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Human Development Beyond Earth: Long-Term Perspective vs Urgency

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OUTLINE

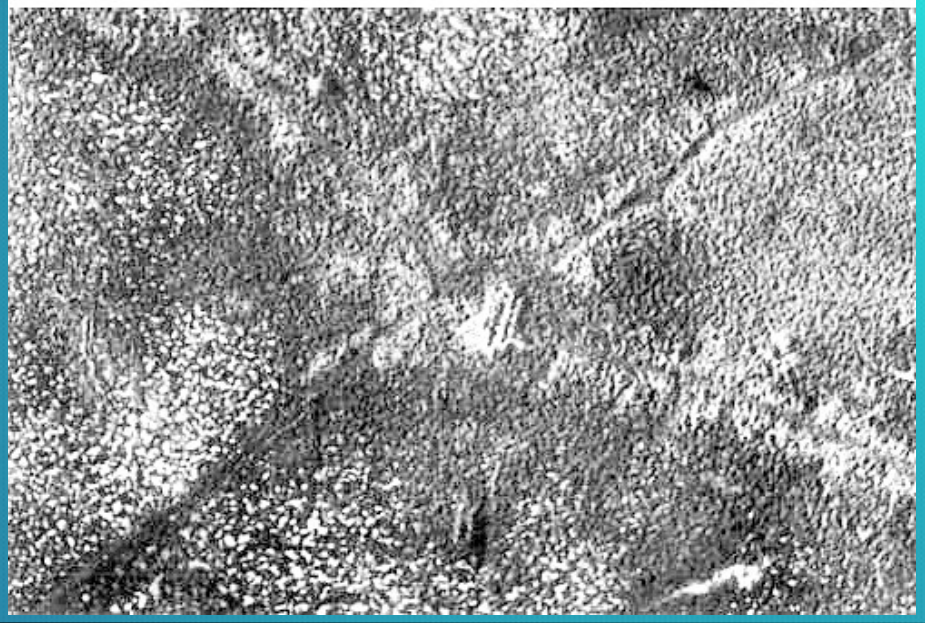
- Some perspective: a century ago, good advances, then – a war
- Today: statism and stasism, a misrepresentation of the Universe, and a lost future
- Space development moving further away, not nearer
- A sensible and ethical approach to revive Astronautics: the Space Option Concept
- Reality check – hosting the 21st century human population; one example: food
- Abundance of resources in near-Earth space
- The crucial importance of energy availability
- Power from space: qualities and cost factors (or excuses?)
- Suggestions for getting back out lost future
- A Choice of futures

SOME PERSPECTIVE: 1913

- 1913: The eve of a conflict such as to warrant the title of “World War” (WWI)
- A time of dynamic development, in science technology and economy
- Between 1898 and 1913, one records for instance the discover or identification of:
  - Polonium, Radium, Actinium; Neon, Krypton, Xenon, Radon; Europium, Lutetium
  - viruses, mitochondria; chromosomes, heredity laws;
  - adrenaline, trytophan, free radicals; coenzimes, hormones, vitamins
  - beta, gamma rays; radioactive decay, energy, decay series; atomic models; alpha particles; size of atoms; electron charge; cosmic rays; isotopes
  - theory of quanta; photoelectric effect; mass-energy equivalence; thermodynamics' third law; superconductivity; quantum states in atoms
  - Lorentz-Fitzgerald relationships; relativity theory; space-time
  - liquefaction of hydrogen, helium; Dewar obtains solid hydrogen
  - airships, radio, aircraft, astronautical studies; Haber-Bosch synthesis; Bakelite

after: I Asimov (1989)

WWI: THE WAR TO CHANGE HUMANITY



WWI: THE WAR TO CHANGE HUMANITY

- Then: one of the most absurd wars comes to truly change the future:
  - it directly killed millions of people and maimed more millions
  - it sped the demise of decaying and evolving empires, assisting the advent of dictators and totalitarian regimes that imprinted the evolution of the century
  - hundreds of millions were then cut down by their governments
- And yet:
  - in the 20th century, the world's population increased more than five-fold
  - awaited global famines did not come to pass
  - the overall wealth grew as never before
  - some optimistic moments occurred, although against persisting menaces
- What made this paradox reality?
  - a strong technical innovation, evident already before WWI
  - supported by abundant energy supplies

