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# PROJECT ARTEMIS

# N91-18141

## MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Nearly 30 years after John F. Kennedy expressed his desire for an expansion of the space program of the U.S.A., we have been given an even greater opportunity. President George Bush, in July 1989, expressed his desire to once again expand the space program of the U.S., as well as that of other nations around the world. The challenge: "To return man to the Moon, this time to stay." And then, to journey to another planet—a manned mission to Mars. Certainly, the challenge is tremendous, and the obstacles great. However, prepared to achieve this incredible goal is Project Artemis, the project that when complete will turn the dream of permanent manned presence in space into reality.

Why is this challenge, with all its complexity, worth pursuing? The list of reasons begins with the fact that the expansion of human presence in space is an exciting and intriguing opportunity. In addition, the opportunities for scientific and technological advancement are great, as are the opportunities to explore and investigate our closer neighbors in our solar system. The educational benefits and the new employment positions necessary to support such an extensive and long-term project are innumerable. There is also the potential to develop and utilize the resources of the bodies that we explore, possibly resulting in economic benefits for the nation as a whole. Finally, as a nation, we have much to gain in security and pride in being the first country to establish permanent human presence on another celestial body. Meeting this will result in benefits that the U.S.A. and the world will enjoy for many years to come.

The goals of Project Artemis are designed to meet the challenge put forth by President Bush. The first goal of the project is to establish a permanent manned base on the Moon for the purposes of scientific research and technological development. The knowledge gained from the establishment and operations of the lunar base will then be used to achieve the second goal of Project Artemis: establishment of a manned base on the martian surface. Throughout both phases of the program, crew safety will be the number one priority. In addition, commonality will be emphasized whenever possible to reduce costs and increase reliability. Vehicles and modules for the lunar portion of the program will be adapted to suit the different needs of the martian phase; subsystems will use as many common components as possible.

The ground rules for Project Artemis are those considerations that have driven the design of the vehicles, bases, and the overall mission. There are four main issues that have governed the entire mission: crew safety and mission success, commonality, growth potential, and costing and scheduling.

The safety of the crew will be the top design priority. In all portions of the mission, the safety of the crew will be maximized. This will govern the following aspects of the

mission: testing, reliability, and abort considerations. No mission involving the transport of crew members will be considered successful unless the crew is returned safely to Earth once the objectives of the mission have been accomplished.

The second design priority will be commonality between systems. Wherever possible, comparable systems in the lunar and Mars missions will be designed to maximize commonality. This includes entire vehicles, bases, and subsystems. Commonality will also be maximized between vehicles in the same mission. Commonality has an added importance as the lunar mission will be used to learn about the technology for the martian mission.

Since permanent bases will be established on both the lunar and martian surface, growth potential is also an important issue. The bases should be designed to promote future growth. Likewise, the vehicles and ground facilities should also allow for the long-range growth possibilities of the mission.

The final design consideration concerns the costing and scheduling of the entire mission. Without compromising the previous considerations, the cost of the mission should be minimized. Similarly, the scheduling of the entire mission should minimize the timespan of the mission and costing peaks.

The first step toward the success of Project Artemis is the establishment of an advanced space launch system that will include an Earth launch system and an orbital transfer node (OTN). The need for these two components is driven by the large amount of cargo necessary to begin both the lunar and martian phases of the project. The transportation of this cargo from Earth to low Earth orbit (LEO) in a timely manner will require a rigorous launch schedule, as well as Earth launch vehicles that are capable of carrying extremely large payloads. Once in LEO, the amount of orbital vehicle assembly and storage space required makes it virtually impossible for Project Artemis to proceed without an OTN designated exclusively for project use. A schematic of the Project Artemis space launch system is shown in Fig. 1.

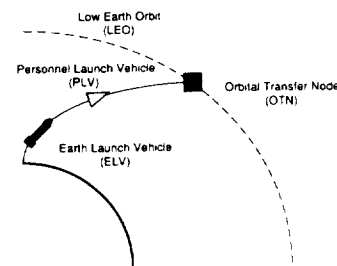


Fig. 1. Project Artemis Space Launch System

A typical mission begins with the launch of cargo from Earth. The Earth launch vehicle (ELV) (shown in Fig. 2) is designed to meet the Project Artemis Earth launch requirements. The ELV is a hybrid liquid/solid multistage rocket capable of carrying a nominal payload of 125,000 kg to LEO. Eight solid rocket boosters comprise the first stage of the ELV. A liquid core using liquid hydrogen and liquid oxygen as fuel makes up the second stage. The upper stage is liquid as well, and it also uses liquid hydrogen and liquid oxygen propellents.

