The Scramble for the Skies:

Why Nation's Care About Space Resources

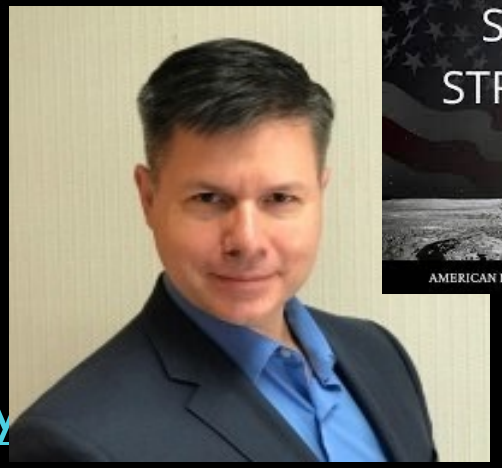
Peter Garretson

Boulder 2023

Key Take-Aways

- The interest of nations is not just science and prestige, but the relative gains in wealth and power that space resources may provide.
- Space is becoming its own theater for strategic competition and grand strategy.
- The Central Competition is over the Moon and Asteroids resources and in-Space Manufacturing
- The Great Power Competition in Space is likely to impact your future and your Children's future – Will you live in 1st or 2nd Rate Nation / Free or Controlled?
- You have agency to: help decide our collective fate; help convince our leaders to take action; help convince your fellow Americans to compete.

Who is your speaker?



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- Strategy Consultant, Government & Industry
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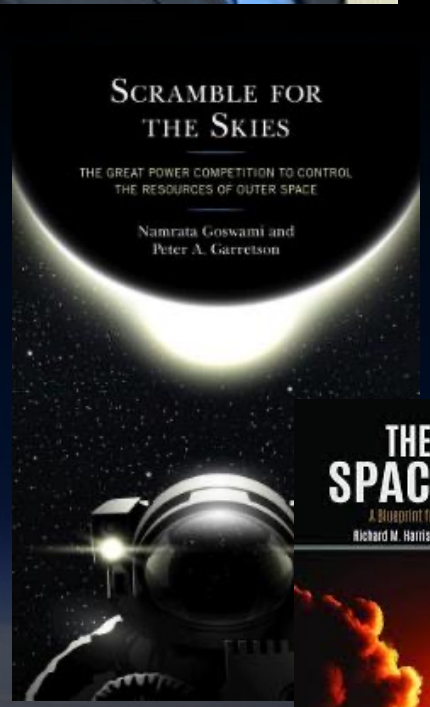
- Former Chief of Future Technology, HQ USAF
- Author, *Scramble for the Skies: The Great Power Competition to Control the Resources of Outer Space*; *The Next Space Race*



My Co-Author

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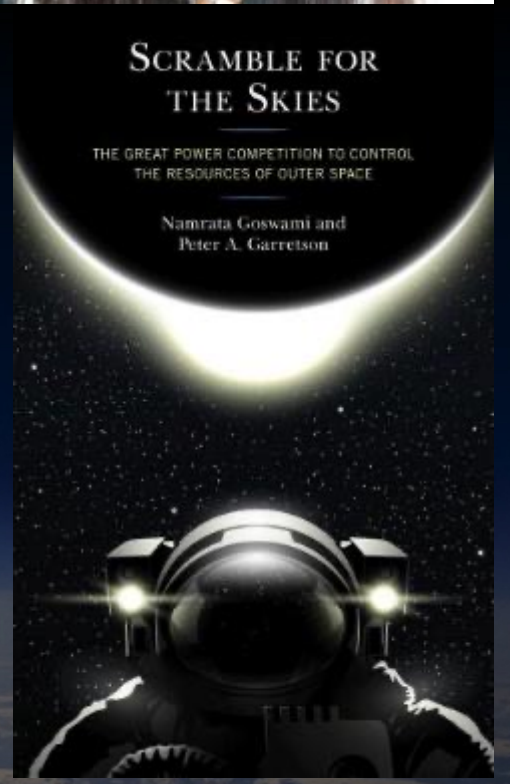
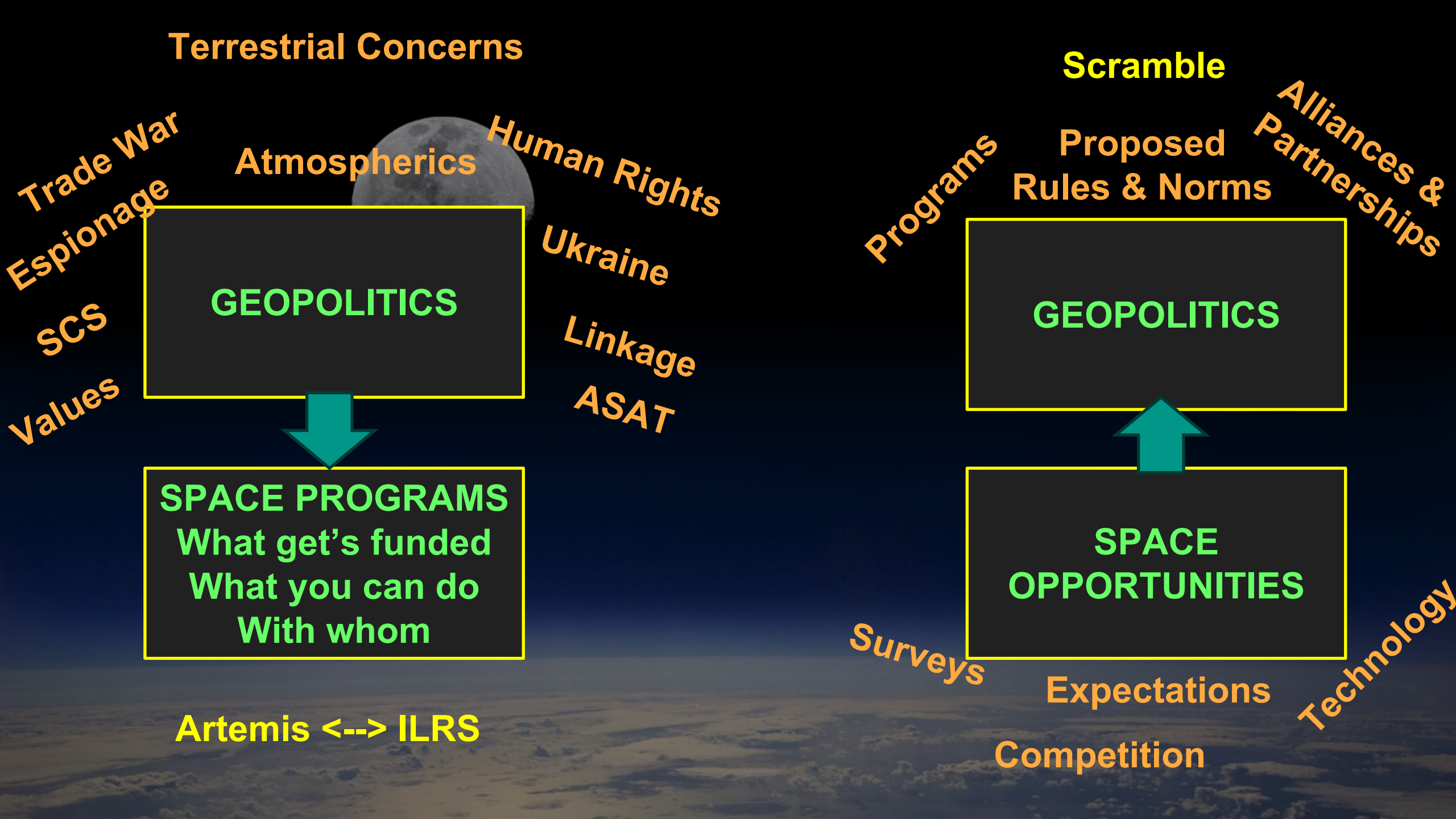
- 10 Years at India's Institute for Defense Studies and Analysis
- Author, *Scramble for the Skies: The Great Power Competition to Control the Resources of Outer Space*




Terrestrial Concerns
Trade War
Espionage
Atmospherics
Human Rights
Ukraine
SCS
Linkage
Values
ASAT
GEOPOLITICS
SPACE PROGRAMS
What get's funded
What you can do
With whom
Artemis <--> ILRS
Scramble
Programs
Proposed
Rules & Norms
Alliances &
Partnerships
GEOPOLITICS
SPACE
OPPORTUNITIES
Surveys
Expectations
Technology
Competition

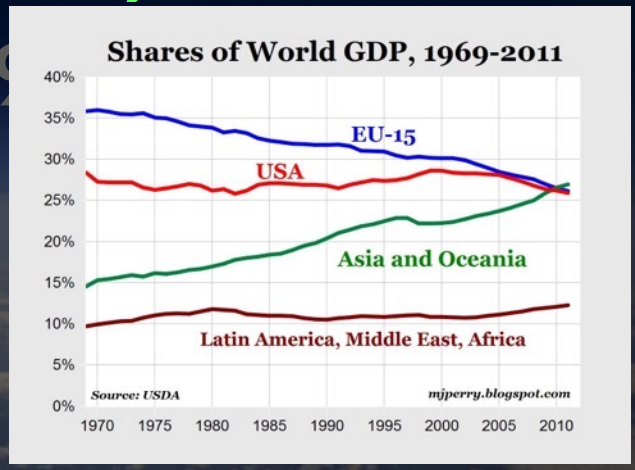
Why would states care about Space Resources?

STATES CARE ABOUT RELATIVE POWER

- Anarchic System

- The "absence of a central authority that sits above states and can protect them from each other" (Mearsheimer, 2001)

- Forces states to be concerned for their own safety and therefore with relative power (Waltz, 197[illegible] Mearsheimer, 2001; Gilpin, 1981) so that…
- Relative gains matter to states



This Takes lots of forms

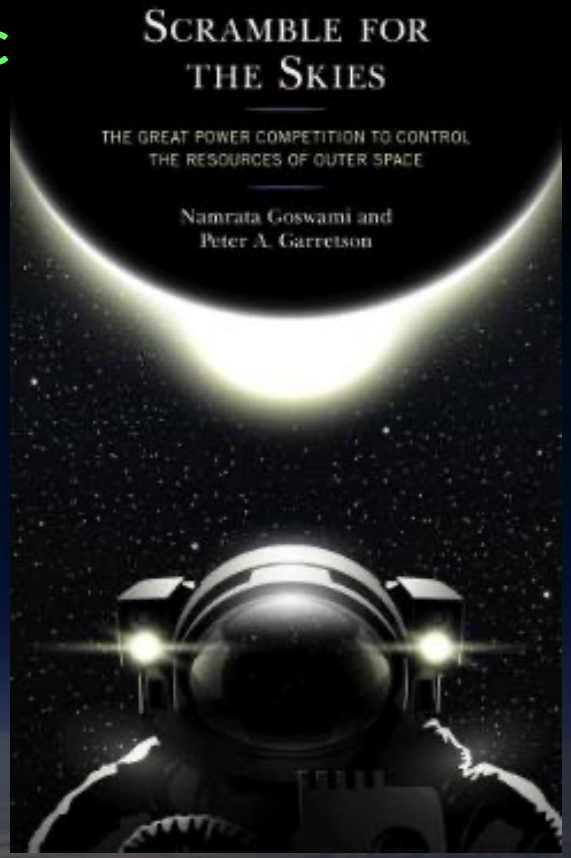
- Fear of constriction / coercion
- Supply-Chains / Trading Blocks / On-Shoring
- Critical / Strategic Minerals
- Alternate Trade Routes
- Alternate Supply Sources
- “Energy Sovereignty”
- Investment flows
- Military Posture (systems, organization, locations)

Why do you care? (per Michael Beckley)

- "The **essence of economic development is efficiency of production**. The higher a state's level of economic development, by definition, the more efficiently its workers produce goods and services. **There may be a natural tendency to view civilian and military realms as separate entities, but militaries are actually embedded within economic systems.**"
- Thus, **countries that excel in producing civilian goods and services also tend to excel in producing military force** there is an important tie between economic development and military power that is likely to hold true for space development and military spacepower as well. The **level of economic development strongly predicts military effectiveness, and developed nations excel in battle**. This has an effect even independent of military spending, and over and above the increase in wealth available to developed nations to buy weapons. Economically developed states derive several advantages from their broader economies. **Historically, this has led to very lopsided victories**.

THE POTENTIAL TO IMPACT RELATIVE ECONOMIC POWER: A NEW WEALTH OF NATIONS?

- Central to the balance of power is **relative economic growth**.
- Kenneth Waltz laid out five criteria by which to rank great powers: "**size of population** and **territory**, **resource endowment**, **economic capability**, **military strength**, political stability and competence."
- Production includes: **land** (including natural resources), **labor** (including population and human capital), and **capital** (machinery, tools, buildings, and infrastructure), the **energy** to transform it, markets that create demand, and entrepreneurs



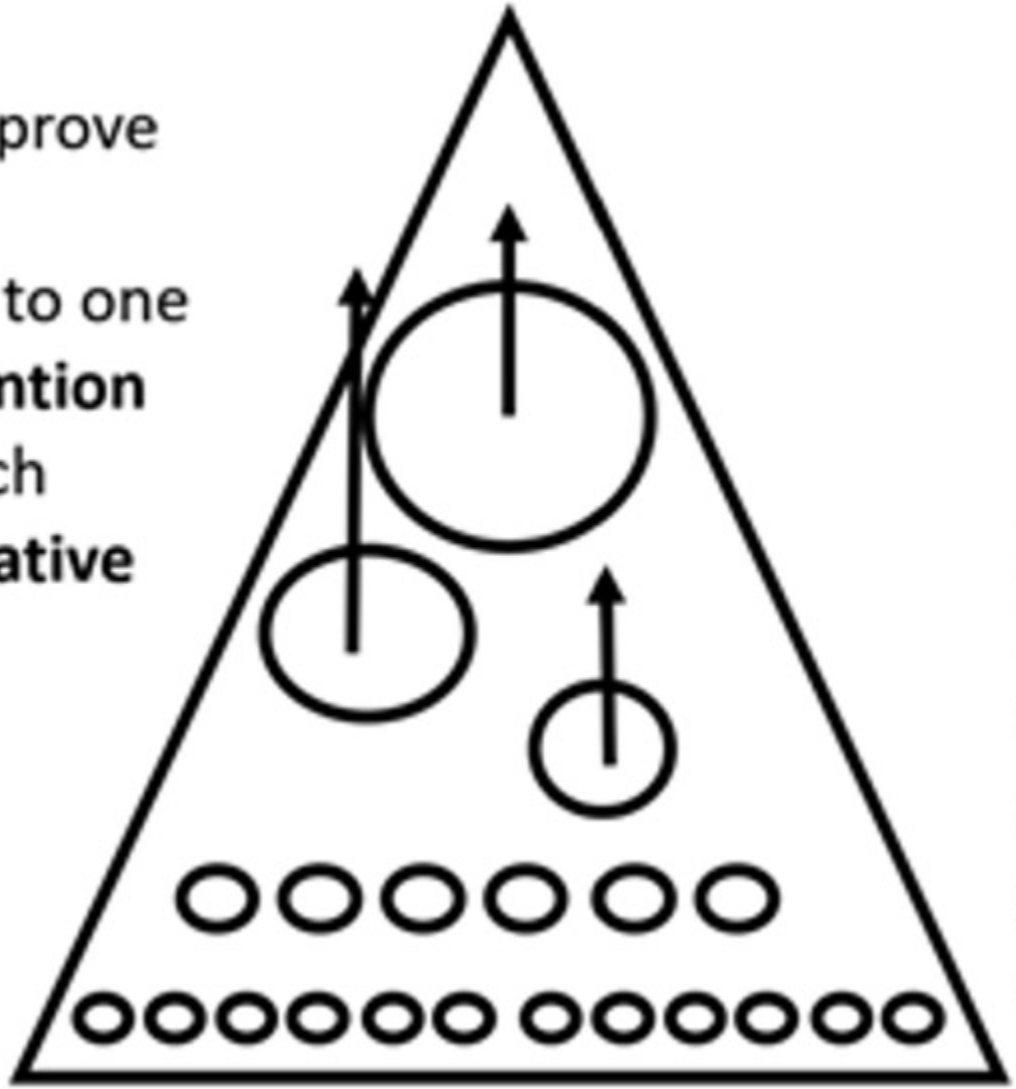
- **The resources of the solar system offer states the opportunity to change the size of their population and territory, their resource endowment, their economic capability, and as a result their military strength.**

“It is not the actual outcomes but the expectations as to what the outcomes can be that shape the issues and determine their politics” -- Theodore Lowi 1964

“If men define situations as real, they are real in their consequences” -- Thomas Theorem 1928

THINK LIKE A STATE.....

Top States seek to improve their relative power position with respect to one another and **pay attention to opportunities** which would affect **their relative power position.**

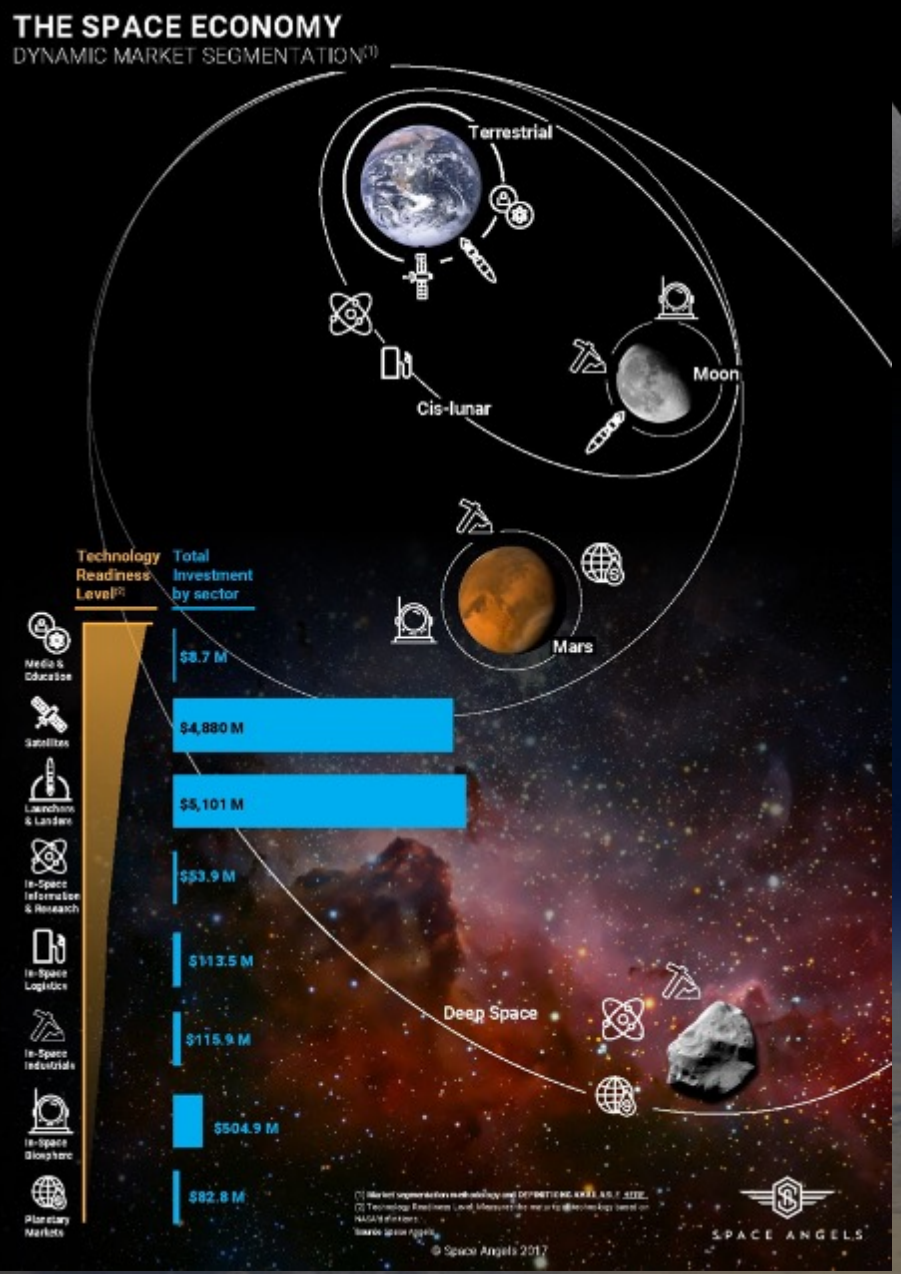


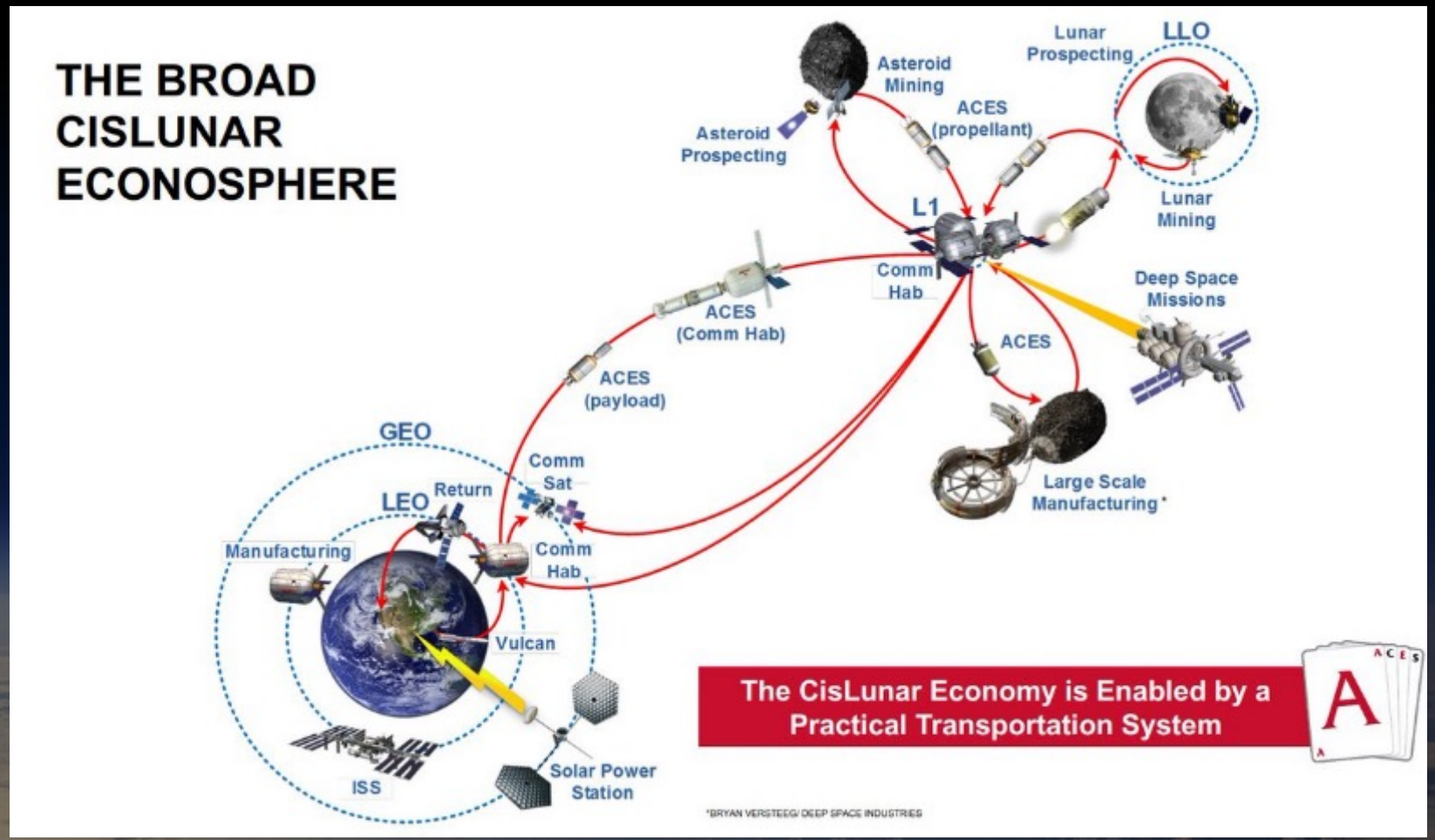
Middle powers attempt to keep the "stag hunt" on target and work to **moderate and benefit from great power activity to exploit new opportunities**

The Geostrategic Importance of Space Resources:

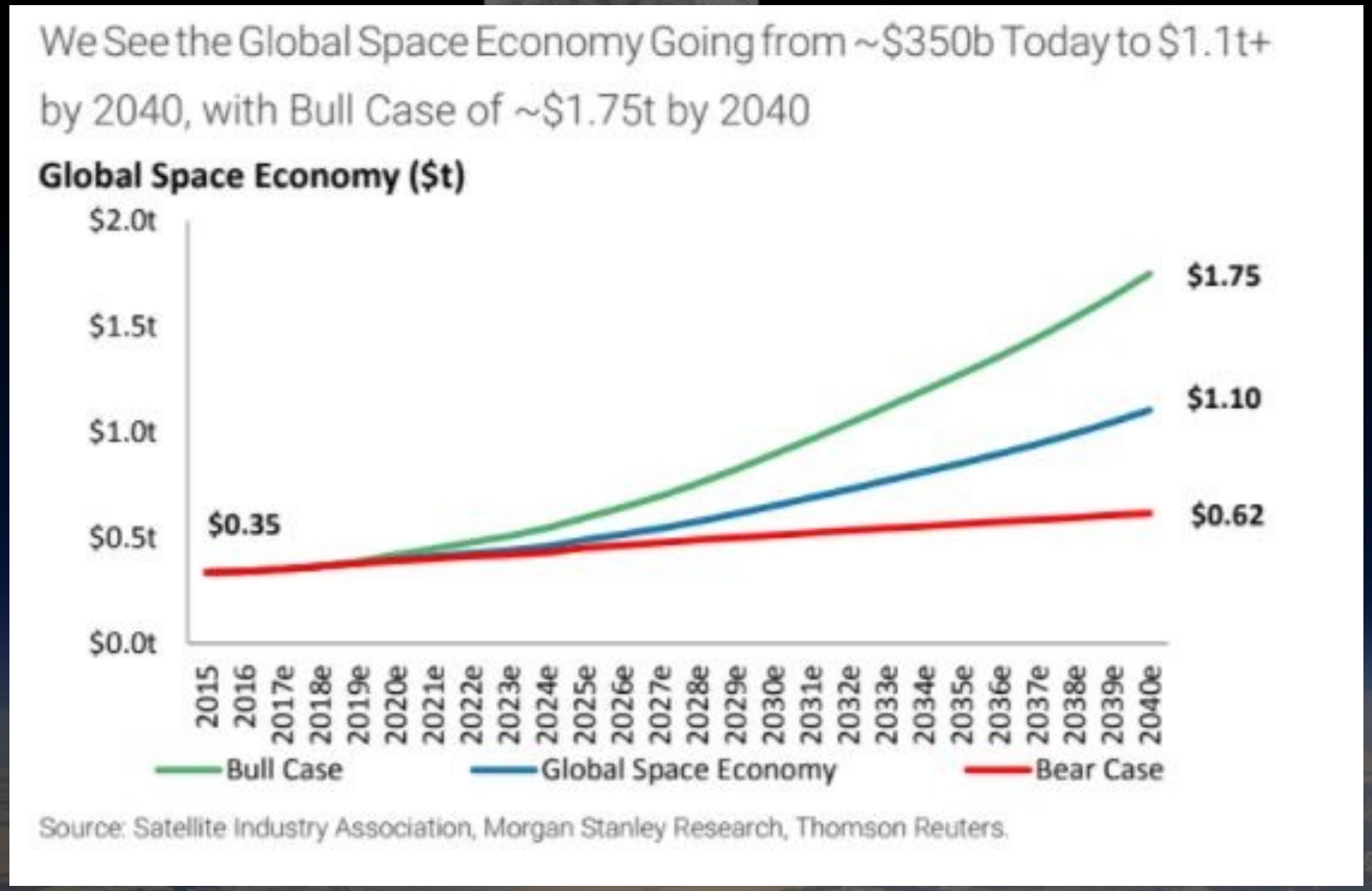
How might Space Resources Affect The Wealth of Nations?

