On Colonizing Mars

Marcos Boniquet Aparicio
MASTER ON NUMERICAL
METHODS ON ENGINEERING
November 2018

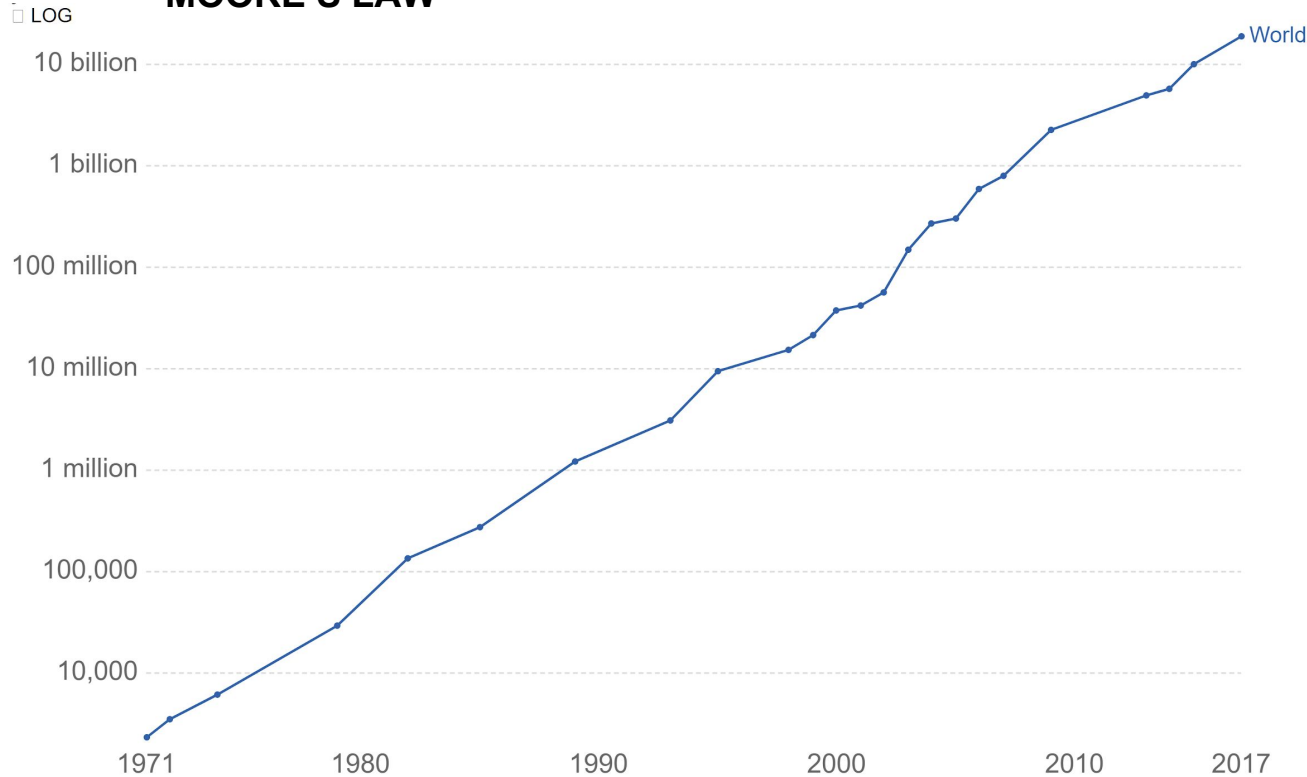# WORLD POPULATION

[ourworldindata.org]