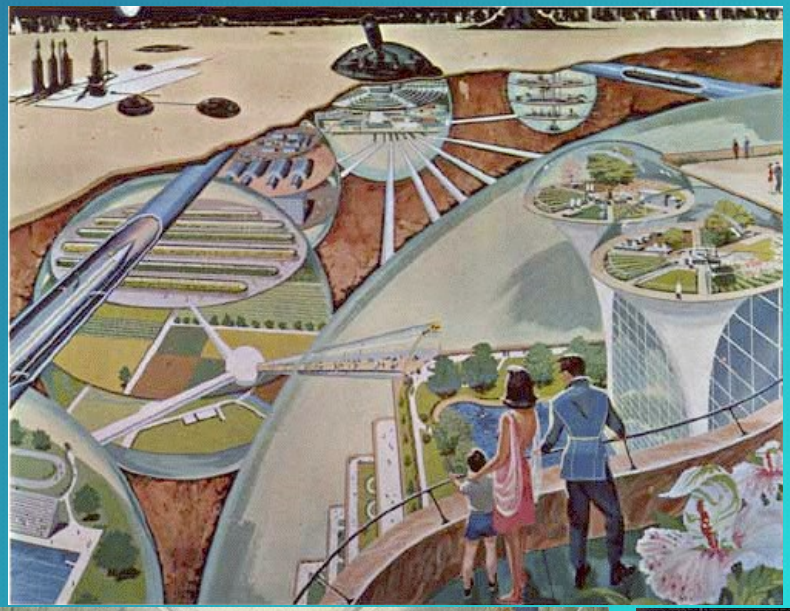
SOME PERSPECTIVE: 2013

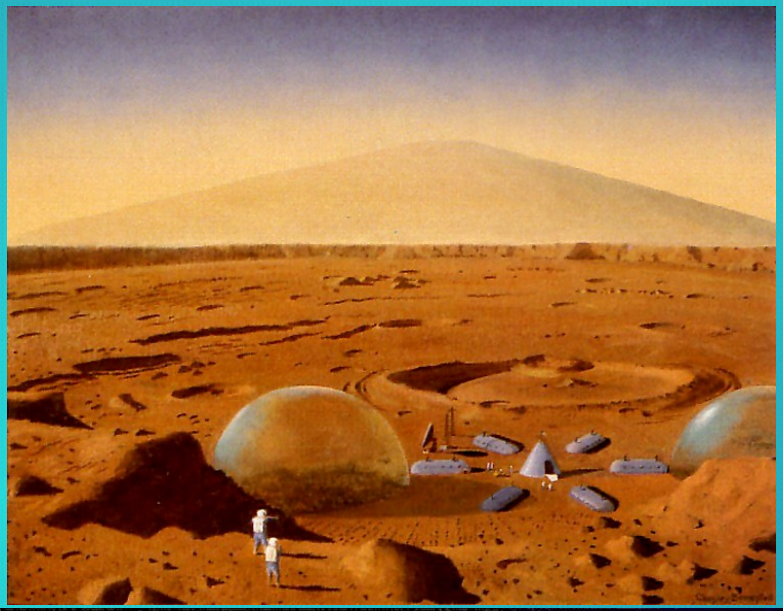
- Today, optimism has evaporated.
- Centralist and collectivist inspirations continue to rule the political proceedings
- Now, resource issues truly become increasingly serious
  - seemingly arguing in favour of politics which, however,
  - in reality only worsen the situation.
- The simple fact that the arena for human actions can reach beyond the terrestrial boundaries goes ignored.

