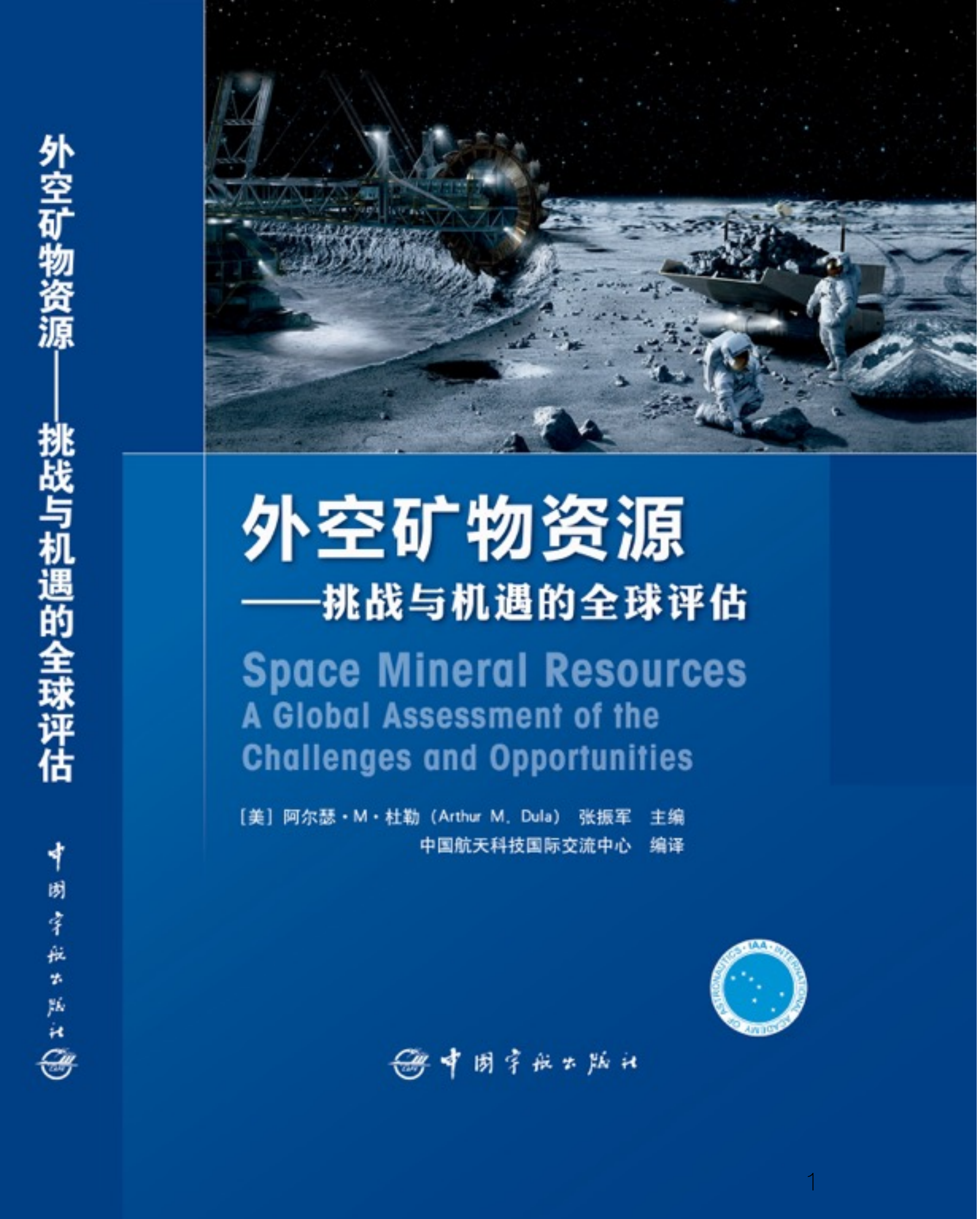


China Center for Aerospace Science & Technology International Communications

July 14, 2017

Art Dula
Trustee

The Heinlein Prize Trust

CCASTIC presentation July 2017

Outline

The Heinlein Prize Trust

Summary of the IAA study
Recent developments

Commercial space activities 2017
Historical context
Flying into the future

Questions?

The Heinlein Prize Trust
awards the
Heinlein Prize
of
$250,000
for accomplishments in
commercial space
activities.


Brett Brewer
10/29/03


The Robert A. and Virg
Heinlein Prize Trus

The trust supports education about commercial space activities worldwide.

Final Results of the Third Flying into the Future-Space Exploration Innovation Contest in Asia

The final results of the Third Flying into the Future-Space Exploration Innovation Contest in Asia were announced in the ancient city of Xi'an on July 18, 2012. The contest was jointly organized by Chinese Society of Astronautics (CSA) and the Robert A. and Virginia Heinlein Prize Trust (The Trust), and supported by Northwestern Polytechnical University in Xi'an.

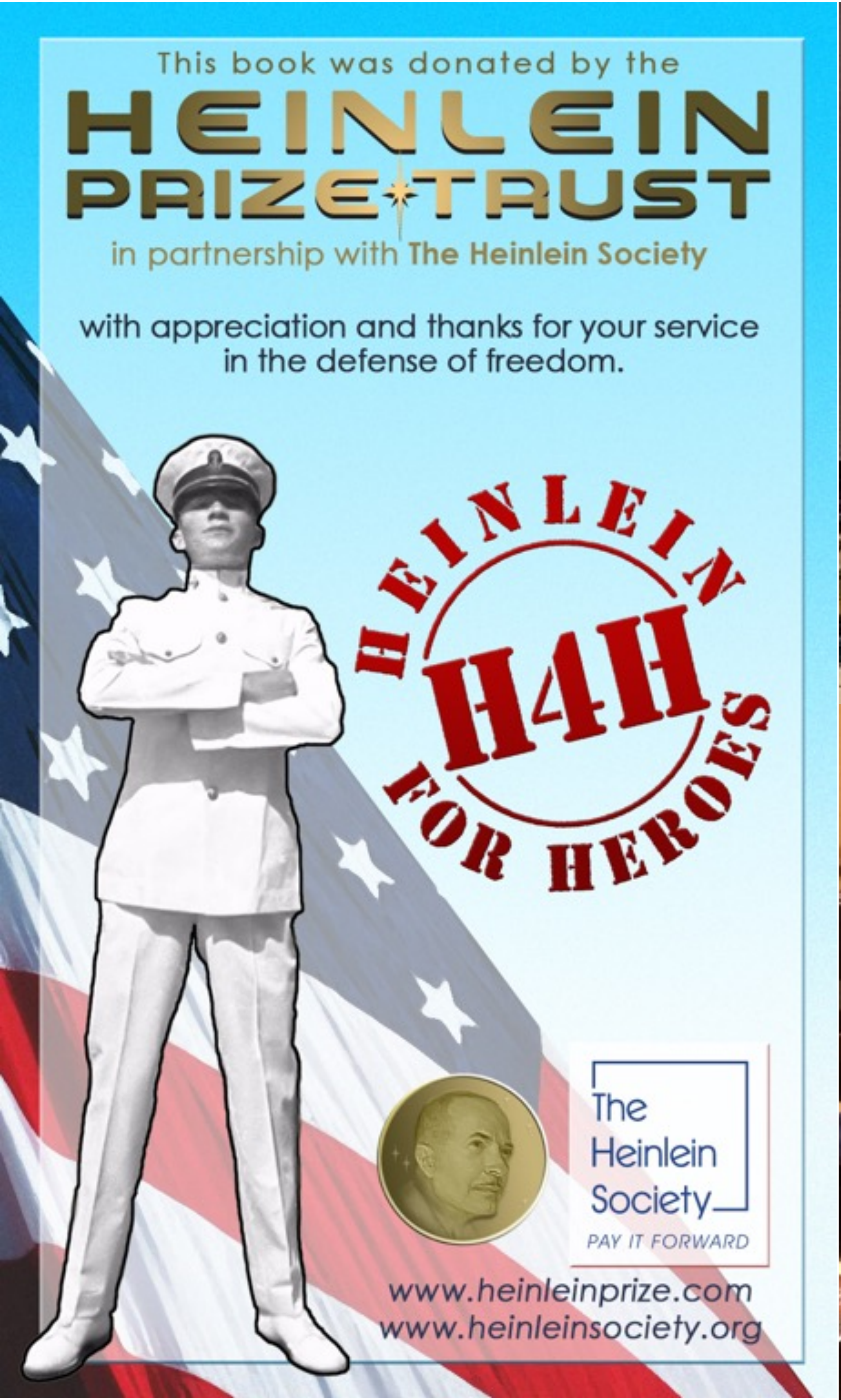
XUE Jikun and the other four co-authors from Nanjing University of Aeronautics & Astronautics (China) won the first prize with the title "The 'morning star' magnet hydro dynamic space power station".

The second prize winners are Chennai Gautham and the other two co-authors from SRM University (India) with the title "Cleaning of Space Debris" and

Partners for the Future- Spacesuit Exhibition
The Heinlein Prize Trust
Chinese Society of Astronautics
中国宇航学会
CSA
CHINESE SOCIETY OF ASTRONAUTICS
HEINLEIN PRIZE TRUST
ORLAN SPACE SUIT DISPLAY
"海鹰"航天服
The Orlan space suit photo stand is brought to you by Excalibur Exploration and the Henlein Prize Trust (HPT). This spacesuit is part of an actual Orlan suit used for training Cosmonauts in the Russian Space program.
The suit itself, including visors and gloves, are about 30 years old. When you step into this display you're putting on an actual piece of space history.
美国神剑探索公司和美国海因莱因基金会（HPT）为您带来"海鹰"航天服照相架。"海鹰号"航天服在俄罗斯航天计划中用于航天员训练，该照相架是"海鹰"航天服实物的一部分。
该航天服（包括面罩和手套）已有30年历史。当您踏入展厅，仿佛置身于一段真实的航天史中。
SOKOL SPACE SUIT
"猎鹰"航天服
The Sokol space suit (Russian: Сокол, meaning Falcon) is a type of Russian space suit, worn by all who fly on the Soyuz spacecraft. It was introduced in 1973 and is described by its makers as a rescue suit. It is not capable of being used outside the spacecraft in spacewalks or extra-vehicular activities. Instead, its purpose is to keep the wearer alive in the event of an accidental depressurization of the spacecraft.
"猎鹰"航天服是俄罗斯"联盟"号飞船使用的一款航天服，于1973年推出。该航天服能够在飞船出现意外减压时保护航天员，但不能用于太空行走或舱外活动，因而被作为救生服使用。


NEW
IAC


for the Future”
ICC בנייני האומה


This book was donated by the
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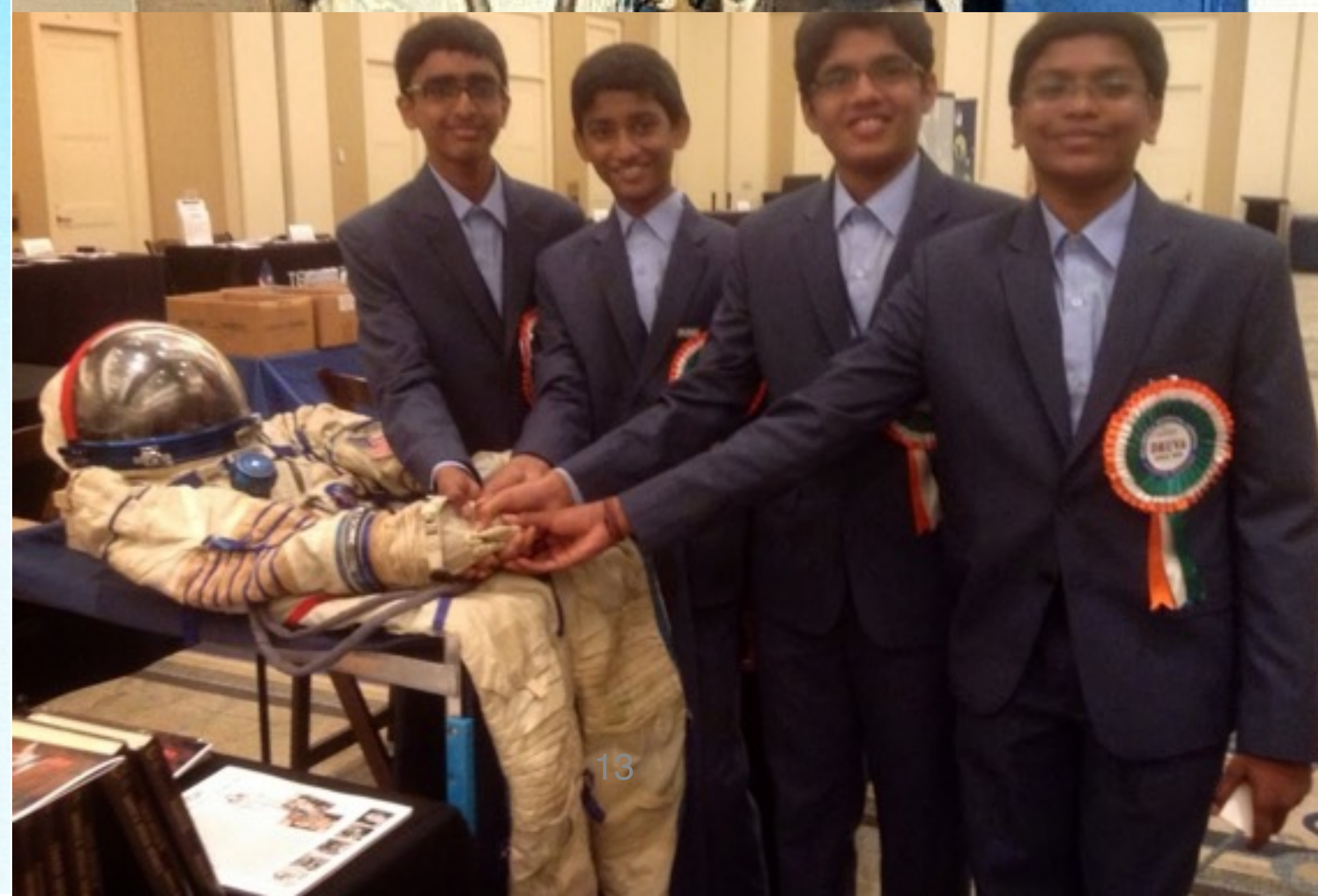
Have Spacesuit Will




