The Mars Society Australia's Mission Architecture, Design Issues and Vehicle Designs for a Manned Mars Mission

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Mars Society Australia

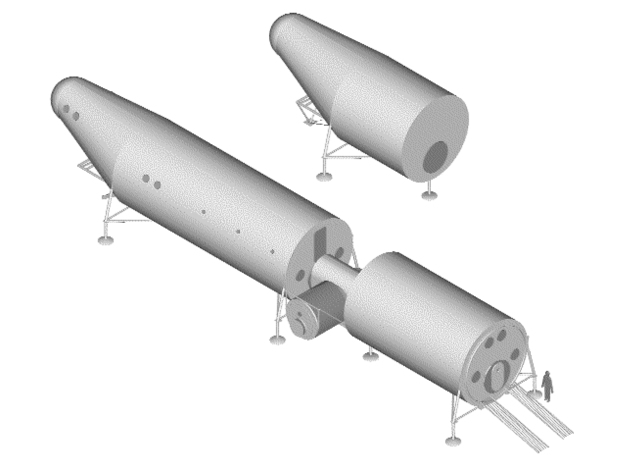
Mission Architecture:- Background

Simulated Bases or Mars Analogue Stations

The Flashline Analogue Station at the Houghton Crater on Devon Island
- A ’tuna can’ shape

The MDRS near Hanksville Utah
- A ’tuna can’ shape

The Euro Mars Station to be located in Iceland
- A ’tuna can’ shape



Mars-Oz (Mars Analogue Research Station – Oz) at Arkaroola South Australia
- Adopting horizontally landed bent biconic vehicles.

The MSA conducted a theoretical exercise as to how a Mars station similar to MARS-Oz could be put on Mars using current technology. This research greatly increased our understanding of the difficulties and risks in undertaking a manned Mars mission.

Overview

- **Mission Architectures:- The Competition**
- **Basic Assumptions and Aims**
- **Types of Orbits**
- **Mission Architecture**
- **Building the Mars Station**
- **Traveling to and from Mars**
- **Vehicle designs**
- **Conclusion**

Mission Architectures:- The Competition.
Mars Direct

Zubrin/Baker- Mars Direct

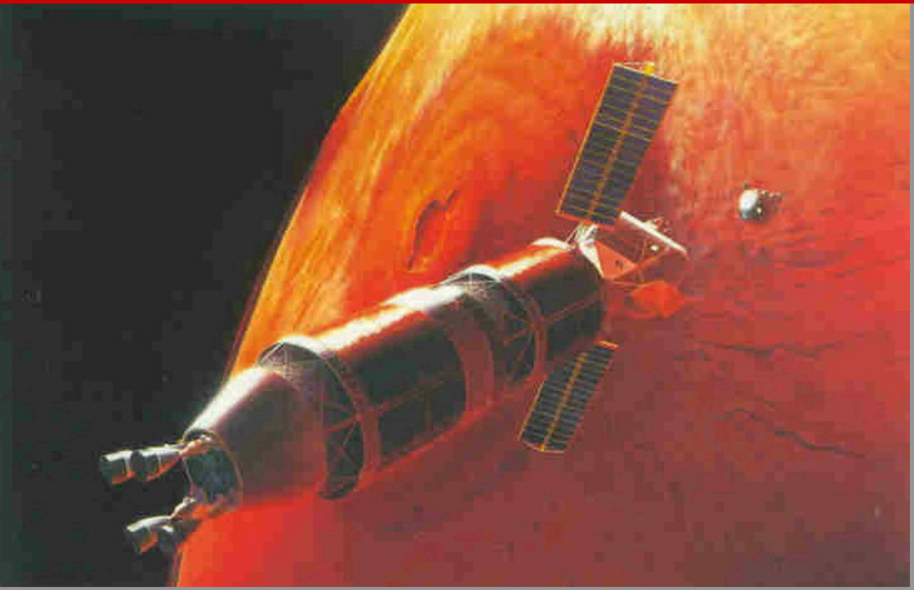
One manned vehicle traveling direct to the Mars surface.

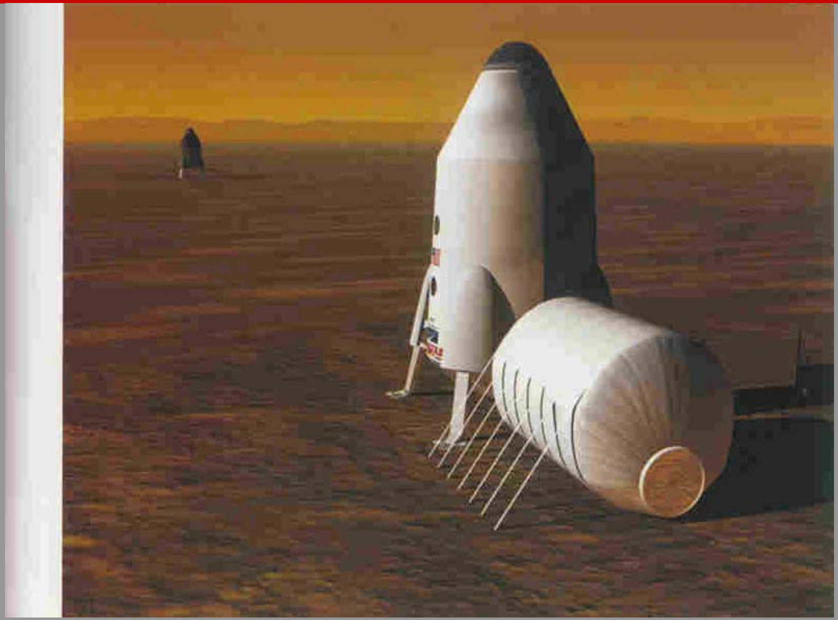
A second Earth return vehicle (ERV) traveling to Earth from the Mars surface.

Requires a nuclear powered manufacturing propellant plant (In-situ resource Utilization -ISRU) on the Mars surface for a a very large ERV.

Technology: Tuna-can structure, aero-capture, IRSU plant powered by nuclear generators.

Mission Architectures:- The Competition.
Mars Semi-Direct





NASAs Design Reference Mission (DRM).

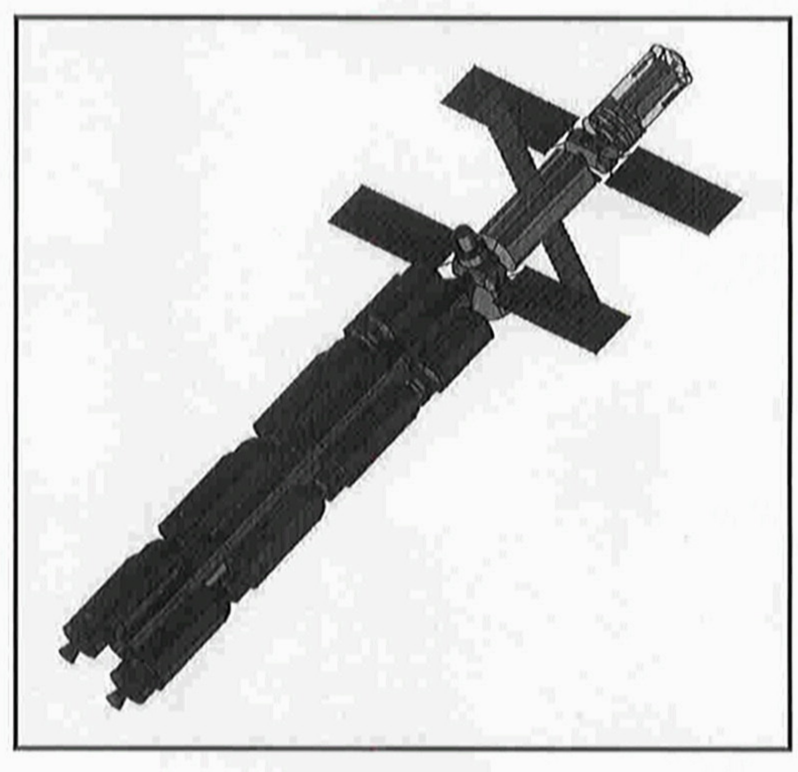
One manned vehicle traveling direct to the Mars surface.

