AFFORDABLE MARS MISSION

Jean-Marc Salotti

Ecole Nationale Supérieure de Cognitique, Institut Polytechnique de Bordeaux

Laboratoire de l'Intégration du Matériau au Système, UMR CNRS 5218

+ Association Planète Mars

Sommaire

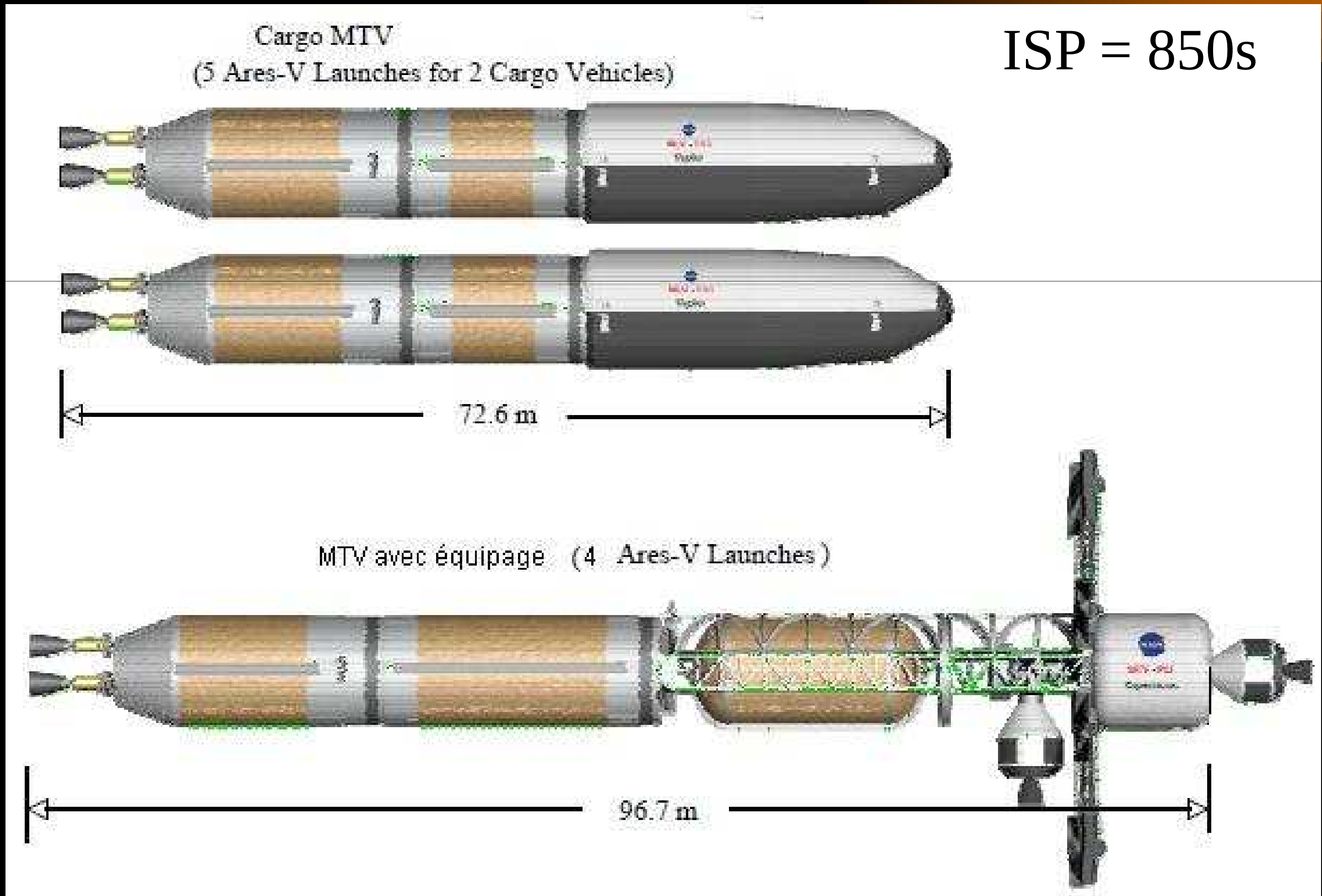
Introduction

1. Risks and costs drivers for NASA DRA5
2. Impact of smaller crews
3. Low costs preparatory missions