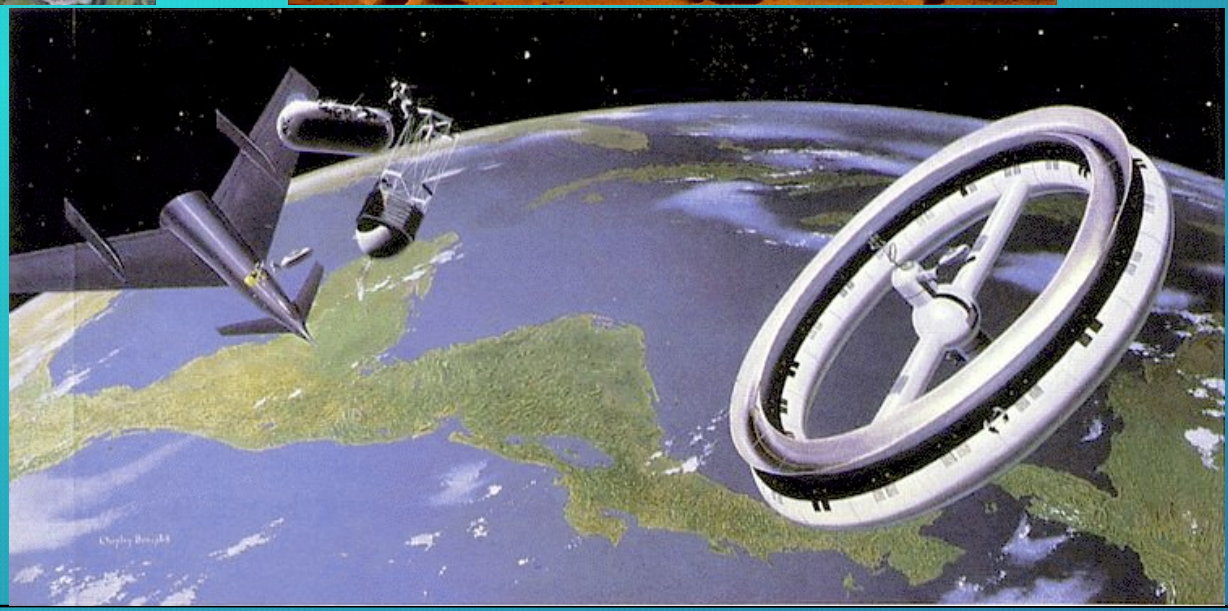
- One speaks of “our lost future” – or calls out...

WHERE IS MY FLYING CAR??