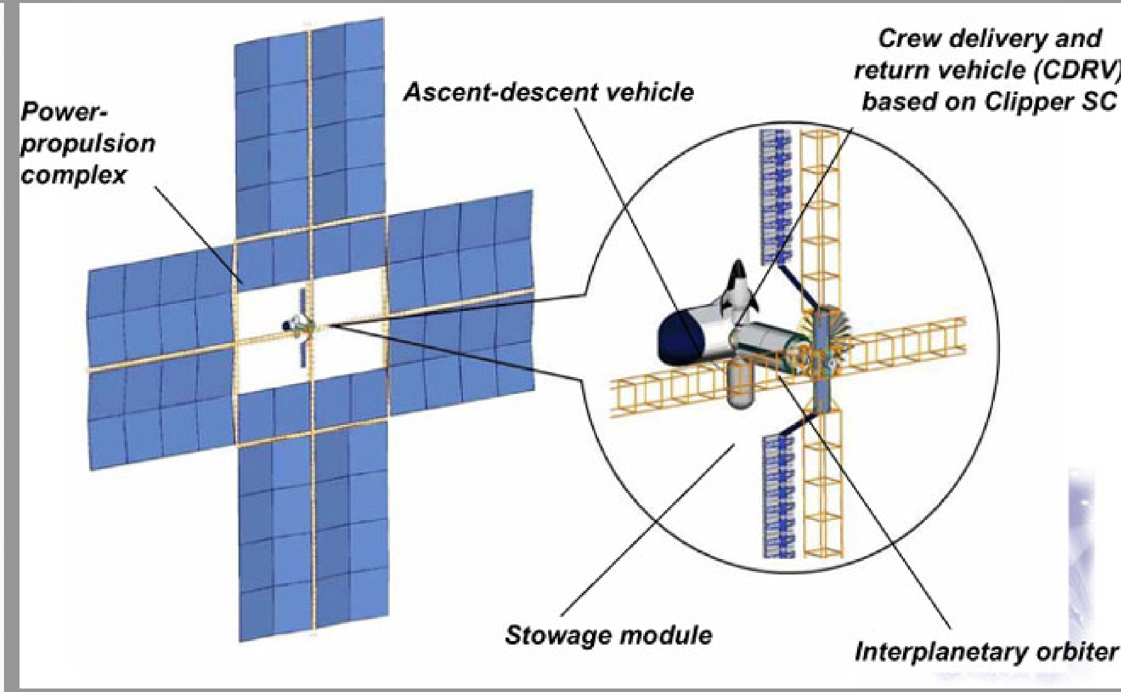
A second cargo vehicle traveling direct to the Mars surface. The Cargo vehicle carries a small Mars Ascent Vehicle and ISRU plant.

A Fourth Mars Transfer Vehicle travels to Mars orbit to return the crew to Earth

Technology: Biconic structure, aero-brake, IRSU plant powered by nuclear generators.

Mission Architectures:- The Competition.
ESA and Russia's Manned Mars Mission Architecture





Russia's Manned Mars Mission

One large vehicle with lander and ascent vehicle

Technology: Ion engine, solar power generators

ESAs Manned Mars Mission

One large vehicle with lander and ascent vehicle

Technology: Aero-brake, solar power generators

Mission Architecture Issues and Choices

- Orbital Trajectory Options;
- Orbit insertion techniques: Aero-brake into the Mars atmosphere or use engines to achieve mars orbit;
- Traveling to Mars in the Mars lander or a Mars Transfer Vehicle;
- Adopting phobos to ‘park’ spacecraft or adopt low Mars Orbit to ‘park’ spacecraft if required;
- The provision of a Propellant manufacturing plant on the Mars surface (In-situ Resource Utilization Plant);
- Aero-brake into Earth orbit or direct landing from hyperbolic orbit;
- Adopt nuclear power generators and engines or solar power generators;
- The crew number;
- The level of recycling; and,
- The type of structures best suited to build a long term base.

Mission Assumptions and Aims

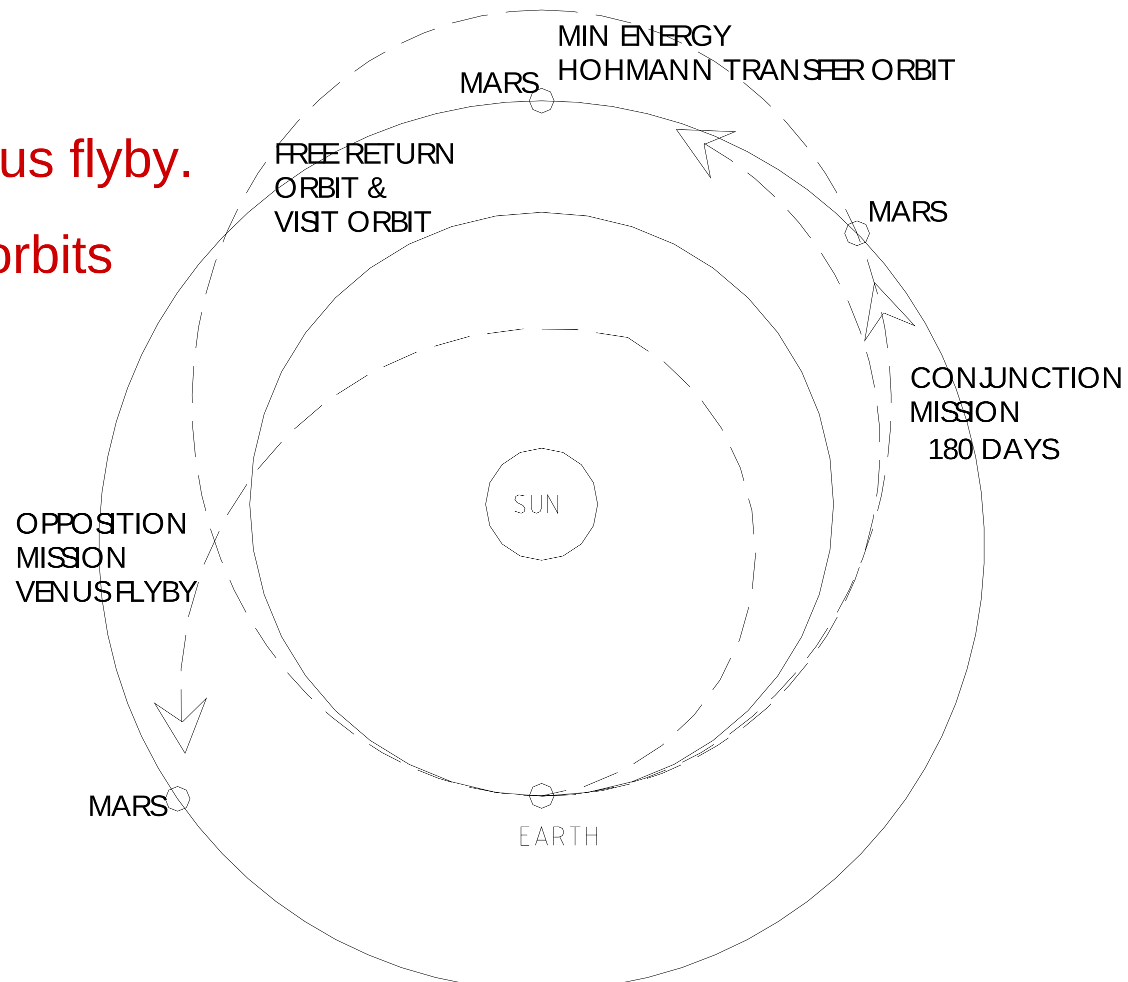
- **Adopt design priorities on order of importance:**
    - **Lowest cost;**
    - **Maximizing safety;**
    - **Minimizing maintenance & complexity and;**
    - **Maximize the science return.**
- **Solar power generators only.**
- **Adopt In-situ resource utilization.**
- **Adopt the aero-capture process.**

Types of Orbits

<u>Orbital Trajectory Options.</u>

Orbital Trajectory to Mars Options include:

- Minimum Energy Conjunction class Hohmann orbit.
- Faster Conjunction class orbit.
- Opposition class orbit with Venus flyby.
- VISIT or UP/DOWN escalator orbits

