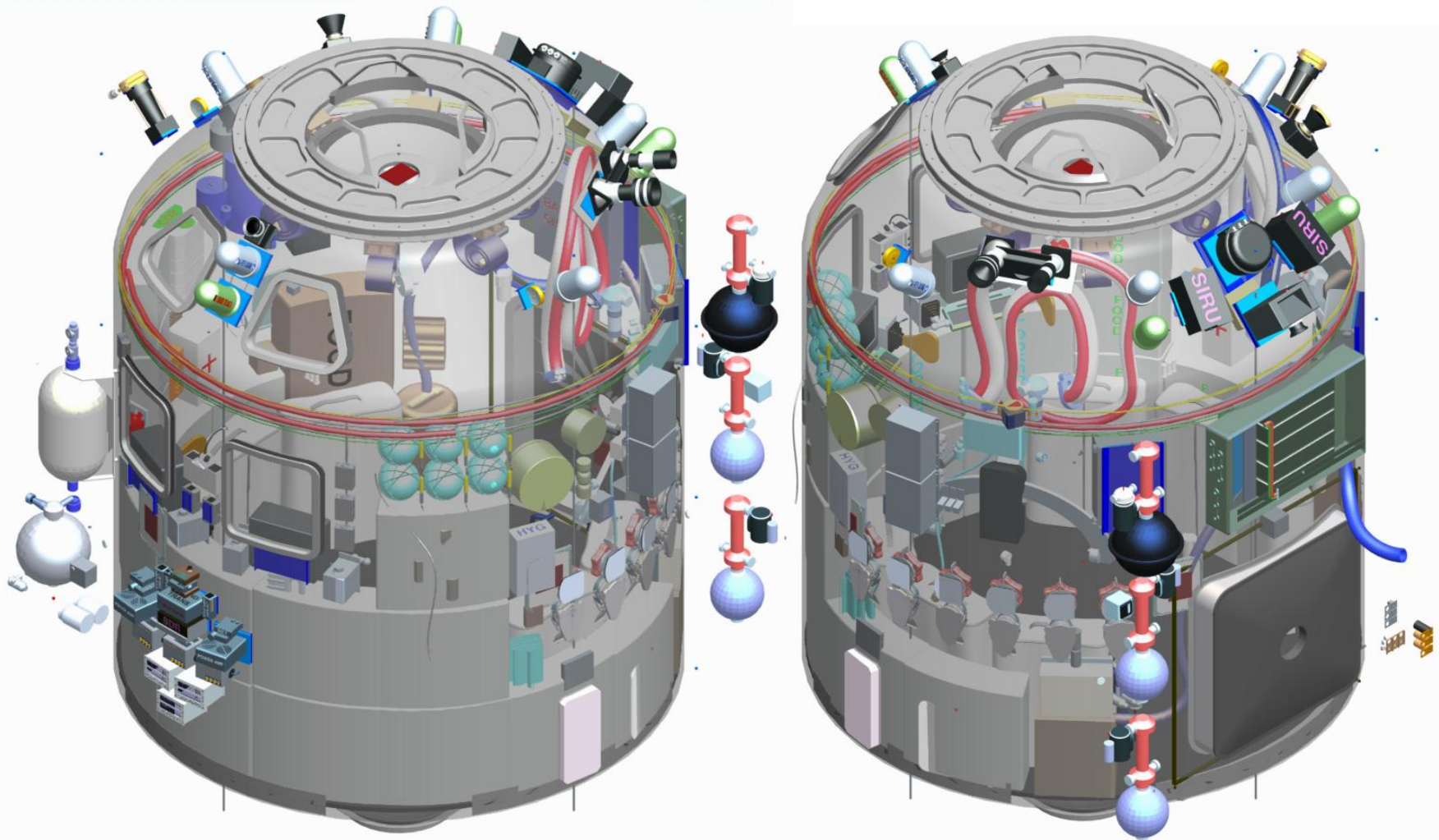
MAV Outfitting #1 (Front)