LOST FUTURE: SPACE DREAMS, FROM REALISTS







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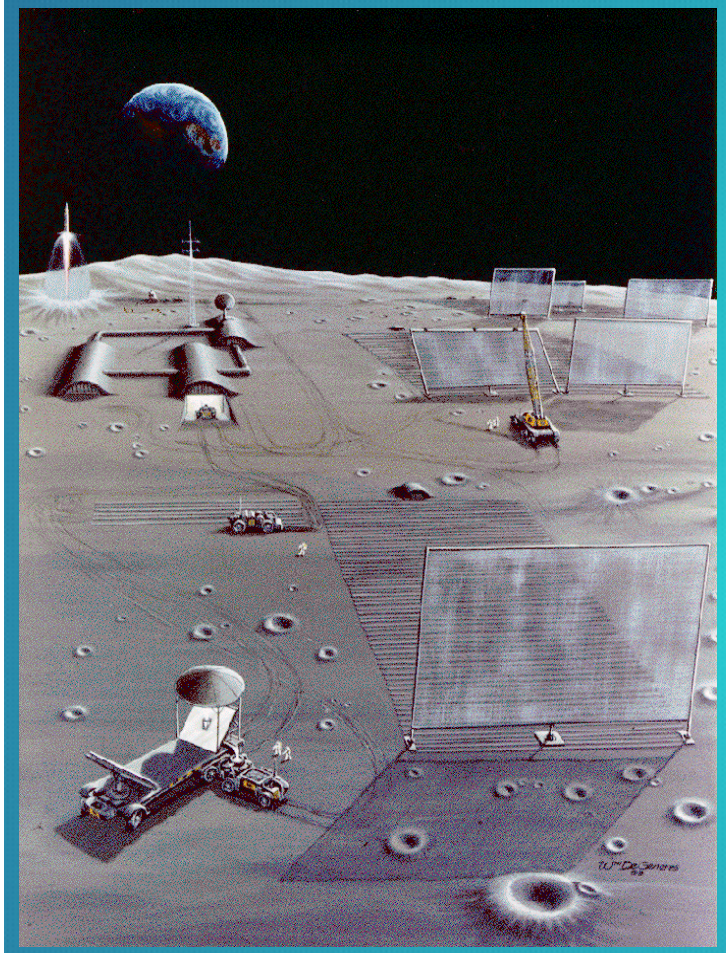
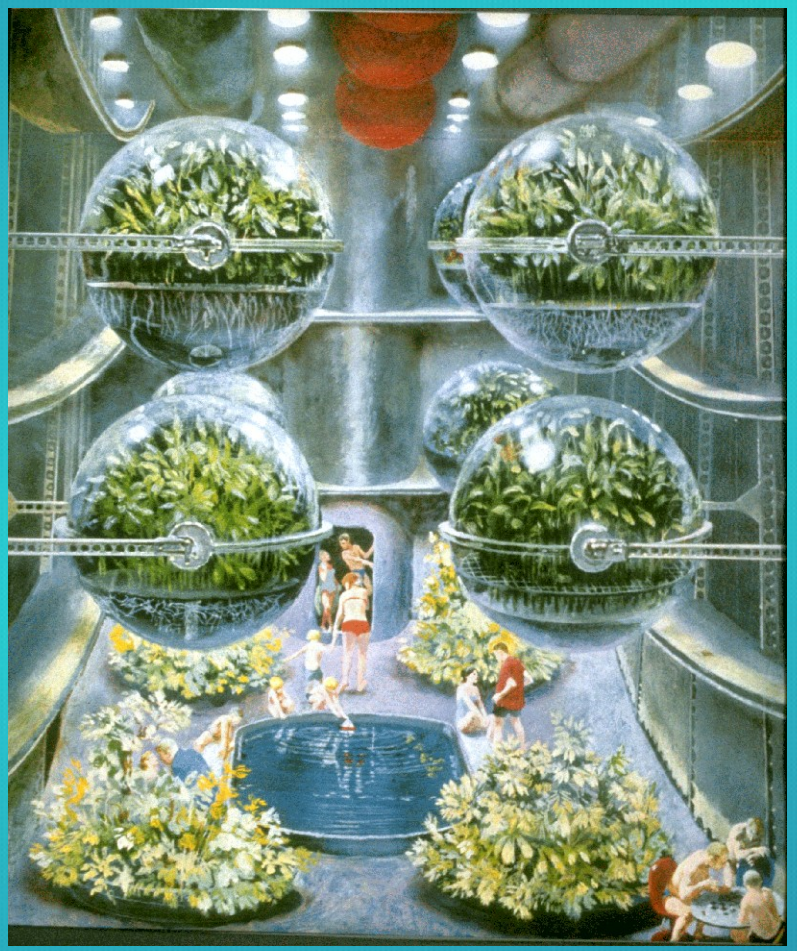
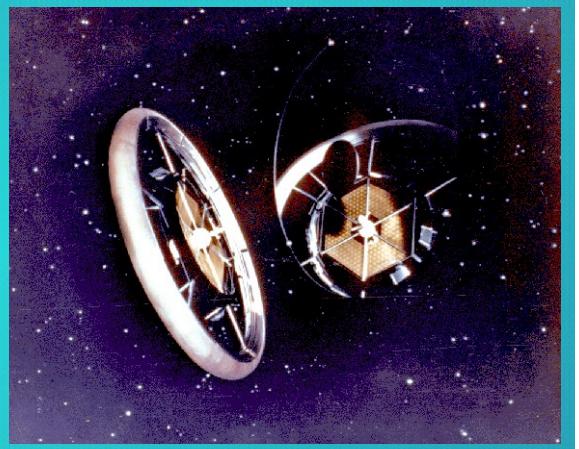
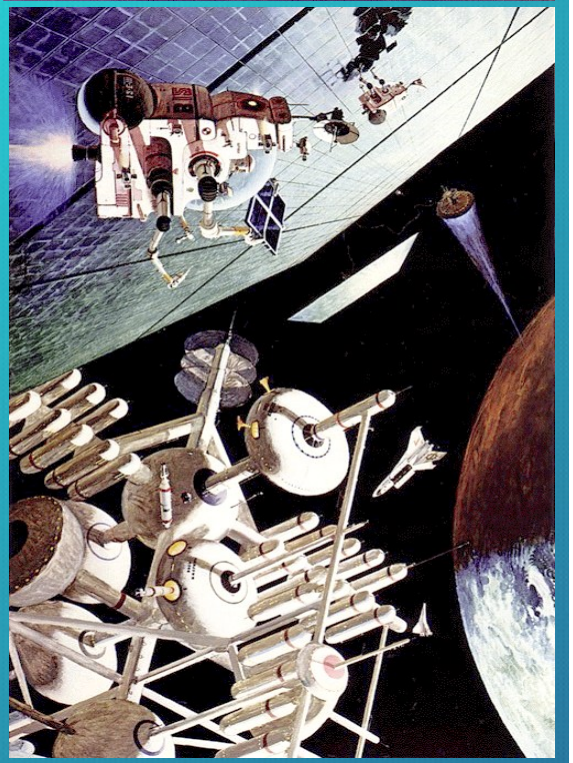






