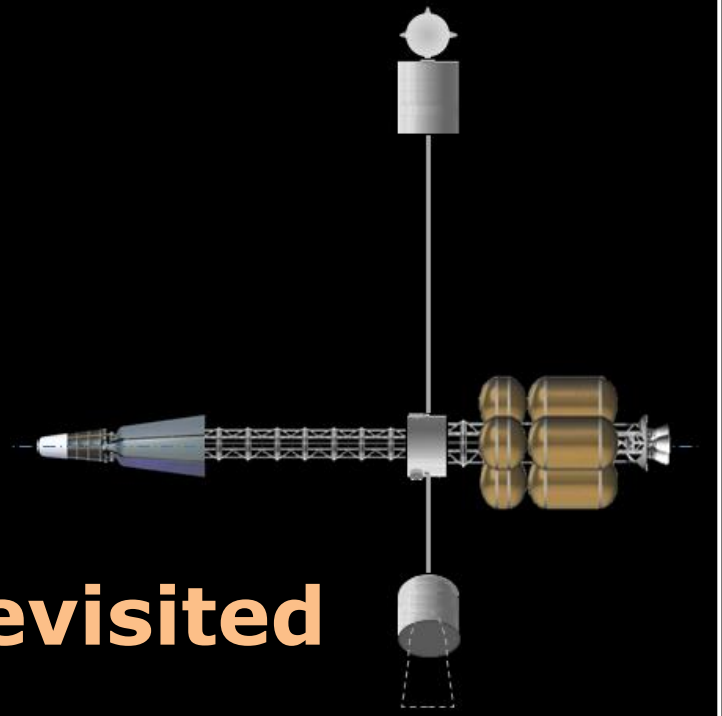
The Interplanetary Transport System of SpaceX . . .



. . . revisited

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Plan of the presentation

1. Critical analysis of the strengths and weaknesses of the SpaceX ITS architecture as presented in 2016 and updated in 2017/2018

2. Proposal of a somewhat different ITS concept aiming in particular at improving the safety/reliability, as well as the flexibility, of the whole system

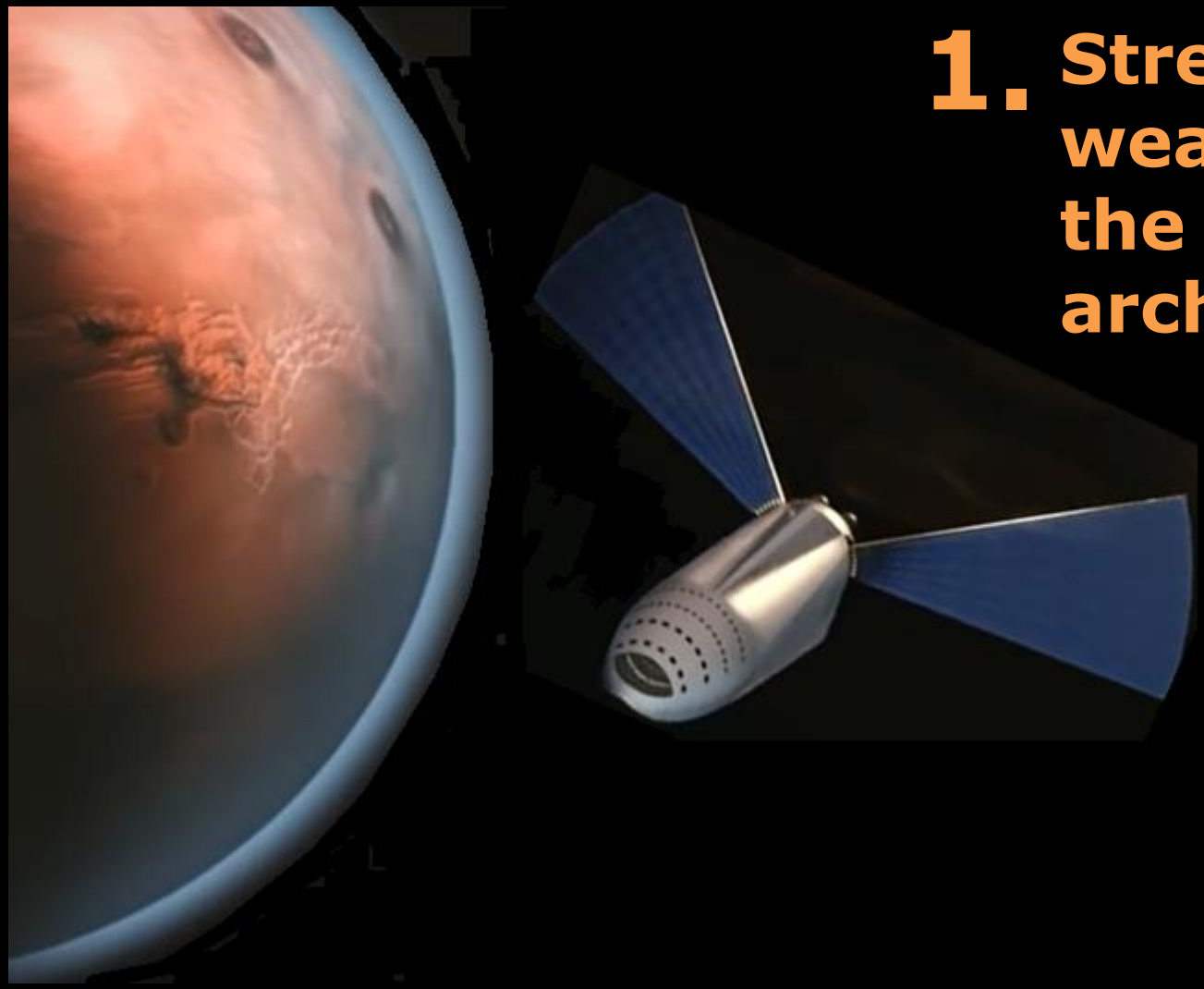
General context

After the exploration phase ...

... that of colonization (settlement)

Regular people transfer from Earth to Mars

Infrastructures exist on the red planet in particular to produce CH_4 and O_2 in situ

