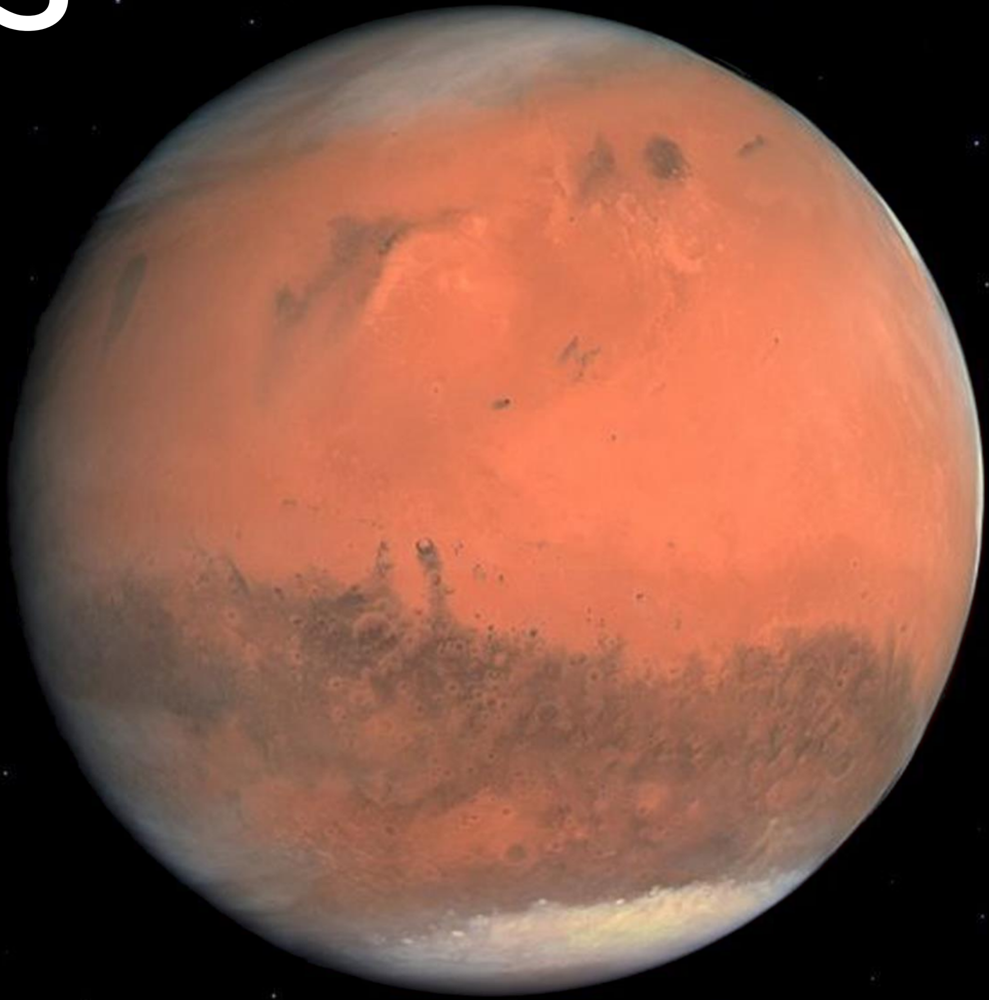
RED MOVERS

Landing 10 tons on Mars

THE MARS SOCIETY

Red Movers



Léopold COMBY
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The Mars Society – EMC 18

We are interested and involved in space

We want to be a part of the exporation of Mars.

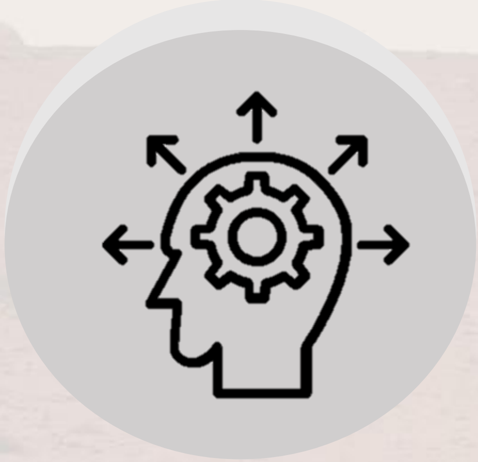
As students, this contest is a way to get a first step towards it.

- Design a 10t lander
- Fit for human spaceflight
- As cheap as possible
- Launched by 2026