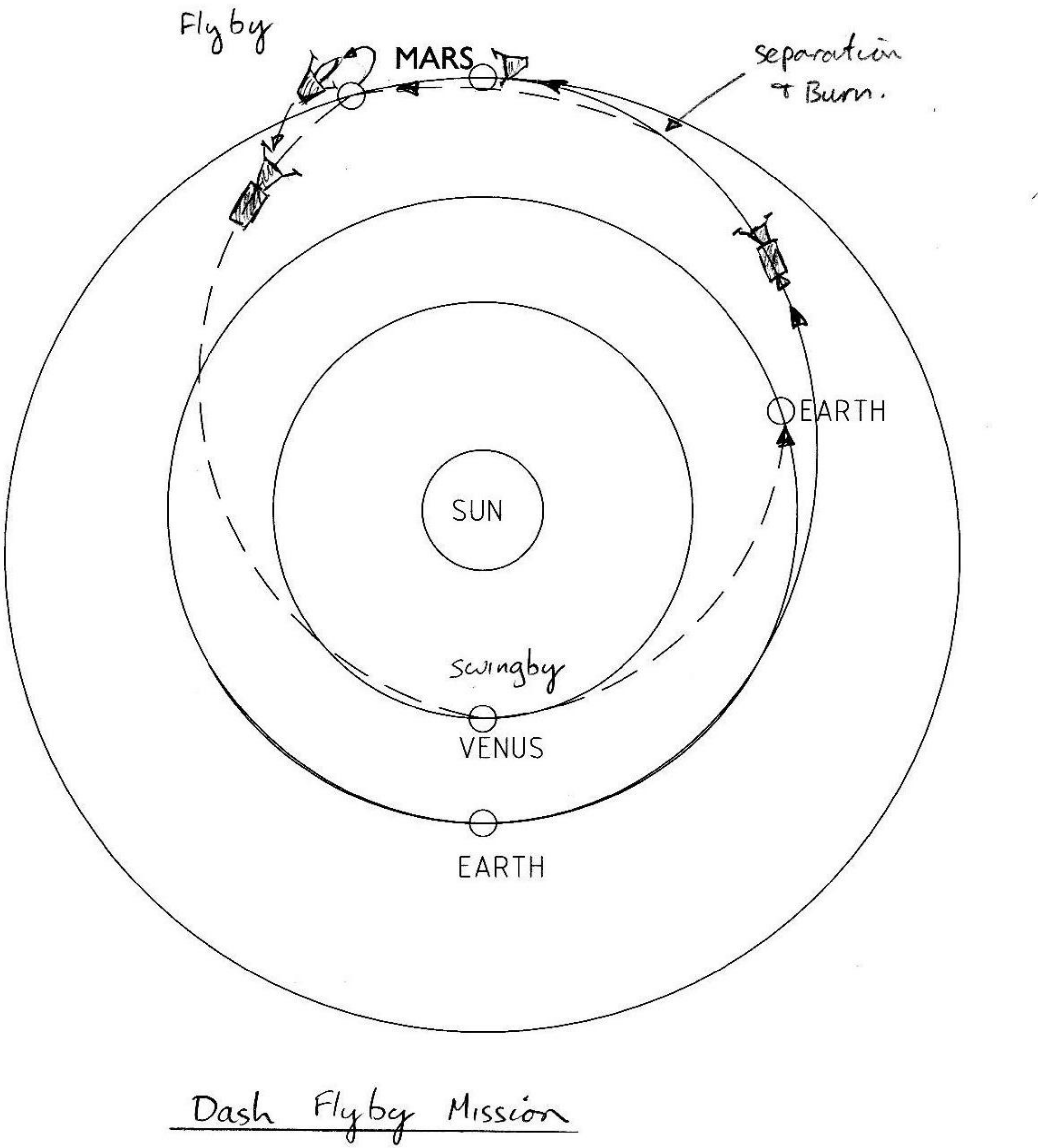


Types of Orbits

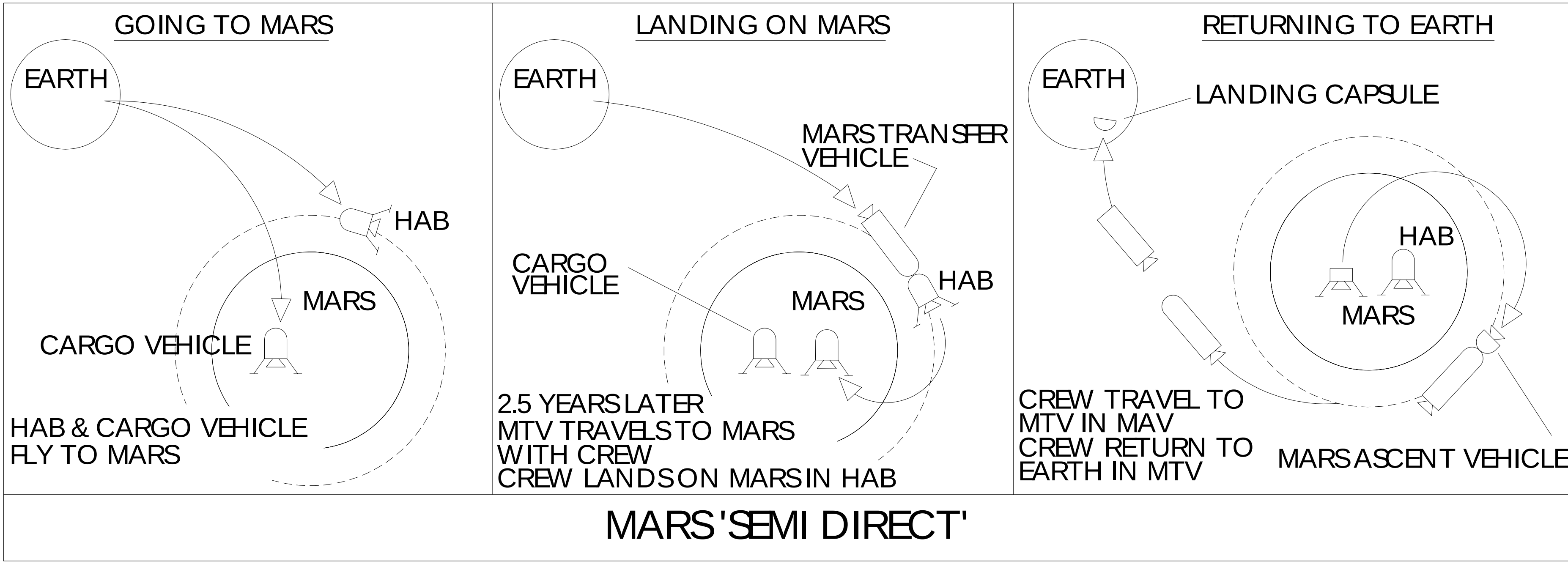
Dash Flyby Trajectory Option.

• **We chose a 180 day Conjunction orbit For simplicity and minimize exposure to Radiation.**

• **We suggest the Apollo style abort Free return as not practical due to 1.5 year period before reaching Earth.**



Mission Architecture: Semi Direct



We adopted 4 vehicles as:

- No nuclear power limited the ISRU plant propellant production. This invoked the need for a small MAV and a MTV waiting in Mars orbit.

We travel to Mars in the MTV as:

- The MTV provides abort options at Earth departure; and
- The MTV can be specifically designed for long duration manned space travel.

We adopted a maximum payload of 62 T for the Cargo and Hab vehicles and 130 T for the MTV. This matches the capacity of the new HLV rockets

Adopting Phobos as a Parking Base

Advantages of using Phobos

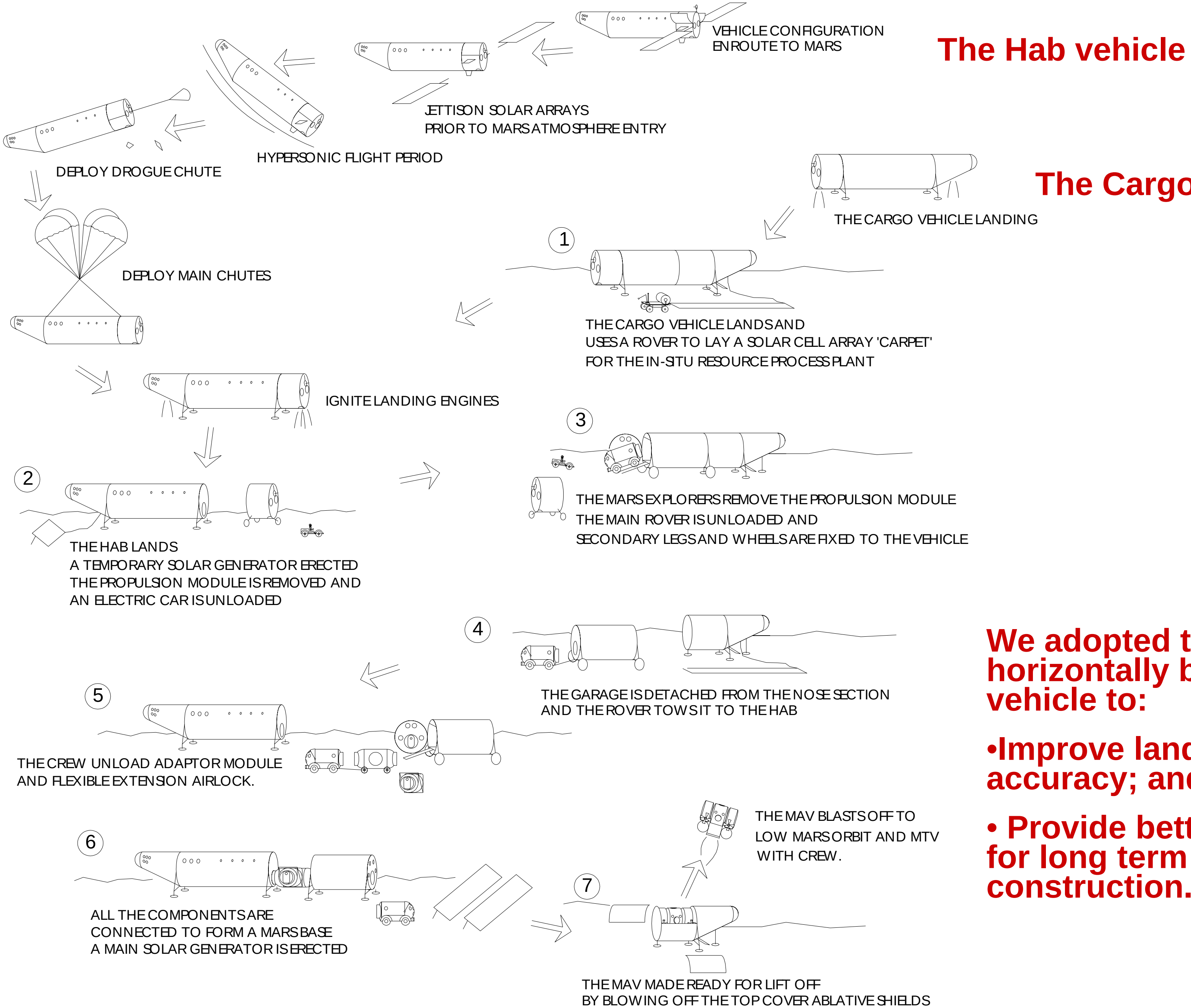
- Space craft can be ‘parked’ on phobos conserving fuel
- Phobos can provide protection from ‘Cosmic Ray’ Radiation

