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TANSTAAFL!

or

How to Colonize Space in Seven Easy Steps

Marco C Bernasconi
MCB Consultants
8953 Dietikon, Switzerland
mcb@ieee.org

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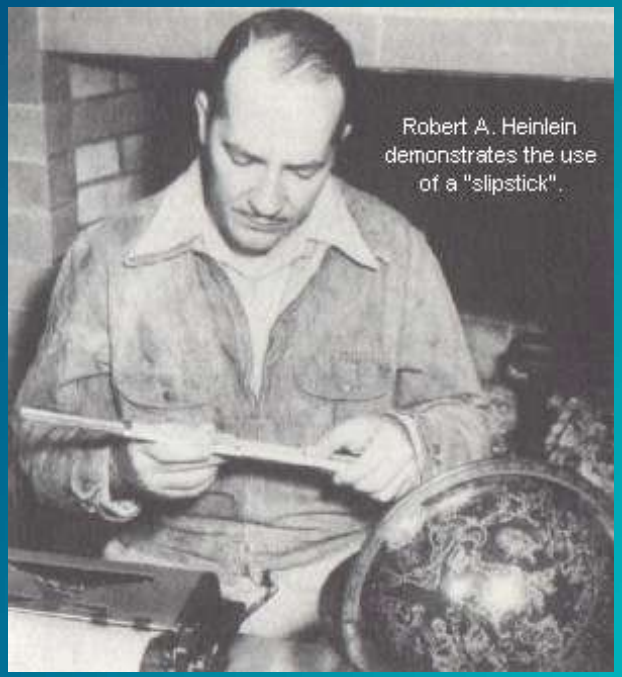
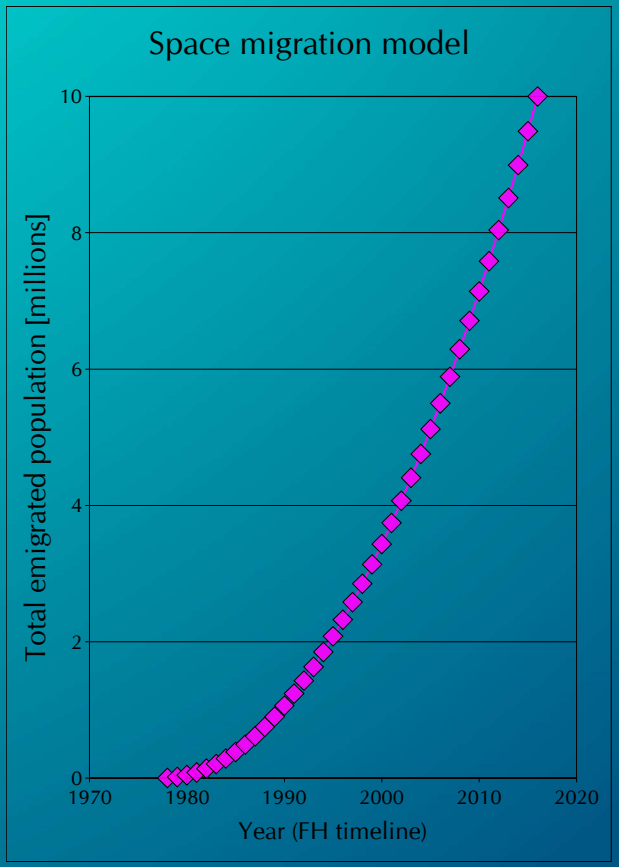
OUTLINE

- A look at astronautical history
  - from the Forties
  - from the Fifties
  - from the Sixties
- A summary of technicalities & scenarios
- Dr von Braun, meet Dr Faust
- Seven simple steps!
- Conclusions

Astronautical Development from the Forties
Robert A Heinlein's Future History



Event	Year
Douglas-Martin sun-power screens	1961
Mechanized roads	1964
Commercial rocket travel	1967
Transatlantic rocket flight	1969
Antipodes rocket service	1977
First rocket to the Moon	1978
Interplanetary travel	1983
Death of Delos D Harriman	1996
Bacteriophage	1998
Limited use of telepathy	2010
Interplanetary travel ceased	2016
Synthetic foods	2066
Weather control	2072
Interplanetary travel resumed	2072



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Future History: Companies, motives

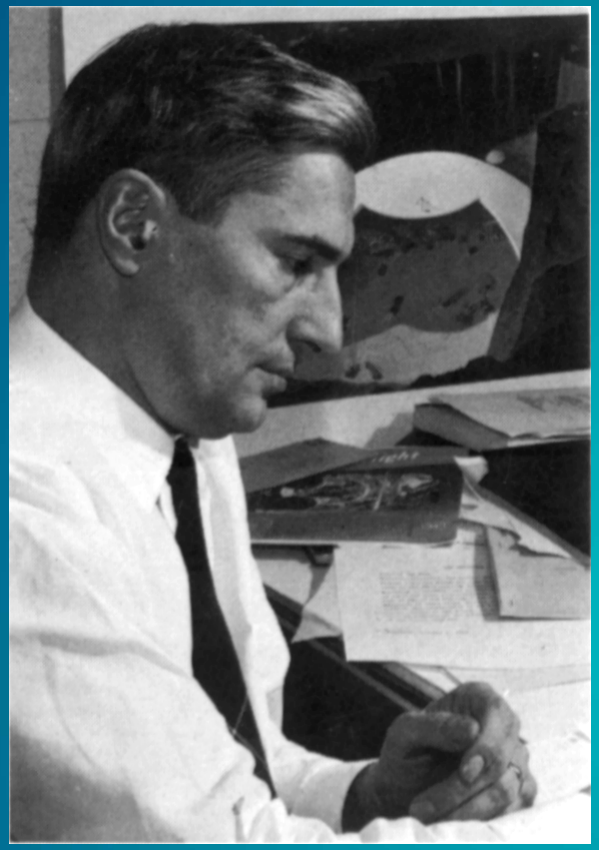
Activity	Firms	Ownership	Location
Communications	2	Various	All planets
Peacekeeping service organization	1	Government	All planets
Youth work agency	1	Government	All planets
Engineering, Building,Space development	4	Private	All planets, free space
Library	1	Private?	Luna
Banking; Financial services	4	Private?	Luna
Retail market	1	Private?	Luna
Safety patrol	1	Private?	Luna
Cosmetic treatments	1	Private	Luna
Hotel	1	Private	Luna
Issuer of gold-backed currency	1	Private	Luna
Mining	2	Private	Luna
Newspaper	1	Private	Luna
Recreation services	2	Private	Luna
Residents administrative association	1	Private	Luna
Lunar penal colonies administration	1	Government	Luna
Scientific research	4	Various	Luna, Terra
Space transportation, Interplanetary travel	8	Private?	Luna, Terra
Technology research	3	Private?	Luna, Terra
Aerospace systems; orbital builders	2	Private	Terra
Space port, Launch sites development?	2	Private	Terra
Video entertainment production	2	Private	Terra
office	2	Government	Terra
Meteorological observation	1	Government	Terra
Recruiting services	1	Private?	Terra?
Space-service training center	1	Government	Terra?