Summary of our project

- Technical aspect
- Scheduling
- Budget
- Limitations





Launched with Falcon Heavy

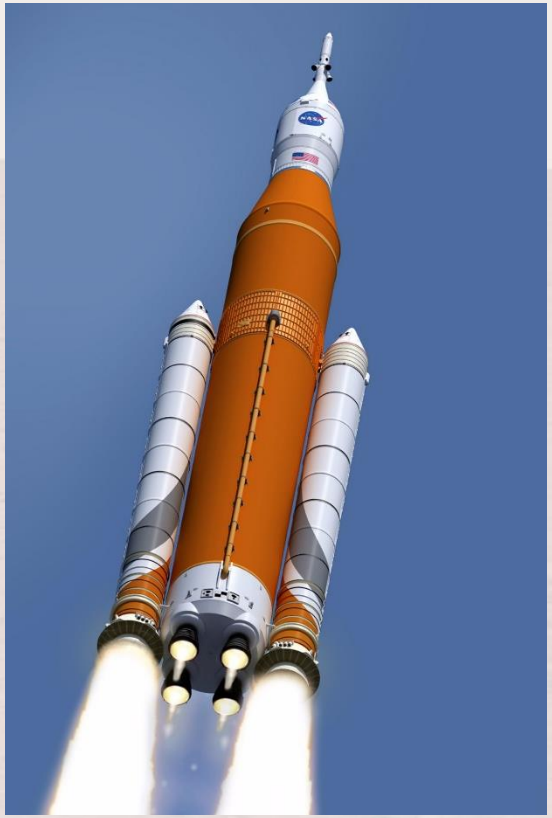
6-ton payload

$150 million

Launched with Space Launch System

10-ton payload

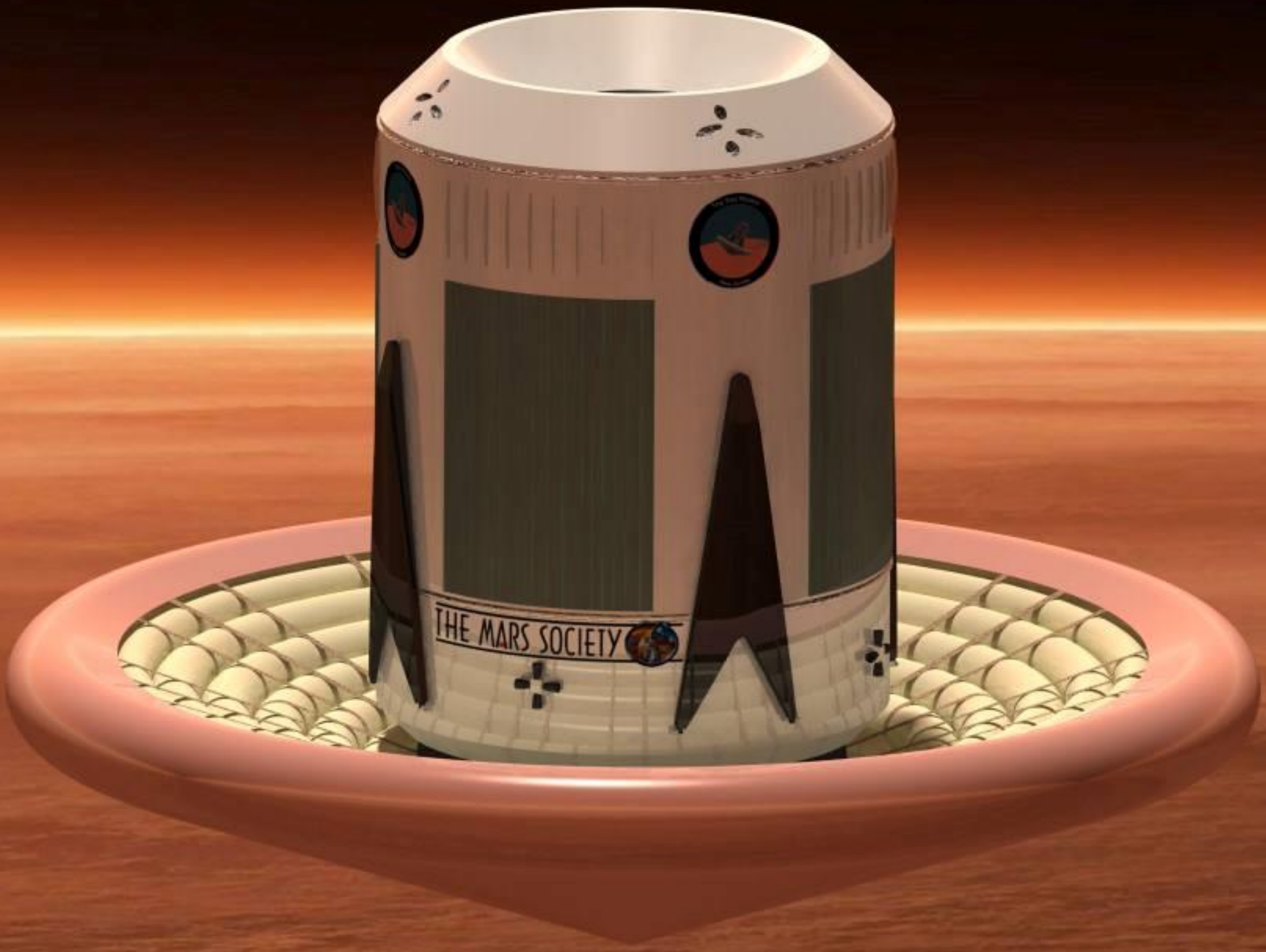
$500 million



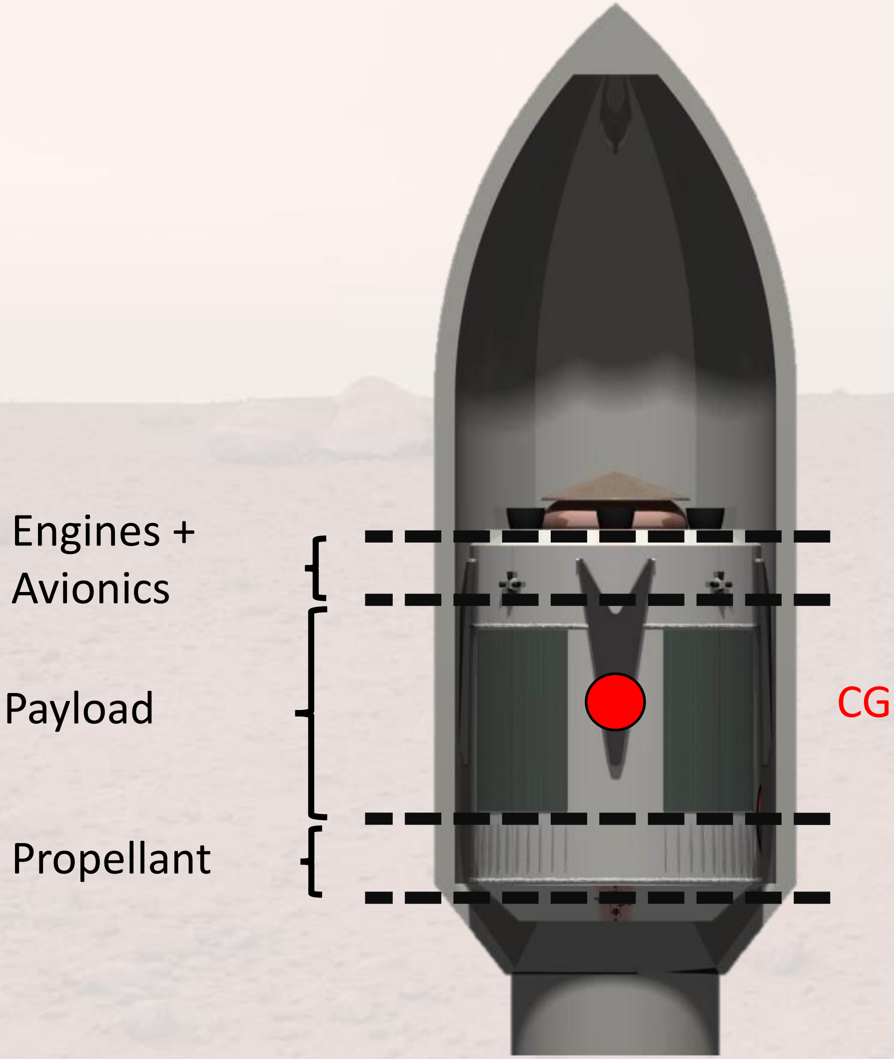
Colibri

Plume

Our Design



Mass breakdown



Pole	Masse - FH	Masse - SLS
Total mass	16.5	40
Propellant	4.5 + 1.5	17.5 + 2.5
Dry mass	3	6
Heat Shield	1.5	4
Payload	**6**	**10**

Benefits of such a choice

Cheaper solution even if more technical

Respect of the rules of the contest

More flexibility

Tools we used

- Orbital mechanics
- Trajectory visualisation
- Temperature and acceleration data

- Computational Fluid Dynamics
- Capsule aerodynamic coefficients

- Acceleration, trajectory, altitude, temperature calculation
- Trajectory choice

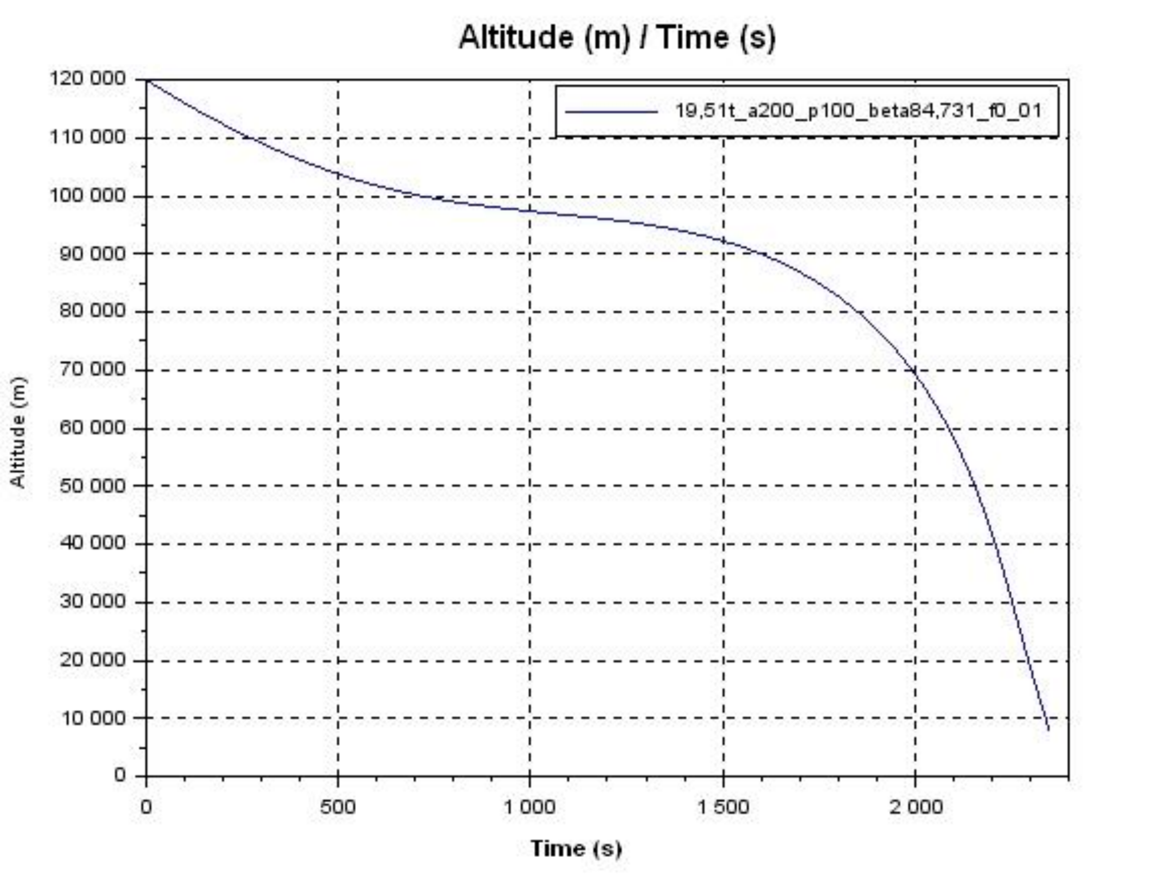
Heavy Lander – Plume (SLS)

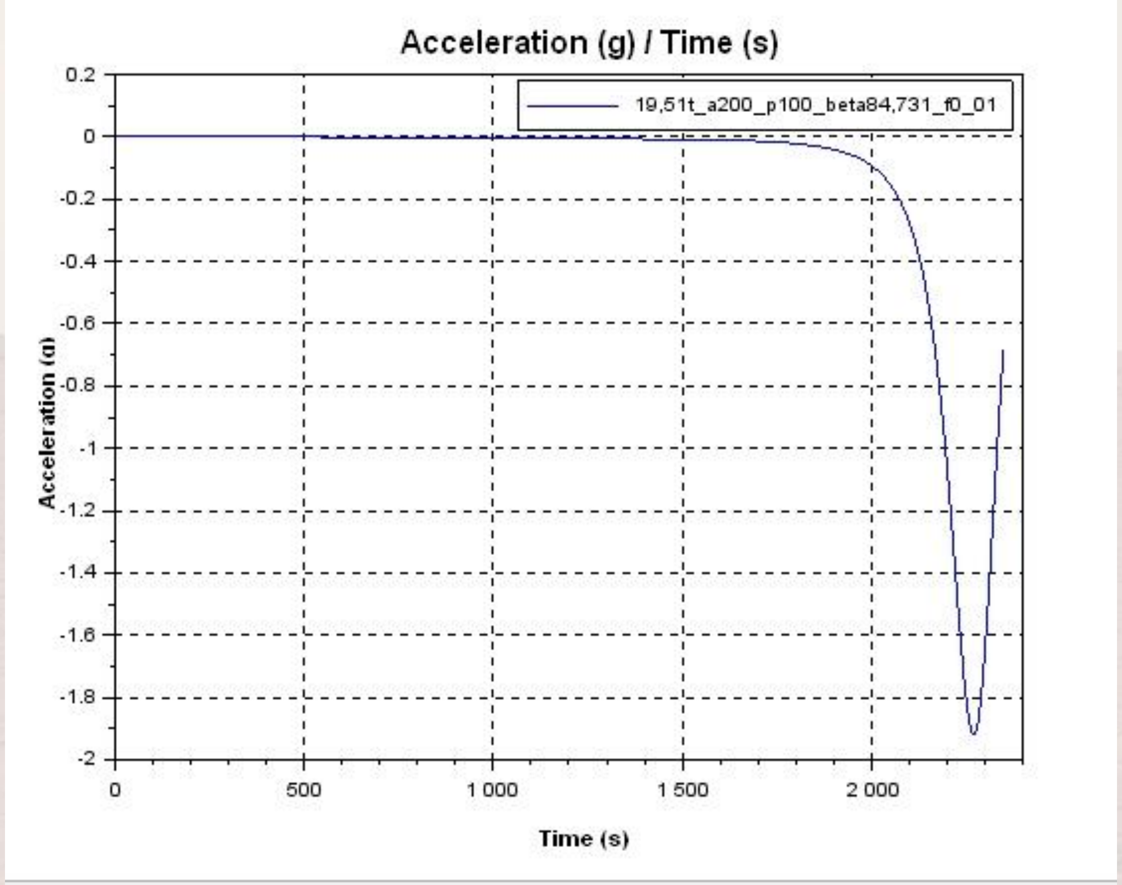
- Launched with SLS (Block 2)