Disadvantages of using Phobos

- Phobos high orbit requires more energy to land and return from the Mars surface compared to a 500 kM circular parking orbit;
- The Phobos orbital inclination limiting access to prime Mars base locations beyond it’s orbital path;
- Reflected energy from the Phobos surface affecting the operation of the MTV radiators; and,
- The quantity and probable adhesiveness of the dust that can stick to solar panels.

We suggest on the first Mars missions Phobos is not safe to park spacecraft

In the long term Phobos may be used as a base to manufacture propellant



We adopted the horizontally bent biconc vehicle to:

- **Improve landing accuracy; and,**
- **Provide better modules for long term station construction.**

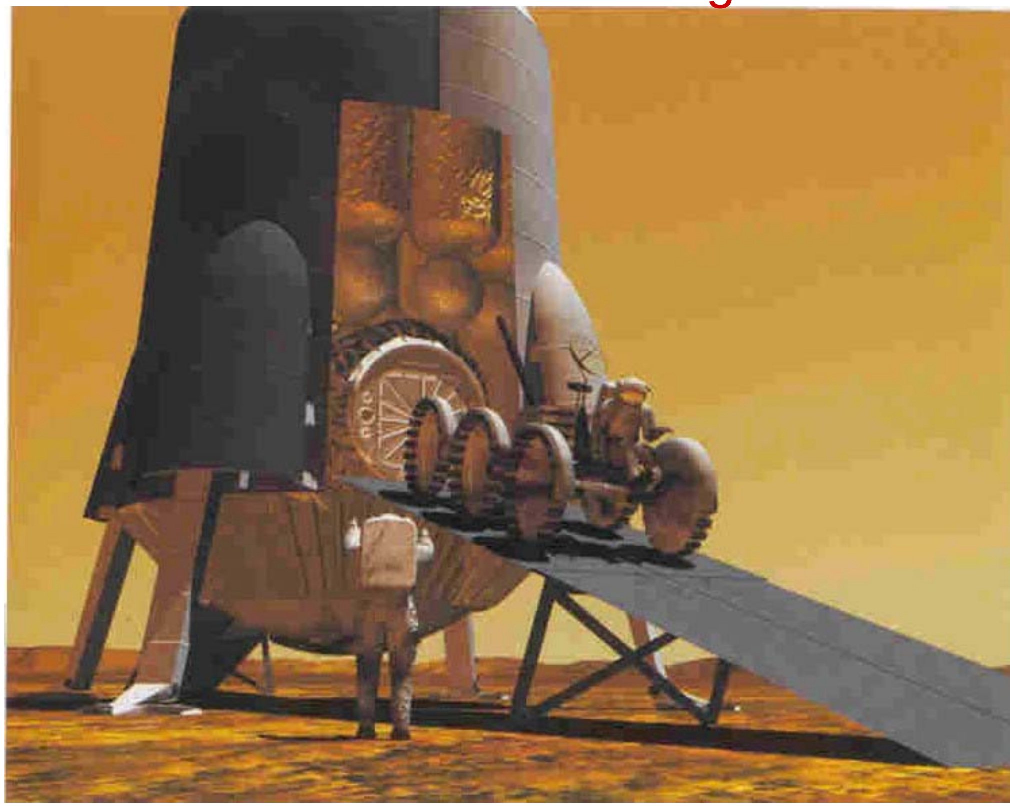
Landers: Landing and assembling the Mars Station

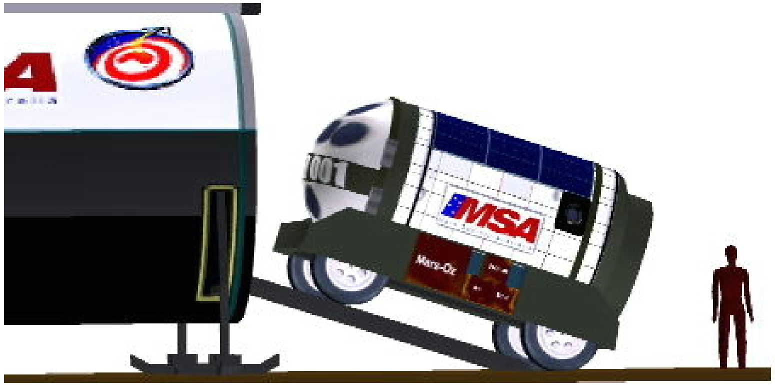
Cargo Vehicle Comparisons

-Horizontally landed vehicles are easier to unload and can carry longer cargo.

-NASAs DRM vertically landed craft ‘stand where they land’ and are difficult to move.