Motives: to live and work, e.g. in:

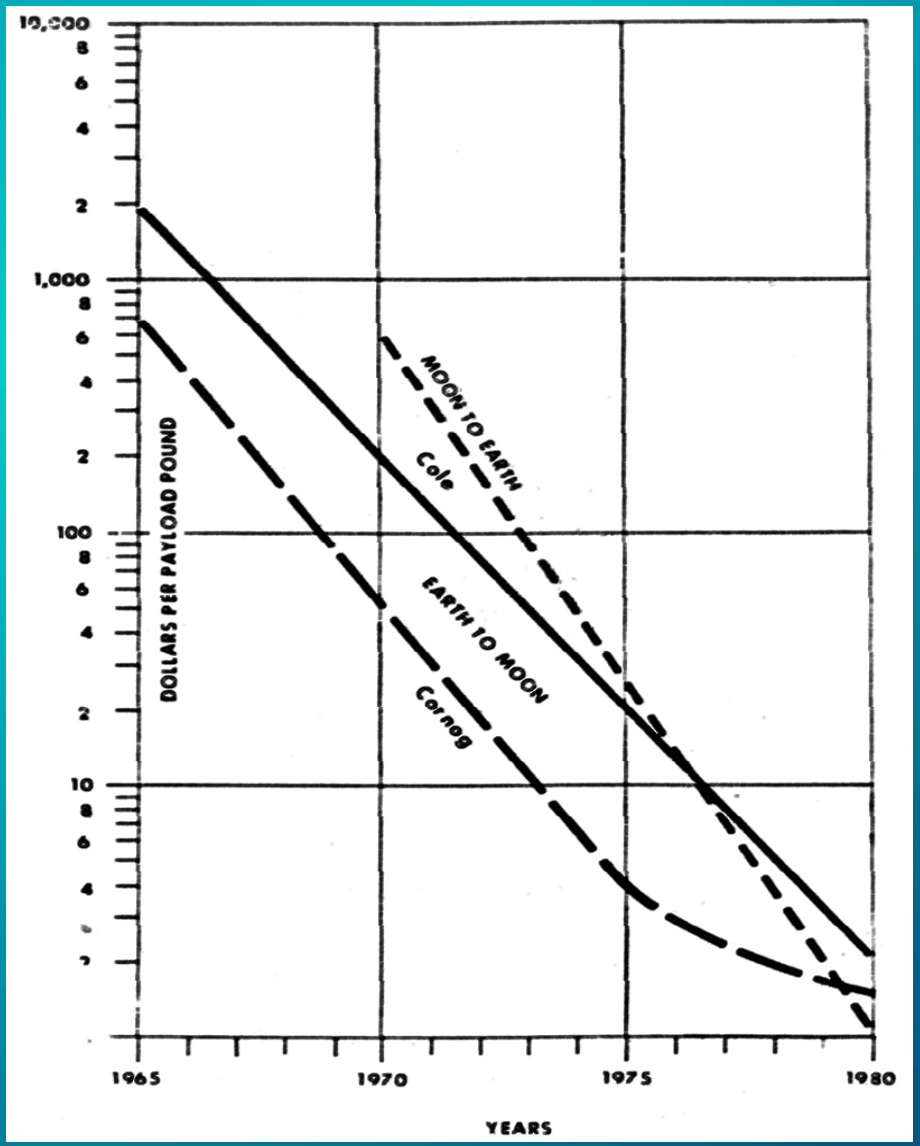
- public service
- scientific research
- technology development & engineering
- construction (civil, mechanical, electrical)
- financial & administrative services
- hospitality & retail activities
- information workers & journalism
- military & civilian peacekeeping
- mining
- information technology
- health[#] & cosmetic services
- food production[#] & preparation
- transportation

[[#] not explicitly mentioned]

Astronautical Development from the Fifties
Dandridge M Cole's Islands in Space

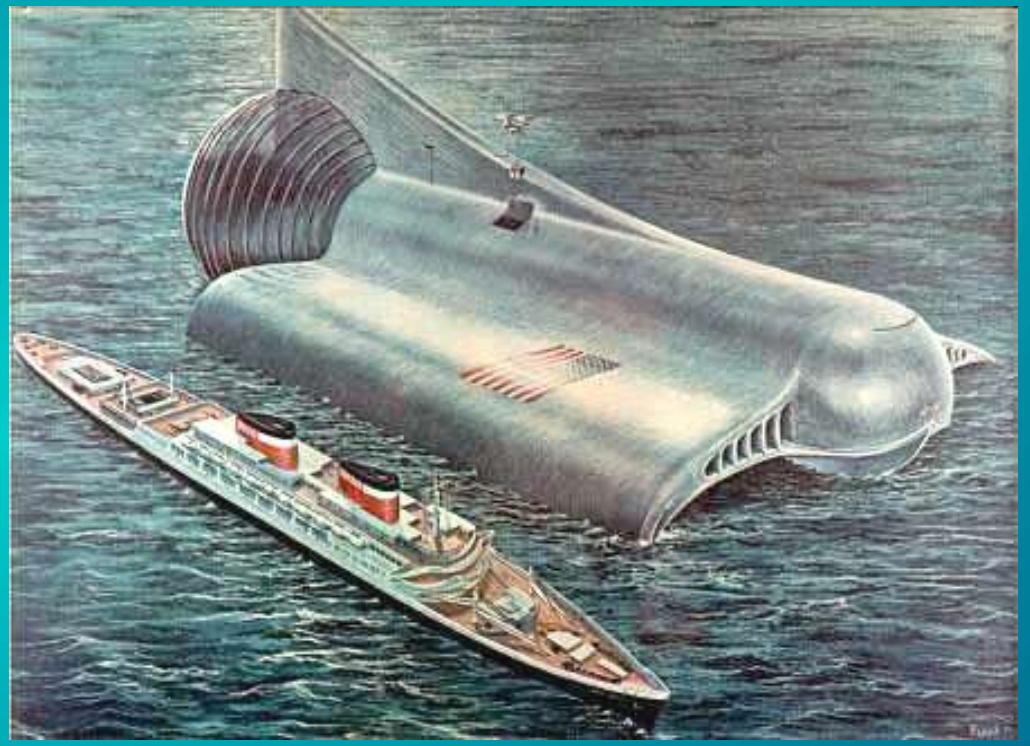


Projected evolution of
lunar transportation costs



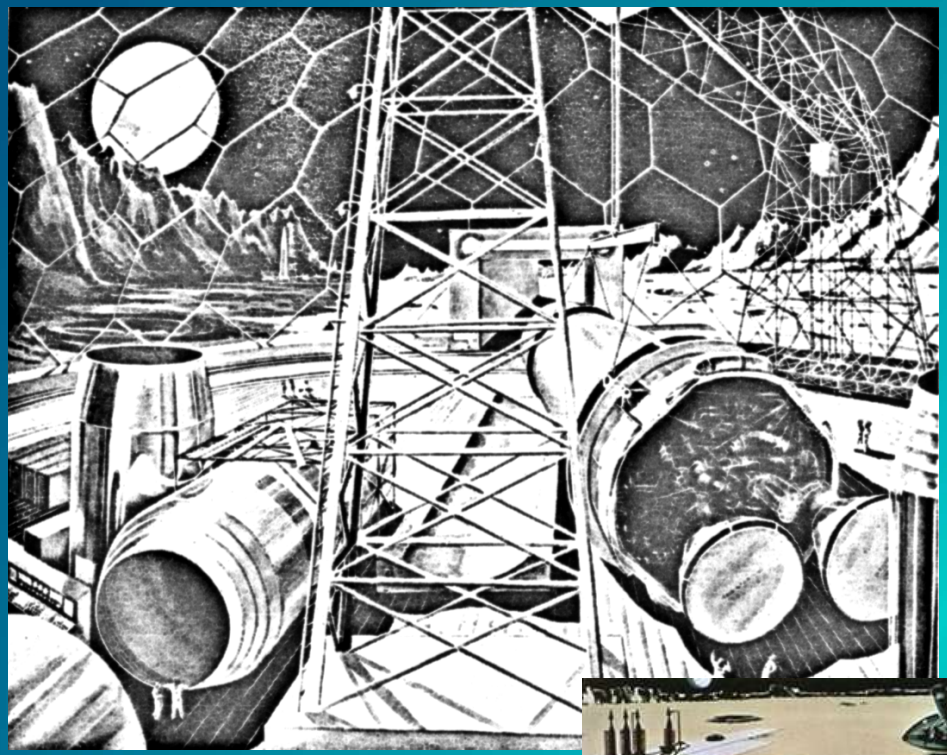
Dandridge M Cole: Commercial Transportation

