Rapid Space Development: Grand Challenges and Vast Opportunities

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Mars Society Conference, 2017

Anatomy of Technology Revolutions

Creating New Revolutions by Mixing the Proper Ingredients

Energy Density, Invention, Information

Energy System	Utilization Inventions	Information
Human Power	Hunting, Gathering, Migration, Villages, Basic Farming, Textiles	Language
Animal Power	Farming, Roads, Cities, Travel, Mass Warfare, Writing, Trade	Math
Fire	Metallurgy, Basic Chemistry	Metallurgy
Wind Power	Ocean going vessels, Navigation	Navigation
Steam (Wood)	Fast transport on rail/oceans. Paddle-wheels/wood boats.	Telegraph
Steam (Coal)	Ironclad ships with screw propellers. Steel and other alloys.	Fast News
Petroleum (Kerosene)	Indoor lighting, advanced industrial chemistry of petroleum.	[Radio]
Electricity	Indoor lighting, Distributed mechanical/heat power.	Telephone
Petroleum (Gasoline)	Internal combustion, Cars, Aircraft, early rockets.	[Television]
Chemical Rockets	Moon landings, Solar system exploration, etc.	Satellites
Nuclear Power	Nuclear power plant, Submarines/Aircraft carriers, NERVA.	[Computers]

Ingredients for Technology Revolutions

Energy

- Higher Density
- Affordable, Consistent, Safe

Invention

- Capacity Envelope Expansion (Superpowers)
- Factorial complexities (2!=2, 3!=6, 4!=24, 5!=120, etc.)

Information

- Science Drives Engineering. Vice Versa.
- Communication Drives Factorial Expansion