Personnel are transported to LEO in the personnel launch vehicle (PLV), which will be boosted into orbit on a Titan IV. The PLV is capable of carrying a crew of eight to LEO and back again to Earth. A schematic of the PLV is shown in Fig. 3.

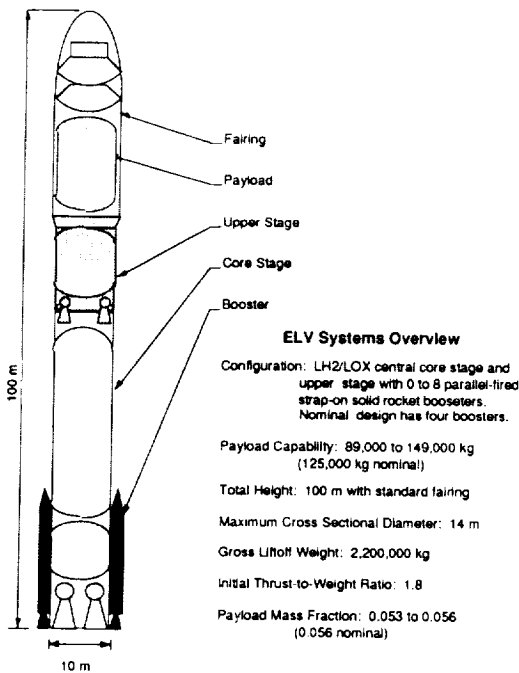


Fig. 2. Earth Launch Vehicle

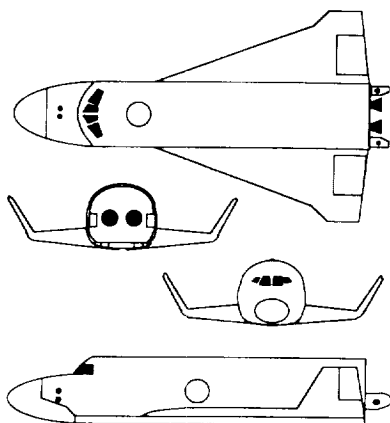


Fig. 3. Personnel Launch Vehicle

Once in LEO, both the cargo and the PLV can be picked up by one of two orbital maneuvering vehicles (OMVs) situated in LEO. The OMVs are NASA vehicles, designed for Space Station *Freedom*, and will not be described in depth within the context of this report.

Once it has picked up its cargo (either mission cargo or the PLV) the OMV transports the cargo to the OTN. The OTN is essentially a space station orbiting the Earth at an altitude of 470 km, and an inclination of 28.5°. Included in the configuration of the OTN are a habitation module, a command module, a vehicle assembly area, a cargo "warehouse," and three vehicle docking interfaces. The OTN is illustrated in Fig. 4.

All Project Artemis vehicles are equipped with common docking interfaces (CDIs). The CDIs ease the docking operations between vehicles and provide a location where the crew can exit one vehicle and enter another.

Once the Project Artemis space launch system is established, the first phase of the lunar mission will take place. The purpose of the lunar mission is to establish a permanently manned base on the Moon. Commonality between the lunar and martian missions is stressed at all times during this process. Since the lunar program will be functional before the martian program, evaluation of the progress of the lunar mission will enable the implementation of necessary modifications to the martian mission.

The lunar mission commences in LEO with necessary vehicles and materials provided by the Earth launch system discussed previously. Figure 5 shows the lunar mission profile.

