Mars Semi Direct

Mars Direct sensitivity to launch capability can be reduced by adoption of Semi-Direct architecture.

The Semi-Direct plan involves three payloads.

- **Mars Ascent Vehicle delivered to surface, where it makes propellant.**
- **ERV delivered to highly elliptical Mars orbit, with propellant from Earth**
- **Crew flies to Mars in Hab, lands near MAV.**
- **Crew explores Mars 1.5 years, then ascends in MAV to ERV**
- **ERV goes on Tran-Earth injection.**
- **Crew bails in capsule for Earth Entry.**

• Mission provides larger ERV than Mars Direct, with less power,

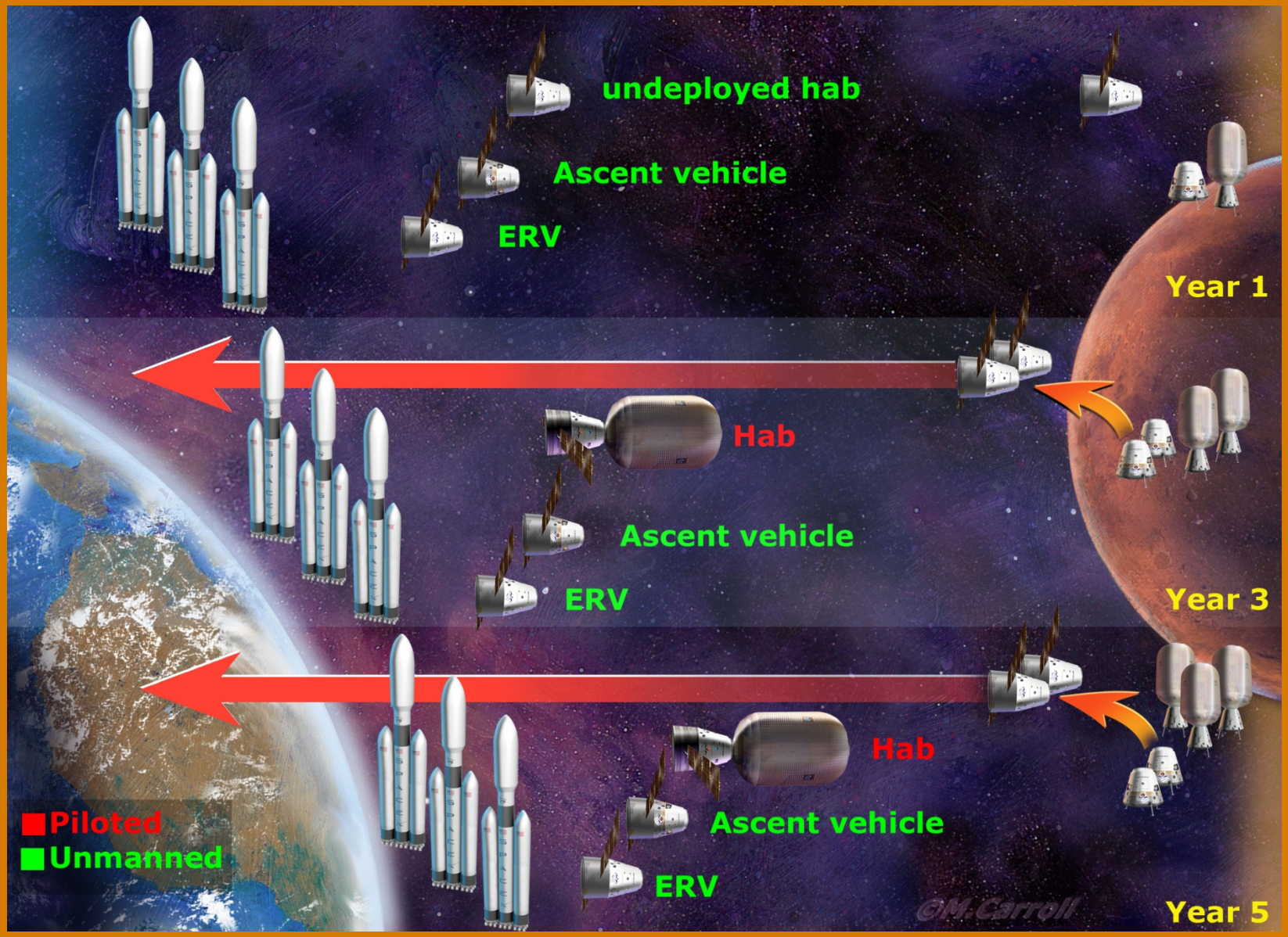
- **If MAV is kept small, power requirement can be met by either 10 kWe Russian Topaz or by surface solar power**
  → eliminates need for new ~100 kWe surface nuclear power system
- **2 tonne (LEM size) ascent vehicle adequate for crew of two**
- **Small MAV allows mission with transported methane, Martian oxygen.**
  → No need for long duration hydrogen storage

