

We only have one earth

Drahflow

28. Dezember 2013










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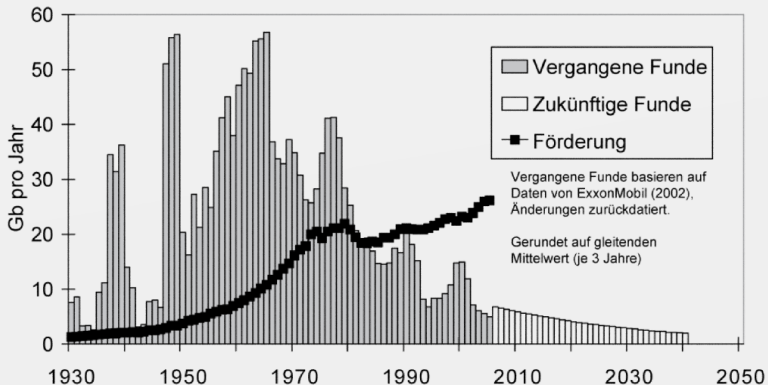
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Environmental problems

Planetary limits of linearity for various important systems:





-  Stratospheric ozone depletion: $> 95\%$ preindustrial amount = 275 DU. Current: Variable. Old state expected to be reached: ca. 2070
-  Freshwater usage: $4000 \text{ km}^3/\text{Y}$. Current: $2600 \text{ km}^3/\text{Y}$
-  Land use: $< 15\%$ of ice-free land = 2 GHa. Current: 1.6 GHa.
-  Ocean acidification: CaCO_3 . $> 80\%$ preindustrial aragonite saturation = $2.75 \Sigma_{\text{aragonite}}$. Current: $2.9 \Sigma_{\text{aragonite}}$.
-  Aerosol concentrations: ???
-  (General) chemical pollution: ???
-  Climate change: 350ppm CO_2 . Current: 387 ppm
-  Nitrogen and phosphorus cycles: $\text{P} < 10\text{Mt}/\text{J}$, $\text{N} < 35\text{Mt}/\text{J}$. Current: $\text{P} = 10\text{Mt}/\text{J}$, $\text{N} = 150\text{Mt}/\text{J}$
-  Biodiversity loss: $< 10\text{x}$ natural extinction rate = 200 species extinct per year. Current: 480 - 13860 (depending on integration interval)

Limits of raw materials



Licence: GFDL, by Association for Peak-Oil Studies

Limits of raw materials





-  Oil: peak oil expected within 50 years
-  Coal: ca. 300 years (lignite), ca. 120 years (bituminous coal)
-  Iron: price difference by factor of 5 over 30 years (compared to rice)
-  Copper: price difference by factor of 2 over 30 years (compared to rice)

https://de.wikipedia.org/wiki/Globales_%C3%96lf%C3%B6rdermaximum

https://de.wikipedia.org/wiki/Kohle/Tabellen_und_Grafiken

<http://www.indexmundi.com/commodities/?commodity=iron-ore&months=360&commodity=rice&indicator=price-rati>

Nuclear war

-  1956: „According to NATO plans, such incidents would have been answered by nuclear strikes, however . . . “
-  1962: „This way an engineer would have been able to start all minuteman-missiles alone.“
-  1979: „General Odom informed US-president Jimmy Carter, that approximately 220 sowjet nuclear missiles were incoming. The counterstrike was being prepared, . . . “
-  1983: „Accordingly, in November of the year the missile units of the CCCP were mobilised and errornous intelligence nearly resulted in a counterstrike.“

https://de.wikipedia.org/wiki/Atomkrieg#Kritische_Situationen

Nuclear war






Multiple refusals to obey orders of various soldiers, which at different times prevented a nuclear war.


Conservative estimate: 2% probability per 50 years \Rightarrow 66% survival chance over 1000 years

Other bad things...