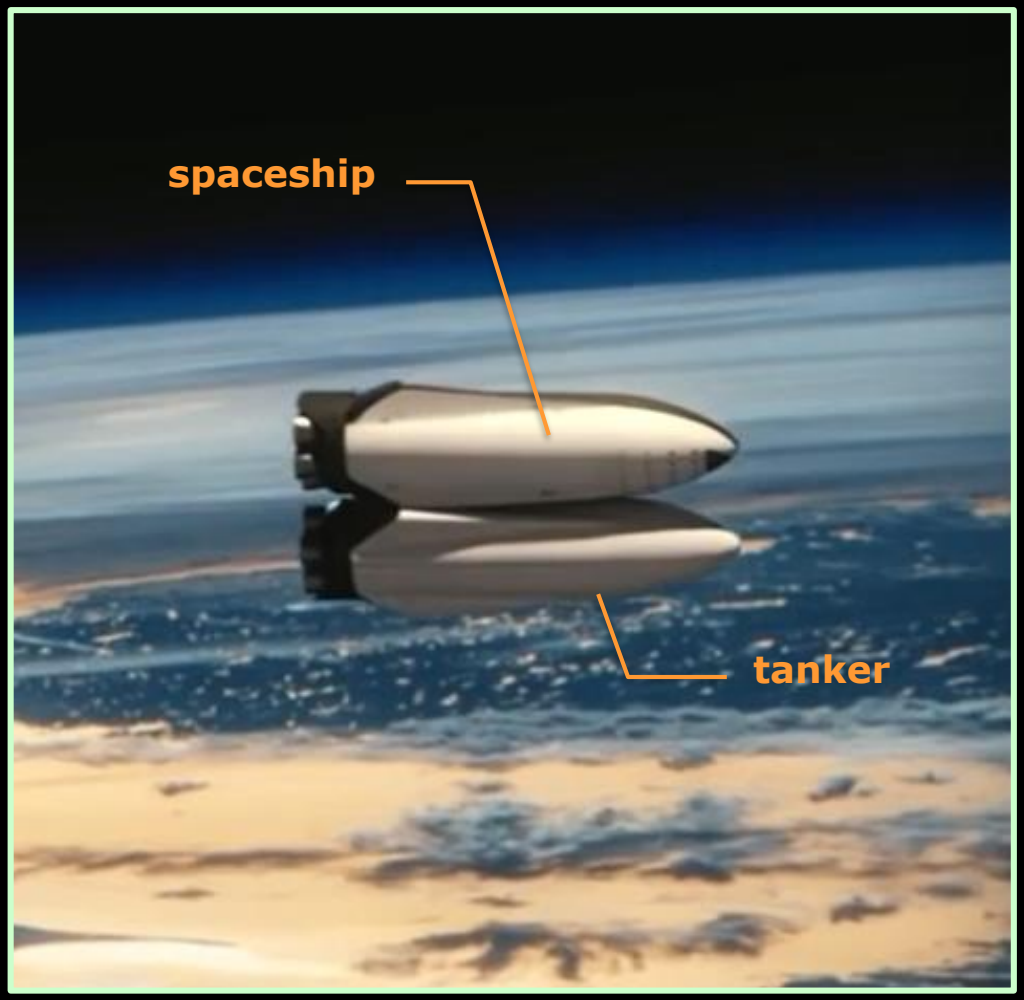


1. Strengths and weaknesses of the SpaceX ITS architecture

Powerful innovative proposals

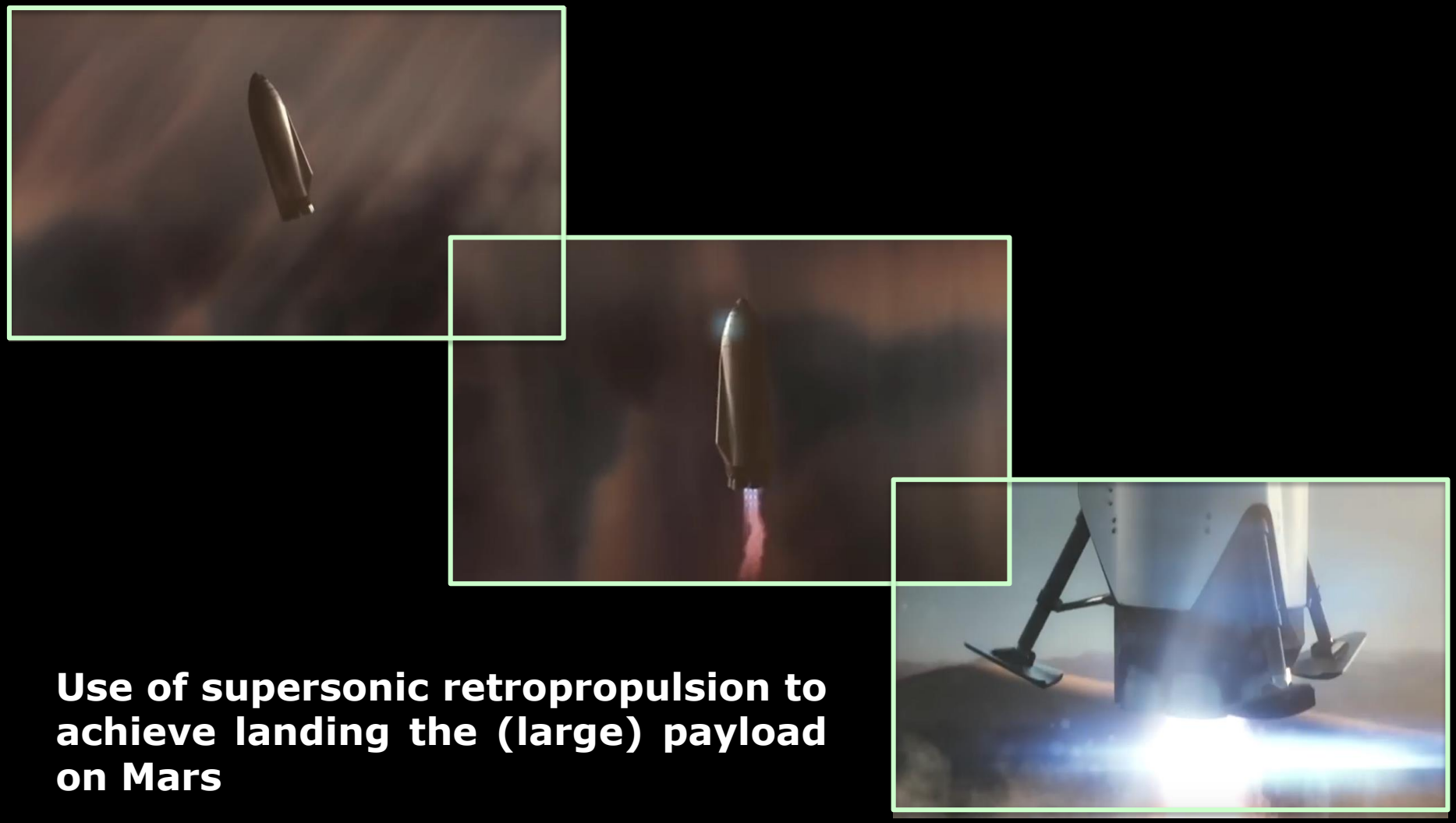
All components of the system fully reusable

Powerful innovative proposals



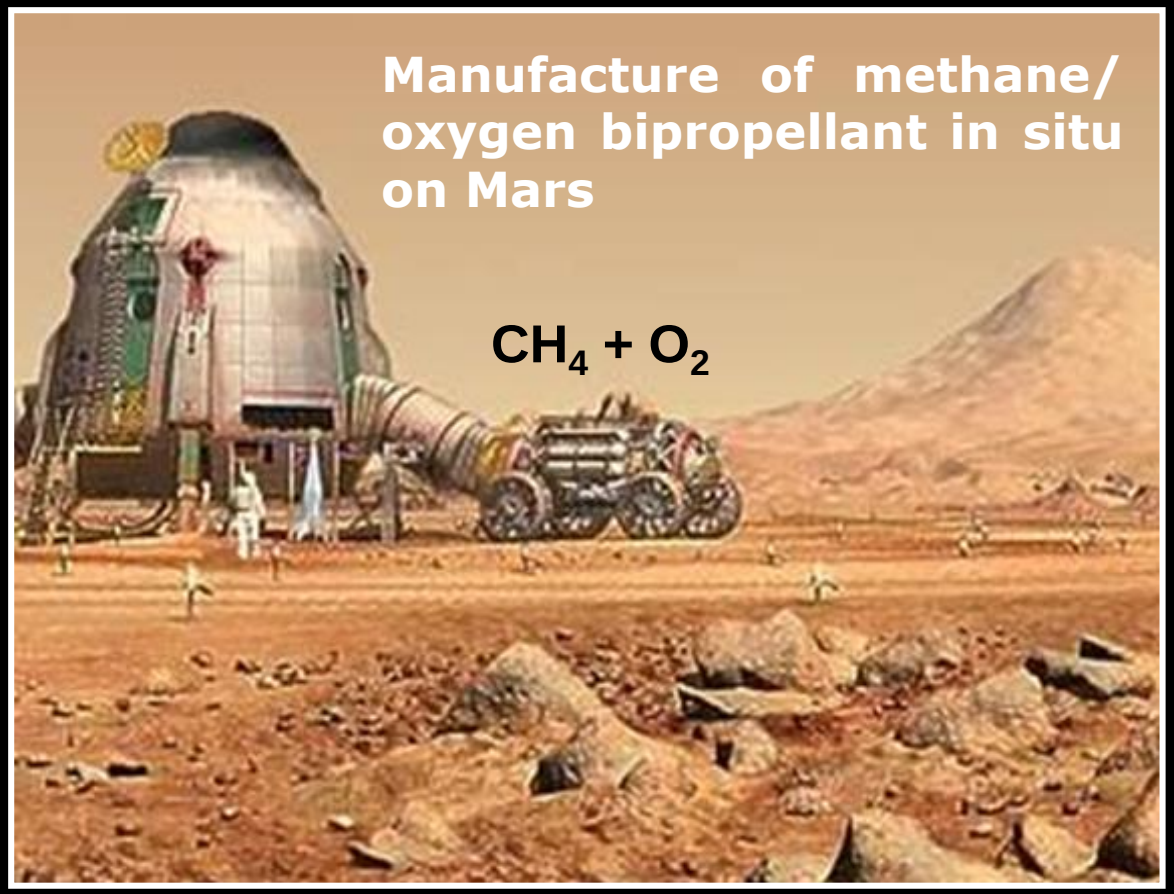
Refueling in Earth orbit before space-ship heads to Mars