A Cislunar Econosphere





SCALE: Expectation: A multi-trillion Space Economy



Expected to grow from ~$400B today to:

2040 Estimates

- Morgan Stanley: $1.1T/yr
- US Chamber: $1.5T/yr

2050 Estimates

- BoA: $2.7T/yr
- ULA: $2.7T/yr
- China: $10T/yr
- But space resources dwarf these estimates

THE SCALE OF RESOURCES

- Total World GDP < $100T ($84.38T $105.5T)
- United States GDP ~~$18.6T~~ $26.84
- U.S. national debt was $19.9T $31.4T
- U.S. Federal Budget $ 3.8T $5.8T

  Defense $686B (18%) $842 (12% budget/3.1% GDP

  USSF. $30B

  NASA ~~$ 20B~~ $25B
- Largest Mrkt Cap, Apple, $1 Trillion $2.54T
- Richest Person ~~Jeff Bezos~~ $160 billion $211 billion
- Total population of the planet Earth was still under 8B people (7.7B).
- Human civilization today requires 18 terawatts (TW) of all forms of energy

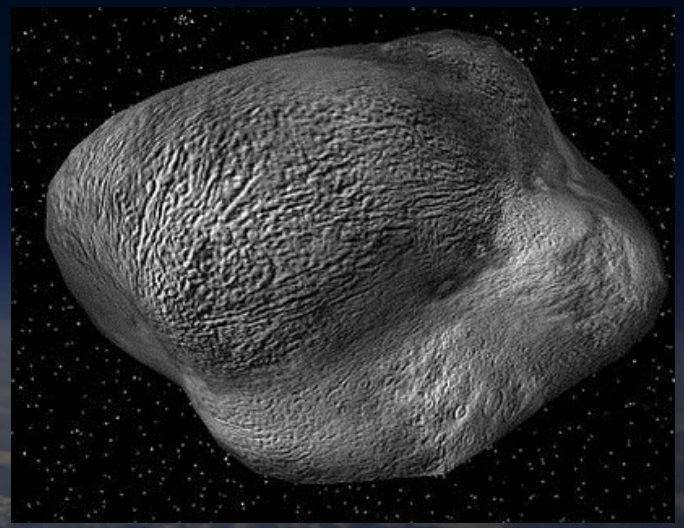
The Material Resources

- The Moon
- The NEAs: 20,000 have been discovered, about 8,500 larger than 140m, and nearly 1000 a kilometer or larger. The overall population of NEAs larger than 10–20 meters is likely tens of millions.
- Mars and its Moons, Phobos and Deimos.
- The Asteroid belt, containing between 1.1 and 1.9 million asteroids larger than a kilometer, and millions of smaller ones

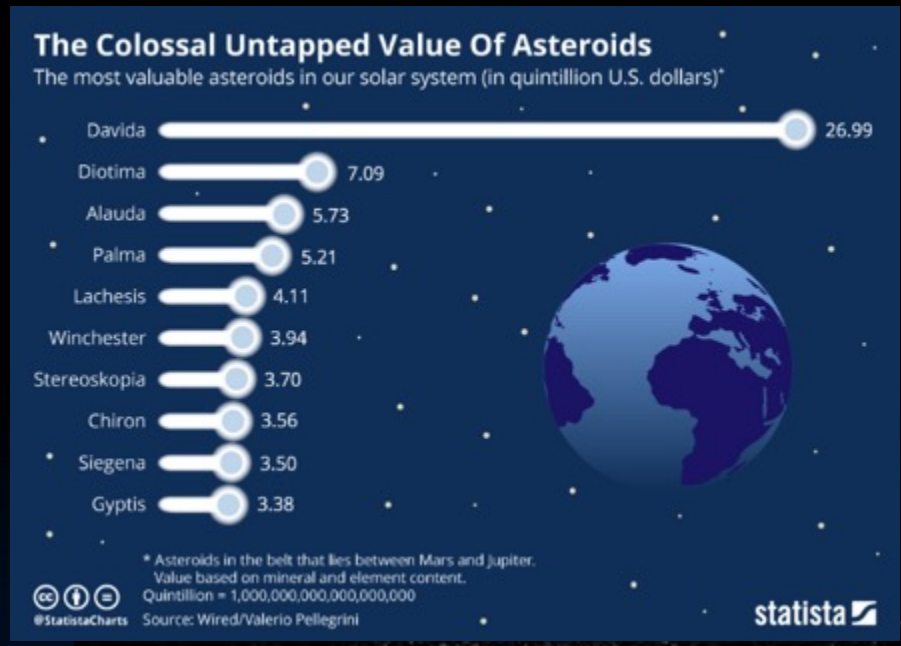
MINERAL WEALTH OF THE SOLAR SYSTEM

- Individual asteroids vastly exceed $1T, eclipsing the wealth of the wealthiest individuals, companies, and many countries.

- Amun 3554, has platinum, nickel, and cobalt worth $20 trillion, bigger than the gross domestic product of Japan, Germany, the United Kingdom, France, and India combined . . . worth 200 times more than all the gold that America mined in California in the gold rush . . . and
- Amun 3554 is “one of the smallest” asteroids in its class.



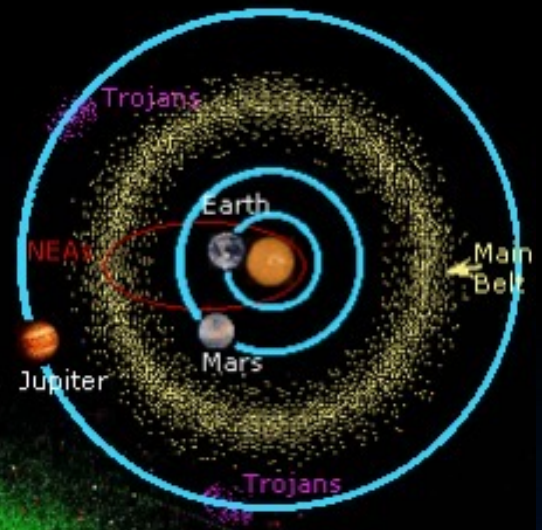
MINERAL WEALTH OF THE SOLAR SYSTEM



- >830 asteroids valued > $1T
- $30T does not touch the upper limit of individual asteroid value.
- at least five hundred of those are valued in excess of $100T
- 16 Psyche, a potato-shaped metallic asteroid (“M-type”), approximately 210 kilometers across reportedly valued at $10,000 quadrillion (a quadrillion is 1,000 trillion).

MINERAL WEALTH OF THE SOLAR SYSTEM

Main Belt
Carrying Capacity
5,000 Billion
People (Lewis)
Wealth $100B for everyone on Earth



NEAs
15,000 known
500k-1m expected
Carrying Capacity
150 Billion People
(Lewis)
Wealth
1739 known Threats

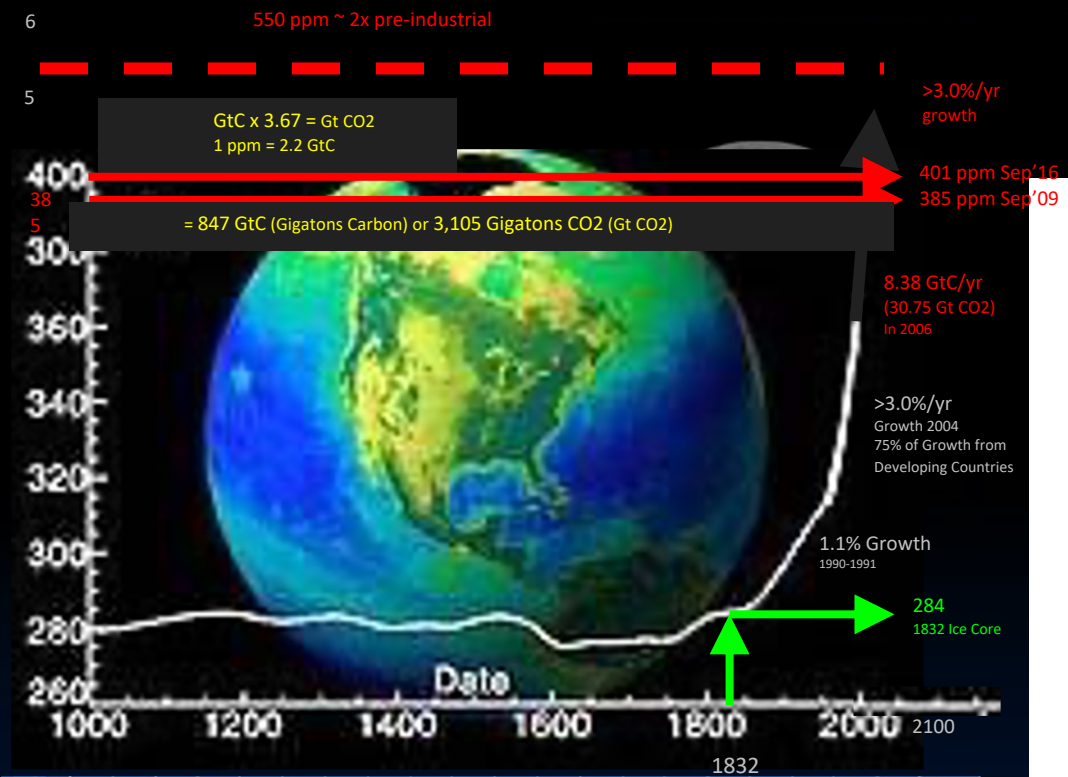
- NASA estimates the Asteroid Belt is worth $700 quintillion [a quintillion is a million trillion] . . .
- That's about $100 billion for each person on Earth

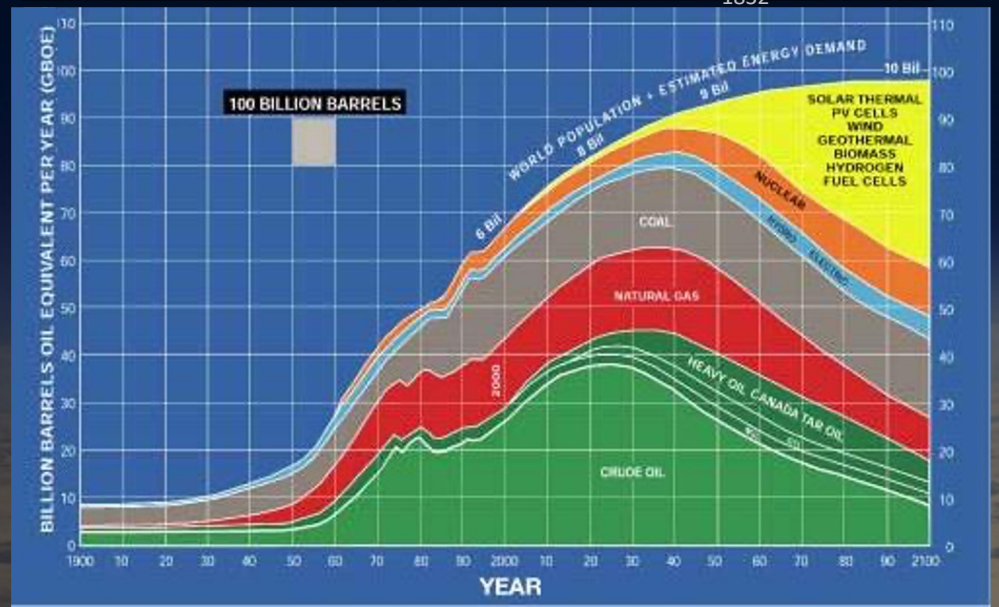
ENERGY WEALTH OF THE SOLAR SYSTEM

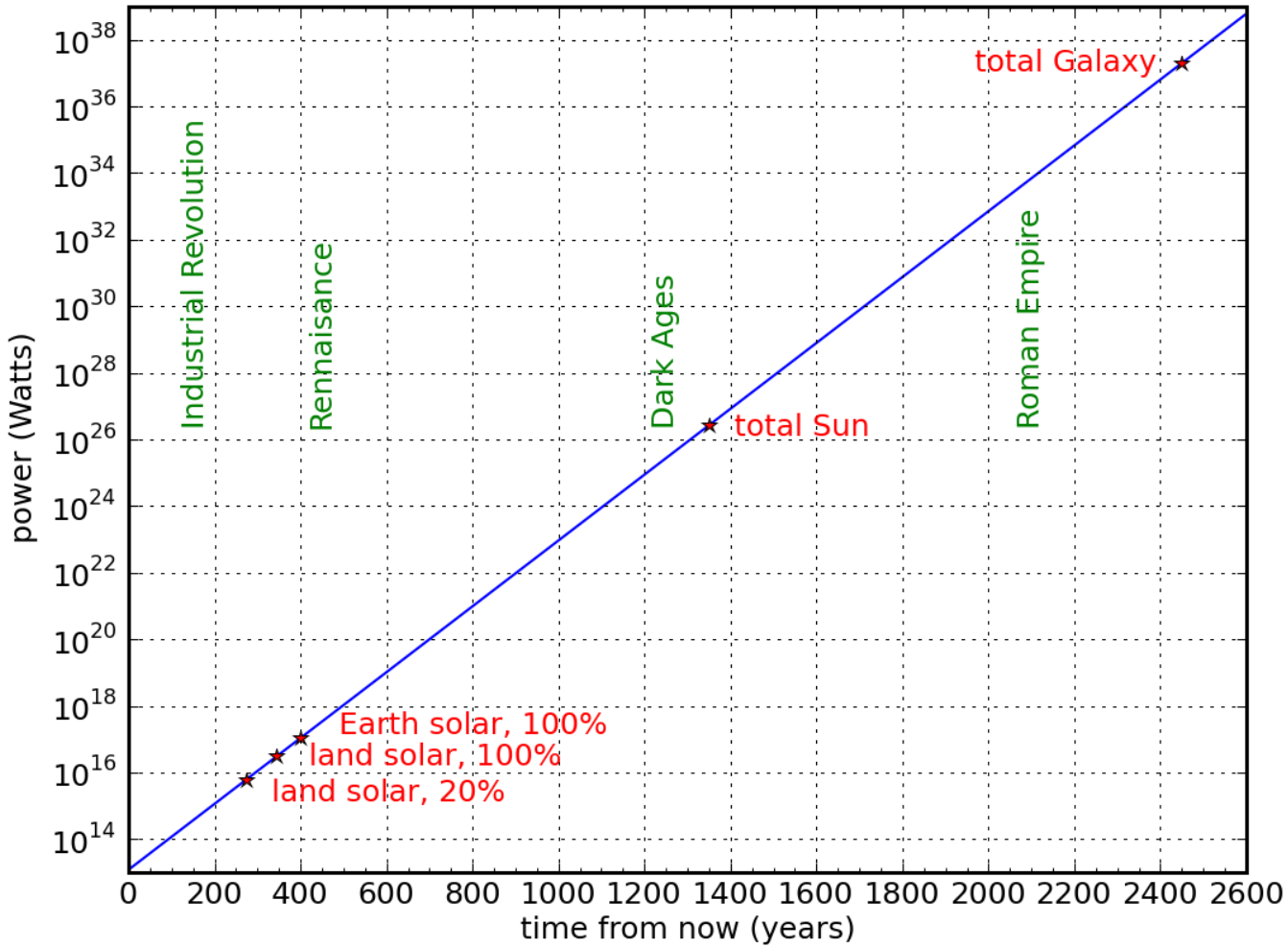
- 18T W to power Human civilization and an economy of $100T.
- 173,000 TW Strikes the disk of the Earth
- 384,000,000,000 TW (384 trillion TW) (or 384.6 yottawatts) output by Sun.
- 331 TW of delivered electrical power available from GEO alone (Snead)

- 1 TW of electric power supports $42T of economic productivity (Criswell).
- 331TW could enable $13,944 Trillion per annum (>166 times Global GDP).

3 Energy Problems



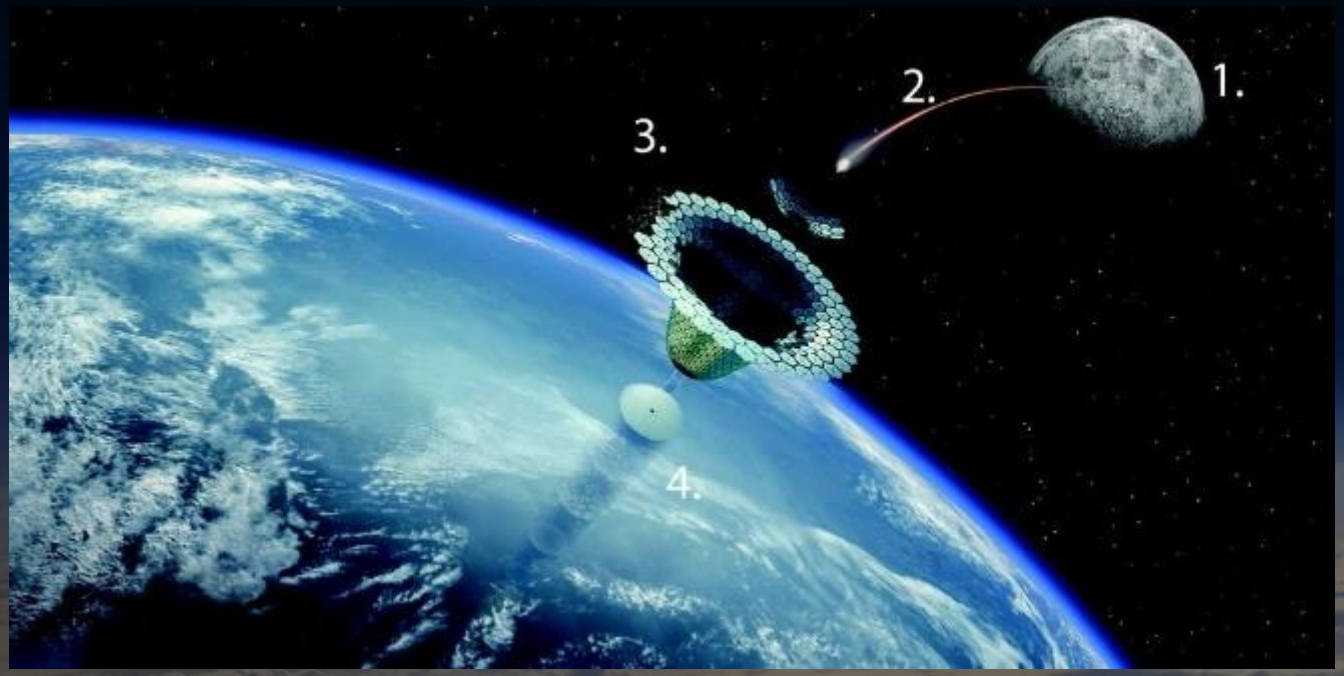




Sustained energy growth at current 2.3%

The Competitive Vision:

- Power to enable Lunar Mining in order to build GEO Satellites at Scale
- 55TW of Green Energy Grows the Global Economy 10x

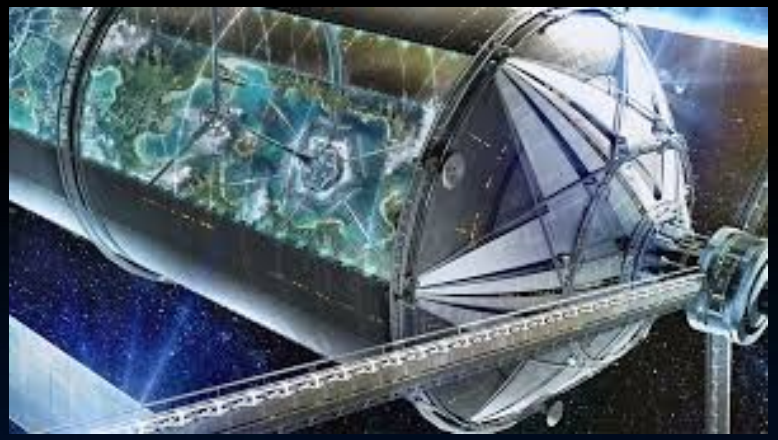


REAL ESTATE WEALTH AND THE LIMITS OF HABITAT EXPANSION

- Even if we limited ourselves to the resources of the asteroid belt (merely the most convenient source of materials, and not the only one), we could still build, in the form of orbital habitats, over 3,000 times the livable surface area of the Earth

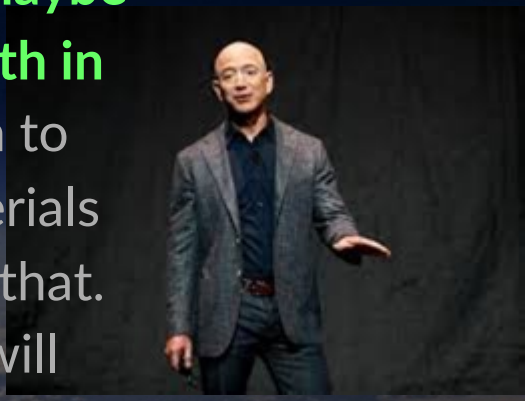
- Dr. John Lewis, a planetary geologist, indicate that the asteroid belt "could support a population of 10 million billion people—a million times the ultimate carrying capacity of Earth," depending solely on the Sun for power.

THE ROLE OF IDEOLOGY AND INDUSTRIALIST AMBITIONS



The Bezos Vision: Million of people living & working in space

It seemed very clear **that planetary surfaces were not the right place for an expanding civilization** inside our solar system . . . There are a lot of other problems with planetary surfaces. But the main one is that they're not big enough. **We have the resources to build room for a trillion humans in this solar system, and when we have a trillion humans**, we'll **have a thousand Einsteins and a thousand Mozarts**. It will be a way more interesting place to live . . . we'll move all heavy, dirty industry off Earth—where, by the way, we'll be able to do it much more effectively with 24/7 solar power . . . The Earth is not a very good place to do heavy industry. It's convenient for us right now, but **in the not-too-distant future, I'm talking decades, maybe 100 years, it'll start to be easier to do a lot of the things that we currently do on Earth in space, because we'll have so much energy**. And then we can send the vitamins down to Earth . . . That's going to be **the Great Inversion**. The beginning is, we'll get bulk materials in space and we'll have to send all the vitamins up, integrated circuits and things like that. We'll have to send all of those up into space, but eventually that will invert, and we will send the vitamins down to Earth.

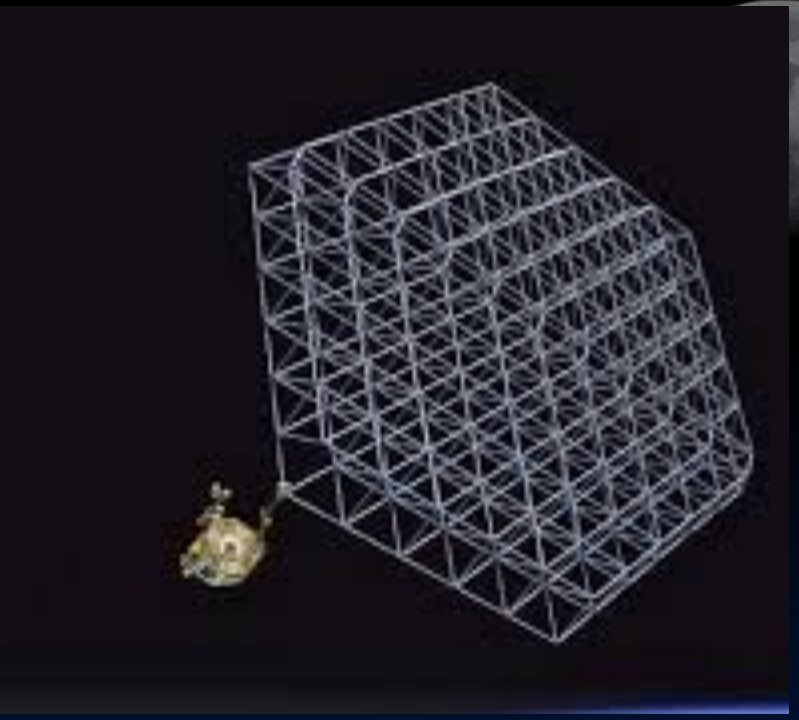


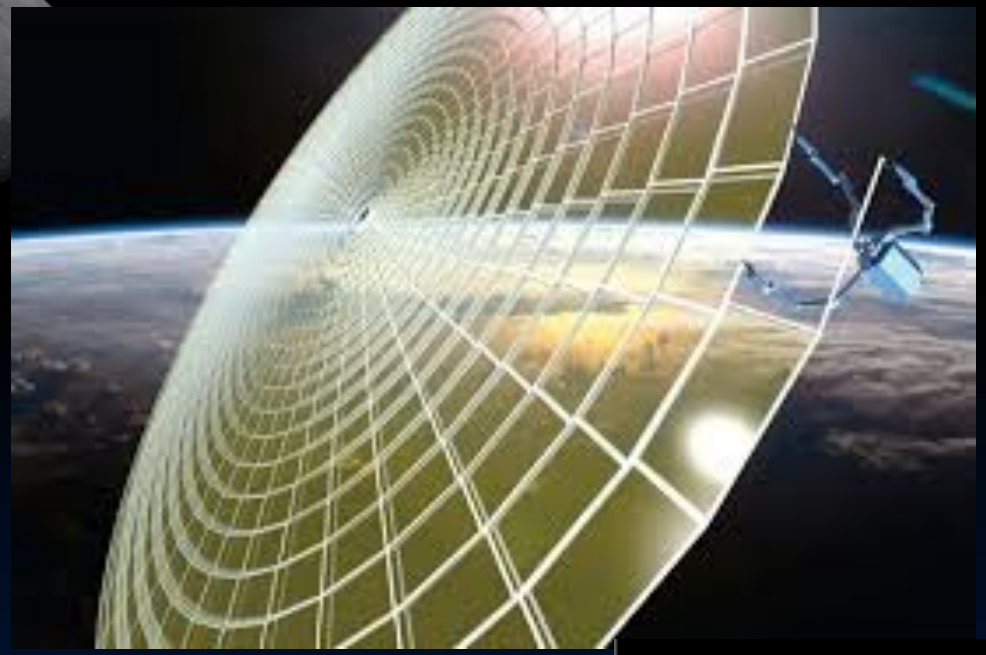
A MASSIVE RETURN ON INVESTMENT (ROI)?