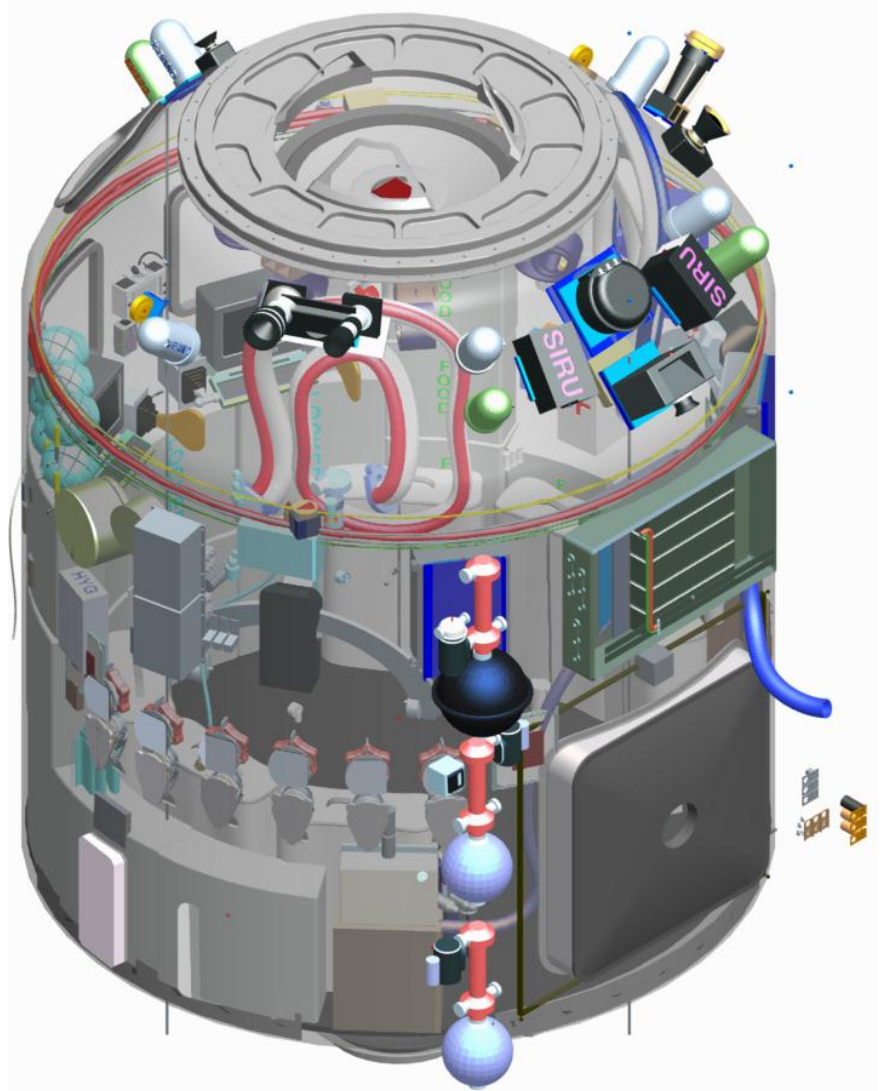
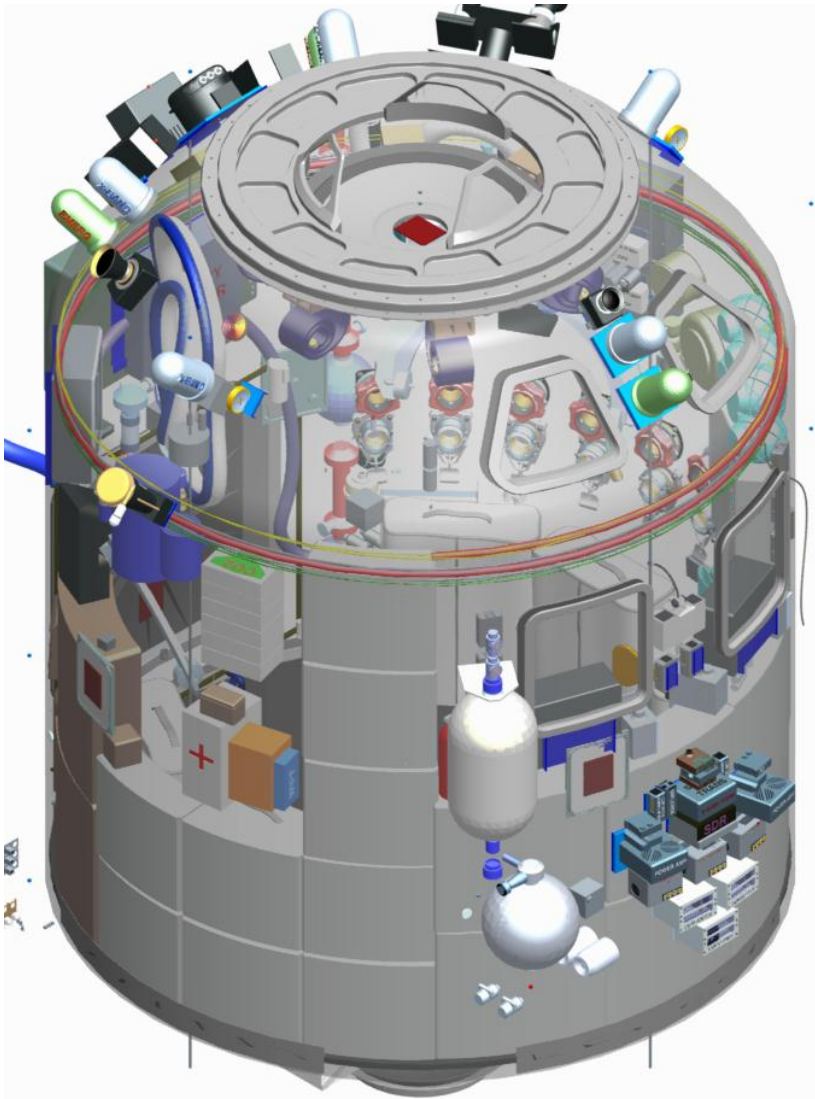
MAV Outfitting #2 (Back)



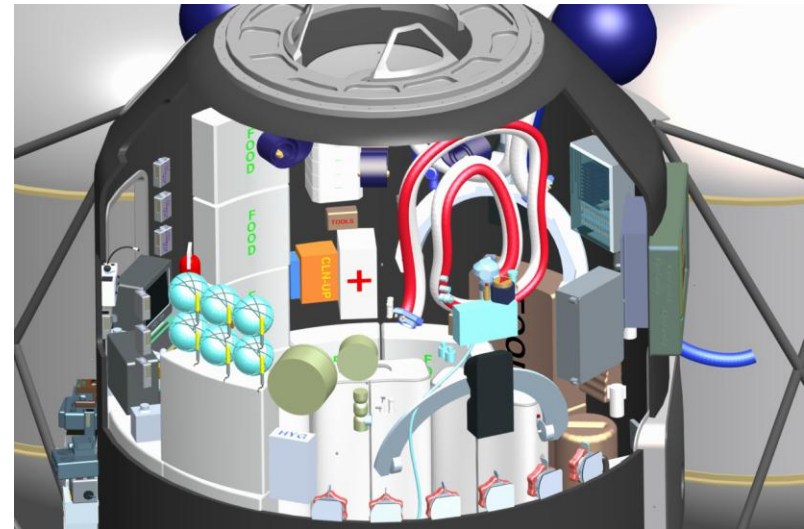
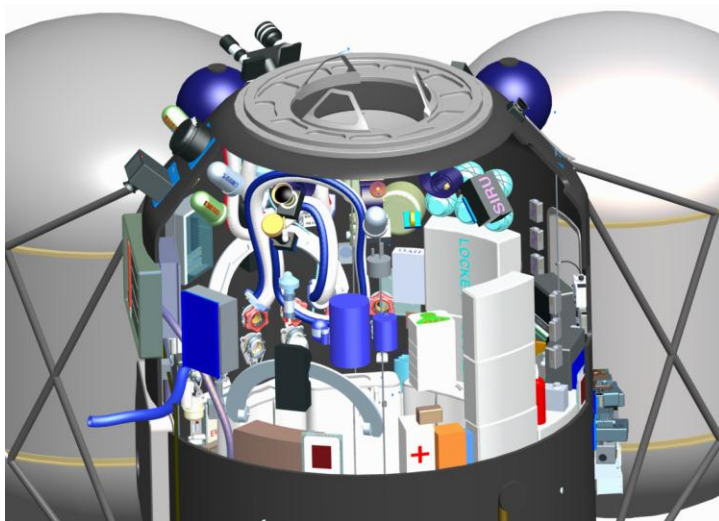
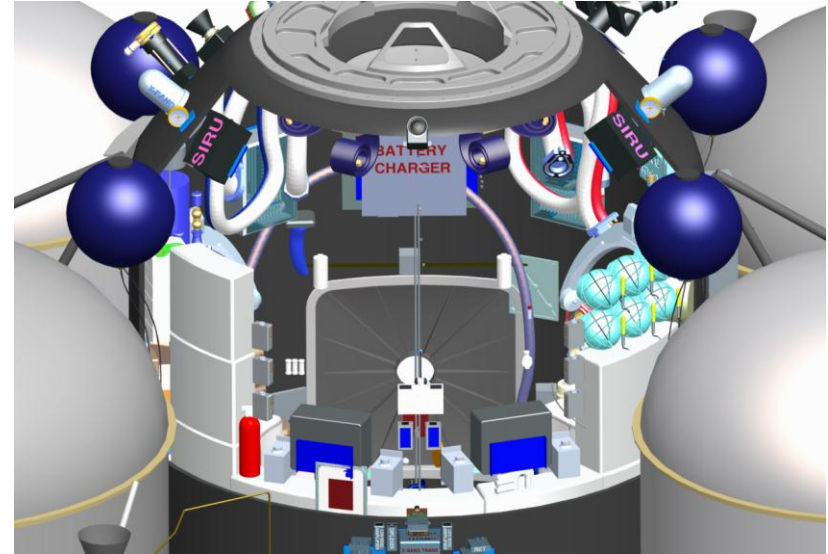
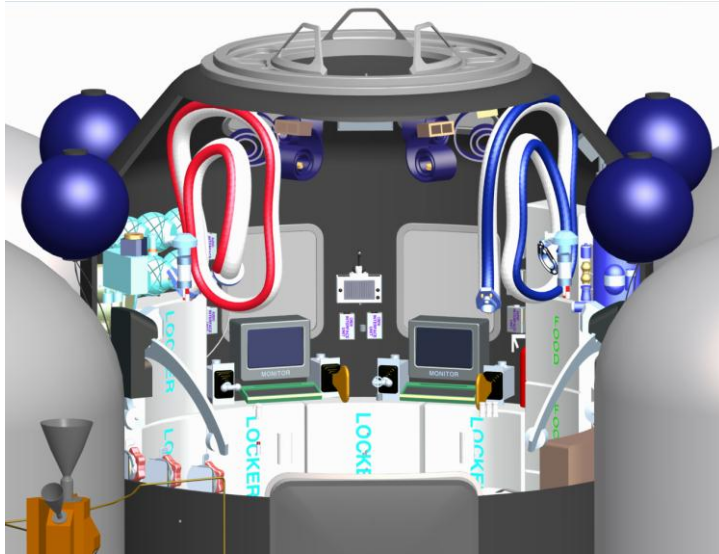
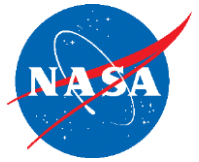
Transparent Cabin #1