- Initial mass send: 40t
- Mass lander: 18.5t

- Payload: 10t

Final landing using retro-propulsion





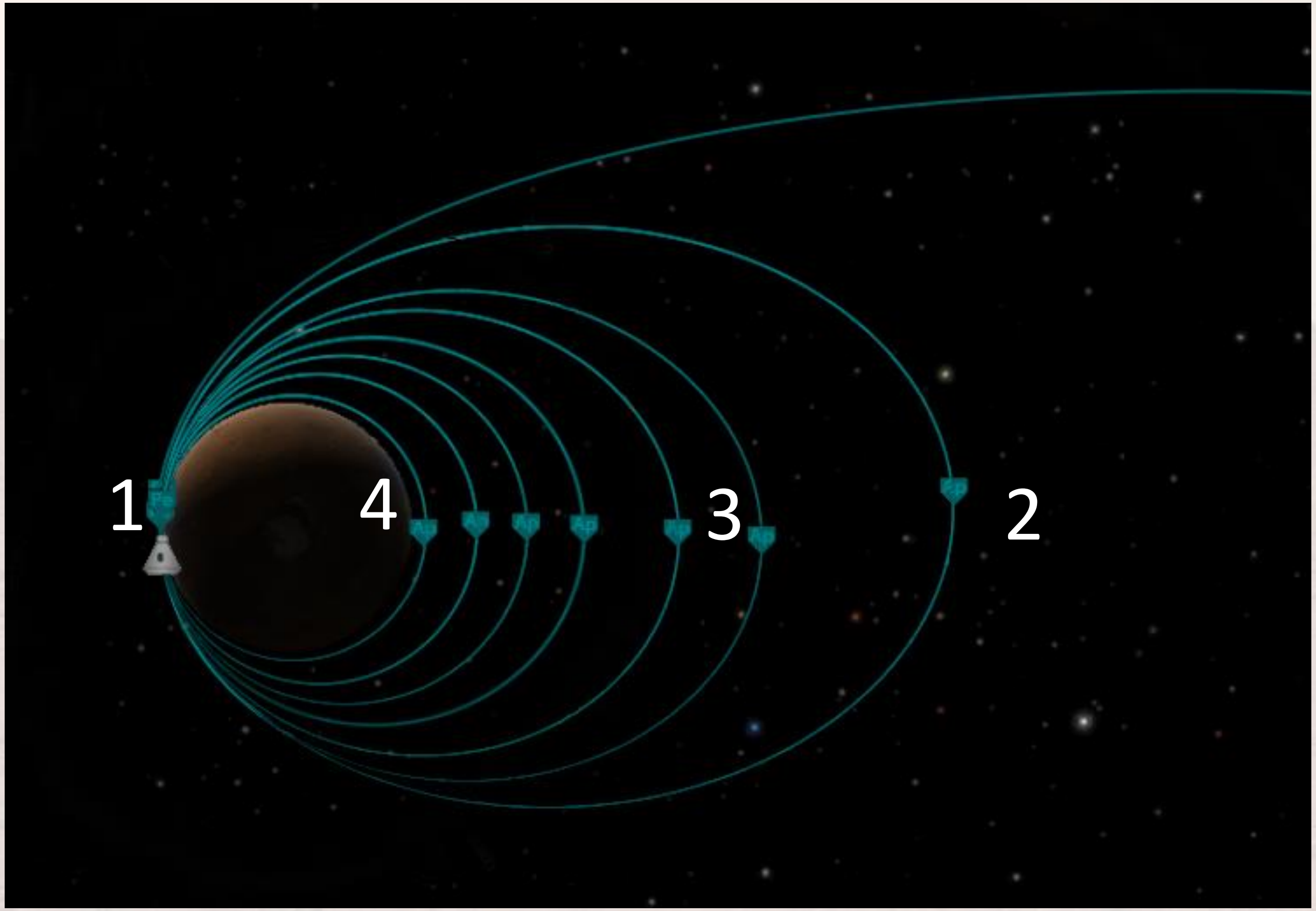
Light Lander – Colibri (Falcon Heavy)

- Launched with Falcon Heavy

- Initial mass send: 16.5t
- Mass lander: 10.5t

- Payload: 6t

Aerobraking to lower fuel requirements

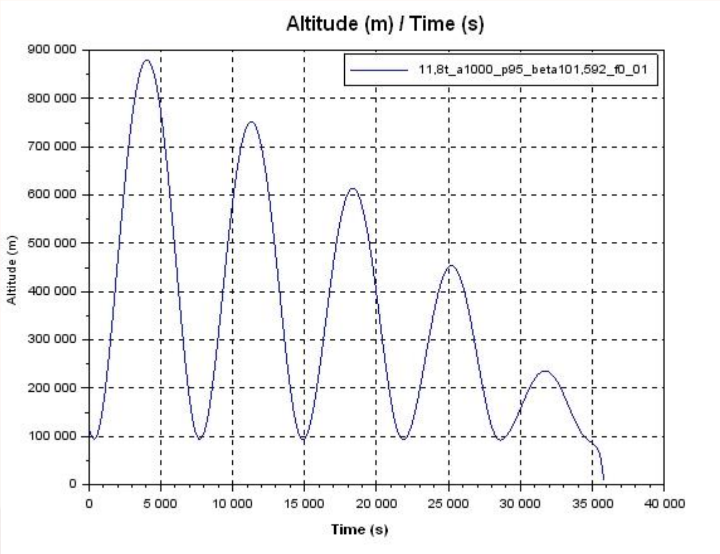


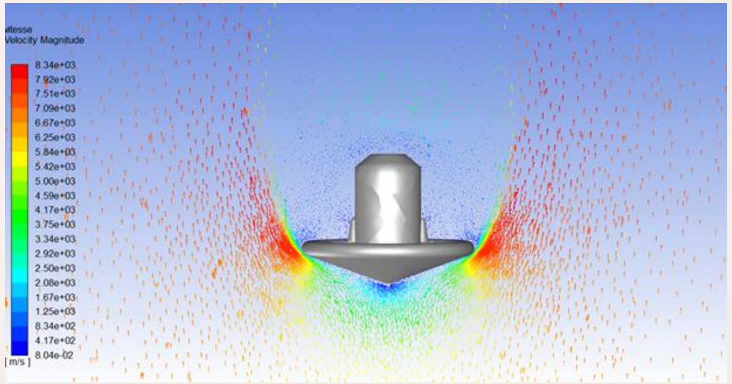
1- Circularise burn

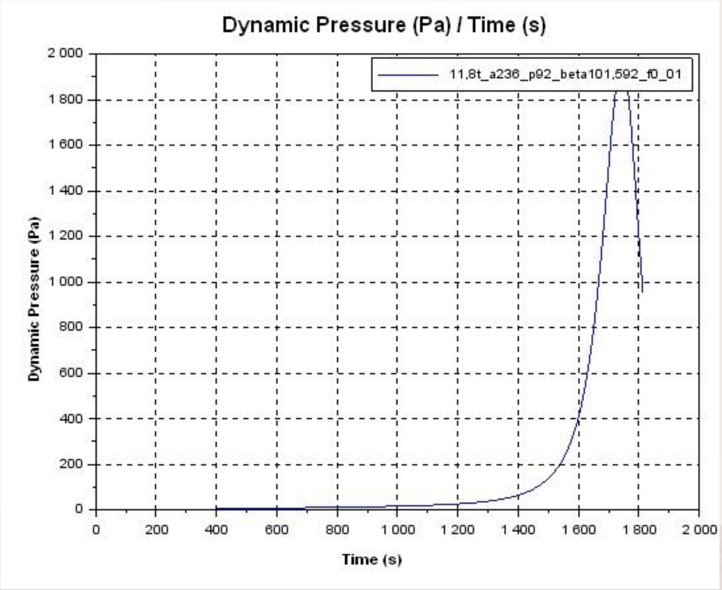
2 - Highly elliptical orbit

3 - Aerobrake to lower apogee

4 - Until capture, then regular EDL



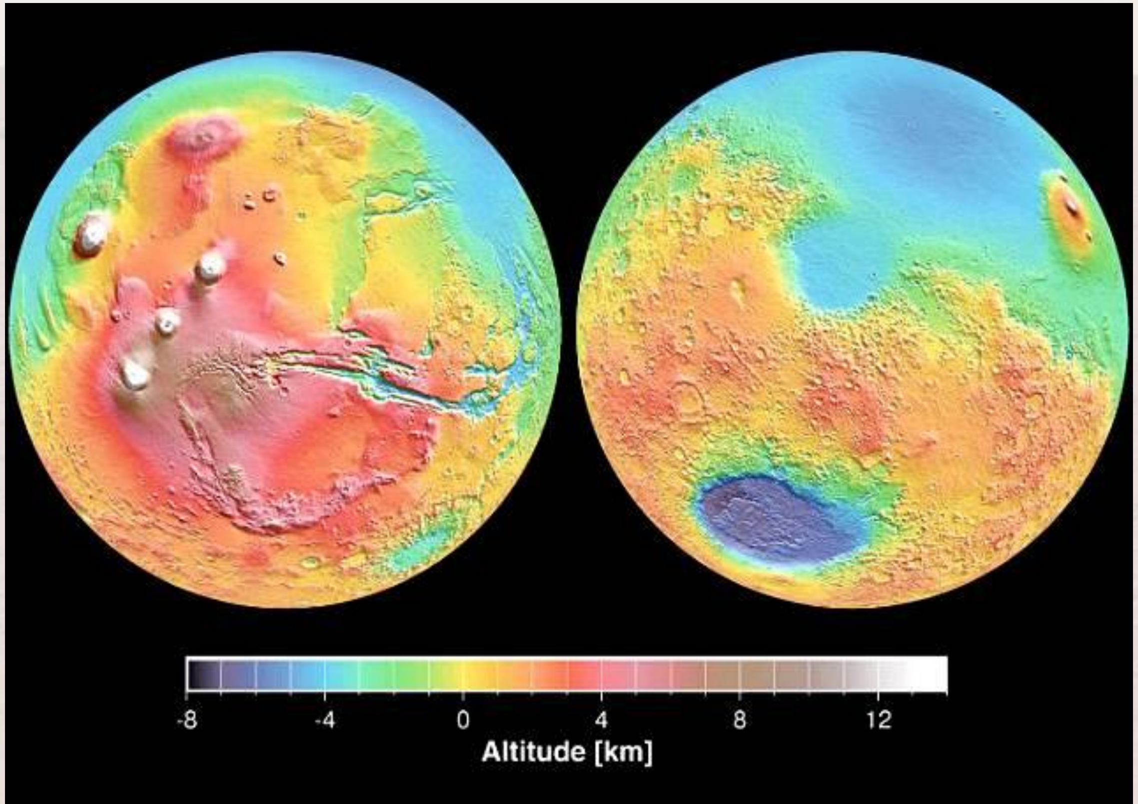




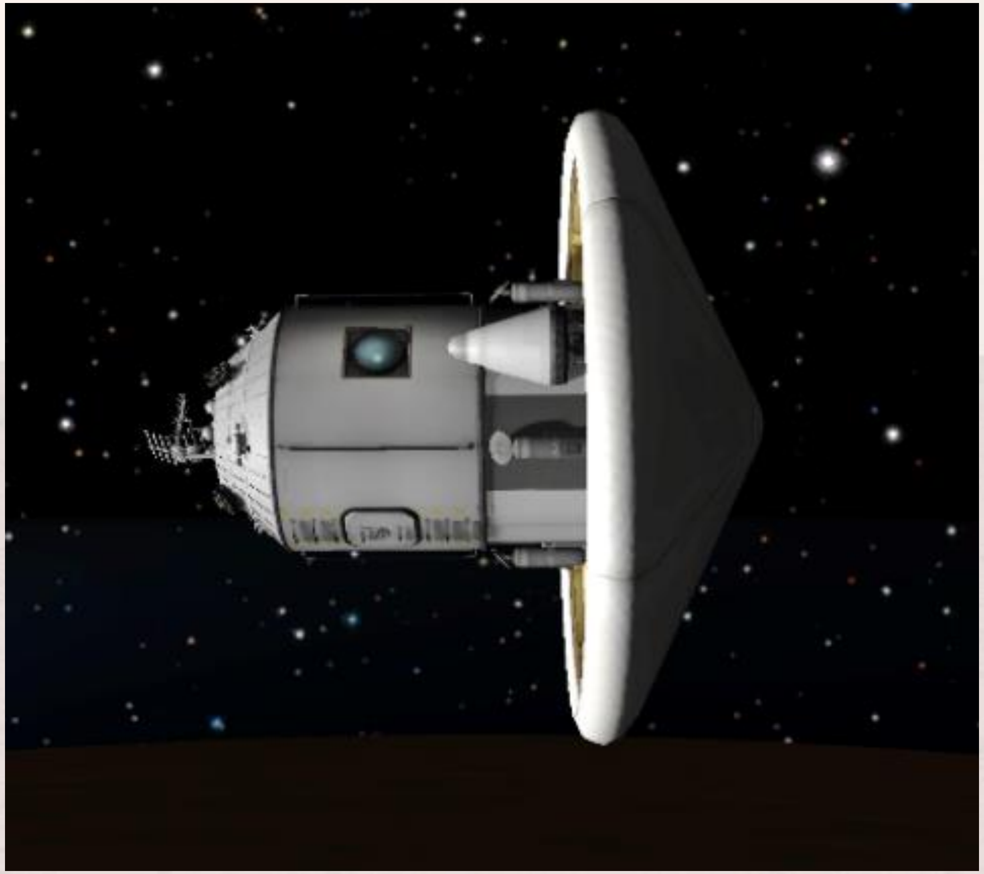
Aerobraking means less stress

Entry Descent and Landing

- Use of HIAD (Hypersonic Inflatable Aerodynamic Deccelerator)
- Final landing (<8km) with retro-propulsion