A single stage “aerospace” plane combining a cluster of ramjet engines and a single nuclear engine



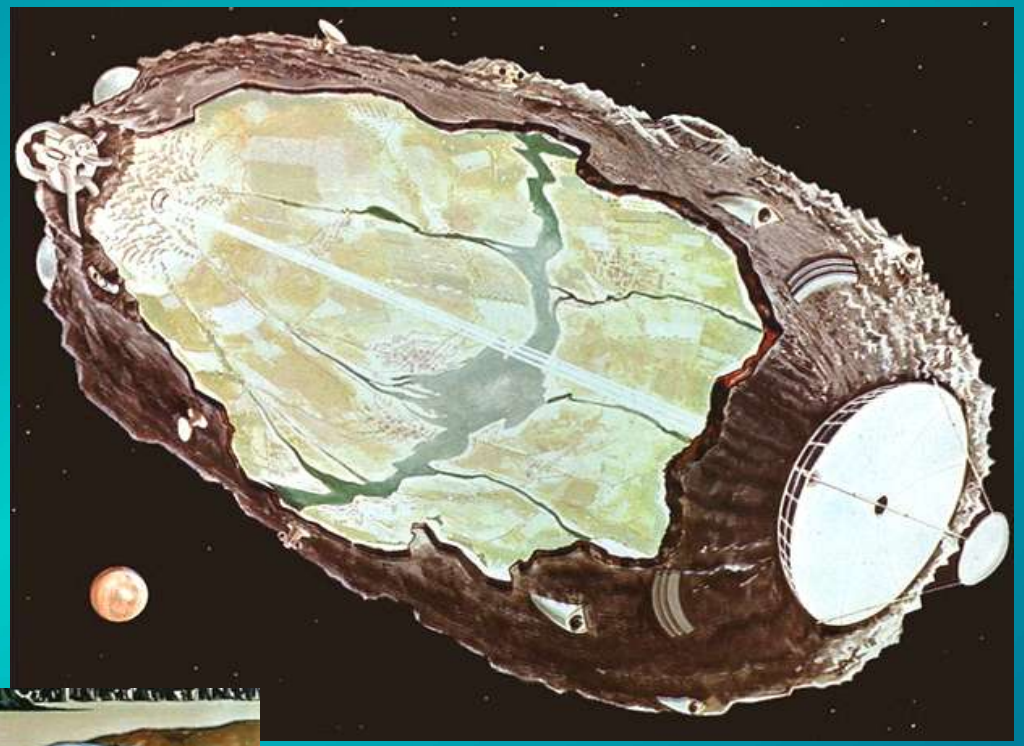
Aldebaran: A conceptual 50,000-ton space ship employing advanced nuclear propulsion