• Requires Mission-critical MOR on Return leg.

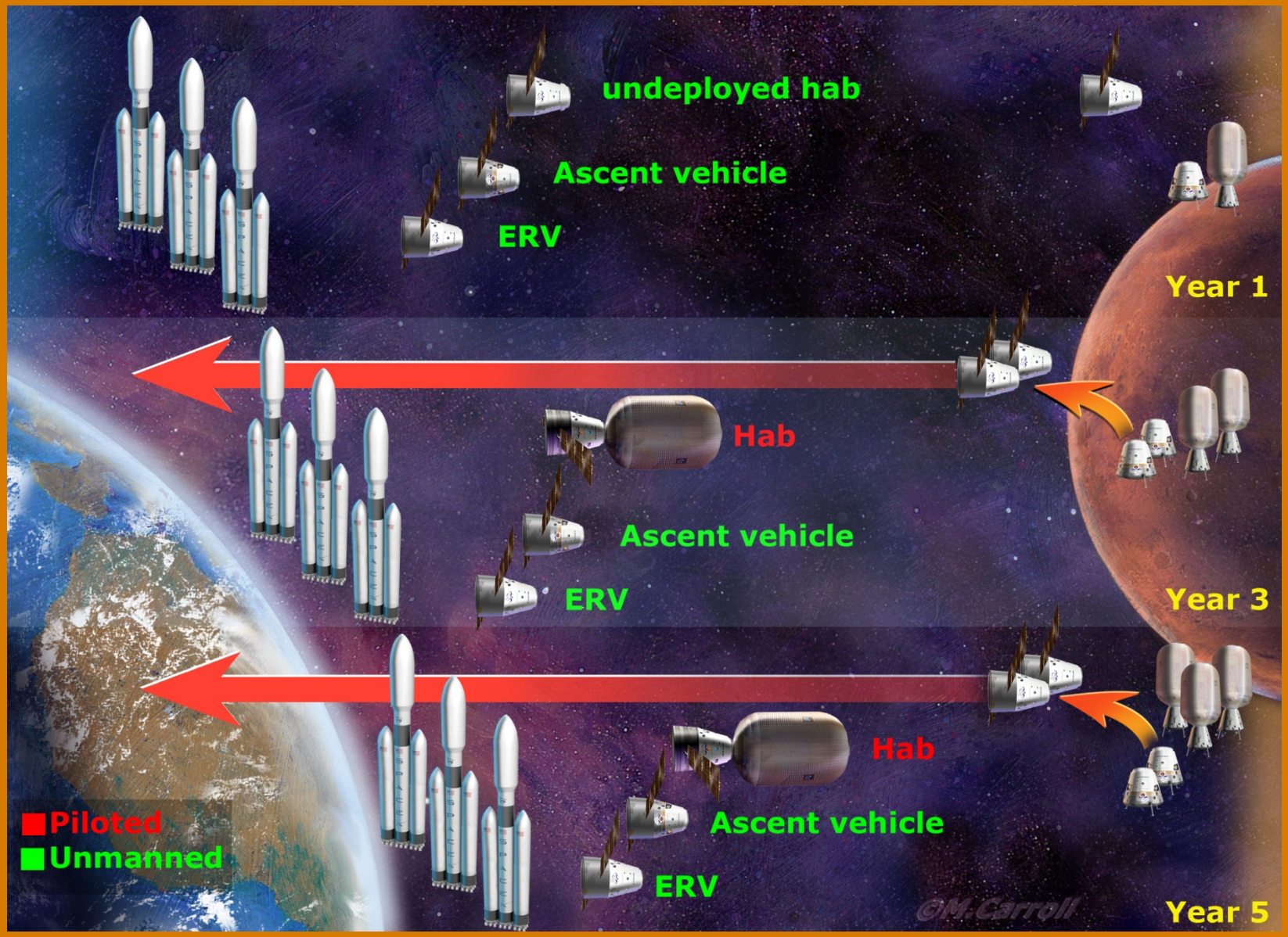
• Described at length by Zubrin and Weaver, 1993. Made basis for NASA DRM.