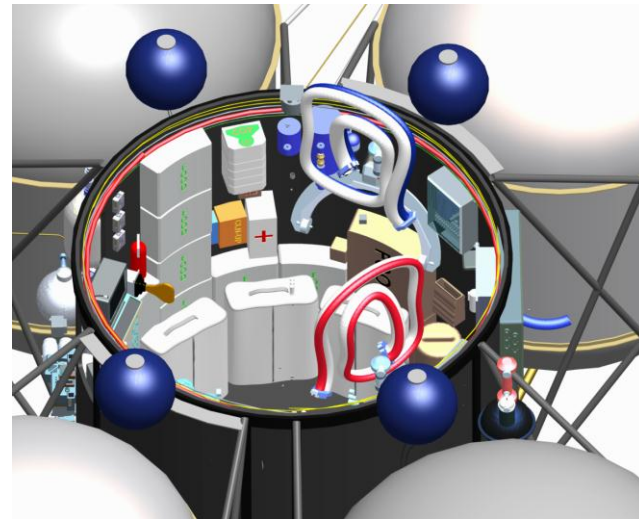
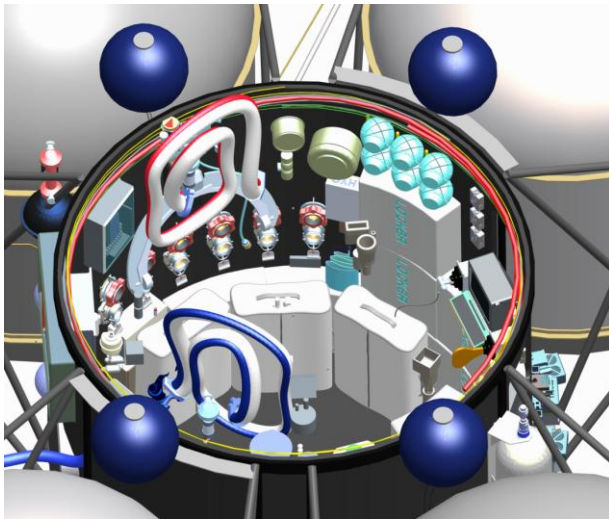
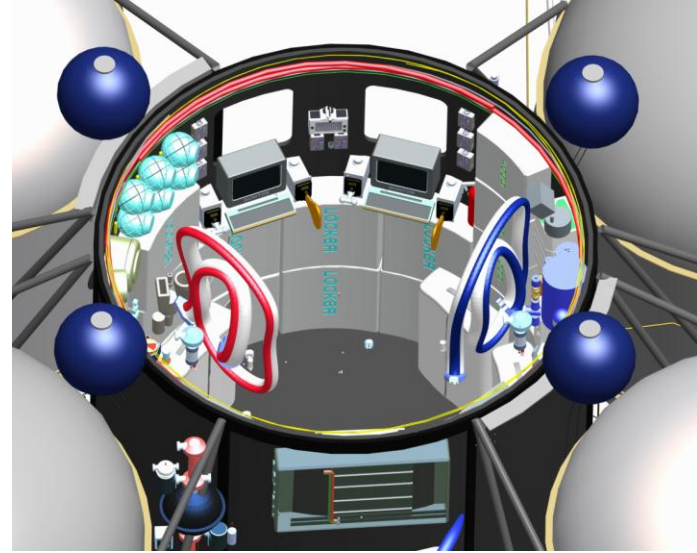
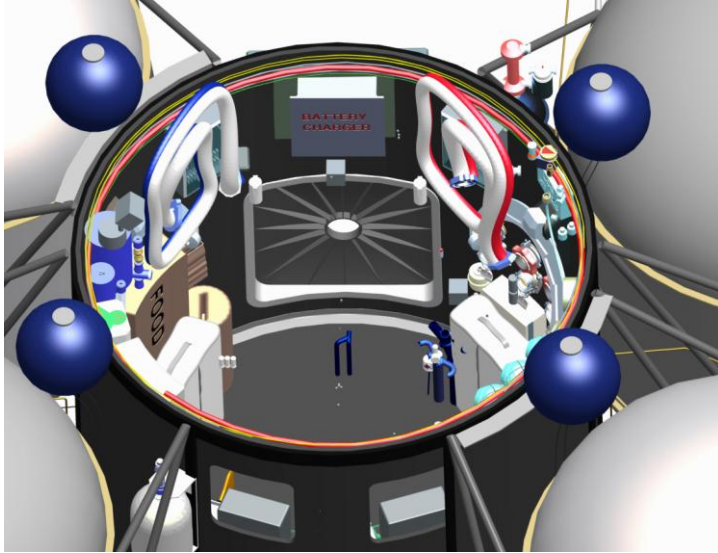
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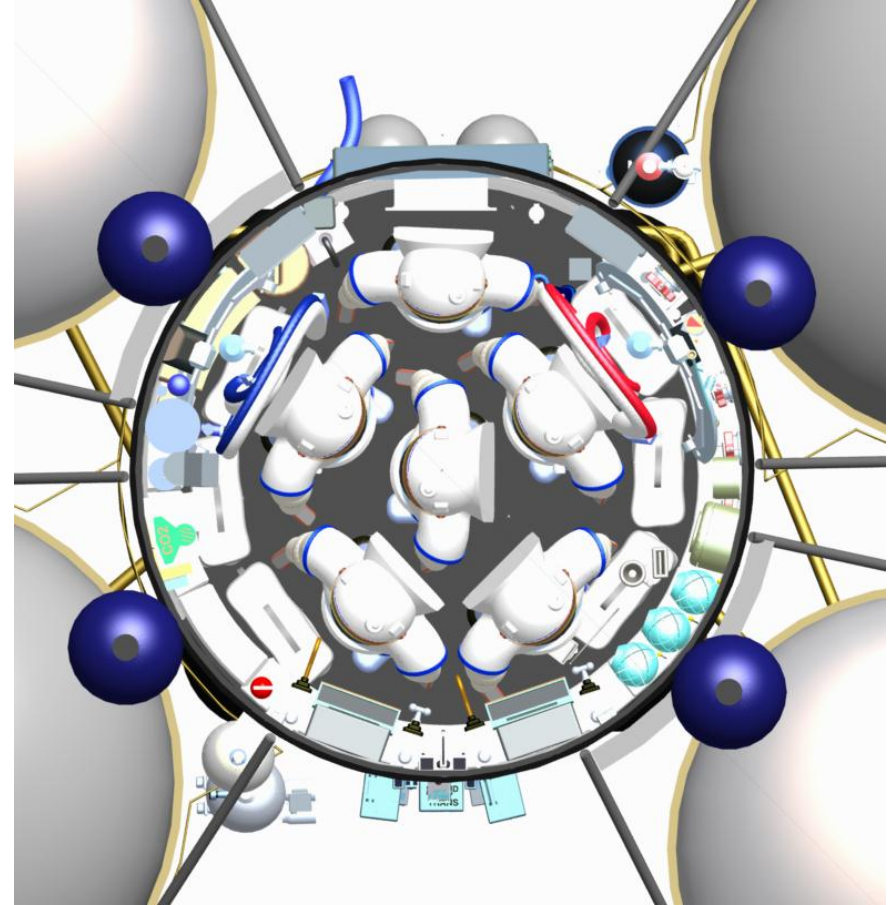
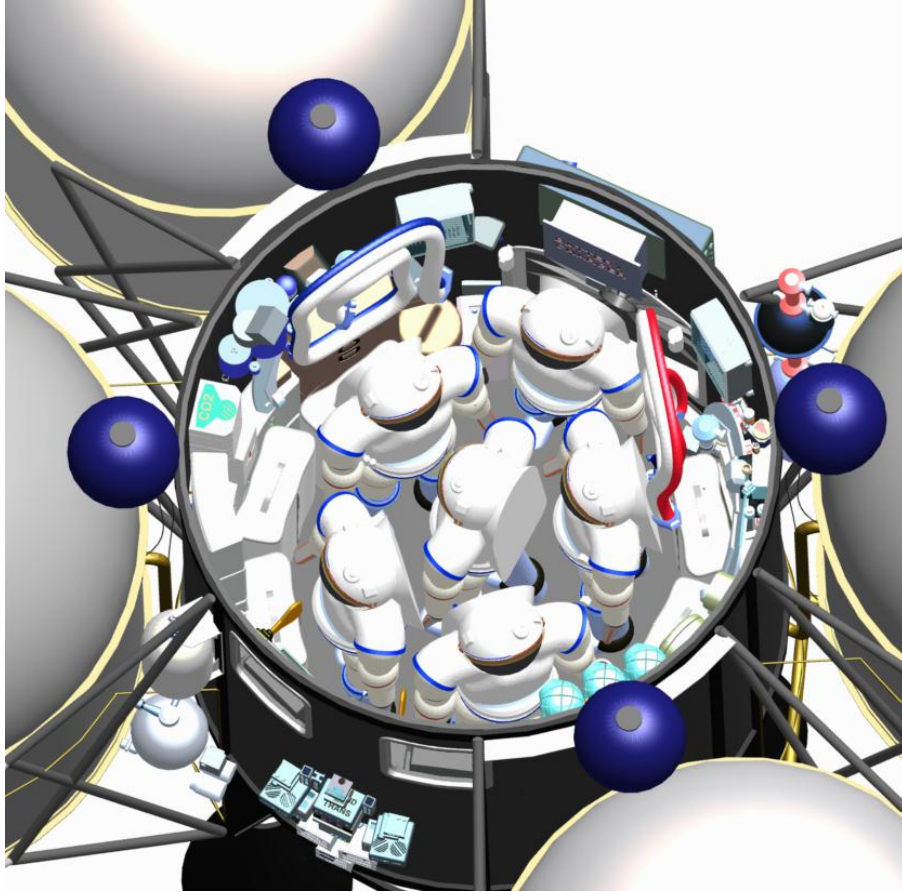
Side Cutaway Views