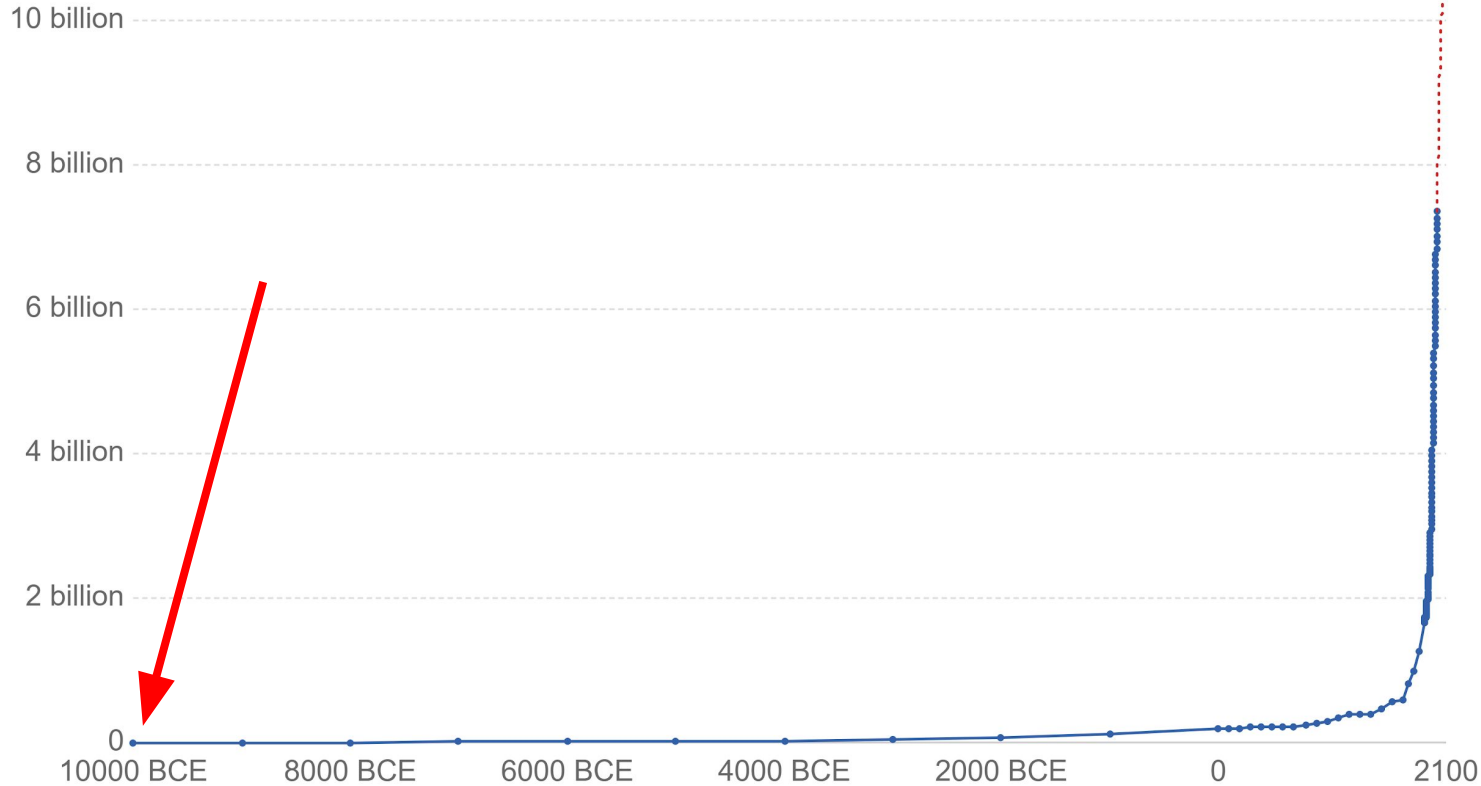
We are growing.

So why should we worry?

CONVERGENCE TO THE SINGULARITY

[ourworldindata.org]

MOORE'S LAW

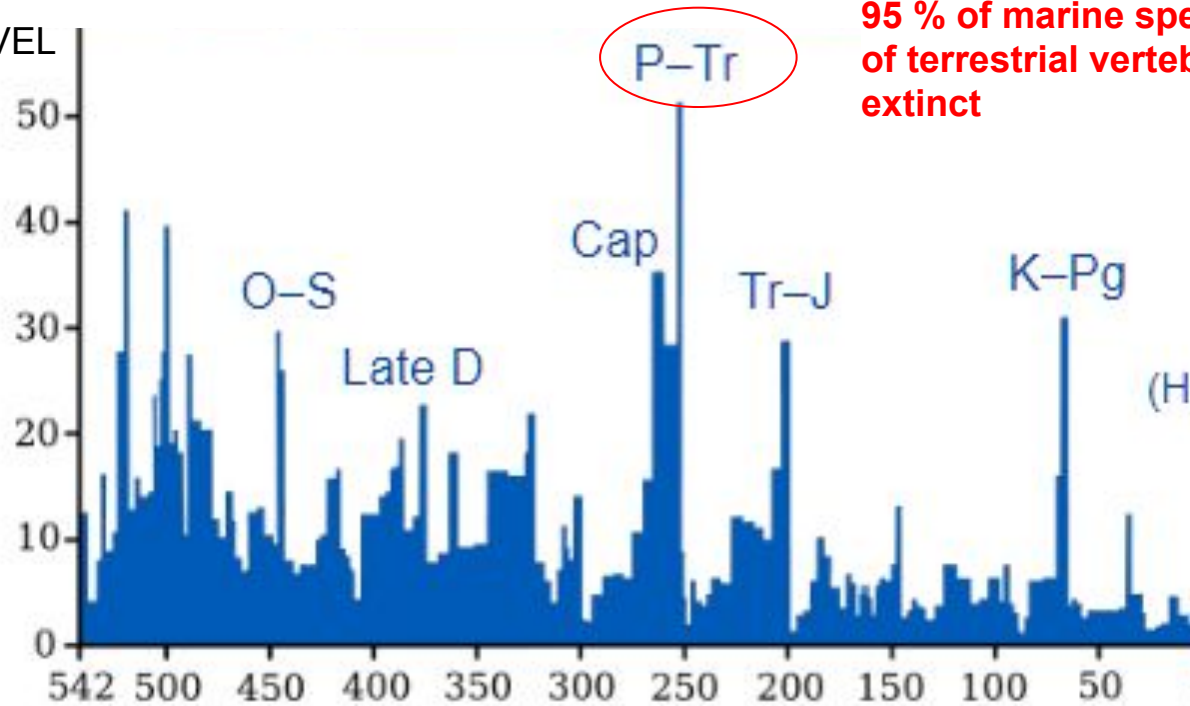

We are the **best**.