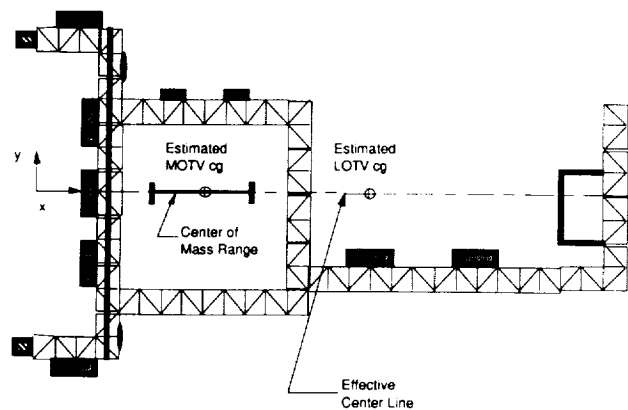


Fig. 4. Orbital Transfer Node

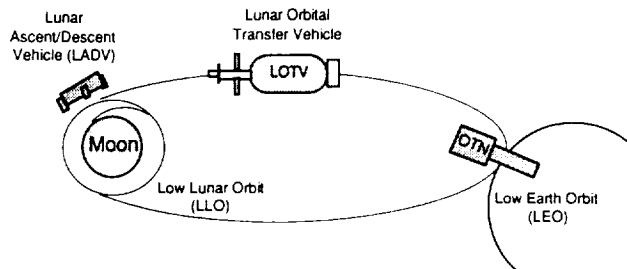


Fig. 5. Lunar Mission Profile

Vehicles used for the lunar phase are the lunar orbital transfer vehicle (LOTV), crew transport module (CTM), and the lunar ascent/descent vehicle (LADV).

The transfer from LEO to low lunar orbit (LLO) will be made in one of three identical LOTVs. Each of these vehicles is propelled by a particle bed reactor (PBR) engine and is capable of carrying a payload of 47,000 kg. Figure 6 shows a more detailed LOTV. The first 10 LOTV missions, each taking about 4 days to reach LLO, will transport necessary cargo. Then, the LOTV will begin its manned journey, transporting a crew of five astronauts to LLO. During transit, the crew will travel in the CTM, which is attached to the LOTV in the payload section.

After firing the LOTV engine to insert into LLO, the cargo or crew will be transferred to the LADV through use of a common docking interface. The LADV is shown in Fig. 7. Each of the three reusable LADVs is propelled by hydrazine and is capable of transporting a payload of 13,000 kg to the lunar surface, and a payload of 9,000 kg off the lunar surface. After a successful transfer, the LADV will transport the crew or cargo to the lunar surface and preparations for assembly of the lunar base will begin.

The lunar base consists of four prefabricated modules connected together providing habitation, communication, health maintenance, and laboratory research facilities. The

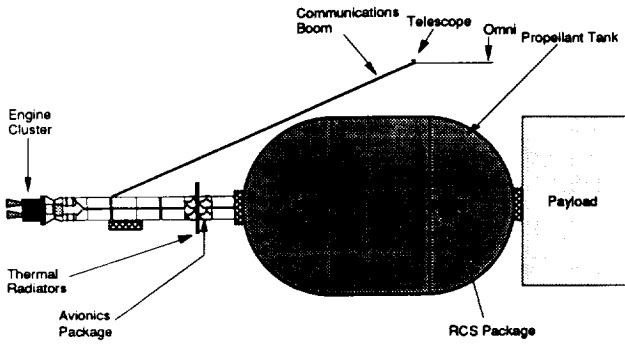


Fig. 6. Lunar Orbital Transfer Vehicle

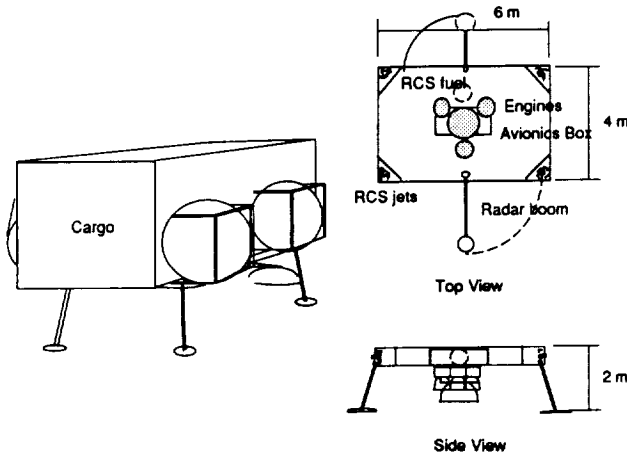


Fig. 7. Lunar Ascent/Descent Vehicle

modules are cylindrical, measuring 6 m in diameter and 10 m in length. The layout of the lunar base is shown in Fig. 8 and will be fully constructed within two weeks of the astronauts' arrival on the lunar surface.

In order to provide support for the base, resupply missions must carry 13,000 kg of supplies to the base every 6 months. In addition, crew rotation will occur every four to six months with an overlap of some crew members to insure familiarity with base operations. During the first operational stage, the base will support 5 to 15 crew members at one time. After the lunar base becomes fully operational, approximately five years into the program, the Mars portion of Project Artemis will begin. The Mars mission will incorporate improvements deemed necessary for project success from the evaluation of the lunar mission progress.