• If scaled down to crew of 2, mission should be achievable with three Falcon heavy launches.

Mission Sequence Chart

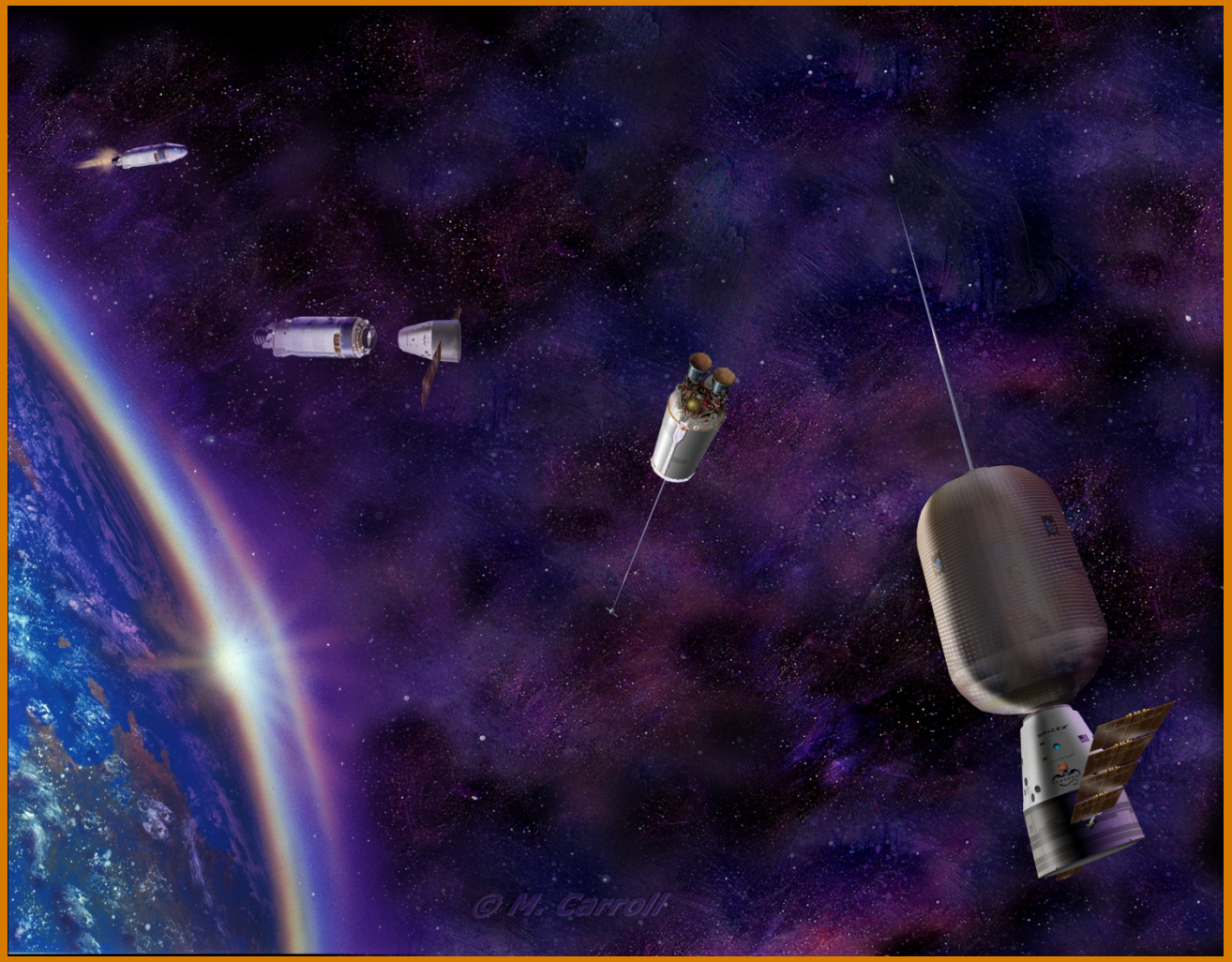


Mars Direkt Missionsszenario



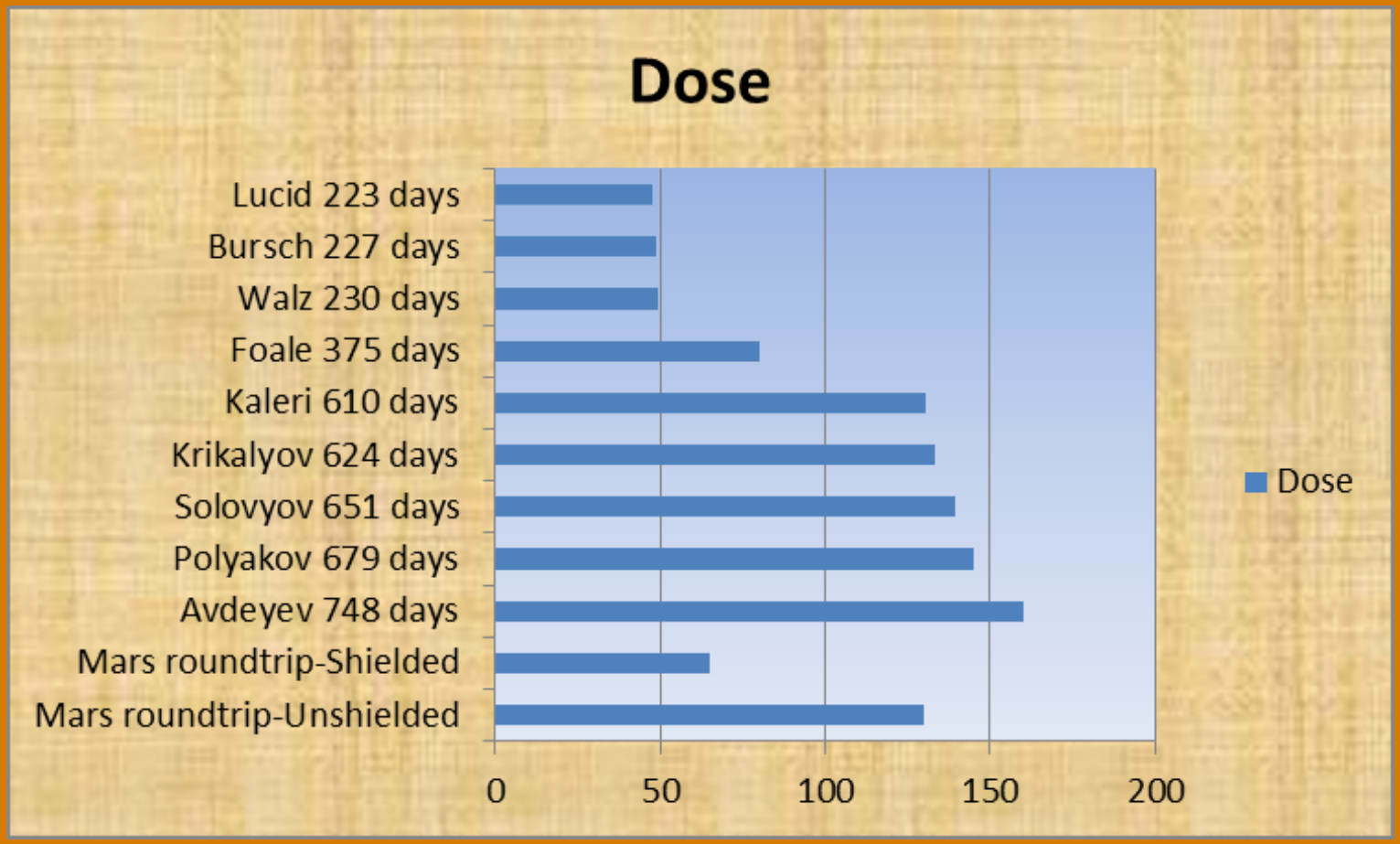
Using Dragon for Crew Transportation

- Crew of 2 is launched in Dragon capsule