So why should we worry?

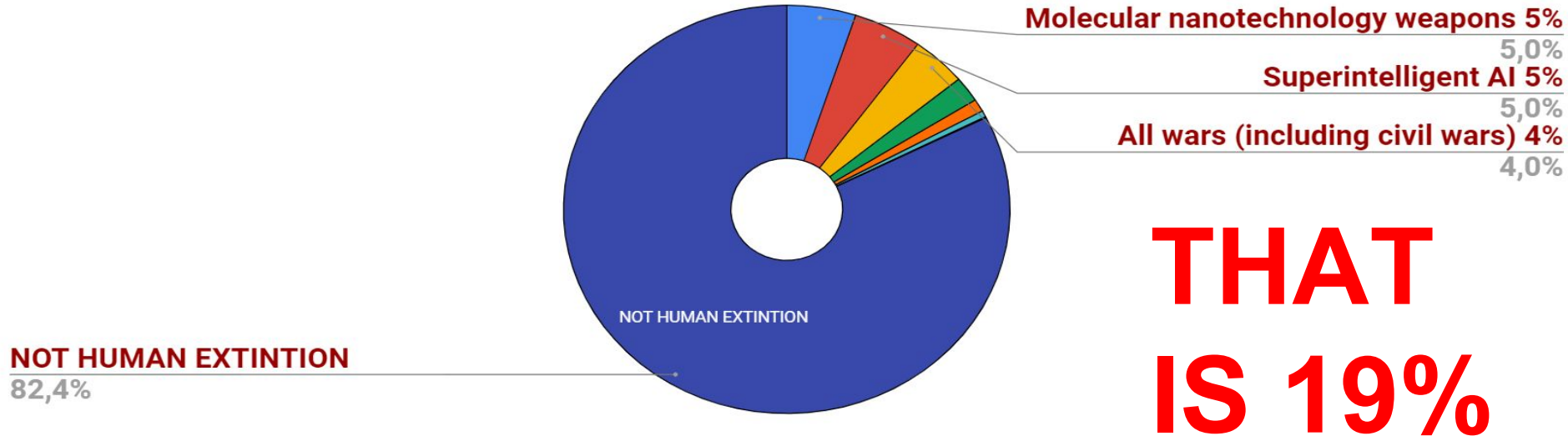# FACING GLOBAL EXTINCTION

BIODIVERSITY/ EXTINCTION LEVEL

95 % of marine species and 70 % of terrestrial vertebrates got extinct

MILLIONS OF YEARS AGO

[WIKIPEDIA]

FACING GLOBAL EXTINCTION

OUR CHANCES FOR THE NEXT 100 YEARS

Molecular nanotechnology weapons 5%
5,0%

Superintelligent AI 5%
5,0%

All wars (including civil wars) 4%
4,0%

NOT HUMAN EXTINTION

NOT HUMAN EXTINTION
82,4%

THAT IS 19%

[FUTURE OF THE HUMANITY INSTITUTE, 2008]

"Human race only has 100 years before we need to colonize another planet"
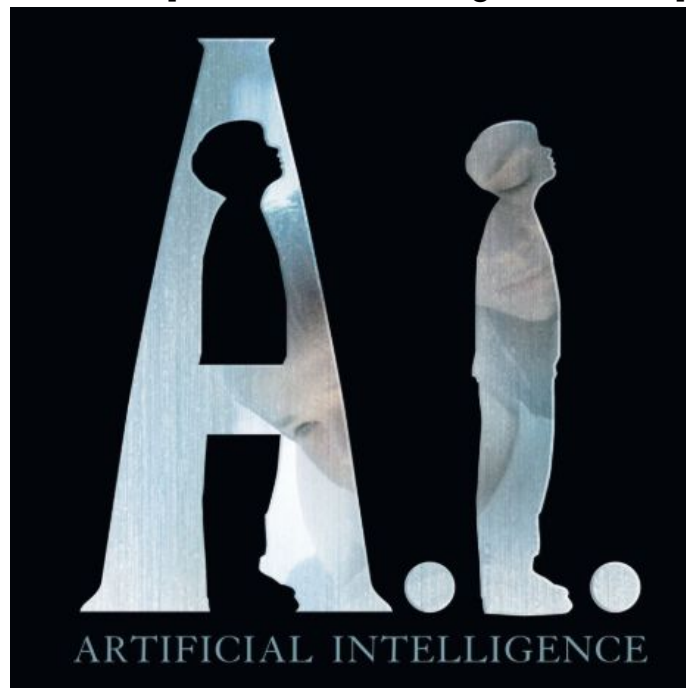[Stephen Hawking-BBC 's "Expedition New Earth" , 2017]