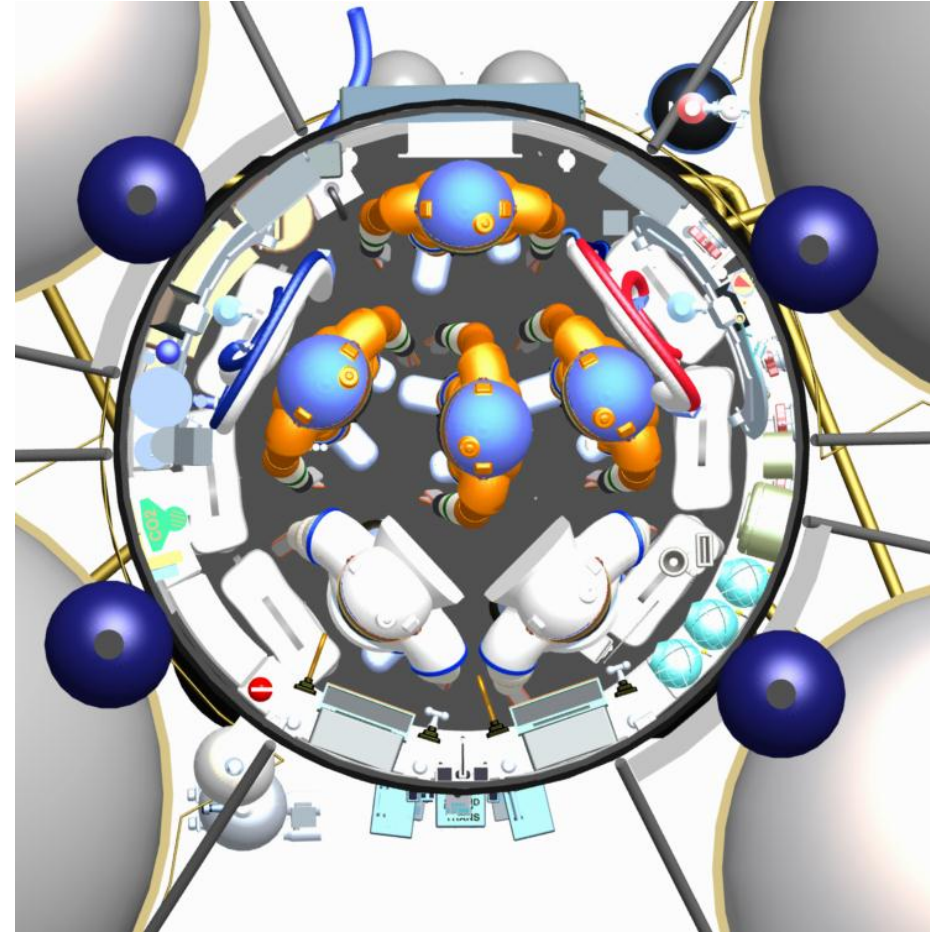
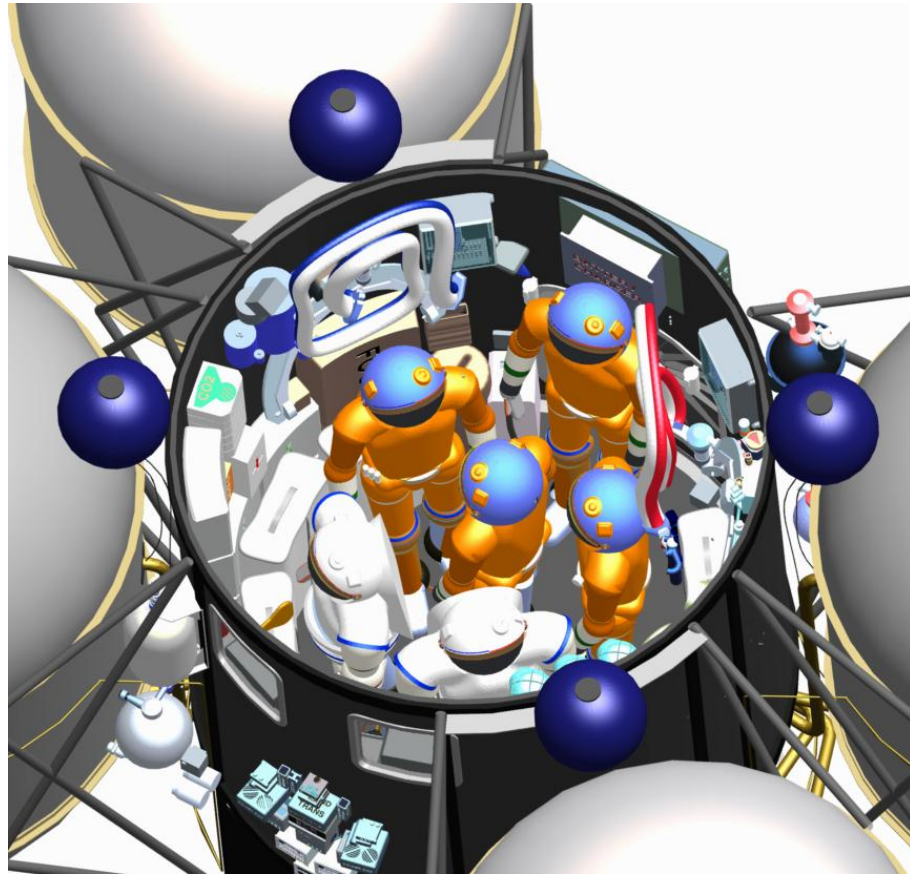
Top Cutaway Views