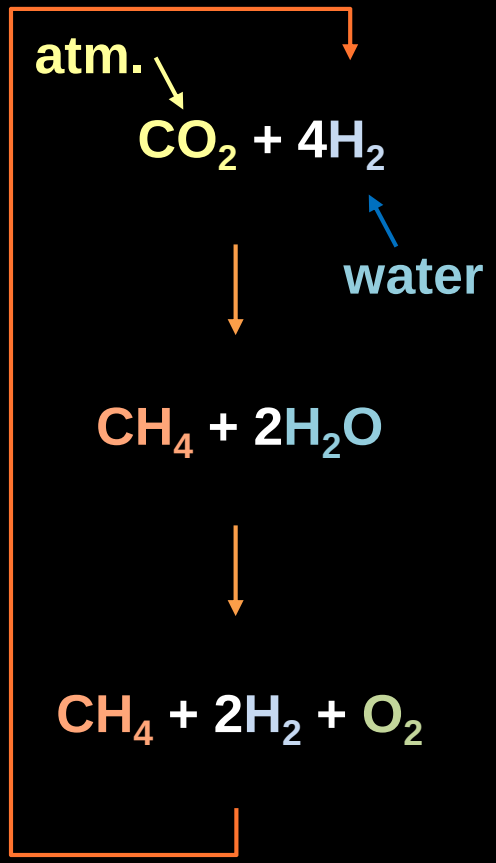
Good, although not really new, ideas



Use of supersonic retropropulsion to achieve landing the (large) payload on Mars

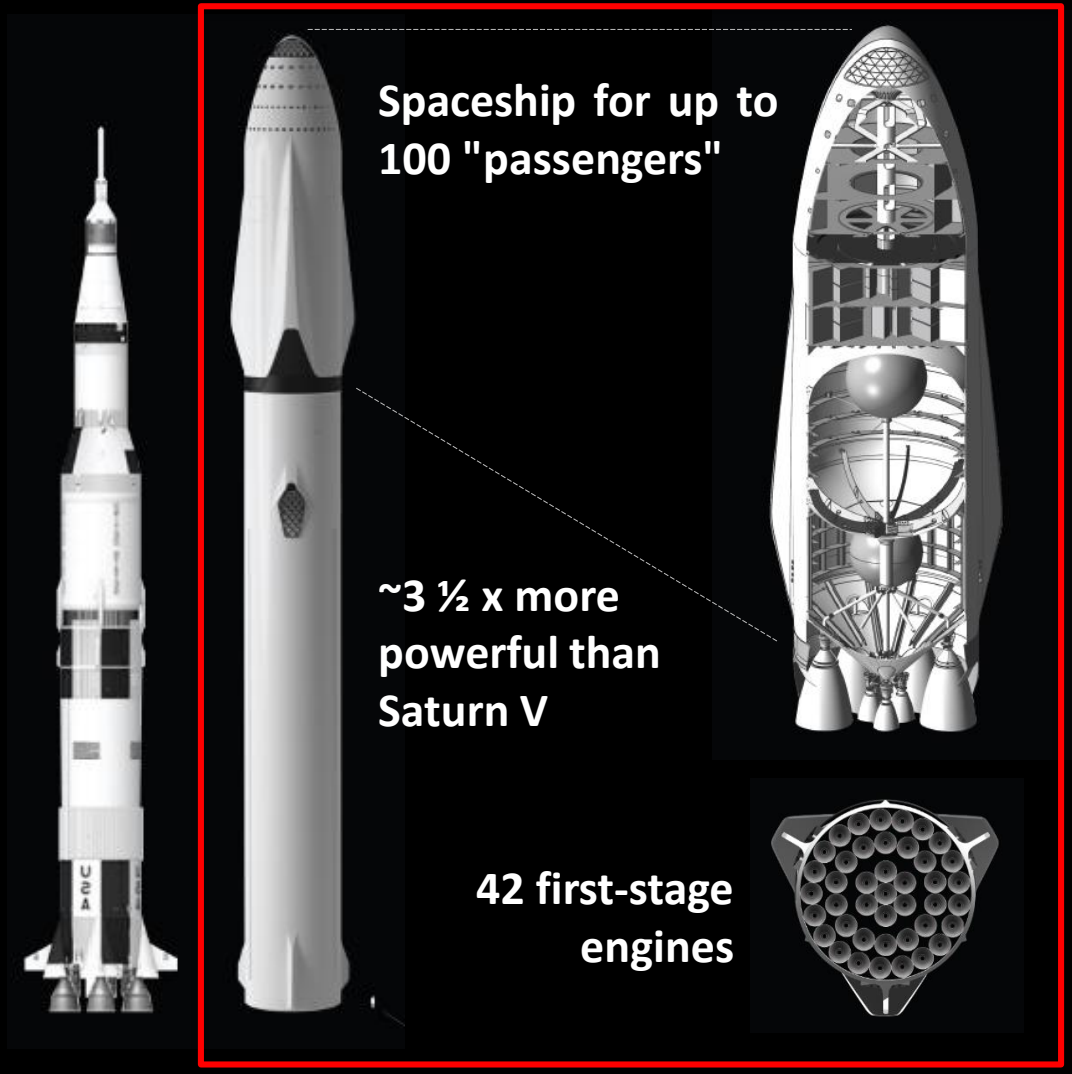
Good, although not really new*, ideas





* See R. Zubrin's "The Case for Mars"

Weaknesses, even flaws, of the SpaceX ITS



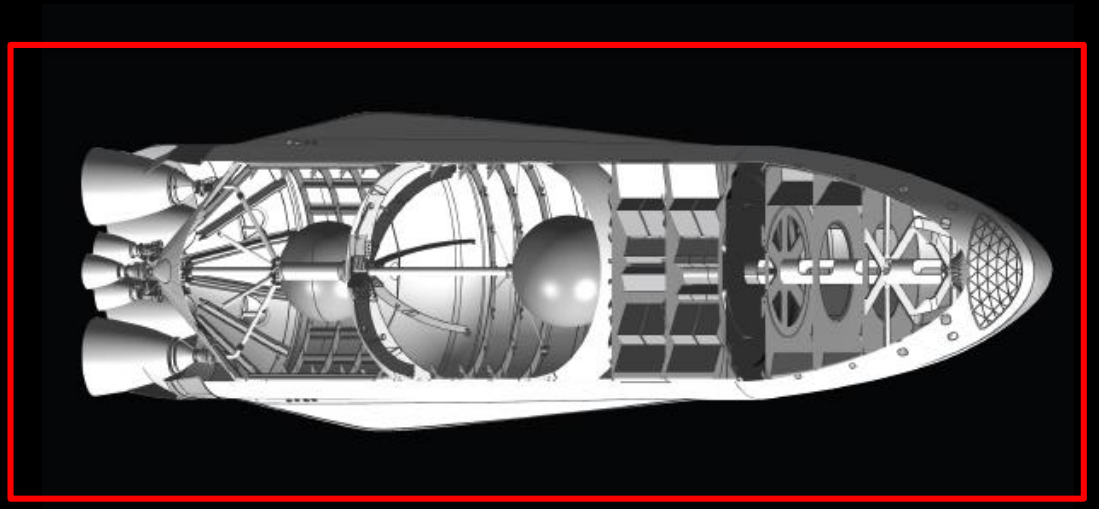
"Too big *not* to fail" ?!

Moreover, the very "monolithic" concept makes it difficult to provide "plans B" in case of possible problems

Weaknesses, even flaws, of the SpaceX ITS

The "swiss army knife concept" is very practical ... for camping, but it doesn't provide:
. the best knife,
. the best saw,
. the best screwdriver,
etc. !

When in the field of human space flights <u>each subsystem</u> should be <u>optimized</u> for the specific task to accom-plish

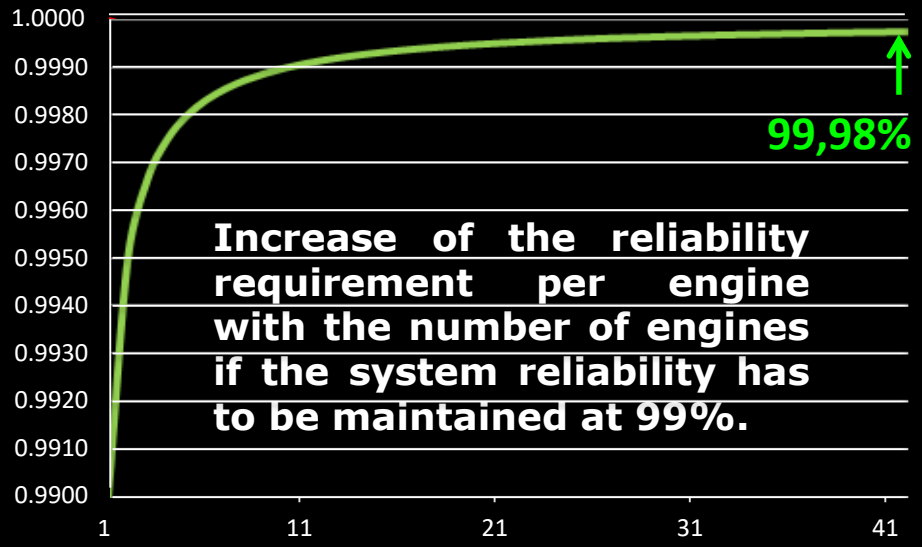


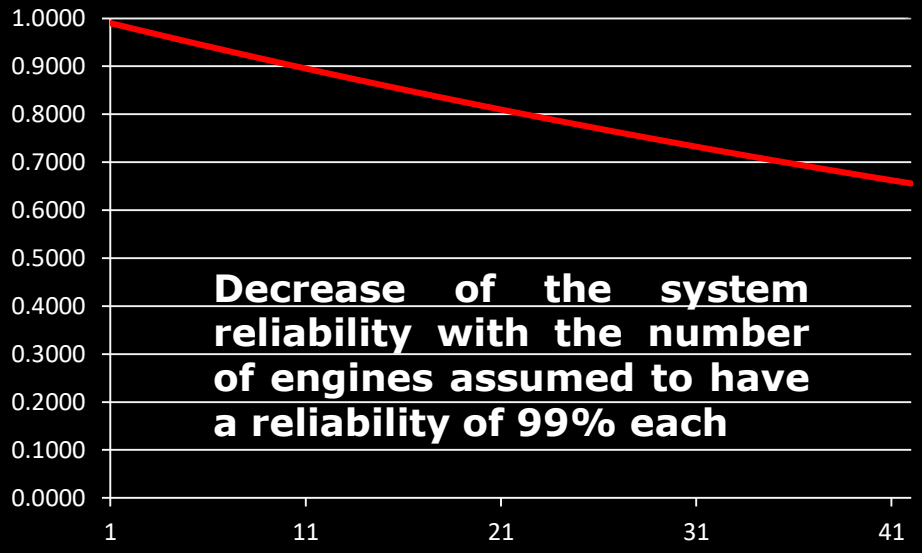
Weaknesses, even flaws, of the SpaceX ITS

Why could the great number of engines be problematic?