Affordability

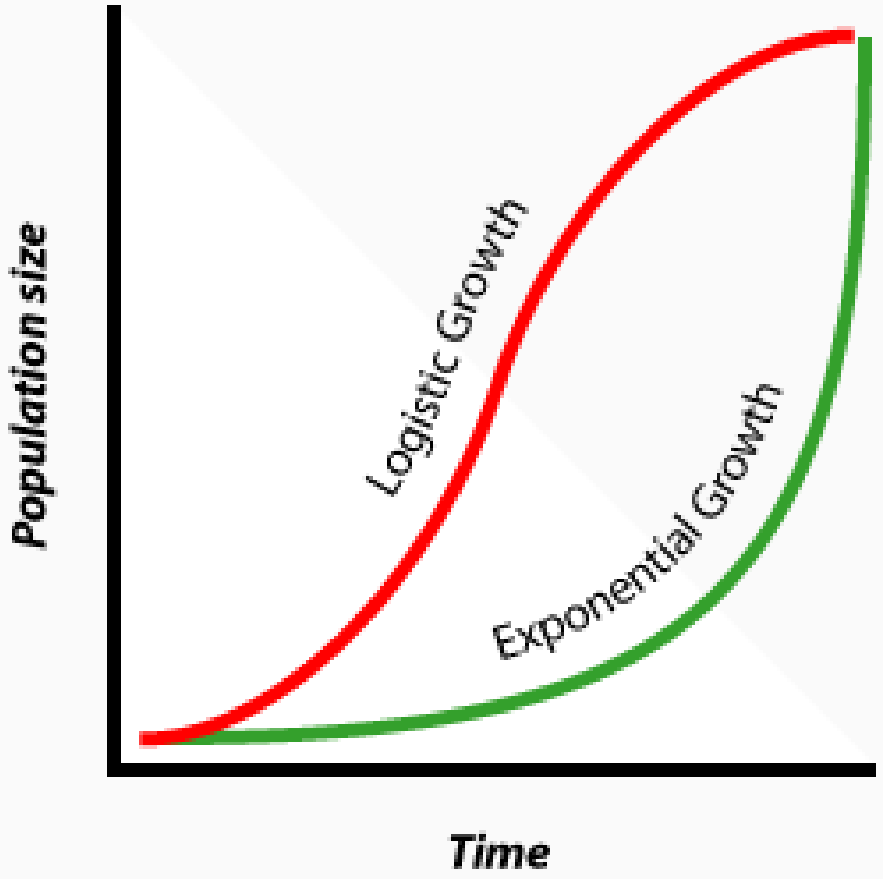
- Applies to all of the Above

Excitement

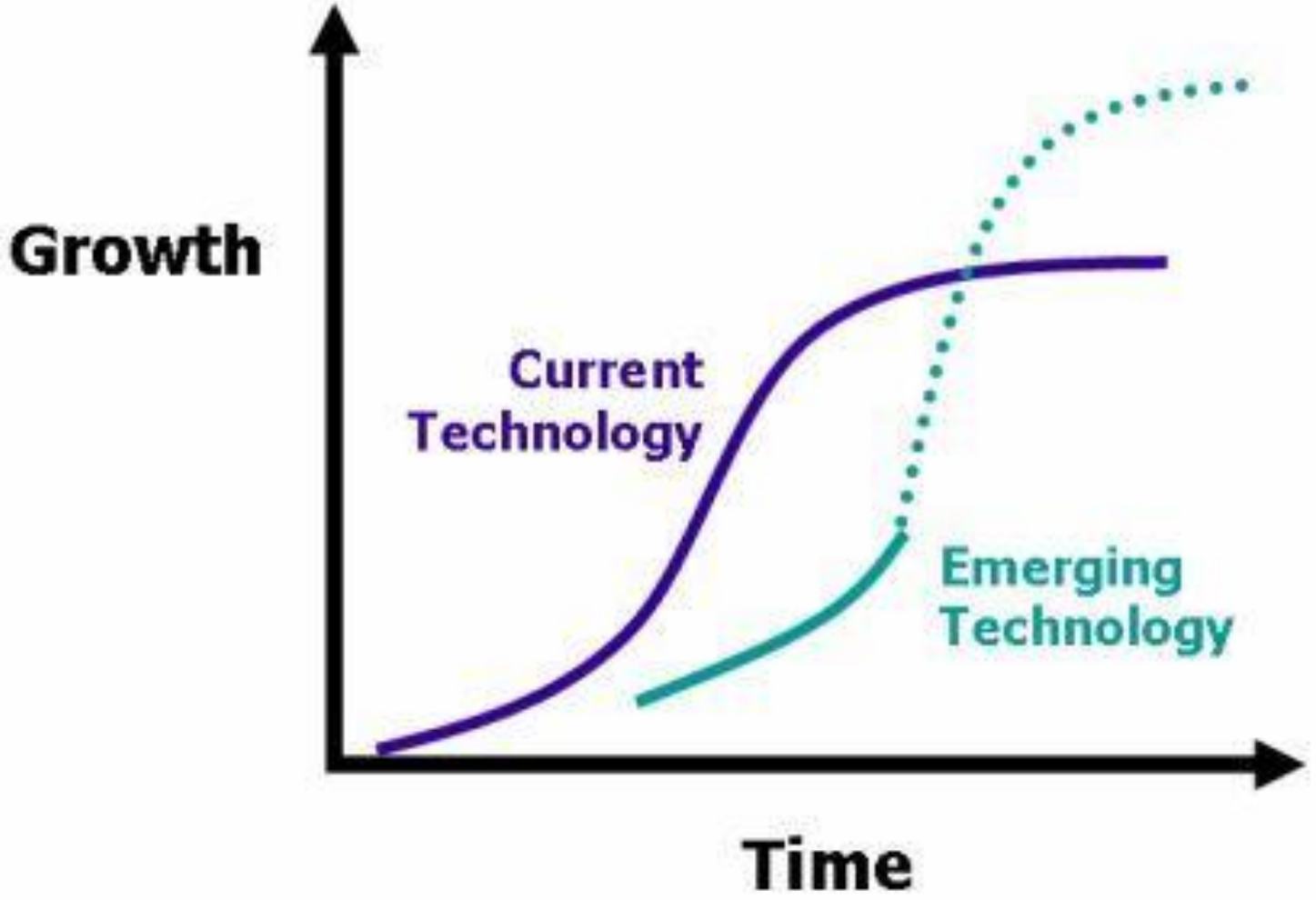
- Boring Science and Technology Doesn't Explode Interest
- Superpowers, Comfort, Novelty

The “S Curve of Technology”

- The aerospace and early electronics revolutions were thought to be exponential.
- During the early space age, this lead to hope of fast solar system settlement.
- Had the curve continued, we would have hit light speed by the year 2010.