- Habitable space is augmented by 8 m long x 6 m diameter inflatable.
  - Two decks, 56.5 m^2 of floor space, 180 m^3 volume
  - Artificial gravity enabled by tethering off TMI Stage



Cumulative Radiation Doses Received in Space

(Scaled from Brookhaven Estimates)



The cumulative radiation dose of a human roundtrip mission to Mars using current propulsion technology has already been experienced by numerous astronauts.

No radiation-induced health effects have been observed.

Logistics for Falcon Mars Semi-Direct mission

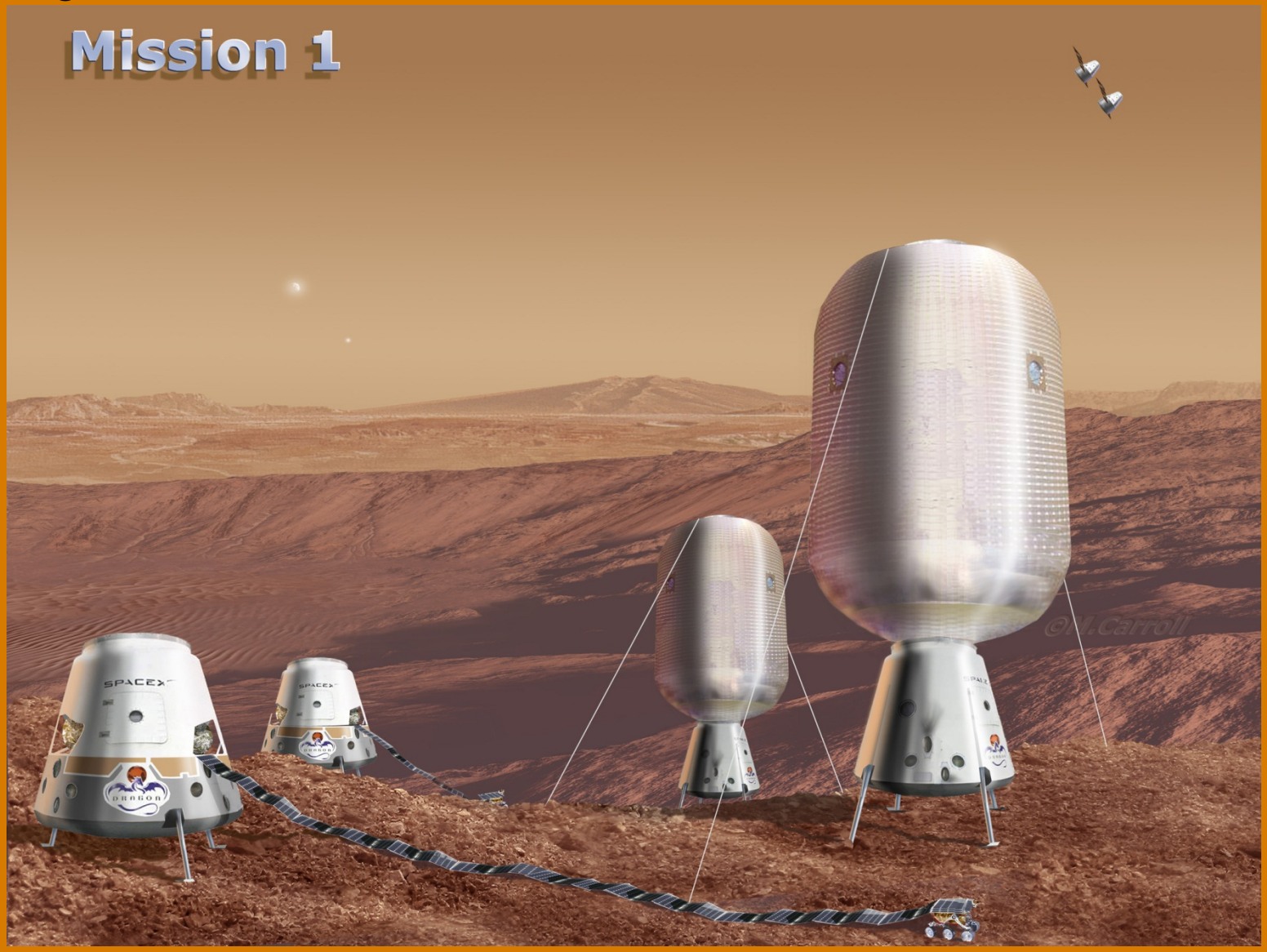
Falcon Heavy Capability	53 tonnes to LEO		17 tonnes to TMI (H2/O2)
	14 tonnes to Mars orbit		11 tonnes to Mars Surface
Dragon mass	8 tonnes	Crew Size	2