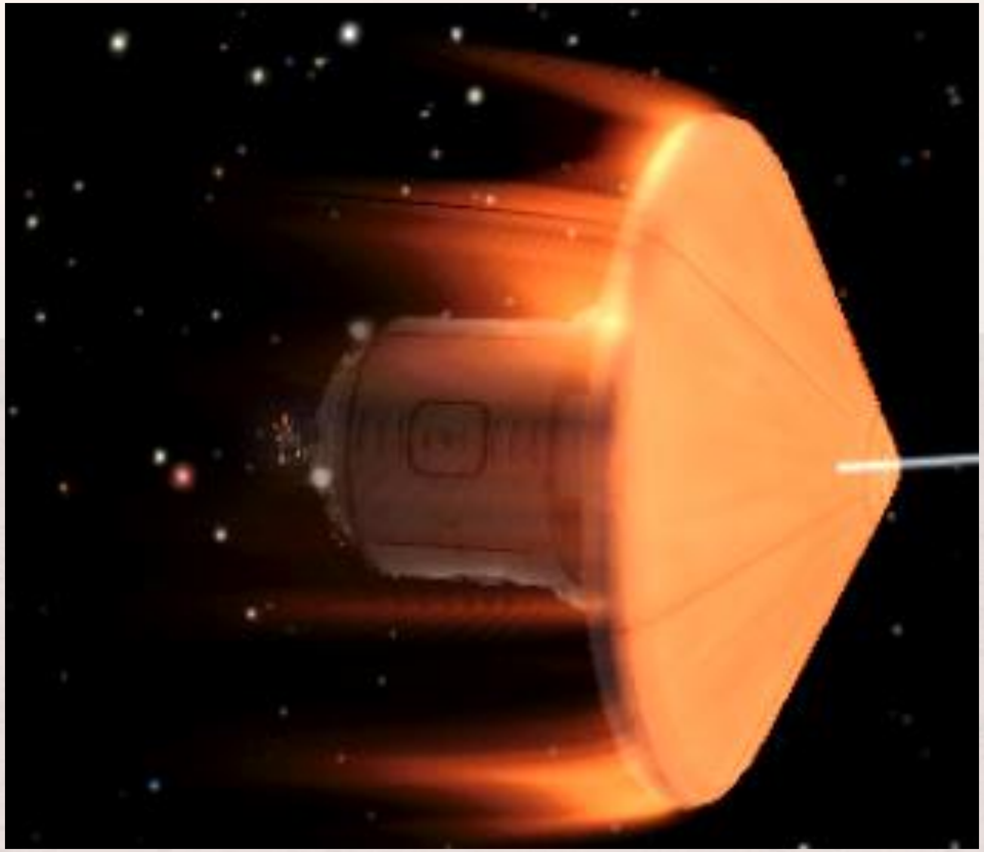


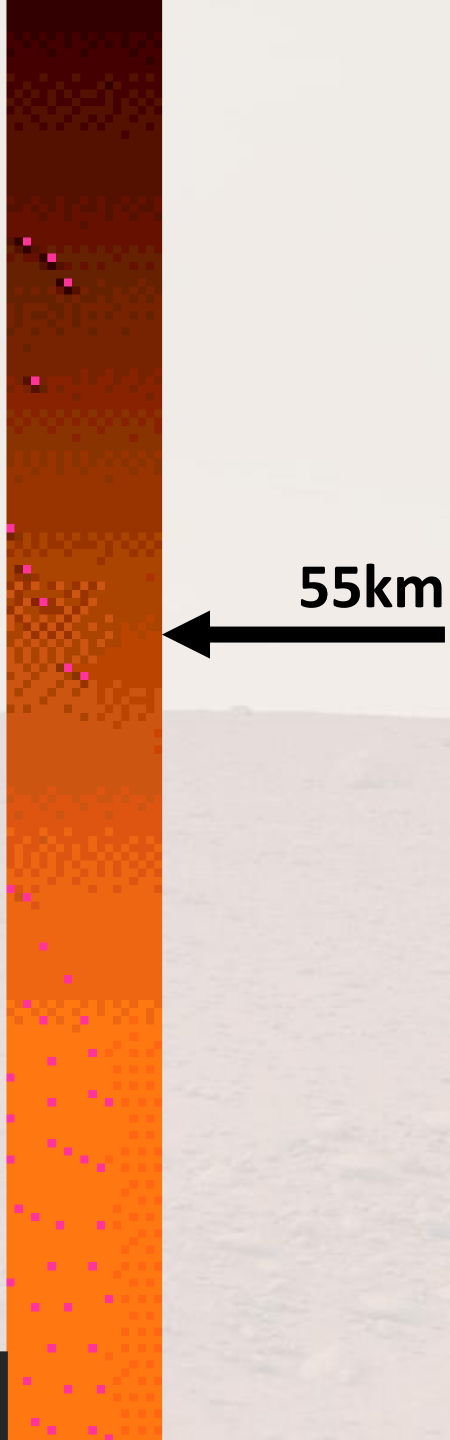
Final Aerobrake orbit



Aerobraking

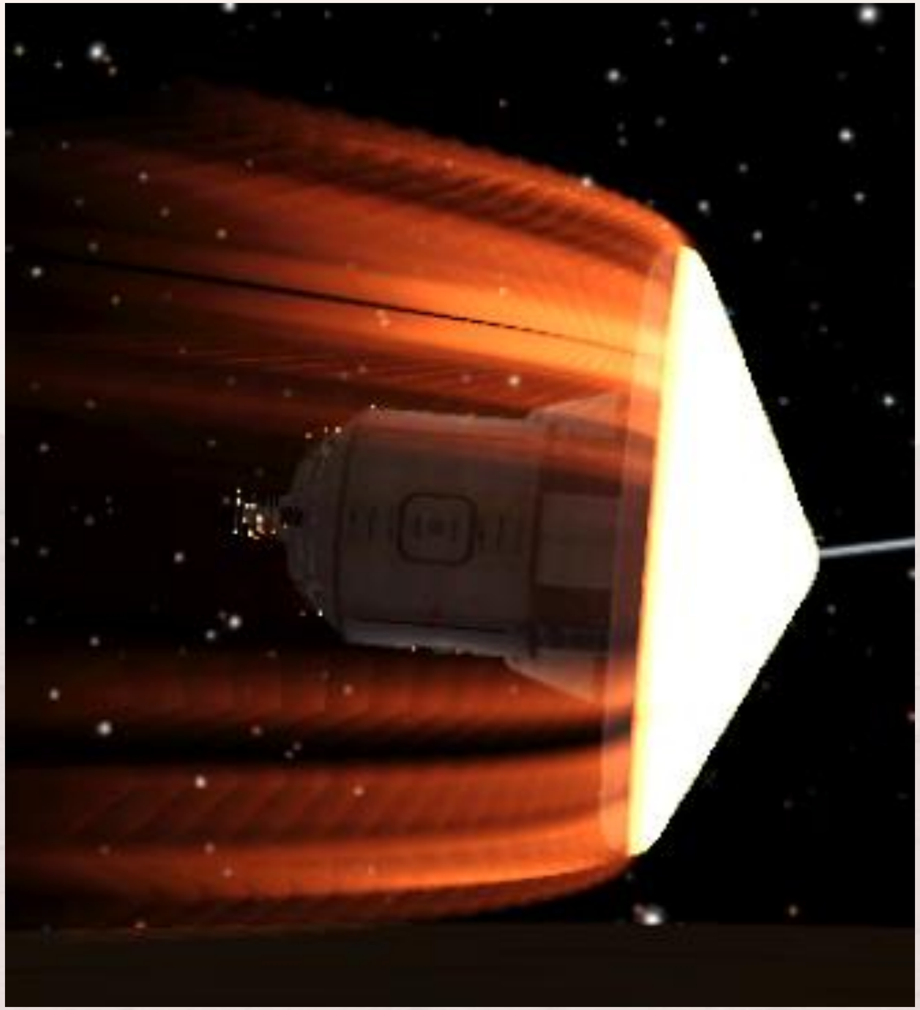
Entering denser part of atmosphere

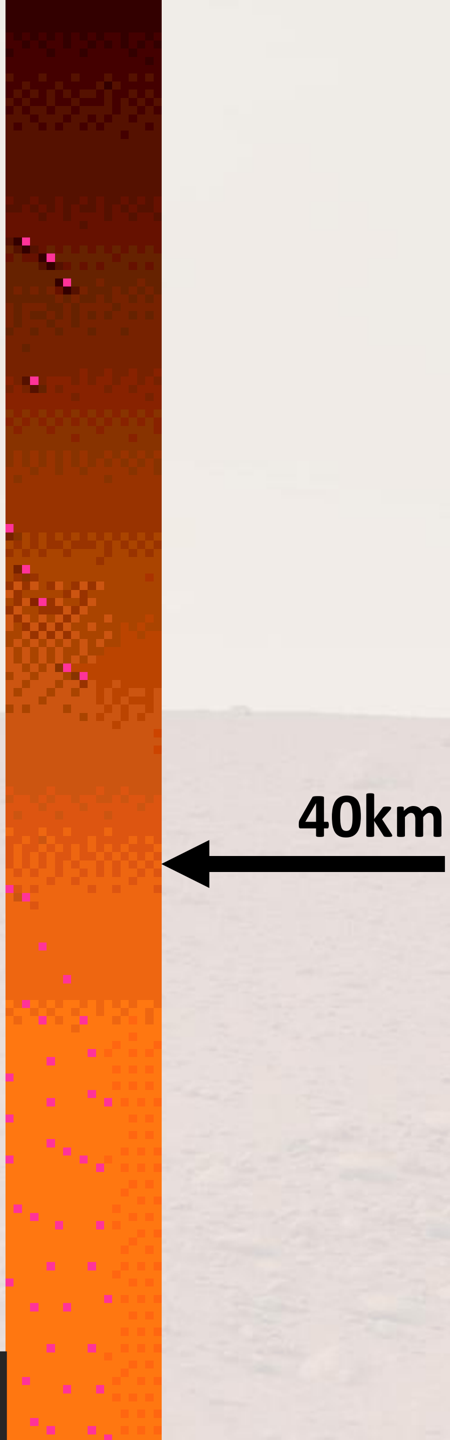




Aerobraking