Global pandemic:

-  Fast spreading thanks to international air traffic
-  Correspondingly short timeframes to enact countermeasures
-  New pathogens (also) by genetic engineering and bio-weapons research

Strong AI:

-  „Hyper-intelligent software may not necessarily decide to support the continued existence of mankind, and would be extremely difficult to stop.“ (Yudokowski)

https://en.wikipedia.org/wiki/Strong_AI







Option 1

The Countess Dôbar Dodókthabost meets with the elf Diplonat Mifava Ecatepe

Mifava Ecatepevó: What a pleasant surprise! Not a single tree here weeps from the abuses meted out with such ease by your people. Joy! The dwarves have turned a page, not that we would make paper. A travesty! Perhaps it is better said that the dwarves have turned over a new leaf, and the springtime for our two races has only just begun.



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Option 1: “Tree Hugging”




-  100% renewable energy
-  100% renewable or recycled raw materials
 -  Construction
 -  Fertilizer
-  Global nuclear disarmament
-  Research stop for high-risk technologies

Nonetheless...

Meteorites:

-  Meteorites >1km diameter ca. 1 / 500.000 years
-  Results highly dependent on impact location

Volcanism:





-  Every ca. 1000 years one VEI 7 incident
-  Every ca. 50.000 years one VEI 8 incident (>100km³ material)
-  Global cooling, hence crop failures etc. and global effects

https://en.wikipedia.org/wiki/End_of_civilization#Meteorite_impact

https://en.wikipedia.org/wiki/Year_Without_a_Summer

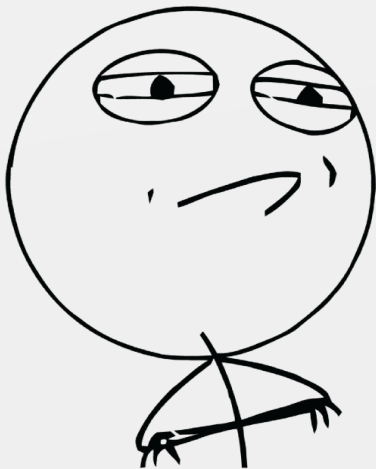
https://en.wikipedia.org/wiki/Volcanic_Explosivity_Index

Great Filter

-  No known civilizations apart from earth
-  Either, the start of intelligent life is unlikely
-  Or, intelligent life is unlikely to spread
-  Are we past whatever the reason is?





https://en.wikipedia.org/wiki/Great_Filter

CHALLENGE ACCEPTED



Redundancy





Deliberate decorellation of risks.

-  A mars colony would already survive all planetary disasters
-  Supernovae type II relevant up to ca. 30 light years
-  Supernovae type Ia relevant up to ca. 1000 light years
-  Gamma-ray bursts relevant up to ca. 6000 light years, but less correlated due to beam geometry

https://de.wikipedia.org/wiki/Supernova#Auswirkungen_auf_die_Erde

<http://arxiv.org/abs/astro-ph/0309415>

Resource waste

-  Assuming only sub-light travel, we lose one galaxy per year from the reachable universe
-  ca. 100 billion stars
-  Earth-like planets in 1.6% of systems
-  1 billion humans for 50 generations per planet

Opportunity costs:





-  Each second, humanity loses resources for 2.5 billion lives

<http://www.nickbostrom.com/astrophysical/waste.html>

https://en.wikipedia.org/wiki/Earth_analog

Minimal colony size

Minimum viable population \leq 5000 for mammals

-  Pitcairn Island: 18
-  Medium term: 50
-  Long term: 500
-  Effective human population size on earth: 11.000–12.000









Radiation exposure could actually be useful.

https://en.wikipedia.org/wiki/Pitcairn_Islands

https://en.wikipedia.org/wiki/Toba_catastrophe_theory

https://en.wikipedia.org/wiki/Space_colonization



Purpose of (another) planet

-  Backup
-  Raw materials for local consumption
-  Raw materials in a shallower gravity well
-  More solar energy
-  More population
 -  Trade of culture and science
 -  Network effects
 -  Data is easier to trade than material

History shows many useful „by-products“ of space research.