Dandridge M Cole: Extraterrestrial Colonies



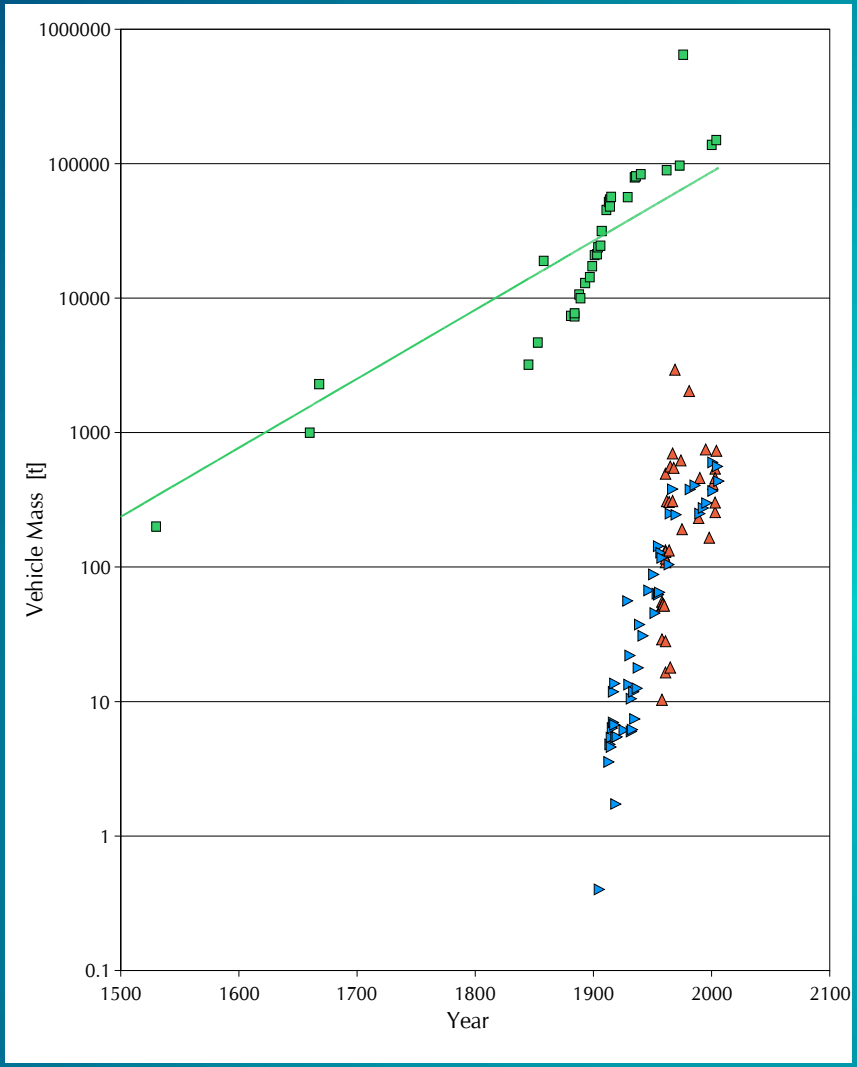
Lunar space terminal

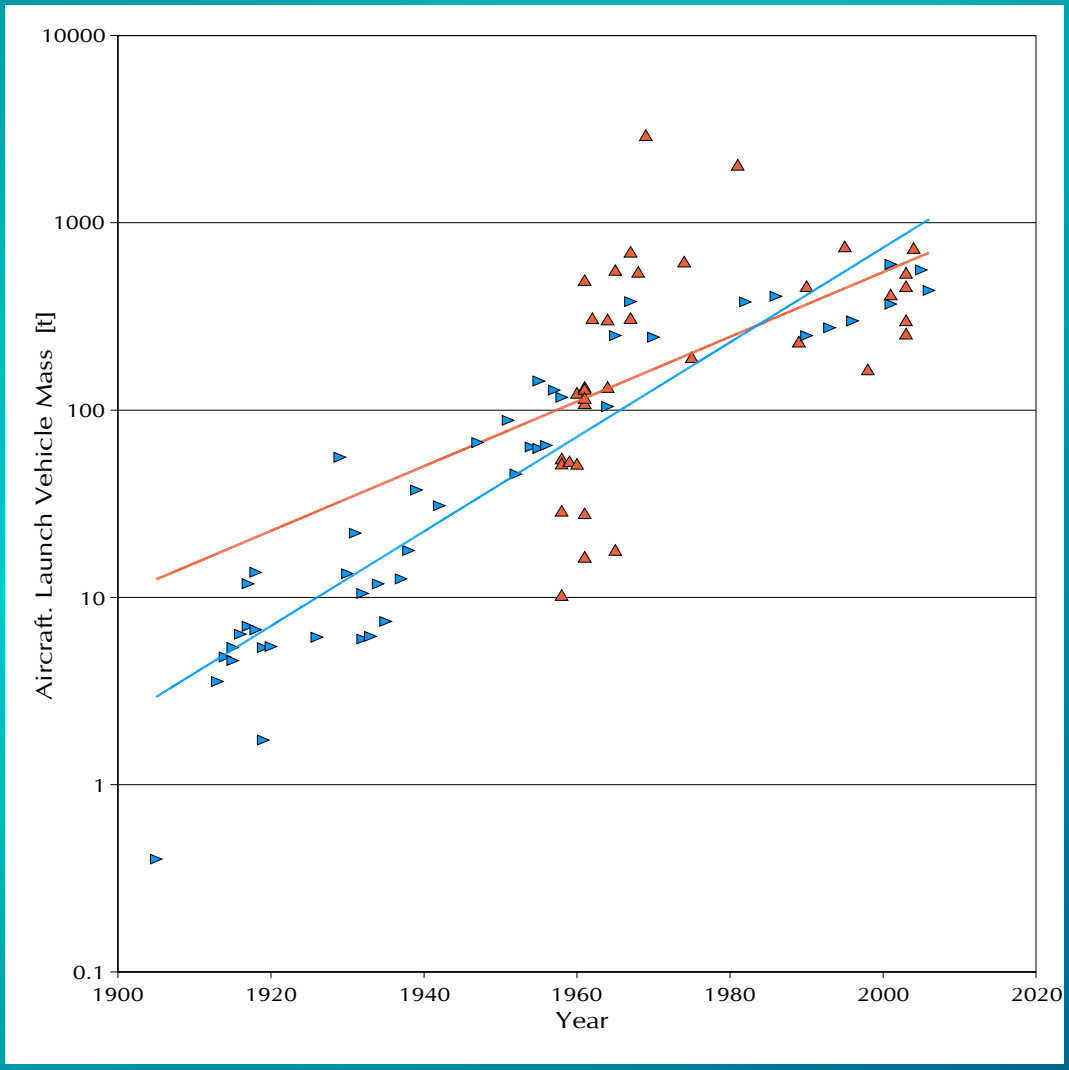
A Moon colony



A cutaway of a hollowed-out asteroid colony: artificial gravity results from a spin about the long axis, light and heat are provided by sunlight reflected down the long axis from a large mirror

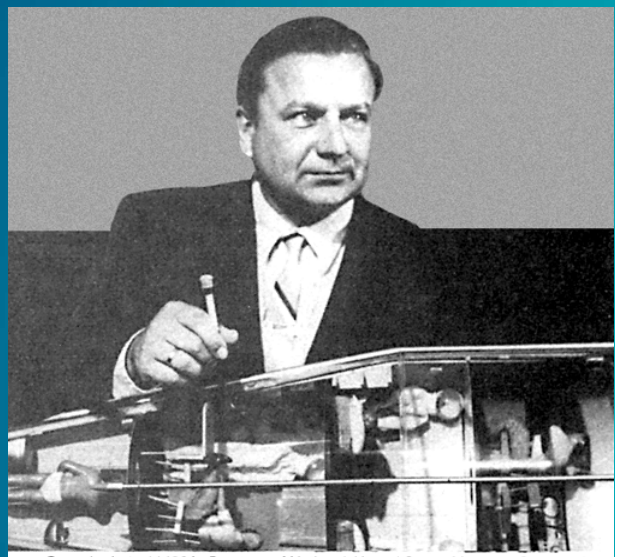
EVOLUTION OF THE TONNAGE OF TRANSPORT VEHICLES





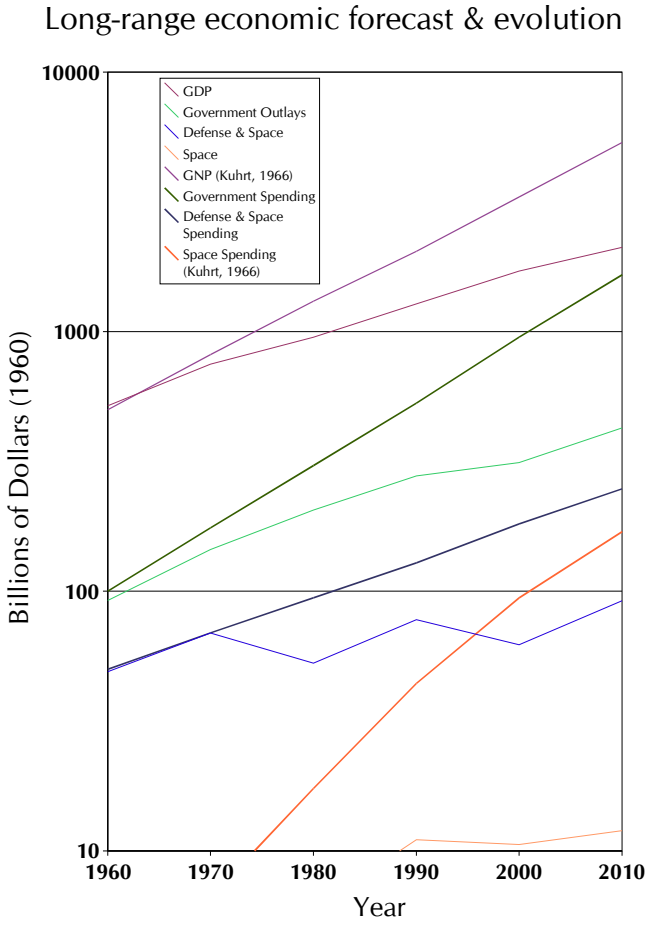
Historical trends in the gross tonnage of transport vehicles -- on sea (green squares), in the air (blue triangles), and to space (red triangles): ships and airplanes follow long-term exponential trends

Astronautical Development from the Sixties
Krafft A Ehricke's Geolunar Space



Convair photo 11403A, Courtesy of National Air and Space Museum, Smithsonian Institution, 84-10330

In 1958 during testimony before Congress, Krafft Ehricke and Arthur Kantrowitz presented a proposal to use the Atlas ICBM as a four man space station. Ehricke is shown here with a model of the concept.