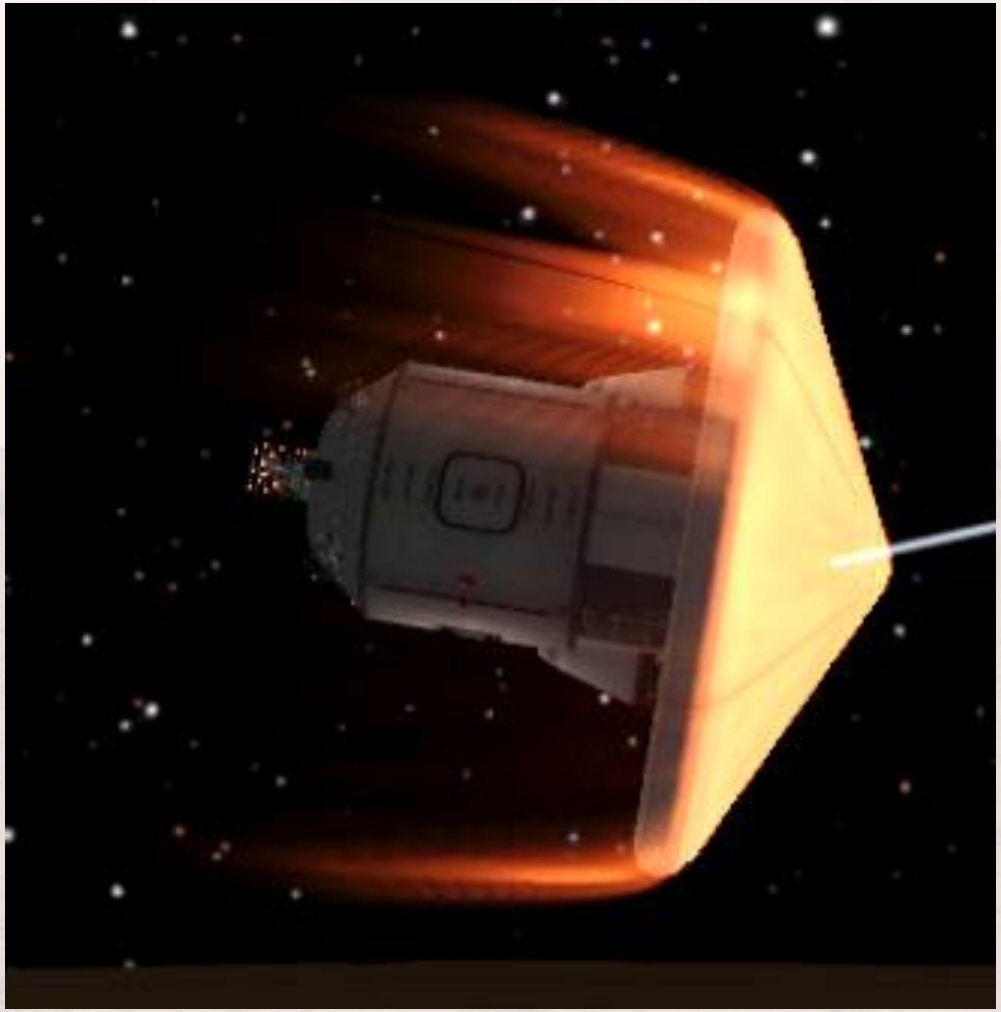
Maximum thermal flux





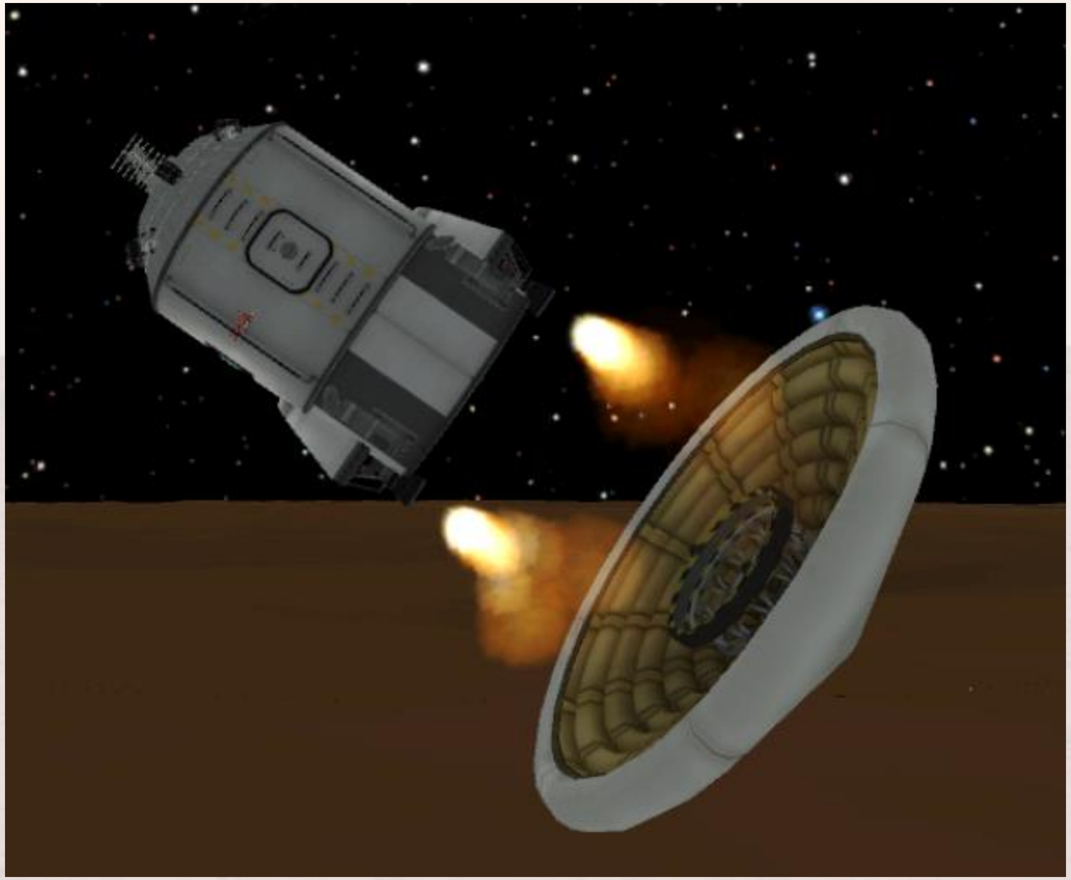
Aerobraking

Maximum Dynamic Pressure



Aerobraking

Shield jetison



8km

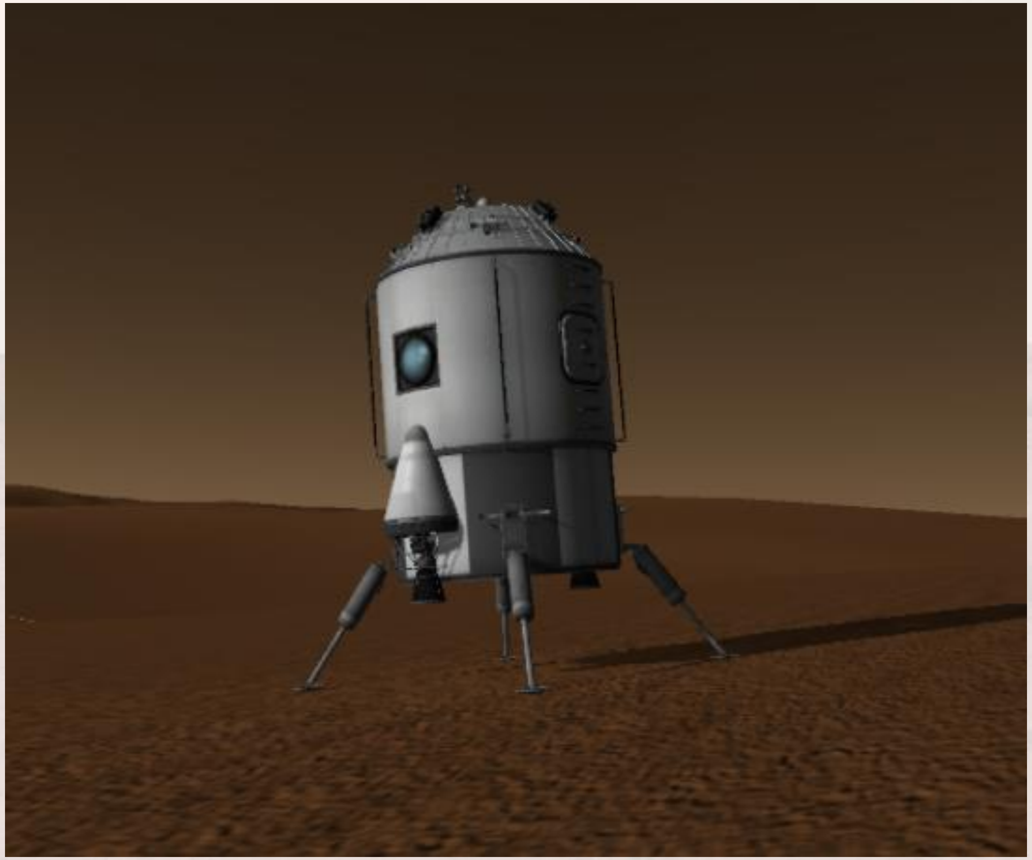
Aerobraking

Final burn & leg deploiment

Landing Burn

~0km

Landed!