The purpose of the Mars portion of Project Artemis is to use the technology developed for the lunar mission to establish a permanent manned base on Mars. In order to meet this goal, commonality with the lunar mission will be maximized in every area possible. As a result, the phases of the Mars mission closely parallel the phases of the lunar mission. A schematic of a typical Mars mission is shown in Fig. 9.

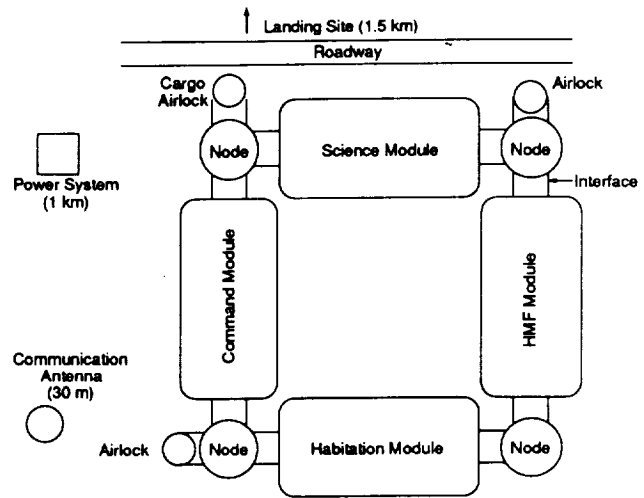


Fig. 8. Lunar Base

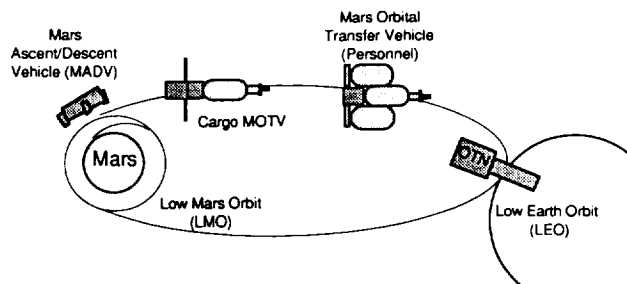


Fig. 9. Mars Mission Schematic

The mission begins in LEO at the OTN. At the commencement of the mission, cargo is carried to low Mars orbit (LMO) on the cargo version of the Mars orbital transfer vehicle (MOTV). This vehicle is shown in more detail in Fig. 10. The transfer of cargo from LEO to LMO takes approximately 280 days. The MOTV is propelled by the same PBR system utilized by the LOTV in the transfer portion of the lunar mission, and is capable of transporting a payload of up to 44,000 kg.

In order to transport all the necessary start-up cargo to LMO, Project Artemis will use six cargo MOTVs, which are expendable. Personnel will be transported to LMO on the personnel MOTV, which is shown in Fig. 11. The personnel MOTV can transport a crew of five, uses a PBR engine, and is reusable.

Once it arrives in LMO, the cargo MOTV will aerobrake in order to attain an acceptable parking orbit. Initial payloads of the cargo MOTV will include the Mars ascent/descent vehicles (MADVs), which are the vehicles that transport cargo and personnel to and from the martian surface. The cargo MADV is shown in Fig. 12. Both MADVs are liquid chemical engines. The cargo MADV can carry a payload of 13,000 kg, and is fueled by liquid hydrogen and liquid oxygen. The personnel MADV can carry five people, and is fueled by monomethylhydrazine and nitrogen tetroxide. The 11 cargo MADVs are expendable, while the 2 personnel MADVs are reusable. As

soon as the payload of the MOTV has been transferred to the appropriate MADV, the MADV begins its descent to the martian surface.

Once the initial cargo is on the surface and trenching and leveling operations have been completed by the unmanned rovers, base assembly can begin. Like the lunar base, the Mars base consists of prefabricated modules, which are attached to one another by common nodes. The Mars base modules are identical in size and structure to the lunar modules shown in Fig. 8; only the interior layout differs, due to the increased storage needs of the Mars base. Like the lunar base, the Mars base includes areas for habitation, communication, laboratory research, and health maintenance.

