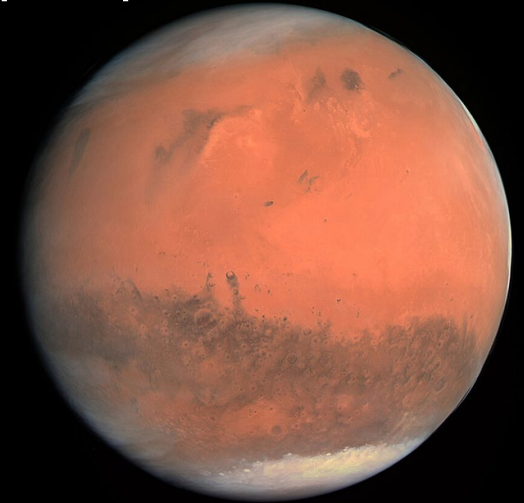


What does it mean to settle space

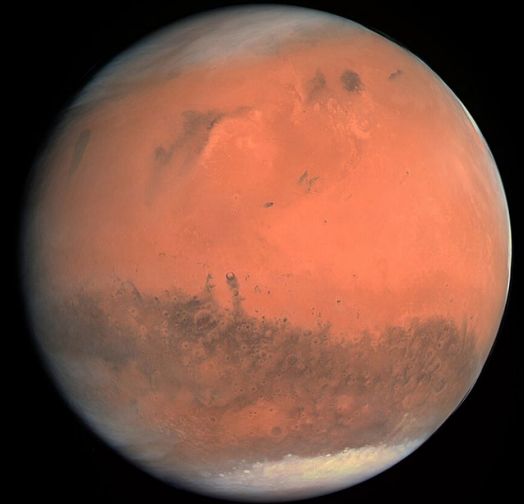
Space exploration from a permanent perspective

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How does the individual survive economically?

- Macro perspective focuses on the riches of space and bringing that back to Earth will pay for big money investment
- How does the individual economics work over a person's life cycle when they will not be returning to Earth



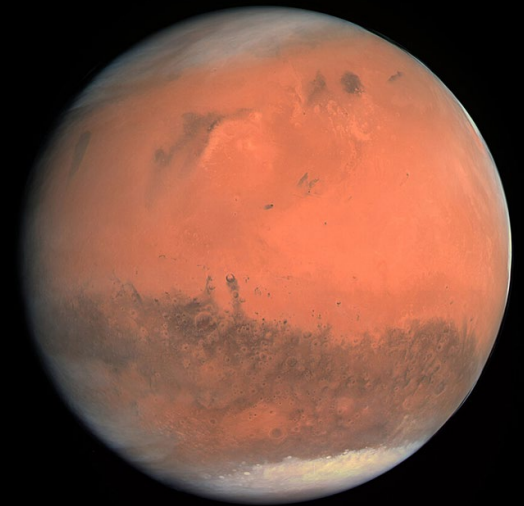
Entry Assumptions

- Settling Space will be hundreds, thousands, and eventually millions of people
- All technology is available
- Somehow cost to settle is arranged
- Cost is prohibitive for bringing people back to Earth, except in rare circumstances
- Growth through procreation
- Self reliant for most products and services
- Total life cycle production and consumption will be based on Earth proven systems, or derivative there of
- Utopian society is not achievable – humans will bring their bad behaviors with them



Settling from the Individual's Perspective

- Getting there
- Early survival
- Flourishing / Family
- Generations beyond



What does it mean to settle a distant land

Settlement of Early pre-1776 USA

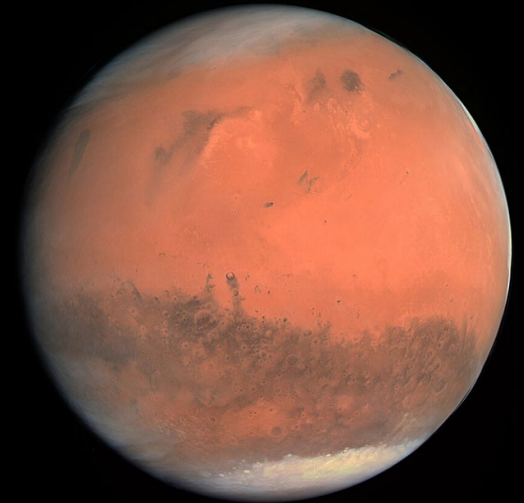
- Religion
- Debtors prison
- Land ownership in the time of feudalism (pre-1776)

The Frontier in American History, Fredrick Jackson Turner (1893)

- Land, Land, Land (wealth, commoner becomes king of their own castle)
- A place for those who do not belong anywhere else

More Modern

- Freedom
- Go where no human has been before
- Wealth accumulation
- A place for those who do not belong anywhere else

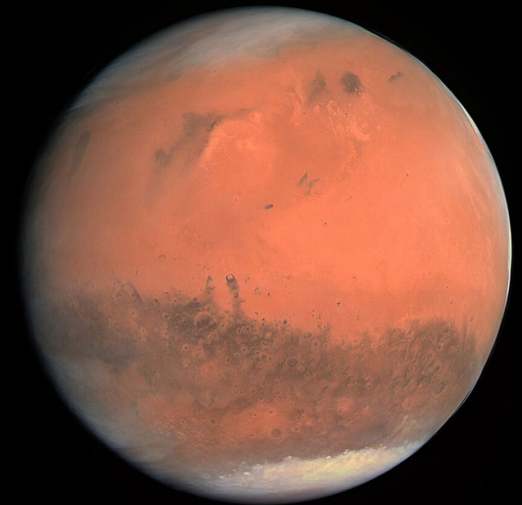


Cost of Venturing Forth

Getting to Mars

- Transportation: \$4.2 Trillion Rocket launch cost (1 billion kg)
- Supplies for flight and initial 2 years: \$500-1000 billion
- Cost per person:

Cost		# of people		
		10,000	100,000	1,000,000
Travel	\$ 4,200,000,000,000	\$ 420,000,000	\$ 42,000,000	\$ 4,200,000
Supplies	\$ 1,000,000,000,000	\$ 100,000,000	\$ 10,000,000	\$ 1,000,000
per person	\$ 5,200,000,000,000	\$ 520,000,000	\$ 52,000,000	\$ 5,200,000
Mass (kg)				
Food (2 years)		18,100,000	181,000,000	1,810,000,000
Humans		1,600,000	16,000,000	160,000,000
Habitats		20,000,000	200,000,000	2,000,000,000
Food production		20,000,000	200,000,000	2,000,000,000
total		59,700,000	597,000,000	5,970,000,000
Available	1,000,000,000	94,030	4,030	(4,970)



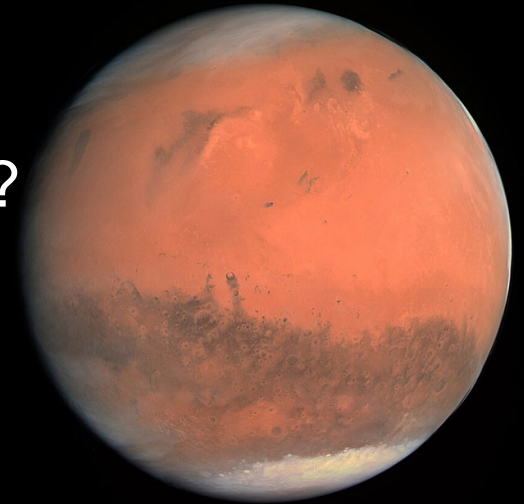
Reimbursement for Cost of Venturing Forth

Early American system

- Pooled resources community – live off land
- Indenture servitude
- Company employee
- Paid Fare

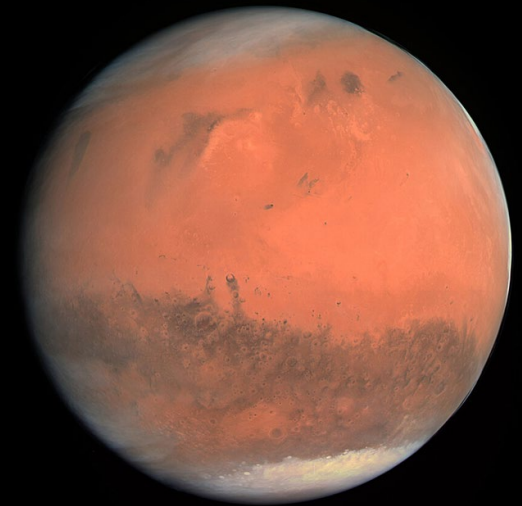
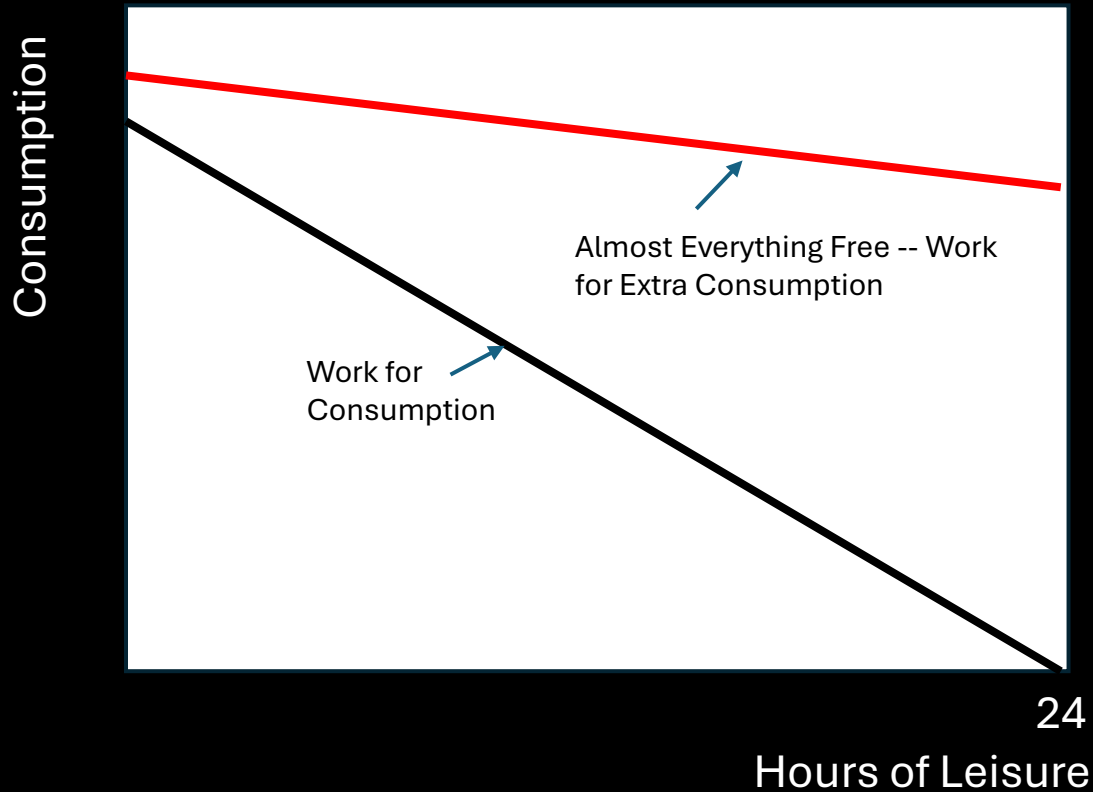
Mars system (?)