Nasa’s DRM cargo vehicle

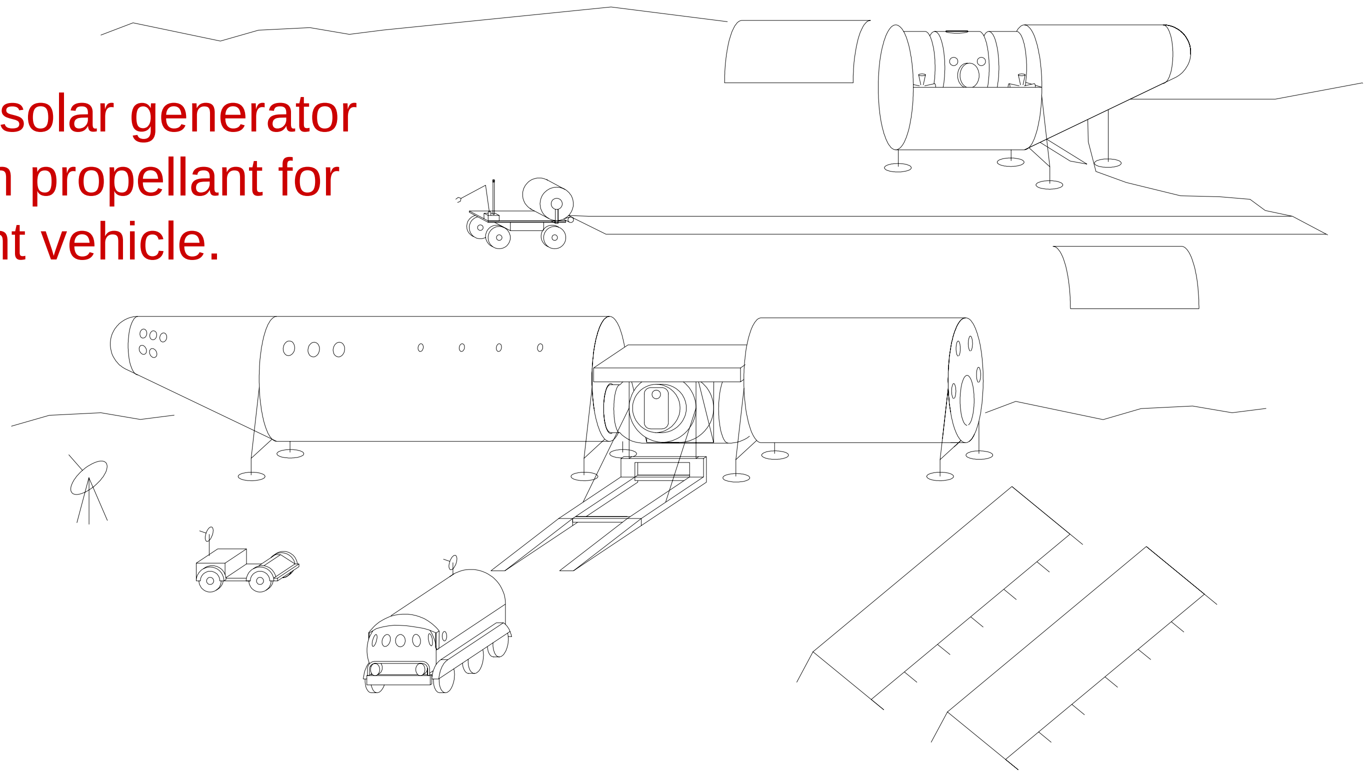




Mars-Oz cargo vehicle unloading a rover

The MSA's Mars Station

We found a 30 kW solar generator
can provide enough propellant for
A small Mars ascent vehicle.

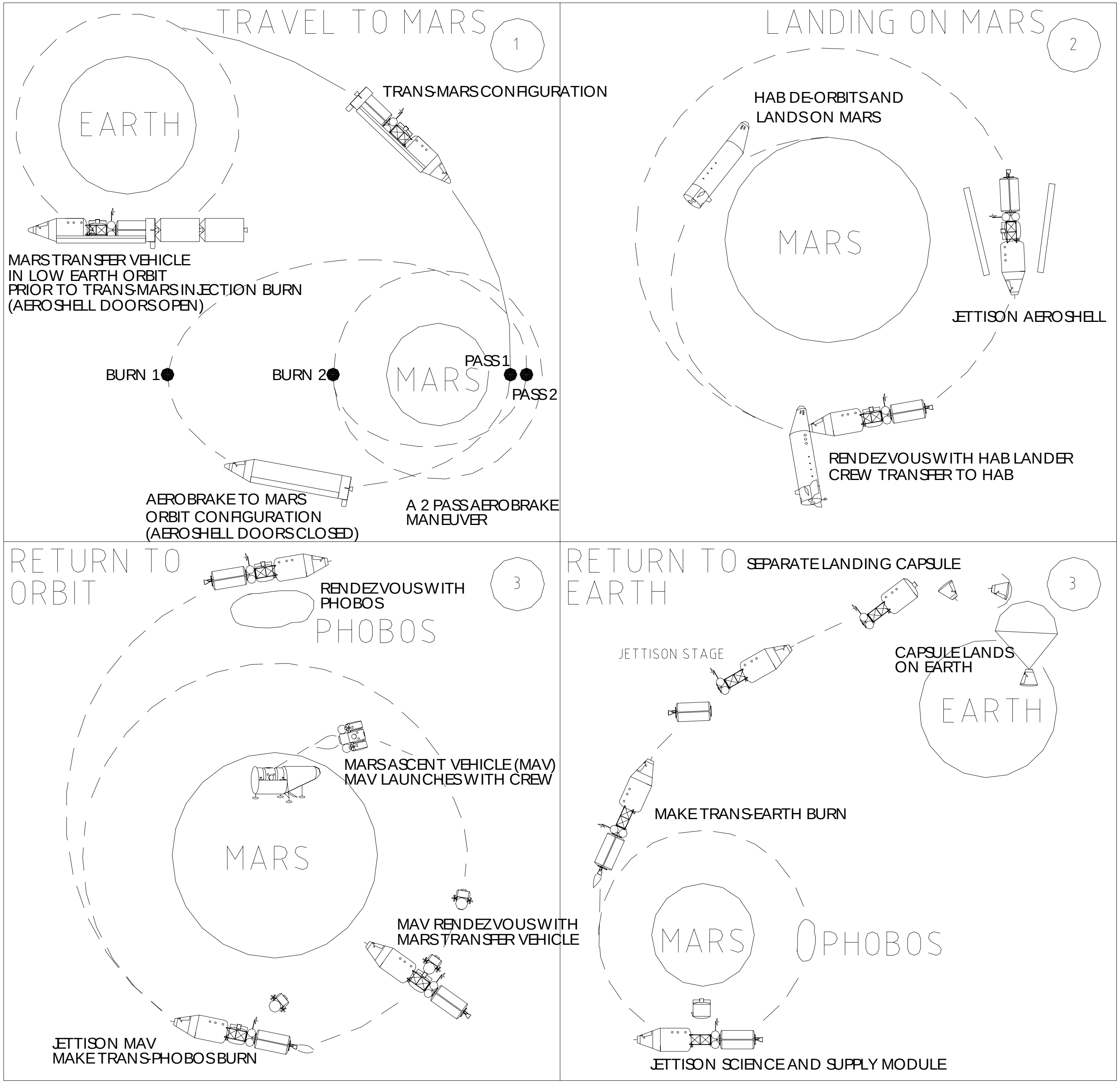


How does our Mars-Oz base compare with other proposed stations for Mars?
The MSA has compared and evaluated different proposed Mars station.

In summary, we see the Mars-Oz type structures better for building long term bases on Mars or the moon.

It is probable the station will need to be buried under 3 m soil for protection against cosmic ray radiation. This will require another Cargo vehicle carrying a large jack up roof and earth moving equipment

Mars Transfer Vehicle Mission.



-Must meet

Hab in LMO

-2 pass

aerobrake

Design Details:-Crew Space

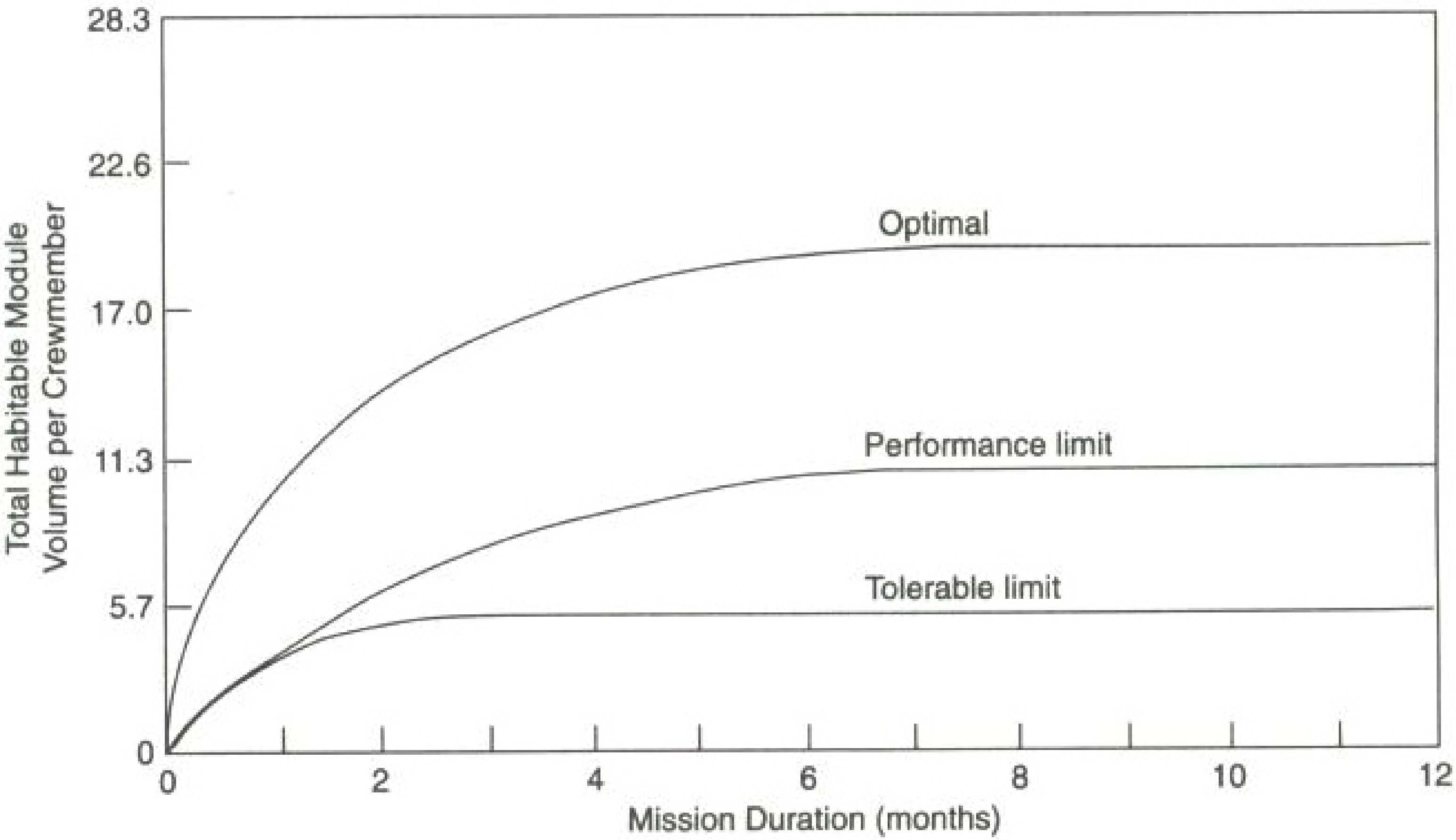


FIG. 6-2. **How Mission Length Affects Habitable Volume per Crewmember.** We can consider the bottom curve, "Tolerable limit," a survival level. Volumes between the top two curves enhance a crew's performance. [NASA-STD-3000]