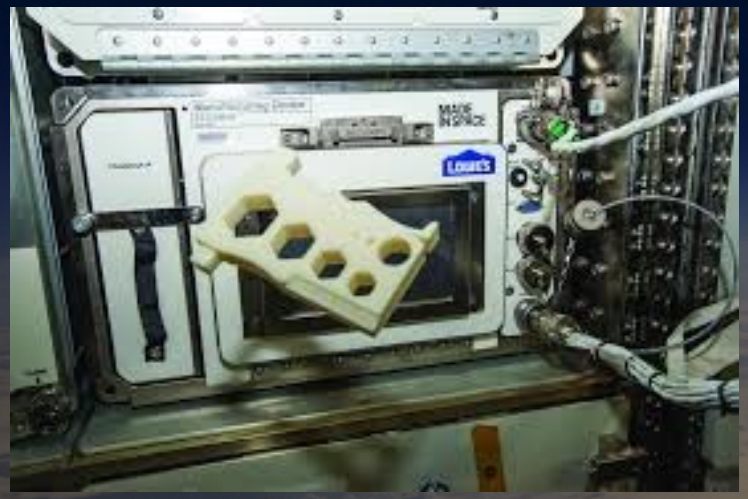
		ROI
1492 Investment	**($300,000)**	
1515 (cumulative)	**$40,000,000**	**130:1**
1600 (cumulative)	**$30,000,000,000**	**100,000:1**
GWNP 1500-1820	**$7,500,000,000,000**	**25,000,000:1**
GWNP 1500-2005	**$1,100,000,000,000,000**	**3,666,666,666:1**

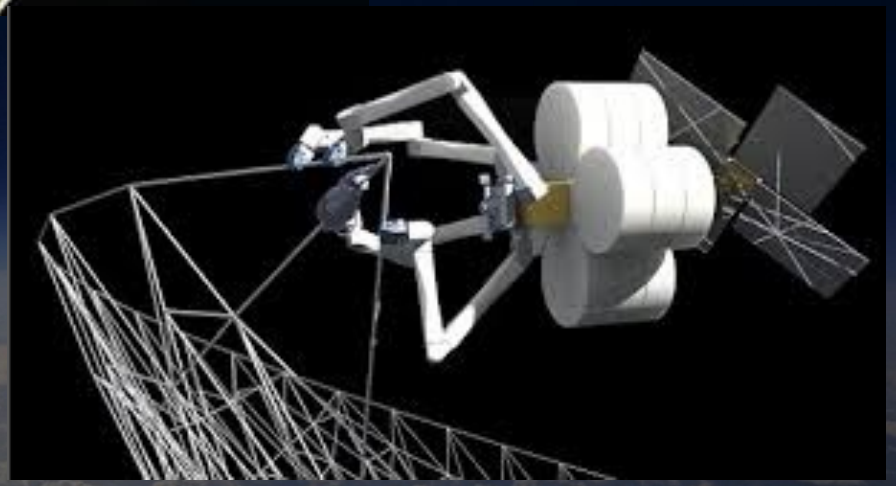
- The Wealth generated IN THE NEW WORLD vastly exceeded the comparatively minor mineral wealth brought back to Europe.
- The scale of Space Resources is vastly greater than the New World
- Imagine an ROI on this scale for space resources

In-Space Manufacturing

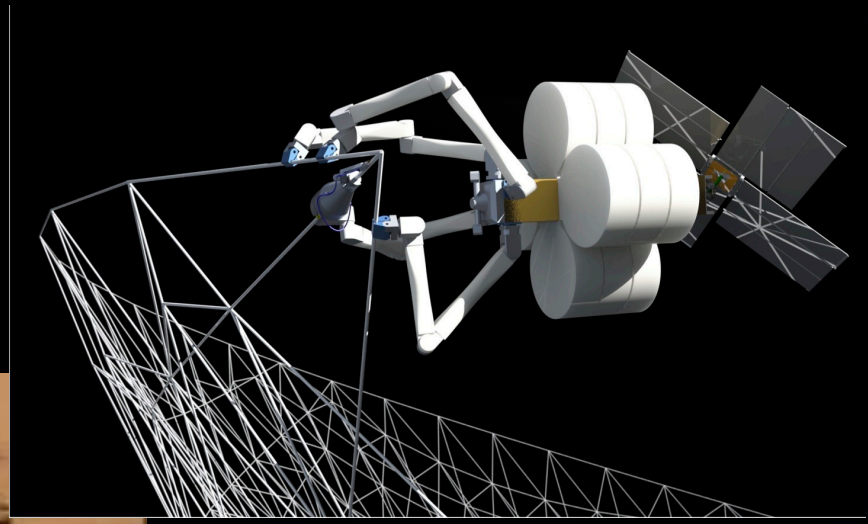


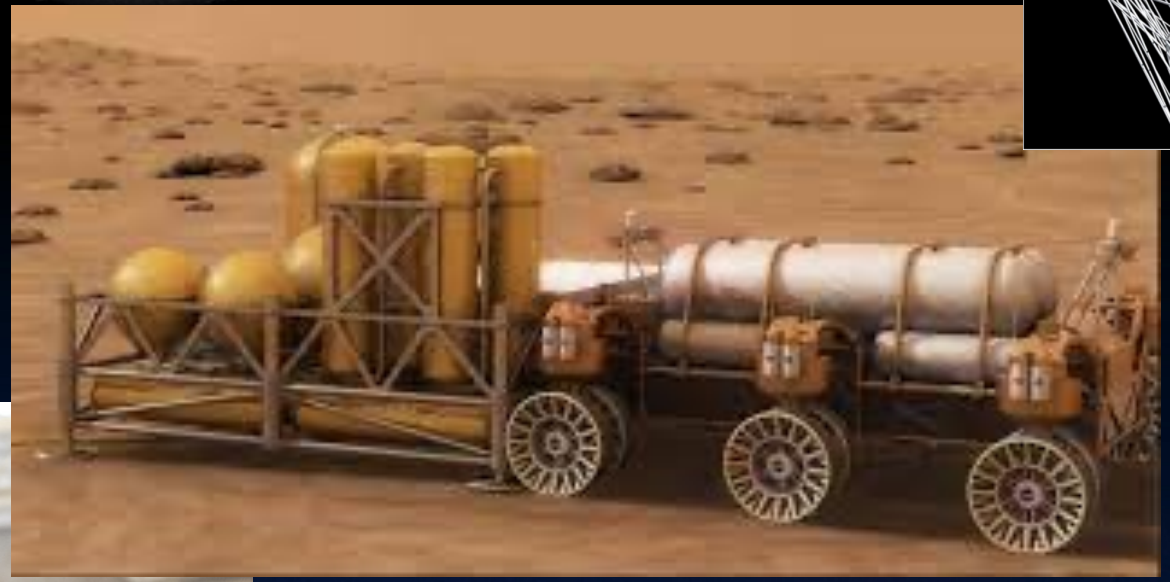


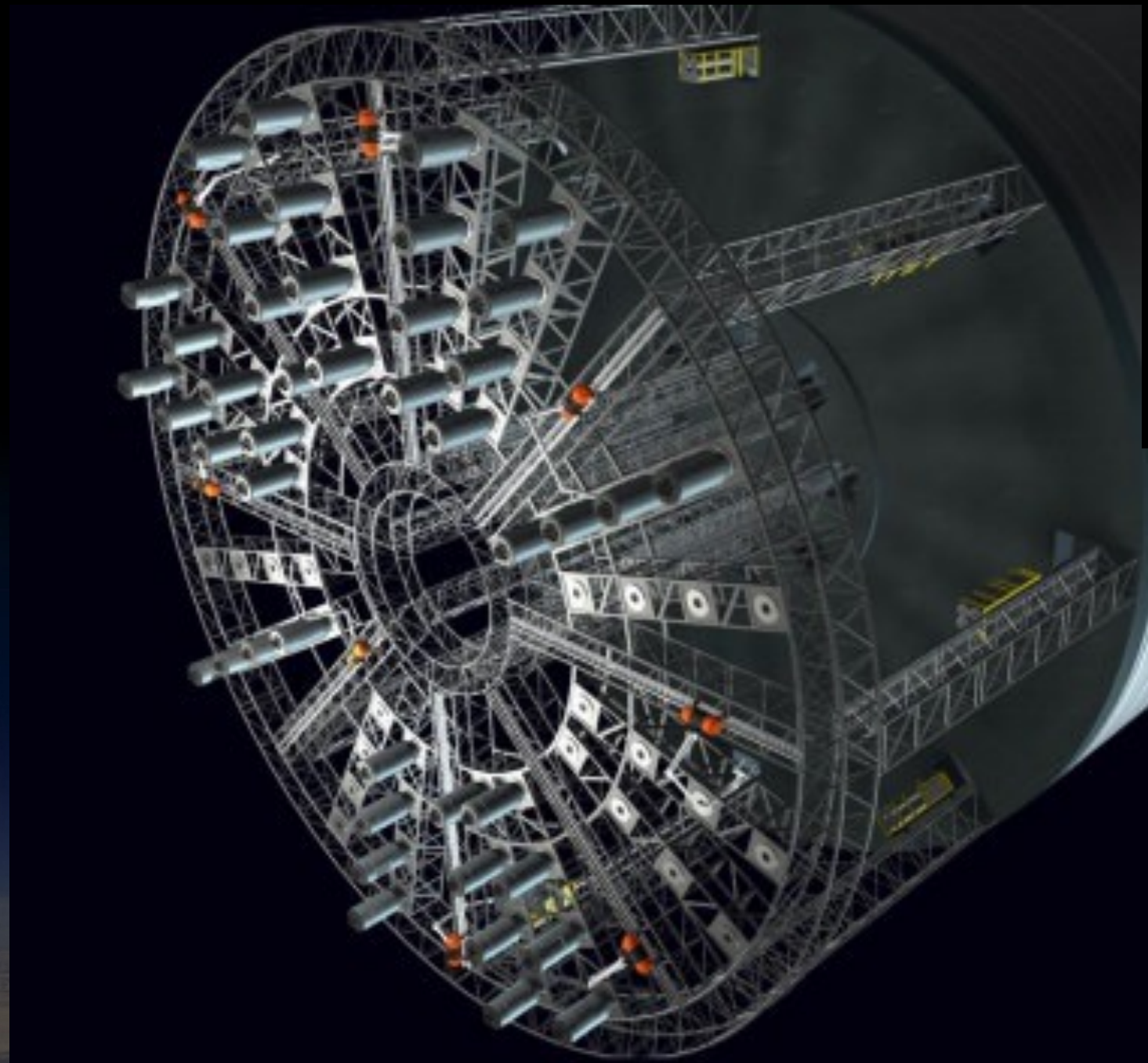


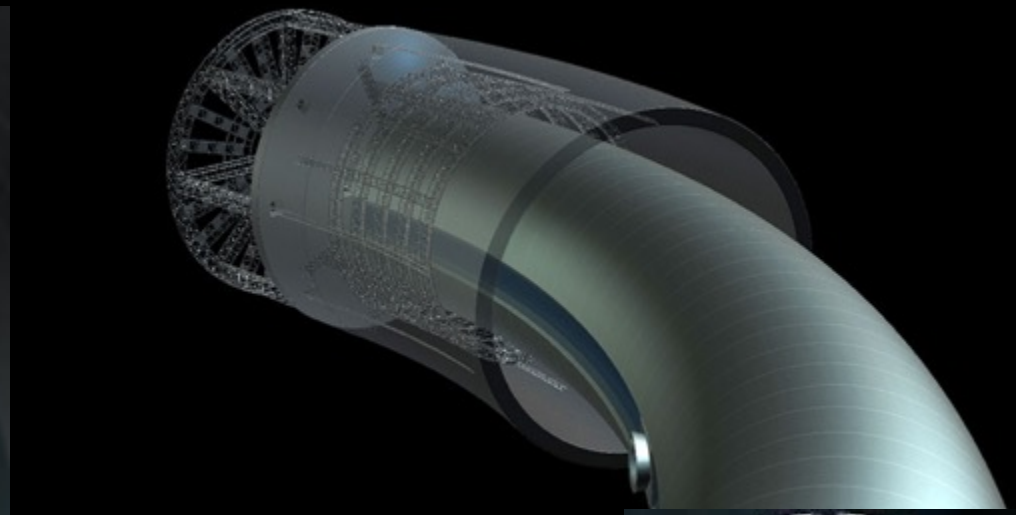


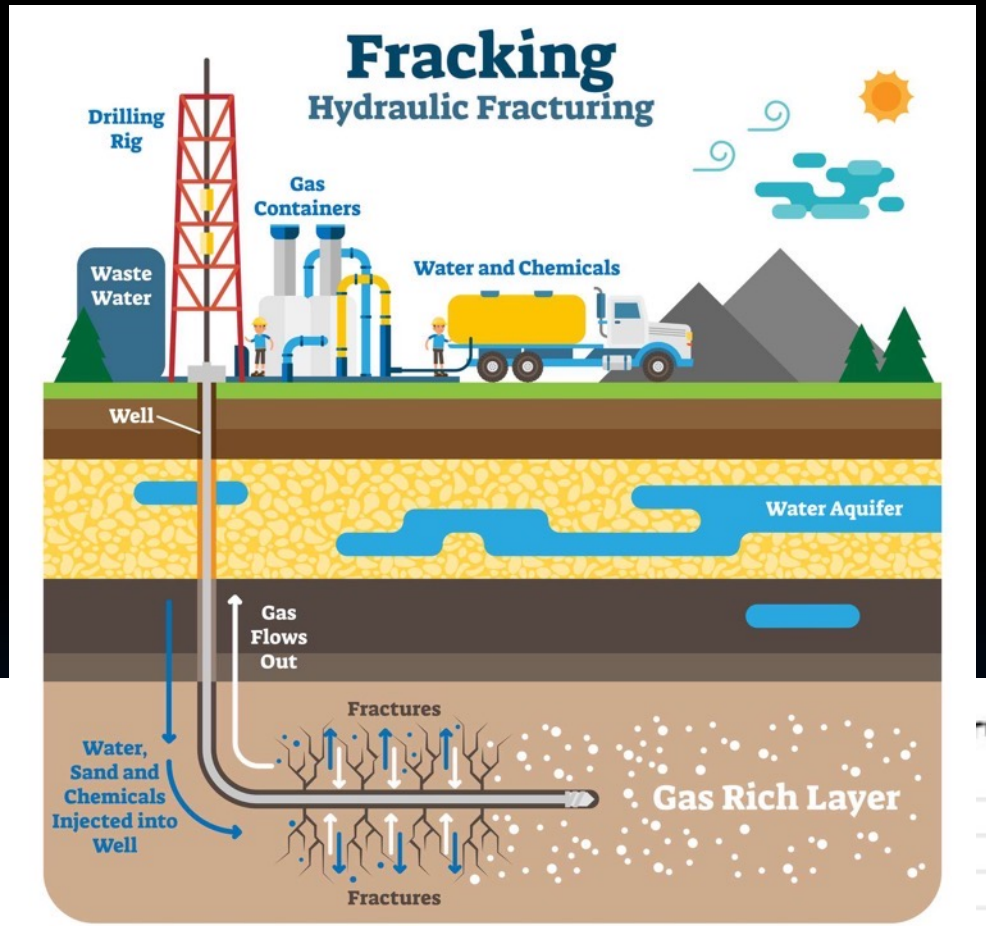
Simple Building Blocks...

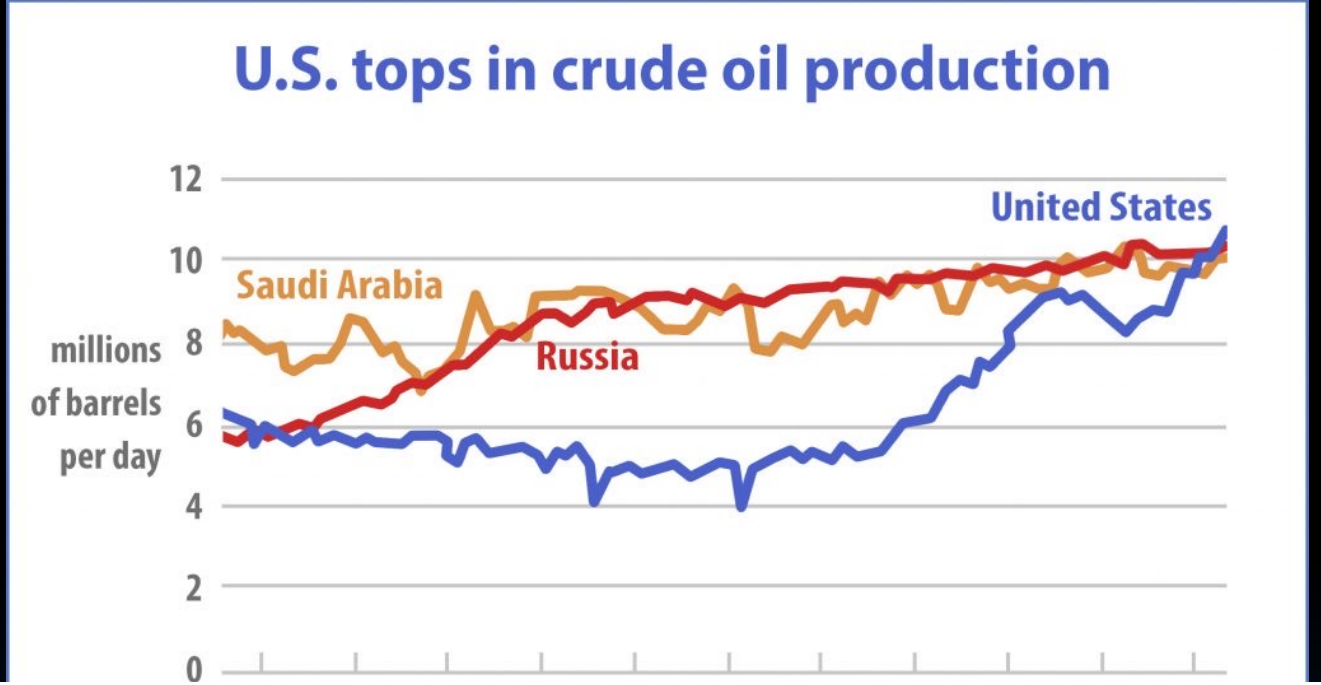


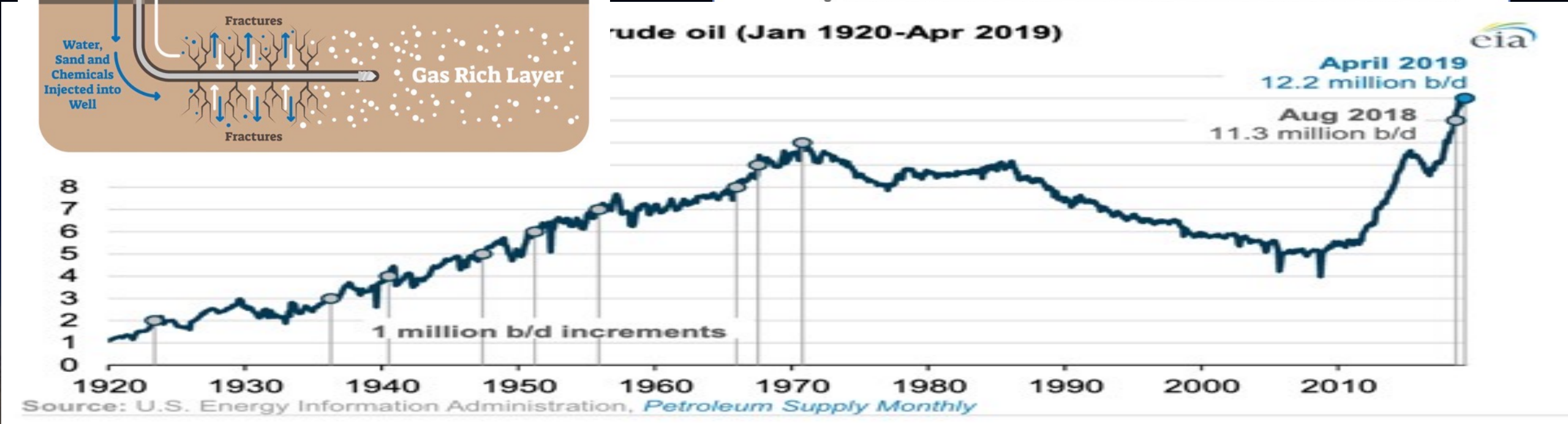







Fracking
Hydraulic Fracturing
Drilling Rig
Gas Containers
Waste Water
Water and Chemicals
Well
Water Aquifer
Gas Flows Out
Fractures
Water, Sand and Chemicals Injected into Well
Gas Rich Layer
Fractures


U.S. tops in crude oil production
12
10
8
6
4
2
0
millions of barrels per day
United States
Saudi Arabia
Russia


ude oil (Jan 1920-Apr 2019)
eia
April 2019
12.2 million b/d
Aug 2018
11.3 million b/d
8
7
6
5
4
3
2
1
0
1 million b/d increments
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Source: U.S. Energy Information Administration, Petroleum Supply Monthly

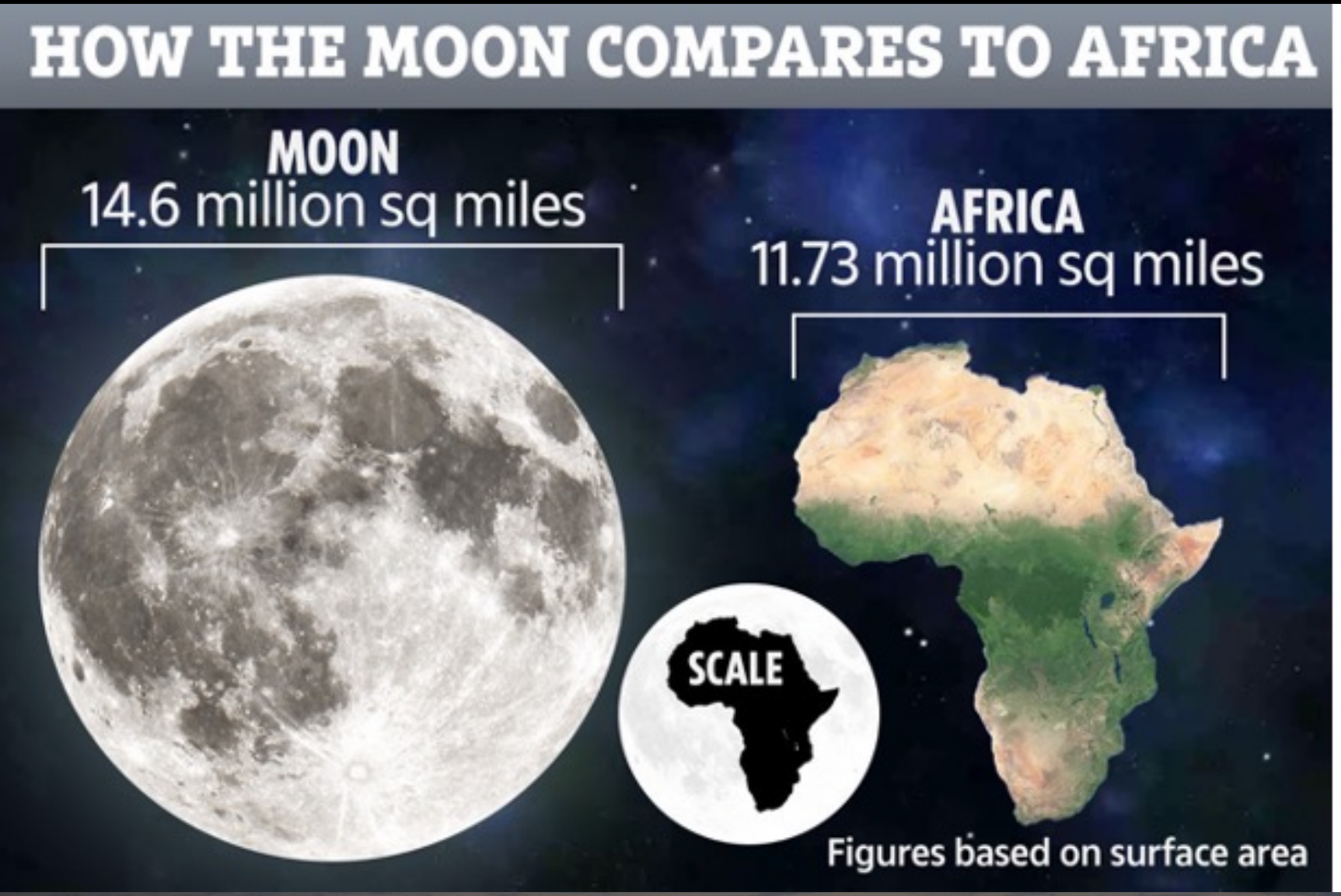

United Kingdom
Ireland
Denmark
Belarus
Poland
Germany
Ukraine
Austria
France
Romania
Italy
Spain
Portugal
Greece
Turkey
Syria
Tunisia
Iraq
Iran
Morocco

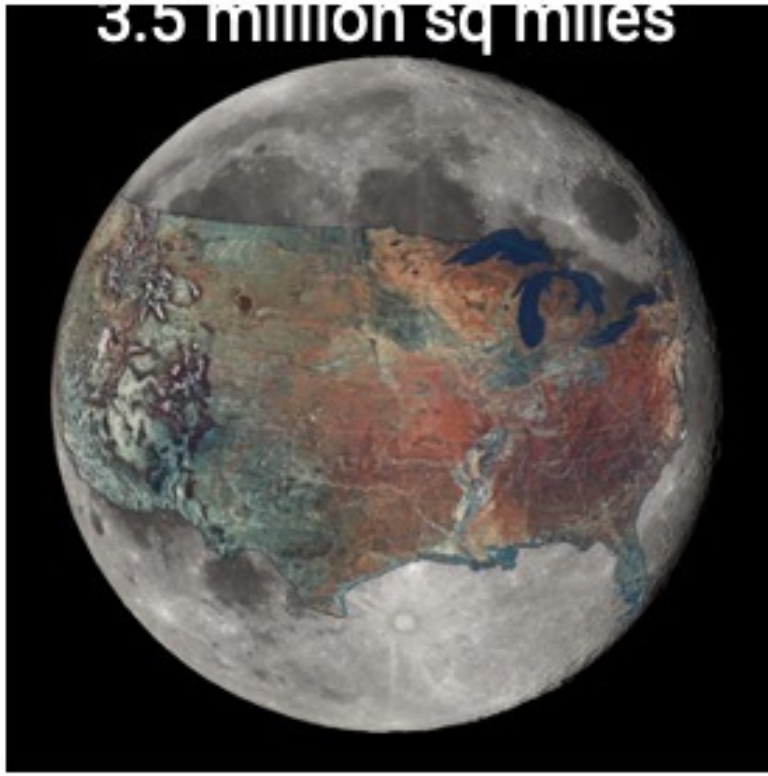

Colonization of Americas
Spanish Territory
Portuguese Territory
French Territory
British Territory
Russian Territory
Dutch Territory