FACING GLOBAL EXTINCTION

Google AlphaGo beats Lee Sedol, World Champion Go

[A.I. Artificial Intelligence, 2008]

Playing against itself for four hours achieves 1400-year humankind's chess knowledge

BLACK DEATH
75 to 200 million people in Eurasia in the 14th century
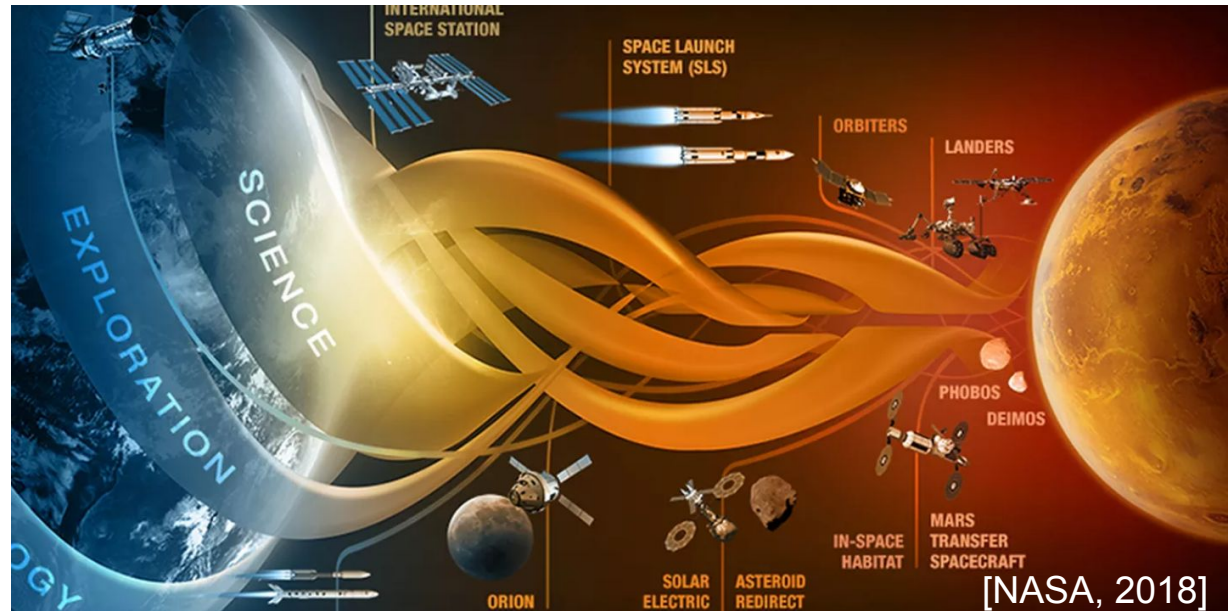
ATOMIC BOMBINGS
of Hiroshima and Nagasaki
The two bombings killed 200.000 people

[@THATERMOS, 2018]

PRIVATE & PUBLIC INTEREST

[NASA, 2018]

AFFORDABLE TRIPS TO MARS: 4 PILLARS

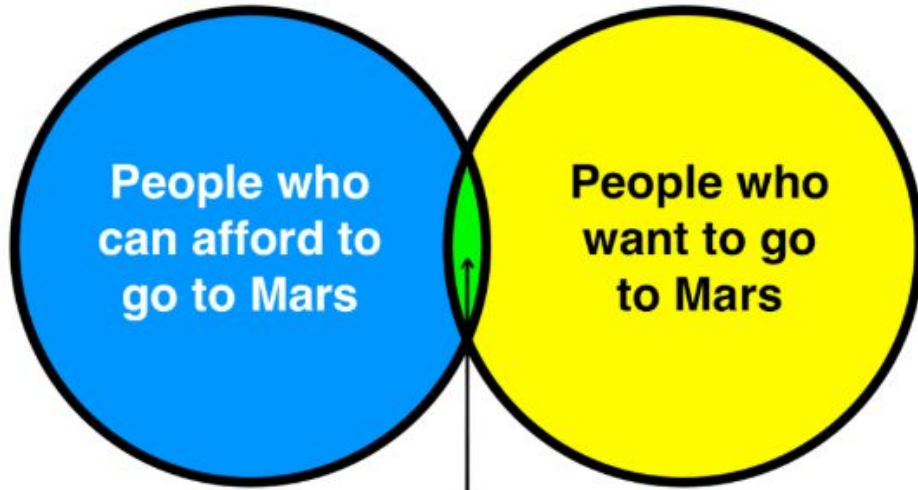**Full reusability**

Multiple-purpose rocket

In-Situ Resource Utilization (ISRU)