LES SPACE SUIT
NASA's Launch Entry Suit (LES) was a partial pressure suit that Space Shuttle crew members wore for the ascent and entry portions of flight. The space suit was used by NASA astronauts from STS-26 in 1988 to STS-65 in 1994. The LES, also called the "pumpkin suit", is a direct descendant of the high-altitude pressure suits worn by crews of the SR-71 Blackbird and U-2. It is also identical to the suits worn by X-15 pilots and Gemini astronauts. The suits were designed to withstand pressures up to 40,000 feet (12 kilometers) and submersion in the ocean for up to 24 hours at 40° Fahrenheit (5° Celsius). In 1994, LES was replaced by the Advanced Crew Escape Suit (ACES), a full pressure that was analogous to the Sokol suits used for Russian Soyuz missions with the only differences being that the Sokol suits did not have a detachable helmet and survival backpack.
Note: NASA has loaned this used suit to the Heinlein Trust for educational exhibition to get additional value from the half penny of your tax dollar that pays for the U.S. space program.
Charles Frank Bolden, Jr.
NASA Administrator
Former NASA Astronaut
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А.КАЛЕРИ
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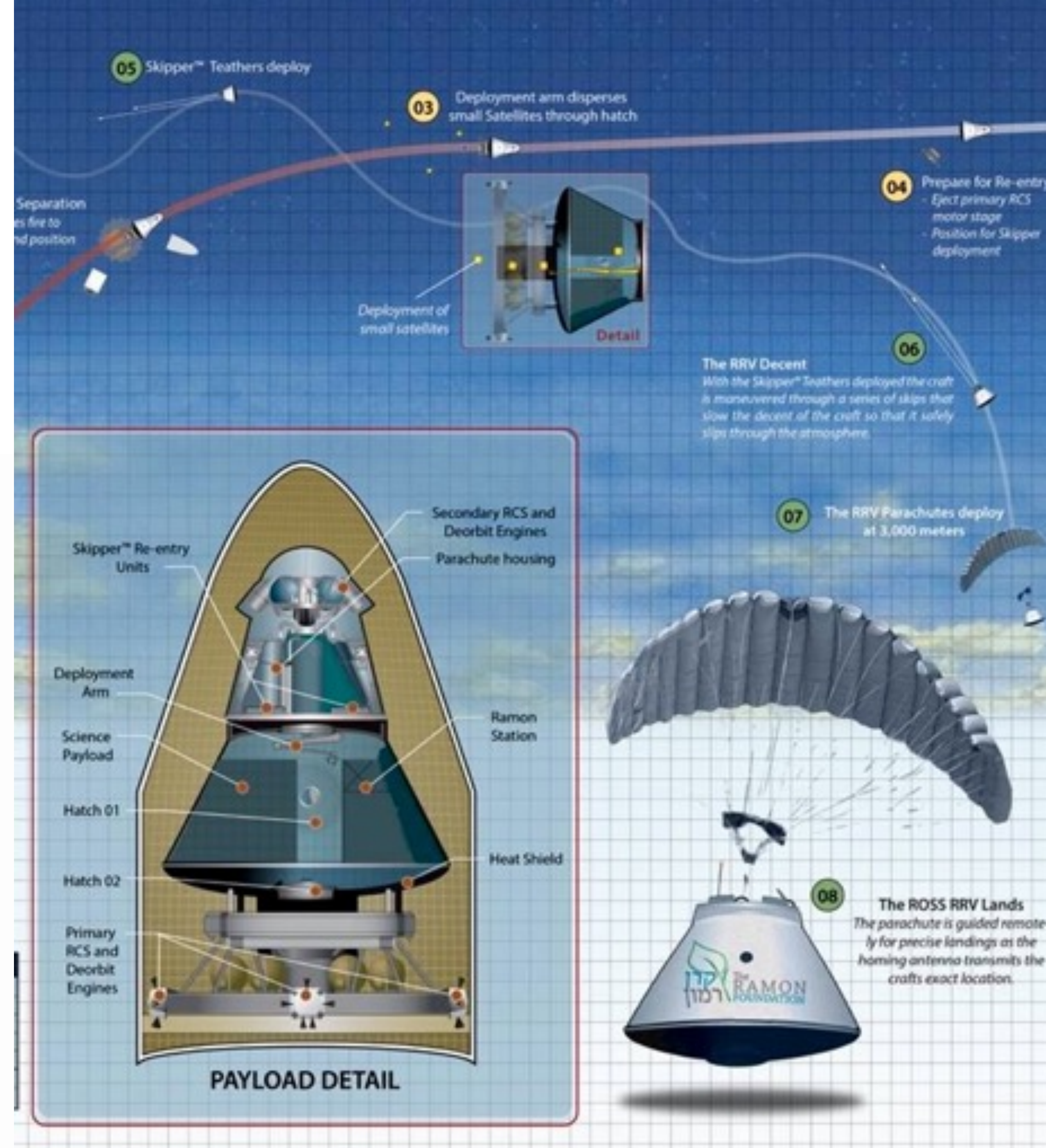
אקסקליבר אלמאז
Almaz Capsule
НПО
МАШИНОСТРОЕНИЯ
ROYAL
AERONAUTICAL
SOCIETY

The trust supports the Ramon Orbital Student Spacelab to fly student experiments in space from all nations of the world.



קרן רמון

The RAMON FOUNDATION

קרן רמון
The RAMON FOUNDATION

09/07/2017

To whom it may concern

Ramon SpaceLab Program

Ramon SpaceLab (RSL) is an advanced education program that enables children to send scientific experiment to International Space Station.

The advanced pedagogy in the program is designed not only to encourage young students to major and excel in STEM, but to assist the children in acquiring the needed skills for changing the realty in the 21st century. The program is considered to be Israel's leading space education program and one of the world's most advanced education programs.

The program includes 7 different missions. Each mission is named after one of the seven brave groundbreaking astronauts who led NASA's Columbia sts-107 mission. Each is a milestone preparing the students for the Ramon SpaceLab Mission – designing and deploying an experiment in space (alongside with researchers and scientists).

Up till today the Ramon Foundation sent dozen experiments to the international space station. We are currently in contact with Excalibur Almaz ("EA") to create the ROSS program. EA offered to provide its capsule to the project without charge and the Ramon Foundation will manage the ROSS educational program. Once the ROSS program will be deployed, we would be honored to send out children and students experiments with one of EA's unflown space capsule .

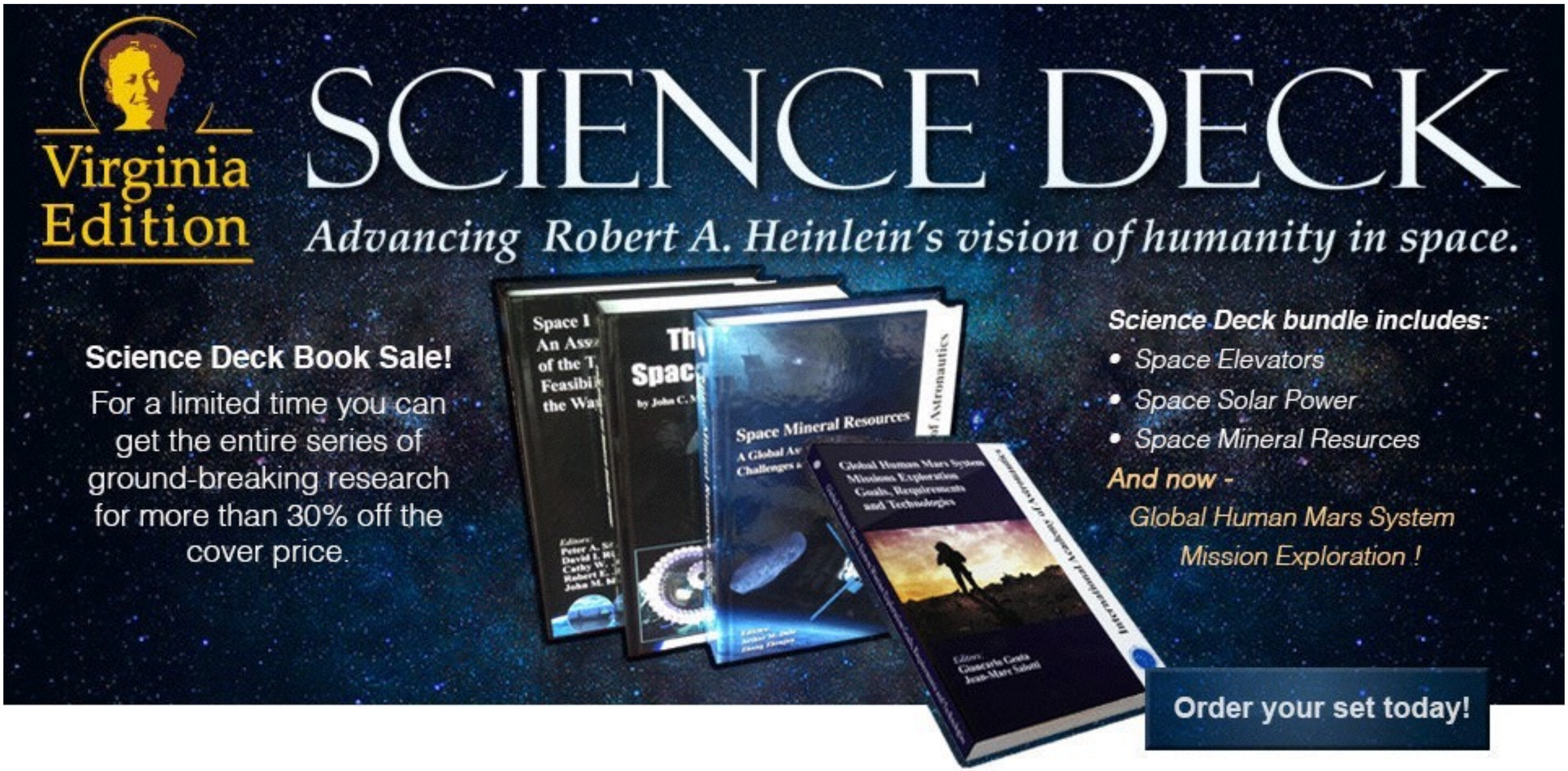
We are aware that EA is negotiating with China Great Wall Industry for space launch services to support the project. We are hereby confirm that we are in consent that during the negotiation process, EA will disclose the potential cooperation with the Ramon Foundation and details re the ROSS project to third parties.

Once the ROSS program will be deployed, we would be honored to send out children and students experiments with one of EA's unflown space capsule. We are aware that EA must negotiate a launch vehicle contract for the project. We hereby confirm that we are in consent that during the negotiation process, EA will disclose the potential cooperation with the Ramon Foundation and details re the ROSS project to third parties.

Ran Livne
Director General
Ramon Foundation

The Ramon Foundation
Remembering Ilan and Asaf Ramon
Tefuzot Israel 5 Givatayim 5358322 Israel

קרן רמון (ע"ר)
לזכרם של אילן ואסף רמון
תפוצות ישראל 5 גבעתיים 5358322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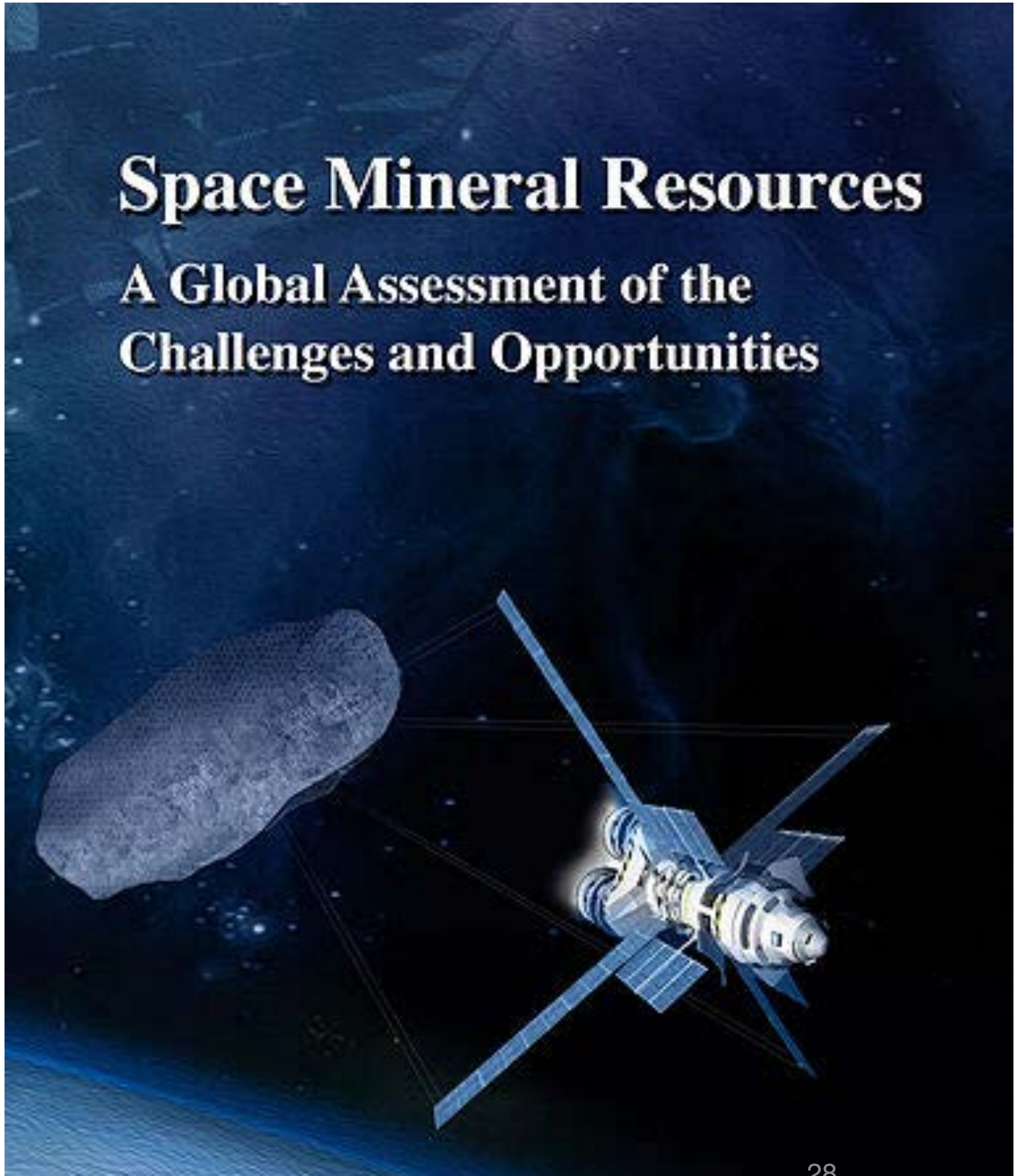