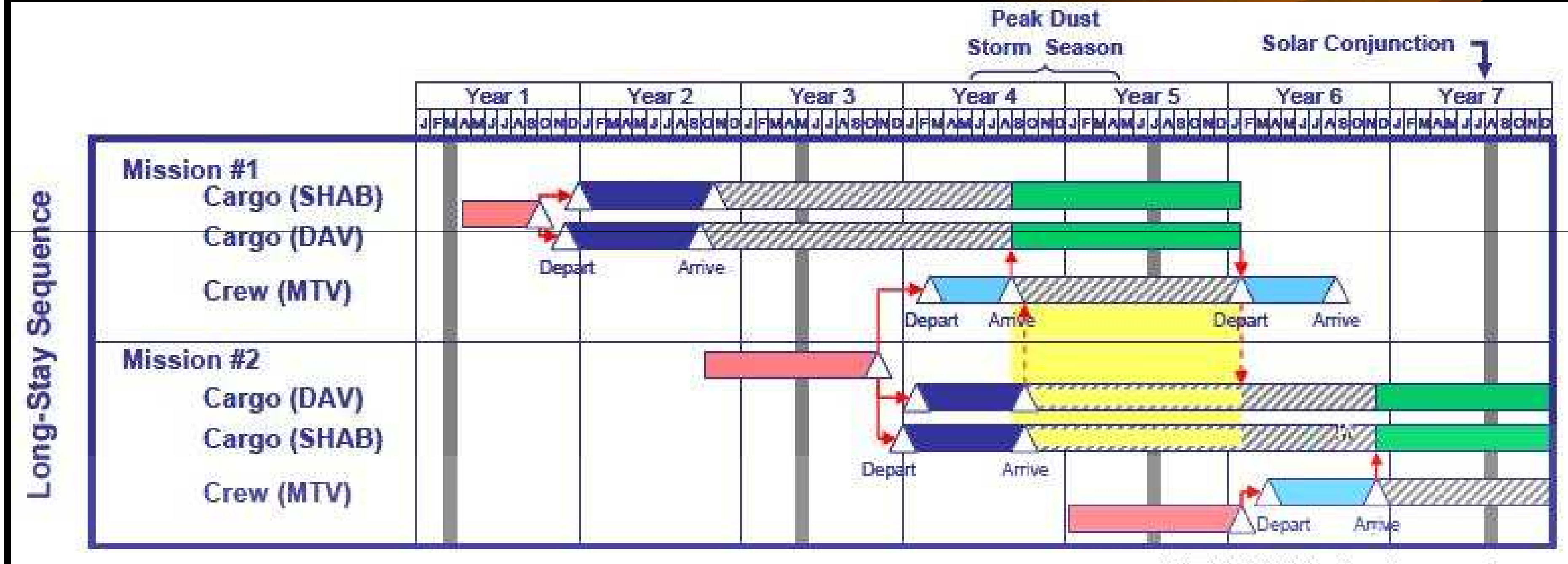
Conclusion

1. Risks and costs drivers for NASA DRA5

NASA reference mission
9 SLS launches + LEO assembly



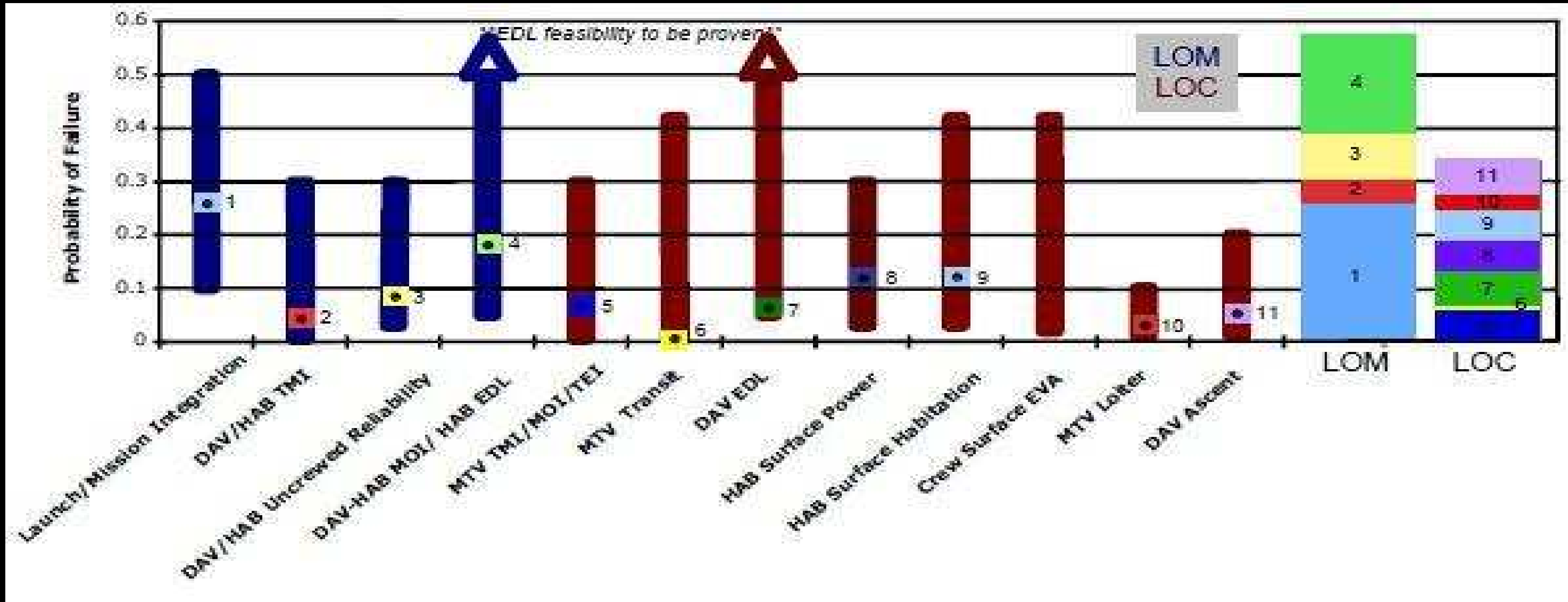
NASA scenario (DRA5, 2009)



SHAB=Habitat de surface

DAV=Véhicule de descente et de remontée

MTV=Véhicule de transfert Terre-Mars A/R



NASA DRA5, page 147: Precursor activities/reliability growth implications

The immaturity of the developmental technologies that are needed to complete a Mars mission will have to be addressed through testing or precursor missions. Through demonstrations and experience, a reliability growth will occur as flaws are tested out of the design. The high-risk developmental technologies that were identified for a Mars mission are (top 3):