Refueling in orbit

AFFORDABLE TRIPS TO MARS: REUSABILITY

Cost of refurbishment<<< Cost new rocket

People who can afford to go to Mars

People who want to go to Mars
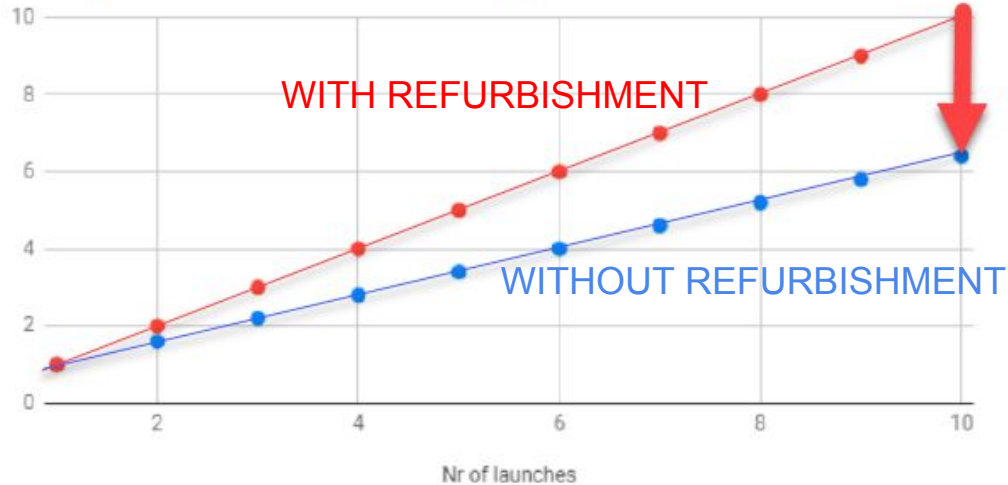
At least a million people

[WAITBUTWHY.COM]

EXPENDABLE:
LIKE USING A PLANE **ONCE**

AFFORDABLE TRIPS TO MARS: REUSABILITY

WITH REFURBISHMENT

WITHOUT REFURBISHMENT

Nr of launches

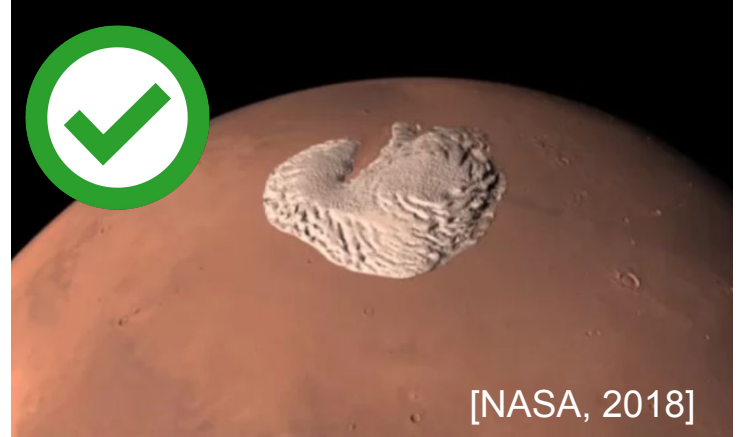RELATIVE ACCUMULATED COST FOR FALCON 9 LAUNCHES

-40% **Being EXTREMELY CONSERVATIVE**

AND IT'S ONLY THE BEGINNING!

- NEW GEN. ROCKET 100% reusable
- 100 times
- Material improvements

AFFORDABLE TRIPS TO MARS: ISRU
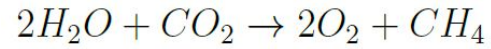

[NASA, 2018]

- 25 TRILLION METRIC TONS OF CO_2

- 5 MILLION CUBIC KM OF WATER ICE

AFFORDABLE TRIPS TO MARS: ISRU

SABATIER REACTION

$$2H_2O + CO_2 \rightarrow 2O_2 + CH_4$$

O_2

150 Tn TO THE SURFACE OF MARS

FUEL

1 Tn

AFFORDABLE TRIPS TO MARS: MULTI-PURPOSE ROCKET
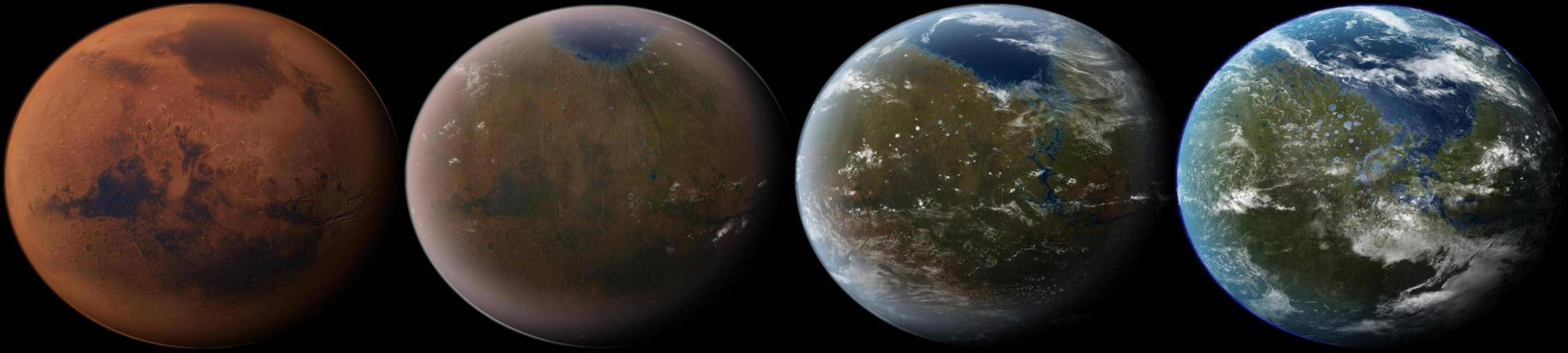
- EARTH-TO-EARTH
- TRIP TO MARS
- SATELLITES
- ISS
- MOON
- ...
- ...
- ...