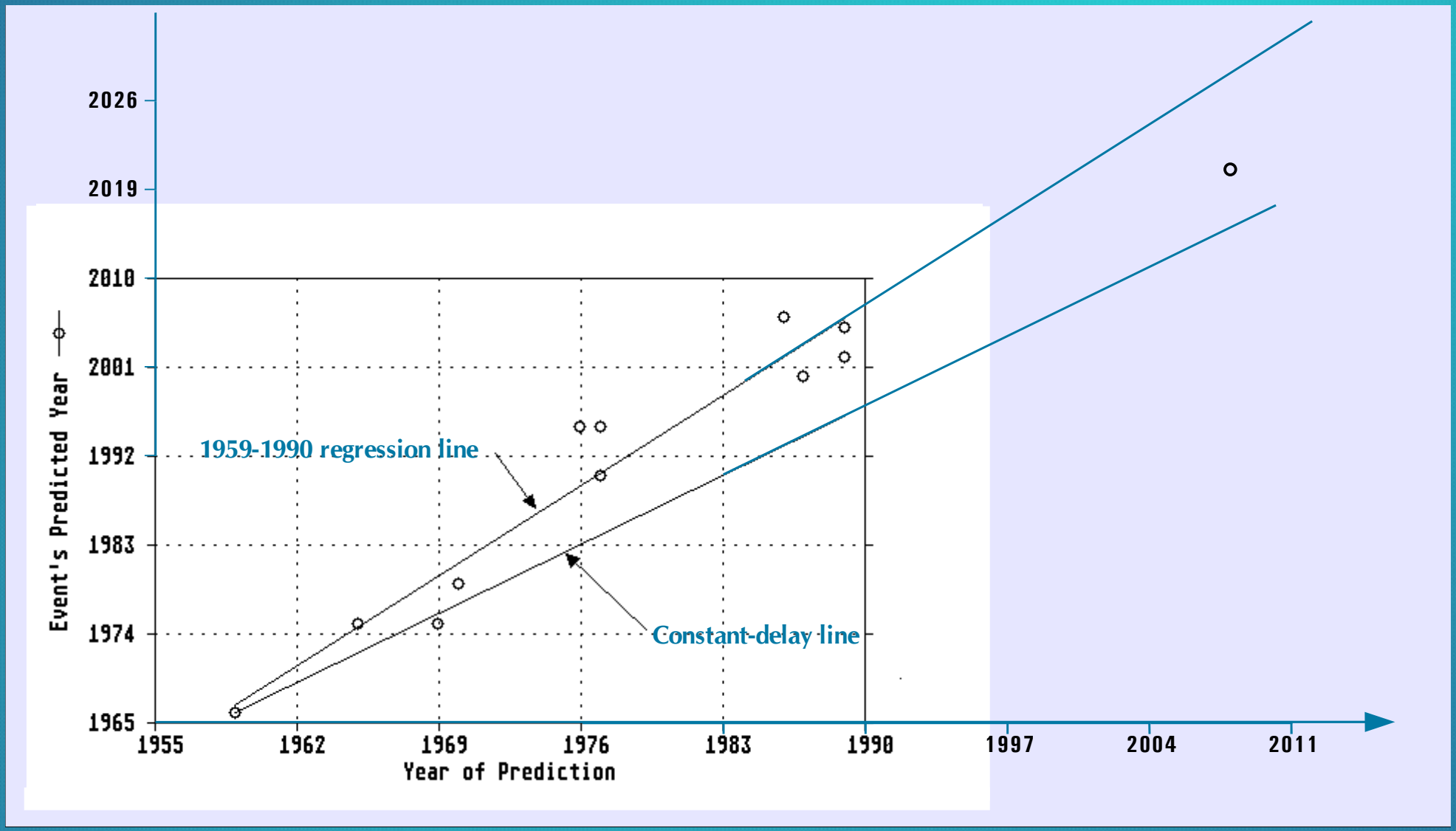


UNFULFILLED PAST PREDICTIONS

Activity	Predicted for	Event Delay	Double Delay	Realized Then?
Orbital operations complex	1972	+6 a	1978	No
Permanent Lunar Base	1982	+16a	1998	No
Orbital hospital	1985	+19 a	2004	No
Orbital manufacturing	1985	+19 a	2004	Probably Not
Space processing	1986	+6 a	1992	No
Lunar resources utilization	1987	+21 a	2008	No
Space NWD	1987	+7 a	1994	No
Lunetta	1987	+7 a	1994	No
Soletta	1993	+13 a	2006	No
Power from space	2001	+21 a	2022	??

compilation of Ehricke's projections -- from Bernasconi (1997)

TOWARDS, OR AWAY FROM, A LUNAR BASE?