Design Details:- Hab Masses

Table of Hab wall masses

Mass per m² of Hab double walled aluminum shell including insulation	30 kg
Mass per m² of Hab floors and walls including insulation	15 kg
Mass per m² of insulation in walls	3 kg

Hab Size

General Method

Vehicle mass = 592 x (the number of crew x mission duration in days x pressurized volume)^0.346

Consumables

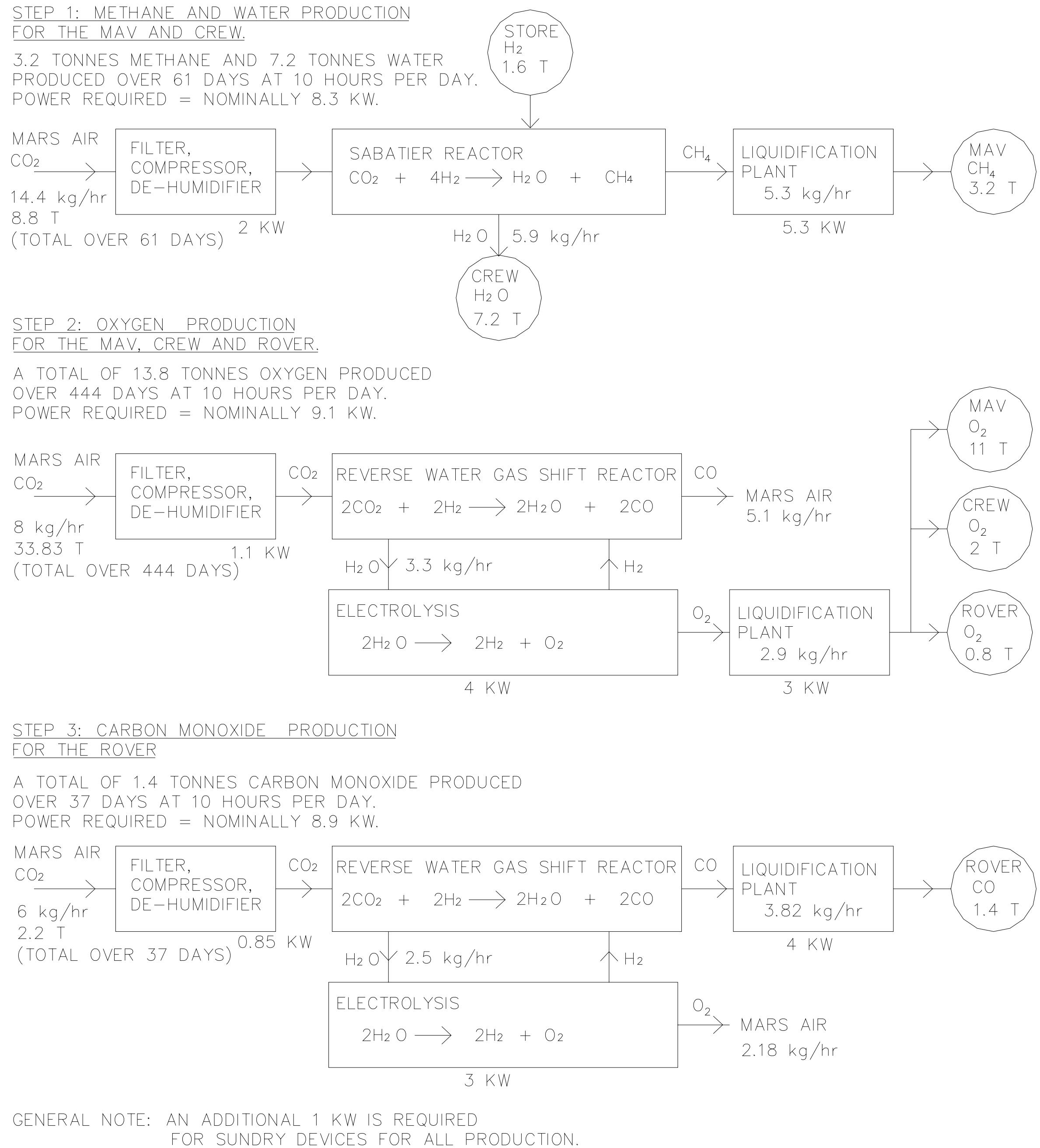
Product provided/person/day	Mass provided/person/day	Product lost/person/day	Mass lost/person/day
Oxygen from stores	0.84 kG	CO2	1 kG
Fresh Drinking water from stores	2.4 kG	Urine	2 kG
Food (2/3 water) from stores	1.8 kG	Faces	0.12 kG
Fresh wash water from stores	0.7 kG	Brine	2.5 kG
Water recycled from air conditioning	1.8 kG		
Water recycled from wash water	22.5 kG		
Total	**27.5 kG**		**5.62 kG**

From W. W Guy, “Spacecraft Life Support and Thermal Management.”,

Design Details

In-Situ Resource

Utilization Plant



Design Details

Fixed Resources and Equipment

Clothing
Personal hygiene kit
Personal stowage/closet space

Freezers
Conventional oven and microwave ovens
sink, spigot for food hydration and drinking water
Dishwasher
cooking utensils

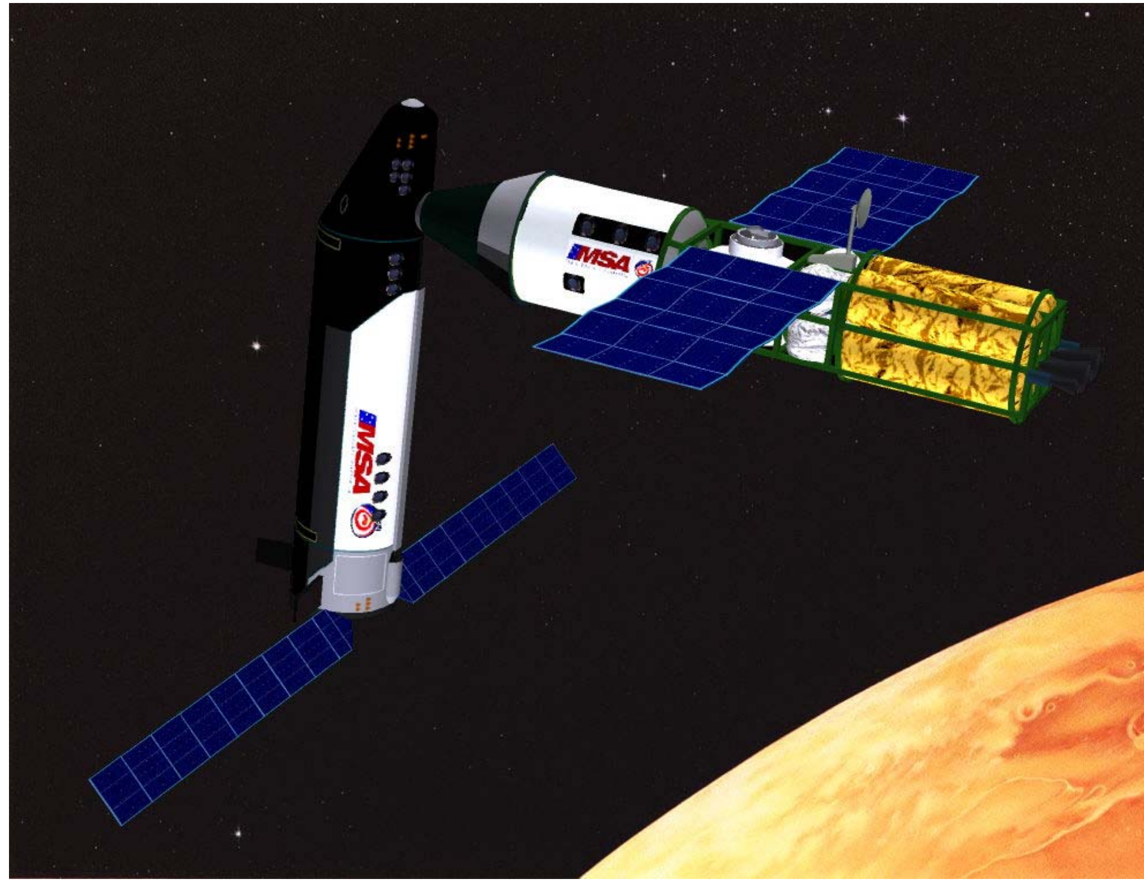
Waste collection system (toilets)
Shower and wash basin
washing machine and dryer