SAME TOOL FOR MANY THINGS

➕ MORE ROCKETS PRODUCED

➕ MORE OPPORTUNITIES

TERRAFORMING

REQUIRES:

- Building up the atmosphere

- Building up the magnetosphere

- Raising the temperature

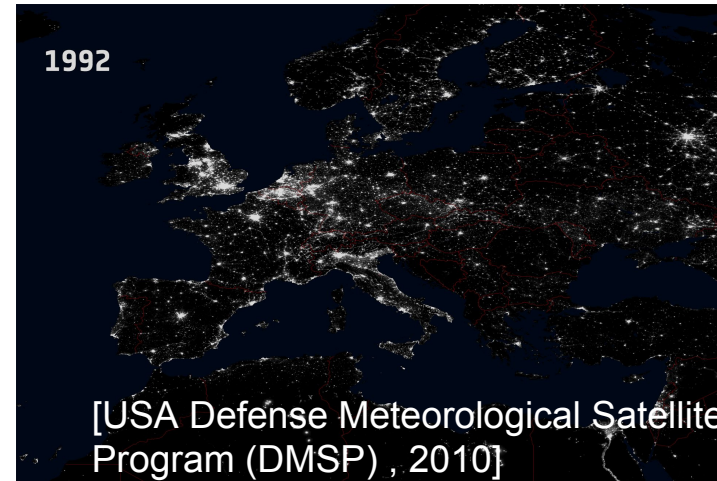IN THE FAR
FUTURE...

[SpaceX, 2018]

TERRAFORMING

CO$_2$ CONCENTRATION

DEMONSTRATED CAPABILITY ON TRANSFORMING OUR PLANET

[ourworldindata.org]

NASA GODDARD, 2018

[NASA, 2018]

1992

[USA Defense Meteorological Satellite Program (DMSP), 2010]
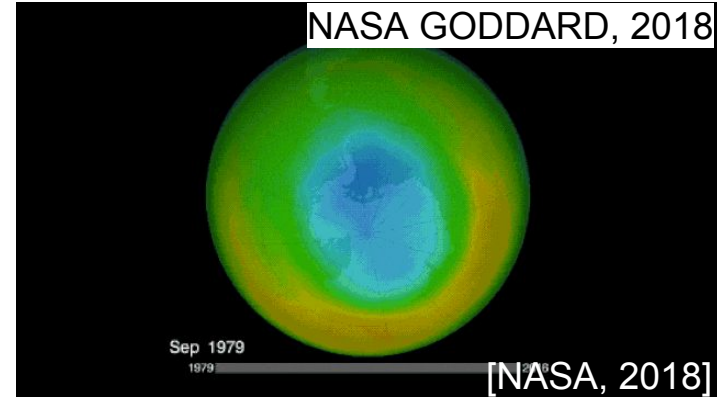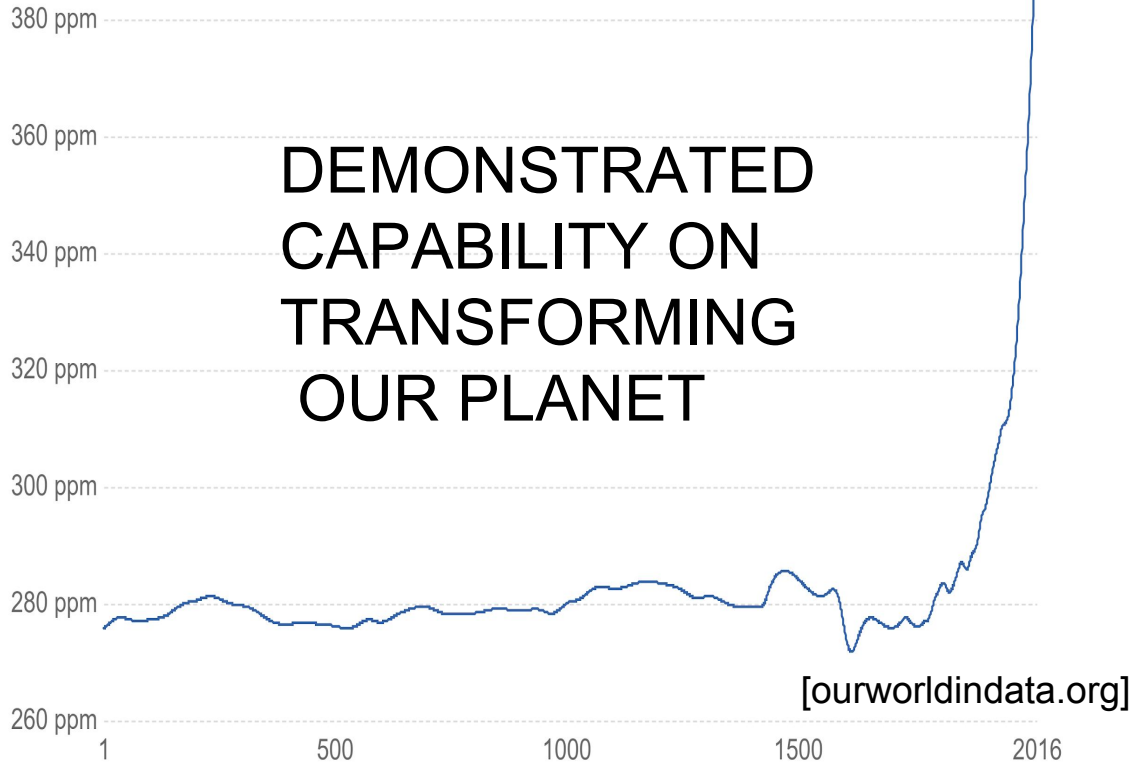
MARS' ATMOSPHERE IS ABOUT 0.6% of Earth's