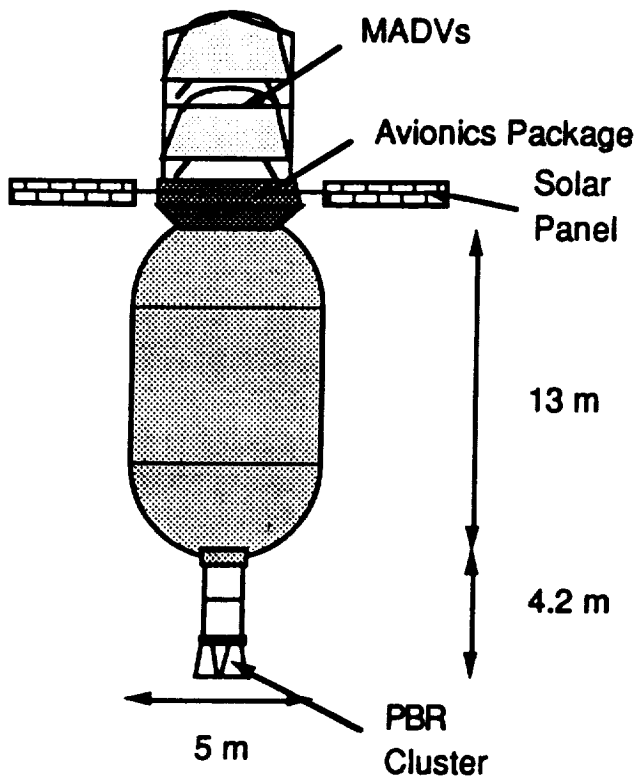


Fig. 10. Mars Orbital Transfer Vehicle - Cargo

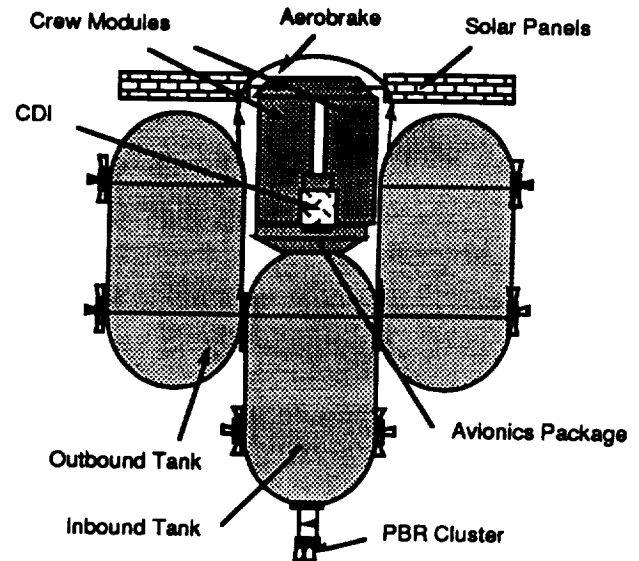


Fig. 11. Mars Orbital Transfer Vehicle - Personnel

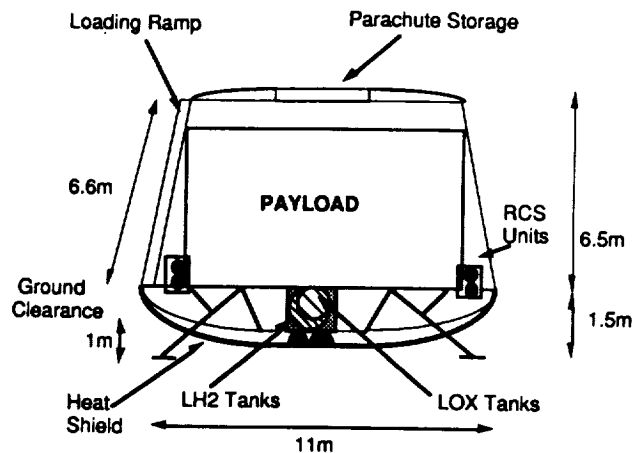


Fig. 12. Mars Ascent Descent Vehicle - Cargo

Initially, a crew of five will construct and operate the Mars base. Crew rotations and resupply will occur every 14 months. The long duration of each rotation is because launch windows only occur every two years. Also, the transfer time for the personnel MOTV takes approximately six months. Eventually, the crew size will increase from 5 to 10, and the base will be at its full operational capacity.

Project Artemis presents technological and logistical problems. Questions of availability of necessary technology, in addition to the cost and time commitments demanded from a single nation for success of this project, need to be addressed before a national endeavor is begun. The project requires the

nation's interest, priorities, and resources for a long period of time. Although in this respect the demands of this project are great, the value of the advancement of human knowledge of our solar system through the completion of Project Artemis would be tremendous.

#### ACKNOWLEDGMENTS

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