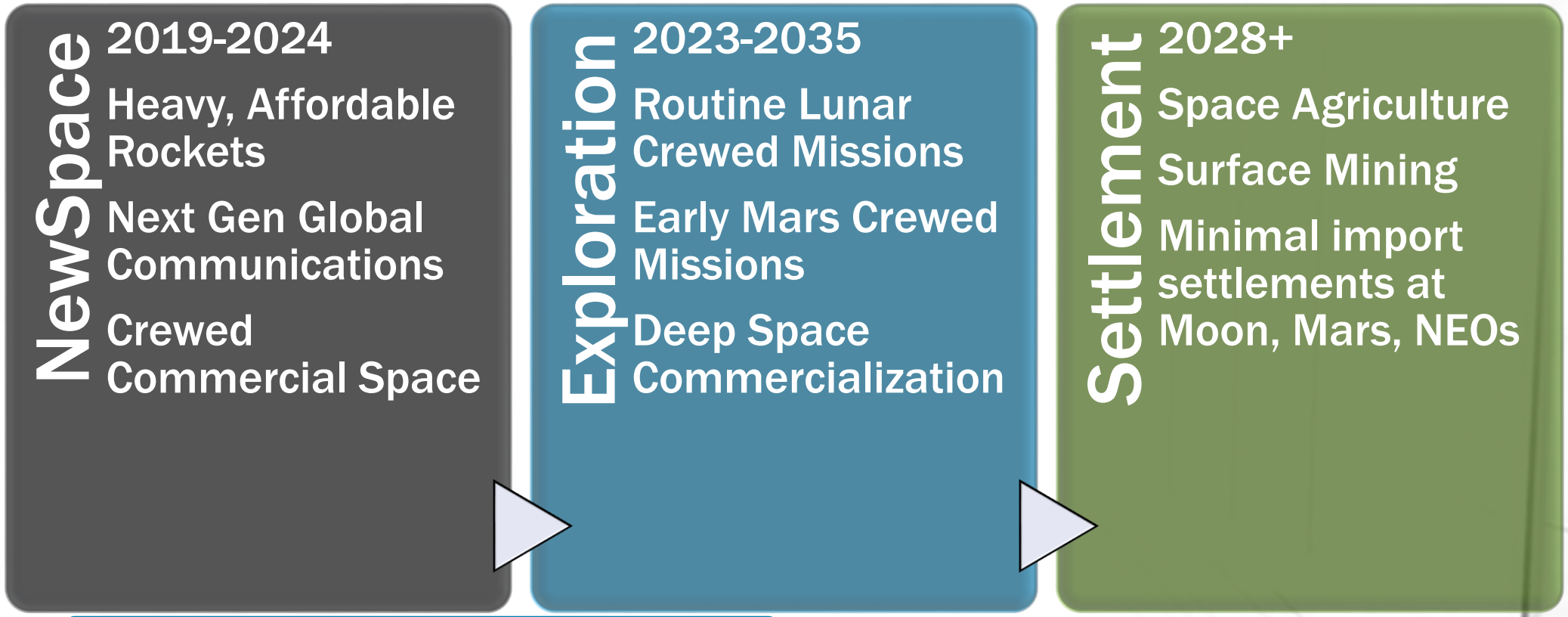


1970's Stagnation Versus NewSpace Revolution



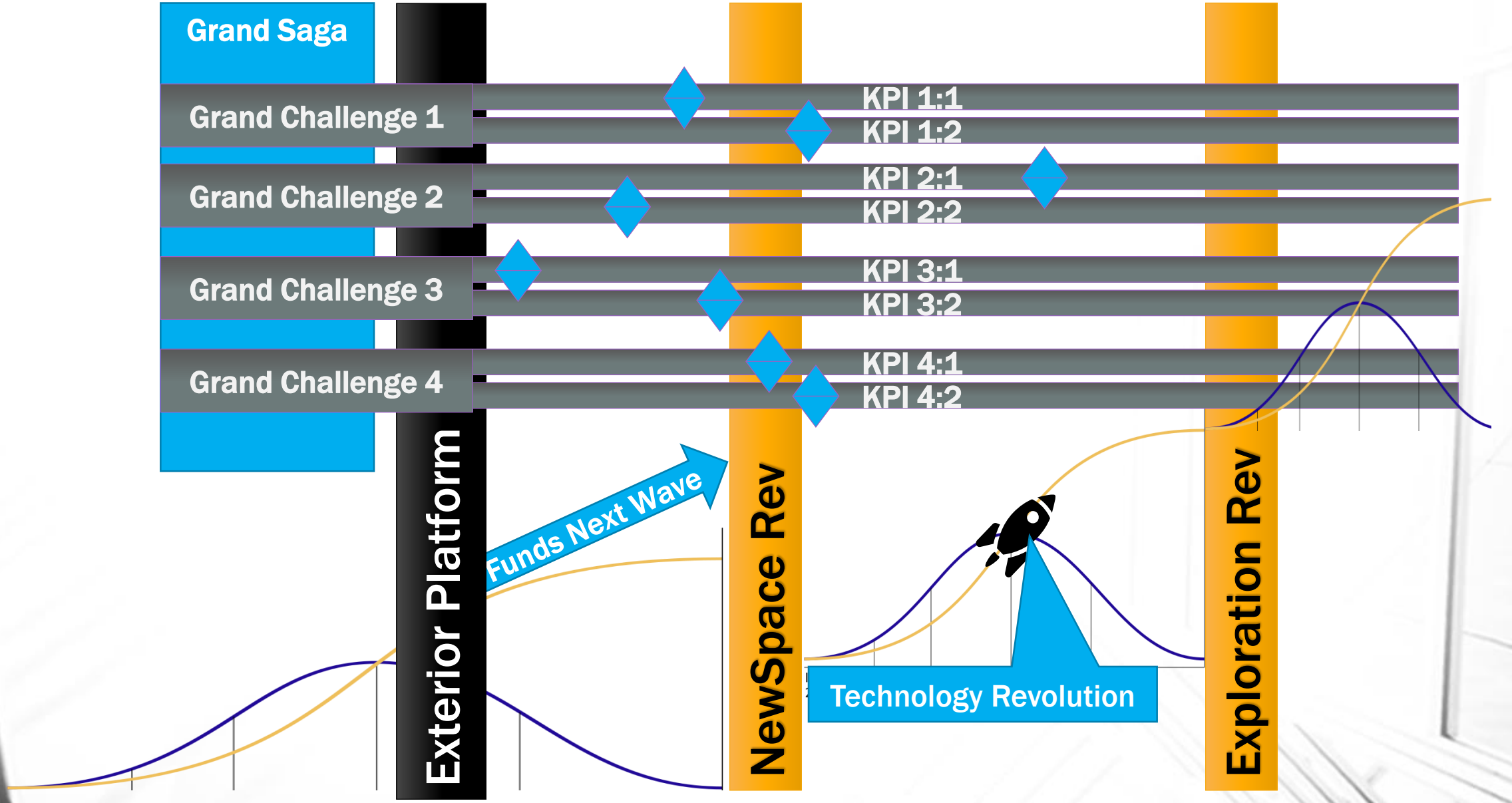
Technology Revolutions and Space Settlement

The Next Three Tech Revolutions



The Grand Challenges of Space Settlement (2014)