LOW PRESSURE→ **NO LIQUID WATER**

[NASA, 2018]

LESS PROTECTION AGAINST COSMIC RAYS AND SOLAR FLARES
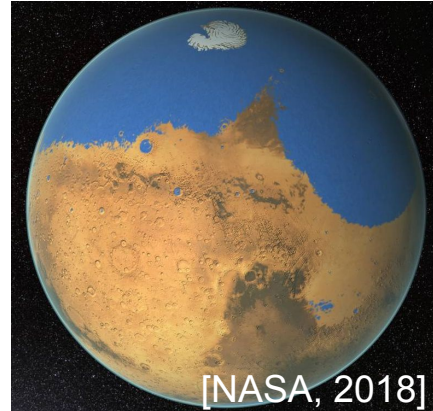
THICKEN ATMOSPHERE WITH CO_2 BY A **RETROFIT** PROCESS
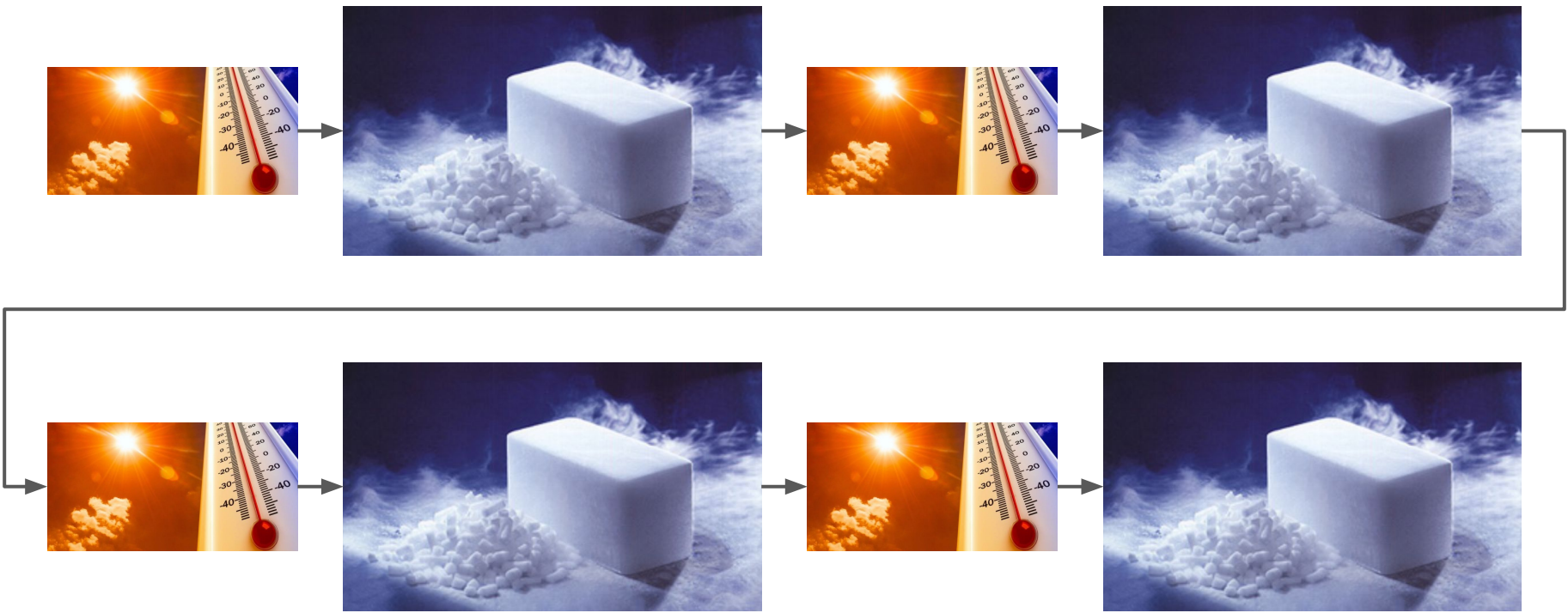
THROUGH THE EONS, MARS HAS LOST ITS ATMOSPHERE, THE REASON: NO MAGNETIC SHIELD