Hypotheses
(for illustration purpose):
. reliability/engine = 99%
. independent events

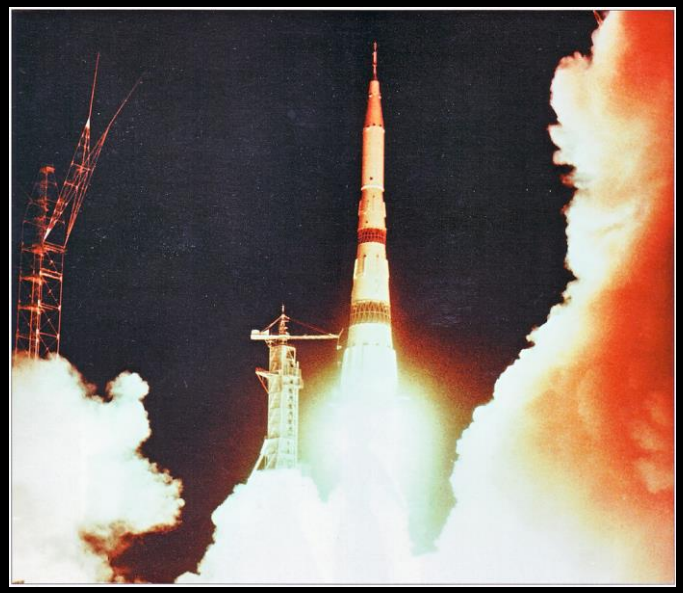
Engines number	Reliability of the booster-launcher (system)
1	0,99 (**1 failures / 100**)
2	$0,99*0,99=0,99^2=0,9801$
3	$0,99*0,99*0,99=0,99^3=0,9703$
⋮	⋮
42	$0,99^{42}=0,6557$ (**~1/3 failures!**)

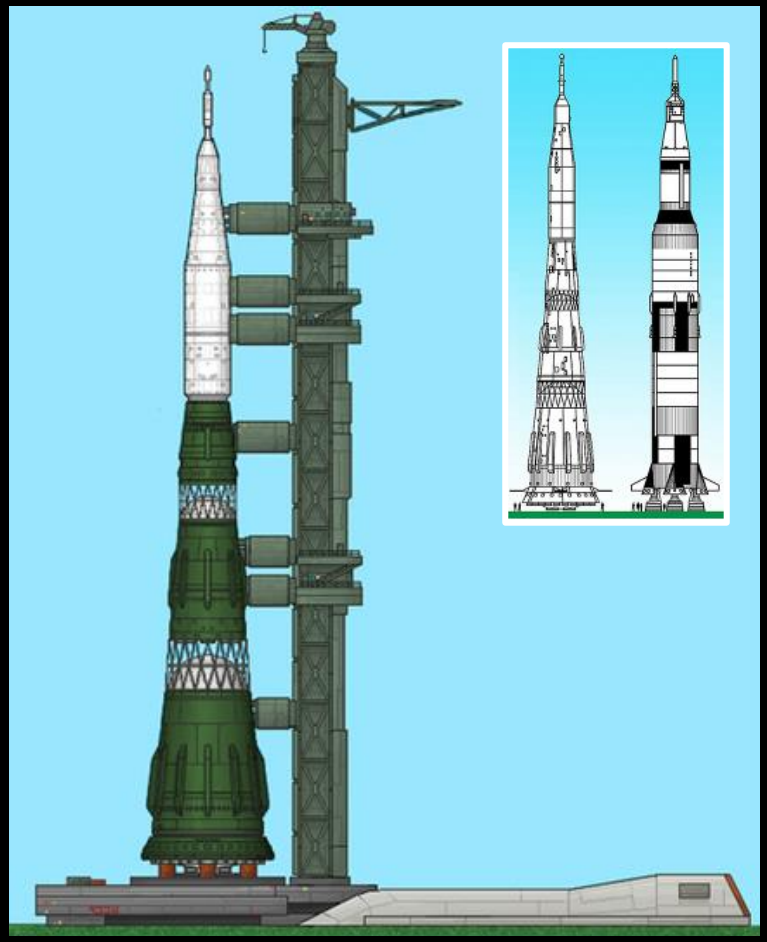




Weaknesses, even flaws, of the SpaceX ITS

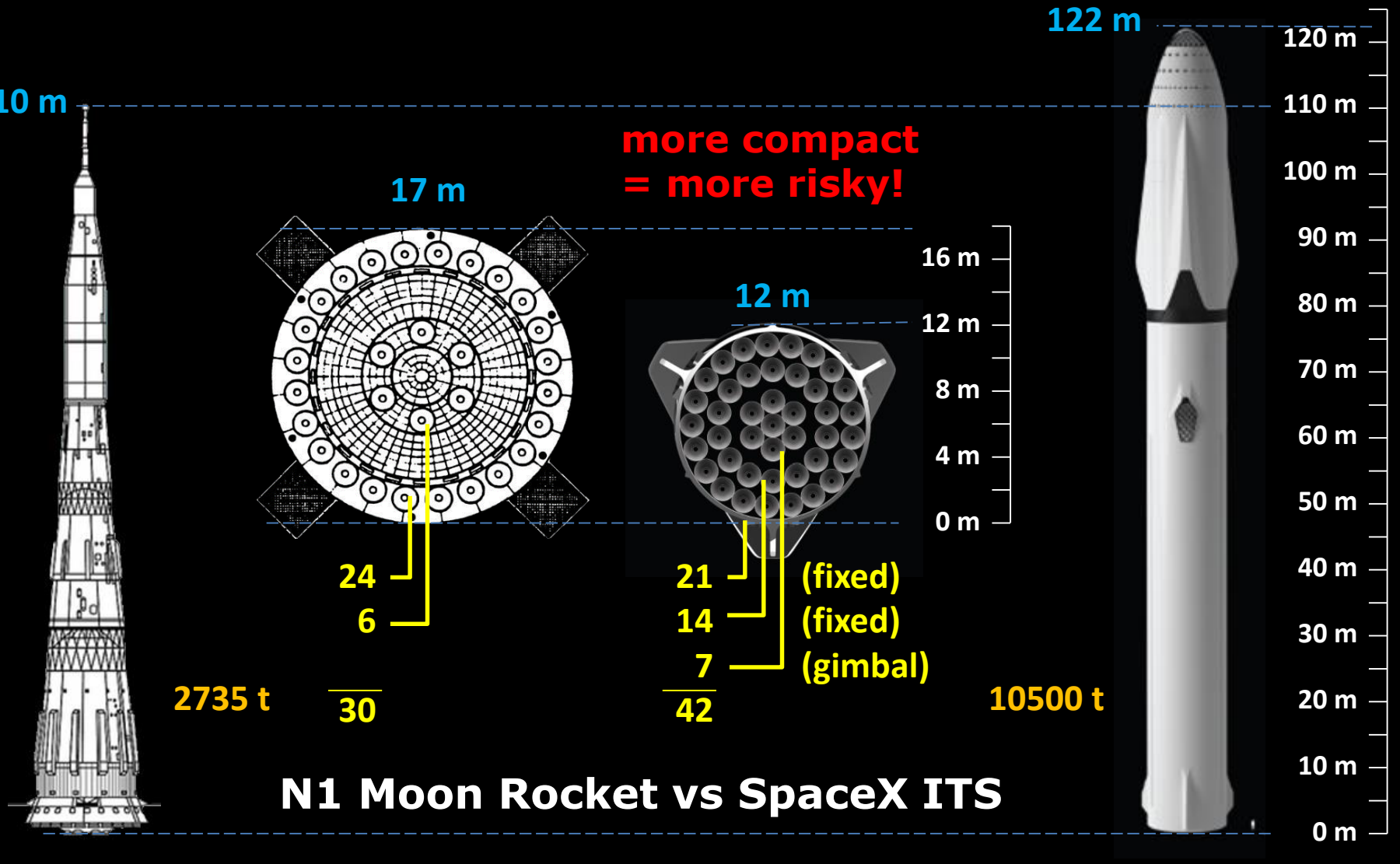
Why could the great number of engines be problematic?





Not a good omen, the soviet Moon rocket N1:
4 launch attempts, 4 failures !

Weaknesses, even flaws, of the SpaceX ITS

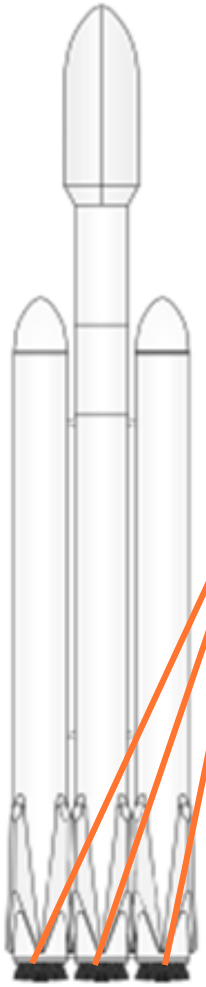


N1 Moon Rocket vs SpaceX ITS

Weaknesses, even flaws, of the SpaceX ITS

What about the first successful test flight of Falcon Heavy ?