- Economic Rational / Altruistic Reasons?
- Compensation for payor ?
- Labor Economics still reigns



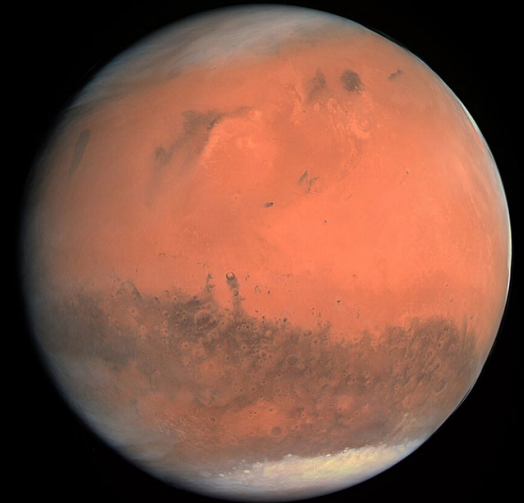
Labor Economics

Everything is free = no work

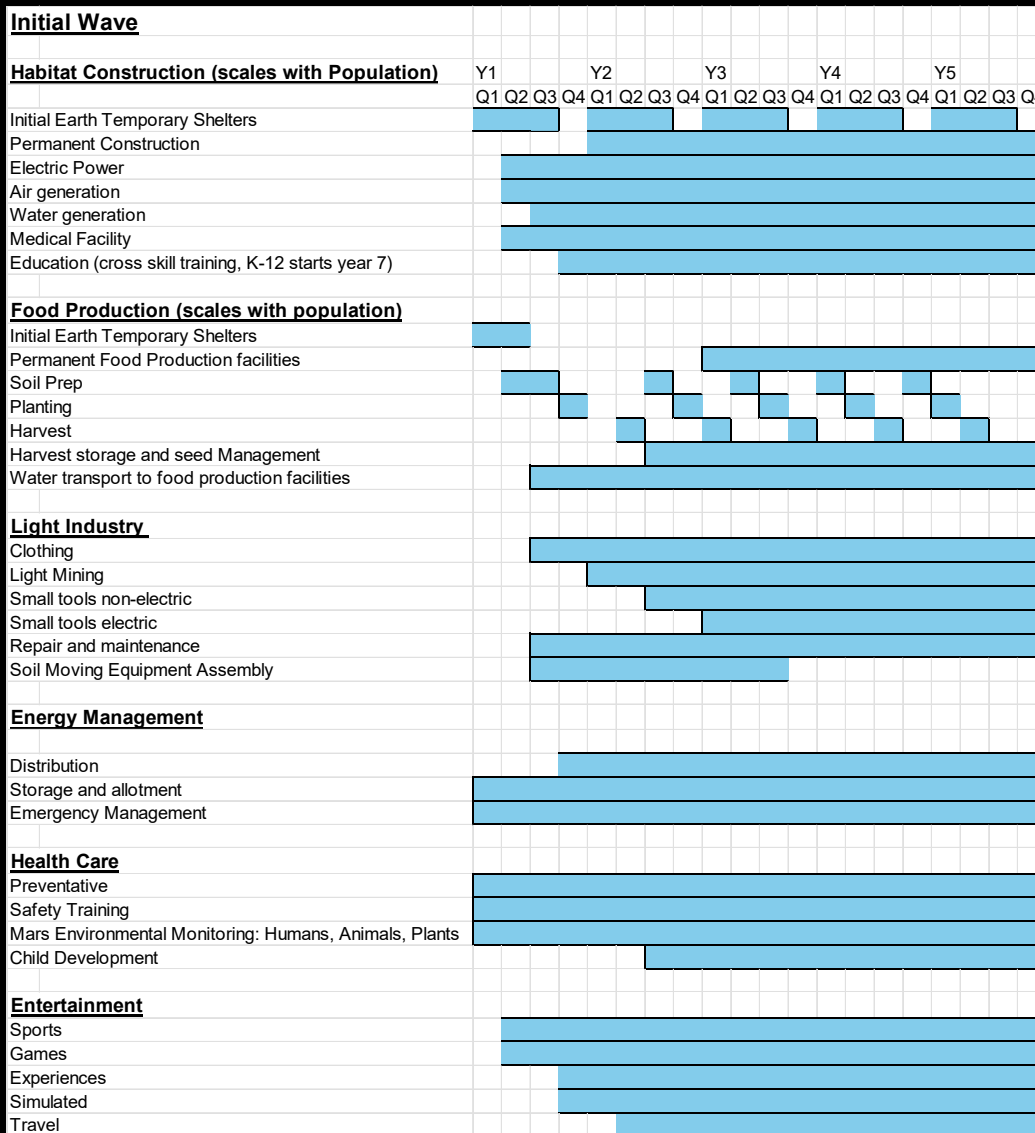


Early Survival

- Transportation cost
- Initial Consumption Needs
 - Food
 - Clothing
 - Air
 - Water
 - Energy
 - Health Care
 - Entertainment