Space Mineral Resources
A Global Assessment of the
Challenges and Opportunities

COMMERCIAL
SPACEFLIGHT
FEDERATION

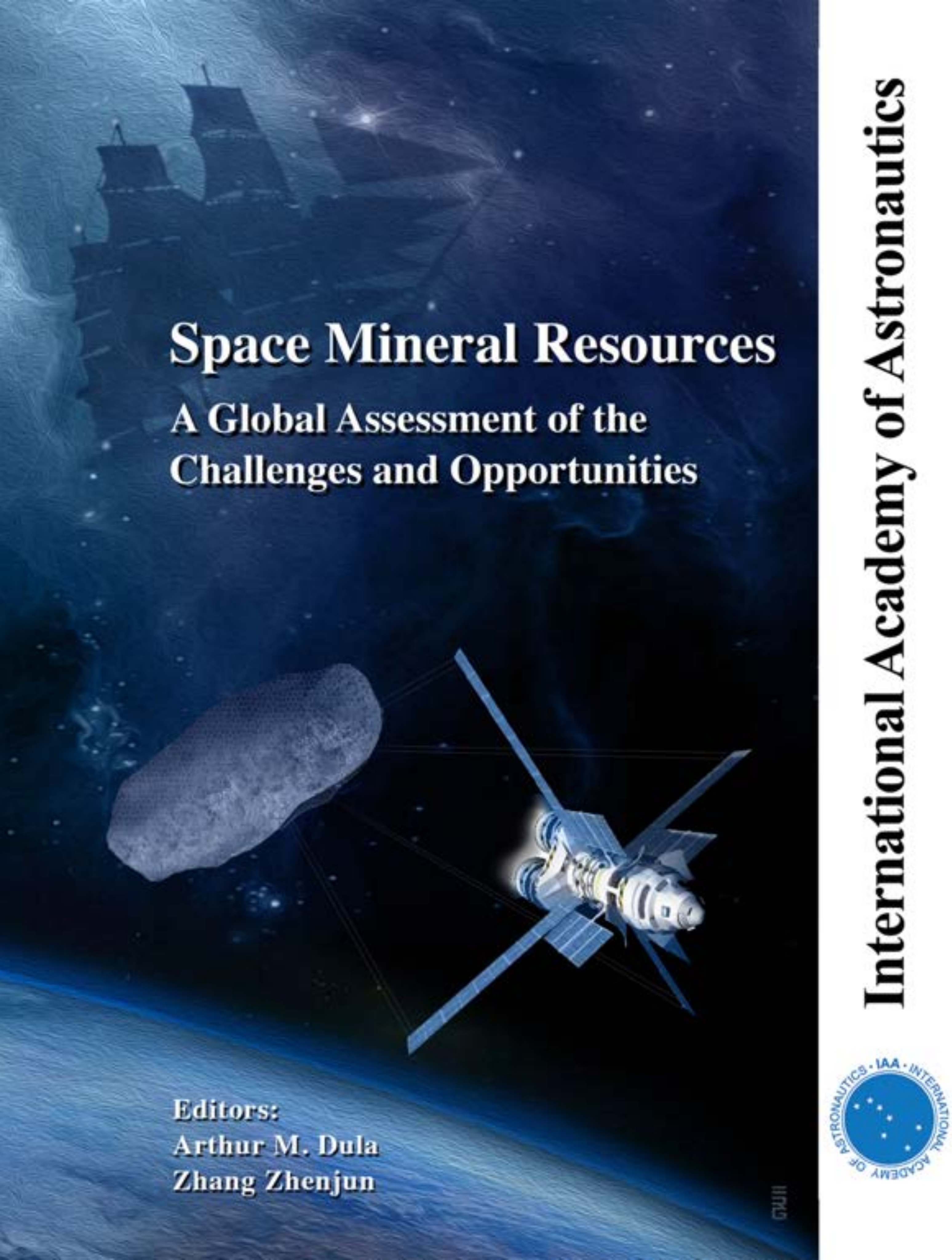
500 New Jersey Avenue Suite 400
Washington, D.C. 20001

To Whom It May Concern:

Harnessing the solar system's abundant resources is key to improving life on Earth, expanding beyond our planet, and exploring deep into space. IAA's Space Mineral Resources study is by far the most comprehensive analysis of the opportunity, the challenges, and the way forward. No entrepreneur, investor, or policymaker interested in this disruptive new capability should be without Space Mineral Resources. It is a desk reference for mining the last frontier, and I predict that it will be found in the first trillionaire's personal library. The Commercial Spaceflight Federation considers it required reading.

Sincerely,

Eric Stallmer
President
Commercial Spaceflight Federation



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Authorized by the
IAA Scientific Commission
October 2012

Published
September 2015

Briefing by the International Academy of Astronautics
Cosmic Study 3.17

Space Mineral Resources
A Global Assessment
Challenges and Opportunities

Art Dula, Editor

To

ISECG

International Space Exploration
Coordination Group

1. Background
2. Study description
3. Principal finding
4. Major conclusion
5. Specific findings
6. Recommendations

Purpose of the study approved by the Scientific Commission of the Academy

To provide, in one document, the current state of the art of the technology, economics, law & policy related to Space Mineral Resource opportunities and to make recommendations for moving forward.

To provide a logical, systematic and practical road map to promote and encourage near term evaluation, development and use of space mineral resources.

No comprehensive summary of the current literature on this subject is now publicly available. This IAA study is the first comprehensive study of the subject; and, thus it should be of significant value to its development for the benefit of humanity.

31 Study Group Members contributed from 17 countries

Oleg Alifanov, Russia; Haithem Altwaijry, Saudi Arabia;
Bohdan I. Bejmuk, Ukraine, USA; Giovanni F Bignami, France;
Andrea Boyd, Australia, Italy; Christophe Bonnal, France
Franklin Chang-Diaz, Costa Rica, USA; Catharine Conley, USA;
Arthur M. Dula, USA; Russell E. Dula, USA; Anat Friedman, Israel, USA; Li Furong, China; Jose Gavira, Spain;
Fernando G. Gonzalez, Spain; Hans E. W. Hoffmann, Germany
Shirazi Jaleel-Khan, Sri Lanka, USA; Roger Lenard, USA;
Susan McKenna-Lawlor, [illegible]kins, USA;
Jacques Masson, France[illegible], USA;
Vladislav Shevchenko, R[illegible] Stott, Isle of Man, USA;
Andrea Sommariva, Italy;[illegible]; Peter Swan, USA;
Tai Sik Lee, Korea; Rick Tumlinson, USA; Yang Junhua, China;
Hiroshi Yoshida, Japan; Zhang Zhenjun, China

11 organizations provided study content

Heinlein Prize Trust
U.S. National Space Society
International Space Development Conference
Texas A&M University – Aerospace Engineering Department
European Space Conference – Turino
Newspace Conference
International Space University
International Space Elevator Consortium
Chinese Society of Astronautics
Canadian Space Society
Australian Space Society

5 firms provided business road maps

Moon Express
Excalibur Exploration Limited
Deep Space Industries
Ad Astra Rocket Company
Shackleton Energy Corporation

Organization:

This study is organized to provide technical information, policy and legal analyses, economic context and opportunity analyses, and recommended steps for moving forward. Finally, an international roadmap showing pathways forward is offered. Following this roadmap will maximize the rate and likelihood of SMR development, as well as have the corollary benefit of saving humanity from one or more potential civilization or species-ending disasters. The layout of the study report is structured across a logical sequence:

First – Set the stage; general background and then "how to mine."
Second – Describe the market and potential roadmaps to profit
Third – Look at the technologies necessary to achieve success
Forth – Conduct analysis between choices
Fifth – Assess the legal, policy and governance issues
Sixth – Summarize conclusions and recommendations

Chapter 1 Introduction: This chapter shows the ideas expanded upon throughout the document, as well as, a description of space mineral resource approaches and a listing of the types of resources being sought. In addition, some quick insights are shown to set the stage for the rest of the report.

Chapter 2 Mining of Space Resources: This chapter will show the mineral content of likely locations for mining and processing materials as well as discussions of the processes and the technological equipment needed. Asteroids have tremendous potential; but, each is different and needs to be understood prior to approaching. Planetary surfaces provide a spectrum of mineral resources; but, where and how to develop them is the question.

Chapter 3 Market Approach: This chapter will look at financial approaches to ensure commercial success. Economic models will look at not only the value of the minerals to be mined, but the investment required to get there, provide mining facilities, store the resources, and then transport them to the customer.

Chapter 4 Roadmaps for SMR Development: This chapter will provide an understanding of "how to" achieve commercial viability on space mineral resource development, four company SMR roadmaps will be shown to lay out the approaches that each of these companies has taken.

- Deep Space Industries
- Shackleton Energy Company
- Excalibur Exploration

Chapter 5 Quick Look at SMR Systems: This chapter will analyze the systems aspects of these solar system level ventures. It will help identify the various risks that much be understoo and mitigated. Technologies will be assessed as to their level of readiness for space with the traditional NASA Technology Readiness Level [TRL] approach and rating. In the end, this will assess the technological feasibility of the effort to provide a profit for SMR commercial venture

Chapter 6 Modeling and Analysis: This chapter will look at the needs of commercial venders in understanding the issues. In addition, the modeling and analyses will help venture understand where to invest near term funding to create a successful venture.

Chapter 7 SMR Policy, Legal and Other Considerations: This chapter will analyze international treaties and policies around the world for operations in space.

Chapter 8 Findings, Conclusions & Recommendations: This chapter will consolidate the findings and lead to the report's conclusions and recommendations.

Chapter 9 Concept for the Future – Water is the Currency for Space: This is a brief extrapolation towards the future recognizing the importance of mining water.

Principle Finding:

SMR ventures cannot wait for government programs to lower technological and programmatic risks. Commercial ventures must determine the optimum path for commercial success and aggressively lead the way beyond low Earth orbit (LEO). During the first half of the 21st century, space leadership will come from commercial enterprises and not depend upon government space programs. One concept that would leverage this series of initiatives is to convince government agencies that commercial enterprises will be there first and will be able to support government explorations by selling products to them at designated locations.

Major Conclusion:

Members of the study group found that mining space mineral resources will enable economic travel between the Earth's surface and near-by locations within our solar system. The process of mining water from asteroids, the Moon or Mars will ensure that key elements are available at the spaceports of the future. Water will ensure that human exploration will expand beyond low Earth orbit with the profit motive driving the exploitation of resources.

With this conclusion, the following is supported.

Finding 1: Technical

Technological risk reduction and engineering design: The mining of asteroids and lunar regolith is within the current state of the technical art. The extrapolation of Earth-based mining seems to be a one-for-one trade with some significant alterations due to vacuum, low gravity and temperature extremes. Many proposed solutions have been suggested and tested [on Earth] leading to positive conclusions on this topic.

Finding 2: Economic:

Financial aspects of any activity focuses upon the initial lift to orbit costs. Low cost access to space will enable space mineral resource utilization. Reducing cost of delivery to an EML-1 Lagrangian spaceport by two orders of magnitude will ensure that commercial entrepreneurs will spring up and pursue the vast opportunities then available.

Finding 3: Legal

Although space is inherently multi-national and international in its scope, experience indicates that national laws are the only framework that individual actors, both private and governmental, will accept as a means for specifically developing and acting in space. Mining and ownership of space mineral resources is parallel to national laws and, as such, is consistent within current international law. International space law has established that national laws govern national activities in outer space within the current framework. History has repeatedly demonstrated that areas controlled primarily by national, as opposed to international, law prosper most readily.

Finding 4 – Publication of this study during 2015 is timely because interest in space mineral resources is growing. Recent events include:

A – “The Economics of NEOs:” A workshop held at NASA's Ames Research center in September 2014 with the aim: “… to serve as a catalyst for discussions and to foster collaborations between industry, academia and government.” Its summary is included in the study as an appendix.

B – “Space Mineral Resources Governance:” A meeting held in the Hague on December 1, 2014, resulting in the formation of “The Hague Space Resource Governance Working Group."

C – “Towards the Use of Space Resources:” A follow-on meeting to the NASA Ames workshop held by the Minister of Economics of the Luxembourg in March 2015 to discuss the relationship and needs of commercial ventures and parallel government activities. Much of the discussion focused on risk identification and investment vs. technological readiness level.

A key feature of Finding #4 is that commercial space ventures are currently aggressively investing in risk reduction and vvbzhhhhh.hhhjhhghghhhhhhhh. out to form commercial and governmental partnerships. These types of actions, in the past, led to development of major new industries. It is reasonable to expect that this will happen in space industry.

Conclusion

The study provides an authoritative summary of the technology, economics, law & policy of Space Mineral Resource opportunities and to make recommendations for moving forward to develop these natural resources for human benefit.

31 Study Group Members from17 countries, 11 organizations provided content, 5 firms provided business road maps

A second IAA study on this subject has begun. The IAA seeks and invites experts from developing countries to join this study group. Please contact the editors for more details.

Principle Finding of the study.

SMR ventures cannot wait for government programs to lower technological and programmatic risks. Commercial ventures must determine the optimum path for commercial success and aggressively lead the way beyond low Earth orbit (LEO). During the first half of the 21st century, space leadership will come from commercial enterprises and not government space programs. Private enterprises will be there first and will support government explorations by selling fuel and water at designated locations. **ULA now offers to pay $3,000 per kilogram of water delivered in low Earth orbit**.

Major Study Conclusion and an update after Trump's election.

Members of the study group found that mining space mineral resources will enable economic travel between the Earth's surface and near-by locations within our solar system. The process of mining water from asteroids, the Moon or Mars will ensure that key elements are available at the spaceports of the future. Water will ensure that human exploration will expand beyond low Earth orbit with the profit motive driving the exploitation of resources.

The USA and Luxembourg have passed laws and made investments to encourage commercial space mining. The first companies are now working. I recommend that the PRC do the same.

Public-private partnerships will likely be the focus of President Elect Trump's space policy. Trump has proposed a stronger manned space program that uses commercial rockets from SpaceX, Blue Origin and others. There could be a return to the moon, possibly to mine fuel. The future of some big government programs - SLS and Orion is uncertain. The key will be probably be more "bang for the buck " by commercial competition.

Spurring Private Aerospace Competitiveness and Entrepreneurship Act of 2015

Signed by President Barack Obama on 25 November 2015 explicitly allows

“US citizens to engage in the commercial exploration and exploitation of 'space resources' [including ... water and minerals]."

The Act further asserts that "the United States does not [(by this Act)] assert sovereignty or sovereign or exclusive rights or jurisdiction over, or the ownership of, any celestial body.