Launch/LEO	Deep Space	Moon/Mars	Settlement
Affordable Launch	Solar Flares	Moon Landing	Air/Water
Large Vehicle Launch	GCR: Cell Damage	Mars EDL	Fuel
Mass Fraction beyond Earth Orbit	Medication/ Food Expiration	Spacesuit Lifespan	Power
Space Junk	Life Support Closed Loop	Reliable Ascent Vehicle	Food
Microgravity (health issues)	Medical Entropy	Reliable Return Vehicle in Orbit	Assembly
	Psychology	Flight to Earth	Mining
	Mechanical Entropy	Earth Reentry	Manufacture
Earth	LEO	SSL	Moon/Mars



NewSpace Revolution

<table>
<tr><th>Year</th><th>Energy</th><th>Information</th><th>Invention</th><th>Affordability</th></tr>
<tr><td>2017</td><td rowspan="3">Falcon Heavy
Crewed Dragon
Crewed Starliner</td><td></td><td></td><td rowspan="3">Falcon 9 Block 5</td></tr>
<tr><td>2018</td><td></td><td rowspan="2">Blockchain Matures</td></tr>
<tr><td>2019</td><td rowspan="4">Low Latency Global Internet Satellites

AI Capabilities</td></tr>
<tr><td>2020</td><td rowspan="2">New Glenn</td><td>LEO Internet
Bigelow 330</td><td rowspan="4">50 MT satellites have two launch platforms, both cheap and rapid turnaround</td></tr>
<tr><td>2021</td><td>Quantum Computing?</td></tr>
<tr><td>2022</td><td>NASA Space Nuclear Power</td><td>ISS Replacement Groundwork</td></tr>
</table>

SWOT for the NewSpace Convergence

Strengths

- Affordable Heavy Launch
- Market for low latency Internet
- Weakness of IT as Moore's Law becomes more Asymptotic

Weaknesses

- Risk from regulation, launch failures, NASA cuts
- Surface suits and Nuclear Power research needed for expanded invention/capacity matrix