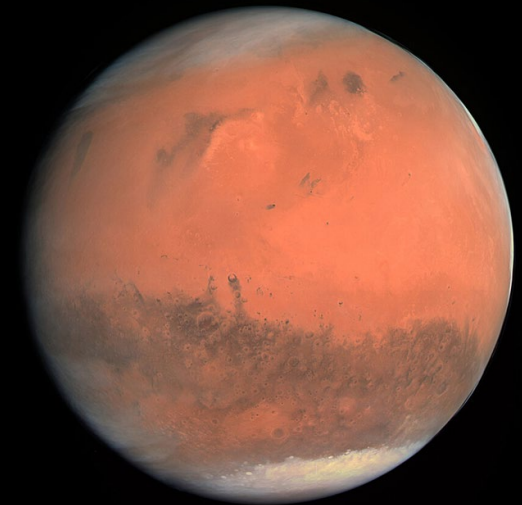


First Five Years



Initial Tasks Suggest

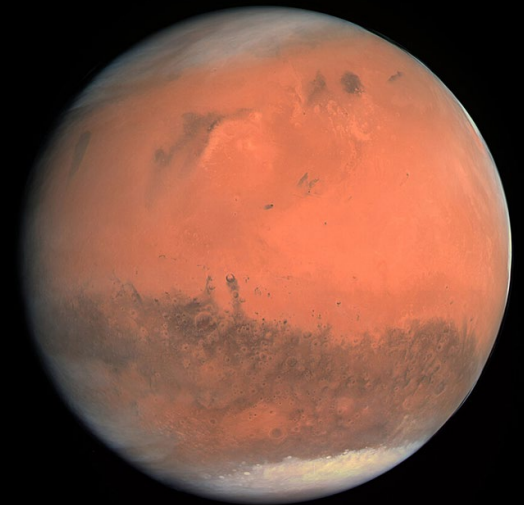
- Blue Collar Workers
- Settle Focused on Survival
- Wealth Extraction will have to wait
- Electric Powered “earth moving equipment” is needed



Flourishing

Permanent Demand Needs

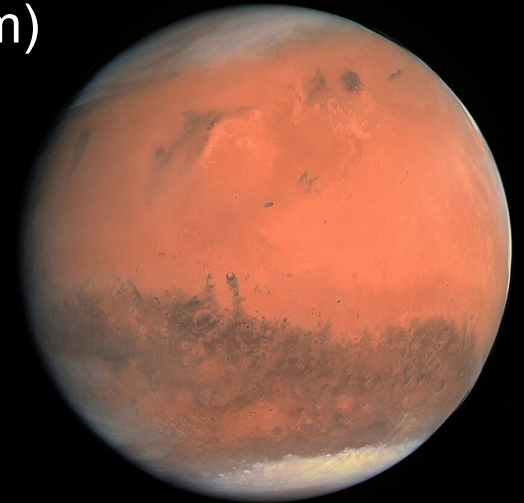
- Food
- Clothing
- Air
- Water
- Energy
- Construction Equip (electrically-powered bulldozers, track hoes, skid steers, dump trucks, etc.)
- Facilities Expansion
- Settlement products and services
- Healthcare
- Child Rearing and schools/universities
- Entertainment
- Retirement and disabled communities



