

Future of Life in the Solar System

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Terra form other planets (Mars most likely)

Space Colonies

Solar Power from space

Dyson spheres

Robots

Von Neumann Devices

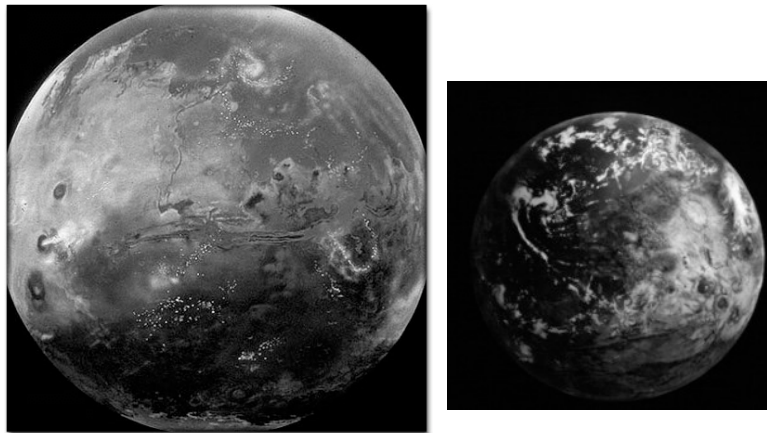
Future of Life in the Solar System

Seed other planets with
“bio-engineered organisms”

Use these to make more habitable for humans

Terraform (need H₂O, O₂, O₃)
e.g. Melt polar caps on Mars (10¹⁴ tons of ice)
2500 to 10000 years to build up atm. pressure, get liquid water

Terraformed Mars



Ocean in northern lowlands covers
25% of planet

Living in Space to Robots...

Space colonies
Solar Power satellites



Dyson sphere (Type II Civilization)

Role of Robots

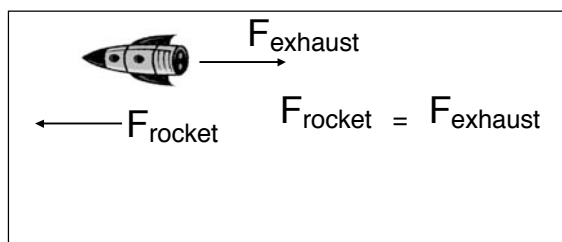


Von Neumann device

Rockets

Principle:

Newton's Third Law



1. Exhaust velocity V_e (km s^{-1})

$$V_e \propto \sqrt{\frac{T}{M}}$$

2. Thrust (Force) $F = \dot{M} V_e$
(Newtons, Pounds)

(\dot{M} = rate of mass ejected)

3. Mass ratio

$$R_M = \frac{\text{Total Mass at Takeoff}}{\text{Mass After Fuel Used Up}}$$

4. Specific impulse (s.i.)

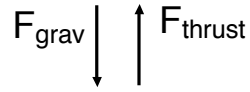
$$\frac{\text{Thrust}}{\text{Rate of Fuel Use}} \quad (\text{Newtons/kg/sec, Pounds/Pounds/sec} = \text{"sec"})$$

A measure of efficiency.

Highest possible s.i. with chemical fuels is < 500

Rockets

To take off: Thrust > Weight



To escape gravity $v > v_{\text{esc}} = 11.2 \text{ km s}^{-1}$
(7 miles/sec)

Rockets

Multi-stage Rockets

Space Shuttle: Mass = $2 \times 10^6 \text{ kg}$

$F_{\text{thrust}} = 29 \times 10^6 \text{ Newtons}$ $R_M = 68$

s.i. = 455 sec. ~ best possible with
chemical fuel

For more adventurous exploitation of Solar System

Probably want Nuclear Propulsion

Fission could give s.i. = $1.5 \times 10^6 \text{ sec}$

(in principle, more likely to get 20,000 sec)

Current Initiative

- Human mission to Mars
- Several attempts to get started in past
- Exploration Vision in 2004
 - First return to Moon
 - Then Mars
 - Long-term program needed
 - http://www.nasa.gov/missions/solarsystem/explore_main.html