Canada
United States
Brasil

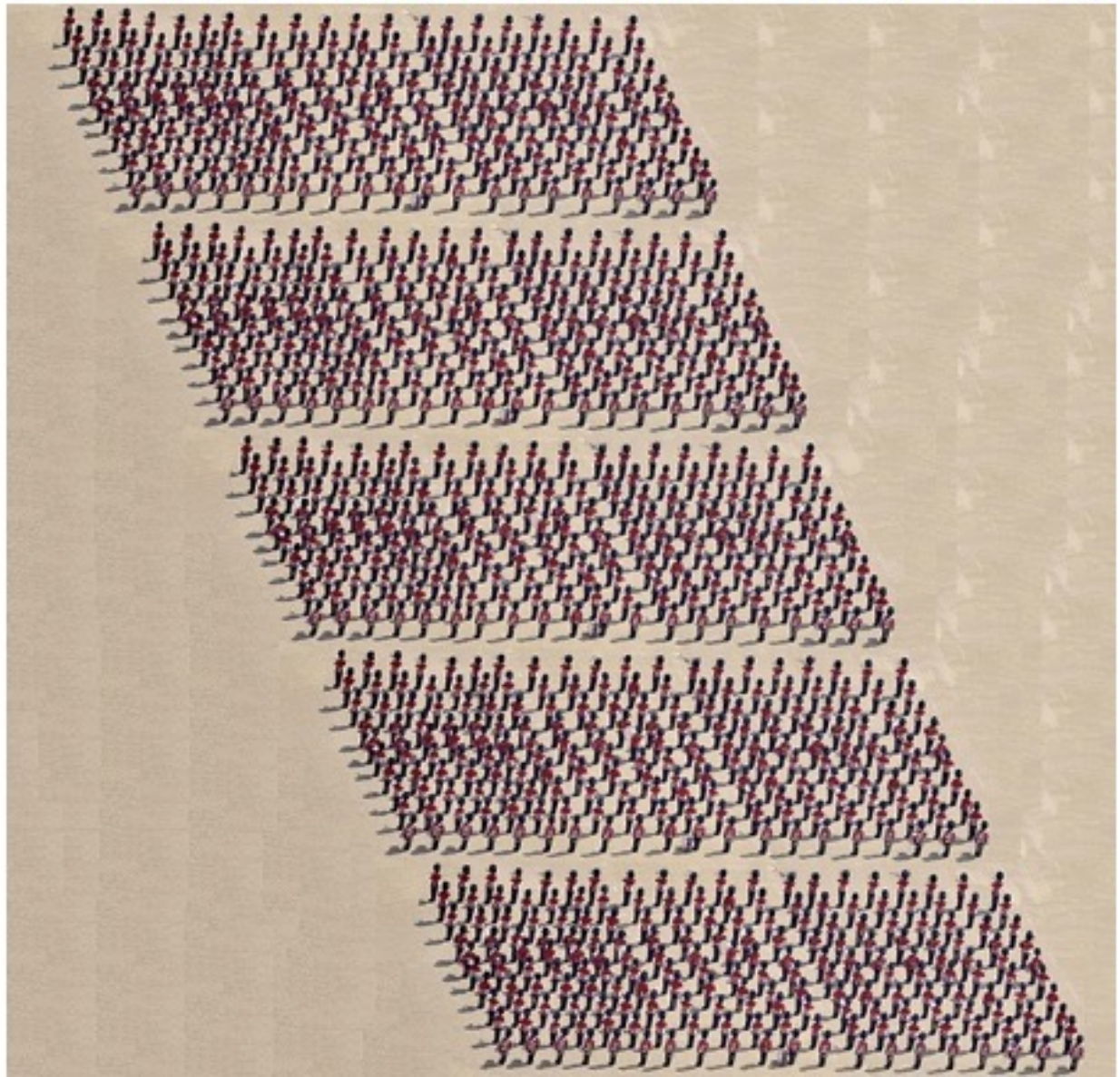

Canada
United States
Brasil

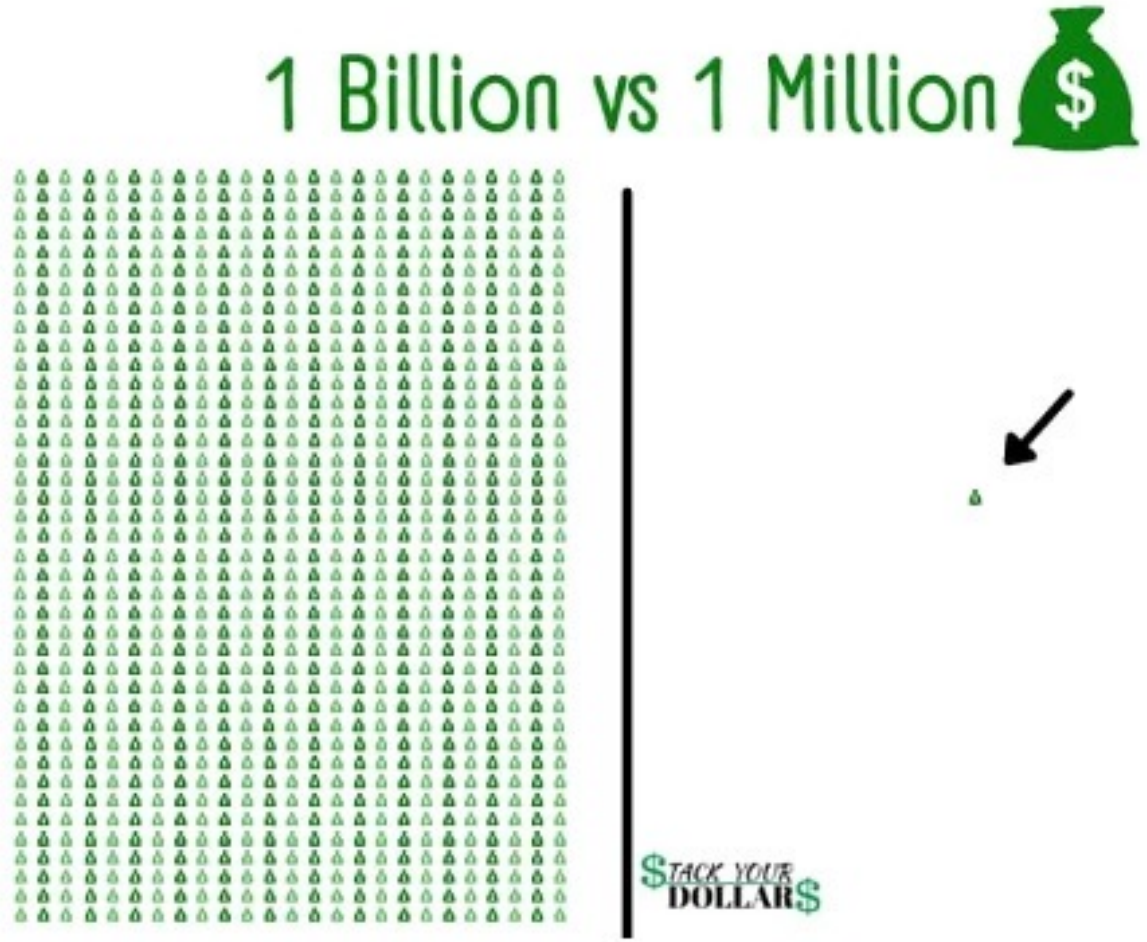

Switzerland
Netherlands
Belgium
Ireland
Austria
France
Italy
U.K.
Portugal
Spain
Eastern Europe (persol)
Greece
Contiguous U.S.
India
China
Japan
Graphic by Bryan Christie and Kai Krause, for Scientific American


HOW THE MOON COMPARES TO AFRICA
MOON
14.6 million sq miles
AFRICA
11.73 million sq miles
SCALE
Figures based on surface area


3.5 million sq miles

a carrying capacity to support a million times our current global population, with in-space habitats supported by a billion times the mineral resources, and a billion times more energy





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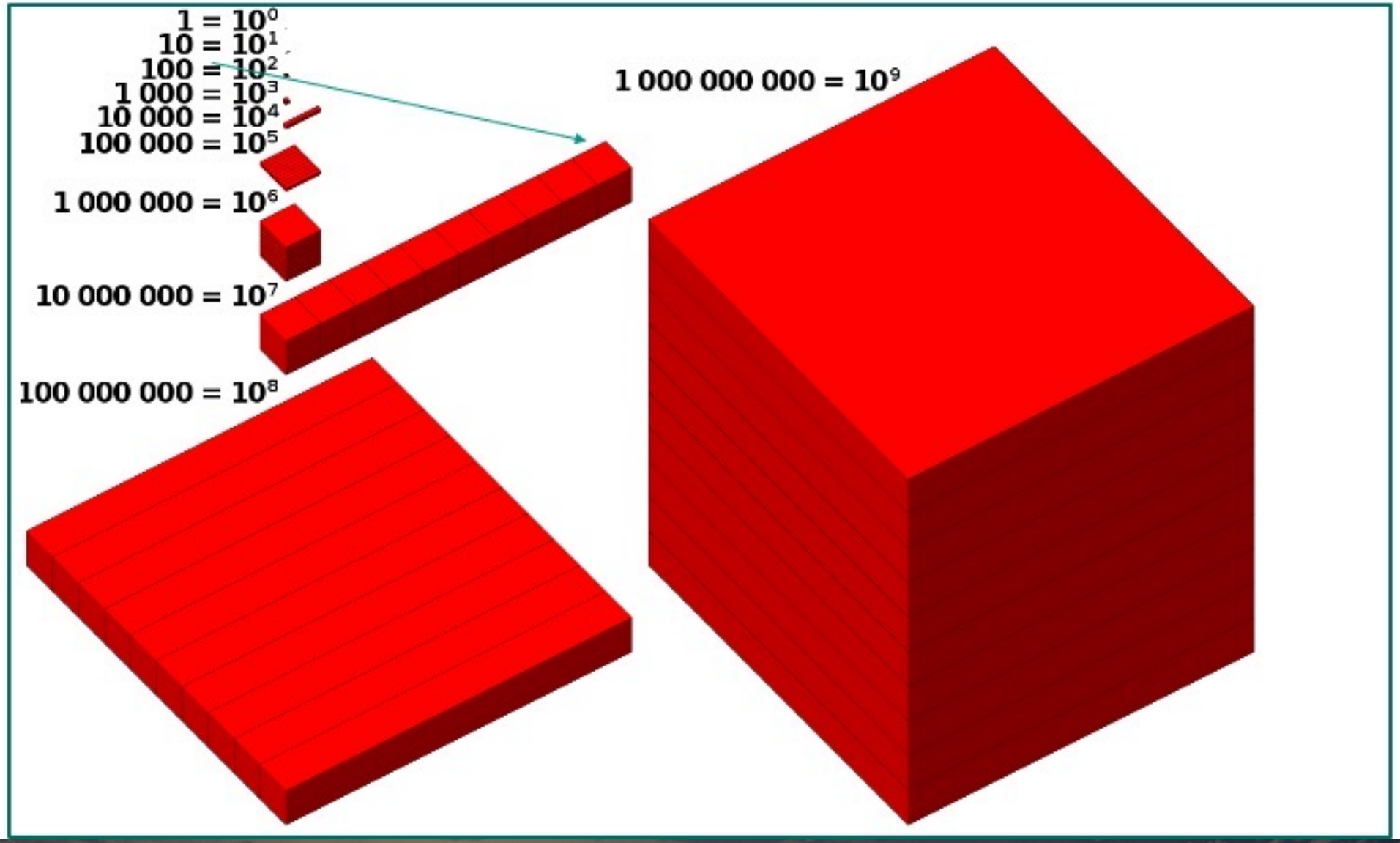
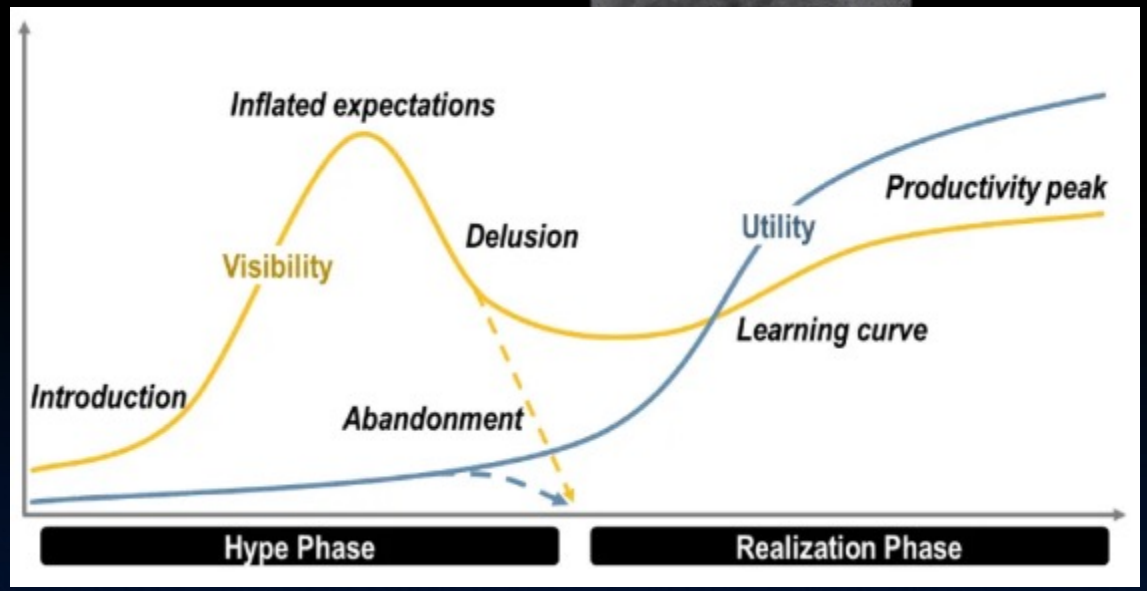
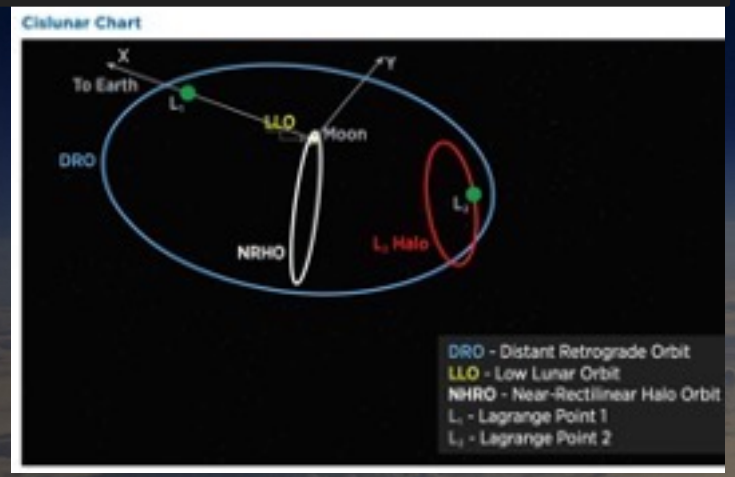


DO SUCH PROJECTIONS DESERVE TO BE TAKEN SERIOUSLY?



- .U.S. Sen. Thomas Benton of Missouri on TCR“an imposture, a humbug; it could have emanated only from a madman . . . Why sir, it’s madness!” . . . “You are one hundred years before your time. “
- “The flying machine which will really fly might be evolved by the combined and continuous efforts of mathematicians and mechanicians in from one million to ten million years
- Arthur C. Clarke warned us, “if we have learned one thing from the history of invention and discovery, it is that, in the long run—and often in the short one—the most daring prophecies seem laughably conservative.”

So Do States Care About Space Resources?



"Human spaceflight and space operations of most types to and beyond the moon will very likely increase in the future. Threats to U.S. and allied military space capabilities will persist as humanity expands its reach into space. Nations are motivated to pursue new scientific missions, compete for military advantage, expand communications and data processing, and obtain greater national and international prestige. **Economic competition to exploit the potentially large amount of natural resources on the Moon**, Mars, or even asteroids, while a nascent endeavor today, will become a driver for more space-capable states or consortiums in the future…**Spacecraft in xGEO are much harder to track and characterize, and could threaten U.S. or allied high-value satellites.** Adversaries could also place operational or reserve satellites in deep space so they are much harder to monitor for later use in lower orbits"

USA

CSCLA
Cislunar Strategy
M2M Objectives
NOM4D / B-SURE
EO on Space Resources
Artemis Accords
Space Diplomacy
Purchase Agreements for precedents (iSpace)

CHINA

ILRS
SSP
Asteroid Mission
Origin Space

India

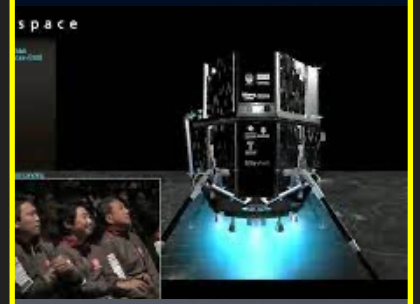
Non-Governmental Entities (NGEs) would be **encouraged to: engage in the commercial recovery of an asteroid resource or a space resource**. Any NGE engaged in such process shall be **entitled to possess, own, transport, use, and sell any such asteroid resource or space resource** obtained in accordance with applicable law, including the international obligations of India.

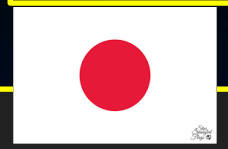
Luxembourg

Approval is granted to an operator for a mission of exploration and **use of space resources for commercial purposes** upon written request addressed to the ministers.

UAE

Exploration, Exploitation and Use of Space Resources
Permits for the exploration, exploitation and use of Space Resources, including their acquisition, purchase, sale, trade, transportation, storage and any Space Activities aimed at providing logistical services



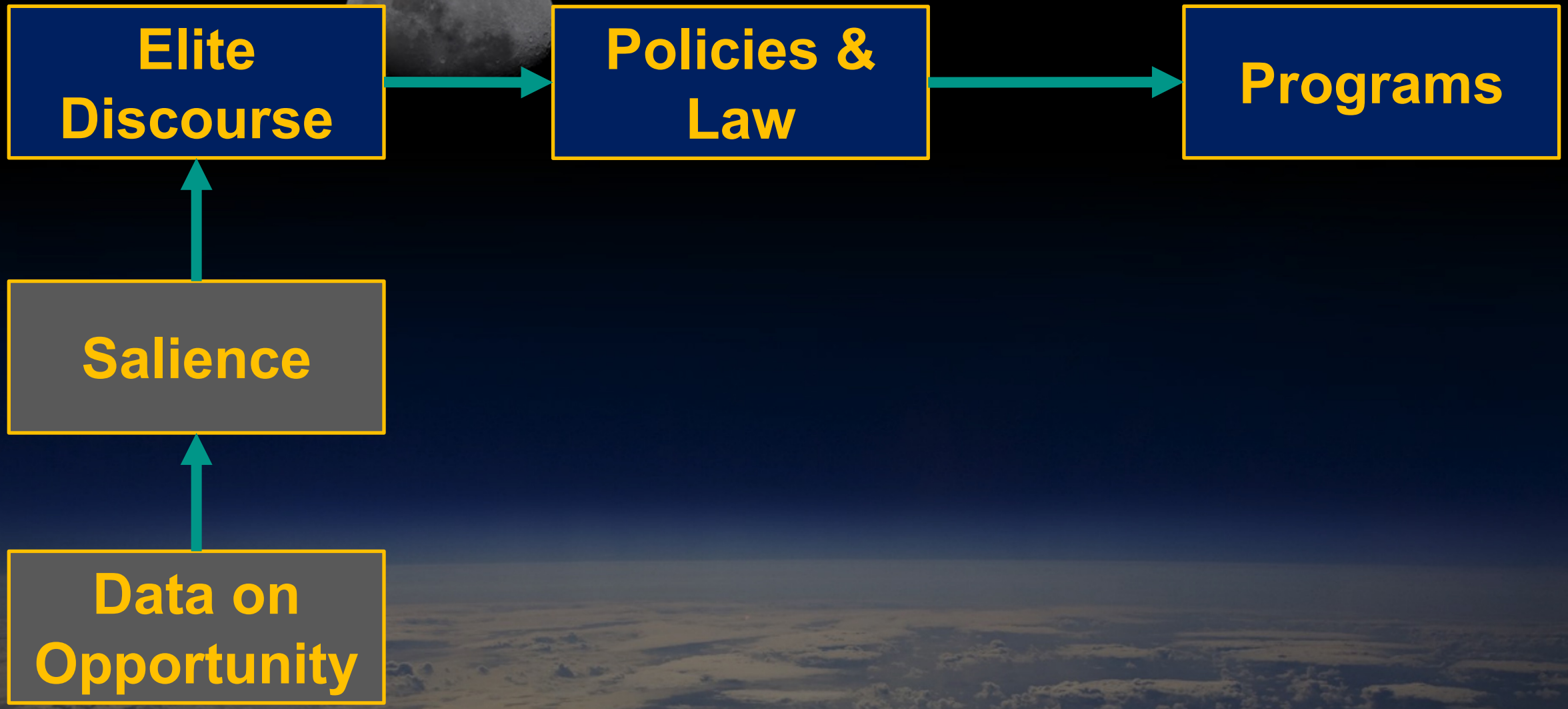


Japan

Defines “space resources” as water, minerals, and other natural resources that exist in outer space, including on the moon and other celestial bodies.
Under the act, a person needs to obtain a permit in order to pursue space resources extraction activities. **The application for the permit is combined with a permit** for launching an artificial satellite - iSpace

Saudi
Turkey
Korea
Canada

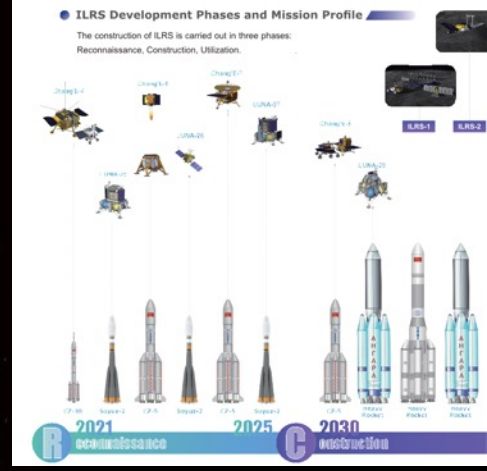
Our Process-Tracing Model



01 ILRS Definition, Composition and Development Phases

Conceptual Design of the ILRS

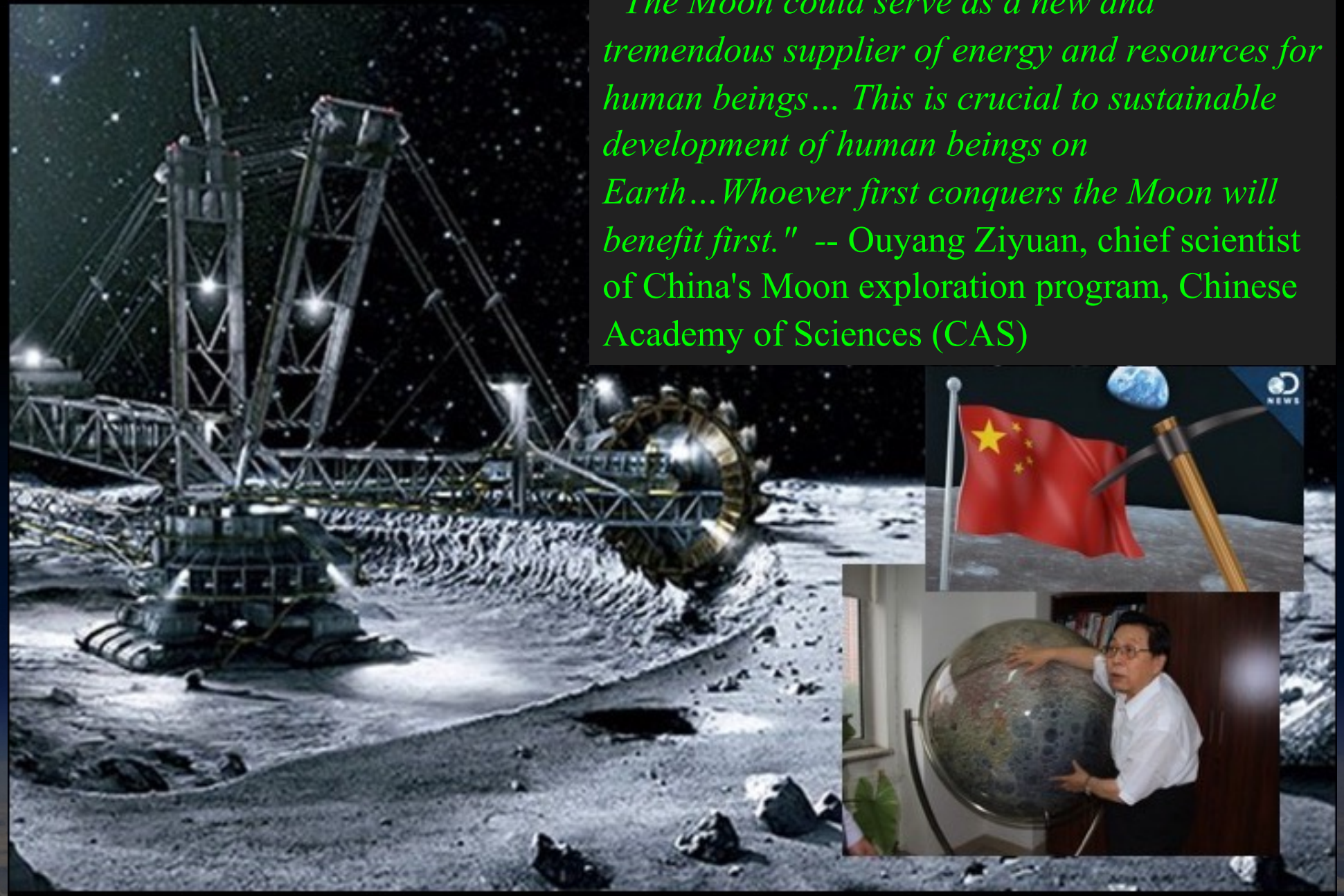
An envisioned design of ILRS at a certain location (or at one of locations) is in Figure 1.



China
Russia
Venezuela?
Argentina?
Brazil?
Pakistan?
UAE?
Iran?
Mongolia
Thailand?
Peru?
Bangladesh?