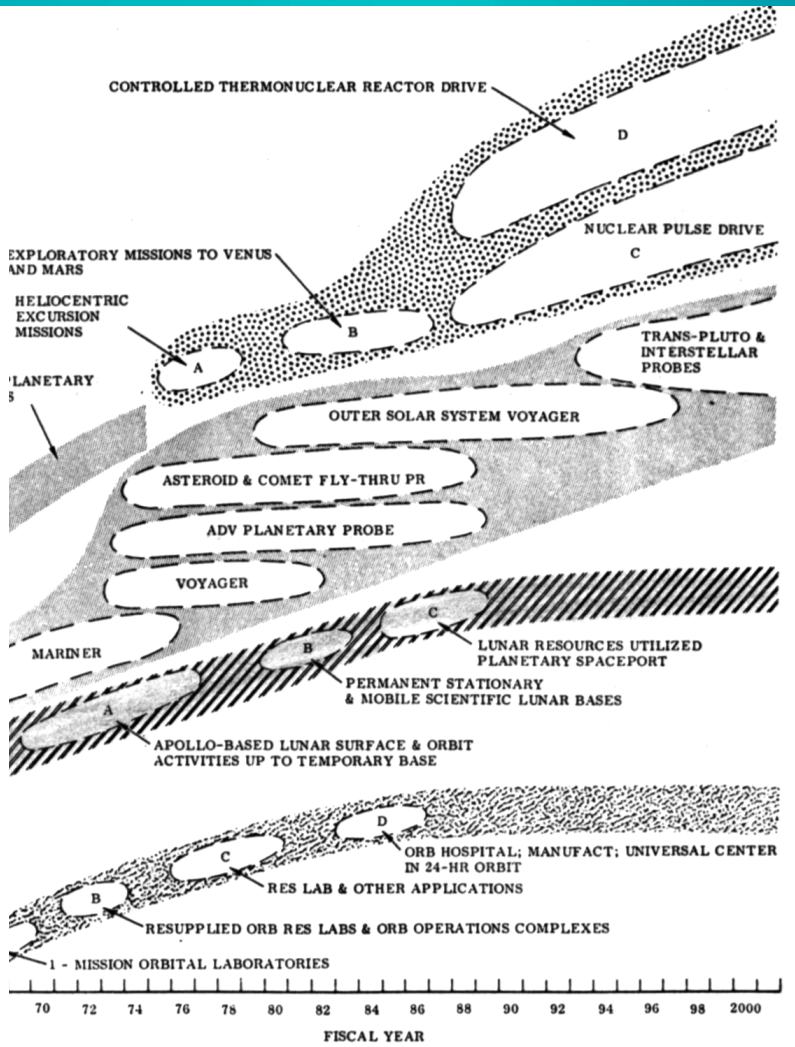
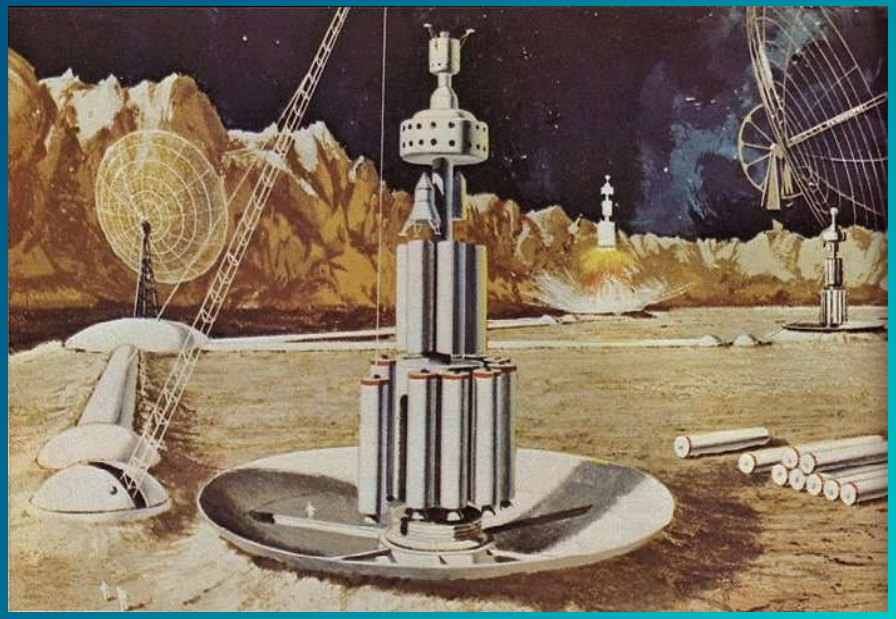
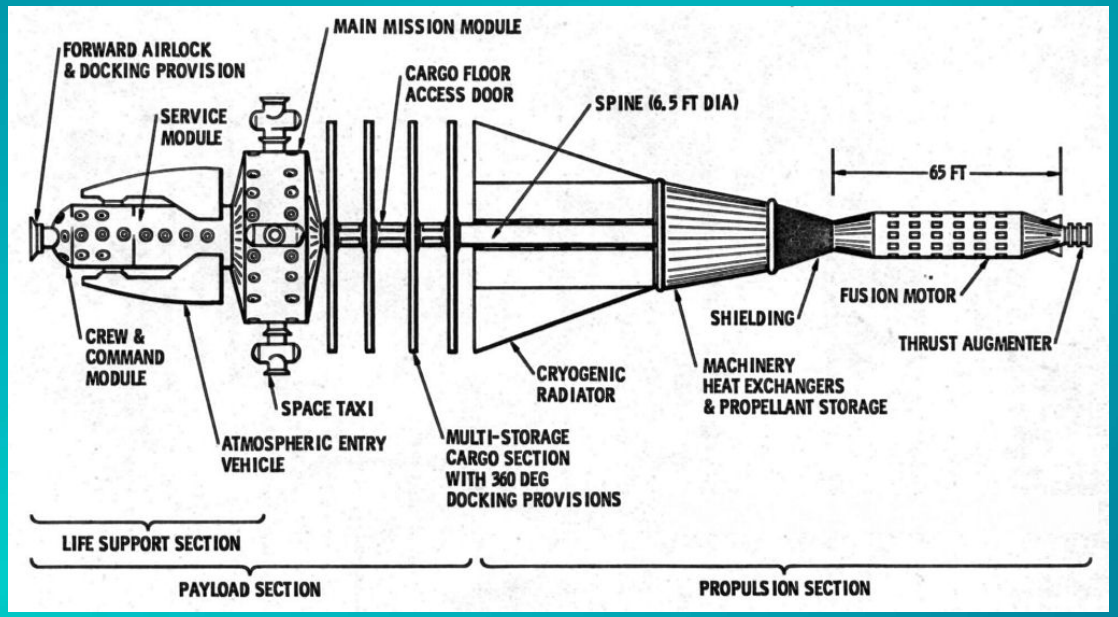


Figure 29. Evolution of Space Flight to F.Y. 2001 - Overview

Krafft A Ehricke: Solar System Transportation

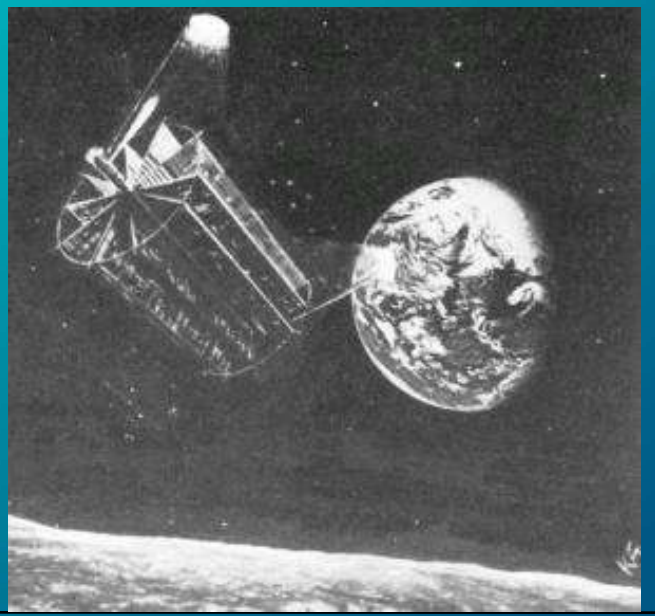


NP interplanetary vehicles at the lunar spaceport in 1988: spacecraft are launched by solid propellant lift-off rockets side-mounted around the lower cylindrical section; the large antenna in background belongs to the lunar deep space network.