- Mars EDL
- Nuclear propulsion in space
- Surface nuclear power

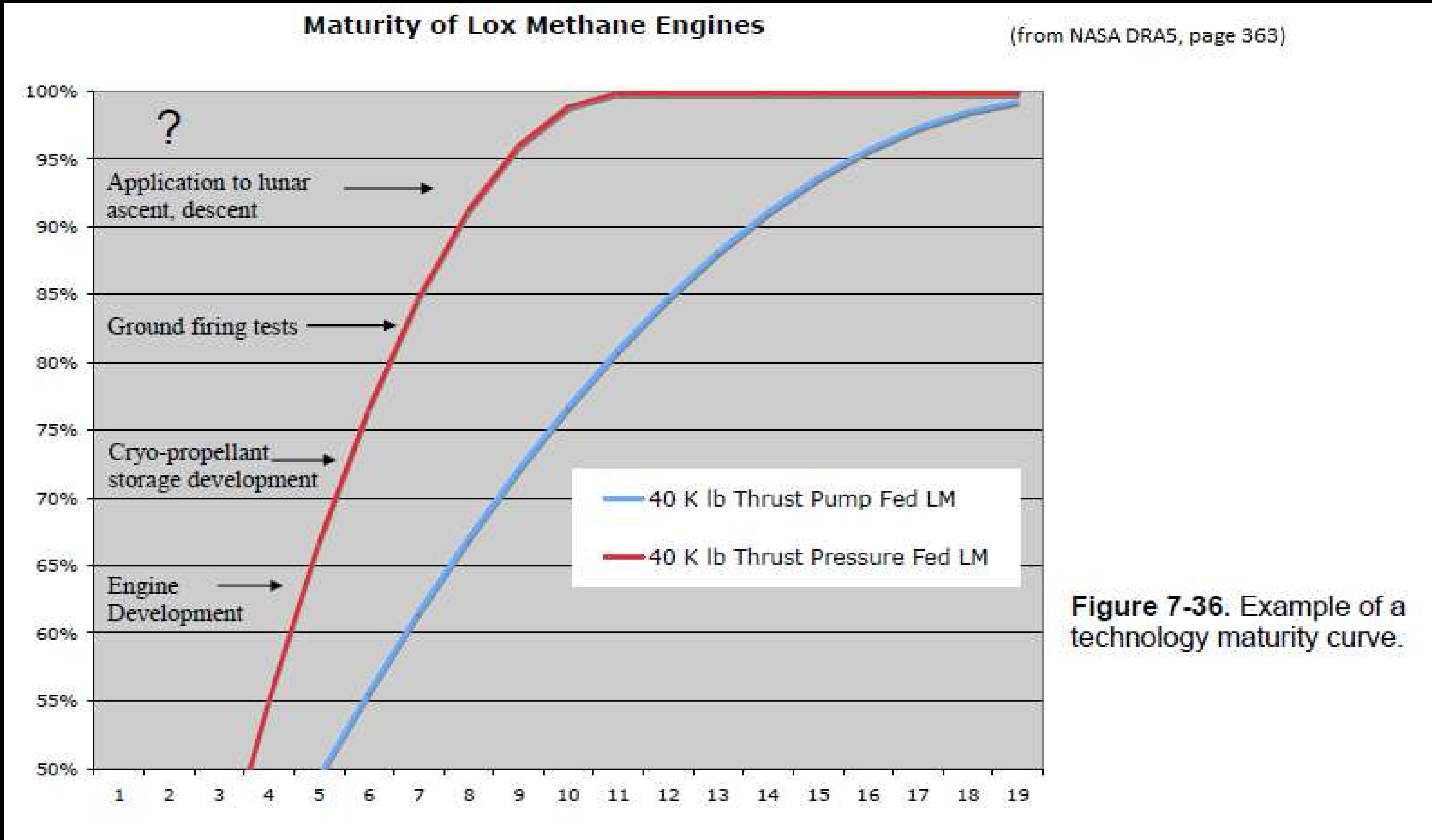


Figure 7-36. Example of a technology maturity curve.

NASA DRA5 page 364: "A reasonable goal would be for the precursor activities of the (first) decade to drive the maturity curves for each technical discipline to such higher values that the probability of safe astronaut return is above 8.5 or 0.9 …."