I

115TH CONGRESS
1ST SESSION

H. R. 2809

To amend title 51, United States Code, to provide for the authorization and supervision of nongovernmental space activities, and for other purposes.

IN THE HOUSE OF REPRESENTATIVES

JUNE 7, 2017

Mr. SMITH of Texas (for himself, Mr. BABIN, Mr. BRIDENSTINE, Mr. PERLMUTTER, Mr. ROHRABACHER, Mr. HULTGREN, Mr. WEBER of Texas, Mr. HIGGINS of Louisiana, and Mr. KILMER) introduced the following bill; which was referred to the Committee on Science, Space, and Technology

---

A BILL

To amend title 51, United States Code, to provide for the authorization and supervision of nongovernmental space activities, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE; TABLE OF CONTENTS.

This Act may be cited as the "American Space Commerce Free Enterprise Act of 2017".

Economic Assessment and Systems Analysis of an Evolvable Lunar Architecture that Leverages Commercial Space Capabilities and Public-Private-Partnerships

Forward

This study by NexGen Space LLC (NexGen) was partly funded by a grant from NASA's Emerging Space office in the Office of the Chief Technologist. The conclusions in this report are solely those of NexGen and the study team authors.

Date of Publication

July 13, 2015

Study Team

Charles Miller, NexGen Space LLC, *Principal Investigator*
Alan Wilhite, Wilhite Consulting, Inc., *Co-Principal Investigator*
Dave Cheuvront
Rob Kelso
Howard McCurdy, American University
Edgar Zapata, NASA KSC

Independent Review Team

Joe Rothenberg, former NASA Associate Administrator for Spaceflight *(Chairman)*
Gene Grush, former NASA JSC Engineering Directorate (*Technical subsection lead*)
Jeffrey Hoffman, MIT Professor, former NASA astronaut (*S&MA subsection lead*)
David Leestma, former NASA astronaut, (*Cost Estimation subsection lead*)
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Jim Ball, Spaceport Strategies LLC
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Steve Isakowitz, Virgin Galactic
Christopher Kraft, former Director NASA Johnson Space Center
Michael Lopez-Alegria, former NASA astronaut
Thomas Moser, former NASA Deputy Associate Administrator for Human Spaceflight
James Muncy, Polispace
Gary Payton, former NASA astronaut, former Deputy Undersecretary for Space, USAF
Eric Sterner, former NASA Associate Deputy Administrator for Policy and Planning
Will Trafton, former NASA Deputy Associate Administrator for Spaceflight
James Vedda, Aerospace Corporation
Robert Walker, former Chairman of the House Committee on Science and Technology
Gordon Woodcock, consultant

Executive Summary

This study's primary purpose was to assess the feasibility of new approaches for achieving our national goals in space. NexGen assembled a team of former NASA executives and engineers who assessed the economic and technical viability of an "Evolvable Lunar Architecture" (ELA) that leverages commercial capabilities and services that are existing or likely to emerge in the near-term.

We evaluated an ELA concept that was designed as an incremental, low-cost and low-risk method for returning humans to the Moon in a manner that directly supports NASA's long-term plan to send humans to Mars. The ELA strategic objective is commercial mining of propellant from lunar poles where it will be transported to lunar orbit to be used by NASA to send humans to Mars. The study assumed A) that the United States is willing to lead an international partnership of countries that leverages private industry capabilities, and B) public-private-partnership models proven in recent years by NASA and other government agencies.

Based on these assumptions, the our analysis concludes that:

- Based on the experience of recent NASA program innovations, such as the COTS program, a human return to the Moon may not be as expensive as previously thought.
- America could lead a return of humans to the surface of the Moon within a period of 5-7 years from authority to proceed at an estimated total cost of about $10 Billion (+/- 30%) for two independent and competing commercial service providers, or about $5 Billion for each provider, using partnership methods.
- America could lead the development of a permanent industrial base on the Moon of 4 private-sector astronauts in about 10-12 years after setting foot on the Moon that could provide 200 MT of propellant per year in lunar orbit for NASA for a total cost of about $40 Billion (+/- 30%).
- Assuming NASA receives a flat budget, these results could potentially be achieved within NASA's existing deep space human spaceflight budget.
- A commercial lunar base providing propellant in lunar orbit might substantially reduce the cost and risk NASA of sending humans to Mars. The ELA would reduce the number of required Space Launch System (SLS) launches from as many as 12 to a total of only 3, thereby reducing SLS operational risks, and increasing its affordability.
- An International Lunar Authority, modeled after CERN and traditional public infrastructure authorities, may be the most advantageous mechanism for managing the combined business and technical risks associated with affordable and sustainable lunar development and operations.
- A permanent commercial lunar base might substantially pay for its operations by exporting propellant to lunar orbit for sale to NASA and others to send humans to Mars, thus enabling the economic development of the Moon at a small marginal cost.

Exhibit 11: Map of active United States launch and reentry sites
Dots represent licensed or government sites; stars represent non-licensed sites

Source: FAA, Goldman Sachs Global Investment Research.

Globally, we highlight 10 countries that manage the most active launch and reentry sites.

Exhibit 12: Map of main active global launch and reentry sites
Russia, China, France, Japan, South Korea, North Korea, Israel, India, Kazakhstan and the US manage the most active facilities

Launch site	Vehicles launched	Launches
Guiana Space Centre	Ariane 5, Soyuz 2, Vega	Orbital
Plesetsk Cosmodrome	Soyuz, Rockot	Sub-orbital / Orbital
Dombarovsky Air Base	Dnepr	Sub-orbital / Orbital
Vostochny Cosmodrome	Soyuz, Angara	Orbital
Baikonur Cosmodrome	Angara, Dnepr, Proton M, Rockot, Soyuz, Zenit	Orbital
Palmachim Air Force Base	Shavit	Sub-orbital / Orbital
Semnan Satellite Launch Center	Safir	Sub-orbital / Orbital
Jiuquan Satellite Launch Center	Long March 2C, 2D, 2F	Orbital
Taiyuan Satellite Launch Center	Polar-bound Long March 4	Orbital
Xichang Satellite Launch Center	GEO-bound Long March 3B	Orbital
Wencheng Satellite Launch Center	Long March 7, 5	Sub-orbital / Orbital
Satish Dhawan Space Center	PSLV, GSLV, Future LMV-3	Orbital
Sohae Satellite Launching Station	Unha	Orbital
Naro Space Center	Naro-1	Orbital
Uchinoura Space Center	Epsilon	Sub-orbital / Orbital
Tanegashima Space Center	H-IIA, H-IIB	Orbital

Source: FAA.

FAST SPACE:

LEVERAGING ULTRA LOW-COST SPACE ACCESS FOR 21ST CENTURY CHALLENGES

December 22, 2016

Air University
Maxwell AFB, AL

Predicate for Success: Reduce Costs through Reusability and Increased Flight Rates

The rich benefits of a Fast Space architecture will only be realized if the cost of space launch can be substantially reduced. Our analysis has scanned the horizon of innovators across the globe who are experimenting with this concept. The research

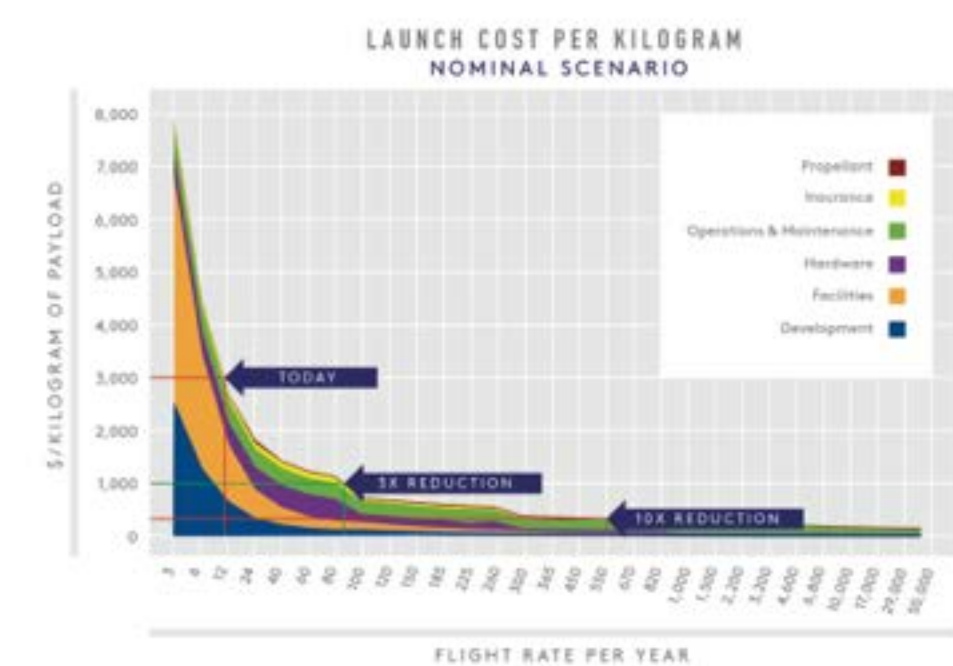


Figure 1 — Cost per Kilogram rapidly decreases as Flight Rate Increases

reveals that reusability is where the big investors are placing their bets. Our RLV analysis finds that launch costs reduce dramatically as launch rates increase. As **Figure 1** indicates, as launch rates increase, costs drop quickly and significantly. The robust analysis that substantiates the figure can be found in the full report. The benefits of Fast Space become real as ultra low-cost access to space (ULCATS) systems mature. Even though RLVs are the current trend, this study recommends that the Air Force ride the leading edge of innovation, no matter where it goes. We cannot predict future winners in this journey, so other technologies such as space elevators, air launch space access, or other techniques may become more affordable.

What the USAF Should Do To Seize This Opportunity

Based on our analysis, we recommend the Air Force should use Other Transaction Authorities (OTAs) to fund commercial partnerships with private space industry leaders. A compelling partnership marries the comparative advantages of both the US government and private industry. The government supplies capital, deep technical expertise and fixed infrastructure beyond the ability of any company to sustain, and the possibility of future purchases if they succeed. Industry capitalizes on their entrepreneurial business models, profit motives, innovative cultures, and extensive research and development to build the technical systems of a Fast Space architecture. A partnership funded through OTAs could put a virtuous cycle of cost reduction into motion to make Fast Space a reality for the joint force.

Fri Jun 3, 2016 | 12:23pm EDT

Luxembourg sets aside 200 million euros to fund space mining ventures

Luxembourg on Friday upped its bid to be a leader in the nascent space mining industry by setting aside 200 million euros ($223 million) to fund initiatives aimed at bringing back rare minerals from space.

Luxembourg in February announced plans for a law that would make it the first state in Europe to give legal clarity to the commercial exploitation of asteroids. A similar law was passed by the United States in November.

"We have a first budget to get started but if we need more money, we will be able to provide it," Etienne Schneider, Luxembourg's economy minister told a news conference.

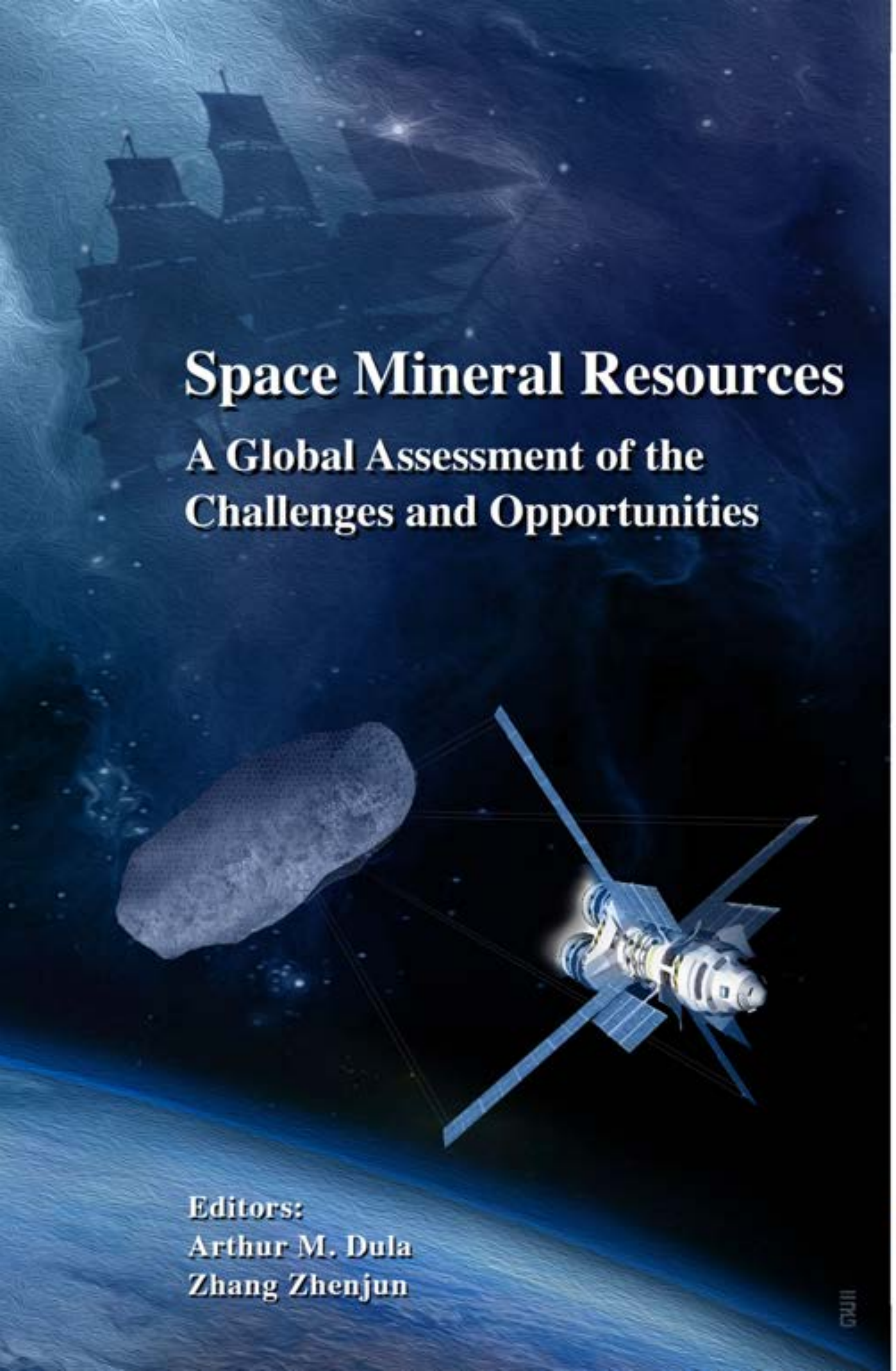
Photograph by Getty Images/Brand X

COMMERCIAL SPACE

Luxembourg to Invest $227 Million in Asteroid Mining

David Z. Morris
Jun 05, 2016

On Friday, the tiny European nation of Luxembourg announced that it would open a 200 million Euro ($227M U.S.) fund to entice companies focused on mining asteroids to locate there. Luxembourg's economy minister said that the fund's budget could expand if needed, and that it is aimed at making the country, which is about the size of the Dallas metro area, a global leader in space.