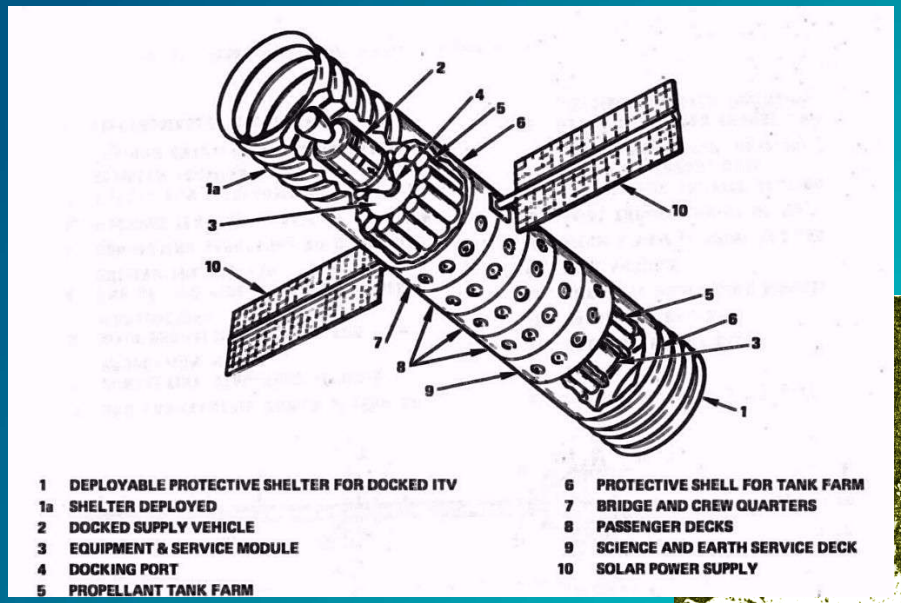


Controlled Thermonuclear Reactor Vehicle Concept, 100-MW thrust power

The Androcell large-habitat concept could also travel the outer solar system



Krafft A Ehricke: Geolunar Transportation

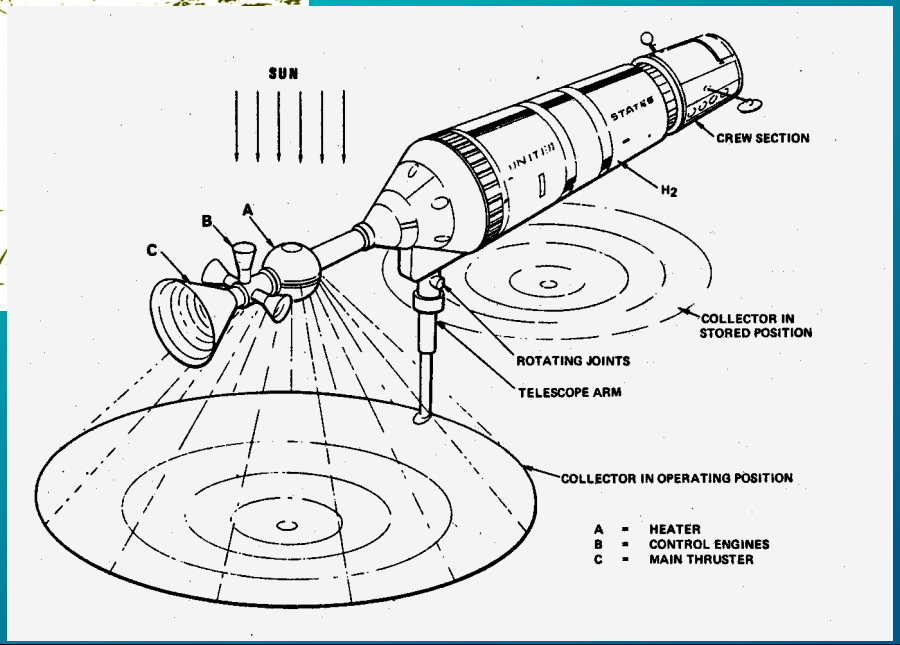


Solar Heat Exchanger (SHE) propulsion achieves specific impulse values comparable to solid-core nuclear systems

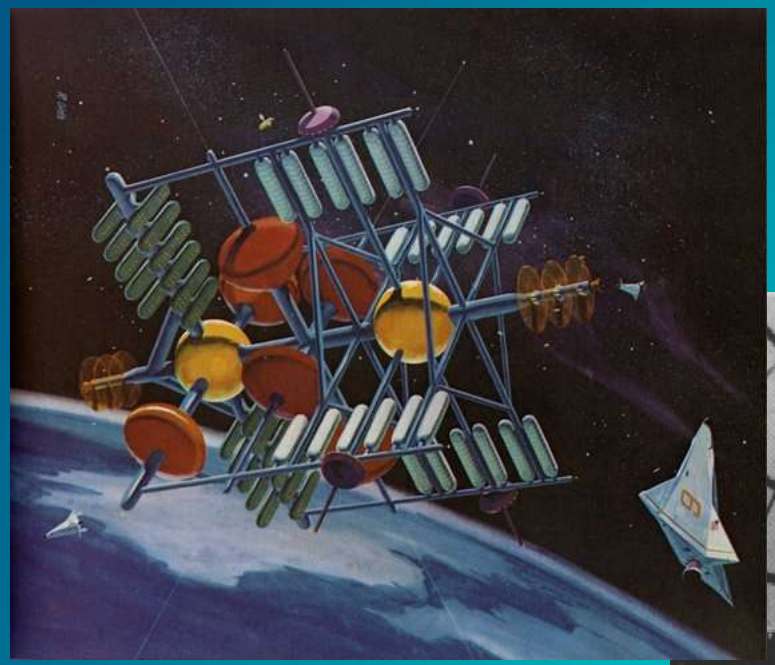
The cycling Cislunar Swing Station improves the economy of traveling to & from the Moon


LUNAR SLIDE LANDER WITH VERTICALLY DEFLECTING BRAKES - OCEANUS PROCELLARUM AT SUNRISE

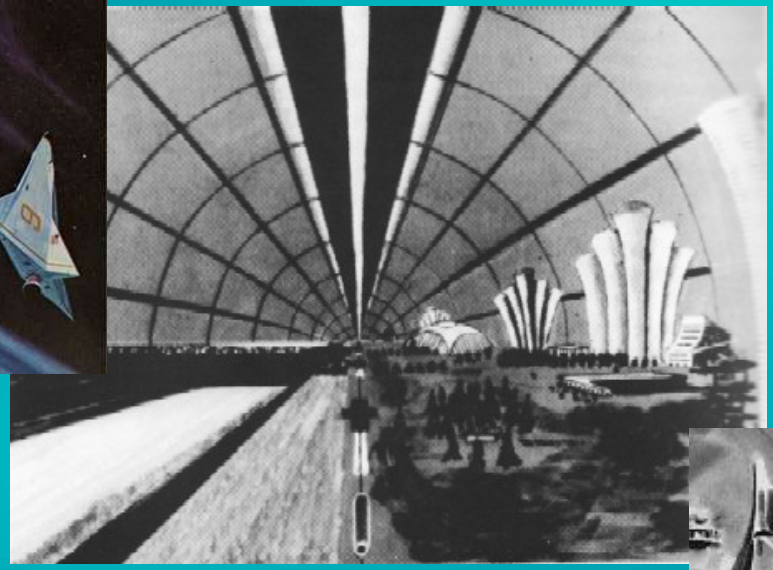
Lunar Slide Landers carry traffic to the Moon surface with little propellants expenditure



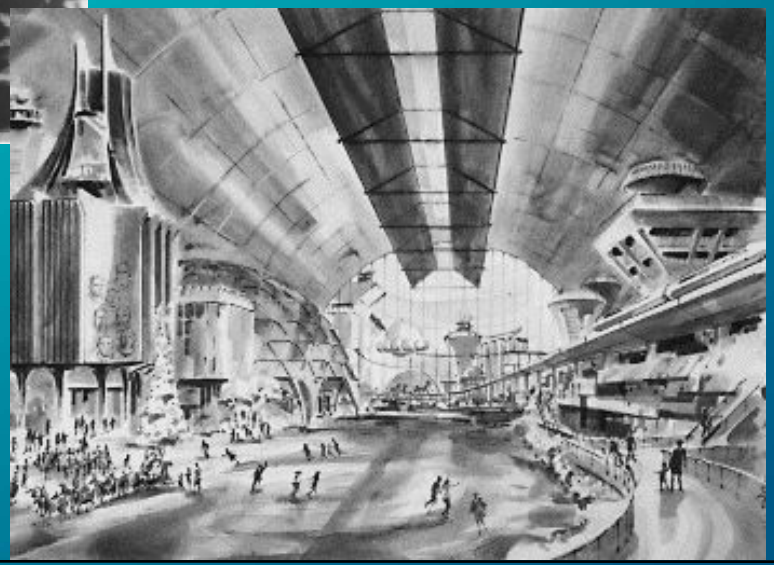
Krafft A Ehricke: Habitation



The Astropolis orbital complex can serve as a resort -- or as the seed for a settlement