Restraints and mobility aids
Vacuum (prine + 2 spares)**
trash compactor/trash lock

Hand tools and accessories
Test equipment (oscilloscopes, gauges etc)
Fixtures, large machine tools, gloveboxes, etc)
Camera equipment (still & video camaras & lenses)

Exercise equipment
Medical/surgical/dental suite and consumables

Mars Transfer Vehicle Mission.

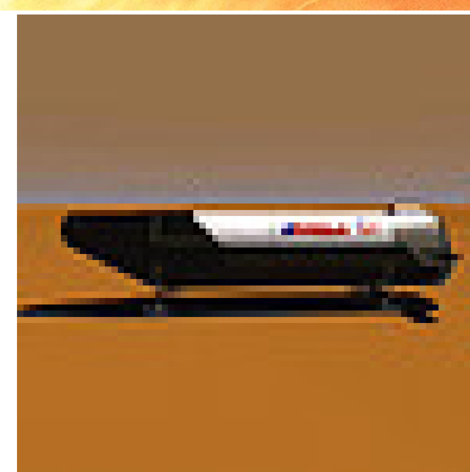


MTV

MARS-OZ MTV
3D model by António Maia (wip)
20060821

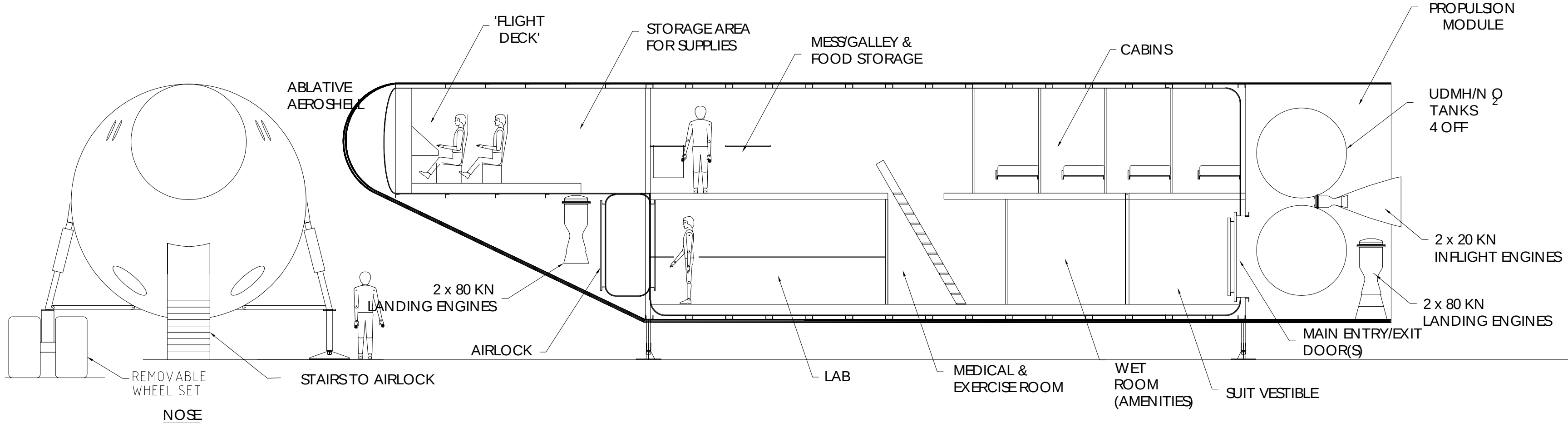
Pictures:

Antonio Maia

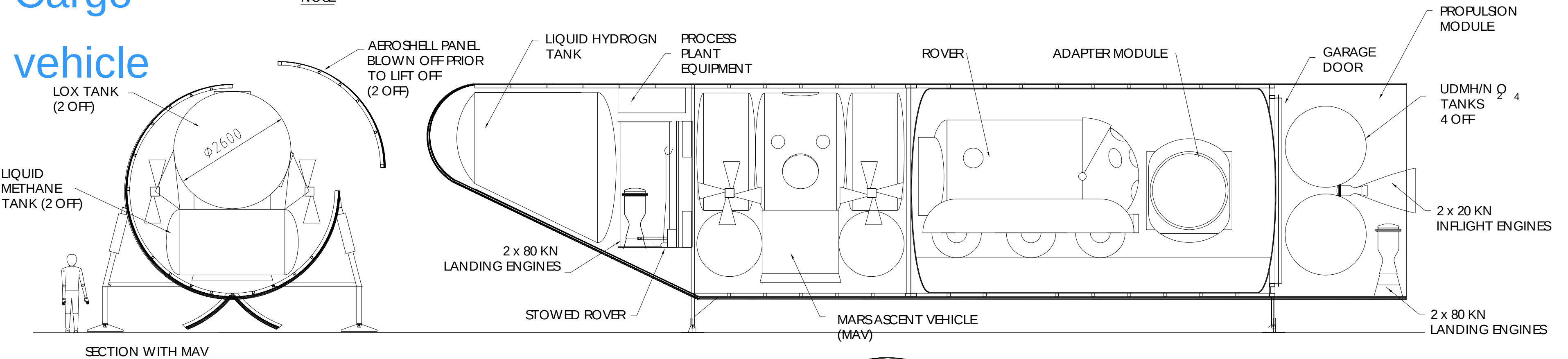


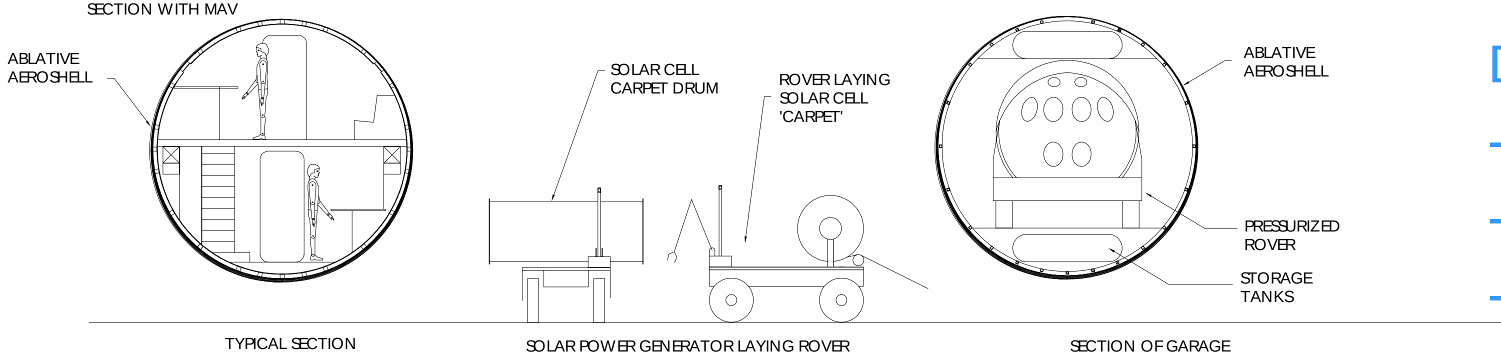
The Vehicle Size: The Hab and Cargo V

Hab



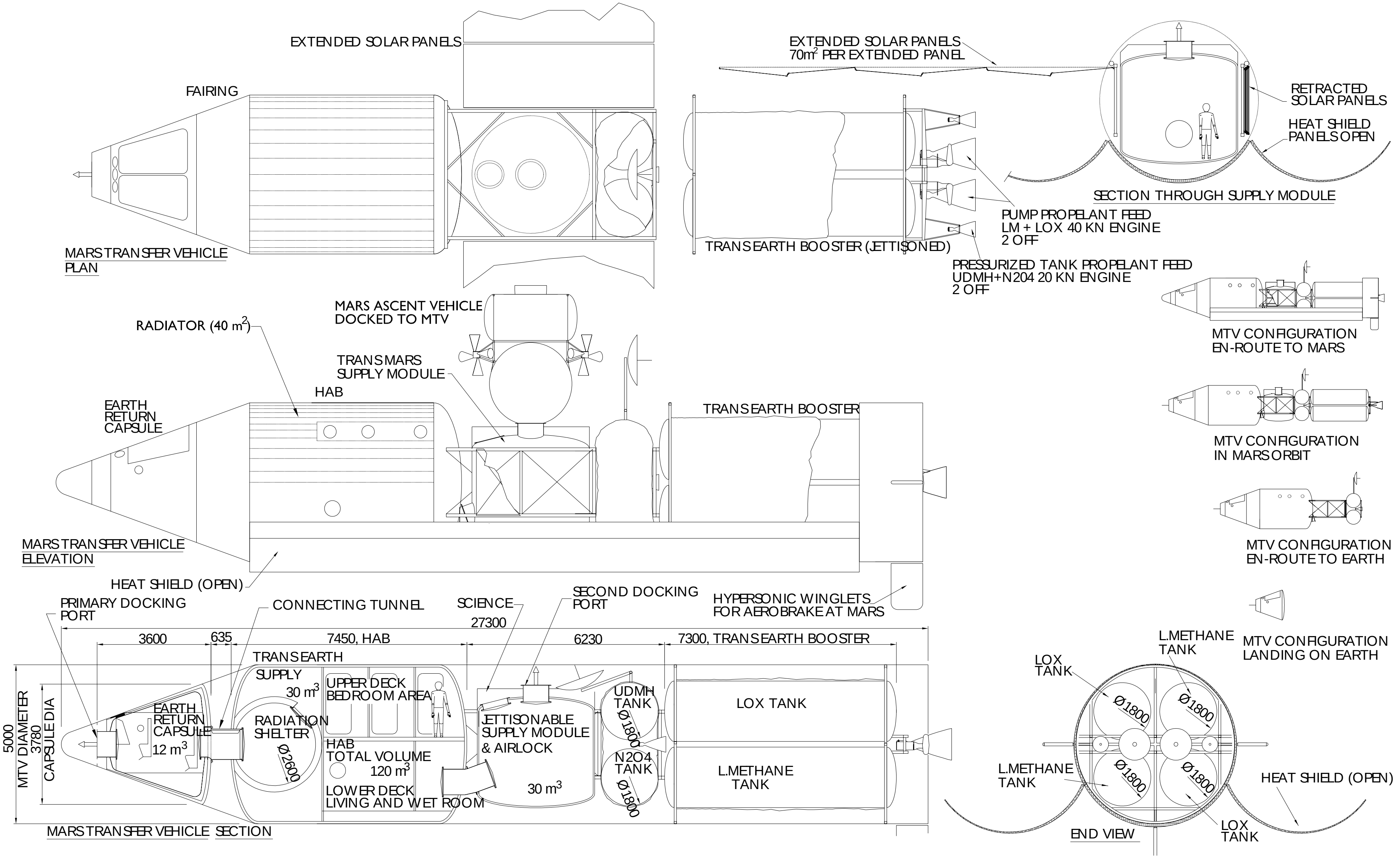
Cargo vehicle





Design issues:

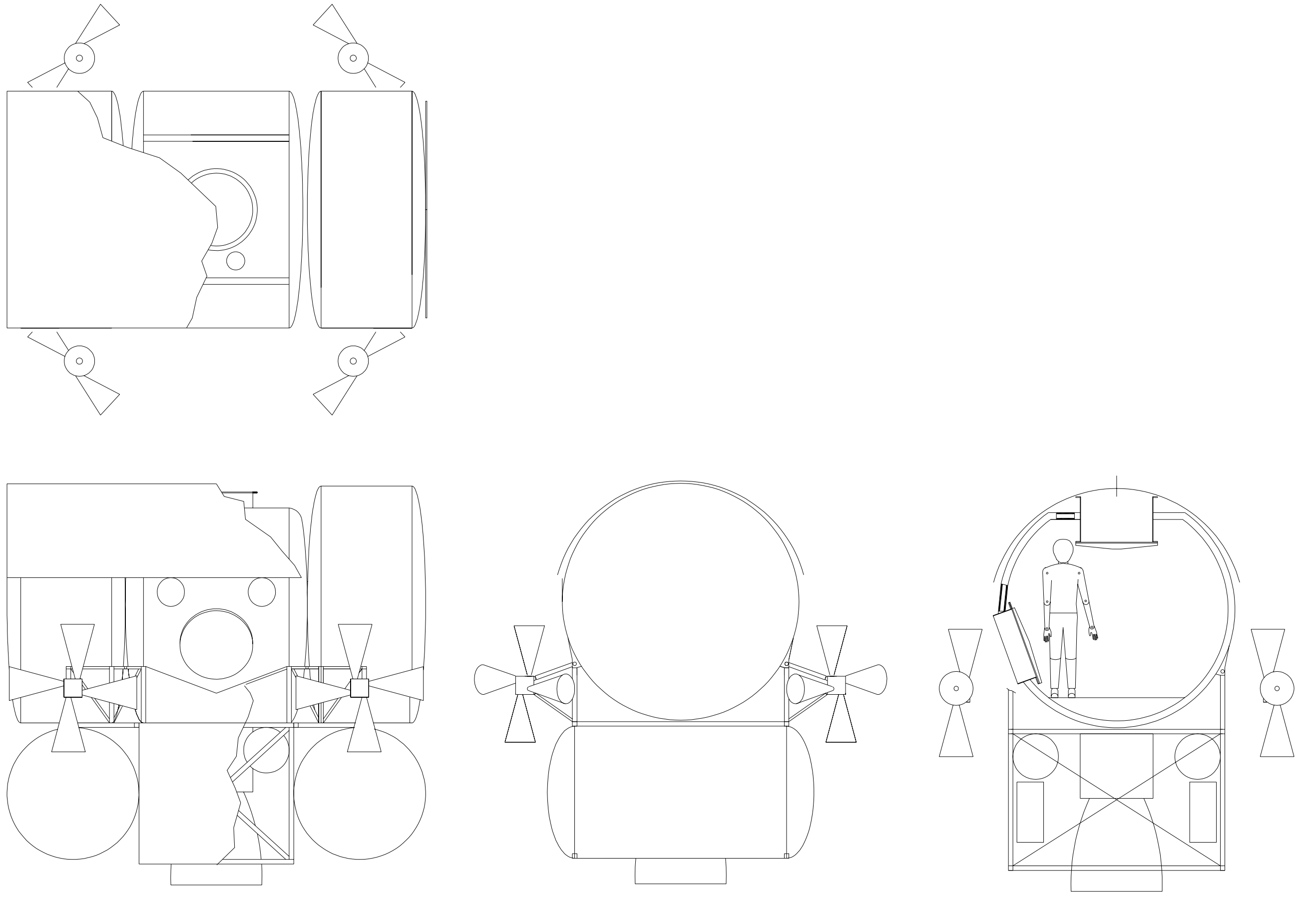
- Room heights
- LH tank size
- MAV size
- Hab diameter



The Mars Transfer Vehicle

Mass = 130 T incl 20% margin

- **A supply module that is jettisoned before the return journey begins**
- **Liquid methane and oxygen as the primary propellant.**
- **High degree of recycling.**
- **Retractable solar panels and a 3 piece heat-shield.**



This vehicle required to be as light weight as possible. Its mass = 4 T dry and 18 T fueled.

It required to fit into the Cargo Vehicle

The Mars Ascent Vehicle

Total Mass to LEO

Manned Mars Mission Total mass in LEO

Payload Lifted into Low Earth Orbit	**TMS(s) required for the Trans-Mars burn**
Hab, 62 tonnes	1TMS, 110 tonnes
Cargo vehicle, 62 tonnes	1 TMS, 110 tonnes
MTV, 130 tonnes	2 TMS, 220 tonnes
Total mass in LEO	**694 tonnes**

Conclusions

The MSA Mission Architecture is possible using 60 T horizontally landed bent biconic vehicles and a 130 T Mars transfer vehicle.

The horizontally landed bent biconic vehicles are well suited to building long term Mars stations.

Traveling to Mars in the Mars transfer vehicle enables the Landers to be specifically designed as long term Mars station structures rather than spacecraft.

Traveling to Mars in the Mars transfer vehicle provides abort options for the crew at Earth departure.

Adopting solar power generators is possible for small crews.