International Academy of Astronautics

<u>Recommendation</u>

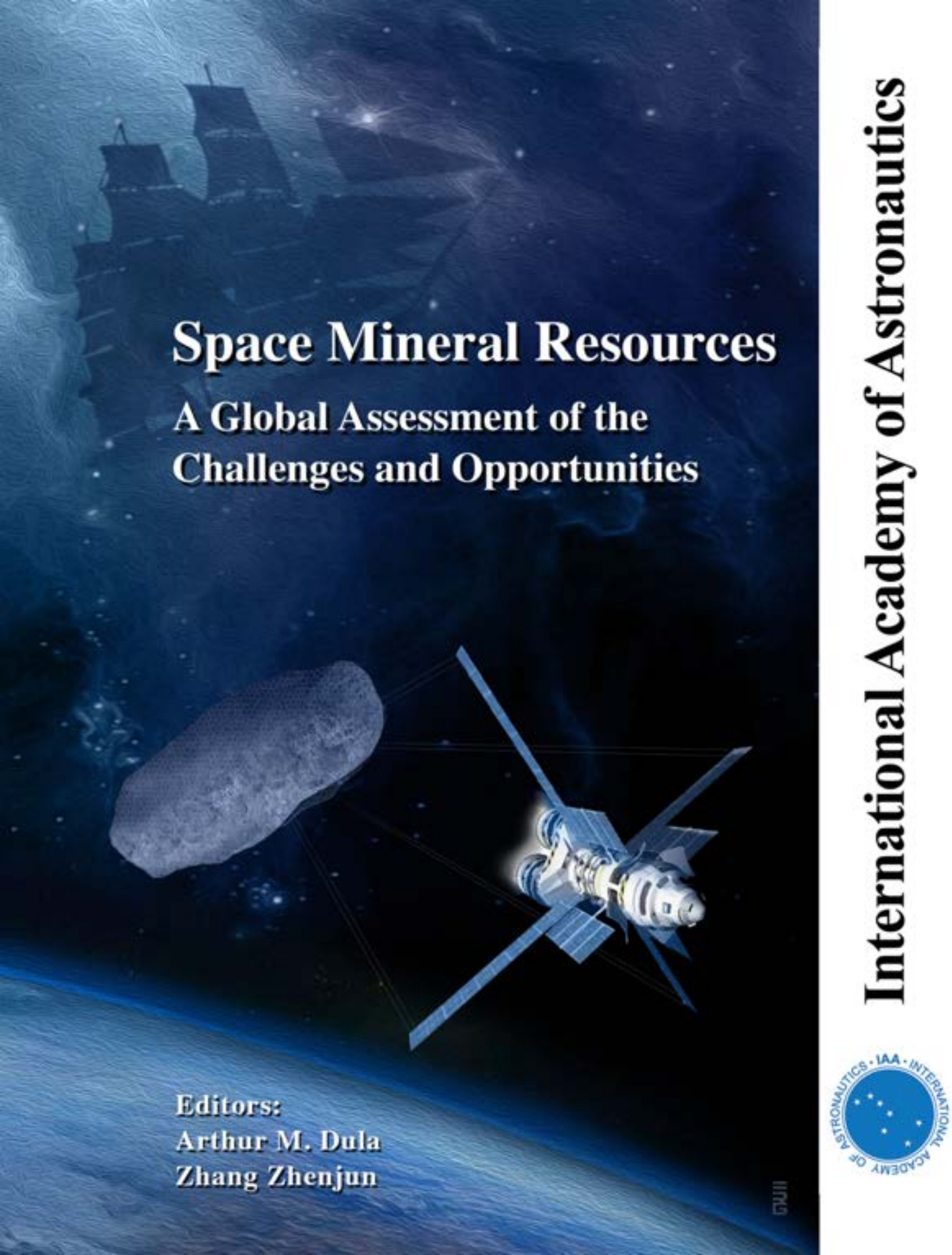
Develop technologies, corporations and government relationships to support the following action plan.

<u>Phase One:</u> Initiate the business infrastructure on Earth 2014-2020

<u>Phase Two:</u> Execute prototype flights to potential asteroids as well as testing hardware in LEO 2015-2022

<u>Phase Three:</u> Initiate mining operations with sale of product 2018-2029

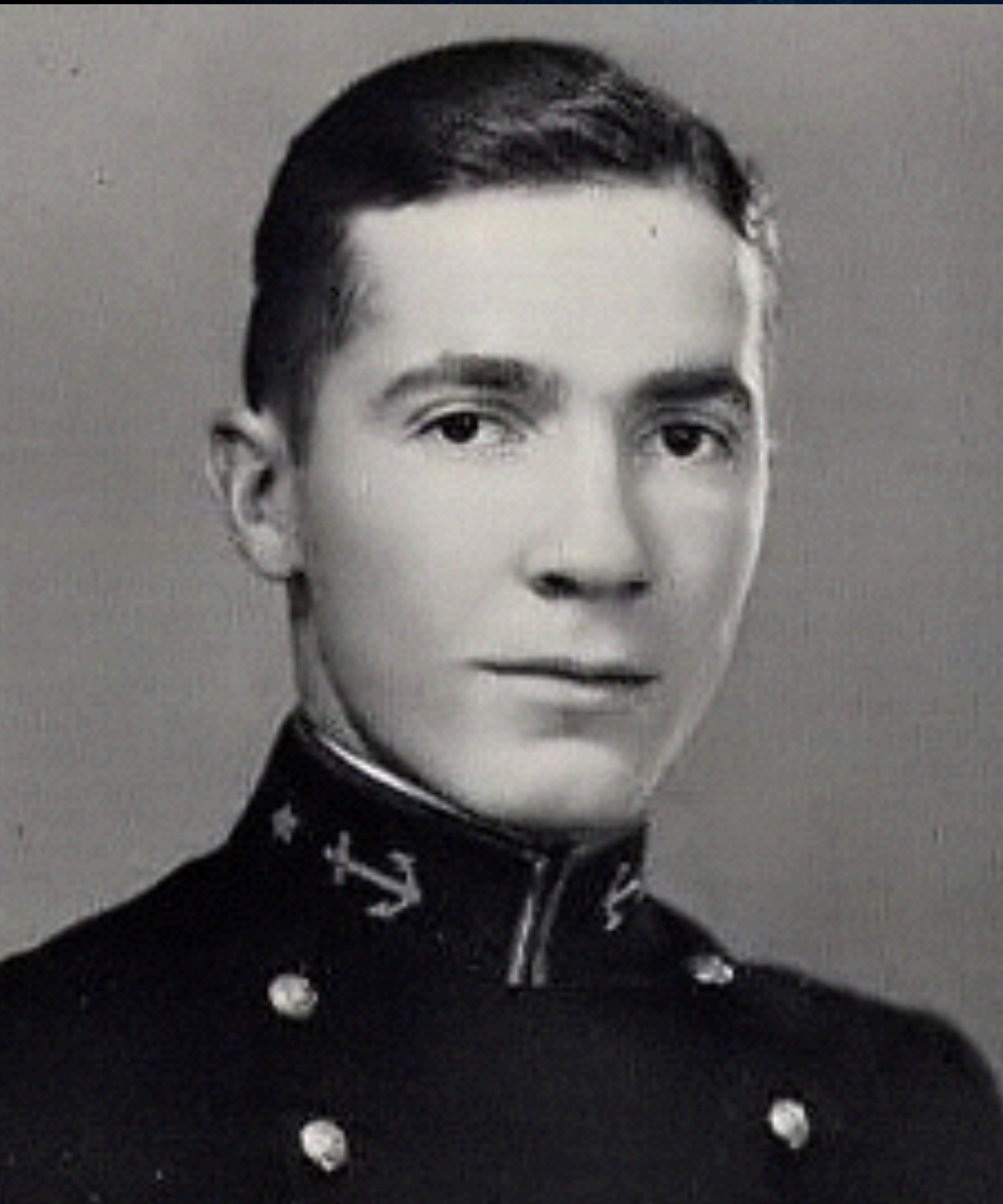
<u>Expected Results:</u> Selling water at the Earth-Moon Lagrangian Point #1.



The participants In this IAA cosmic study acknowledge that this study is only a beginning. A second IAA study on this subject has already begun. The participants hope that their work will be of value to those that follow.

Let's talk about where we are now and where we are going.

HEINLEIN PRIZE TRUST



What are the facts? Again and again and again — what are the facts? Shun wishful thinking, ignore divine revelation, forget what "the stars foretell," avoid opinion, care not what the neighbors think, never mind the unguessable "verdict of history" — what are the facts, and to how many decimal places? You pilot always into an unknown future; facts are your single clue. Get the facts!

R. A. Heinlein
Class of 1929


CONESTOGA 1
PIONEERING THE COMMERCIAL SPACE FRONTIER
September 9, 1982, Matagorda Island, Texas


“A Hundred Miles Up and You’re Halfway to Anywhere!”
Robert A. Heinlein

EQUITY RESEARCH | April 4, 2017

Goldman Sachs

A new Space Age is emerging. Rocket launches are being privatized, the most ambitious satellite constellation ever is being deployed, man is looking back to the Moon and to Mars, and militaries are vying for the ultimate high ground. In the latest in our **Profiles in Innovation** series, we examine where new industries are being created, and where others are being disrupted in the latest race to harness the cosmos. We show how technological advances and necessity are creating a wave of opportunity as business and governments invest in a new Space Economy.

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INSIDE:
VENTURE CAPITAL HORIZONS
Private Company Ecosystem

PROFILES IN INNOVATION

SPACE

The Next Investment Frontier

The Goldman Sachs Group, Inc.

The Second Space Age has begun, and the forces of innovation and disruption are overtaking formerly stagnant industries. New technology is emerging, as old assets fossilize and certain legacy industries wrestle with structural change. Space has always played an important role in our lives, a lynchpin in the modern era, with so many components of everyday life either due to, or reliant on, space and its players. But the space economy is also now inflecting, and we believe will become a multi-trillion dollar market within the next two decades.

The key driver of change today is the enabling power of major change in the commercial launch and satellite manufacturing industries. While relatively small markets today, rapidly falling costs are lowering the barrier to participate in the space economy, making new industries like space tourism, asteroid mining, and on-orbit manufacturing viable, and growing the existing flagship communications satellite services business while taking exploration deeper into space.

Space is becoming a military focal point as governments pivot off Earth and space becomes more congested. If conflict were to start between substantial powers, the opening salvos could be in space, where years of underinvestment have left key assets vulnerable. This looks set to drive an immediate resurgence in US military space investment.

THE NEW SPACE AGE in numbers

START-UP SUPPORT

$13.3 BILLION

Total investment in space start-ups since 2000, heavily weighted toward the last 10 years. (p. 60)

WORLD WIDE WEB

50% The share of the world's population that satellite connectivity could bring online. (p. 36)

THE SPACE(X) RACE

40% The launch discount that SpaceX offers versus incumbents, though at lower success rates. (p. 25)

The US share of global commercial launch revenues, averaged over the last decade. Europe dominated with a 45% share over the same period, while Russia held 25%. (p. 23)

The US share of global commercial launch revenues in 2016, driven largely by SpaceX, creating a virtual duopoly between US (SpaceX) and European (Arianespace) launchers. (p. 23)

OUTGROWING THE BUDGET

6% The CAGR we expect for the US defense and intelligence space budget over the next five years as the Pentagon seeks to defend half a trillion dollars worth of friendly assets in orbit. We believe many A&D investors underestimate the size of the government space budget. (p. 80)

SATEL-LITE

10cm x 10cm x 10cm

The size of a CubeSat, one of the smallest satellites and also the most common. A CubeSat weighs only 1 kg and has up to a 3-year lifespan vs. thousands of kilograms / 15 years for traditional commercial and government satellites. While CubeSats have to be replaced more frequently because of their shorter lifespan, the benefit is a newer and more technologically advanced fleet in orbit. (p. 10)