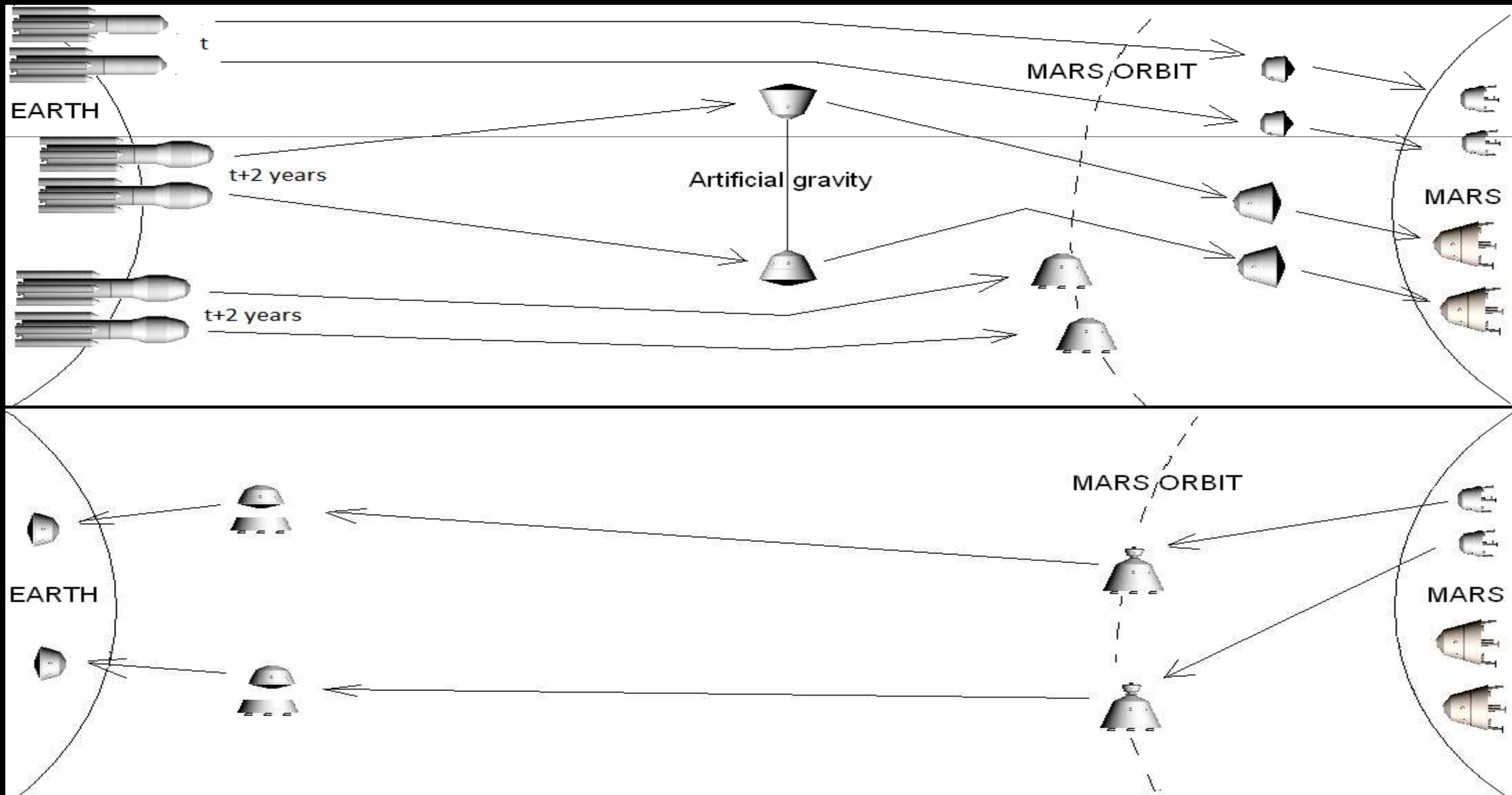
Risks and costs are tightly linked

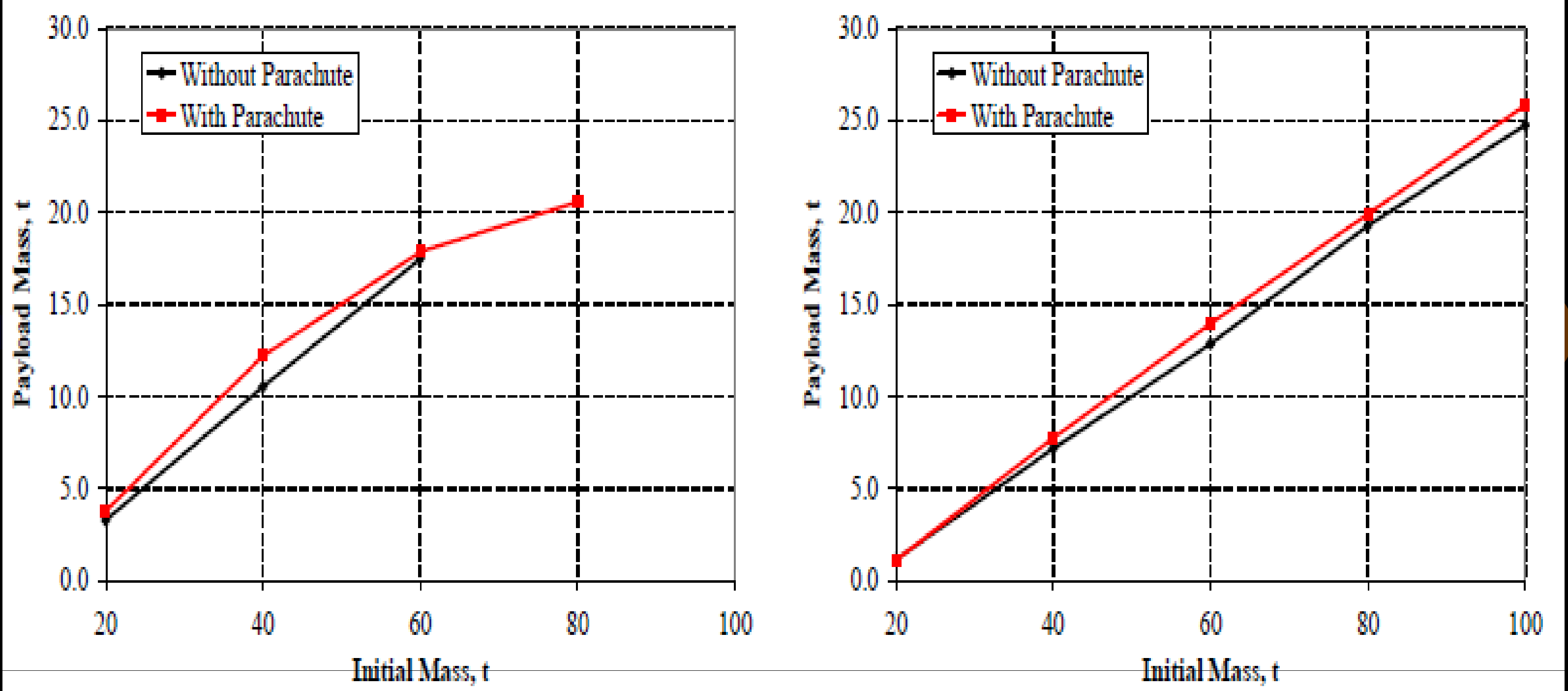
- New EDL systems for giant spaceships with complex procedures => low maturity => numerous scale-1 tests in Martian atmosphere => expensive preparatory missions

- Nuclear propulsion systems for giant spaceships => low maturity => numerous scale-1 long duration tests in space => expensive preparatory missions

2. Impact of smaller crews

2-4-2 concept (Salotti 2011). IMLEO: 540 tons ???





a) 10 m diameter vehicle *b) 15 m diameter vehicle*

Payload delivered to the Martian surface for L/D=0.3.

Graph from Christian and co-authors, Journal of Spacecraft and Rockets, 2008.

24 tons of payload => total: option a) 2x40 or option b) 1x95

2 small < 1 big !!!