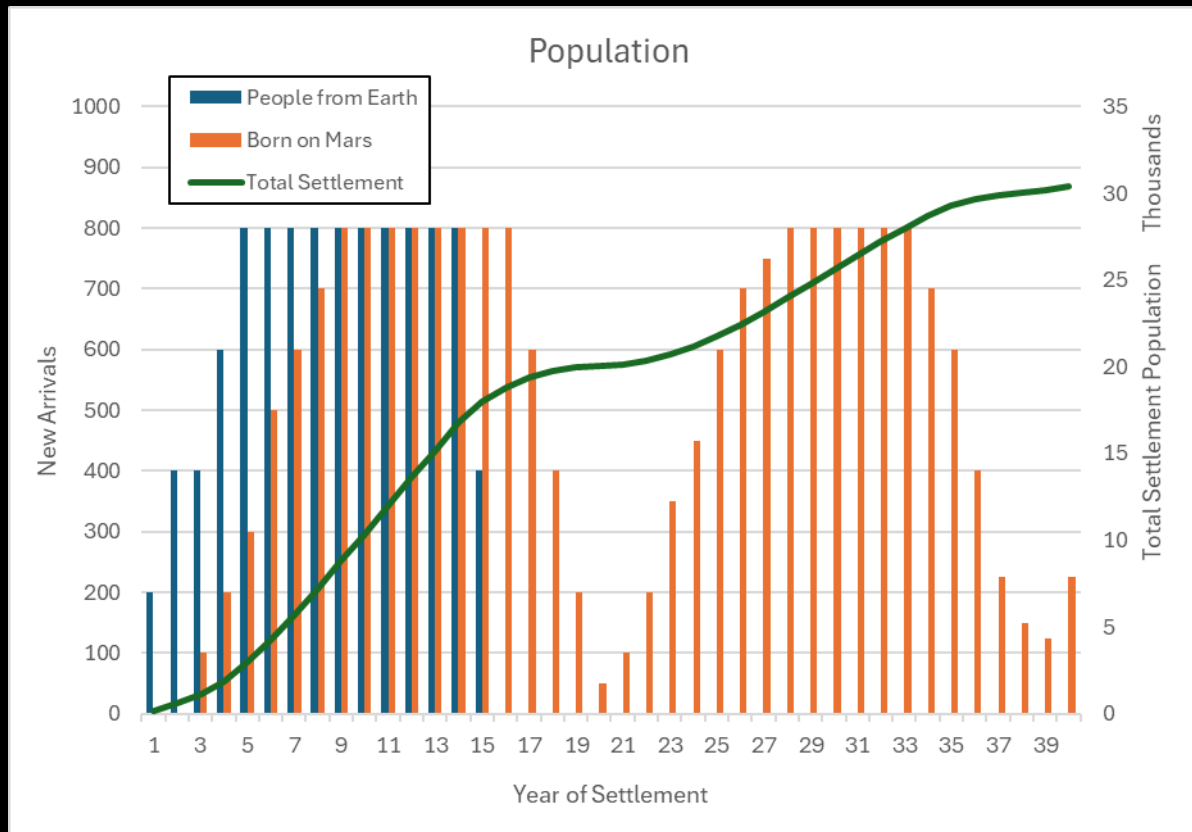
Flourishing

Permanent Supply Needs

- Stable resources
- Skill mix adjustment of initial settlers
- Children to start permanent settlement
- Children education and settle skill needs versus children & young adult interests
- Industry development for settlement products and services
- Off-Mars travel capability (tether-based system)
- Wealth Extraction
- Life-style development
- Property rights
- Laws of settlement
- Labor economics
- Retirement economics

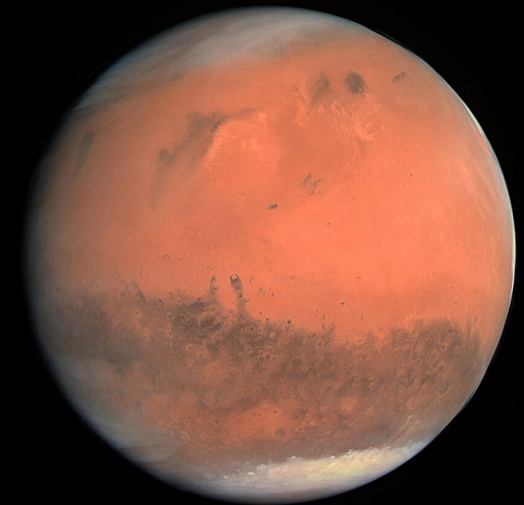


Population Projections (first 40 years)

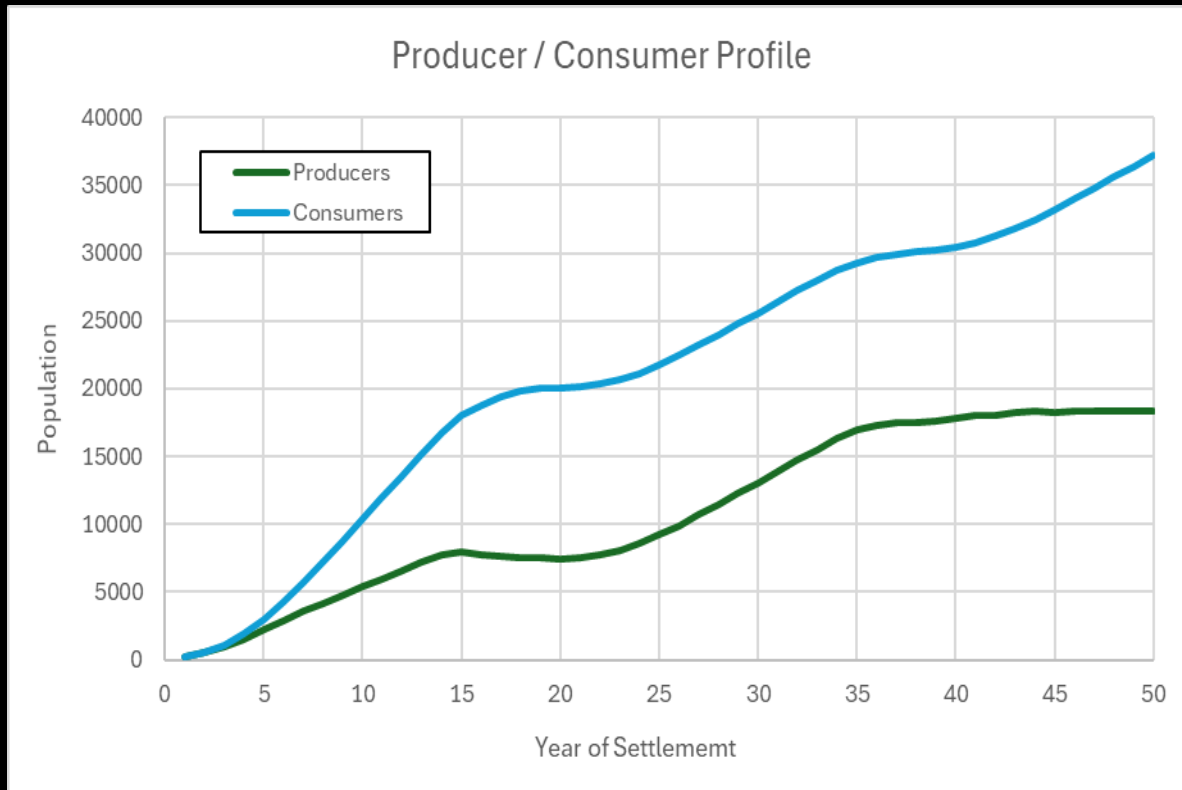


Assumptions:

- Average age: 25
- Couples having children after 2 years
- 2 children per couple every other year