Payload	Hab	ERV	MAV Payload
Dragon	8000 kg	8000 kg	-
MAV cabin	-	-	2000 kg
Inflatable cabin	200 kg	200 kg	-
Food	900 kg	300 kg	20 kg
Water	400 kg	150 kg	50 kg
Methane	-	900 kg	2600 kg
Oxygen	100 kg	3150 kg	0
Propulsion System	-	400 kg	1170 kg
Power System	200 kg	400 kg	1500 kg
ISRU System	-	-	500 kg
Other Cargo/margin	1200 kg	500 kg	3160 kg
Total	11000 kg	14000 kg	11000 kg

- Food = 0.75 kg/person-day = 2100 cal/day for food with average of 2800 cal/kg
  Peanut butter = 5000 cal/kg, pasta = 3700 cal/kg, pork chops = 2200 cal/kg
- Water and oxygen are recycled
- With thickness of 0.8 mm, pressure of 5 psi, Kevlar inflatable has 10 X min strength
- Inflatable hab is potentially stowable prior to entry, enabling reuse on Mars

Development of Mars Base: First Landing

First Crew has 2 habs, 2 ERVs, 2 Mars ascent vehicles, 20 kWe, 8 tonnes cargo
Dragon serves as airlock for inflatable two-deck surface hab.



Development of Mars Base: Third Landing

Third Crew has 4 habs, 2 ERVs, 2 Mars ascent vehicles, 40 kWe, 16 tonnes cargo
By mission 3, added facilities and availability of Mars water could enable expanded crew

"This proposition being made publike and coming to the scanning of all, it raised many variable opinions amongst men, and caused many fears & doubts amongst themselves . Some, from their reasons & hops conceived, laboured to stirr up & incourage the rest to undertake and prosecute the same; others, againe, out of their fears, objected against it, & sought to diverte from it, aledging many things, and those neither unreasonable nor unprobable; as that it was a great designe , and subjecte to many unconceivable perills & dangers. . .

"It was answered that all great & honourable actions are accompanied with great difficulties, and must be both enterprised and overcome with answerable courages."

-Governor William Bradford, "Of Plimoth Plantation," 1621