Satellite drawn to scale

STRIKE IT RICH

$25-50 BILLION

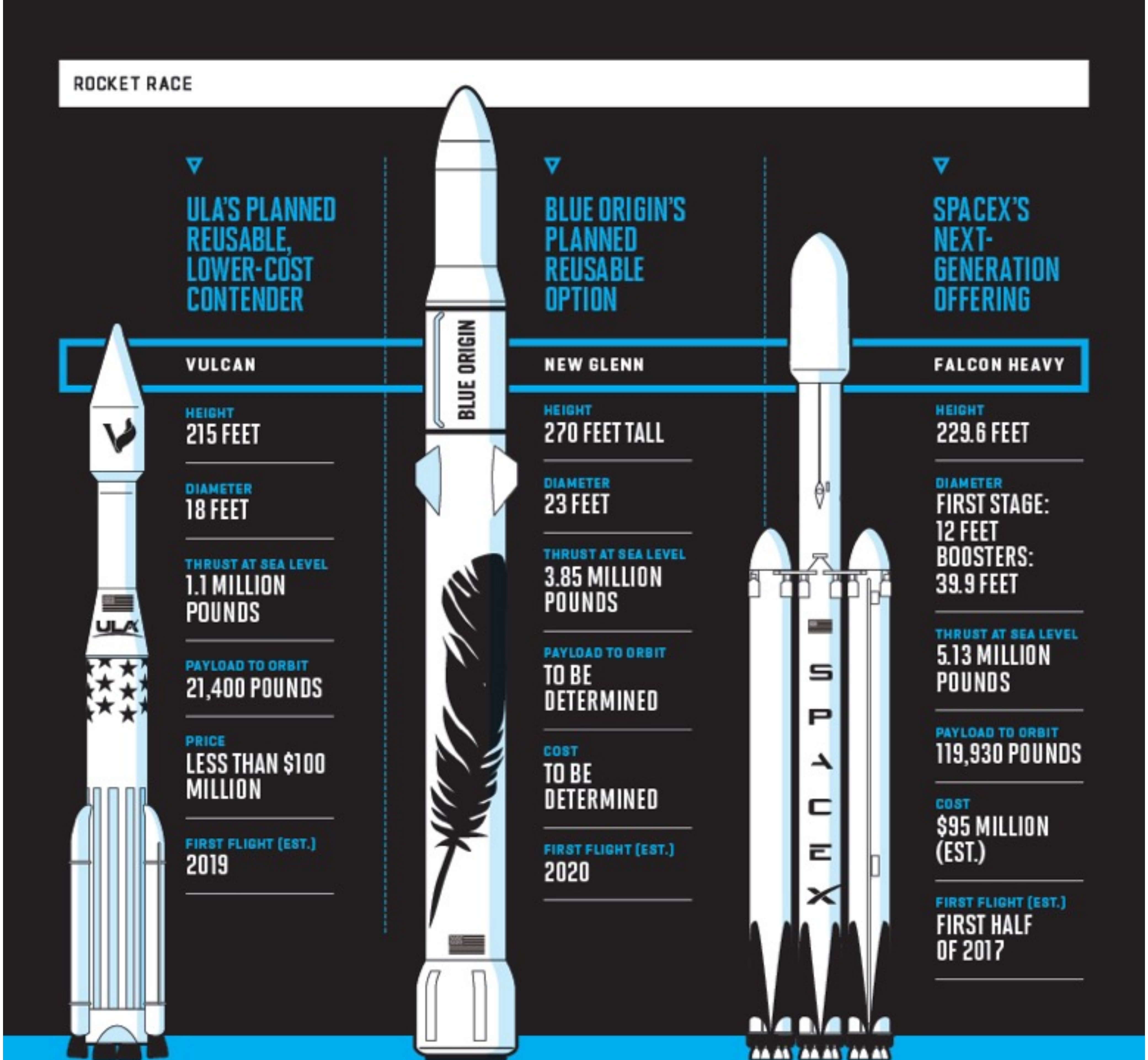
The value of platinum on an asteroid the size of a football field, according to Planetary Resources. Asteroids are also rich in water, which can be converted into rocket fuel (orbiting gas stations, anyone?). We believe space mining is still a long way from commercial viability, but it has the potential to further ease access to space and facilitate an in-space manufacturing economy. (p. 74)

FOR THE LONELY-PLANET TYPES

$35 MILLION / PERSON

$250,000 / PERSON

The historical price of a tourist seat on a Soyuz rocket vs. a tourist seat on Sir Richard Branson's new Virgin Galactic sub-orbital spacecraft. (p. 73)


ROCKET RACE
ULA'S PLANNED REUSABLE, LOWER-COST CONTENDER
VULCAN
HEIGHT
215 FEET
DIAMETER
18 FEET
THRUST AT SEA LEVEL
1.1 MILLION POUNDS
PAYLOAD TO ORBIT
21,400 POUNDS
PRICE
LESS THAN $100 MILLION
FIRST FLIGHT (EST.)
2019
BLUE ORIGIN'S PLANNED REUSABLE OPTION
NEW GLENN
HEIGHT
270 FEET TALL
DIAMETER
23 FEET
THRUST AT SEA LEVEL
3.85 MILLION POUNDS
PAYLOAD TO ORBIT
TO BE DETERMINED
COST
TO BE DETERMINED
FIRST FLIGHT (EST.)
2020
SPACEX'S NEXT-GENERATION OFFERING
FALCON HEAVY
HEIGHT
229.6 FEET
DIAMETER
FIRST STAGE: 12 FEET
BOOSTERS: 39.9 FEET
THRUST AT SEA LEVEL
5.13 MILLION POUNDS
PAYLOAD TO ORBIT
119,930 POUNDS
COST
$95 MILLION (EST.)
FIRST FLIGHT (EST.)
FIRST HALF OF 2017
ULA
BLUE ORIGIN
SPACEX

Capex

While the psychological barrier to mining asteroids is high, the actual financial and technological barriers are far lower. Prospecting probes can likely be built for tens of millions of dollars each and Caltech has suggested an asteroid-grabbing spacecraft could cost $2.6bn. We expect that systems could be built for less than that given trends in the cost of manufacturing spacecraft and improvements in technology. Given the capex of mining operations on Earth, we think that financing a space mission is not outside the realm of possibility.

Regulations

The exploration and extraction of resources from celestial bodies – like minerals found on the Moon – are generally regulated by the Outer Space Treaty of 1967, which limits claims on celestial bodies but allows for resource extraction. In the US, former President Obama signed Commercial Space Launch Competitiveness Act, which opened the door for US companies to explore, extract, and recover space resources.

China develops sea launches to boost space commerce

by Staff Writers
Beijing (XNA) Jul 10, 2017

China has a clear plan to provide sea launches for commercial payloads to be carried by Long March rockets, according to an aerospace official.

Tang Yagang, vice head of the aerospace division of the No.1 institute of the China Aerospace Science and Technology Corporation (CASTC), said that the technology is not difficult and a sea launch platform can be built based on modifying 10,000-tonne freighters.

CASC

CHINA AEROSPACE SCIENCE AND TECHNOLOGY CORPORATION (CASC)

Currently, Long March carrier rockets have provided 60 commercial launches for domestic and international users, Fu said.

China will use solid carrier rockets which rely less on launch facilities and feature mature technology, Tang said, adding that key technology for the carrier rockets will be tested at sea this year and the service is expected to be available for international users in 2018.

At that time, Long March launch vehicles will be able to send satellites weighing 500 kilograms to a 500-kilometer-high sun-synchronous orbit with an inclination of zero to ten degrees, Tang said.

Countries in the equator region have growing needs for launching near-equatorial and low-inclination satellites, said Fu Zhiheng, deputy general manager of China Great Wall Industry Corporation, affiliated to the CASTC.

"The closer to the equator we launch a satellite, the less carrying capacity it will lose, and the lower the cost will be," Fu said, adding that space powers are competing to develop near-equatorial sea launches.

Currently, Long March carrier rockets have provided 60 commercial launches for domestic and international users, Fu said.

Source: Xinhua News

Daily Mail .com

Will we soon build a VILLAGE on the moon? China is in talks with Europe about launching a lunar settlement

- **Tian Yulong, secretary general for China's space agency, confirmed the plans**
- **ESA has described its 'Moon Village' as a launching pad for missions to Mars**
- **The lunar site could also support space mining missions and even tourism**
- **It could also act as a 'pit stop' for the further exploration of deep space**

By DAISY DUNNE FOR MAILONLINE and ASSOCIATED PRESS

PUBLISHED: 01:50 EDT, 26 April 2017 | **UPDATED:** 07:27 EDT, 26 April 2017

China is talking with the European Space Agency about collaborating on a human settlement on the moon.

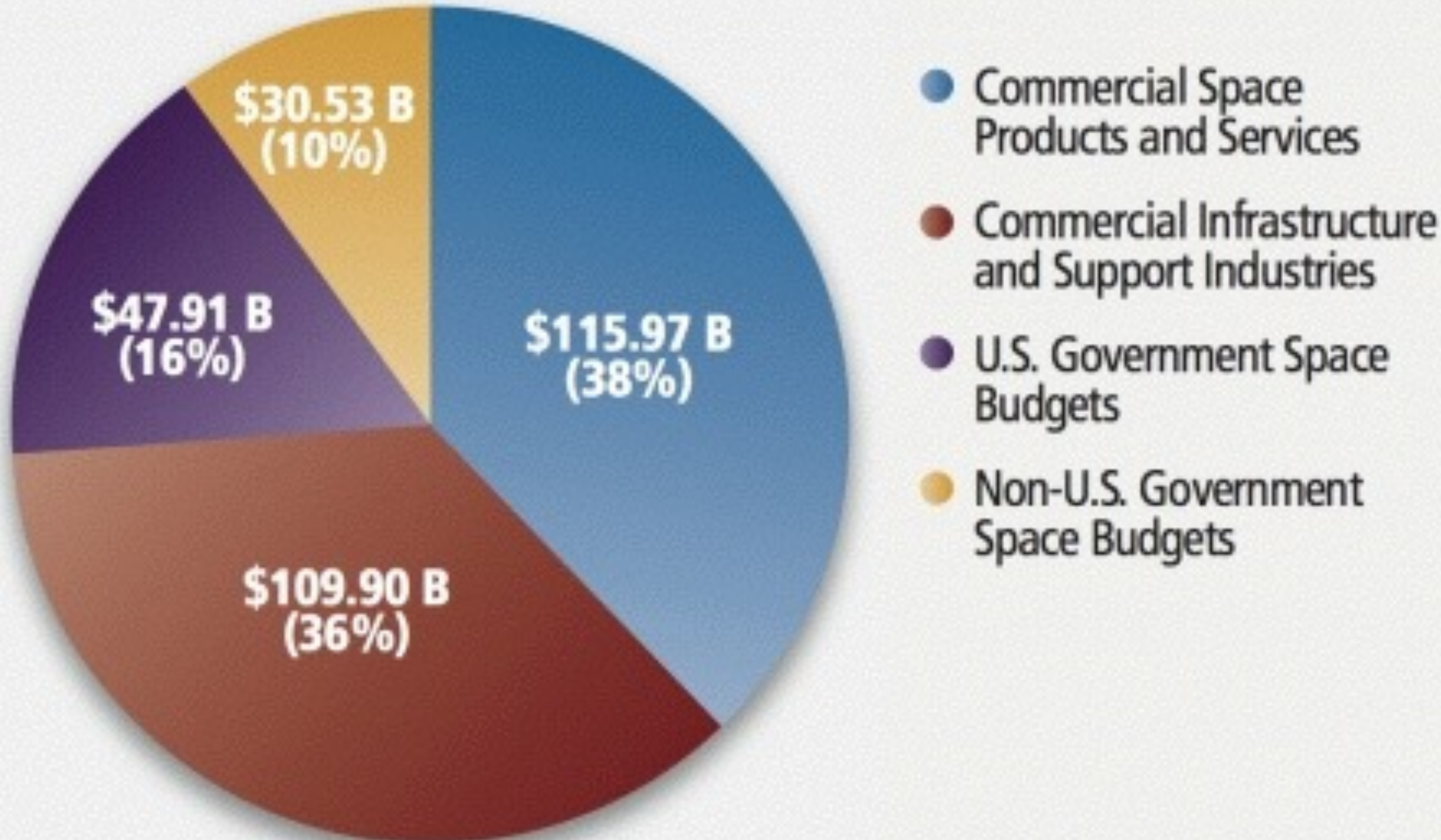
The secretary general for **China**'s space agency, Tian Yulong, disclosed the talks today in Chinese state media.

The ESA has previously described its 'Moon Village' as a potential international launching pad for future missions to Mars.[71]

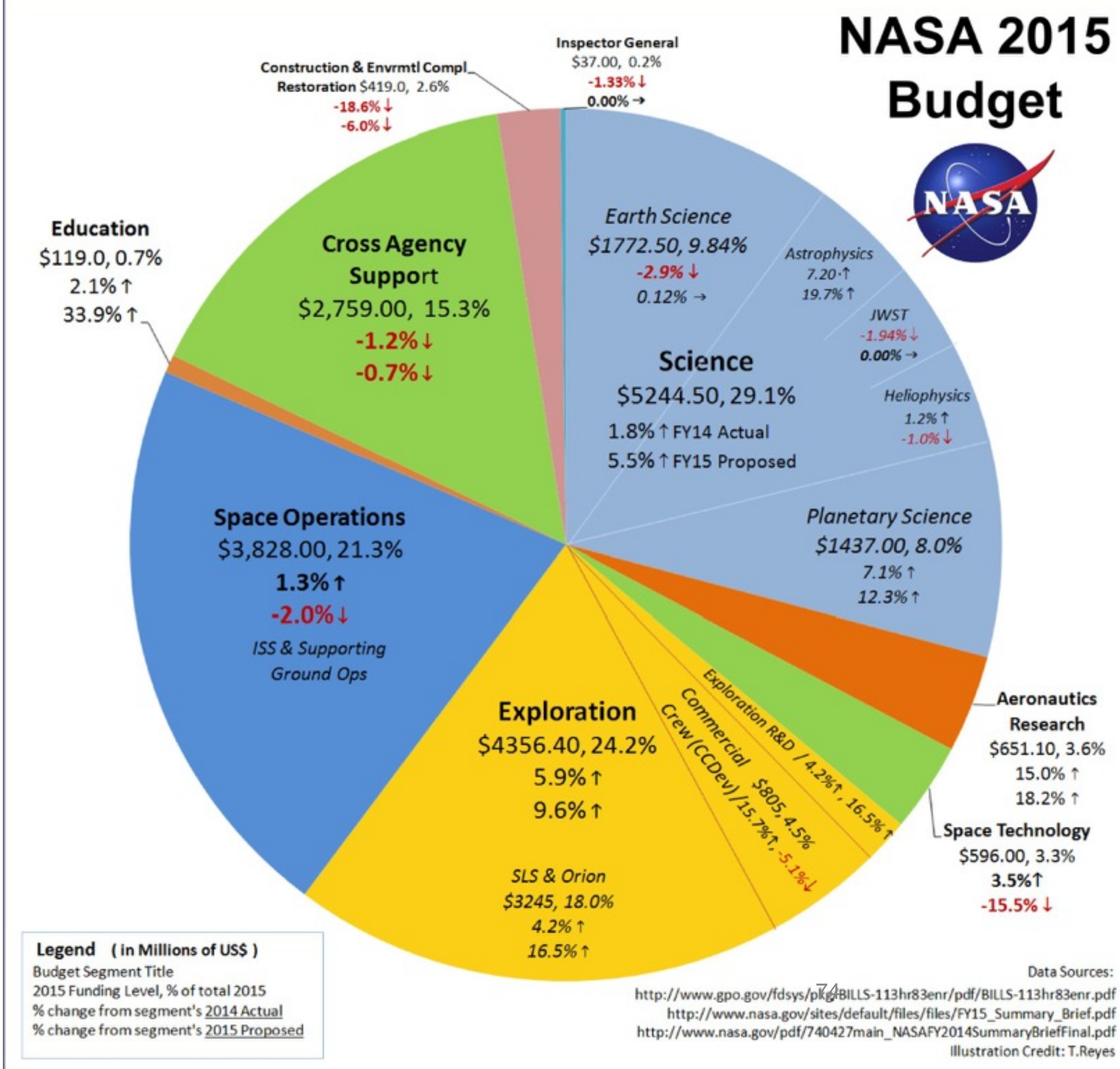
Commercial [illegible]s the future of space.

- NASA has invested about $5 billion over 10 years to create new commercial space industry in the United States.
- Europe and Japan are also actively encouraging the development of private space companies.
- These national investments have already yielded real success at a cost of less than 10% of government programs.