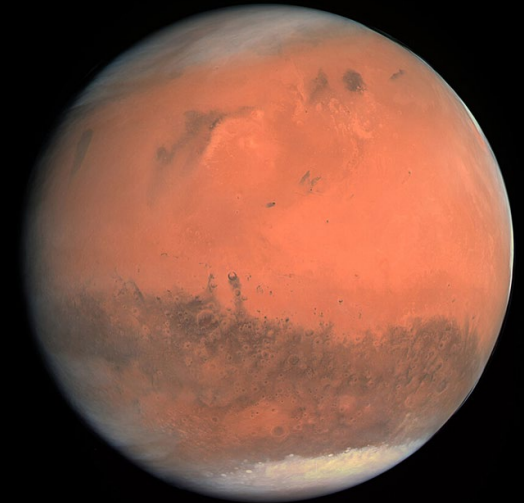


Production vs Consumption



Assumptions:

- Children productive at 18
- One adult 25% less productive due to child rearing
- Retire at 65 live to 75



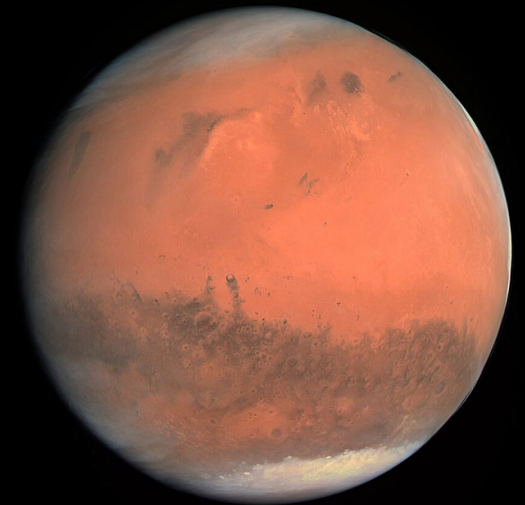
Family

- Children require care in a hostile environment
- Safety issues for children and young adults (CYA) and other settlers
- Education of CYA matching interest with settlement needs
- Incentivizing CYA for production
- The role of humanities in the settlement
- YA living arrangements upon adulthood
- YA providing for themselves
- YA career choices



Retirement

- Exiting workforce
- How is consumption paid for
- Health provisions
- Entertainment
- Leisure time
- Dementia / Alzheimer's / etc. and safety for the person and settlement



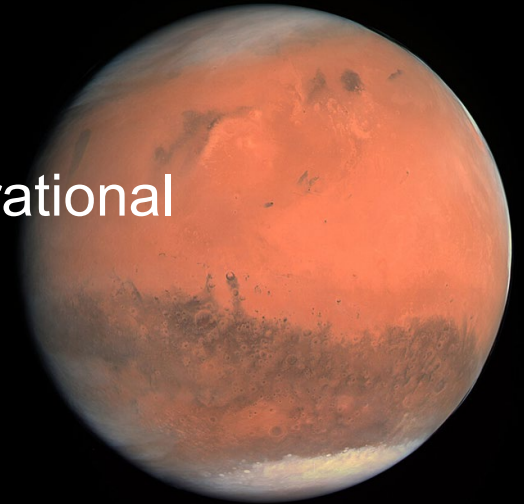
Follow-On Generations

- Population cycling
- Settlement growth versus creating new location
- Multi-settlement specialization
- Skill mix needs versus persons career interest
- Motivation/incentivization of population to continue being productive
- Mars industry expansion and more self-sufficient especially tech
- Legal considerations for property rights, wealth, inheritance, etc.



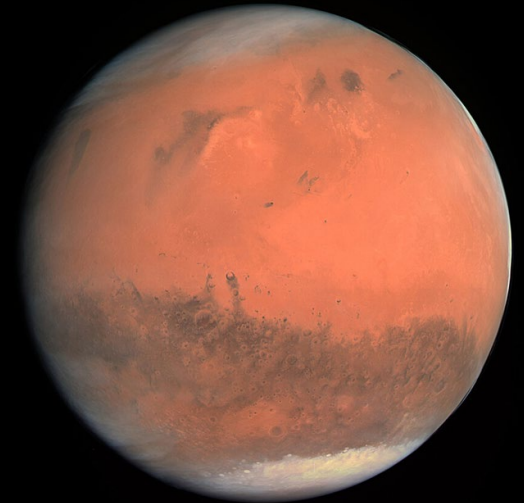
Permanent Space Settlement Requires

- Initial Cost payback model & Wealth extraction for trade
- Life cycle assessment
- Consumption needs
- Production needs
- Quality of life needs
- Scarce resources environment
- Hostile environment & safety issues
- Labor Economics
- Skill set changes and supply in multi-generational environment
- Location Bucks



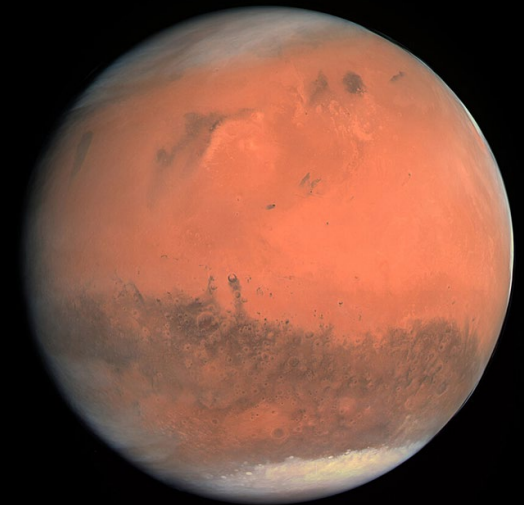
Economic Considerations

- Initial payback for settlement
- Initial required skill mix and changes over time
- Raising children impact on consumption and production
- Children incentivization and skill development
- Initializing industry
- Price based economy
- Mars Bucks
- Crime and punishment
- Retirement and consumption
- Concept of wealth basis
- Concept of income / expenses