Impressive indeed, but …



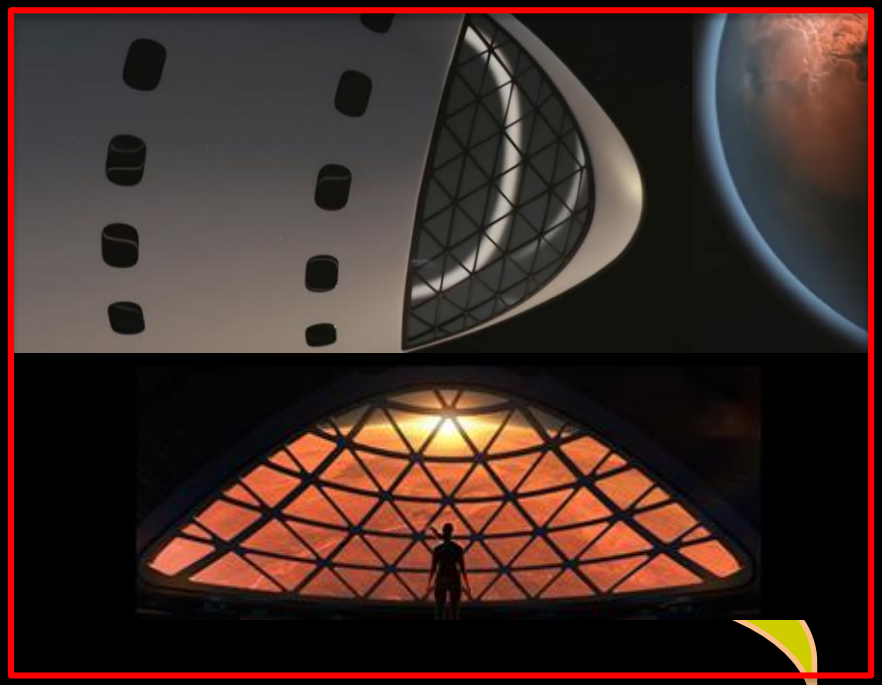
in risk analysis
3 x 9 ≠ 27

Союз

as 4 x 4 ≠ 16

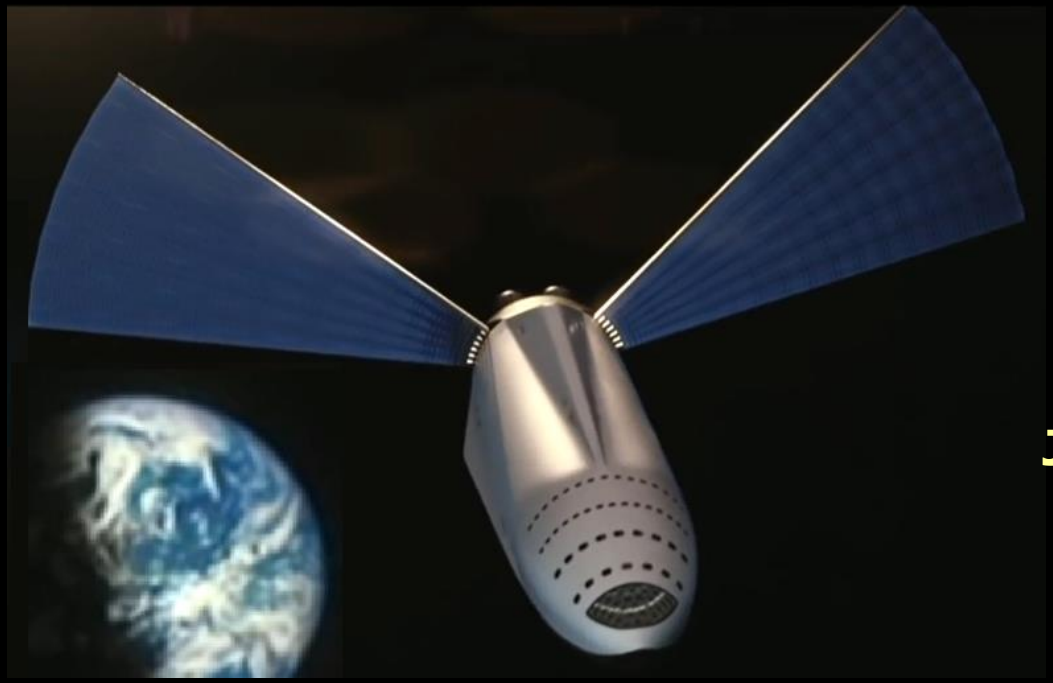
(Soyuz rocket, very reliable)

Weaknesses, even flaws, of the SpaceX ITS



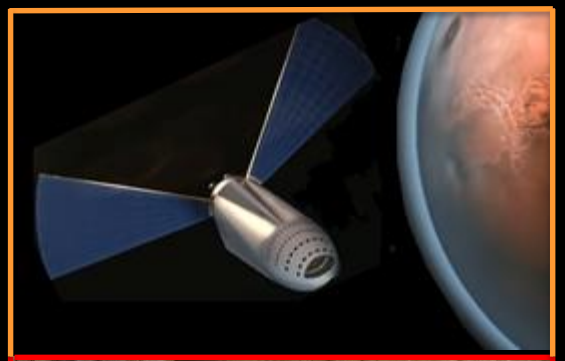
Too much inspired by *Star Trek* ?!

Weaknesses, even flaws, of the SpaceX ITS



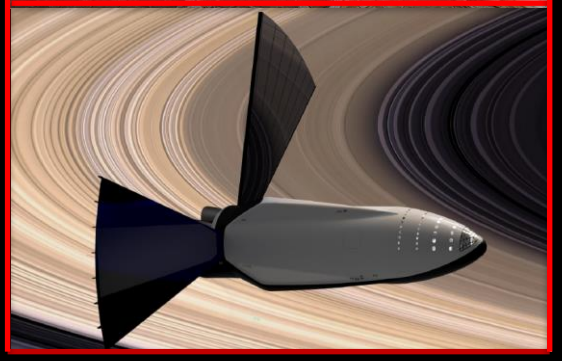
Earth orbit:
200 kWe
2.00 kWe/pass.
(space shuttle: 3.00 kWe/pass.)