EXHIBIT 1. Global Space Activity, 2012



Total: $304.31 Billion



NASA 2015
Budget
Inspector General
$37.00, 0.2%
-1.33%↓
0.00%→
Construction & Envrmtl Compl
Restoration $419.0, 2.6%
-18.6%↓
-6.0%↓
Education
$119.0, 0.7%
2.1%↑
33.9%↑
Cross Agency
Support
$2,759.00, 15.3%
-1.2%↓
-0.7%↓
Earth Science
$1772.50, 9.84%
-2.9%↓
0.12%→
Astrophysics
7.20·↑
19.7%↑
JWST
-1.94%↓
0.00%→
Science
$5244.50, 29.1%
1.8%↑ FY14 Actual
5.5%↑ FY15 Proposed
Heliophysics
1.2%↑
-1.0%↓
Planetary Science
$1437.00, 8.0%
7.1%↑
12.3%↑
Space Operations
$3,828.00, 21.3%
1.3%↑
-2.0%↓
ISS & Supporting
Ground Ops
Exploration
$4356.40, 24.2%
5.9%↑
9.6%↑
SLS & Orion
$3245, 18.0%
4.2%↑
16.5%↑
Exploration R&D / 4.2%↑, 16.5%↑
Commercial $805, 4.5%
Crew (CCDev)/15.7%↑, -5.1%↓
Aeronautics
Research
$651.10, 3.6%
15.0%↑
18.2%↑
Space Technology
$596.00, 3.3%
3.5%↑
-15.5%↓
Legend (in Millions of US$)
Budget Segment Title
2015 Funding Level, % of total 2015
% change from segment's 2014 Actual
% change from segment's 2015 Proposed
Data Sources:
http://www.gpo.gov/fdsys/pkg/BILLS-113hr83enr/pdf/BILLS-113hr83enr.pdf
http://www.nasa.gov/sites/default/files/files/FY15_Summary_Brief.pdf
http://www.nasa.gov/pdf/740427main_NASAFY2014SummaryBriefFinal.pdf
Illustration Credit: T.Reyes

NASA Funding Timeline

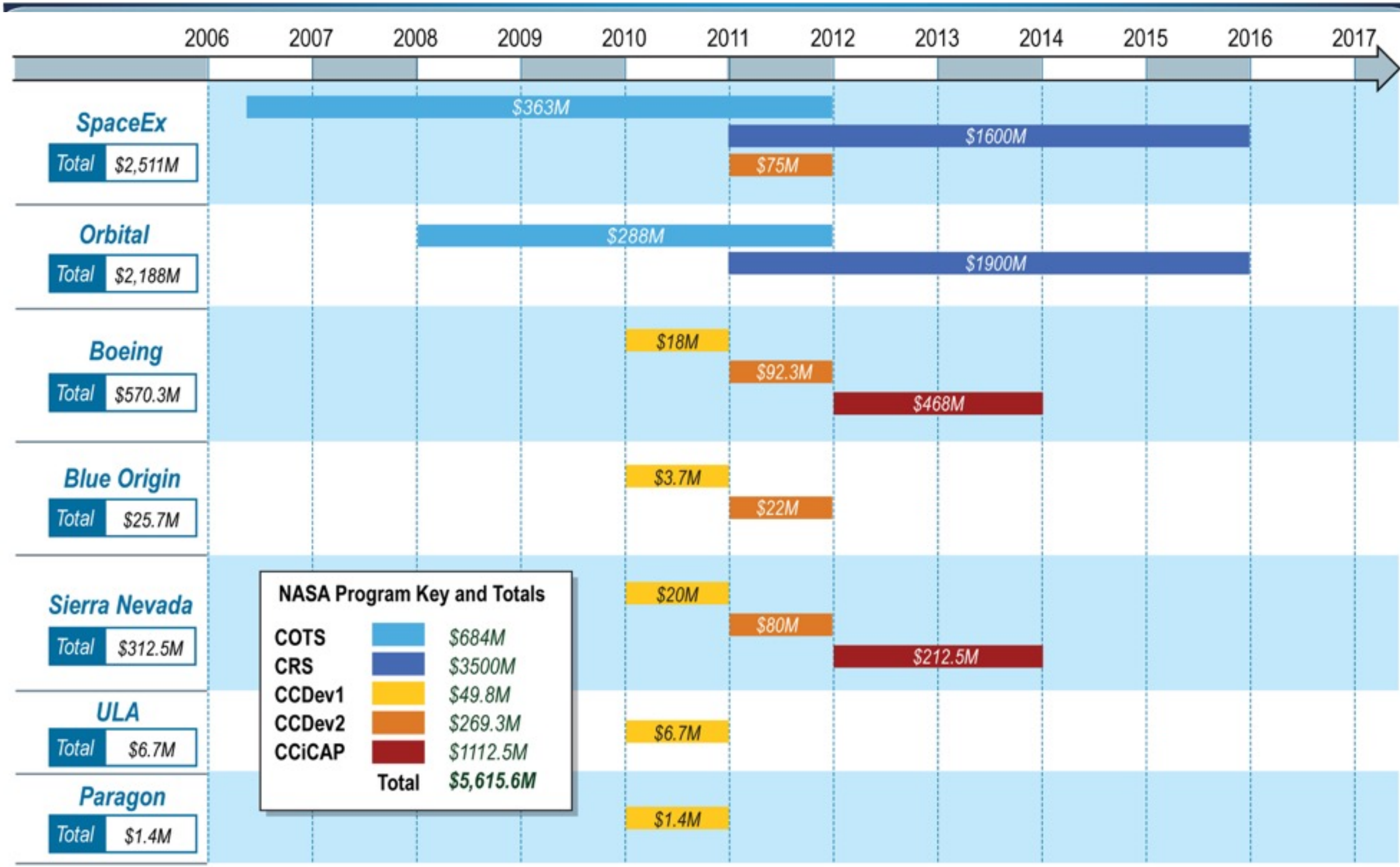


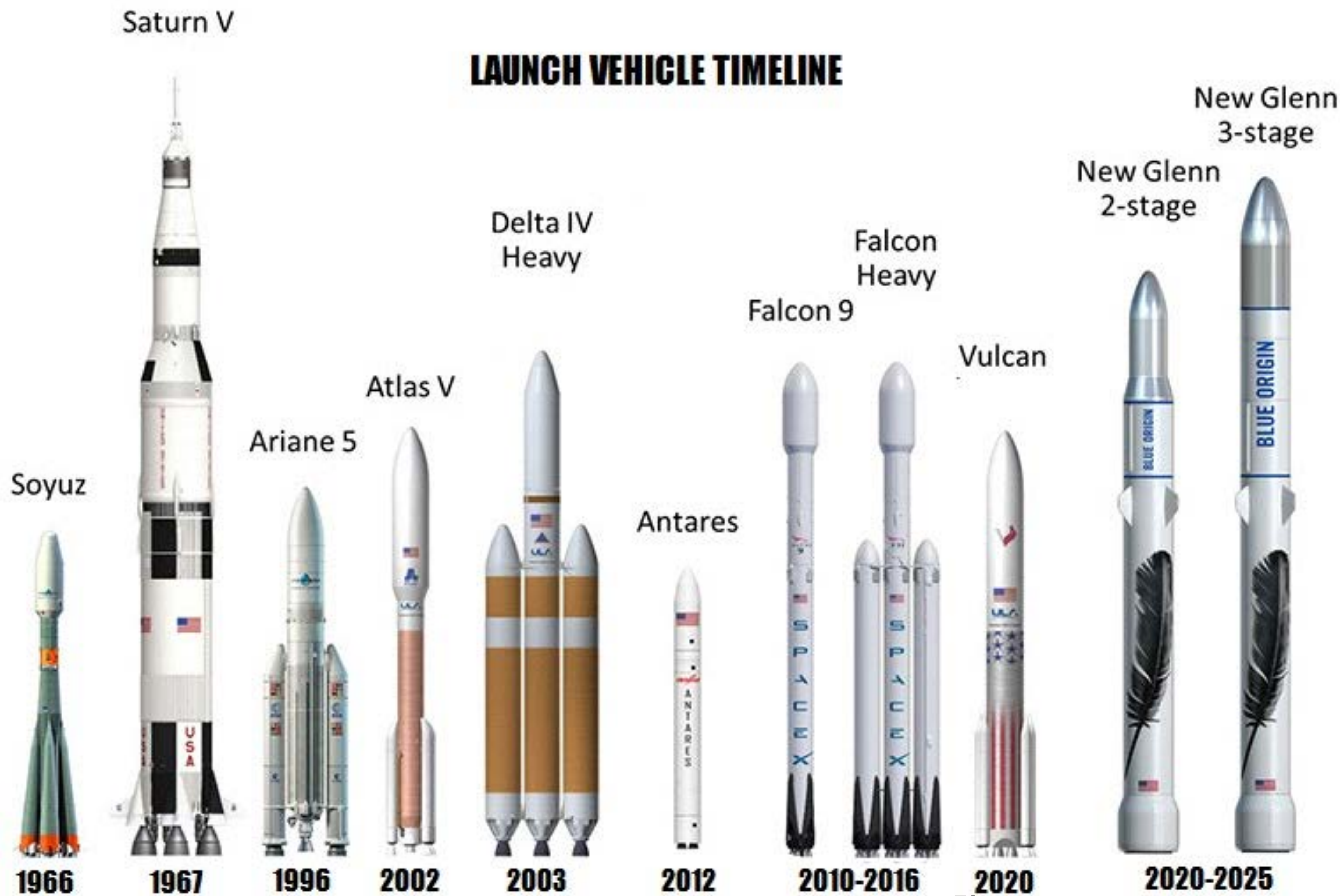
Fig. 4 – NASA Cost Analysis Comparing NASA's Predicted Cost vs. SpaceX Falcon 9 Actual Costs: >10X Cost Reduction (NASA 2011)

		NASA Model Based Prediction				SpaceX Actual Performance		
		NASA Approach				Firm Fixed Price Acquisition		
Elements	Weight (lbs)	DDT&E (FY2010 $M)	Flight Unit (FY2010 $M)	Total (FY2010 $M)	Weight (lbs)	DDT&E (FY2010 $M)	2 Test Flt Units (FY2010 $M)	Total (FY2010 $M)
Stage One (Including Engines)	39,080	$1,535	$206	$1,741	39,080	$188.7	$109.3	$298.0
Stage Two (Including Engine)	6,520	$608	$44	$651	6,506	$89.0	$23.6	$112.6
Fee (12.5%)		$268	$30	$298		$0.0	$0.0	$0.0
Program Support (10%)		$241	$21	$263		$0.0	$0.0	$0.0
Contingency (30% Vehicle, 10% Engine))		$674	$68	$741		$0.0	$0.0	$0.0
Vehicle Level Integration (8%)		$258	$24	$282		$22.2	$10.6	$32.8
Total	**45,600**	**$3,584**	**$393**	**$3,977**	**45,586**	**$299.9**	**$143.6**	**$443.4**

>10X Cost Reduction

This modest investment in commercial space industry has produced operational systems faster and cheaper than government programs.

- Falcon 9 and Dragon
- Anteres and Cygnus

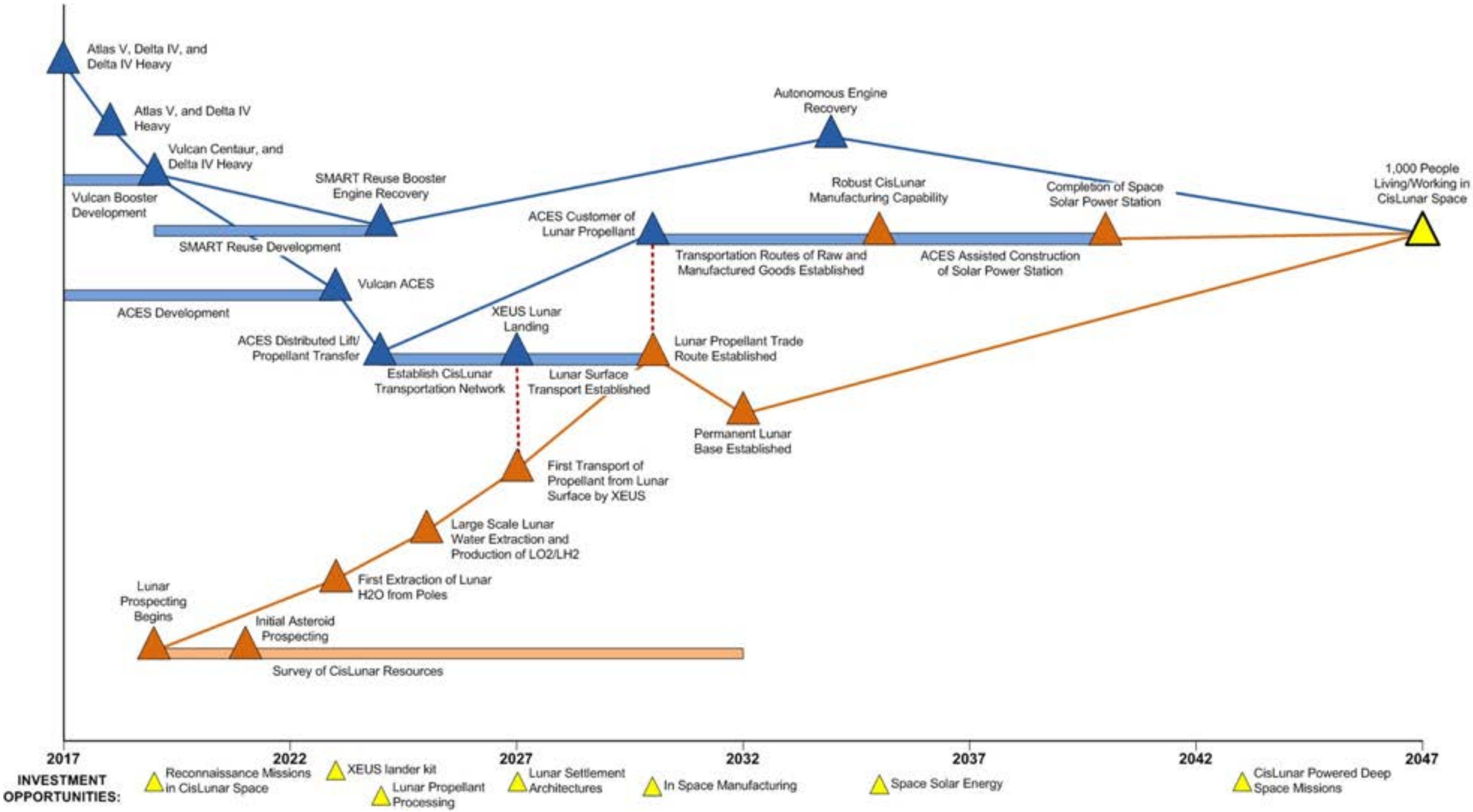


LAUNCH VEHICLE TIMELINE
Soyuz
Saturn V
Ariane 5
Atlas V
Delta IV Heavy
Antares
Falcon 9
Falcon Heavy
Vulcan
New Glenn 2-stage
New Glenn 3-stage
USA
ANTARES
SPACEX
SPACEX
BLUE ORIGIN
1966
1967
1996
2002
2003
2012
2010-2016
2020
2020-2025