Selenopolis explifies the underground cities of lunar colonization



TECHNOLOGY OPTIONS DISCUSSED - 1

Item	RAH (Future History)	DMC (various publications)	KAE (various publications)
Infrastructural architecture	Earth-to-orbit transport orbital stations cislunar transport (w/ & w/o direct descent) lunar- or lagrange-orbit stations lunar base and colonies ...	- -	Earth Launch Vehicle (ELV, ESV) Small orbital research laboratories (SORL) Earth Entry Module (EEM) Reusable orbital transport (ROT) Swing stations; unconventional lunar landing modes...
Earth-to-orbit transport	Chemical and nuclear	Chemical and nuclear	Earth Launch Vehicle (ELV – chemical) Reusable orbital transport (ROT) (personnel); HLLV (cargo)
Orbital stations	Artificial gravity, toroidal?	?	Small & Large orbital research laboratories (SORL & LORL) orbital operations complex (OOC, NES, GSS) Orbit Launch Preparation Modules (OLPM)
Earth to Moon transfer	Nuclear ferries included	Direct nuclear ferries, as well	Swing stations (CSS), Interstation Transfer Vehicles (ITVs), Moon Shuttle Vehicle (MSV), Nuclear Space Transport (NST)
Lunar surface transport	Underground tubes, rolligon vehicles	- -	Ballistic transportation
Moon to space transport	Electromagnetic launchers	- -	Electromagnetic launchers, enclosed chemical launch facilities
Lunar colonies	Underground	Largely underground, with surfacing domes; maintenance depots	LOS (supply depot & more); Lunar Deep Space Communication Network; Underground;
Interplanetary travel	Slow transfer, artificial gravity, nuclear power	Internal nuclear pulse propulsion	Solar-thermal propulsion, solid-core reactor; external nuclear pulse (NP) drive; nuclear electric (NE) drive; controlled thermonuclear reactor (CTR)
Further colonies	Mainly planetary	Mars, reconstructed asteroids	Astropolis -- individual services in space,for therapeutic and recreational purposes; Androcell

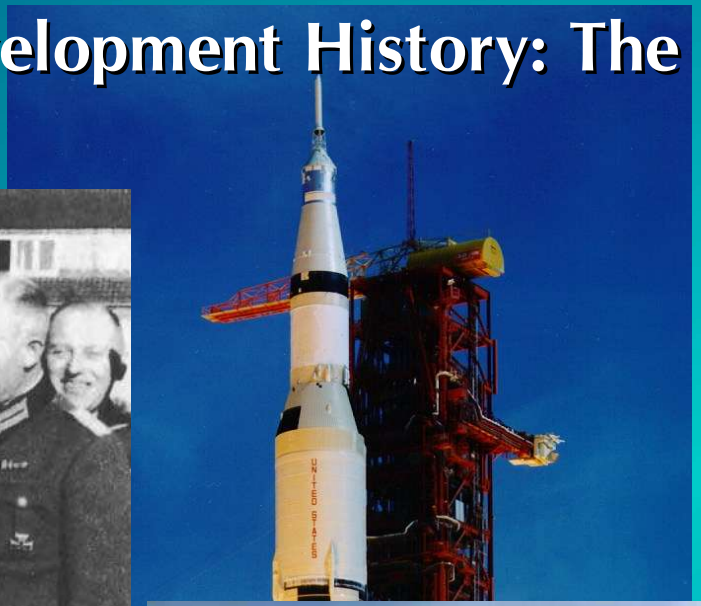
TECHNOLOGY OPTIONS DISCUSSED - end

Item	RAH (Future History)	DMC (various publications)	KAE (various publications)
Propulsion	Largely nuclear based	Solid-core nuclear, gas-core reactor, nuclear-pulse rocket, fusion systems	Chemical; Solar heat exchanger; Nuclear solid core reactor: Nuclear electric (MHD generator) Nuclear pulse; Controlled thermonuclear reactor drive
Extraterrestrial resources used	Mainly from Moon, Mars, Venus; lunar water ice mined	Lunar (incl propellants), asteroidal – for terrestrial use as well	Illumination from orbit Beamed in-space power supply Lunar sources: Oxygen, water extraction, mining for minerals, lunar biocultures Solar energy concentration for terrestrial humidity control Nuclear waste disposal
Supporting technologies	Photovoltaic	Inflatable domes; large-area reflectors for solar power;	Orbital mating, maintenance & refueling of trans-lunar vehicles; assembly & launch capability of manned interplanetary spacecraft
	laser mining tools	Nuclear power & explosives	
		Asteroid mining, capture, & colonization	Solar thermionic; nuclear MHD
			Composites, space-resistant plastics, cryogenic elastomers Pressure-stabilized, woven, & flexible rigidizable structures
			Field radiation shielding; "Astroskin" advanced pressure suits; artificial-g provisions
			Long duration ecological system (inorganic-organic, closed)
			Space manufacturing (electronic & precision mechanical equipment, initially)
			In-space processing of chemical supplies, e.g. water, methane, ammonia

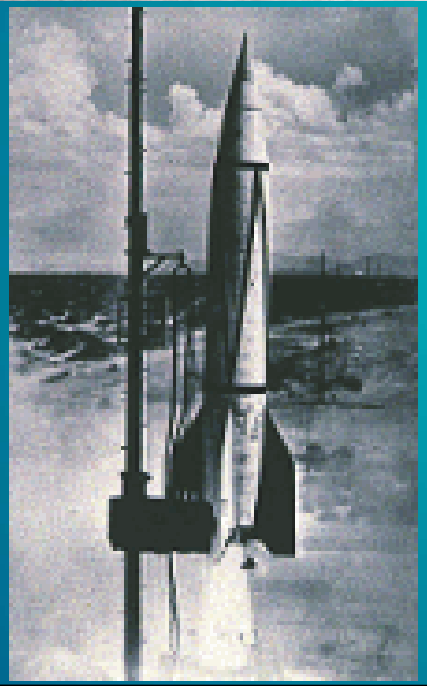
PREDICTED DATES FOR SELECTED EVENTS

Event	RAH	DMC	KAE	Historical date
First artificial Earth satellite		n.a.	n.a.	1957
Commercial rocket travel	1967	n.a.		2010?
First lunar landing	1978	n.a.	n.a.	1969
Moon travel ceased				1972
Small orbital research facility			1972-1973	1971?, 1973? 1989?
Commercial spaceflight	After 1979	1980		??
Orbital hospital			1985	
Space manufacturing facilities			1987	
Lunar facilities			1981 (Lunar bases) 1983 (science lab) 1988 (DSCN, spaceport)	??
Lunar rocket propellants			1987	
Lunar colony		Post 1971	Post 2000?	
First Mars landing	1983	Post 1975	1984	??
Mercury landing			1988	
Mars base		1980	1992	
Titan landing			1995	
Asteroids utilization		Post 1978		??
Mercury mining			1997	
Interplanetary travel ceased	2016			
Space colonies		By 1990		
Interplanetary travel resumed	2072			

Astronautical Development History: The Faustian Bargain



Event	Year
First artificial Earth satellite	1957
First rocket to the Moon	1969
Moon travel ceased	1972
Commercial rocket travel	2010?
Interplanetary travel	??
Permanent lunar facilities	??



THE "VON BRAUN PARADIGM"

- Space reformers criticize it, to support eliminating the human flight part from future programs
- Best factual, explicit statement of a von Braun paradigm:

"Space development (Astronautics) involves the physical settlement and use of the solar system by human beings"

- Suggested meaning (through analysis of "hidden" elements)

"The ***Faustian Bargain***: space development can advance only through state sponsorship – the sole way to achieve real and rapid progresses"

- Note that von Braun's bargained successfully: he achieved lunar landings after 37 years of state sponsoring – 39 years ago!