"China to establish organization to coordinate international moon base"
"China plans to land astronauts on moon before 2030"

"The Moon could serve as a new and tremendous supplier of energy and resources for human beings… This is crucial to sustainable development of human beings on Earth…Whoever first conquers the Moon will benefit first." -- Ouyang Ziyuan, chief scientist of China's Moon exploration program, Chinese Academy of Sciences (CAS)

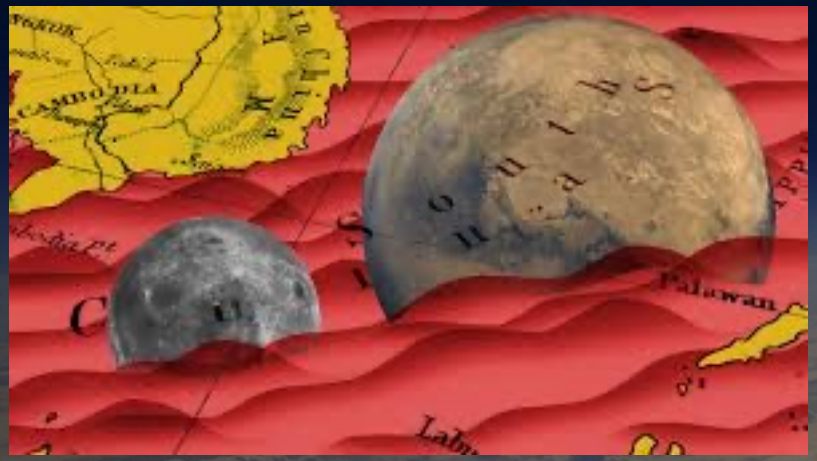


"China would next begin to exploit Earth-Moon space for industrial development. The goal would be the construction of space-based solar power satellites that would beam energy back to Earth…The earth-moon space will be strategically important for the great rejuvenation of the Chinese nation." – Lt Gen Zhang Yulin, CMC

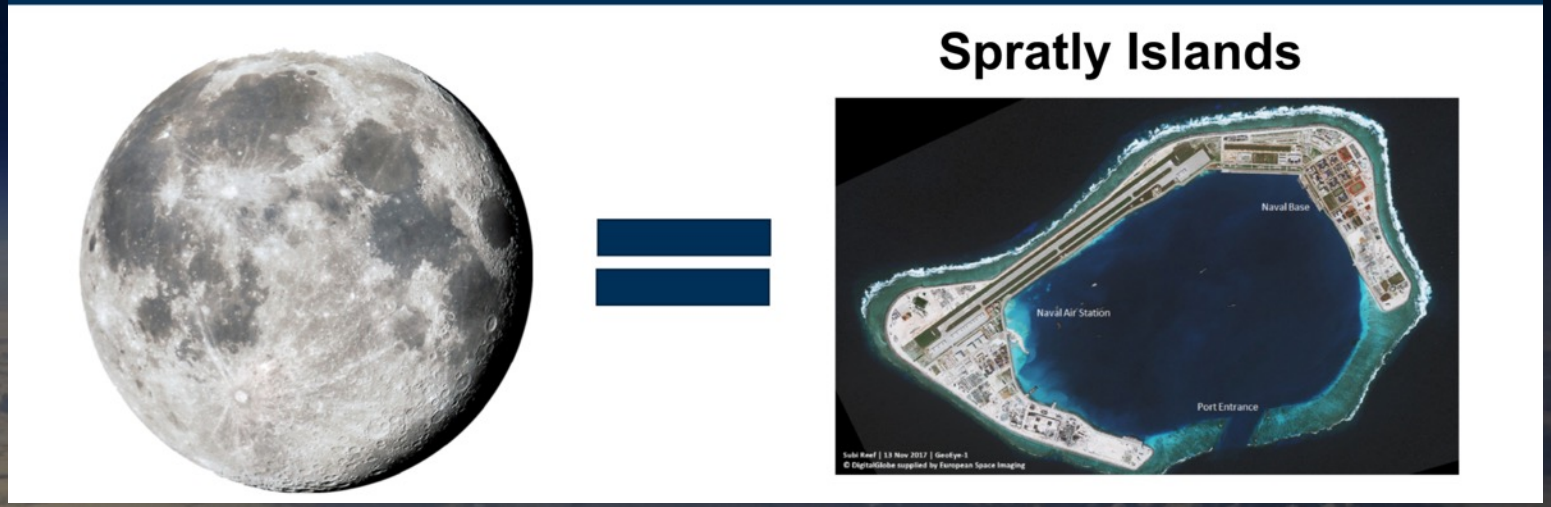
https://www.youtube.com/watch?v=XhgJwnpYRGc

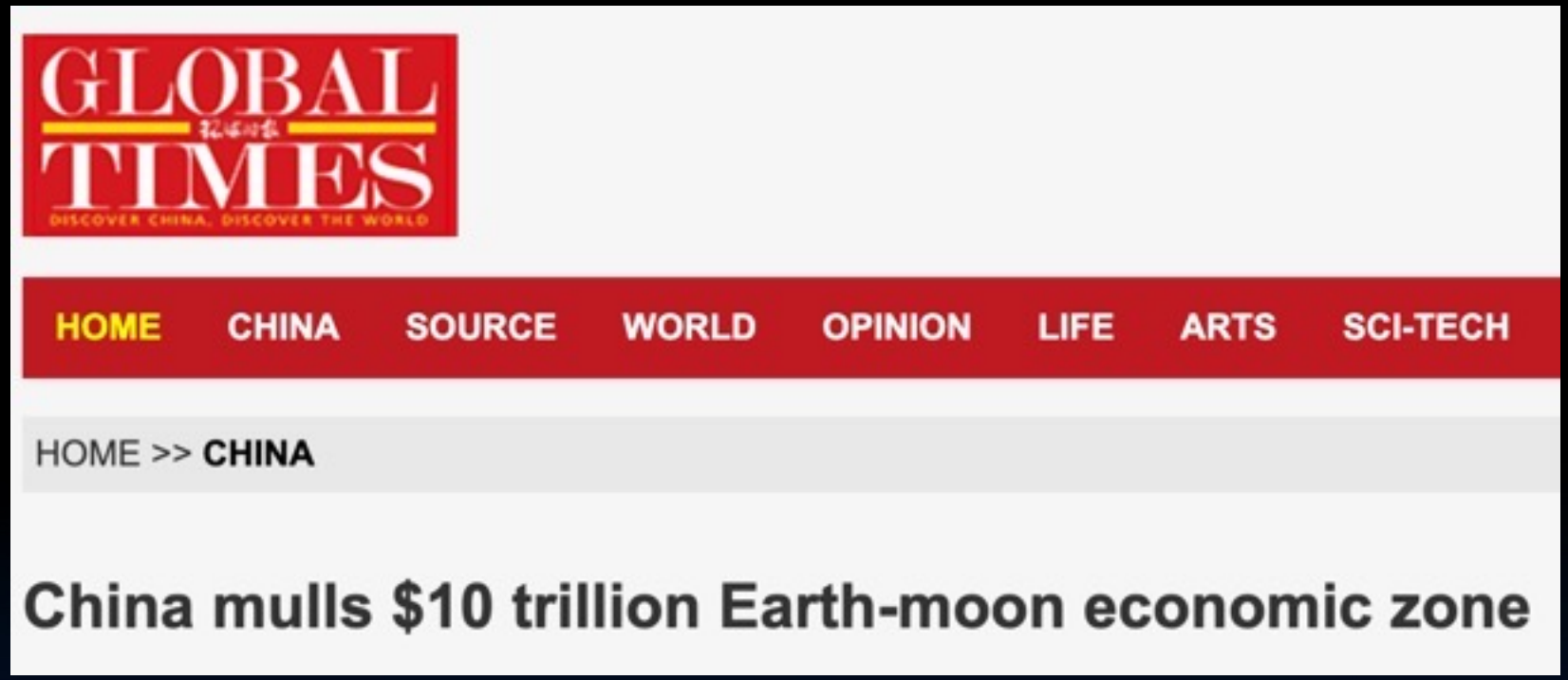
https://www.youtube.com/watch?v=XhgJwnpYRGc

Senkaku and Scarborough Shoal



“The universe is an ocean, the moon is the Diaoyu Islands, Mars is Huangyan Island…If we do not go there now even though we can, then we will be blamed by our descendants…If others go there, then they will take over, and you will not be able to go even if you want to. This is reason enough.” -- Ye Peijiann, head of China’s lunar exploration program





- "China strives to build an Earth-moon space economic zone in the middle of this century, --Bao Weimin, director of China Aerospace Science and Technology's sci-tech commission

- "such a zone could produce $10 trillion in annual economic benefit for China by 2050."

3.3 System Specification

SPS system	Orbit	GEO
	Delivered power	~1MW
	Size	~150m(X)×820m(Y)×100m(Z)
	Total mass	~300t
Solar Energy Collection and Conversion	Solar cell	Thin-film GaAs
	Efficiency	~40%
	Output power	~24MW
	Voltage of solar array modules	~500V
	Mass	~60t
Microwave Power Transmission	Frequency of microwave	5.8GHz
	Diameter of transmitting antenna	~150m
	Beam precision	0.003°
	Diameter of receiving antenna	~5km
	Mass	~100t
Power Transmission and Management	Voltage of main cable	5000 V
	Number of rotary joints	24
	Mass	~65t
Structure	Module	Deployed truss
	Mass	~40t
Attitude and Orbit Control	Thrusters	20kW electric thruster
	Mass	~20t
others	Mass of thermal Management	~10t
	Mass of ISRM	~5t
Operation mode	Continuous transmission	

3. Bishan SPS Experimental Base Project

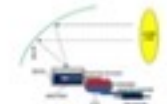
The towers and cables scheme. The height of tower is about 75m.

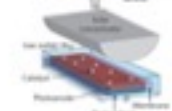
Roam_1

Roam_2

About PHASE Group

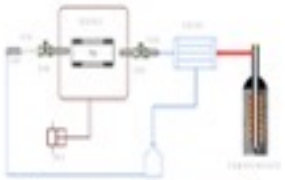
Planetary Habitability And Sustainable Exploration


In-situ solar thermal generator

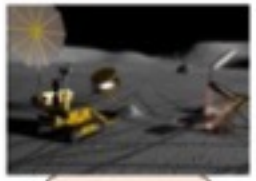

Artificial photosynthesis processes


ISRU method


Multiphase physical processes

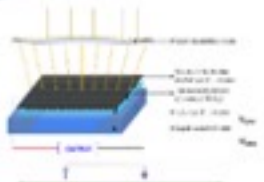

Planetary Volatiles detection and extraction device


Artificial photosynthesis device


In-situ synthetic depot

Space exploration missions

Development roadmap


Micro solar system, Solar water splitting


Solar fuel, solar CHP system


Green building, habitable environment

Earth sustainable development

2018 2019 2020 2021 2022 2023 2024 2025

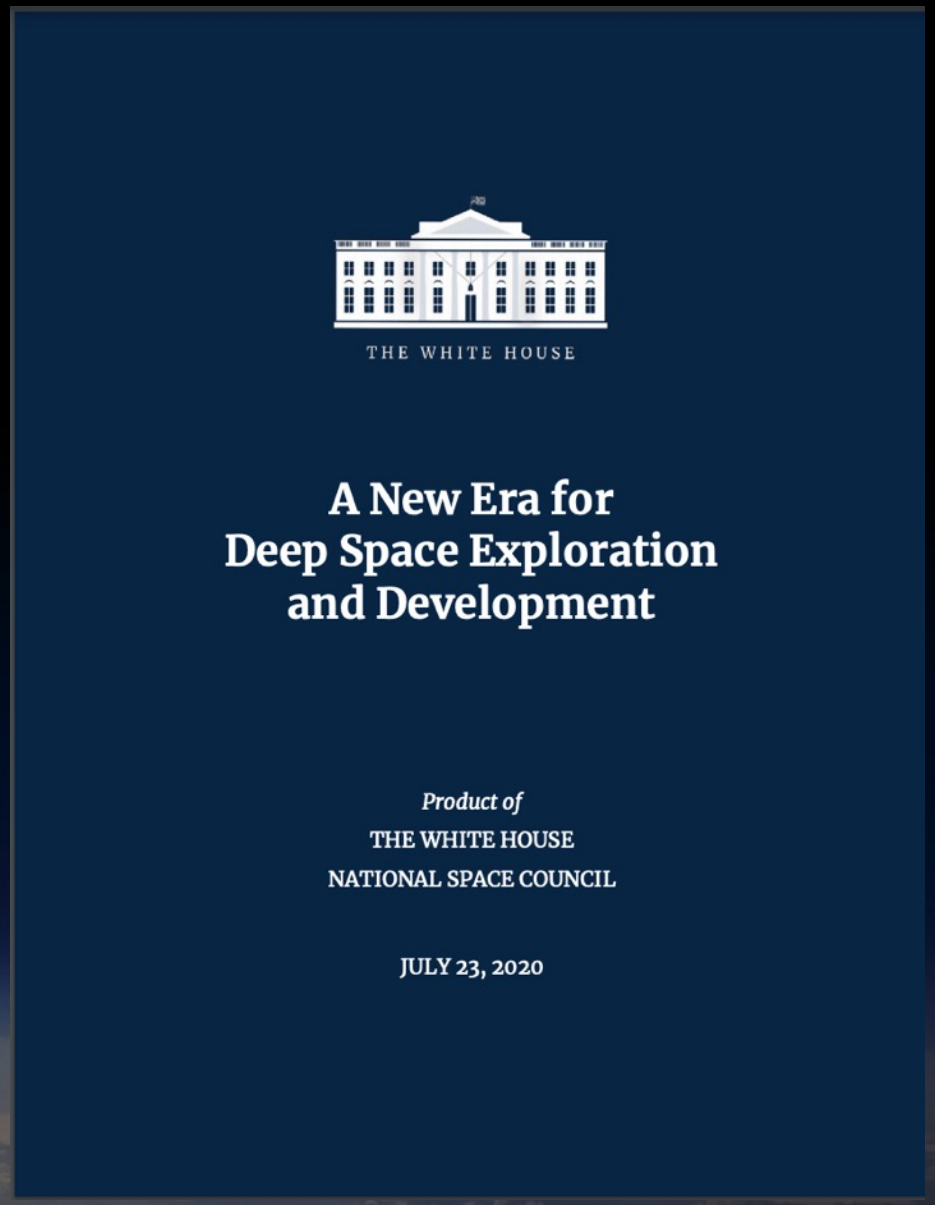
"It must be stated that constitutionally, the U.S. government is required to provide for the common defense. This includes defending American military assets in space AND commercial assets in space, many of which have and will have a dual role of providing commercial and military capabilities.

The U.S. government must establish a legal framework and be prepared to defend private and corporate rights and obligations all within keeping the Outer Space Treaty. And to enable freedom of action, the United States must have cis-lunar situational awareness, a cis-lunar presence, and eventually must be able to enforce the law through cis-lunar power projection."

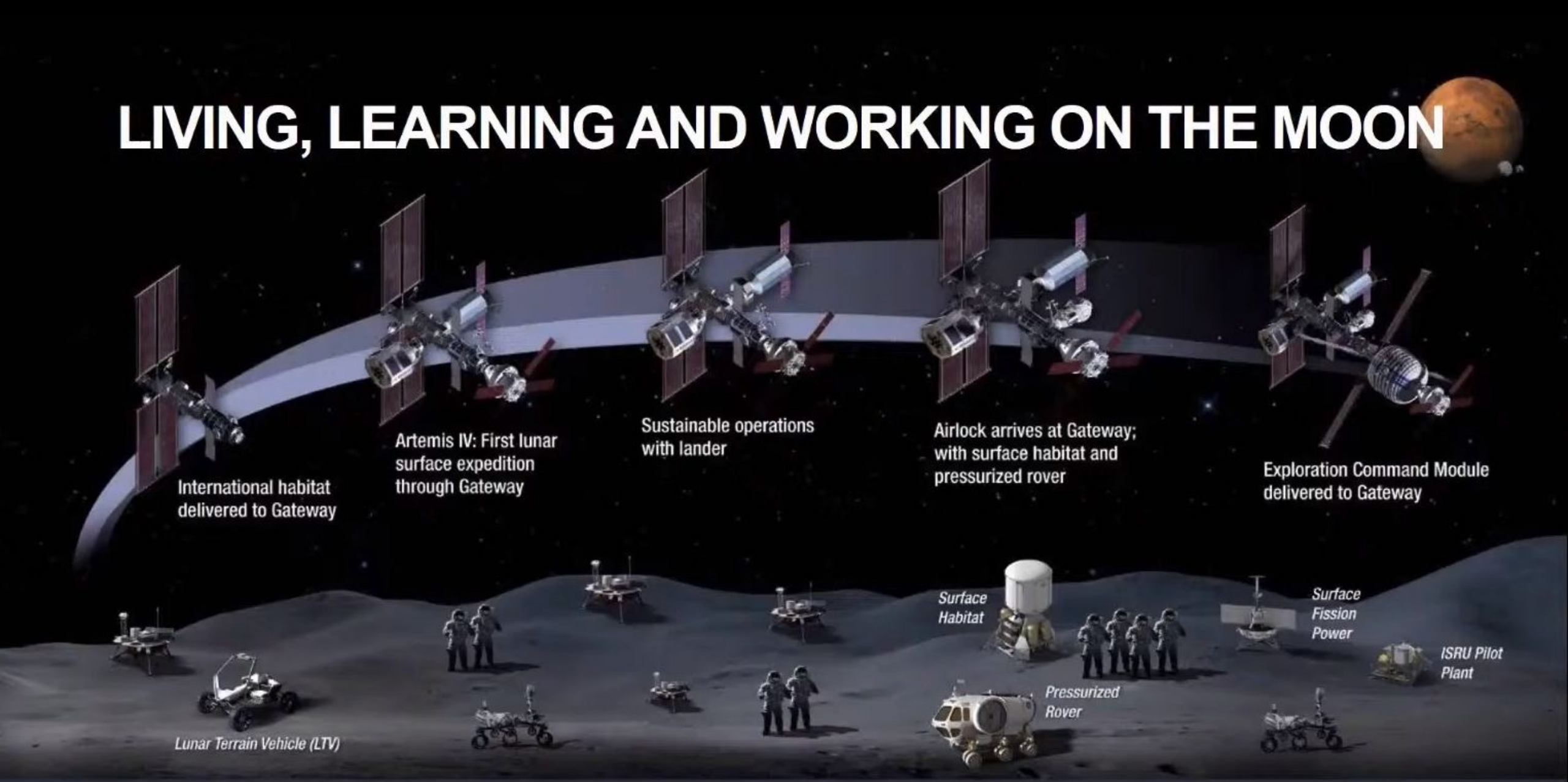
https://okgrassroots.com/?p=642815

"This vision begins with a campaign to utilize Earth's orbital environment, the surface of the Moon, and cislunar space to develop the critical technologies, operational capabilities, and commercial space economy necessary for a sustainable human presence on the Moon, Mars, and beyond

…The United States Space Force (USSF) does not have a direct role in the civil exploration and development of space per se – its responsibilities focus on organizing, training, and equipping the forces needed to support combatant commands and ensure unfettered access to and the use of space by the United States and its allies and partners. However, activities such as space transportation and logistics, power, communication, navigation, and space domain awareness, are of dual-use value to all space sectors – civil, national security, and commercial."



LIVING, LEARNING AND WORKING ON THE MOON



SUSTAINABLE LUNAR ORBIT STAGING CAPABILITY AND SURFACE EXPLORATION

MULTIPLE SCIENCE AND CARGO PAYLOADS | U.S. GOVERNMENT, INDUSTRY, AND INTERNATIONAL PARTNERSHIP OPPORTUNITIES | TECHNOLOGY AND OPERATIONS DEMONSTRATIONS FOR MARS

"…has invested significant resources in exploring the national security and economic value of this area, including *its potential for space-based manufacturing, resource extraction, and power generation.*"

"**Ensure U.S. Space Command and any future space-oriented service are responsible for protecting freedom of navigation and keeping lines of communication open, safe, and secure** in the space domain, as the U.S. Navy does for U.S. interests in the maritime commons."

- The **U.S. should establish space settlement and human presence as a primary driver of the nation's civil space program** to determine the path for large-scale human space settlement and ensure America is the foremost power in achieving that end. Accordingly, civil space programs must be assessed as to their utility to further space settlement goals.
- The U.S. must continue to lead in developing a rules-based, democratic international order for space. The U.S. must commit to having a military force structure that **can defend this international space order and defend American space interests, to include American space settlements and commerce.**
- The U.S. military must define and execute its role in promoting, exploiting, and defending the expanded commercial, civil, and military activities and human presence in space driven by industry, NASA, and other nation-states.

https://apps.dtic.mil/sti/pdfs/AD1101899.pdf

Protect and Defend Space Lines of Commerce

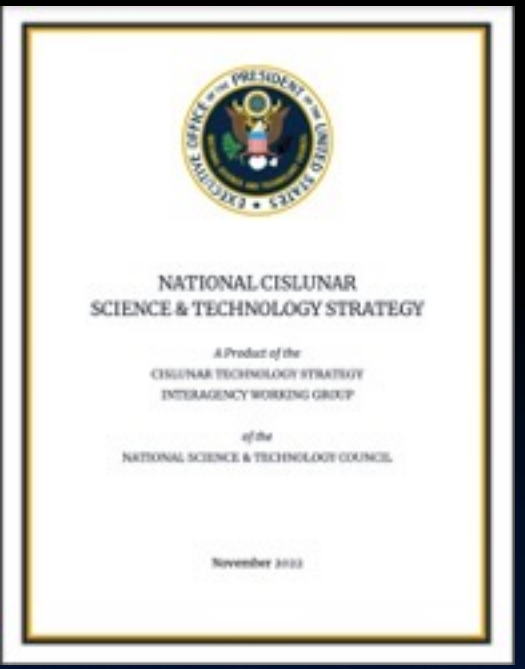
Rescue
Medical Evacuation
Vessel Search & Seizure
Non-Combatant Evacuation
DSCA (Law Enforcement)

The Cislunar Economy is enabled by military patrol & safety of navigation services.


STATE OF THE SPACE INDUSTRIAL BASE 2021
Infrastructure & Services for Economic Growth & National Security

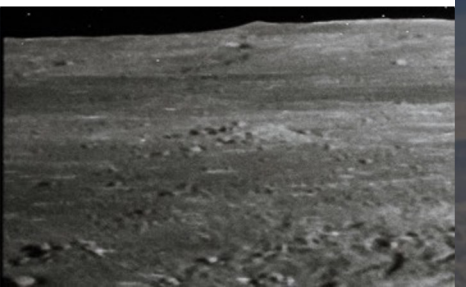
https://assets.ctfassets.net/3nanhbfkr0pc/43TeQTAmdYrym5DTDrhjd3/1218bd749befdde511ac2c900db3a43b/Space_Industrial_Base_Workshop_2021_Summary_Report_-_Final_15_Nov_2021.pdf Page 41

National Cislunar Strategy



- Beyond network communications and PNT, **capabilities of interest** include **mapping, in-space and Lunar surface transportation**, radio frequency spectrum management, **in-situ mobility, Lunar surface power generation and storage**, **use of Lunar resources**, **search and rescue**, and space situational awareness.
- The U.S. government **will support** the development of orbital and Lunar surface technologies and other scalable capabilities that support an enduring human presence on planetary surfaces. These include **refuellable Lunar landers**, environmental control and life support, **lunar surface power systems**, mobile and dust-resistant spacesuits, **surface mobility** in extreme environments, and sustainable habitats on planetary bodies.
- Further, the United States government **will support Lunar resource assessments**, as well as the advancement of research, development, and demonstration of capabilities for using materials sourced from the Moon and other celestial bodies. Such capabilities include **resource characterization and surveys**, **manufacturing of components from in-situ materials**, **autonomous assembly of structures**, **construction of structures that maximize the use of in-situ materials**, and **processing of useful molecules** such as water and oxygen.
- The U.S. government, **in collaboration with private entities**, will **demonstrate the ability to use the products** created by these capabilities to enable an enduring human or robotic presence on the Lunar surface. U.S. government organizations **will leverage collaborations with private entities to enable capabilities for large-scale ISRU and advanced manufacturing at the Moon**, consistent with the U.S. National Strategy for In-space Servicing, Assembly, and Manufacturing. Use of Lunar materials should be included in the trade space for Lunar surface elements and operations.

- vision: "**Create a blueprint for sustained human presence and exploration throughout the solar syste**m."
- With an eye toward future exploration, the strategy allows for humanity to learn to **adapt, live, thrive, navigate, produce, and prosper in each new domain** – which then prepares for the next
- Commerce and Space Development: **Foster the expansion of the economic sphere beyond Earth orbit to support U.S. industry and innovation**.
- Goal: Create an interoperable global lunar utilization infrastructure where U.S. industry and international partners can maintain continuous robotic and human presence on the lunar surface for a robust lunar economy without NASA as the sole user, while accomplishing science objectives and testing for Mars.
- LI-1 through LI-3 address the overarching "utilities," that will be needed to support continuous lunar presence: power; communications; and position, navigation, and timing. These areas are fundamental elements that are essential to multiple scales of exploration throughout the build-up of assets on the lunar surface. LI-4 through LI-6 describe additional primary capabilities that will enable robust exploration and sustained presence: mobility, precise landings, and manufacturing and construction**. LI-7 and LI-8 are the advanced capabilities that suggest industrial scale production and a fundamental shift to the use of lunar surface resources for sustainment and reduced logistics from Earth.**



INFRASTRUCTURE OBJECTIVES

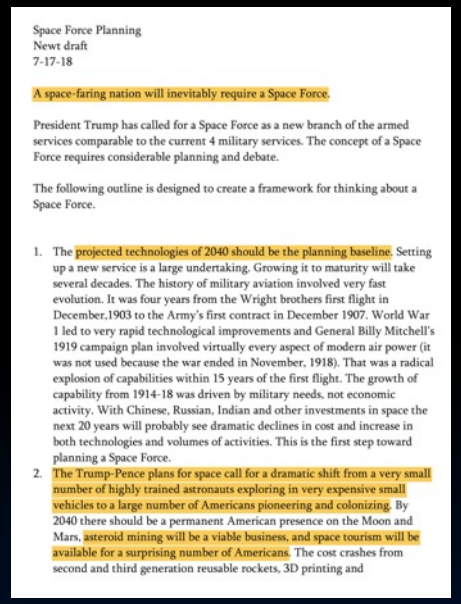
Lunar
Mars

Lunar Infrastructure (LI) Goal: Create an interoperable global lunar utilization infrastructure where U.S. industry and international partners can maintain continuous robotic and human presence on the lunar surface for a robust lunar economy without NASA as the sole user, while accomplishing science objectives and testing for Mars.

LI-1[L]:	Develop an incremental lunar power generation and distribution system that is evolvable to support continuous robotic/human operation and is capable of scaling to global power utilization and industrial power levels.
LI-2[L]:	Develop a lunar surface, orbital, and Moon-to-Earth communications architecture capable of scaling to support long term science, exploration, and industrial needs.
LI-3[L]:	Develop a lunar position, navigation and timing architecture capable of scaling to support long term science, exploration, and industrial needs.
LI-4[L]:	Demonstrate advanced manufacturing and autonomous construction capabilities in support of continuous human lunar presence and a robust lunar economy.
LI-5[L]:	Demonstrate precision landing capabilities in support of continuous human lunar presence and a robust lunar economy.
LI-6[L]:	Demonstrate local, regional, and global surface transportation and mobility capabilities in support of continuous human lunar presence and a robust lunar economy.
LI-7[L]:	Demonstrate industrial scale ISRU capabilities in support of continuous human lunar presence and a robust lunar economy.
LI-8[L]:	Demonstrate technologies supporting cislunar orbital/surface depots, construction and manufacturing maximizing the use of in-situ resources, and support systems needed for continuous human/robotic presence.
LI-9[L]:	Develop environmental monitoring, situational awareness, and early warning capabilities to support a resilient, continuous human/robotic lunar presence.

AMERICAN FOREIGN POLICY COUNCIL

Gingrich Space Force Planning Memo



Space Force Planning
Newt draft
7-17-18

A space-faring nation will inevitably require a Space Force.

President Trump has called for a Space Force as a new branch of the armed services comparable to the current 4 military services. The concept of a Space Force requires considerable planning and debate.

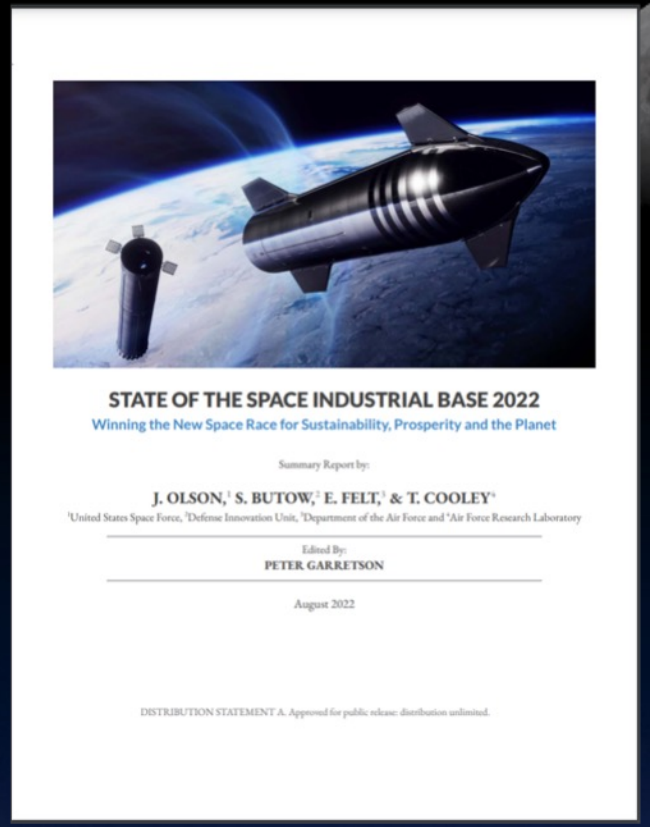
The following outline is designed to create a framework for thinking about a Space Force.

1. The projected technologies of 2040 should be the planning baseline. Setting up a new service is a large undertaking. Growing it to maturity will take several decades. The history of military aviation involved very fast evolution. It was four years from the Wright brothers first flight in December,1903 to the Army's first contract in December 1907. World War 1 led to very rapid technological improvements and General Billy Mitchell's 1919 campaign plan involved virtually every aspect of modern air power (it was not used because the war ended in November, 1918). That was a radical explosion of capabilities within 15 years of the first flight. The growth of capability from 1914-18 was driven by military needs, not economic activity. With Chinese, Russian, Indian and other investments in space the next 20 years will probably see dramatic declines in cost and increase in both technologies and volumes of activities. This is the first step toward planning a Space Force.
2. The Trump-Pence plans for space call for a dramatic shift from a very small number of highly trained astronauts exploring in very expensive small vehicles to a large number of Americans pioneering and colonizing. By 2040 there should be a permanent American presence on the Moon and Mars, asteroid mining will be a viable business, and space tourism will be available for a surprising number of Americans. The cost crashes from second and third generation reusable rockets, 3D printing and

In that parallel **NASA** encourages, facilitates and sometimes **organizes the space equivalent of the wagon trains**. It is **NASA's job to maximize the development of pioneers and colonizers.**

The **Space Force** in a sense is parallel to the role of the United States cavalry in opening the West. Properly designed, the Space Force itself will be supporting US government actions that are mandated for an accepted societal purpose.