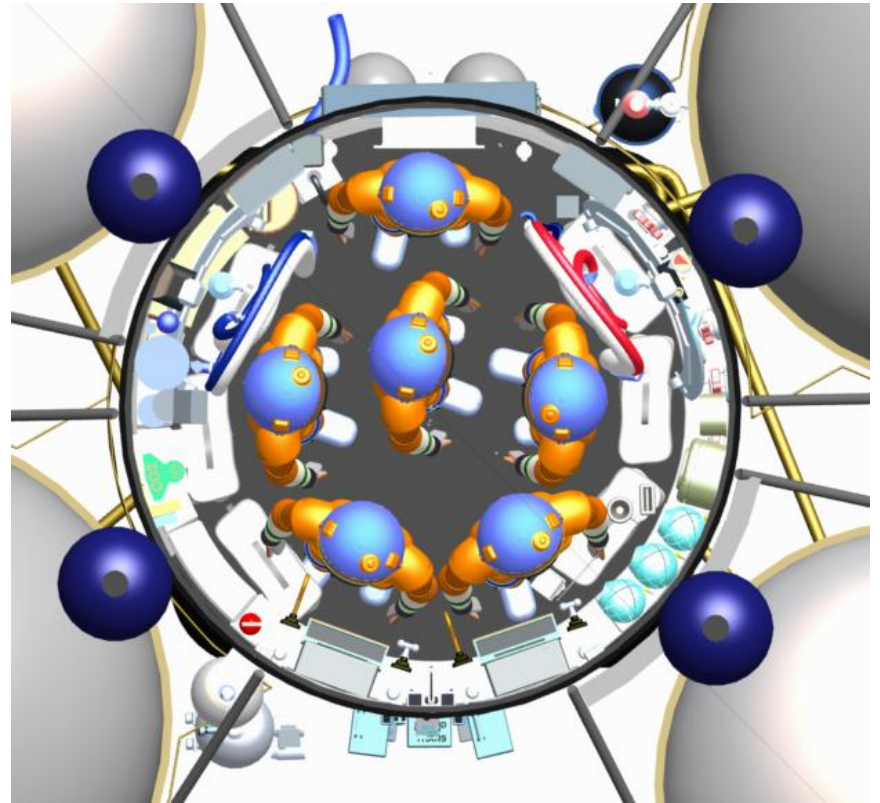
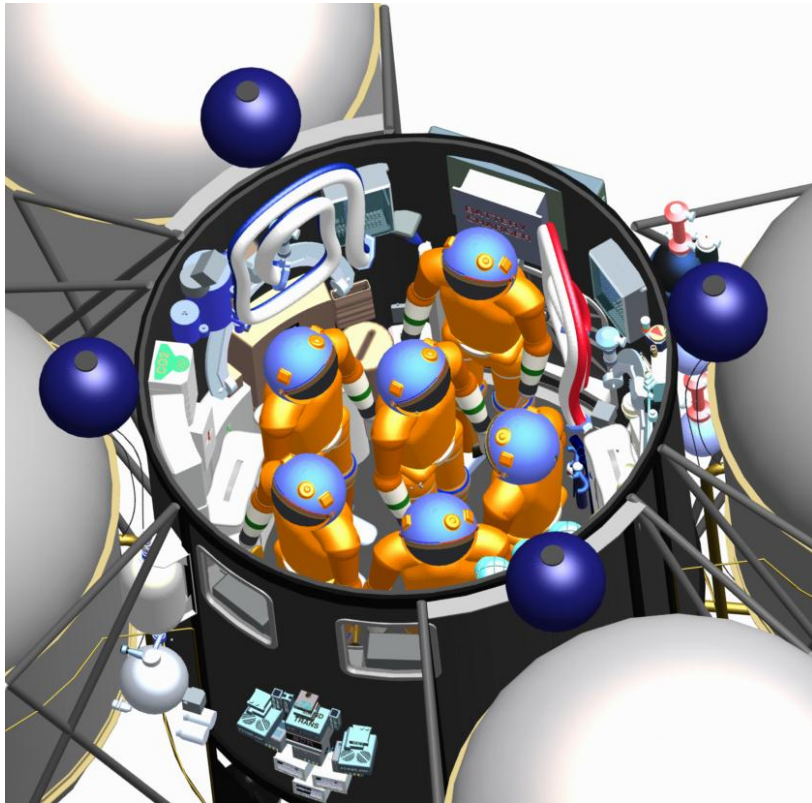
1. Ascend in White Suits without PLSS