Mars:
86 kWe



Jupiter:
7 kWe

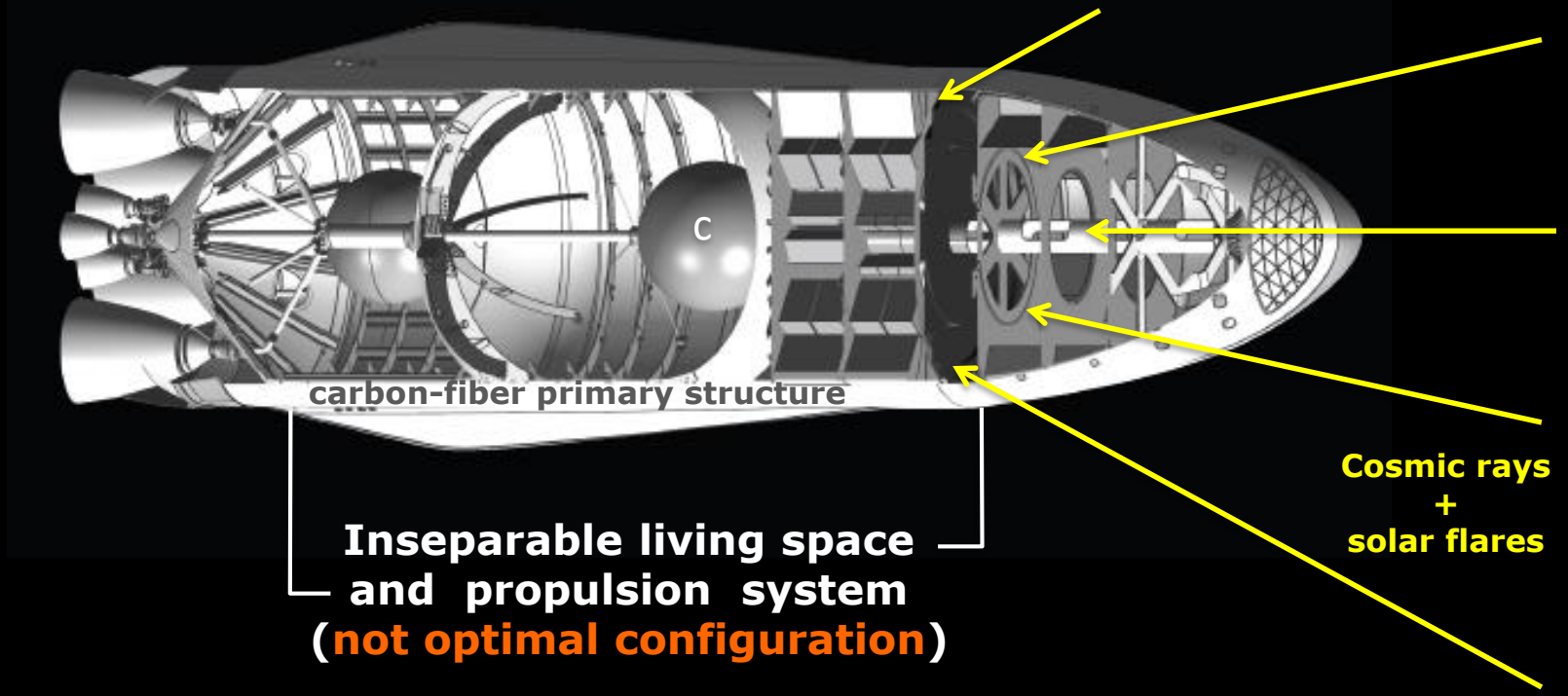
Saturn:
2 kWe

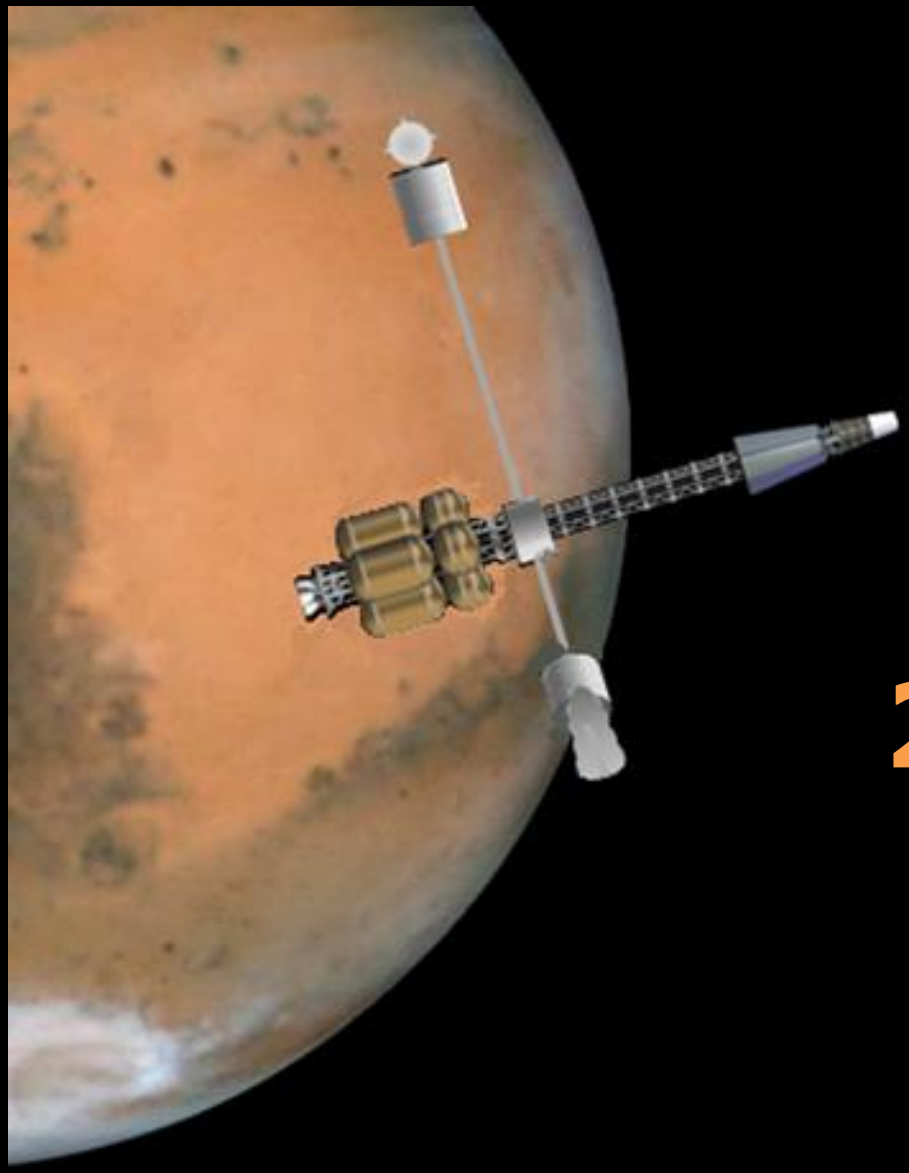


Weaknesses, even flaws, of the SpaceX ITS

No artificial gravity, and no possibility of creating one because of the solar pannels (physiological problems)

. Passenger cabins in periphery
. No reinforced shielded refuge
. Low-Z spaceship structure material
(not optimal for radiation protection)





2. Proposal of an alternative, safer and more flexible, ITS concept

Compared to SpaceX ITS

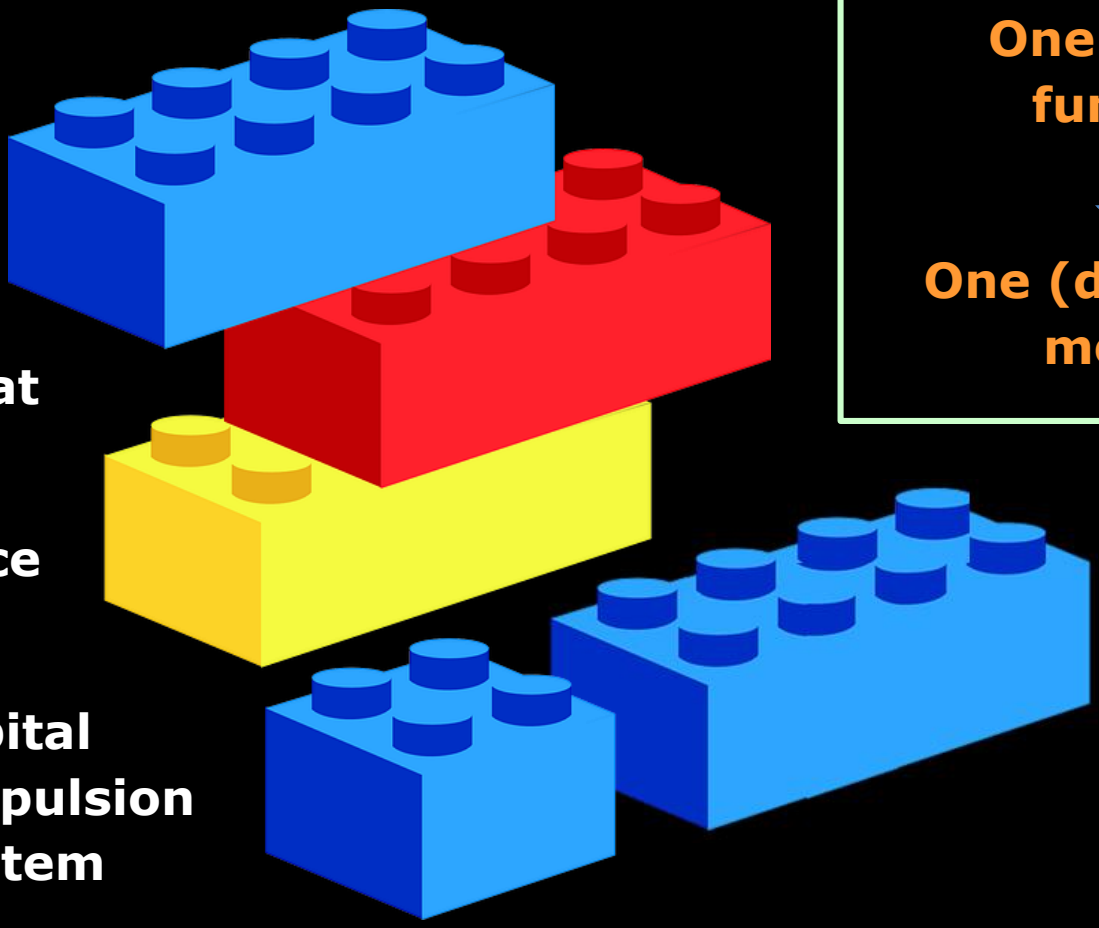
what is left

- All elements of the system fully reusable
- Refuelling in Earth orbit before heading to Mars
- In situ manufacture of Earth return propellants on Mars using local resources (CO_2, H_2O)

what is changed

- Too big a "fucking" system
- Too "monolithic" approach
- Little redundancies and possible plans B
- System not globally optimized
- No artificial gravity during flight
- Little radiation protection

Basic and essential principle: "modularity"



Ascent/ Descent Shuttle

Space Habitat

Nuclear Power Source

Orbital Propulsion System

Launcher/ Booster

One (main) function

One (dedicated) module

Components of the proposed ITS

Saturn V
or
SLS class
(no BFR!)

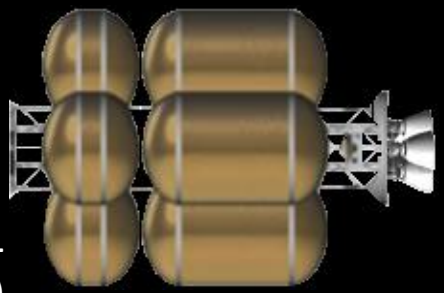
Reusable
Launcher/
Booster

Space
Habitat
Modules

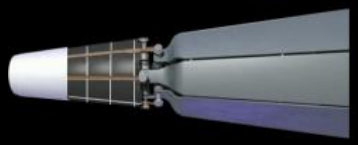
Interchangeable tanks (no cryoge-nic fluid transfer)