2 main reasons:

Heavier spaceships => higher ballistic coefficients

a) => higher heat loads per cm^2 => thicker heat shields and heavier thermal control systems

b) => more lift required to avoid surface crash => vertical velocity ok but higher horizontal velocity => more propellant required for final braking phase => heavier landing vehicle

Crew size impact on NASA scenario, chemical option, from Salotti, Heidmann and Suhir, submitted to IEEE Aerospace Conferencec, 2014:

System	**Reduction rate if a crew of 3 is chosen instead of a crew of 6**	**New IMLEO (starting at 1252 tons for a crew of 6, NASA DRA5, branch 3)**
Direct impact: Consumables, life support systems, rover, propellant, engines, etc.	C1: 36% C2: 37,5% MV: 34%	C1: 230t C2: 230t MV: 352t Total: 810t
Entry, descent and landing of the two cargos	C1: 26% C2: 26% MV: 0%	C1: 172t C2: 172t MV: 352t Total: 696t
Aerocapture for the manned vehicle	C1: 0% C2: 0% MV: 29.3%	C1: 172t C2: 172t MV: 249t Total: 548t
No LEO assembly. 3 cargo vehicles instead of 2 and separation of the TEI propulsion module for the manned vehicle.	C1:-23t C2:-23t MV:-22t	C1: 149t or: C1:99t (ex.) C2: 149t C2:99t C3:100t MV: 227t or: MV:113t ERV-Prop:114t **Total: 525 tons**

3. Low costs preparatory missions

Hypothesis: crew of 3, 30-40 tons à Mars entry

EDL systems:

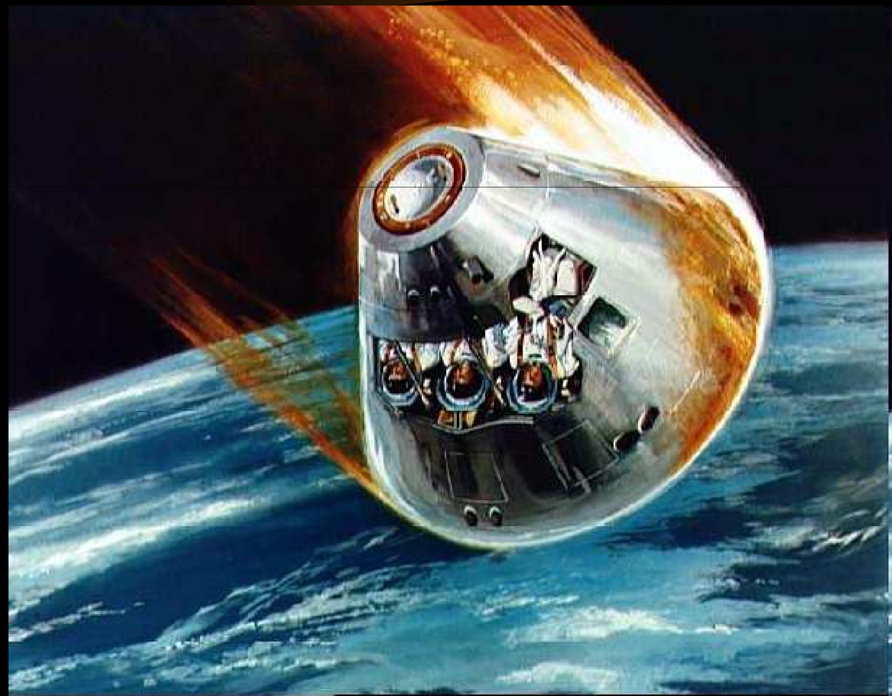
- 70° sphere cone

heat shields (highest TRL)

- 30 meters DGB parachutes
- Well-known procedures

⇒ 1 or 2 preparatory missions

Idea: MSR with 30-tons entry vehicle !!! 1 SLS launch!!!



Other costs

SLS TMI capability = 45 tons

Cargo 1, MAV => 1 SLS launch

Cargo 2, SHAB => 1 SLS launch

Cargo 3, tools and rovers => 1 SLS launch

Manned vehicle, 227 tons ???