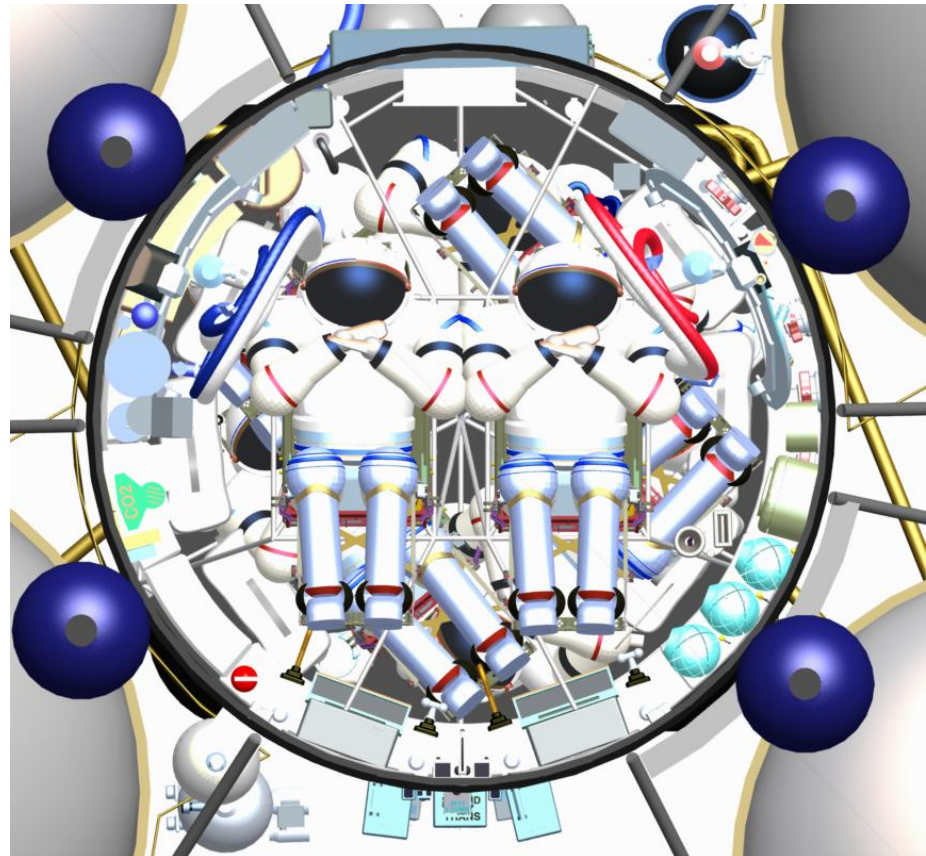
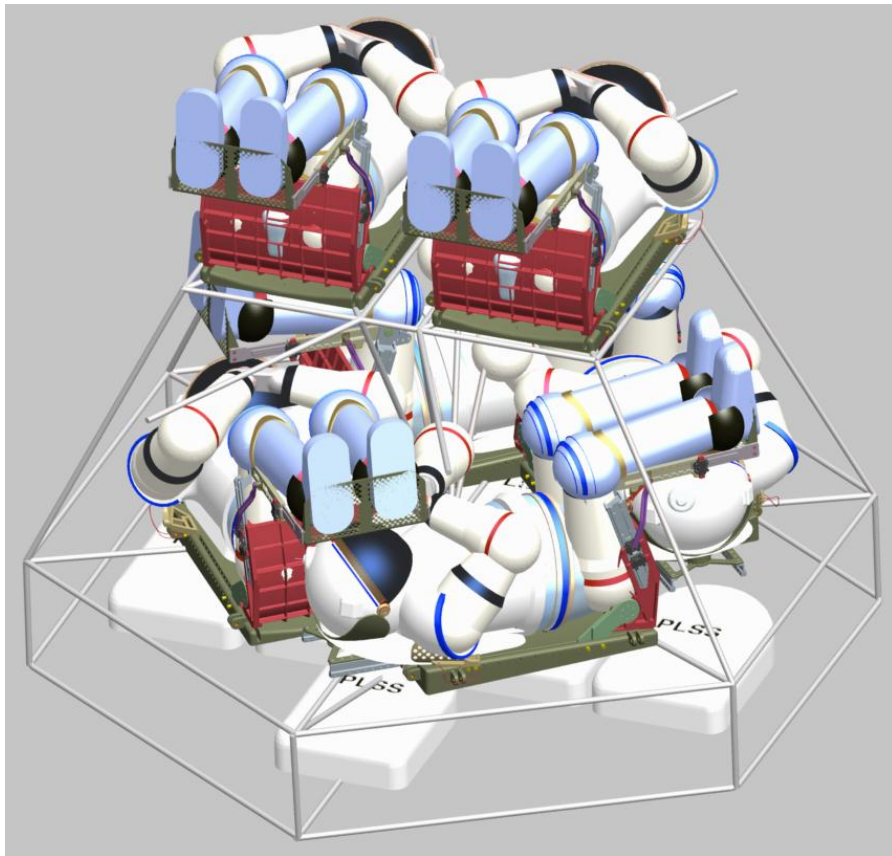
2. Ascend in Mix of White/Orange Suits