Central
Connection
Module

Descent / **A**scent **S**huttles

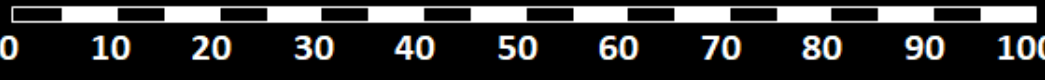


Orbital
Propulsion
System

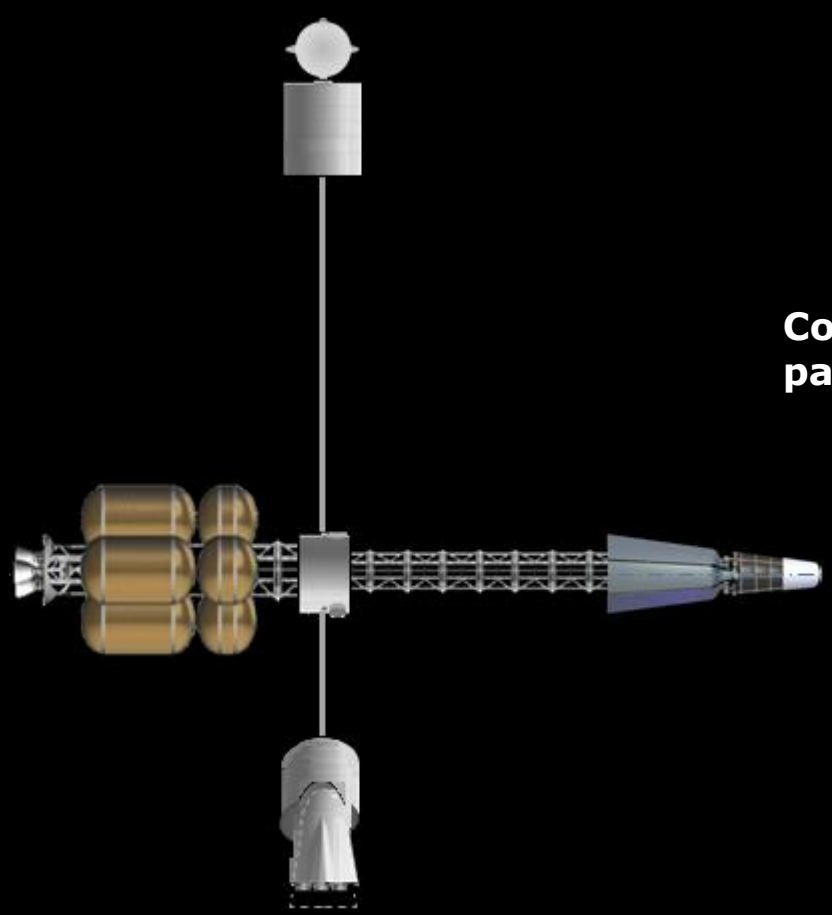


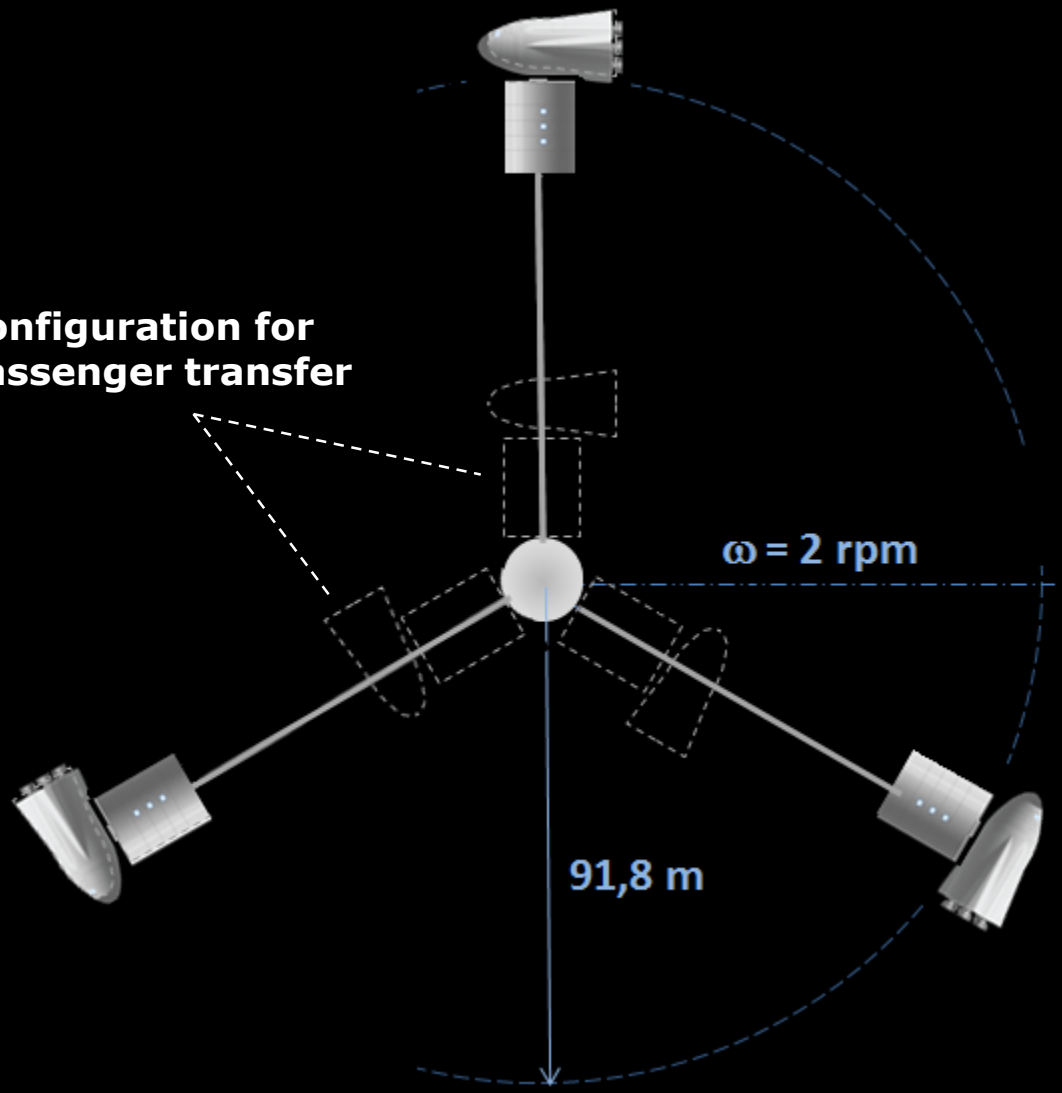
Nuclear
Power
Source

Once assembled, remains in space

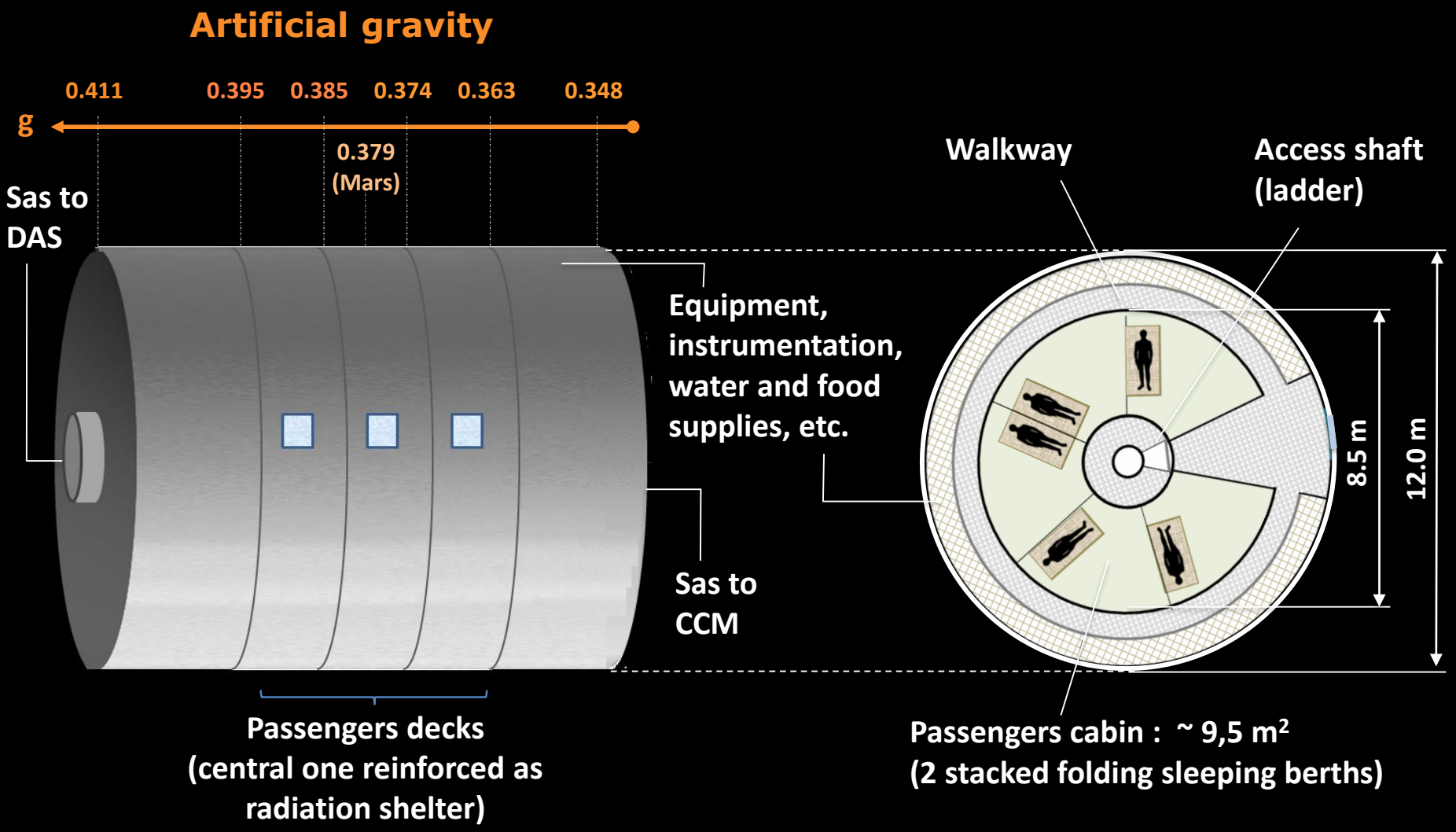


Assembled system in transfer orbit configuration

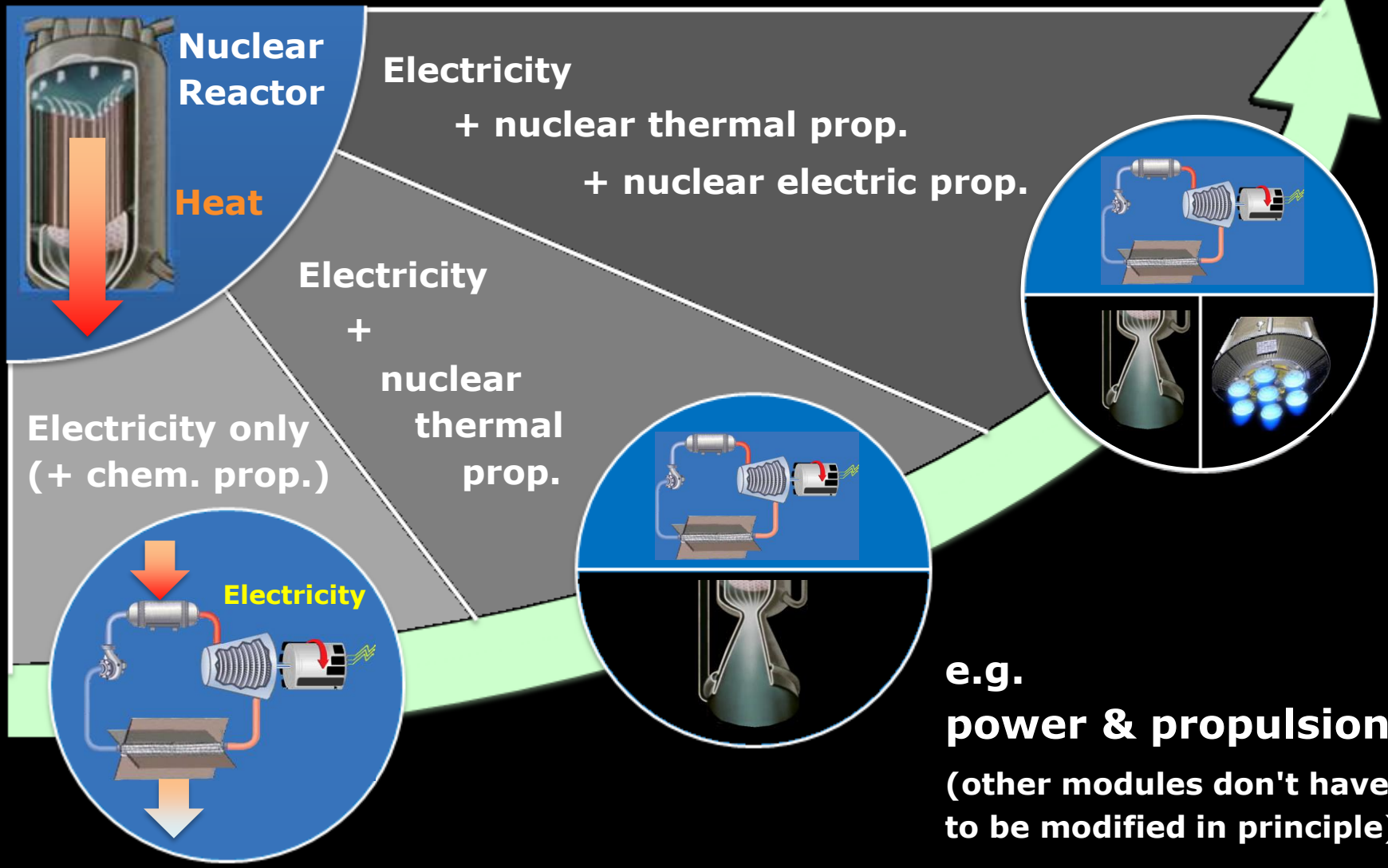




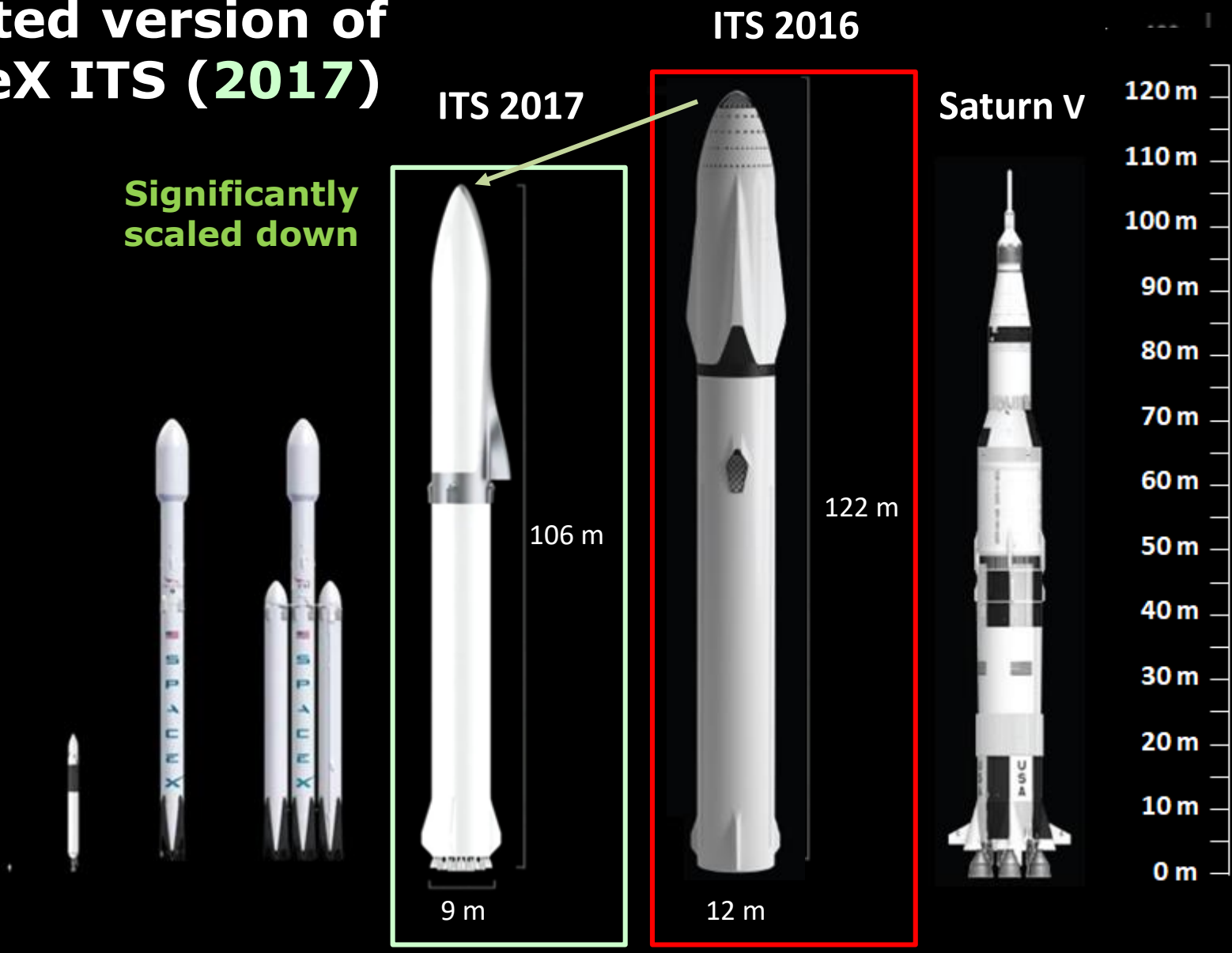
Details of space habitat module



Modularity ⇒ possibility of stepwise evolution



Updated version of SpaceX ITS (2017)



Launcher of a more "reasonable" size (~ Saturn V)