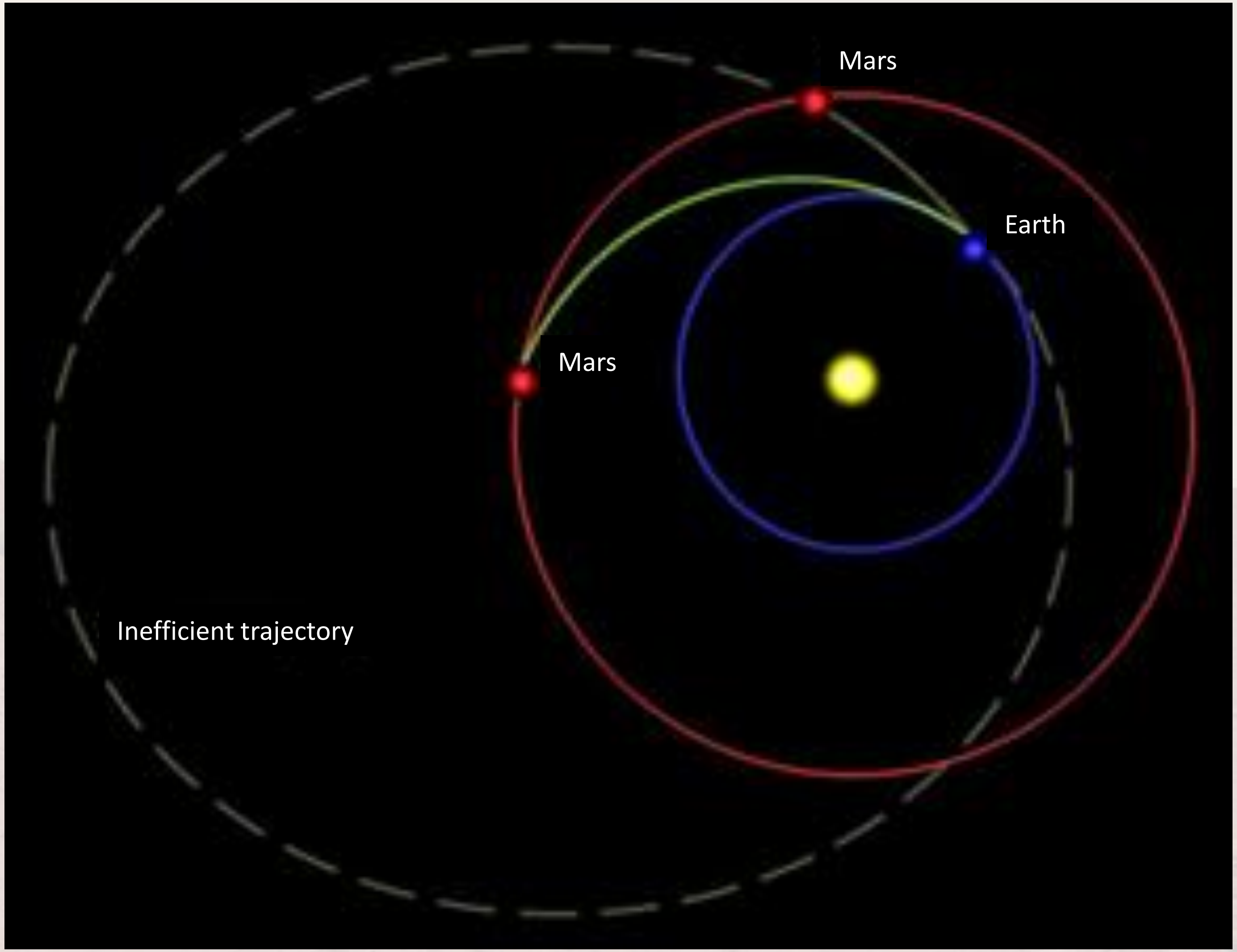


Land

0km

Launch window

- Opposition every 26 months
- Launch window : november 11th 2026



Schedule

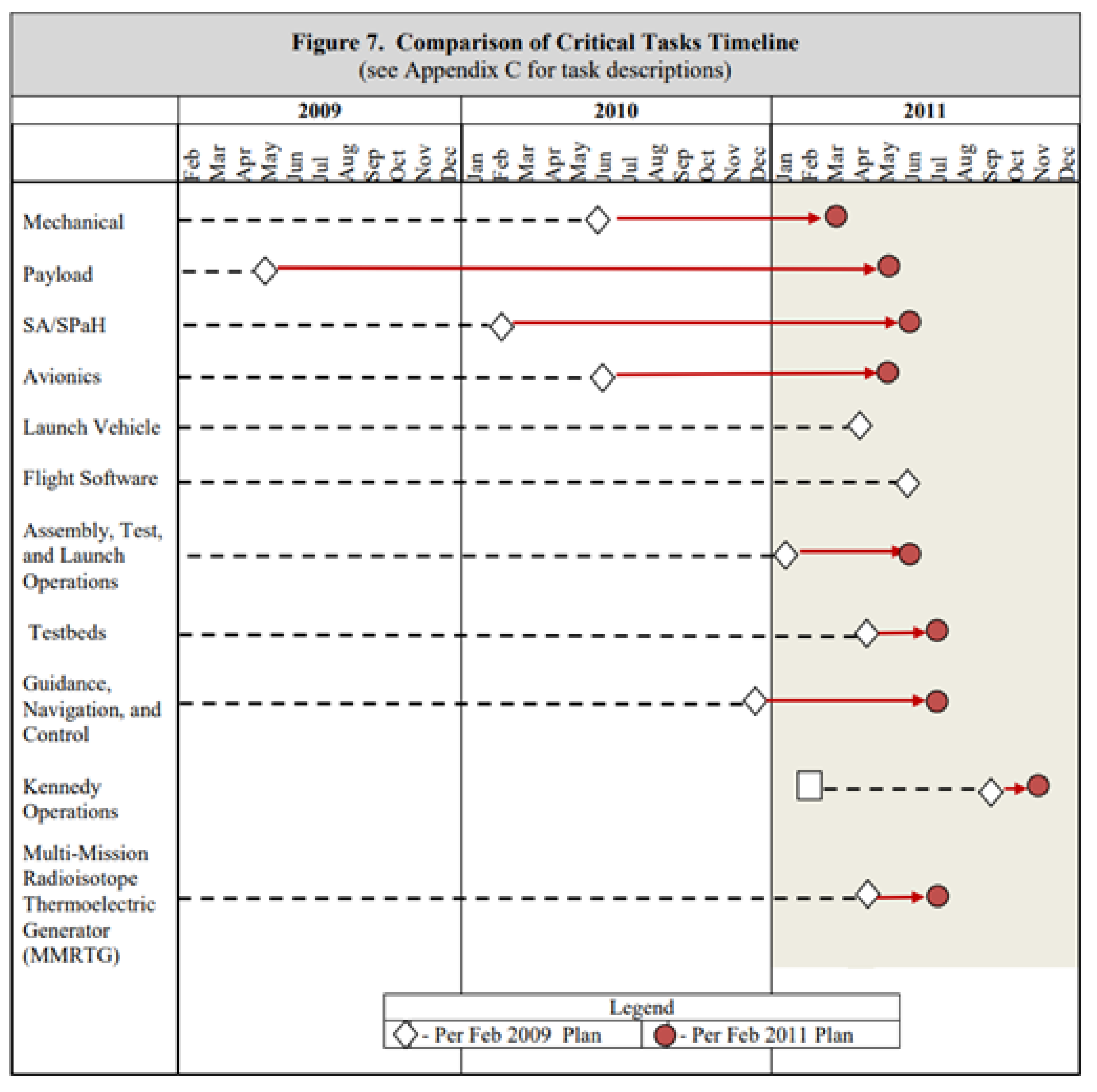
MSL timeline and Falcon Heavy / SLS

MSL Timeline

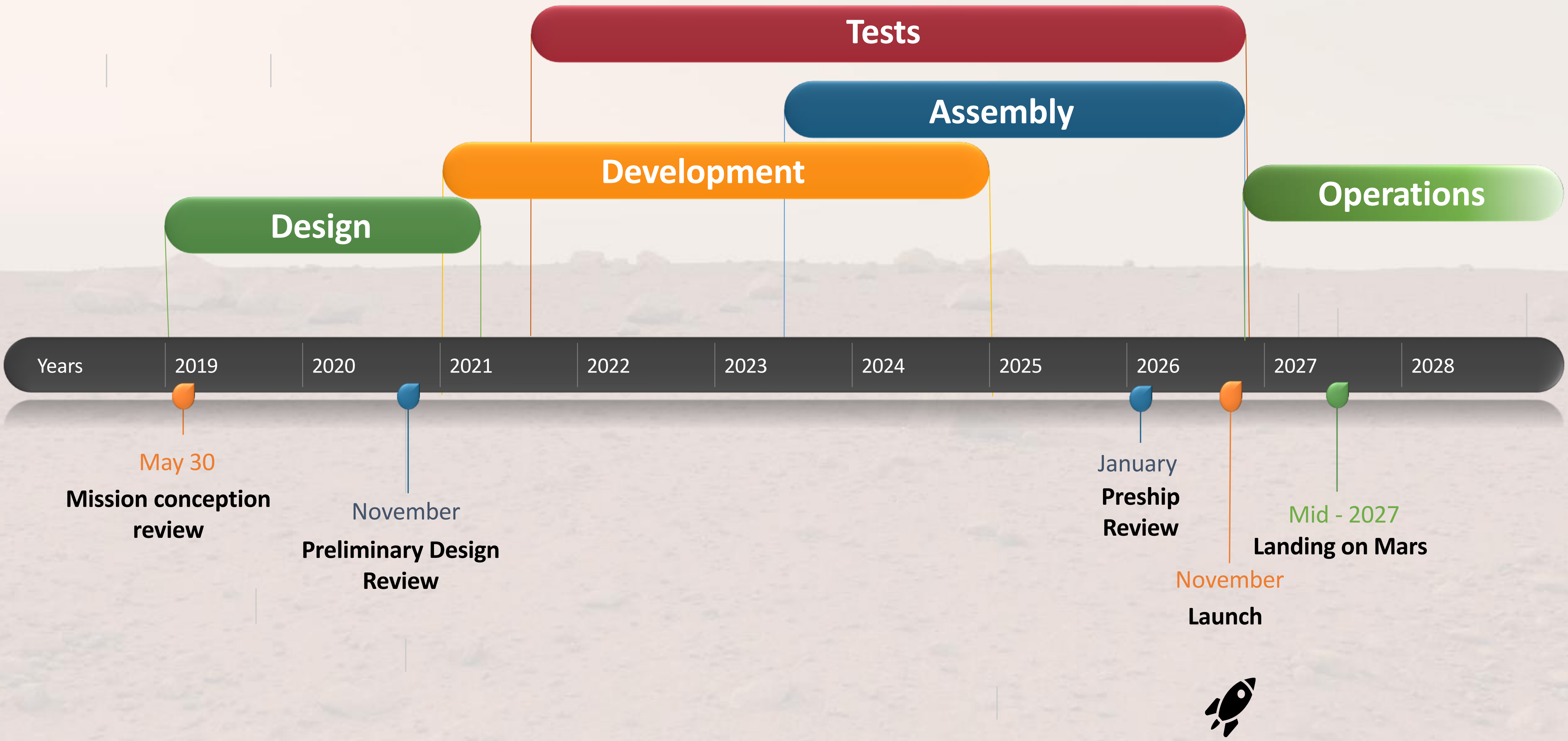
September 2003 - September 2006	September 2006 - December 2011	December 2011 - December 2014
Formulation and Design	Development (Final Design, Fabrication, Integration and Testing)	Operations

MSL critical tasks timeline

Minimum delay possible for 2026, then would go for 2028.