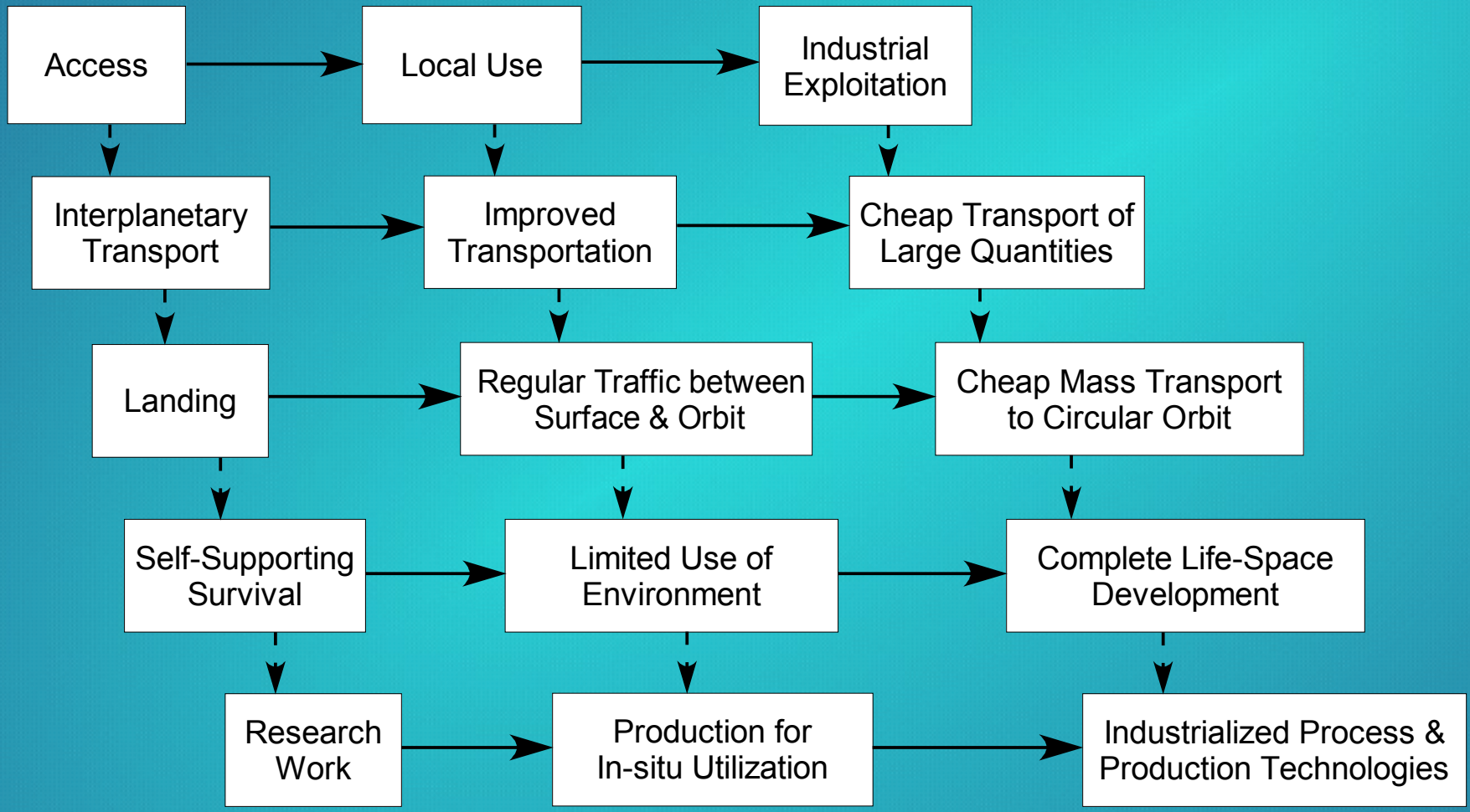


THE SPACE OPTION CONCEPT

"The end objectives of solar system exploration are [...] social objectives in the sense that they relate to, or are dictated by, present or future human needs [...] Thus, the payoff of solar system exploration involves both full understanding of our own planet's dynamics & the utilization of extraterrestrial resources. Scientific objectives are fundamental and important. But there is really no logical reason why solar system exploration should not be related to this greater perspective from the start."

Krafft A Ehricke (1970)

EVOLUTION OF ASTRONAUTICAL ACTIVITIES



after Ehricke (1976)

THE SPACE OPTION CONCEPT

- The strong decline of space activities into the 1990's seemed due to a separation between space programs and national agendas,
- The Space Option – i.e. the application of ***extraterrestrial resources,*** not for in-situ utilization (e.g., for exploration purposes), but through the import of space products to Earth, not in a sporadic manner, but ***to provide for a significant fraction of the needs for ground-based societies*** – emerged as the rational motive to continue and expand space activities
- Multiple connections between Space Option and societal fabric were identified:
  - aspiration to a humane future
  - need for economic development
  - creation of new wealth
  - wish for environment protection
  - quest for resources, in particular energy
  - assuring external and internal security
  - scientific and technological research

MATERIAL NEEDS: METABOLIC ENERGY

Use / Commodity	Net Global Need	Primary-Production Equivalent	Fraction of Global Production
Vegetable food	1.04 TW	2.08 TW	2.04%
Herbivore animal food	0.208 TW	2.60 TW	2.55%
Carnivore animal food	0.052 TW	5.91 TW	5.79%
Total	1.3 TW	10.59 TW	10.38%

Simplifications:

- 130 W/person (FAO recommendation; 11 MJ/d,
  - 80% from vegetables
  - 16% from herbivores (cattle, rabbits, ...)