As a **provider of security and a rescue system** (in this aspect the Space Force has a little of the Coast Guard's functionality) the Space Force will accelerate the American evolution as a spacefaring nation…. synergistic with and supportive of civilian activities, just as it is the U.S. Navy that, for most of the world,..guarantees the freedom of the high seas.



STATE OF THE SPACE INDUSTRIAL BASE 2022

Winning the New Space Race for Sustainability, Prosperity and the Planet

Summary Report by:

J. OLSON,[1] S. BUTOW,[2] E. FELT,[3] & T. COOLEY[4]

[1]United States Space Force, [2]Defense Innovation Unit, [3]Department of the Air Force and [4]Air Force Research Laboratory

Edited By:

PETER GARRETSON

August 2022

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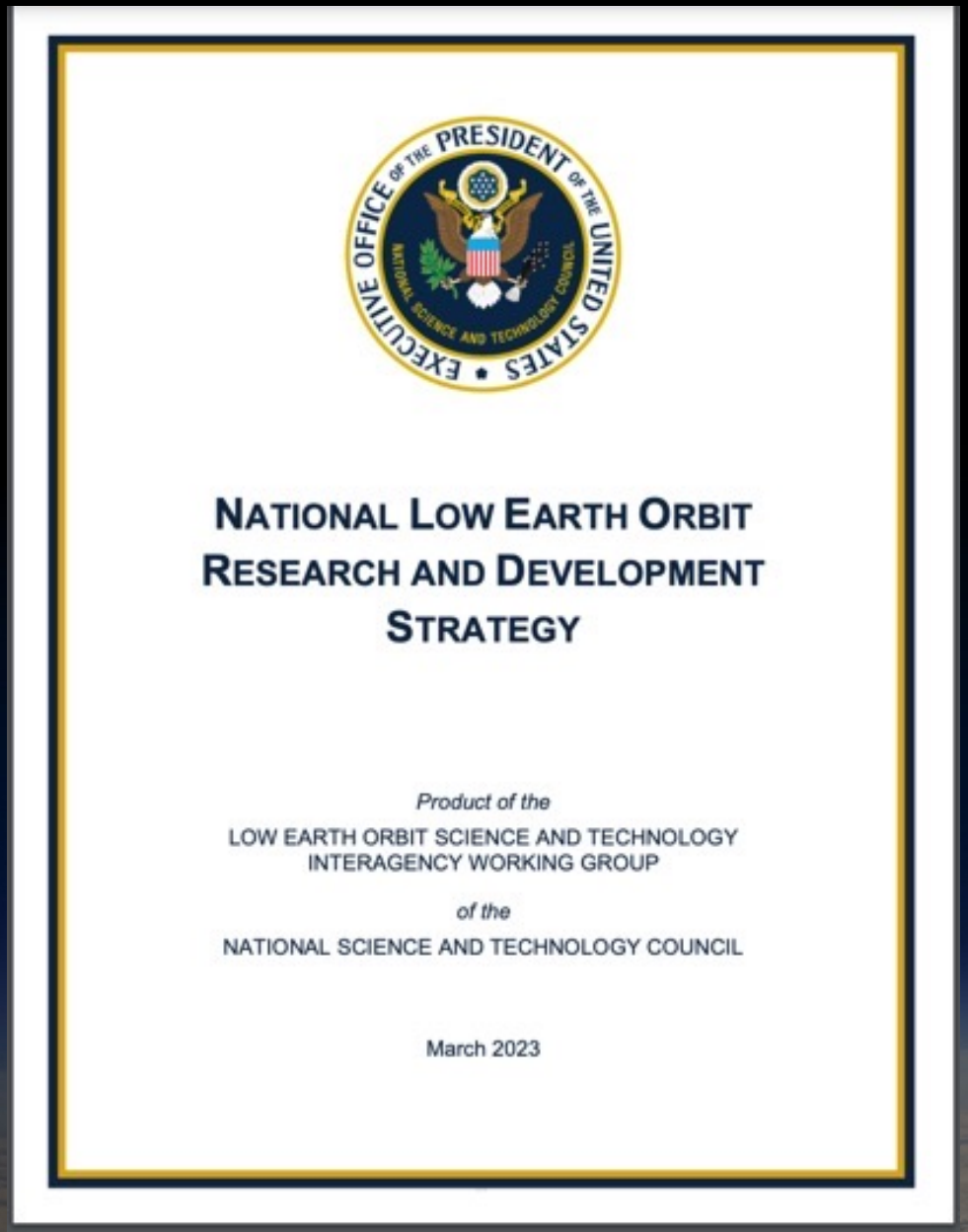
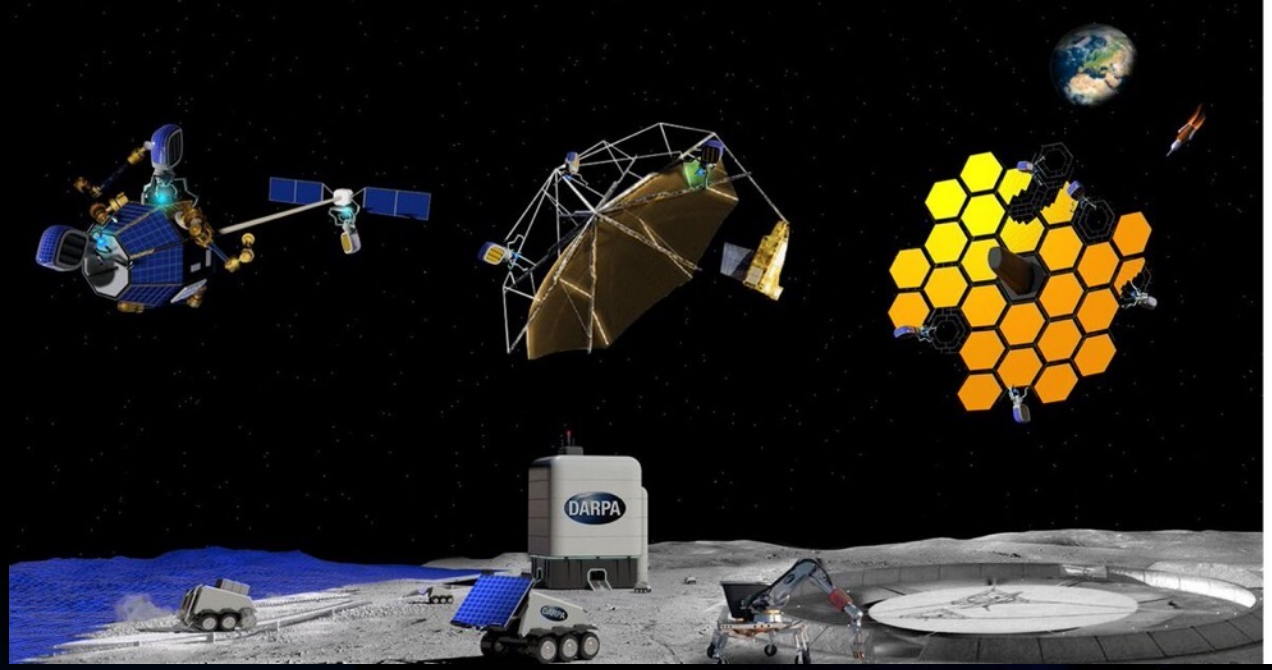
Prosperity Must Be Central - Much as the recent Indo-Pacific Economic Framework for Prosperity provides a platform for mutual prosperity in an important terrestrial theater, we need an Economic Framework for Prosperity in Space, or a Cislunar Framework for Prosperity. **Much as the U.S. Navy provides for freedom of commerce across the open oceans of Earth, the USSF may one day be necessary to assure the freedom of commerce across the vast Cislunar region and beyond.**



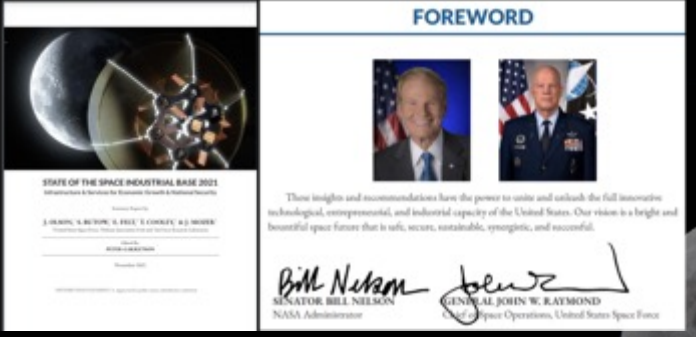
Understanding the effects of solar and galactic radiation on both humans and microelectronics is necessary to achieve the goal of enabling human transportation and **settlement within the solar system**.


DARPA

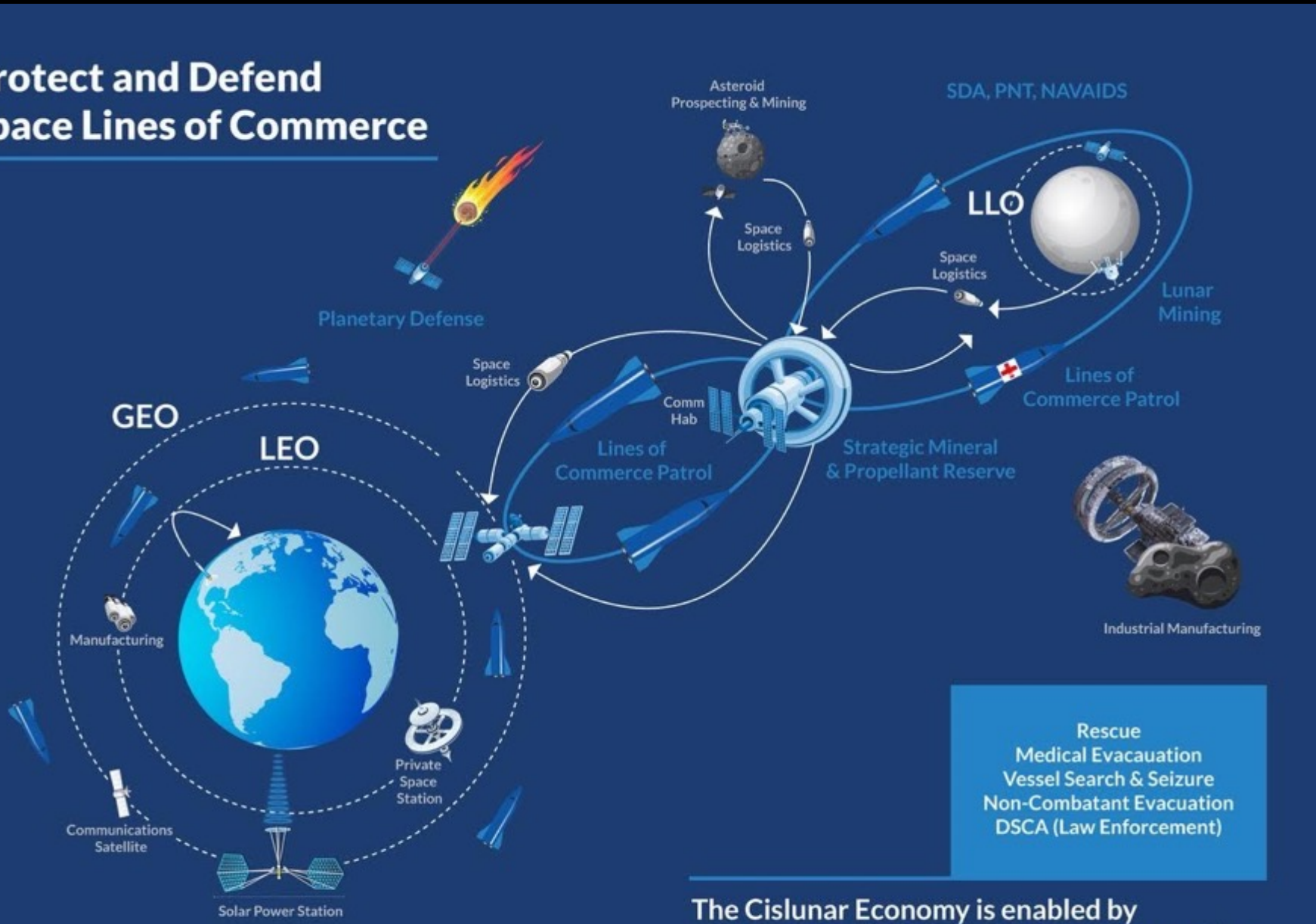
DARPA

B-SURE


2030 Space Logistics
Orbit Repositioning
Removal of derelict spacecraft
Move assets at will
HVA Life Extension
(Phasing Out Legacy)
Extend legacy HVA EOL
STOP building spacecraft this way
Cis-lunar SDA
Provide support for US interests
Manned Operations/
Propellant Production
Extract fuel from lunar surface
Debris Removal
Clean up LEO
xGEO/Cis-lunar Operations
Enable and protect commercial shipping lanes
Support civil exploration of deep space
Maneuver Without Regret
Dominate the AOR's from Earth to Moon
Maneuver and reposition assets with impunity
Protect and defend US govt, civil and commercial interests
Enable resilient, persistent occupation at lower cost
Responsive Launch
Launch to any orbit from any location
NEVER launch ballast again
On-Orbit Assembly and
Manufacturing
Assembly and construction of large
structures
Novel Orbits
Learn how novel, low-energy
orbits can be exploited
VLEO - MEO
GEO – 2x GEO
3x GEO – L1/L2
UNCLASSIFIED



SSIB21: *"by 2040, USSF missions may include: increased space information services; projection of offensive and defensive operations in space and from space to other domains; dynamic offensive/defensive operations and transport across the Cislunar domain to ensure freedom of civil, commercial, military operations; environmental monitoring, stewardship and debris clean-up; protection of critical space national infrastructure; enforcing space law and norms of behavior; Search and Rescue / Personnel Recovery (PR) / Non-Combatant Evacuation (NEO); and planetary defense."*



ARTEMIS

ARTEMIS ACCORDS

Australia 

Bahrain 

Brazil 

Canada 

Colombia 

Czech Republic 

France 

Israel 

Italy 

Japan 

Luxembourg 

Mexico 

New Zealand 

Nigeria 

Poland 

Republic of Korea 

Romania 

Rwanda 

Saudi Arabia 

Singapore 

Spain 

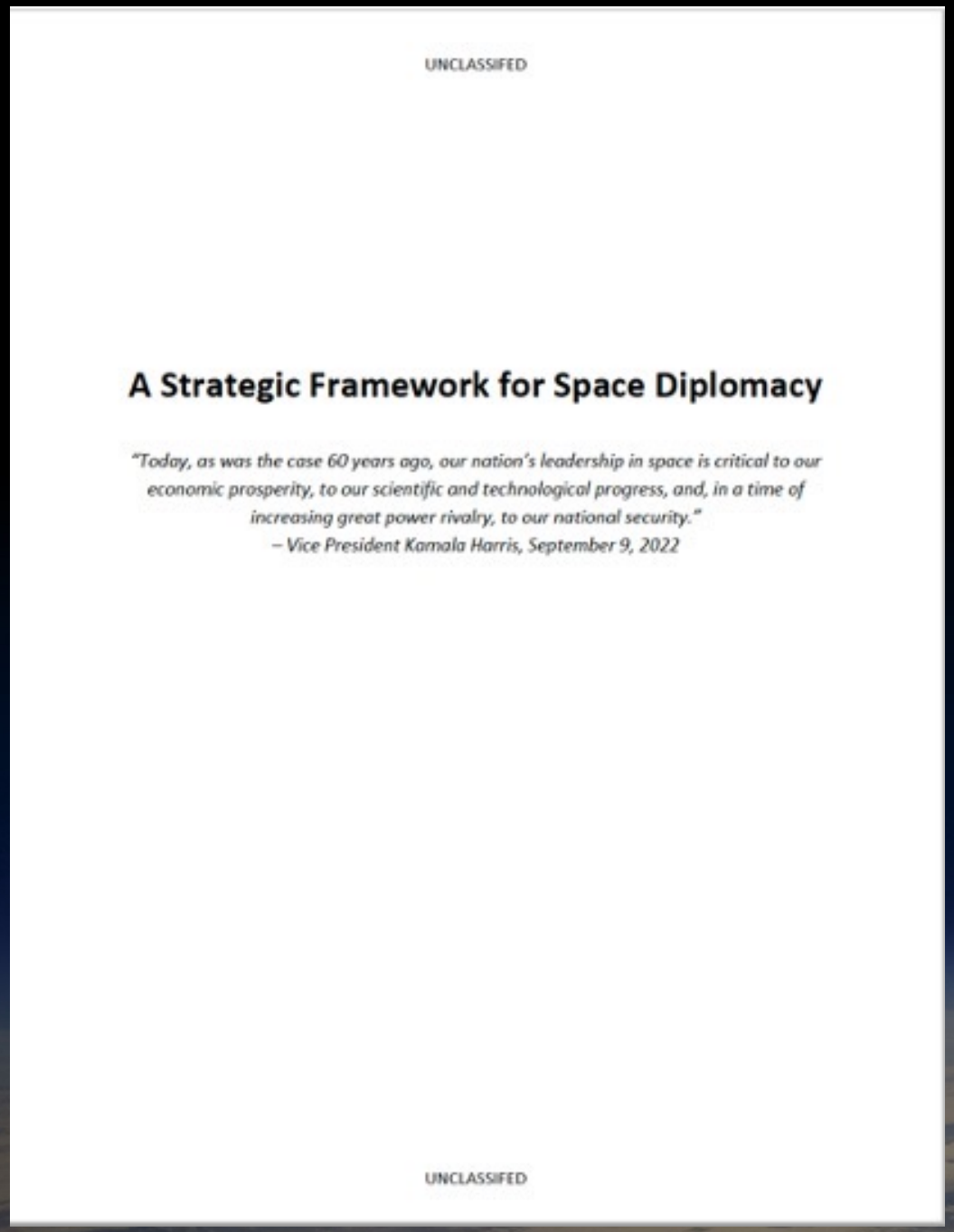
Ukraine 

United Arab Emirates 

United Kingdom 

The United States of America 

United for Peaceful Exploration of Deep Space



- **In international governance, policy, and regulatory fora, the Department will exercise U.S. leadership** across space-related issues, tackling current space safety and sustainability challenges such as congestion in the space domain, near Earth objects, and severe space weather, and leading early action on the challenges of tomorrow**, including those related to the recovery and use of outer space resources, lunar operations**, and other novel space activities (Such as: **In-space servicing assembly and manufacturing (ISAM), future lunar operations**, debris remediation, space tourism, **recovery and reuse of space resources, asteroid mining**, space launch vehicles, and new satellite applications.)


HOW DOES IT MATTER?

How to Win: Hegemony Formula ala Wallerstein-Gilpin-Dolman

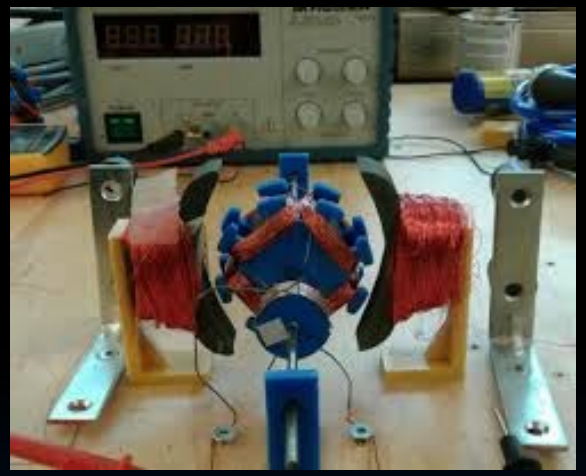
1. Dominate production of the most valuable commodities (the forefront of innovation). Premier status achieves economies of scale that make routine space production cost-effective
2. Dominate trade by becoming the carrier or shipper of choice
3. Use profits made from the transfer of bulk trade in the system (through dominating shipping and movement of goods) to become the financial or banking leader of the world

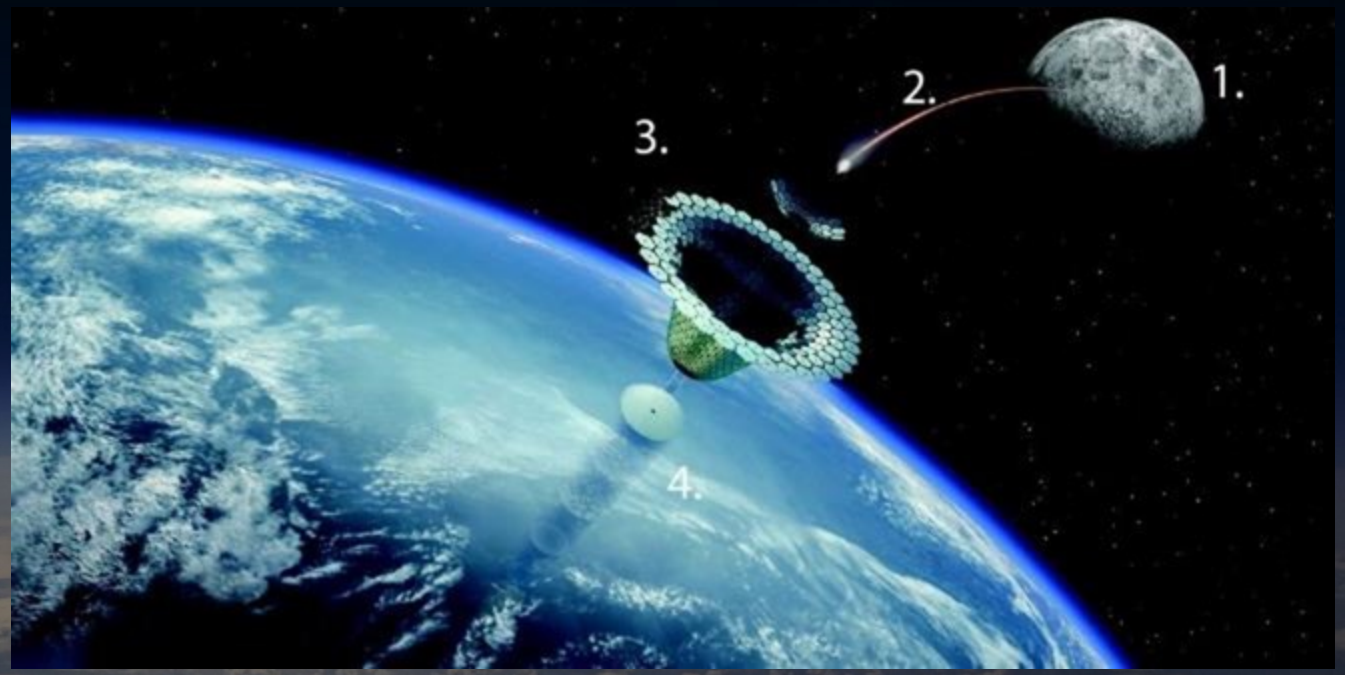
Exponential industrialization of space

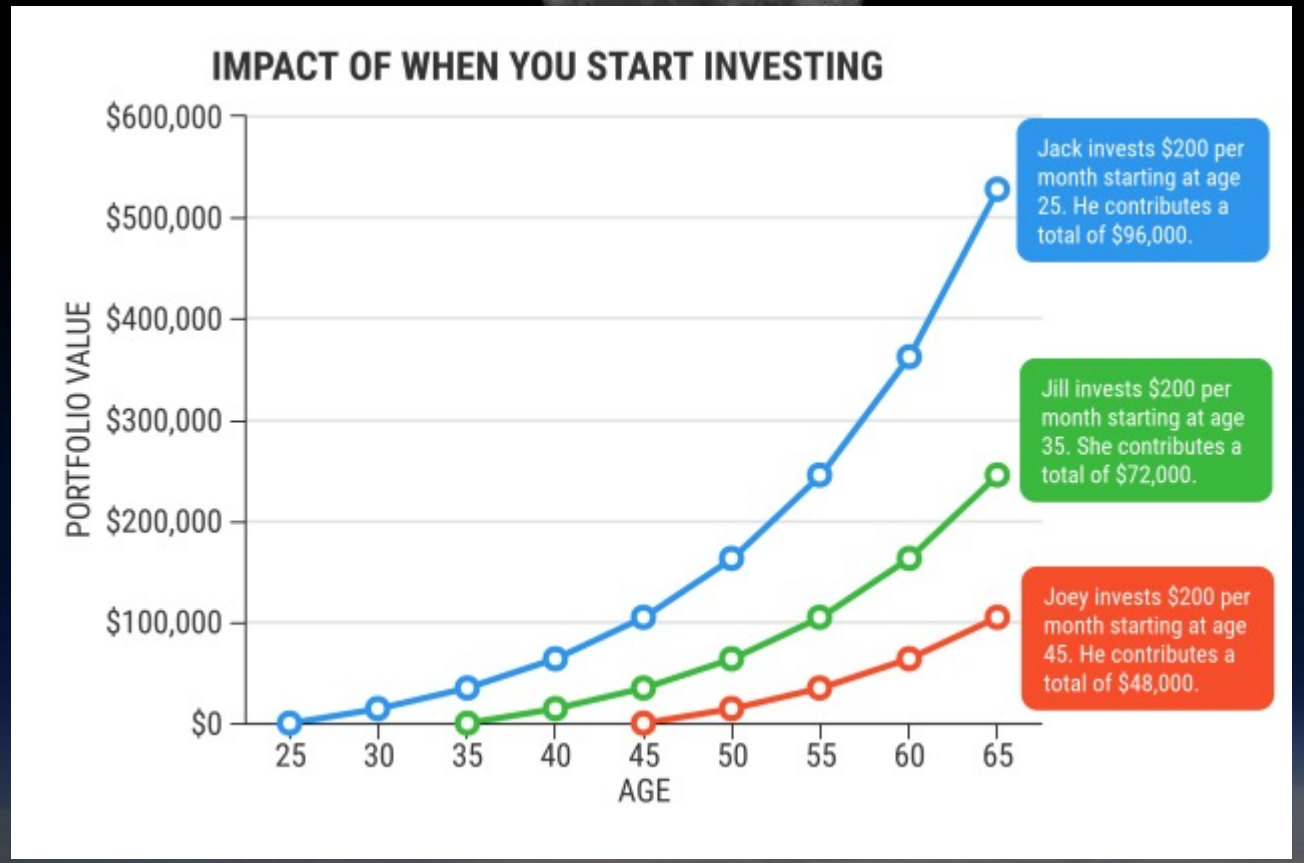
nextBIG FUTURE

Exponential industrialization of space is more important than combat lasers and hypersonic fighters

Brian Wang | October 26, 2017






IMPACT OF WHEN YOU START INVESTING
PORTFOLIO VALUE
$600,000
$500,000
$400,000
$300,000
$200,000
$100,000
$0
25
30
35
40
45
50
55
60
65
AGE
Jack invests $200 per month starting at age 25. He contributes a total of $96,000.
Jill invests $200 per month starting at age 35. She contributes a total of $72,000.
Joey invests $200 per month starting at age 45. He contributes a total of $48,000.


COMPOUND INTEREST:
WHO WILL EARN MORE?
This example shows how the earlier a person takes advantage of compound interest, the more time that money has to grow.
$787,180
at age 65
$611,730
at age 65
INVESTOR 1:
-Starts at 25
-Sets aside $5,000 a year for 10 years in a row.
-No more investments after age 34.
INVESTOR 2:
-Starts at 35
-Invests $5,000 each year for 30 years in a row until reaching age 65.
$800,000
$700,000
$600,000
$500,000
$400,000
$300,000
$200,000
$100,000
25
30
35
40
45
50
55
60
65
NOTES: Assumes an 8 percent interest rate, compounded annually. Balances shown are approximate.
SOURCE: Author's calculations.
FEDERAL RESERVE BANK of ST. LOUIS

Exponential industrialization of space

Preprint. To appear in Journal of Aerospace Engineering.