For any real progress, we have to reject Dr Faust's inspiration of Dr Braun's vision

COMPLEX MENACES, MATERIAL NEEDS, CULTURAL LIMITS

Basic impulse for bettering one's living & survival conditions motivates push for a private access to extraterrestrial space

"Worrying about the future"

- identify crises and risks well before they strike or materialize (if at all)
- used as an utilitarian reason for expanded space activities (mentioned by ESA LSPC)
- crises result from complex interaction of physical, social, random factors

Inventory of basic human needs

- evaluate the material needs for humans to survive
- builds on physical facts
- shows how necessary a Space Option implementation becomes in the 21st century

Analysis of bad, eventually dangerous behaviours

- lists mainly socio-cultural factors (with overlap or contiguity)
- many derive or receive support from governments of all colors
- a complex of destructive ideas, ensnaring attempts of positive actions

HUMAN NEEDS, CRISES, MENACES

Ecological problems for the human enclave (from Poley, 1997)	"Mega-crisis & space: A paradigm change" (from ESA SP-1187 Annex, p 42)	Major problems of today's world (personal notes by the author, 1999)	
		Impoverishment	Not enough wealth to pay for the available work
		Incompetence	Its generalization and the price it engenders
Enough space	Food shortages and famines	Disenfranchisement	Through remoteness,diffusion of power
Food & water	Population explosion	Stupidity	Its too-long survival
Energy supply	Global pollution	Overcrowding	The passive acceptance thereof
Materials supply	Energy shortages	Gigantism	The blind fascination therewith
Aesthetics – smell, noise, visual	Ecological crises	Democratic fallacy	Confusing democratic mechanisms with methods for the determination of truth
Toxicity of waste & by-products	Depletion of natural resources	Anti-ethical beliefs	An advancing wave
Others?		Hypocrisy	And its promotion as leadership methodology
		Romanticism	The arbitrary separation between human & natural elements

LOOKING FOR A NEW PERSPECTIVE

A sound ethical framework helps to guide decisions & promotes making of an apt future

- preeminence goes to moral rights, giving modern governance theory's its foundation
- only respect & protection of said moral rights makes a governance scheme legitimate

Historical evidence shows that

- 20th century collectivist governmental schemes failed to create such foundations
- they installed arbitrary (i.e. rejecting both physical law & human nature) regulations masquerading as morality made into law
- with time, all governments drift into a stark collectivist mode
- states show little inclination to solve mega-crises or to enable for the provision of human needs

In reality, only private human actions can begin and sustain any & all moral behaviours

Fruitful space actions must indeed grow from the initiative of private individuals – not from state-created mercantilistic corporations

ECONOMIC POTENTIAL

A range of studies have documented the potential wealth creation of space enterprises:

- Geolunar space tourism (Collins, 1997)
  - $200-billion cumulative investments till 2030
  - associated turnover estimated at some $100 billion/year
- Lunar Power System (Criswell & Waldron, 1991)
  - $600-billion investments in R&D, initial production, and start of operations
  - revenue stream eventually reaching $14 trillion/year for full system
- Lunar Power System (Waltz & Thompson, 1993)
  - $74-trillion excess returns – wealth generated thanks to power availability
- Assessment of available energy's impact on economic growth (Bernasconi, 1998)
  - energy available at 2.5%/a growth rate vs constant energy availability
  - enables creation of additional wealth $300 trillion (world scale) over 30 years

All these examples necessitate multi-billion level investments to achieve indicated returns
Common repartee: these project are simply too expensive to be viable.

STATE-FINANCED DEVELOPMENTS

State bodies do not lack the money – only the pressure to spend

- Contemporary state institutions sink hundreds of billions of AU at a time to cover:
  - war expenses,
  - liquidity crunches, or
  - stimulus packages
- Funding for a project for economic fertilization of geolunar space can be found:
  - one can easily add an order of magnitude to space expenses by using “fiscal income” raked in by taxes, levies, duties, &c &c charged on energy sources
  - anchoring this increase to acquisition of power in space and to climate mitigation works would offer full legitimization
- Some smaller amounts, budgeted & used during the last thirty-five years, confirm that
  - governments do not feel any limits in term of money –
  - nor in term of the bona fide viability of any technical project
  - how many billions AU have gone to projects to develop biomass technologies?

Neither factual analysis nor lack of funds ever hampered a state in financing one of his friends' pet projects.

NEW SPACE PROGRESS

For private enterprise financing, funds have to be found, minimum accountability applies

Private enterprises have coped with up-front costs comparable to some space projects'

High development & realization risks form the primary argument against space projects

- “Plenty of Formula-1 and Indy racers, but no cars and no lorries”
- Fifty years of space activities (1-trillion-unit expenditures?) have delivered ever new, better, more sensitive and more advanced techniques & instruments, but – not made available designs, technology, know-how for lower applications

A few monopolists talking to a couple of monopsonistic buyers do not a market make

New Space industry represents an interesting & heartening phenomenon – sooner or later, it will grow into an astronautical industry, & make RAH, DMC, KAE visions reality

Rather, later – Three non-technical dangers:

- Breadth: limited scope, North-American occurrence
- Financing: slow progress may cause withdrawal of more impatient founders
- Jurisdiction: regulations (or a 'stroke of the pen') can destroy any company any time

HOW TO COLONIZE SPACE

1. dismiss the concept of space expansion as human destiny
2. respect the levels of astronautical understanding
3. recognize that politicians do not intend to help you
4. understand that TANSTAAFL!
5. forget the space agencies
6. acquire historical, technical and practical knowledge of Astronautics
7. contribute to an “open source” astronautical network –

AND COLONIZE SPACE!!

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Alternative for the fast adopters:

- convince the state to create labor camps on the Moon
- commit a crime (pts 6 & 7 above will probably suffice)

... and there you are!!!

CONCLUSIONS

- Historical astronautical discussions show a strong private component in space activities – and a significantly faster rate of progress
- Vehicles' overall weight grows exponentially over time (5 centuries in shipbuilding)
- Astronautical progress stagnated during last 30 years
- The Faustian bargain worked only for Dr von Braun
  - modifications – fixing the mega-crisis, providing for human needs – also failed
  - governments never lacked the ability to fund space projects
- Private access to space may become a more successful paradigm
- The road ahead remains fraught with obstacles & financial, cultural, & political risks
- Eventually, an astronautical industry will assemble and provide “space for growth”:
  - through the dedication of the founders
  - by bootstrapping itself with projects joining financial and technical returns
  - with an “open hardware” initiative curating experience and creating standard parts

A MODEST VISION FOR THE CENTURY

- Acquisition of geolunar space to the human economic arena
- Modest specific technology needs, mainly for:
    - Transportation
    - Propulsion & power
    - Habitats
    - Mining, construction, agriculture
    - Industrial production
- Episodic planetary surfaces' exploration

A MODEST VISION FOR THE CENTURY

Technology Demonstration

INITIAL SOLAR SAIL TECHNOLOGY DEVELOPMENT STAGES

1 - Initial ground test article (IGTA) -
- single PIC assembly of 14-m diameter (150 m^2)
- fits within existing facilities, LOAD-10 experience applicable
- compatible with scaled-down flight tests (e.g. TU Munich)

2 - The Protohelioscaphe / Part I -
- Butterfly configuration, 28-m diameter saillets (1200 m^2)
- flight demonstration vehicle, scaled up IGTA by a factor 2
- same caliber of ground test article

3 - The Protohelioscaphe / Part II -
- Cloverleaf configuration, 4 saillet duplicates of the above design (2400 m^2)
- can comply with the LPO (Lagrange Point Observer) mission

4 - The Mesohelioscaphe -
- Cloverleaf configuration for the reference mission (10,000 m^2)
- Cloverleaf configuration for Vivaldi-class missions (20,000 m^2)
- saillets scaled-up almost by factor of 2 - 3: 56, 80 m diameter

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