3. Ascend in Orange Suits

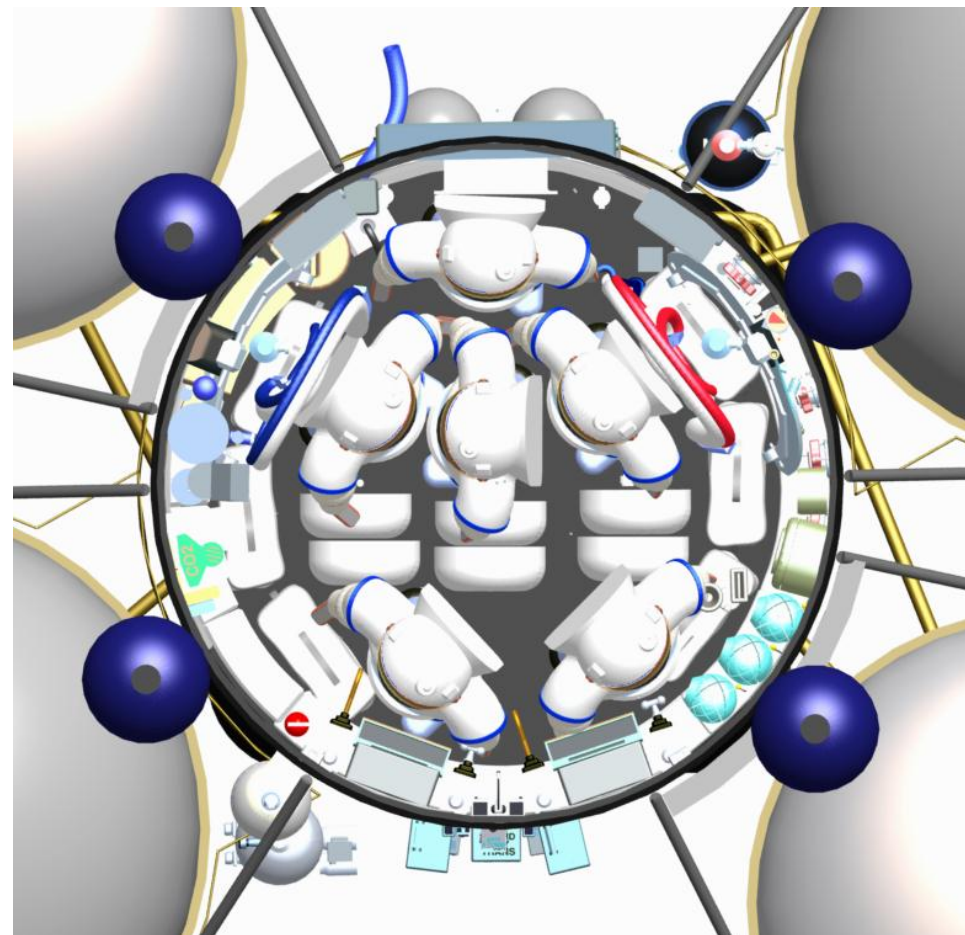
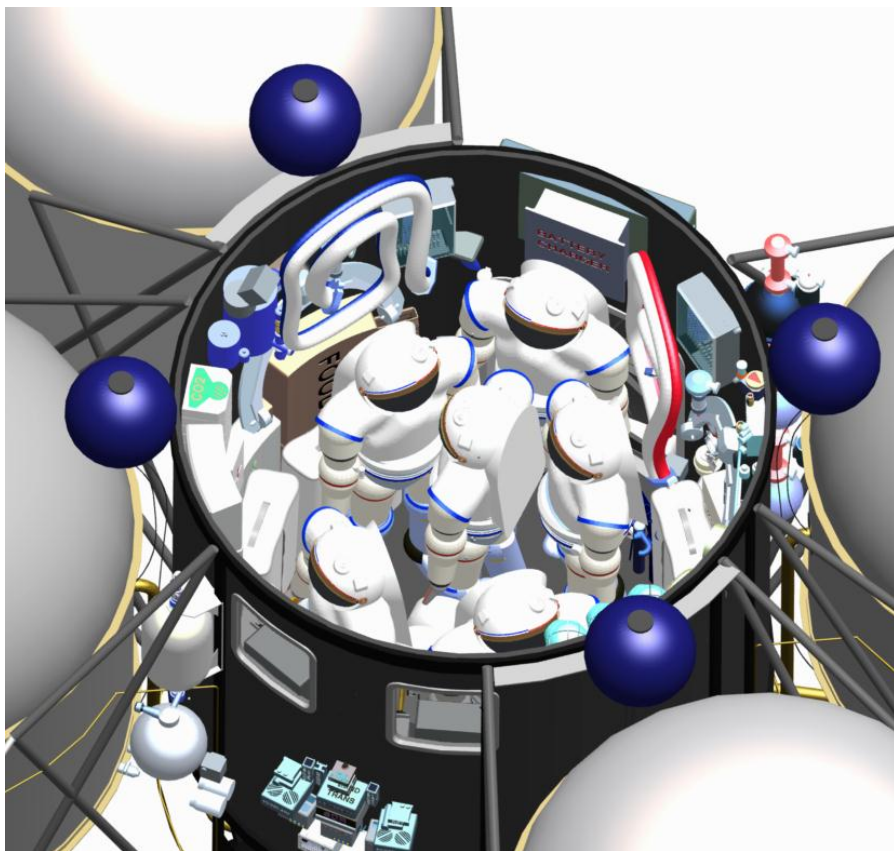