Red Movers scheduling timeline



Cost Estimation

Cost development : $1 billion

Colibri – Falcon Heavy	Plume – SLS
Lander: $300 million	Lander: $400 million
Launch: $150 million	Launch: $500 million
6t for $450 million	**10t for $900 million**

Red Movers cost repartition

Limits of the project

Information

- Lack of accessible studies
- Not that much recent studies

Technical

- General concept, more proof of idea
- Lots of assumptions and approximations
- Use of student accessible tools
- Only based on simulations
- IADs still in development

Schedule / Budget

- No existing comparaison
- We are engineering students

Sum-up of the project

- Can land 6t or 10t
- First lander send by 2026
- Aerobraking to reduce fuel and mass
- Development cost of $1 billion
- 2 landers very similar, simply size difference

Acknoledgments

- Jerome Daniel for AReS

  Engineer at CNES, member of Association Planète Mars

- Guillaume Duchesne for KSP

  President of Kerbal Space Challenges

- Richard Heidmann for data, studies and advice

  Vice-President of Association Planète Mars

Conclusion

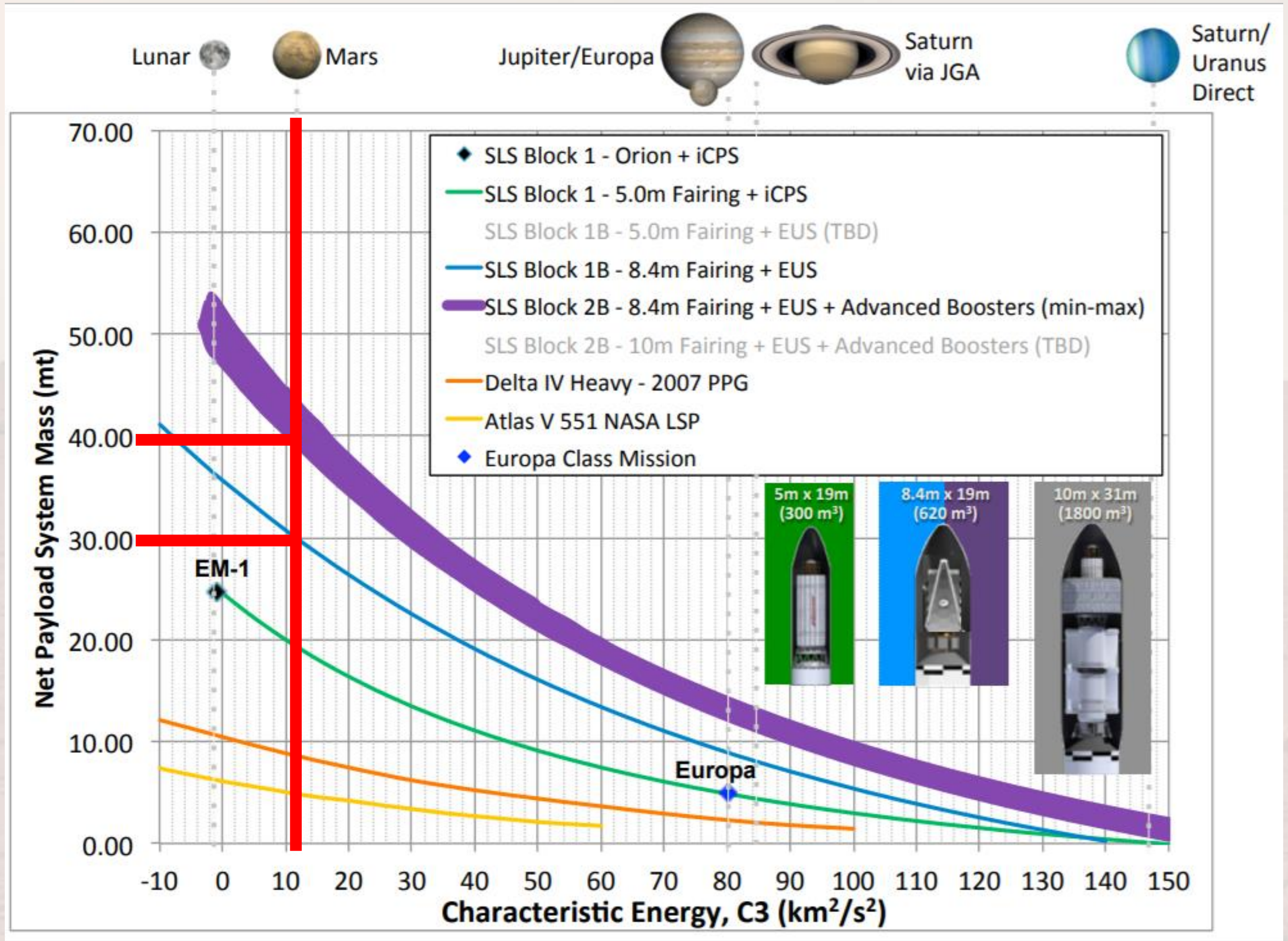
We hope we can help make humans on Mars happen!

Thank you for your attention

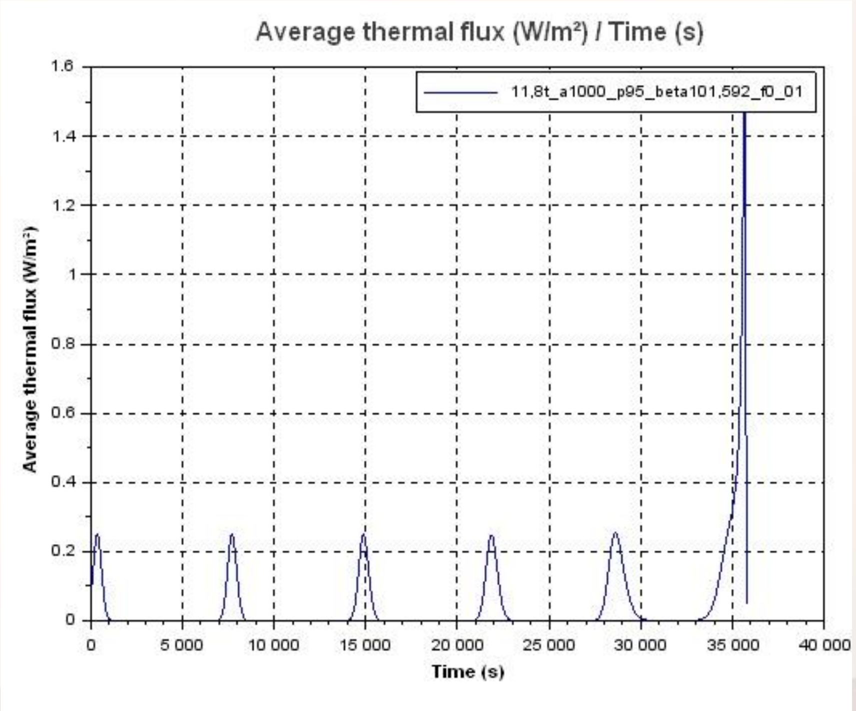
Any questions?

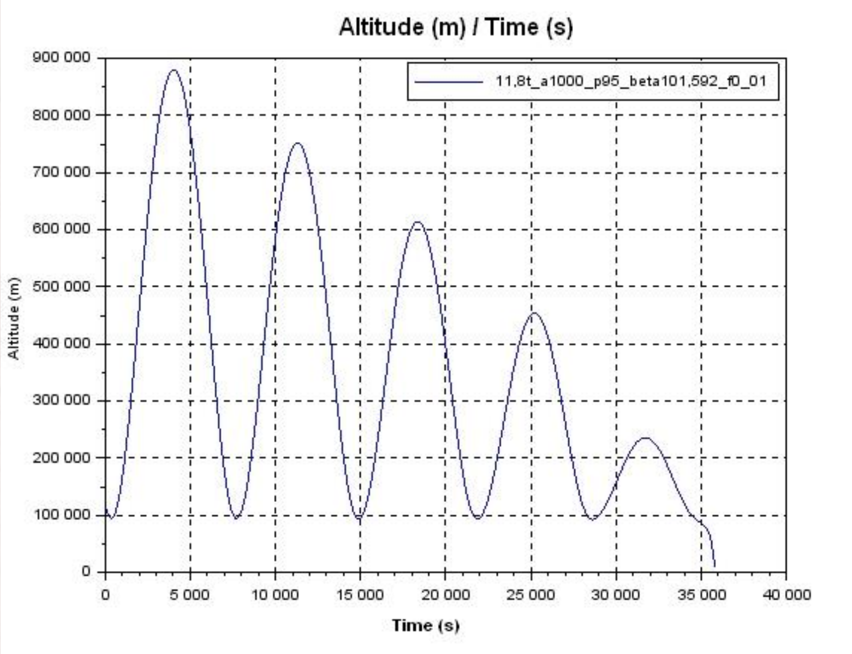
SLS version capacity

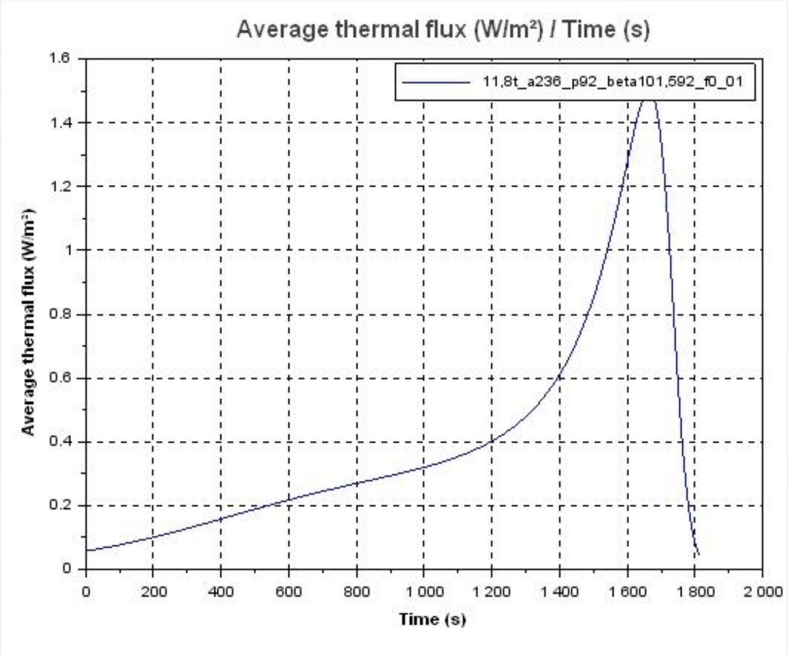
Rocket	Configuration	LEO payload	First flight
Saturn V	Apollo	140 t (310,000 lb)	1967
Space Shuttle		122.5 t (270,142 lb)[A]	1981
Energia	Buran	100 t (220,000 lb)	1987
Falcon Heavy	Expendable (0/3)[B]	63.8 t (141,000 lb)	N/A[D]
	Part. reusable (2/3)[C]	57 t (126,000 lb)[10]	N/A[D]
SLS	Block 1	95 t (209,000 lb)[12]	2020 (planned)[13]
	Block 1B	105 t (231,000 lb)[14]	2023 (planned)[15]
	Block 2	130 t (290,000 lb)[16]	2029 (planned)[17]
New Glenn	2-stage	45+ t (99,000+ lb)[18]	2020 (planned)[18]
	3-stage	TBA[E]	N/A
BFR		150 t (330,000 lb)[19][F]	2022 (planned)
Long March 9		140 t (310,000 lb)[20]	2030s (planned)