↓

Risk reduction (launching failure)

Fewer engines (42 → 31)

↓

Reduced reliability requirements

Suppression of the big window

↓

More credible for atm. entry

Reinforced shielded central refuge (but cabins remain in periphery)

General design remains very "monolithic"

↓

Few redundancies and "plan *B*"

Still many engines

↓

Reliability problem

Still numerous pass. windows

↓

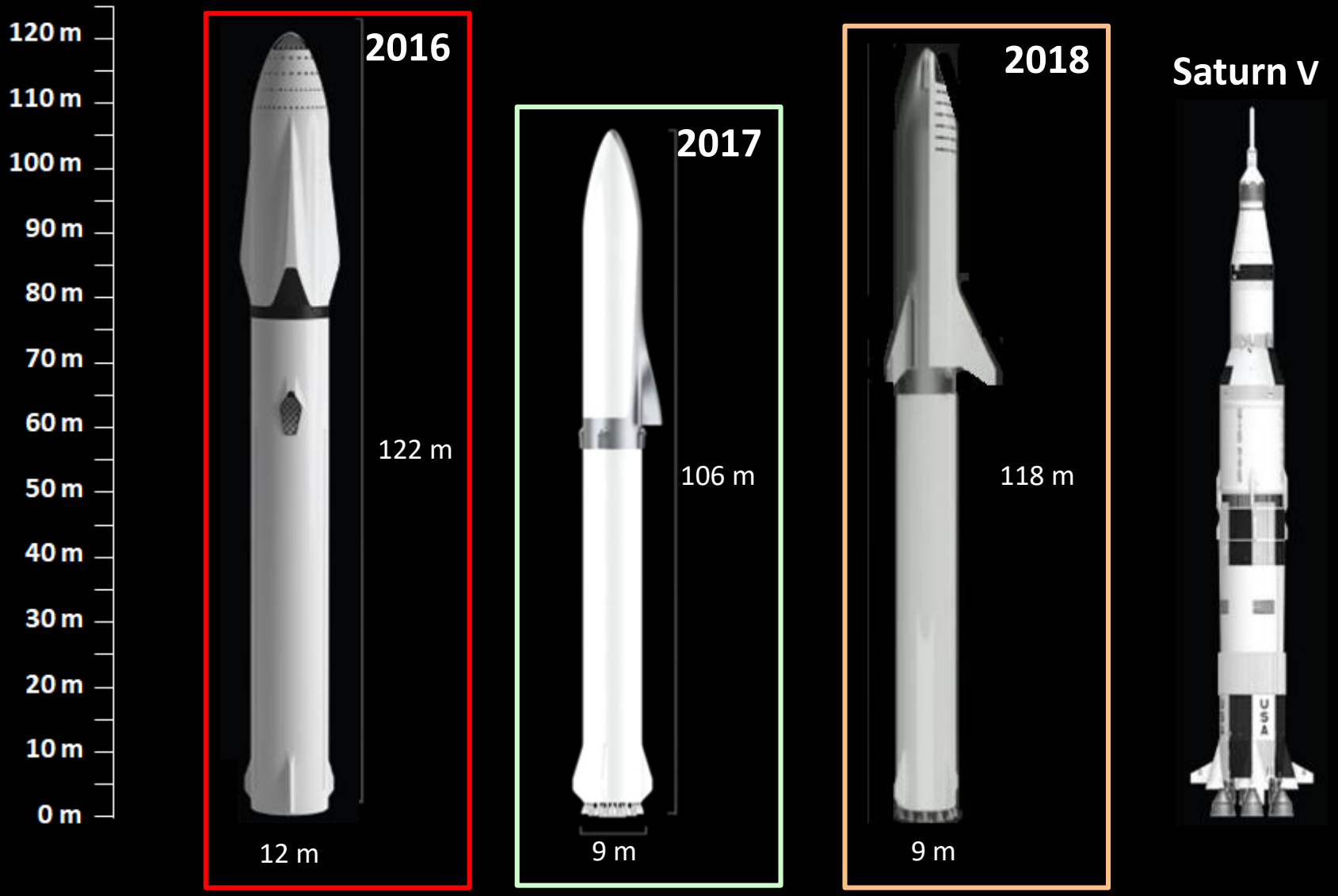
Structural weaknesses

No artificial gravity

↓

Physiological problems

Once again a new design (2018) !



2018 version of SpaceX ITS

Thank you for your attention !

Any questions ?