Affordable, rapid bootstrapping of space industry and solar system civilization

Philip T. Metzger, Ph.D., A.M. ASCE[1], Anthony Muscatello, Ph.D.[2], Robert P. Mueller, A.M. ASCE[3], and James Mantovani, Ph.D.[4]

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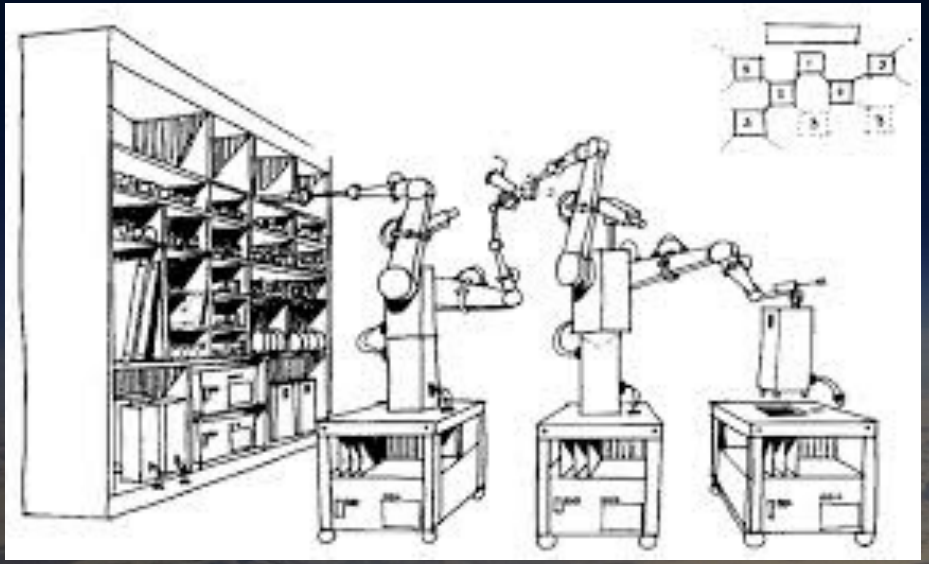
[2] Chemist, Applied Chemistry Lab, NASA Kennedy Space Center, Anthony.C.Muscatello@nasa.gov, NE-S-2, Kennedy Space Center, FL 32899

[3] Aerospace Engineer, Surface Systems Office, NASA Kennedy Space Center, Rob.Mueller@nasa.gov, NE-S, Kennedy Space Center, FL 32899

[4] Physicist, Granular Mechanics and Regolith Operations Lab, NASA Kennedy Space Center, James.G.Mantovani@nasa.gov, NE-S-1, Kennedy Space Center, FL 32899

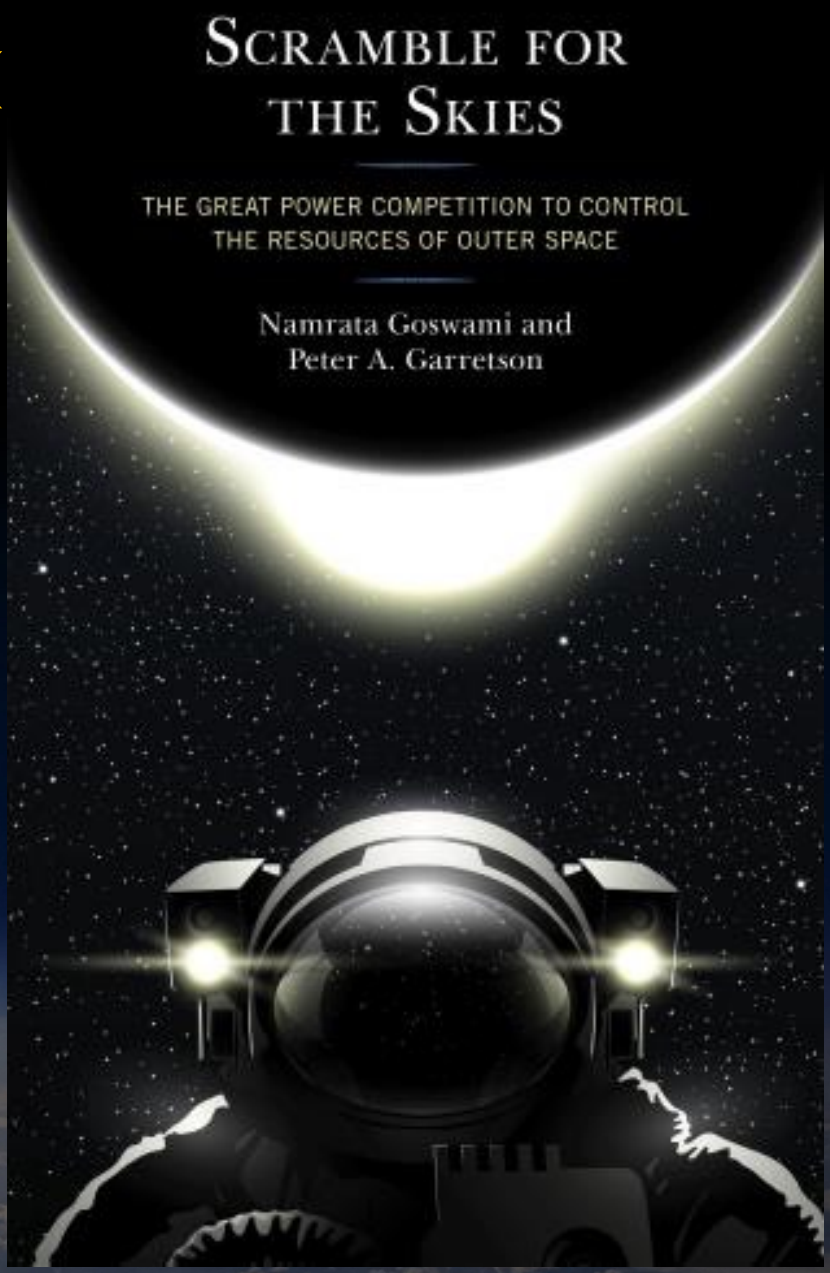
Abstract:



- The asteroid belt has everything necessary: water, carbon, silicates, metals, oxygen, solar energy …*There, the billion- fold greater resources could allow the industry to expand exponentially until it dwarfs that of the entire Earth within just a few decades* . . . Multiplying this by a factor of 3 per year, it would exceed the energy usage of the US within 11 more years. *After 12 more years it would exceed the US economy by a factor of a million. After another decade it would exceed the US economy by a factor of a billion.*
- "The modeling also indicates a significant national security risk. On Earth, the industry of a nation is limited by its resources …a robotic industry occupying a solar system, the resources and real estate are a billion times greater… Until this industry begins to feel the limits of the entire solar system, it can grow exponentially. If any nation initiates and controls such an industry first, then it will have a perpetual lead in industrial power over another nation that initiates the same capability second.

An Overview of our Book

- Discount Code: **LEX30AUTH23**
- https://**rowman.com**/ISBN/9781498583114/Scramble-for-the-Skies-The-Great-Power-Competition-to-Control-the-Resources-of-Outer-Space
- THESIS: The great powers are beginning to compete for space resources.
- WHY: Because they have an expectation it might alter the relative balance of power



SPATIAL AND TEMPORAL SCOPE

How far out? Just Earth to the Asteroid Belt

- Travel time and exploitability: the largest asteroids in the belt is less than a year-and-a-half using the most efficient trajectory and current technology
- Columbus' journeys to the New World lasted between one and three years
- Near-term nuclear propulsion (such as is being developed by the PRC and NASA)), the journey to the asteroid belt might be only 10 months (8 w/less efficient traj).
- Theoretically, could be less than two months with constant acceleration profiles.

How far out? Just~200 years:

- United States is 243 years.
- Oldest surviving sovereign state, San Marino, now 1,718 years old
- If the PRC (est. 1949) and Republic of India (est. 1947), are as durable, in 200 years, they will be barely older than the United States is now.
- It seems reasonable that currently powerful states such as the United States, PRC, and India might still be important actors across this timespan.

ANALOGIES: The last scramble

- Age of Exploration or Age of Discovery, which lasted until the early seventeenth century (200 years).
- Followed the Age of Old Imperialism (200 years).
- *Age of New Imperialism* in (1870 – 1914) (44 years), which included the
- *Scramble for Africa* (1881–1914) (33 years)
- These global scrambles for resources, markets, and strategic position to command them created the power configuration and conflict points that set the stage for two world-spanning wars (1914–1945).
- It then took at least until the end of Decolonization (1945–1960) to adjust.

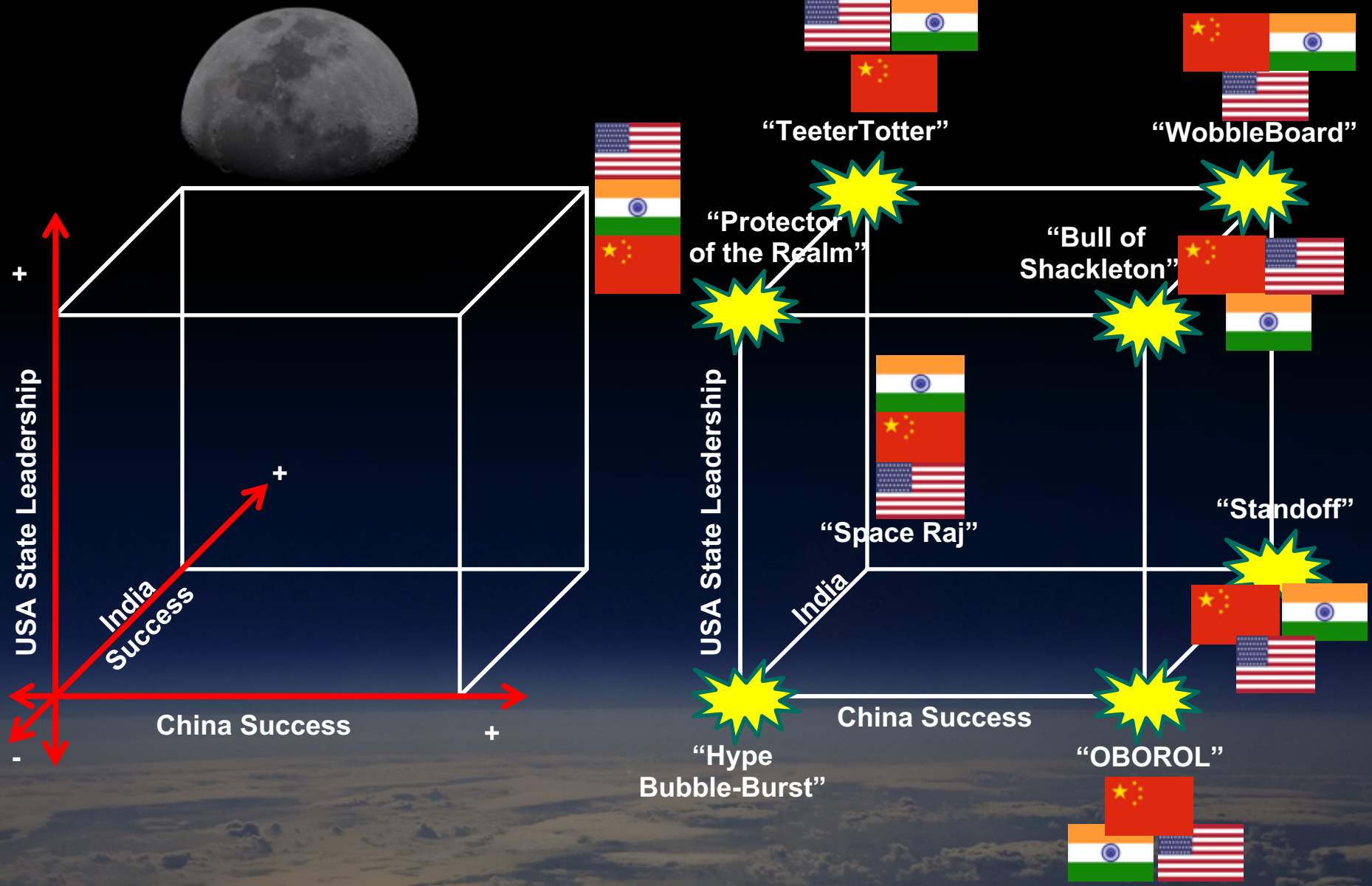
KEY CONCEPTS AND TERMS

- *space resources*
- *strategic culture*
- *strategic trauma*
- *resource nationalism*
- *territoriality*
- *global order* or *international system*
- *great powers*
- *middle powers*
- *space expansionism*
- *space development*

SITUATIONAL SCENARIOS

- Claim Disputes
- Trafficking
- Unsafe Practices
- Piracy
- Defection of Citizens or Facilities
- False Promises via Lawfare
- “Over-fishing”
- One-Sided National Lawfare
- Cartographic Aggression
- Infrastructure Aggression
- Limitations on Innocent Passage
- Defense Identification Zones
- Deniable Duel-Use Infrastructure
- Malicious funding of competitors
- Hostile financial takeover
- Claim Jumping
- Facility Blockage
- Blockade
- Impounding
- Impressment
- Hostage Taking
- Tourism Aggression
- Tourism Aggression
- Economic Punishment
- Privateering
- Deliberate Harmful Interference
- Sabotage
- Issuing Private Law

GEOPOLITICAL SCENARIOS



Common Path

OBERAL

Bull of Shackleton

Protector of the Realm

Space Raj

2047 Crisis

Today

WHAT WE EXPECT TO HAPPEN

- We **conceptualize space as a geography** and expect behavior very similar to **colonial powers seeking advantage** from their neighborly rivalries in wealth and resources abroad…not unlike **the South China Sea or Arctic today**.
- Nations will perceive (at different speeds) that space resources are strategic.
- Space resources will become “securitized” and perceived as strategic interests. Those that have the ability to compete will compete.
- **United States and China will be the actual competitors.**
- **India will be a late arrival to the endeavor.**
- Russia, Japan, France, largely due to a lack of resources and competitive industrial base, will operate within the ecosystem of norms and institutions established by the three great spacefaring powers.

More Details Here: @GarretsonPeter

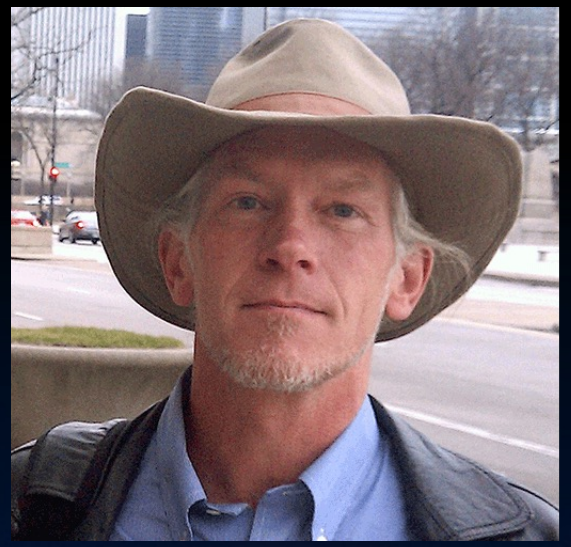
SCRAMBLE FOR THE SKIES: THE GREAT POWER COMPETITION TO CONTROL THE RESOURCES OF OUTER SPACE

THE NEXT SPACE RACE: A BLUEPRINT FOR AMERICAN PRIMACY

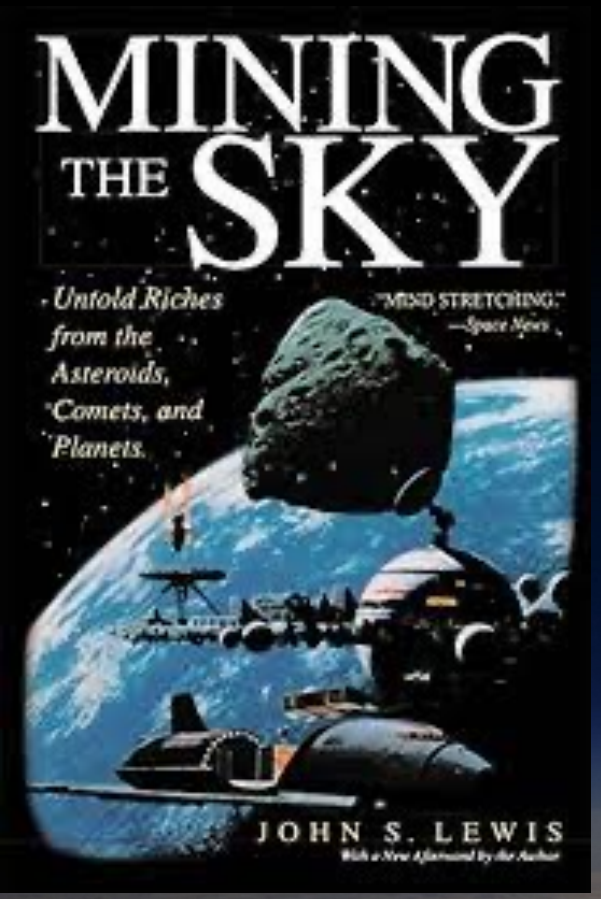
THE SPACE STRATEGY PODCAST


BACKUPS

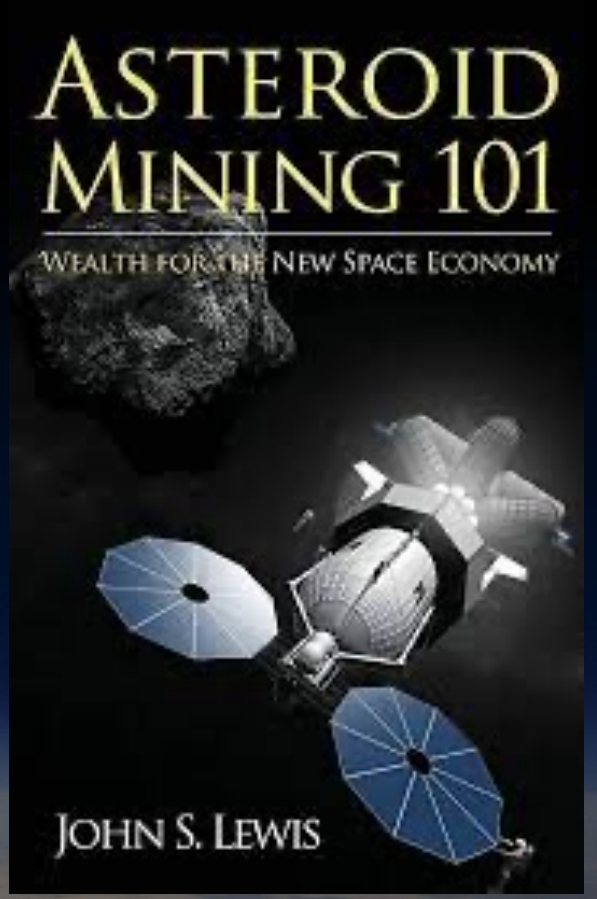
Space Resource Pioneers

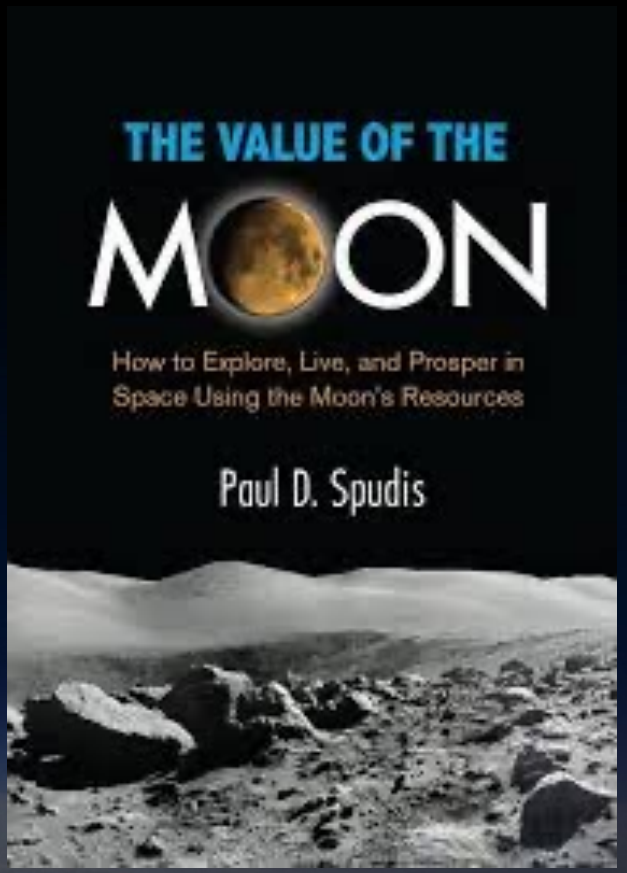


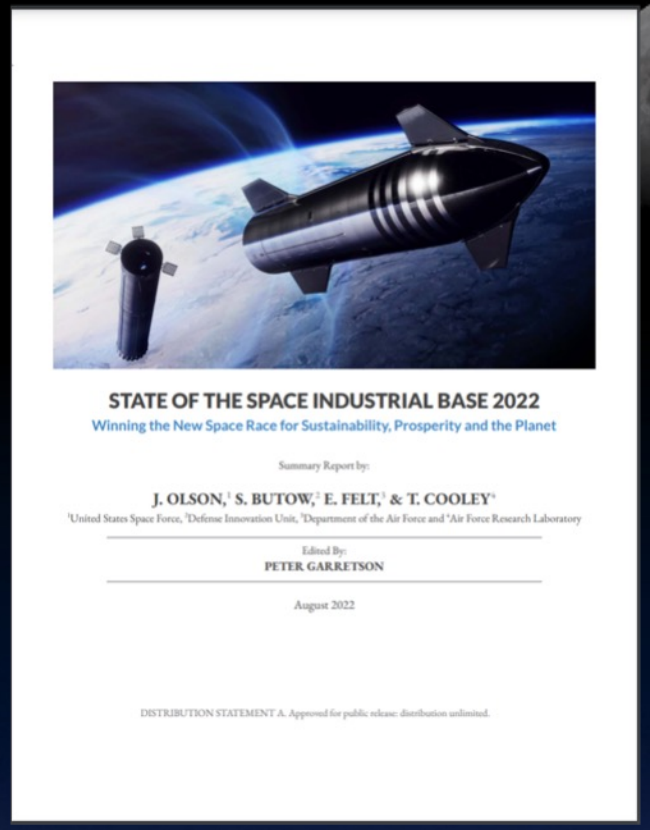
- Paul Spudis
- Bernard Kutter
- Brad Blair
- Mark Hopkins


MINING THE SKY
Untold Riches from the Asteroids, Comets, and Planets.
"MIND STRETCHING."
—Space News
JOHN S. LEWIS


MOONRUSH
Improving Life on Earth with the Moons Resources
Dennis Wingo


ASTEROID MINING 101
WEALTH FOR THE NEW SPACE ECONOMY
JOHN S. LEWIS


THE VALUE OF THE MOON
How to Explore, Live, and Prosper in Space Using the Moon's Resources
Paul D. Spudis



STATE OF THE SPACE INDUSTRIAL BASE 2022

Winning the New Space Race for Sustainability, Prosperity and the Planet

Summary Report by:

J. OLSON,[1] S. BUTOW,[2] E. FELT,[3] & T. COOLEY[4]

[1]United States Space Force, [2]Defense Innovation Unit, [3]Department of the Air Force and [4]Air Force Research Laboratory

Edited By:
PETER GARRETSON

August 2022

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The New Space Race Defined.

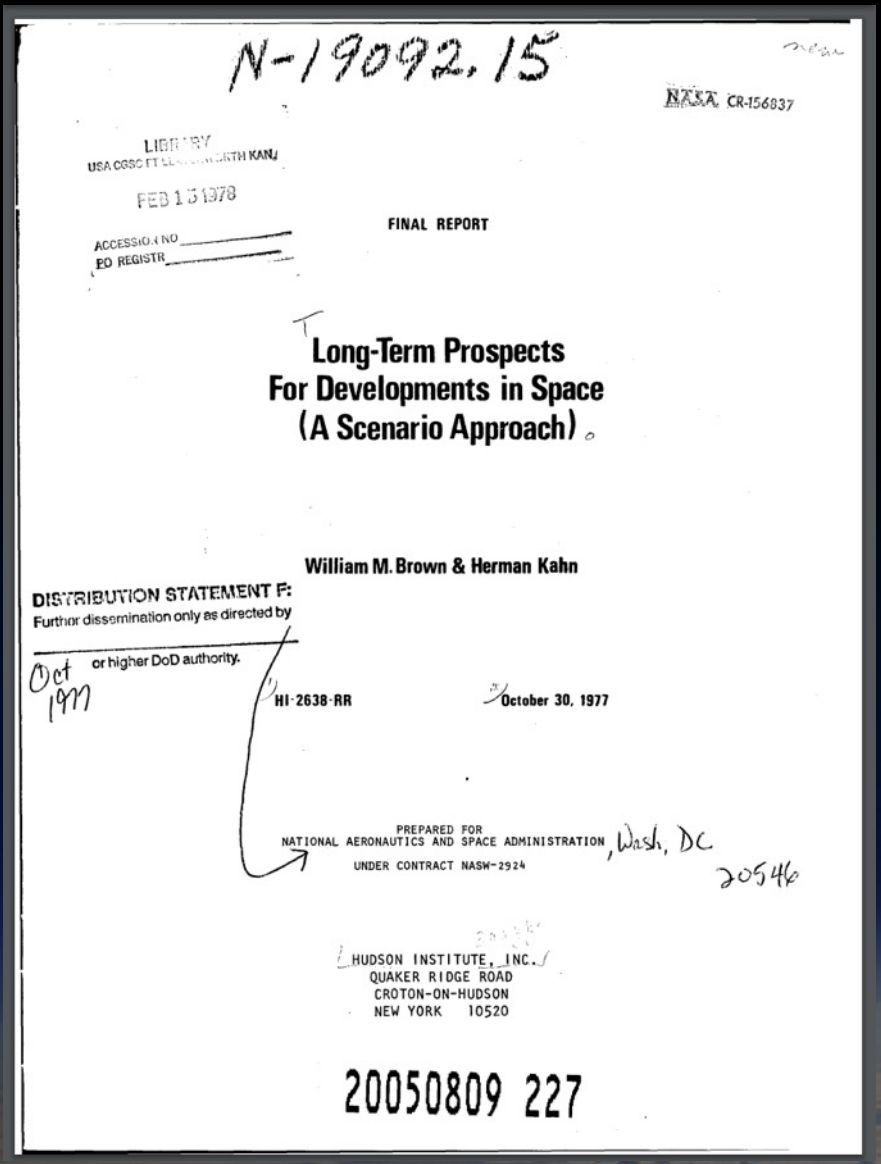
China has defined both the timespan and scope of the new space race for sustainability, prosperity and the planet. China's national space timeline is 2045 where it intends to be the foremost spacepower: 1) eclipsing the U.S. in its economic activities and services; 2) eclipsing the U.S. in its foreign partner relations and shaping of the space governance system; 3) eclipsing the U.S. in feats that inspire the world, and 4) eclipsing the U.S. in military power.