Cost to Mars




Mission with ≤ 10 people:

-  One-time: 5-50 billion EUR
-  Of these: ca. 50% booster rockets

Comparison: Defense budget of Germany: 33 billion EUR per year

[http://www.wired.com/wiredscience/2012/08/
is-a-privately-funded-manned-mission-to-mars-possible/](http://www.wired.com/wiredscience/2012/08/is-a-privately-funded-manned-mission-to-mars-possible/)
http://quest.arc.nasa.gov/mars/ask/humans-on-mars/Cost_of_Manned_Mars_Mission.txt




Interstellar travel

-  „'It is highly improbable that humans will ever explore beyond the Solar System.' This downbeat opinion comes from the Joint Propulsion Conference in Hartford, Connecticut“
-  „How could a trip to Proxima Centauri be achieved if we'd need 100 times more energy than the entire planet currently generates?“
-  „What's the catch? That 10-million-gigawatt laser. That power level is ten thousand times more than the power used on all the Earth today.“ (NASA)

Conclusion: Shit!

<http://www.universetoday.com/17044/bad-news-insterstellar-travel-may-remain-in-science-fiction/>
<http://www.nasa.gov/centers/glenn/technology/warp/ideaknow.html#sail>

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Conclusion: More Science is clearly needed!

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Interstellar travel

- 📄 Accelerate 1 metric ton to 0.1 c: $4.494 \cdot 10^{17} J$, 1/30 of total energy production of the USA in 2001, 5kg mass equivalent
- 📄 $1000 N * 1 \text{ year} / 1 \text{ ton} = 0.1 c$

Conclusion: Challenge accepted.

https://en.wikipedia.org/wiki/Interstellar_travel

Current propulsion technology

-  Solid fuel etc.: Specific impulse ca. 250 s
-  Solar sail: 100 m/s in 6 month, no maximum (successfully deployed)
-  Ion thruster: specific impulse: 1640 s, power consumption: 1.2kW, final delta-v: 3.9km/s, maximum $>100\text{km/s}$ (successfully deployed)
-  Variable Specific Impulse Magnetoplasma Rocket: specific impulse: 5000 s, power consumption: 200kW, maximum delta-v: $>100\text{km/s}$ (soon at a space station near you)







https://en.wikipedia.org/wiki/Specific_impulse

<https://en.wikipedia.org/wiki/SMART-1>

<https://en.wikipedia.org/wiki/IKAROS>

https://en.wikipedia.org/wiki/Variable_Specific_Impulse_Magnetoplasma_Rocket

Propulsion research

-  Dual-stage 4-grid ion thrusters: specific impulse 19300 s, power consumption 250kW (initial engineering)
-  Q-thruster: 1 N per 3kW. At 10% efficiency of all other parts: 30 MW power consumption (initial experiments successful)
-  Gamma ray laser rocket propulsion (theoretical prediction)
-  Alcubierre drive: Faster than light travel (initial experiments running)
-  „We are at the point where we know what we do know and know what we don't, but do not know for sure if faster than light travel is possible.“ (NASA)
-  „Is there any way around Special Relativity? Maybe.“ (NASA)

https://en.wikipedia.org/wiki/Dual-Stage_4-Grid

<http://www.esa.int/gsp/ACT/doc/PRO/ACT-RPR-PRO-IAC2006-DS4G-C4.4.7.pdf>

<https://en.wikipedia.org/wiki/Q-thruster>

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http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20110015936_2011016932.pdf

Relevant institutions

-  17.6 bil. \$: National Aeronautics and Space Administration
-  5.6 bil. \$: Russian Federal Space Agency
-  5.5 bil. \$: European Space Agency
-  2.5 bil. \$: Japan Aerospace Exploration Agency
-  1.3 bil. \$: China National Space Administration
-  1.0 bil. \$: Indian Space Research Organisation

https://en.wikipedia.org/wiki/List_of_space_agencies

Private institutions

-  Bigelow Aerospace – inflatable habitats (two prototypes in orbit)
-  Planetary Resources – asteroid mining (planning)
-  Mars One – mars colonization (planning)

<http://www.planetaryresources.com>






<http://www.bigelowaerospace.com>

<http://www.mars-one.com>

Utilization of planetary resources

Gross world product: $84.97 \cdot 10^{12}$ \$

Expenses:

-  Military: $1.5623 \cdot 10^{12}$ \$
-  International tourism: $1.137 \cdot 10^{12}$ \$
-  Science: $1 \cdot 10^{12}$ \$
-  Marketing: $0.466 \cdot 10^{12}$ \$
-  Space agencies: $0.033 \cdot 10^{12}$ \$

https://en.wikipedia.org/wiki/Gross_world_product

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Questions



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