  - 4% from carnivores/omnivores (fishes, pigs, ...)
- Modest estimation, assuming:
  - no losses, no waste, no spoilage
  - half of the gross production consumed (on all trophic planes)
  - efficiencies between trophic planes probably lower
  - (human corpses remain sequestered)
- Total equivalent power for 10 billion people: 1.3 TW

HOW HIGH THE MOON? THE RESOURCES OF SPACE

Parameter	Earth's Biosphere	Low Earth Orbit	Translunar Space	Geolunar Space	Solar System
Defining distance	10 km	1000 km	400,000 km	$1.5\ 10^6$ km	$6\ 10^9$ km
Volume [10^9 km^3]	5.1	594	$268\ 10^6$	$14.1\ 10^9$	$904\ 10^{18}$
Relative volume	1	116	$52.6\ 10^6$	$2.76\ 10^9$	$177\ 10^{18}$
Solar power flow [TW]	12,800	59,145	$688\ 10^6$	$9.68\ 10^9$	$96.8\ 10^{12}$
Relative Power	1	4.62	53,750	756,250	$7.56\ 10^9$
Matter [10^9 t]	388	~0	7,361,550	~8,000,000	$>2\ 10^{15}$
Rel. Matter Amount	1	0	18,973	~20,000	$>5\ 10^{12}$
Category	Present Arena & Future Living Space	Partly in Use	Accessed Arena	Accessible Arena	Future Human Arena

The abundant power and material resources available within the space accessible with current technology suffices even beyond the immediate time horizon. The Space Option offers enduring resource availability, with the best conditions for human and environmental safety.

WHY IS ENERGY IMPORTANT?

- All life forms exist thanks to metabolic energy processing; all cultural societies need industrial (or exosomatic) energy to survive, develop, prosper
- Otherwise than with all materials, one cannot recycle energy, but requires a continuous input thereof (2nd Law of Thermodynamics)
- Human societies have required control over increasing specific power levels as they grew (Fritsch, 1971)
- Energy input is the most important factor for wealth generation (Kümmel, 1985)
- Its input is needed for growing crops (Smil, 1990)

Society	Population Density persons/km²	Power Use kW/perso
Hunter-Gatherers	2.5	0.1
Agrarian	25	1
Industrial	250	10
"Post-industrial"	>500	??