The role of agency

- “Then there’s becoming a multiplanet species and space-faring civilization. *This is not inevitable. It’s very important to appreciate this is not inevitable.* The sustainable energy future I think is largely inevitable, but being a space-faring civilization is definitely not inevitable. If you look at the progress in space, in 1969 you were able to send somebody to the moon. 1969. Then we had the Space Shuttle. The Space Shuttle could only take people to low Earth orbit. Then the Space Shuttle retired, and the United States could take no one to orbit. So that’s the trend. The trend is like down to nothing. *People are mistaken when they think that technology just automatically improves. It does not automatically improve. It only improves if a lot of people work very hard to make it better*, and actually it will, I think, by itself degrade, actually. You look at great civilizations like Ancient Egypt, and they were able to make the pyramids, and they forgot how to do that. And then the Romans, they built these incredible aqueducts. They forgot how to do it. “

Cost & Ingenuity

- “Historically, all rockets have been expensive, so therefore, in the future, all rockets will be expensive. But actually that’s not true. If you say, what is a rocket made of? It’s made of aluminum, titanium, copper, carbon fiber. And you can break it down and say, what is the raw material cost of all these components? And if you have them stacked on the floor and could wave a magic wand so that the cost of rearranging the atoms was zero, then what would the cost of the rocket be? And I was like, wow, okay, it’s really small—it’s like 2% of what a rocket costs. So clearly it would be in how the atoms are arranged—so you’ve got to figure out how can we get the atoms in the right shape much more efficiently. And so I had a series of meetings on Saturdays with people, some of whom were still working at the big aerospace companies, just to try to figure out if there’s some catch here that I’m not appreciating. And I couldn’t figure it out. There doesn’t seem to be any catch. So I started SpaceX



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FINAL REPORT

Long-Term Prospects For Developments in Space (A Scenario Approach)

William M. Brown & Herman Kahn

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- Long-Term Prospects For Developments in Space (A Scenario Approach)
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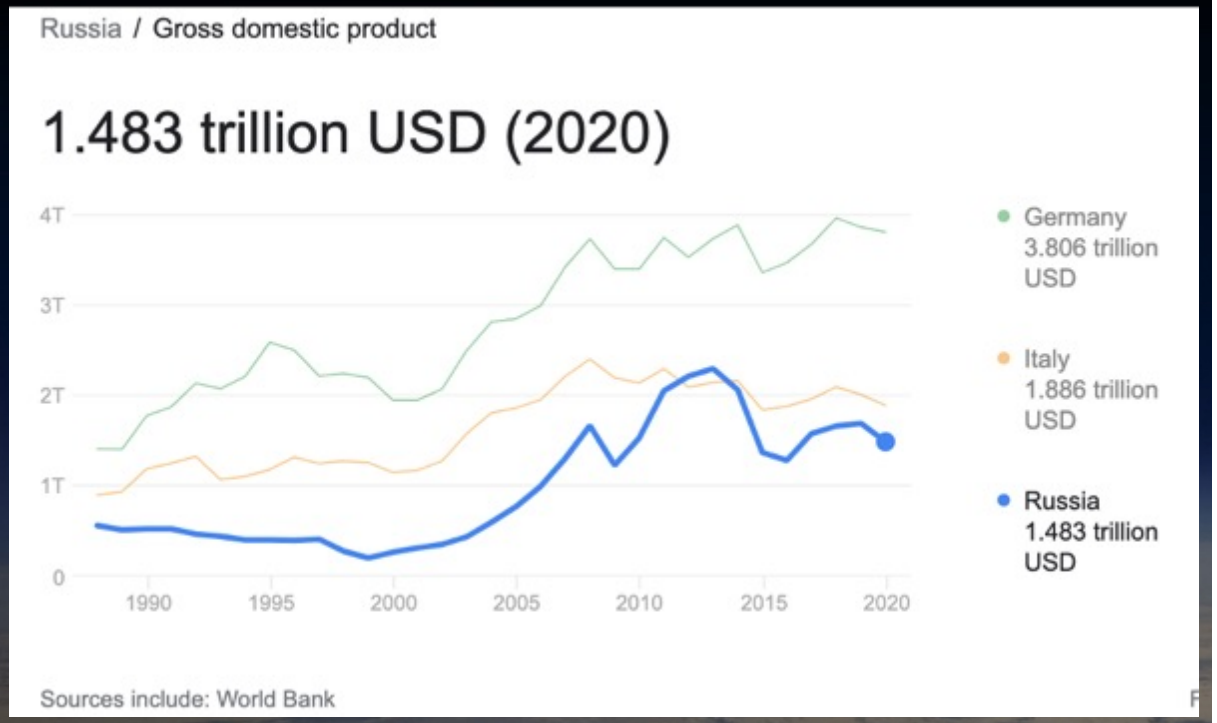
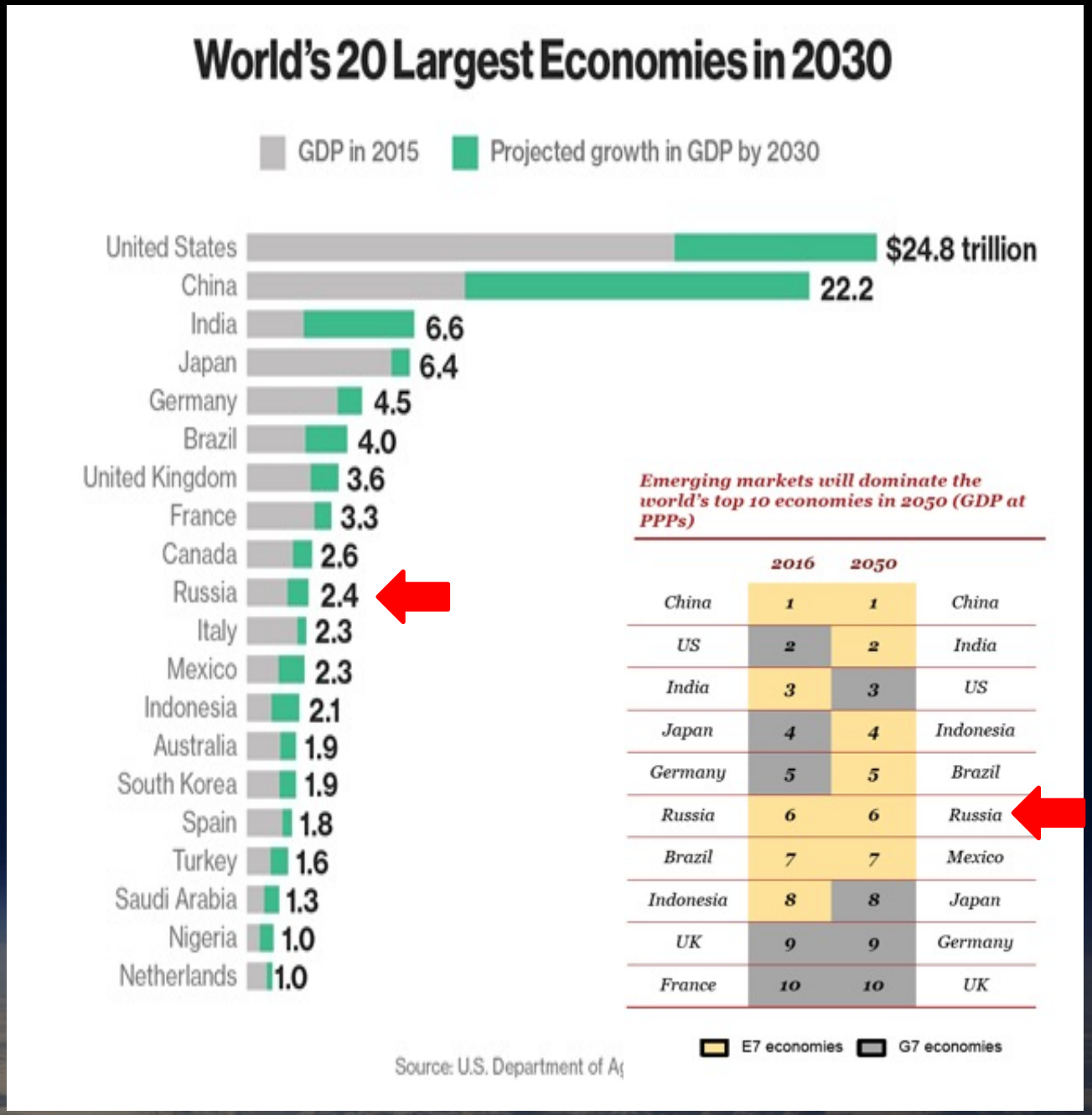
- https://apps.dtic.mil/sti/pdfs/ADB310563.pdf

Why not Russia?





A Primer on Cislunar Space

M. J. Holzinger[1], C. C. Chow[2], P. Garretson[3]

[1] Associate Professor, H. J. Smead Faculty Fellow, Ann & H. J. Smead Aerospace Engineering Sciences Department, University of Colorado Boulder

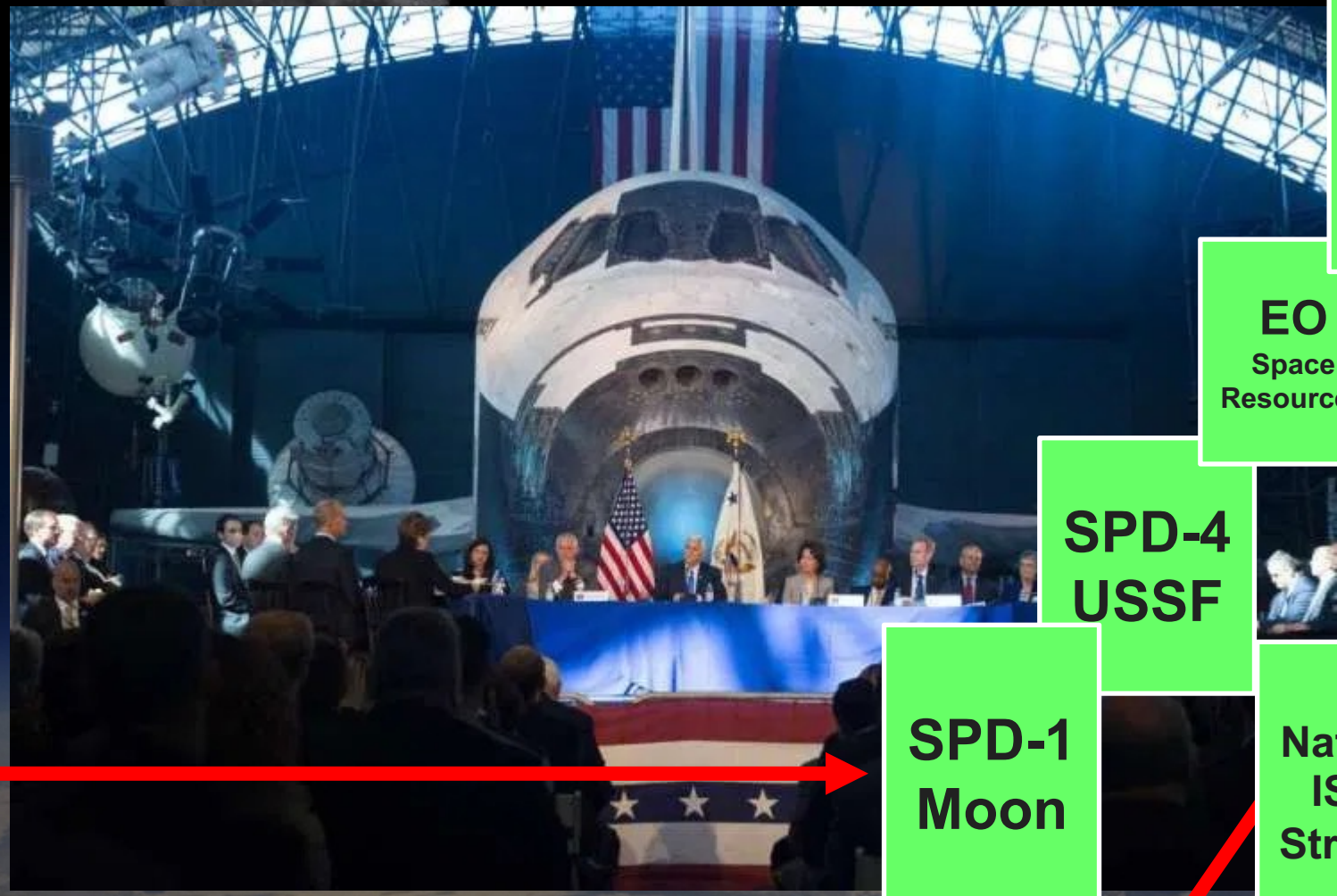
[2] Founder & CEO, Cloudstone Innovations LLC

[3] Space Vehicles Directorate, Air Force Research Laboratory, USSF

- This primer aims to familiarize the reader with “cislunar space.” It is targeted at military space professionals who will answer the call to develop plans, capabilities, expertise, and operational concepts. Cislunar space has recently become prominent in the space community and warrants attention,

United States Strategy and Space Resource Ambitions

Elevated National Focus



2015 CSLCA

SPD-1 Moon

SPD-4 USSF

EO Space Resources

A New Era for Space Exploration and Development

NSP 2020

SPD-6 SNPP

National ISAM Strategy

National Cislunar Strategy

National LEO Strategy

- 2015 President Obama Signs Asteroid Act
- 2017 SPD-1
- 2018 National Near-Earth Object Preparedness Strategy and Action Plan
- 2019 SPD-4 US Space Force
- 2020 U.S. Space Force Established
- 2020 Executive Order on Encouraging International Support for the Recovery and Use of Space Resources issued
- 2020 A New Era for Space Exploration and Development published by the National Space Council.

President Biden has

- Kept the Artemis Program
- Kept the Artemis Accords
- Kept the National Space Council
- Kept the Space Force
- Released a Space Priorities Framework
- Release an In-Space Servicing Assembly and Manufacturing (ISAM) strategy

In U.S. Policy

- Public Law No: 114-90: A United States citizen engaged in commercial recovery of an asteroid resource or a space resource under this chapter shall be entitled to any asteroid resource or space resource obtained, including to possess, own, transport, use, and sell the asteroid resource or space resource obtained in accordance with applicable law, including the international obligations of the United States.
- Deep Space Vision: This vision begins with a campaign to utilize Earth's orbital environment, the surface and resources of the Moon, and cis-lunar space to develop the critical technologies, operational capabilities, and commercial space economy necessary for a sustainable human presence on the Moon, Mars, and beyond…Initially, government support for research and demonstration will be needed to determine the feasibility of extracting useful resources, such as water. As soon as possible…commercial firms should take over routine operations to provide consumables like water, hydrogen, oxygen, and utilities such as power and communications. The transition to private sector responsibilities will represent an important step beyond space exploration to development and industrialization.
- Executive Order on "Encouraging International Support for the Recovery and Use of Space Resources" made it the policy of the United States to encourage international support for the public and private recovery and use of resources in outer space.
- National Space Policy: The United States will pursue the extraction and utilization of space resources in compliance with applicable law, recognizing those resources as critical for sustainable exploration, scientific discovery, and commercial operations.; Encourage international support for the recovery and use of outer space resources; conduct scientific investigations; map and characterize water, mineral, and elemental resources;
- Biden Space Priorities Framework: U.S. regulations must provide clarity and certainty for the authorization and continuing supervision of non-governmental space activities, including for novel activities such as on-orbit servicing, orbital debris removal, space-based manufacturing, commercial human spaceflight, and recovery and use of space resources.

Trickle down?

- SCP: Today, the entirety of economic and military space activities is confined to the geocentric regime; however, commercial investments and new technologies have the potential to expand the reach of vital National space interests to the cislunar regime and beyond in the near future. As technology marches forward, U.S. military spacepower must harmonize with the other instruments of power to protect, defend, and maintain the Nation's strategic interests in space.
- U.S. prosperity and economic security increasingly rely on the peaceful use of space. Space Security protects these interests by establishing conditions for the safe and secure access to space for civil, commercial, Intelligence Community (IC), and multinational partners. Space Security is a presence mission that helps assure partners that the U.S. military is positioned to monitor and protect their interests. Ultimately, Space Security seeks to encourage partners, not compel an adversary; however, if necessary, Space Security includes protecting these mission partners from dangerous or illicit actions. In this regard, combat forces provide a deterrent role for Space Security. Space Security may also include sharing information and domain awareness, developing self-protection capabilities, coordinating anomaly resolution support, maneuver de-confliction, EMS monitoring, launch vehicle ridesharing, protecting lines of communication and national space commerce, and building partner capacity through combined training and exercises.

U.S. Strategy and Space Resource Ambitions

- The United States finds itself at the top of the world order. In 2019, it was ranked #1 of the most powerful countries by U.S. News and World Report.2 Global Firepower ranks it as #1 in military power.3 The Stockholm International Peace Research Institute (SIPRI) estimates its military spending at $609,758 Billion (Bn). The International Institute of Strategic Studies (IISS) estimates it at $602.8Bn and places it as #1 in the military balance.
- Today, the United States has a population of 329,093,110, growing at 0.71 percent,6 with a Human Development Index (HDI) score of 0.924 (ranked #13/189 countries). Its total energy consumption was 2,201 million tons of oil equivalent (MTOE) (47.7 barrels of oil (BOE) per capita), growing at 0.27 percent, with a carbon output of 5,073 MtCO2.9 Its electrical consumption is 3,808 TWh growing at −2.1 percent, with a per capita electrical usage of 12,984 Kw-hr/annum.11
- According to International Monetary Fund (IMF) figures, its GDP (real) was $19,390.6 Bn, and $19,390.6 Bn at purchasing power parity (PPP), with a per capita income of $59,501. The United States spent 35.6 percent of its GDP on government expenditures, its estimated gross national savings was 17.4 percent of GDP, and the United States had a current account balance of $ −466.246 Bn (−2.4 percent of GDP).
- However, despite continued growth, the United States is expected to be outgrown by China and India, and to move from a position of economic dominance to a position of second or third place depending upon metric. According to PricewaterhouseCooper, its economy is expected to grow from $20.1 trillion (T) in 2020 to $34.1T in 2050 at market exchange rates (MER; real) and from $20.1T to 34.1T in PPP, suggesting it will be the #2 economy in 2050 at MER and the #3 economy (after China and India) measured by PPP, with 12 percent share of the total global economy (down from 16 percent in 2016). The Carnegie Endowment for International Peace (CEIP) similarly estimated it to be the #2 economy in 2050 at $38.646 T. The Economist Intelligence Unit (EIU) placed the United States #2 at MER, with a projected GDP rising from $17.4T in 2014 to $70.913T in 2050.
- As a consequence, if the United States does nothing to significantly grow its economy (such as to access the vast resources of space), it will decline in relative economic power, and therefore total power.

CHINA'S CURRENT AND FORECAST POWER

- At the time of writing, the People's Republic of China (PRC) finds itself in the first ranks of nations in the world order. Ranked #3 among the most powerful countries by U.S. News and World Report. Global Firepower ranks it as #3 in military power. The Stockholm International Peace Research Institute (SIPRI) estimates its military spending at $228,231Bn. The International
- Institute for Strategic Studies (IISS) estimates it at $150.5Bn and places it as #2 in the military balance. China has a population of 1,420,062,022 growing at 0.35 percent, with a Human Development Index score of 0.752 (ranked #86/189 countries). Its total energy consumption was 3,105 million tons of oil equivalent (MTOE8; 15.62 barrels of oil (BOE) per capita), growing at 2.9 percent, with a carbon output of 9,297 MtCO2.9 Its electrical consumption is 5,683 TWh growing at 5.9 percent, with a per capita electrical usage of 3,927 Kw-hr/annum.11 According to the IMF figures, its GDP (real) was $12,014.61Bn, and $23,159.11Bn at Purchasing Power Parity (PPP), with a per capita income of $8,643.11. It spent 31.5 percent of its GDP in govern ment expenditures, its estimated gross national savings was 45.84 percent of GDP and had a current account balance of $164.887Bn (1.372 percent of GDP). According to the World Economic Forum, it spends $6.111Bn on its space program (0.07 percent of GDP), whereas Euroconsult estimated its space spending at $4.909 billion. The most recent (and somewhat dated) Futron Space competitiveness report, gave it an overall space competitive score of 19.44 (ranked #5),14 with an overall military space capability score of 25.27 (ranked #4). Latest media reports indicate that China's space budget in 2019 was about $8billion.
- According to PricewaterhouseCoopers, China's economy is expected to grow from $16 trillion (T) in 2020 to $49.9T in 2050 at market exchange rates (MER or "real" GDP) and from $26.9T to 58.5T in PPP, suggesting it will be the #1 economy in 2050 at MER and the #1 economy measured by PPP, with 20 percent share of the total global economy (up from 18 percent in 2016). The Carnegie Endowment for International Peace (CEIP) similarly estimated it to be the #1 economy in 2050 at $46.265T.18 The *Economist Intelligence Unit* (EIU) placed the PRC at #2 at MER, with a projected GDP rising from $10.335T in 2014 to $105.916T in 2050.

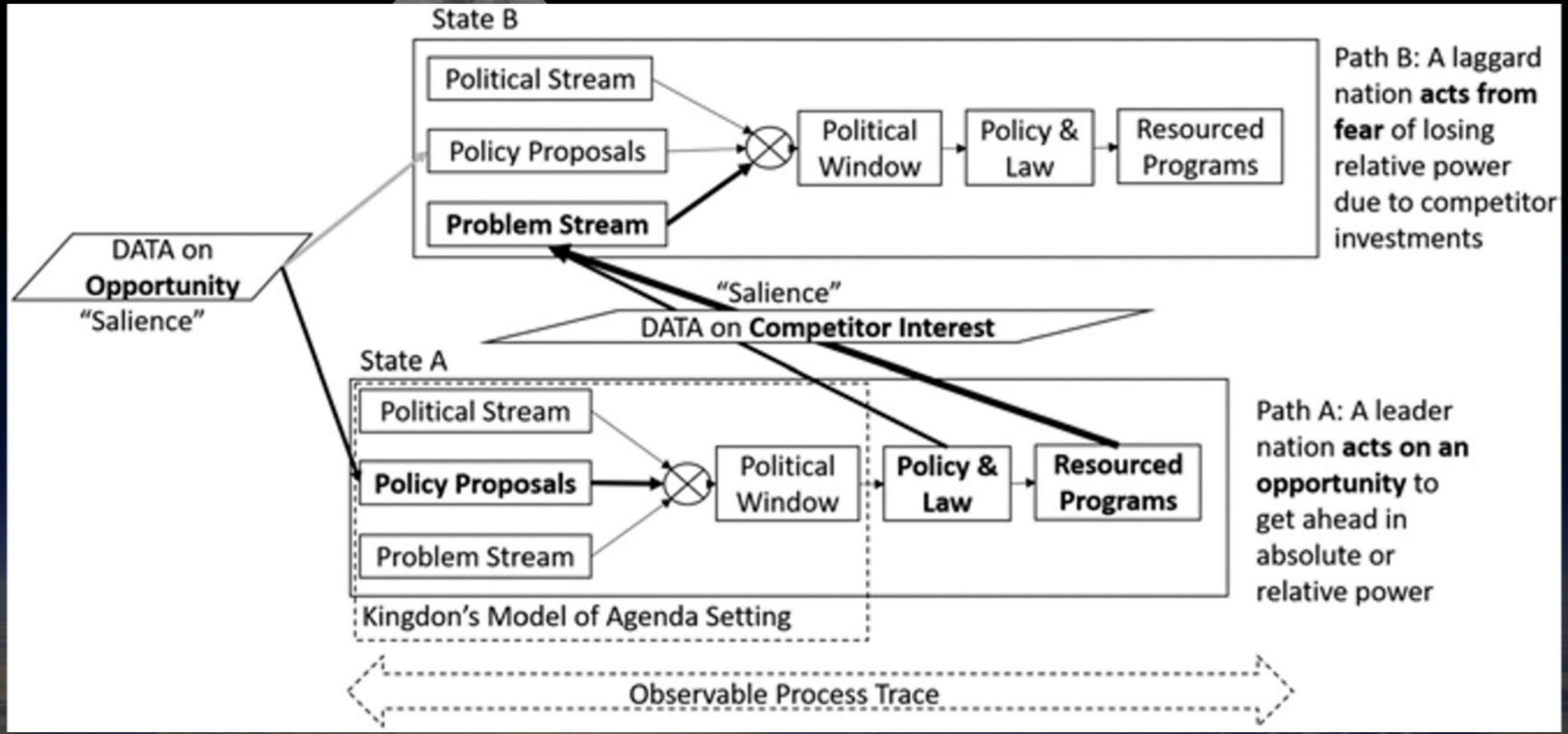
INDIA CURRENT AND FORECAST POWER

- At the time of writing (2019), India finds itself significantly behind the United States and China but projected to gain in the next two decades. India is ranked #15 on the list of the most powerful countries by U.S. News and World Report. Global Firepower ranks India as #4 in military power. The Stockholm International Peace Research Institute estimates its military spending at $63.924Bn. The International Institute for Strategic Studies estimates it at 52.5$Bn and places it as #5 in the military balance. India has a population of 1,368,737,513 growing at 1.08 percent, with a Human Development Index score of 0.640 (ranked #130/189 countries). Its total energy consumption was 934 million tons of oil equivalent (4.87 barrels of oil per capita), growing at 4.4 percent, with a carbon output of 2,234 MtCO2.11 Its electrical consumption is 1,156 TWh growing at 5.3 percent, with a per capita electrical usage of 806 Kw-hr/annum.13
- According to International Monetary Fund figures, its GDP (real) was $2,611.01Bn ($2.6 T), and $9,459.00Bn at purchasing power parity (PPP), with a per capita income of $1,982.70. It spent 27.7 percent of its GDP in government expenditures, its estimated gross national savings was 29.7 percent of GDP, and had a current account balance of $51.214Bn (1.961 percent of GDP). According to PricewaterhouseCoopers, its economy is expected to grow from $3.6T in 2020 to $28.0T in 2050 at market exchange rates (MER or “real” GDP) and from $11.8T to $44.1T in PPP, suggesting it will be the #3 economy in 2050 at MER and the #2 economy (after China) measured by PPP, with 15 percent share of the total global economy (up from 7 percent in 2016).14 The Carnegie Endowment for International Peace similarly estimated it to be the #3 economy in 2050 at $15.384T.15 The Economist Intelligence Unit also placed India at #2 at MER, with a projected GDP rising from $2.055T in 2014 to $63.842T in 2050.16
- INDIA: SPACE CAPACITY: According to the World Economic Forum, India spends $1.159 billion on its space program (0.06 percent of GDP), whereas Euroconsult estimated its space spending at $1.092 billion. The most recent (and somewhat dated) Futron Space competitiveness report, gave it an overall space competitive score of 15.33 (ranked #7), with an overall military space capability score of 10 (ranked #7).

What's in our Book

1 Introducing the Concept of Great Power Competition for Space Resources
2 The Role of Myths, History, and Strategic Culture on Space-Based Resources
3 The Epistemic Community and the Foundations of Discourse in the United States
4 U.S. Strategy and Space Resource Ambitions
5 China's Strategy and Space Resource Ambitions
6 India's Strategy and Space Resource Ambitions
7 Middle Power Strategy and Ambitions for Space Resources: Luxembourg and the UAE
8 Are We Observing the Beginning of a Race or Scramble for Space Resources?
Scenarios and Concluding Thoughts

Our Causal Process



Why it matters

Table 1.1 Title: Policy "Pascal's Wager" Payoffs for a Space Resource Scramble

	Assume a Probability of Scramble for Space Resources	*Dismiss Probability of Scramble for Space Resources*
No Scramble for Space Resources Emerges	Overprepared/Early to need. Small opportunity cost due to lost time preparing	No loss. No opportunity cost
A Scramble for Space Resources Emerges	State is properly prepared to take full advantage of the opportunity	State is unprepared to take advantage of the opportunity, potentially experiencing major losses in relative power

- Science & Exploration -> Economic Advantage -> Power -> Security
- Science & Exploration are the means, not the end
- Space is not special or exceptional
- States structure their environment to win—set the rules of the game
- International law will not save you
- NASA is a paramilitary organization created to win great power competition in peacetime
- We are in a new space race and a new cold war
- What you do has consequences