How to start making sense of it all

- Initial settlement travel and setup cost do not appear to be repayable
 - Pay it forward with building the settlement for new arrivals
 - Other compensation based on performance
- Defining the new concept of wealth for space settlement
 - Land
 - Water, energy, food, air, raw material, finish goods???
- Labor economics with non-portable workforce (concept of income)
 - Supply/demand/wages/incentives/value economics of Mars production
 - Income wages and other incentives based on value of skills on Mars
 - Producer / consumer population cycling theory
- Intra-settlement transactions
 - Theory of the commons (air/water?)
 - Barter system
 - Various forms of Mars Bucks (cryptocurrency)
- Ricardian Theory of Comparative Advantage
- Interplanetary Interactions
 - International Trade Theory
 - International Finance Theory



Future settlers require deeper understanding

- We better have a preliminary understanding of how this will work before we get there
- We must take human behavior into account
- We must recognize that until we get there, we will not know how it will really work

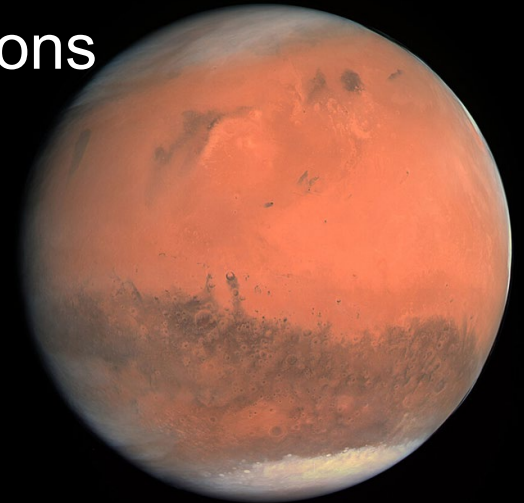


Contact Info

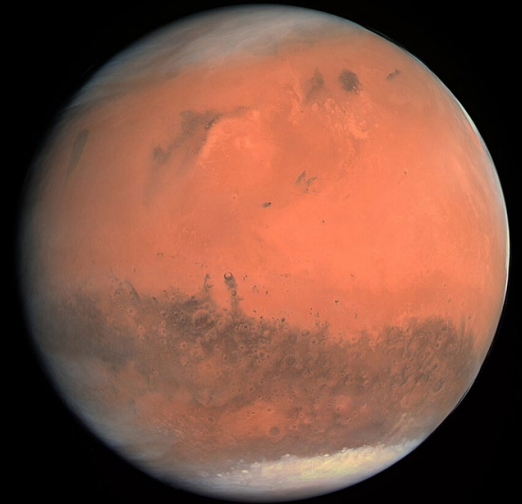
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Backup Slides



Space Faring Society Realities

Major Off-World and Down-Earth Transport Needs - Millions of kg (Mkg)						
	Off-World (Mkg)	Down-Earth (Mkg)	# Rockets Equivalent Falcon Heavy	Rocket Cost \$ Billions	Time to Complete (1 launch/wk)	Time to Complete (5 launch/wk)
Moon Village	500		29,762	2,024	572 years	114 years
SpaceX Colony Mars	1,000		59,524	4,048	1144 years	228 years
Space Solar Power	5,000		187,000	11,594	3596 years	719 years
L-5 O'Neill Colony	10,500		392,700	24,304	7551 years	1510 years
Sun-Earth L-1 Sun Shade	20,000		748,000	46,376	14384 years	2876 years
Space Tourism	TBD	TBD	TBD			
GEO Manufacturing	TBD	TBD	TBD			
Asteroid 3554 Amun Mining Products		30,000,000	Unknown Vehicle			
Other Asteroids and Space Products Returning to Earth		XXX,000,000	Unknown Vehicle			
Current Total Marketspace Needs	37,000	X30,000,000	1,383,900	\$85,758	26,613 years	5,322 years