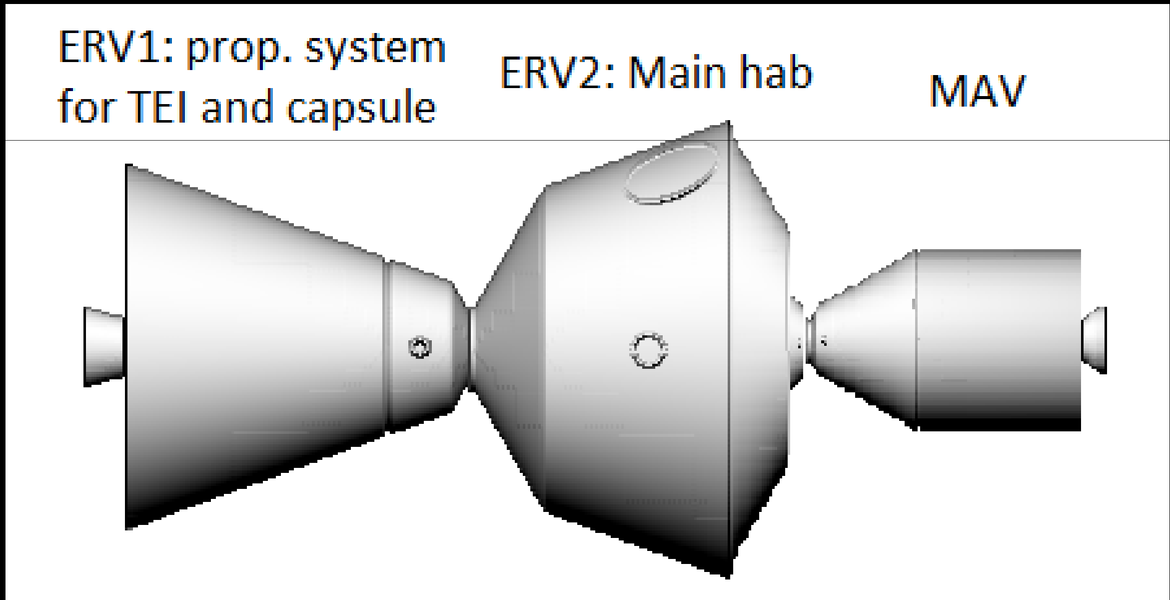
Idea: separate the propulsion stage for the return and the hab!!!

⇒ 2 SLS launches

Impact on costs: no LEO assembly, no NTR development and no NTR preparatory missions to achieve maturity

=> important savings!

Rendezvous in Mars orbit for the return




Conclusion:
reduced costs and
simplified roadmap
=> Mars closer than ever
16

References

- J.M. Salotti, Simplified scenario for manned Mars missions, Acta Astronautica, vol. 69, 266–279, 2011.
- J.M. Salotti, 2-4-2 Concept for Manned Missions to Mars, Proceedings of the 62nd International Astronautical Conference, IAC-11-A5.4.11, Cape Town, South Africa, 3-7 October 2011.
- J.M. Salotti, “Revised scenario for human mission to Mars”, soumis à Acta Astronautica, mars 2012.
- J.M. Salotti, Chapter 11: New Trends for Human Missions to Mars, in Mars: Evolution, Geology and Exploration, Nova Science Publishers, p. 267-288, 2013.
- J.M. Salotti and E. Suhir, Manned Missions to Mars: Minimizing Risks of Failure, Acta Astronautica, January 2014 (accepted).
- J.M. Salotti, New Trade Tree for Manned Mars Missions, proceedings of the 8th IAA Symposium on the Future of Space Exploration: Towards the Stars, Giancarlo Genta ed., p. 319-326, Turin (Italy), July 03-05, 2013.J.M.
- Salotti, Mars Sample Return as a Key Step in the Roadmap of the Manned Mission, proceedings of the 8th IAA Symposium on the Future of Space Exploration: Towards the Stars, July 03-05, 2013.