1. Descend in White Suits with PLSS stowed away

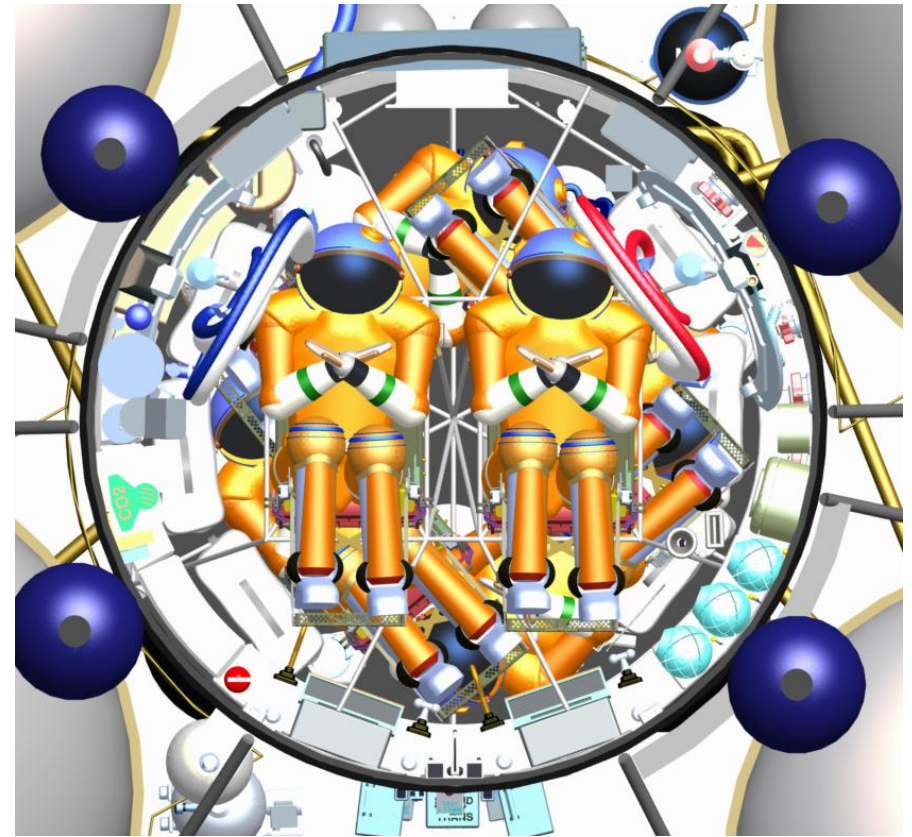
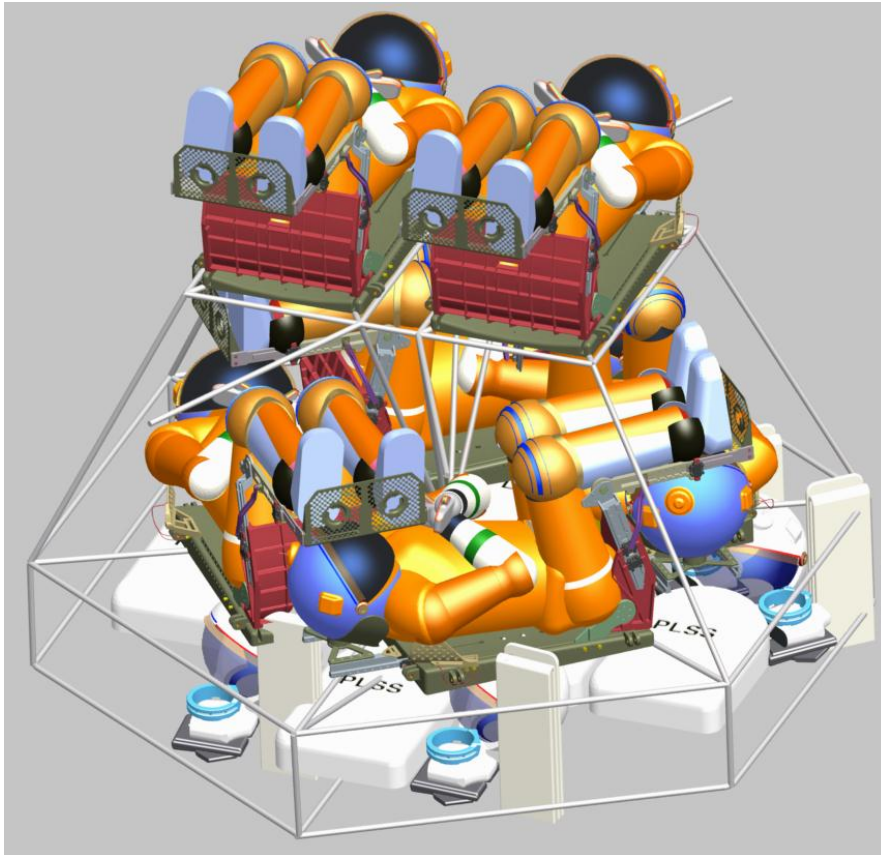


Seats taken from Orion

1. Descend in White Suits with PLSS stowed away (cont'd)



2. Land in Orange with White, PLSS stowed away



Seats taken from Orion

2. Land in Orange with White, PLSS stowed away (cont'd)