Need something with higher cycle times and high payload

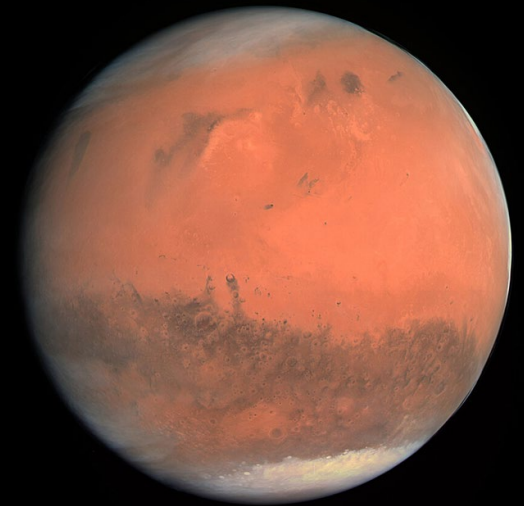
Space Faring Society Possibilities

Major Off-World and Down-Earth Transport Needs - Millions of kg (Mkg)							100 mt Elevator	
	Off-World (Mkg)	Down-Earth (Mkg)	# Rockets Falcon Heavy	Rocket Cost \$ Billions	Time to Complete (1 L/wk)	Time to Complete (5 L/wk)	Time to Complete (1 L/day)	Time to Complete (5 L/day)
Moon Village	500		29,762	2,024	572 years	114 years	13.7 years	2.74 years
SpaceX Colony Mars	1,000		59,524	4,048	1144 years	228 years	27.4 years	5.48 years
Space Solar Power	5,000		187,000	11,594	3596 years	719 years	137 years	27.4 years
L-5 O'Neill Colony	10,500		392,700	24,304	7551 years	1510 years	287.7 years	57.54 years
Sun-Earth L-1 Sun Shade	20,000		748,000	46,376	14384 years	2876 years	548 years	109.6 years
Space Tourism	TBD	TBD	TBD					
GEO Manufacturing	TBD	TBD	TBD					
Asteroid 3554 Amun Mining Products		30,000,000	Unknown Vehicle					
Other Asteroids and Space Products Returning to Earth		XXX,000,000	Unknown Vehicle					
Current Total Marketspace Needs	37,000	X30,000,000	1,383,900	\$85,758	26,613 years	5,322 years	1013.7 years	202.74 years

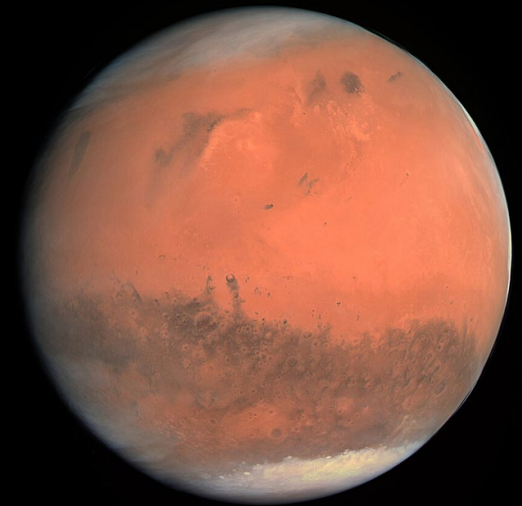
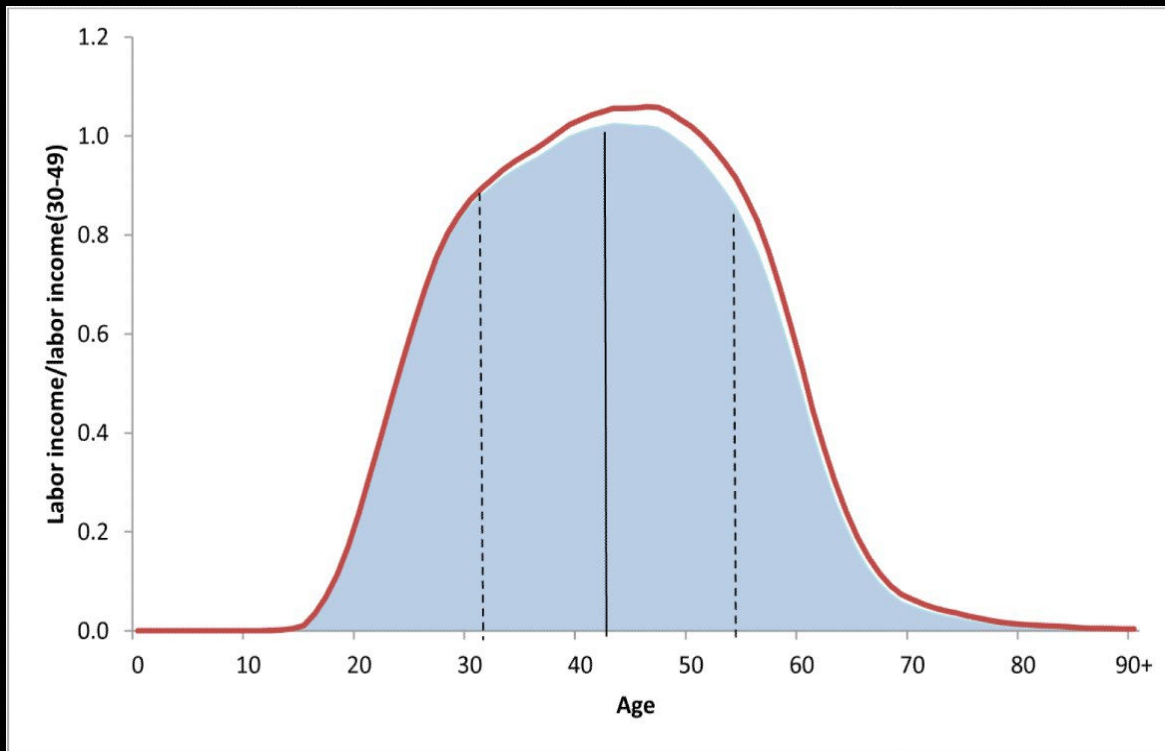
Data suggests at least 100 mt payload with five launches a day

GEO Differences for Tether Applications

Object	GEO (km)
Earth	35,786
Mars	17,033
Moon	86,493



Labor Income as a fiat for Value to Settlement



Consumption Over a Life Cycle

- Per capita effective consumption by age, simple average of values for 14 high income countries. Calculated as per capita consumption divided by average per capita consumption of persons 30-49. Unweighted and survival weighted values. The solid line marks the mean age of effective consumption and dashed lines mark the mean age \pm one standard deviation for survival weighted values.