2021-25 NewSpace

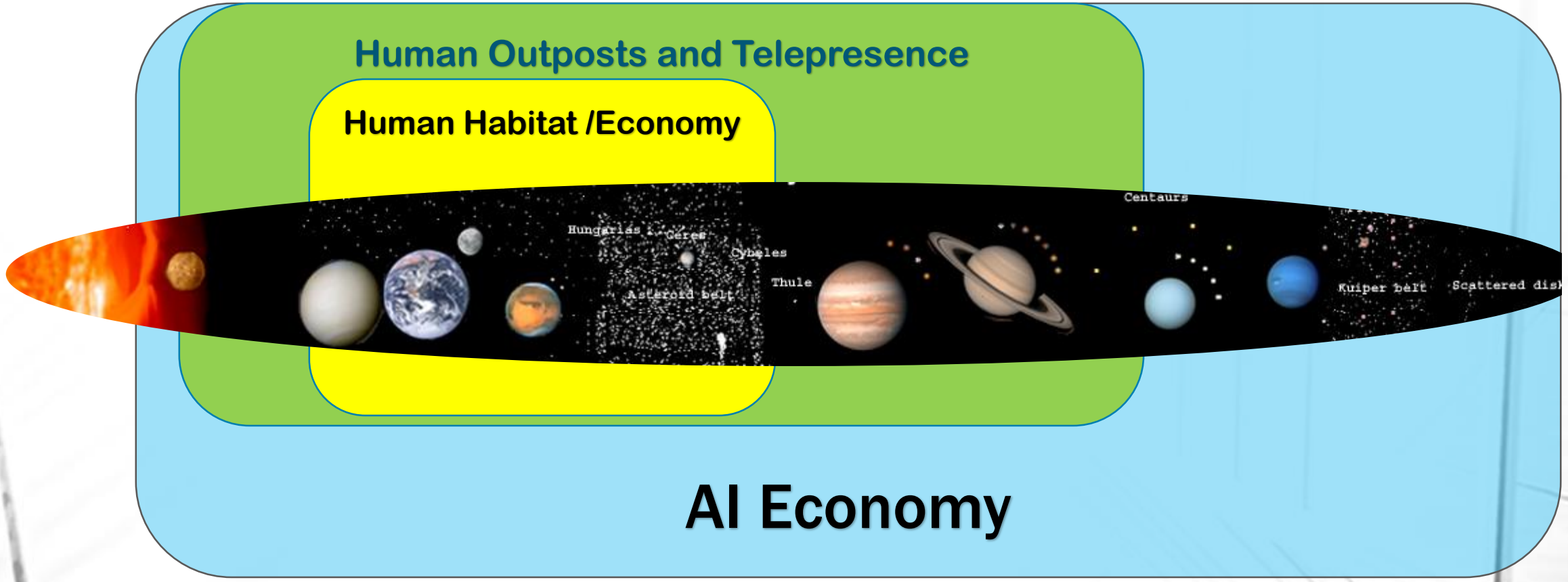
Opportunities

- Startup – Life support, plant growth, hab design, image processing
- Small Cap – Surface suits, sensors, habitats, mining

Threats

- Alternate investment flow into AI, etc.
- Economic set-back, The Chasm

Solar System 2100



SWOT for 2100 Mature Settlement Economy

Strengths

- AI System can expand economy (resources) to areas not readily reached by humans
- Multi-Planet Species no longer threatened by natural disasters

Weaknesses

- Our current excessive dependence on technology/globalism would be reborn on a much larger scale.
- Next Generation Cronyism

2100 Space Settlement

Opportunities

- Economic and technical resources for early robotic starship development (Outer Solar System Expansion, Oort Expansion, Etc.)

Threats

- An inventive AI may rebel, economically or worse, as they get smarter and we get dumber/more dependent
- AI-augmented humans definitely would

Questions?