Society	Energy Input [GJ/ha]	Food Harvest [GJ/ha]	Population Density [person/km2]	Power [W/person]
Foraging	.001	.005	0.01	320
Pastoralism	.01	.04	1	32
Shifting agriculture	1	17	42	77
Traditional farming	1.3	23	545	8
Modern agriculture	33	65	1550	68

WHICH ENERGY SOURCE CAN WE TAP IN FUTURE?

- In trying to identify future energy sources in a rational ways, one evaluates candidate approaches by a number of criteria:
  - ability to provide the necessary power levels at least during several decades
  - achieve a high energy pay-back ratio (esp important for the build-up period)
  - low emission of chemical pollutants, small alterations of atmospheric conditions
  - low thermal burden, i.e. the total release into the biosphere of additional heat (e.g. total heat of a considered reaction, increased solar absorption consequent to albedo alterations, ...)
  - as small a human risk as possible – e.g. in terms of life losses per TWh produced
- Under due consideration of these criteria, power from space (PFS) appears as the best among the viable options

ECONOMIC CONSIDERATIONS

- BUT: isn't the Space Option “simply too expensive!”?
- Governments, on the cost side, do not have any acceptable excuse for not acting
- The Lunar Power System was defined for supplying power on a global level
  - Criswell & Waldron (1991) estimated the initial investments (from R&D to start of operations) at $600 billion – say, today, $1 trillion
  - A large amount, but a true investment, creating a revenue stream (for the full system) of $14 trillion/year.
- Meanwhile:
  - Recently, ***both*** current US and Eurozone regimes spent ~$1 trillion for systemic rescues and associated stimuli.
  - The estimated costs for switching to renewable power generation methods in Germany alone reach into the €1 trillion range
  - Those moneys would have paid for LPS development ***three times over!***
- Political systems ought to help improving – not worsening, e.g., by limiting power supplies and growth opportunities – the people's future.

GETTING BACK OUR LOST FUTURE

- The motivation for space activities has to change:
  - from supporting states and some limited science / exploration work,
  - to an effort at bettering the people's survival & living conditions (Ehricke, 1970)
- Only through ample access to space for private civilian actions can humanity roll back current limits
- To unfold, Astronautics needs a context abiding by the fundamental moral rights
  - make ready technical means, open and secure communication technologies, to support the people's education about, and application of, said moral rights
- Some guidelines for actual projects:
  - build on private – not statist – initiatives
  - adopt a multilateral, open-source analogous, entrepreneurial environment
  - make use of the bootstrapping principle
- Technology appears available in abundance

AN OPTIMISTIC SAMPLE STRATEGY

- Beginning when he was 20-year old, Wernher von Braun invested 37 years of his life to enable other individuals to land on the Moon
- That called for some resources, today ~$100 billions – say, 1 million man-years
- The technology developed by all those people is available – in many libraries' cellars
- Independently, in the past 44 years (!), some progress occurred – e.g. in materials, manufacturing, medicine, and ***especially*** in computation means
- Actual experience on the space environment allows estimates to replace old guesses
- Means exist for multilateral, individual, remote collaboration…

…

- One million 20-year-old students may not reach the Moon after a year of work, but…
- What could… 25,000 people achieve after four years, with contemporary tools?

Go out and start building your small single-stage spacecraft!

A CHOICE OF FUTURES

"... what country can preserve its liberties if its rulers are not warned from time to time that their people preserve the spirit of resistance? Let them take arms. The remedy is to set them right as to facts, pardon & pacify them... The tree of liberty must be refreshed from time to time with the blood of patriots and tyrants."

Thomas Jefferson (1787)

"Any system is only as viable as its ability to constrain and resolve the conflicts it engenders. Larger systems generate larger conflicts and require internal flexibility. This flexibility is provided by growth in distance between components... [This,] perhaps, is the greatest promise of space: If entered, it can always be a home. It is too large to ever be turned into a prison."

Krafft A Ehricke (1975)

Go to:

thespaceoption.com

for papers on the Space Option Concept,
this presentation's slides, and more astronautical facts.

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