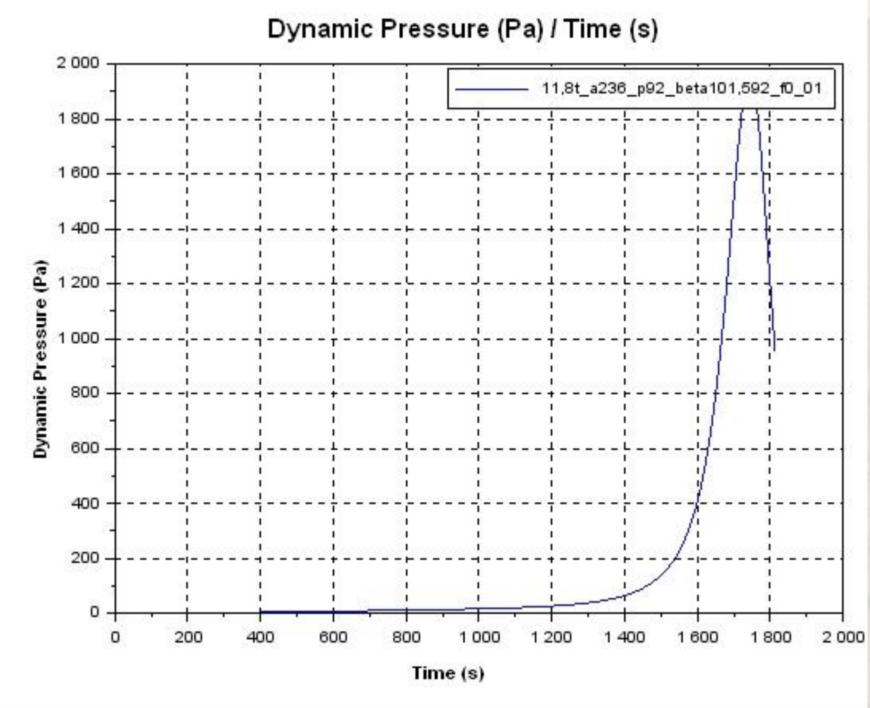


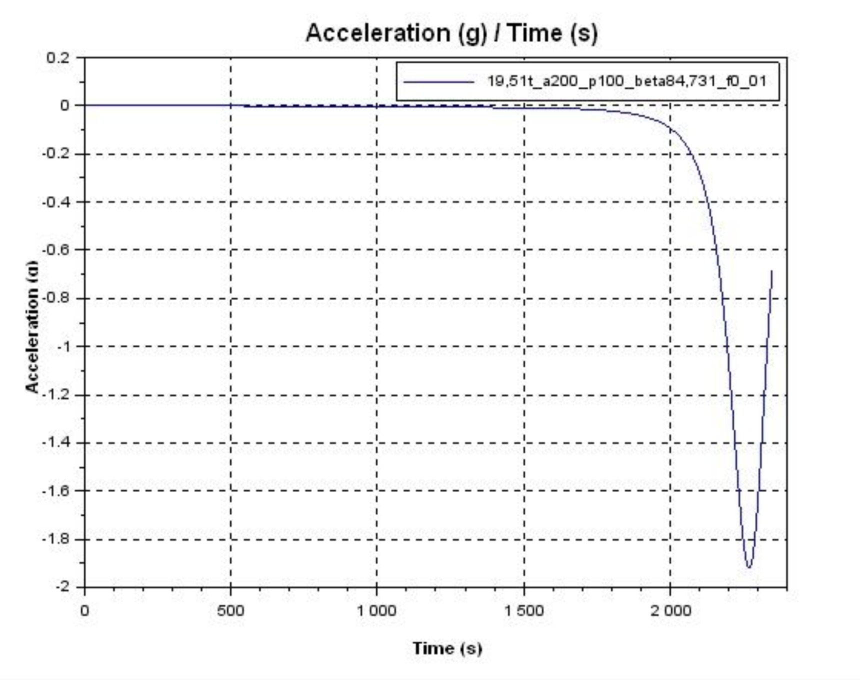
Plume simulation results



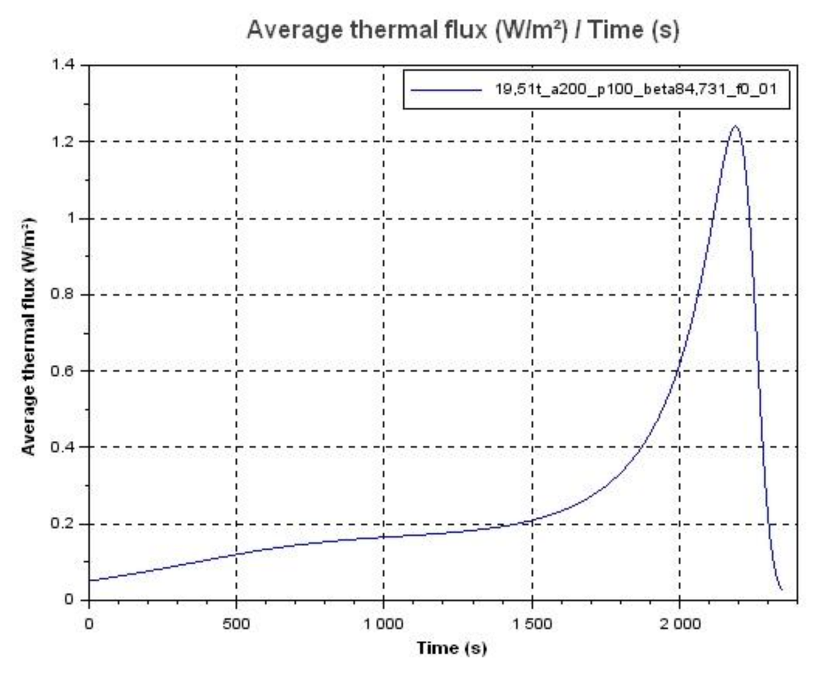


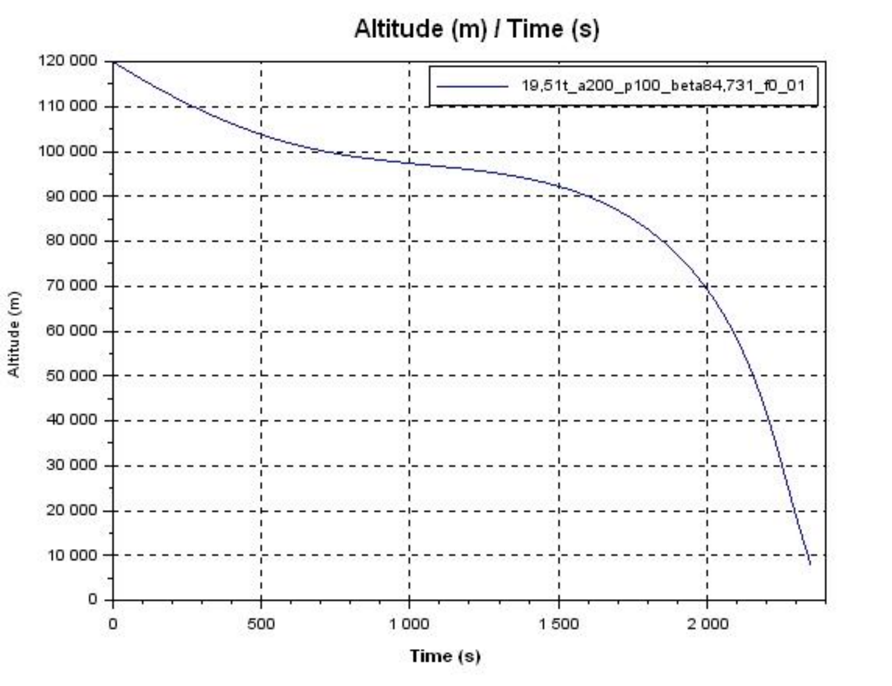


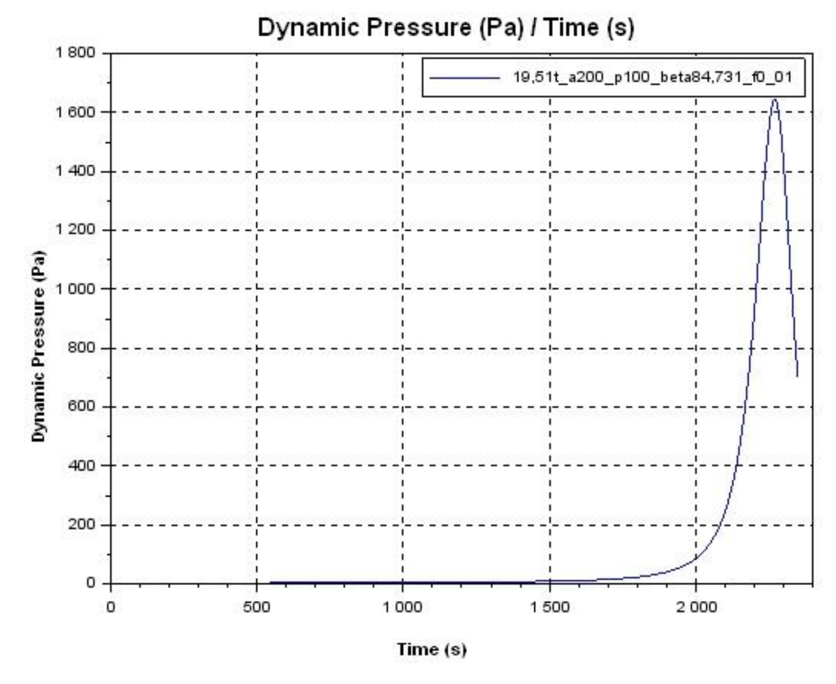




Colibri simulation results







Detailed Technical Limits of our Project

- Use of seperate stage or not before EDL?
- What instrumentation?
- Lack of detailed knowledge on IADs
- No detail of the mechanical properties of IAD deployment
- No idea of the aging of IAD
- Mass distribution done with multiple uncertainties
- Large quantities of RCS required to stabilise during aerobraking
- No detail of the electrical requirements
- No thorough study of fuel selection