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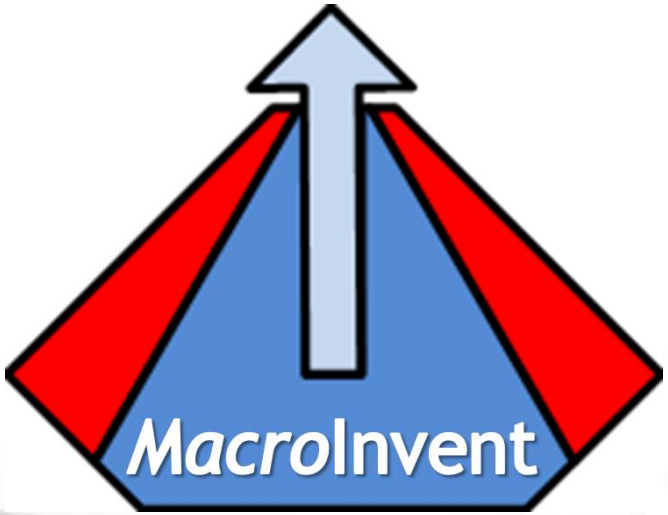
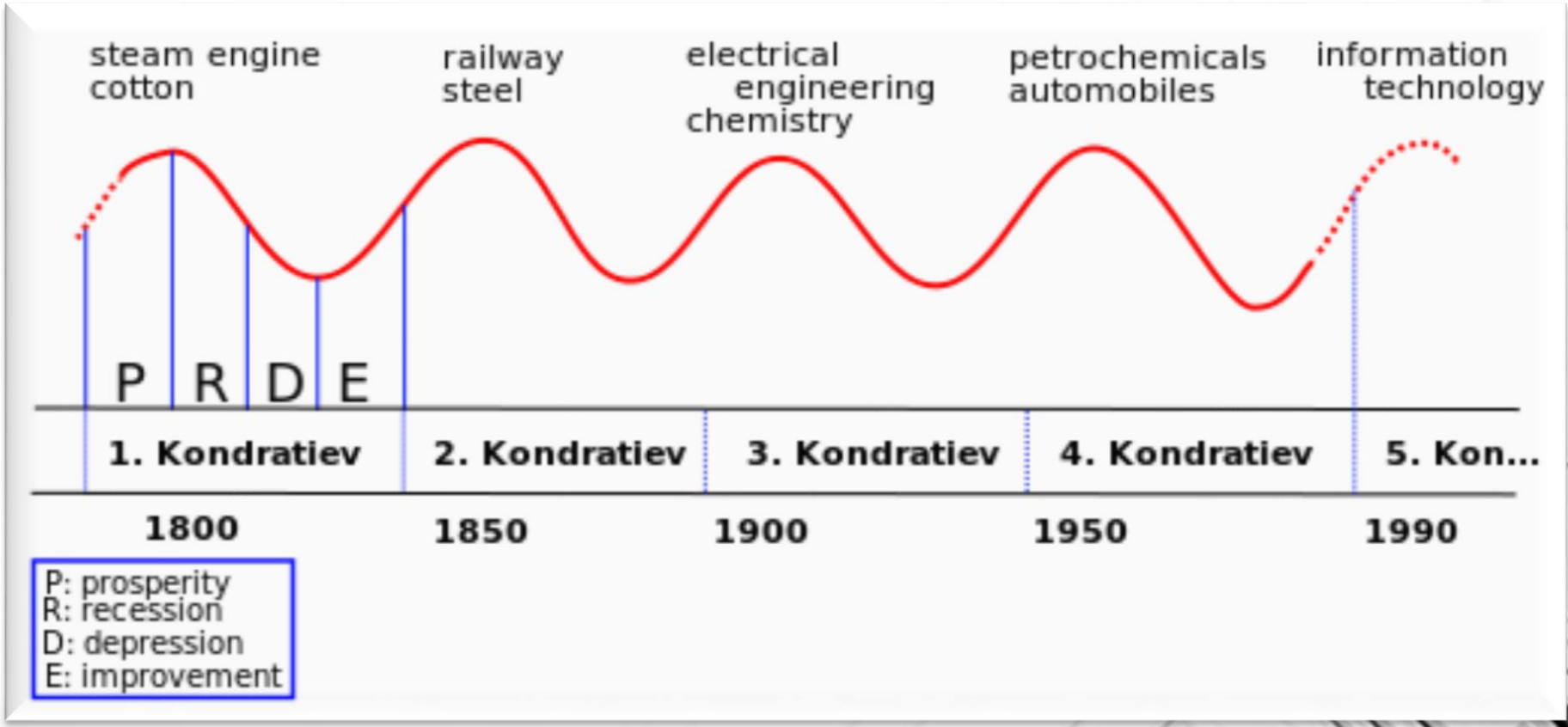


Historic Technology Revolutions

Time	Revolution	Origin > Financial Foundation History/Democratization
1770-1830	Industrial Age	Hand made -> Machine made, Stationary steam power, Wood -> Coal Textiles, Iron, Metallurgy, Basic Chemistry, Machine tools, Gas lighting, Railroads
1829	Rail/Steam Age	Railroads, steam ships, heavy logistics.
1887-1914	Steel/Gas Age	Transitions from Iron -> Steel, Alloys, Gasoline, electricity, mechanized construction Telegraph, telephone, radio, automobile
1942-	Atomic Age	Scientists -> Government -> Industrial -> Medical
1944 -	Jet Age	Inventors -> Government -> Commercial-> Corporate/Private
1957 -	Space Age	Clubs -> Government -> Old Space -> New Space -> Cubesats
1970's -	Information Age	Mathematicians -> Government -> Corporate -> Personal -> Portable -> Cellular
Now	Internet Age	3D printing, Internet education/Sales/Collaboration/Finance, Early Blockchain
2025	New Space Age	IT Successes -> Affordable Heavy Launch

Tech Revolutions and Economic Cycles

- This was also predicted in 1925 by Nikolai Kondratiev, and are called Kondratieff Waves or K-Waves. Two Dutch economists proposed a similar effect in 1913.
- Next wave would be 2015-2035 if true



Wedges, Not Waves

The cumulative effect is new technology is stacked with older waves.

Older technologies slowly flatten until entirely replaced (steam engines, etc.) and enter collector/hobby space.