[NASA, 2017]

LAGRANGIAN POINTS BETWEEN TWO CELESTIAL BODIES
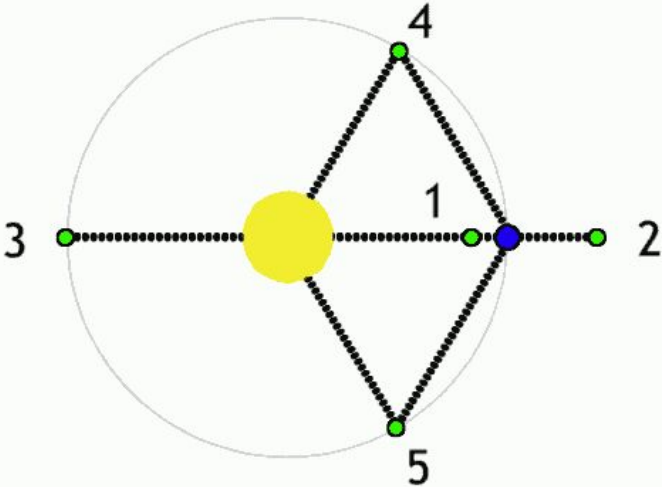
MAGNETIC DIPOLE AT L1 OF TWO TESLAS

Magnetotail

L1 = ~320 R_{Mars}

MARS

Magnetopause

Magnetosheath
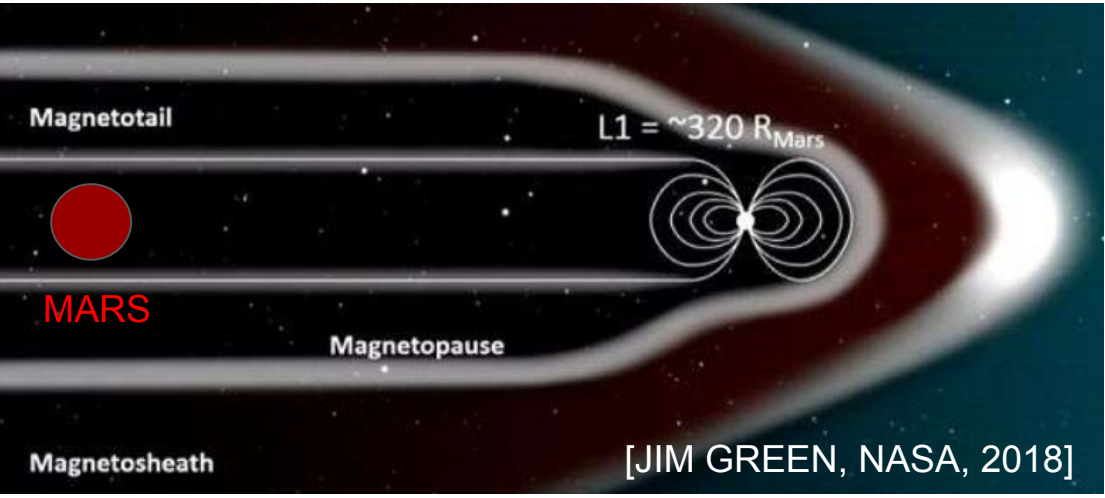
[JIM GREEN, NASA, 2018]

3

4

1

2

5

[WIKIPEDIA]

[2001, A SPACE ODYSSEY]

FAR FUTURE: **BECOMING A CIVILIZATION CAPABLE OF INTERSTELLAR TRAVEL**

[HUBBLE, 2006]

[Interstellar, 2014]

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[4] Gwynne Shotwell. Spacex's plan to
y you across the globe in 30 minutes (2018),
https://www.ted.com/talks/

[5] Green, J.L.; Hollingsworth, J. A. Future Mars Environment
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Planetary Science Vision 2050 Workshop 2017.

[6] Robert Zubrin. NASA's Worst Plan Yet (2018)
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[10] Wikipedia. Extinction event (2018)
https://en.wikipedia.org/wiki/Extinctionevent

[11] Wikipedia. Apolo 11 (2018) https://es.wikipedia.org/wiki/Apolo 11

SUMMIT
OLYMPUS MONS
The solar system's highest peak

PHOBOS & DEIMOS
TAKE A SPACE-AGE CRUISE ABOARD THE MOONS OF MARS

DISCOVER
VALLES MARINERIS
LAND OF MARTIAN CHASMS AND CRATERS

THE END

[SpaceX, 2018]