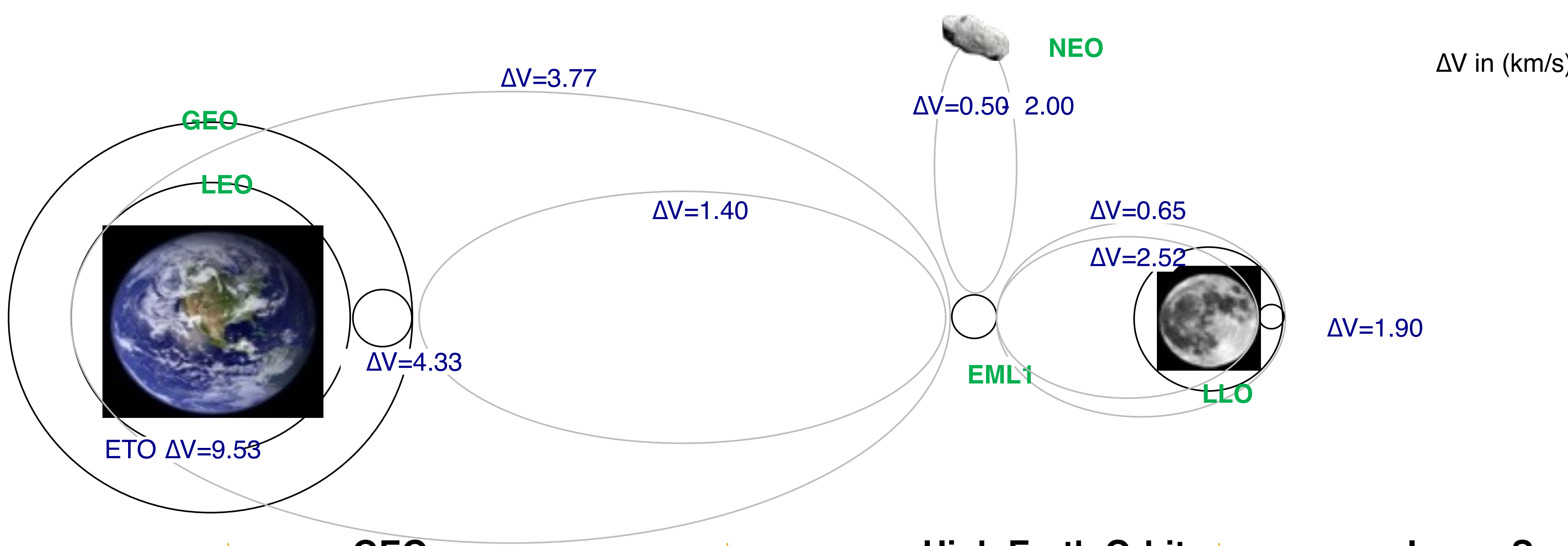
It's hard to make predictions

Especially about the future

https://www.youtube.com/watch?v=0qo78R_yYFA



Atlas V, Delta IV, and Delta IV Heavy
Atlas V, and Delta IV Heavy
Vulcan Centaur, and Delta IV Heavy
Vulcan Booster Development
SMART Reuse Booster Engine Recovery
SMART Reuse Development
Autonomous Engine Recovery
ACES Customer of Lunar Propellant
Robust CisLunar Manufacturing Capability
Completion of Space Solar Power Station
1,000 People Living/Working in CisLunar Space
Transportation Routes of Raw and Manufactured Goods Established
ACES Assisted Construction of Solar Power Station
Vulcan ACES
ACES Development
XEUS Lunar Landing
ACES Distributed Lift/ Propellant Transfer
Lunar Propellant Trade Route Established
Establish CisLunar Transportation Network
Lunar Surface Transport Established
Permanent Lunar Base Established
First Transport of Propellant from Lunar Surface by XEUS
Large Scale Lunar Water Extraction and Production of LO2/LH2
First Extraction of Lunar H2O from Poles
Lunar Prospecting Begins
Initial Asteroid Prospecting
Survey of CisLunar Resources
2017
2022
2027
2032
2037
2042
2047
INVESTMENT OPPORTUNITIES:
Reconnaissance Missions in CisLunar Space
XEUS lander kit
Lunar Propellant Processing
Lunar Settlement Architectures
In Space Manufacturing
Space Solar Energy
CisLunar Powered Deep Space Missions



LEO

ISS
Remote Sensing
Commercial Station
Communication
Space Control
Debris mitigation
Science
R&D
Tourism
Manufacturing
Propellant Transfer
Data Servers

GEO

Observation
Communication
Space Control
Debris Mitigation
Space Solar Power
Repair Station
Satellite Life extension
Harvesting

High Earth Orbit

Science / Astronomy
Communication Link
Way Station
Propellant Depots
Repair Station
Lunar Solar Power Sat
Manufacturing
Planetary Defense

Lunar Surface

Science/ Astronomy

- Lunar
- Observatory

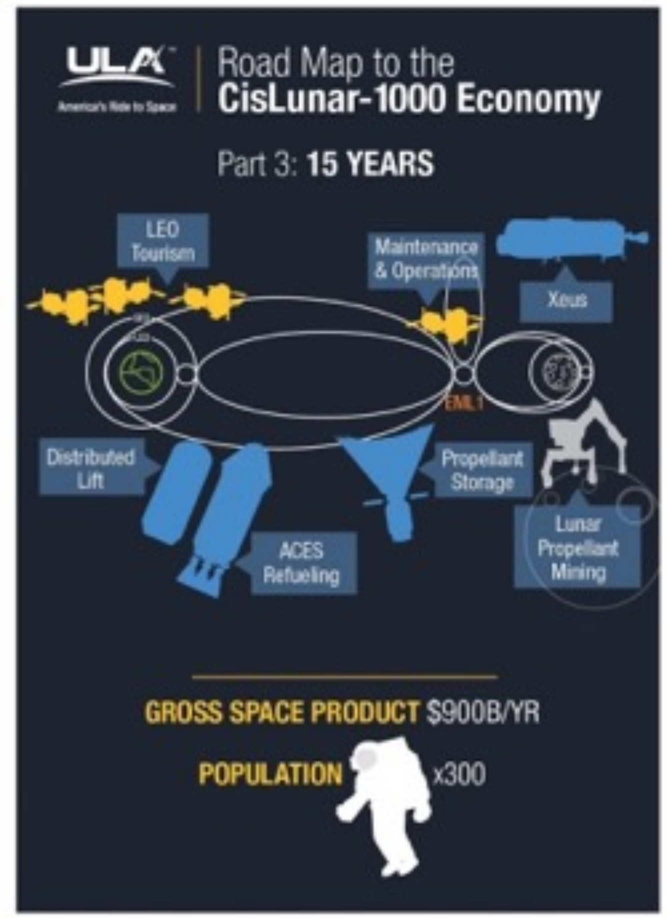
Human Outpost
Tourism
Mining

- Oxygen/Water
- Regolith
- Rare Earth Elements
- HE3

Manufacturing
Propellant Depots


ULA
Road Map to the
CisLunar-1000 Economy
Part 1: TODAY
Research
Communications
International Space Station
GEO
LEO
Crew
Research, Imagery
Cargo
Expendable Launch Vehicles
GROSS SPACE PRODUCT $330B/YR
POPULATION x5


ULA
Road Map to the
CisLunar-1000 Economy
Part 2: 5 YEARS
Space Manufacturing
Commercial Habitats
Commercial Research
GEO
LEO
Prospecting (lunar, asteroids)
ACES Long Duration Upper Stage
Vulcan
GROSS SPACE PRODUCT $500B/YR
POPULATION x20


ULA
Road Map to the
CisLunar-1000 Economy
Part 3: 15 YEARS
LEO Tourism
Maintenance & Operations
Xeus
EML1
Distributed Lift
Propellant Storage
ACES Refueling
Lunar Propellant Mining
GROSS SPACE PRODUCT $900B/YR
POPULATION x300


ULA
Road Map to the
CisLunar-1000 Economy
Part 4: 30 YEARS
Asteroid Mining
ACES Transports Finished Parts
EML1
XEUS Transports Raw Material
GEO Space Solar Power
EML1 Large Scale Manufacturing
Lunar Habitat
Lunar Regolith Mining
GROSS SPACE PRODUCT $2.7T/YR
POPULATION x 1,000

Investment in new space companies by members of the Forbes Billionaire list is becoming increasingly fashionable. The list of six space-investing Billionaires (as counted by Forbes) in 2011 [Messier, 2011] has grown to ten in 2013 with a combined net worth of over $106 Billion Dollars as shown in the table below. Compare that to the estimated 2013 NASA budget of $17.8 Billion US Dollars.

rank	name	age	net worth	source	space investment
19	Jeff Bezos	49	$25.20	Amazon	Blue Origin
21	Sergey Brin	40	$22.80	Google	Google Lunar X Prize
20	Larry Page	40	$23.00	Google	Google Lunar X Prize, Planetary Resources
53	Paul Allen	60	$15.00	Microsoft	SpaceShipOne, SETI telescope array
138	Eric Schmidt	58	$8.20	Google	Planetary Resources
272	Sir Richard Branson	63	$4.60	Virgin Group	Virgin Galactic
527	Elon Musk	42	$2.70	PayPal, Tesla Motors	SpaceX
831	Guy Laliberte	53	$1.80	Cirque du Soleil	Visitor to ISS
922	K Ram Shriram	56	$1.65	Google	Planetary Resources
1031	Ross Perot, Jr.	54	$1.40	Oil & Gas	Planetary Resources
			$106.35	**Total Net Worth**	

“If one can figure out how to effectively reuse rockets just like airplanes, the cost of access to space will be reduced by as much as a factor of a hundred. A fully reusable vehicle has never been done before. That really is the fundamental breakthrough needed to revolutionize access to space.”

--Elon Musk

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

SpaceX
Elon Musk

Total Star Wars fan…

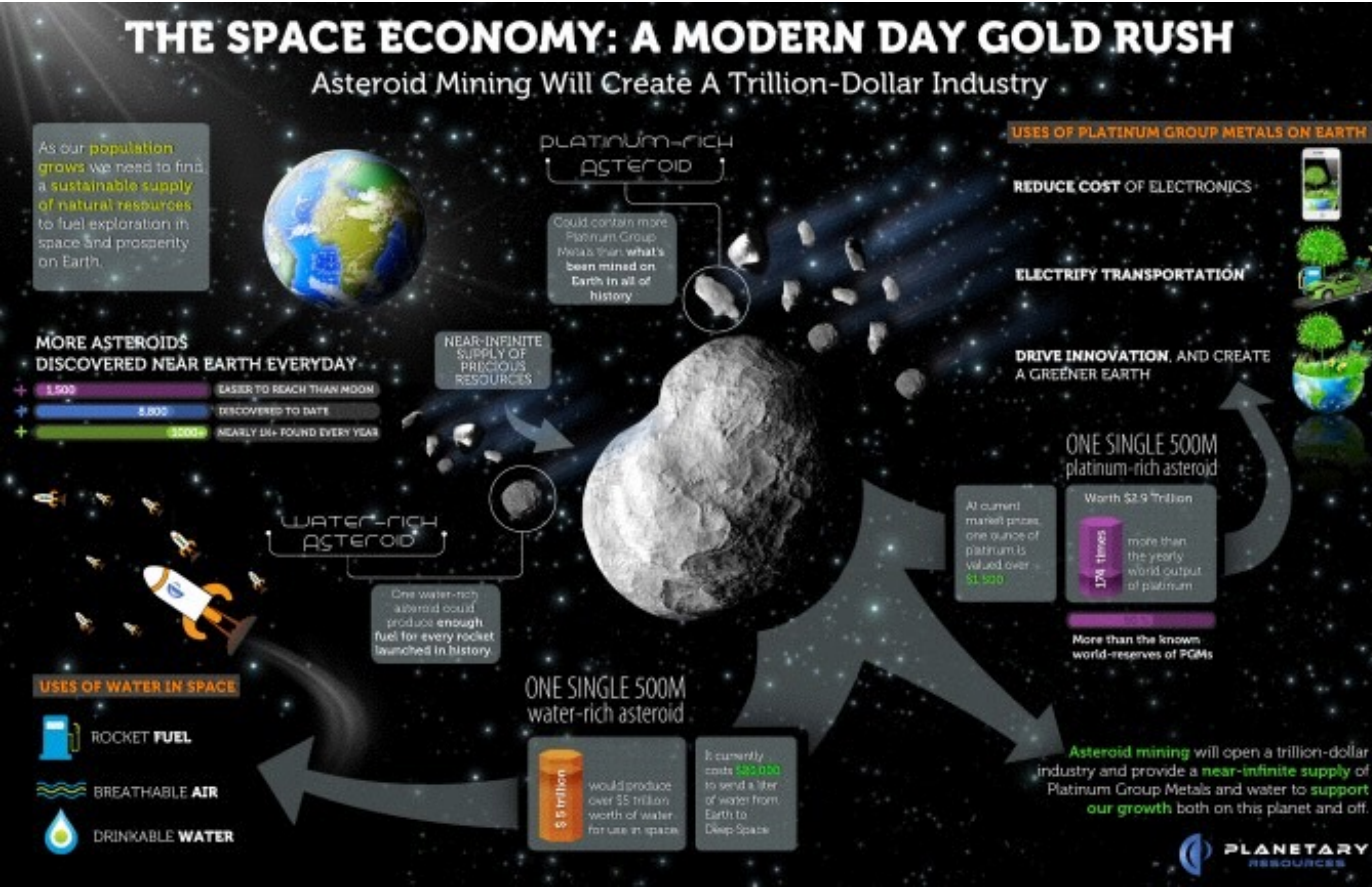
Blue Origin
Jeff Bezos

Book Worm

Stratolaunch
Systems
Paul Allen

Programming Nerd

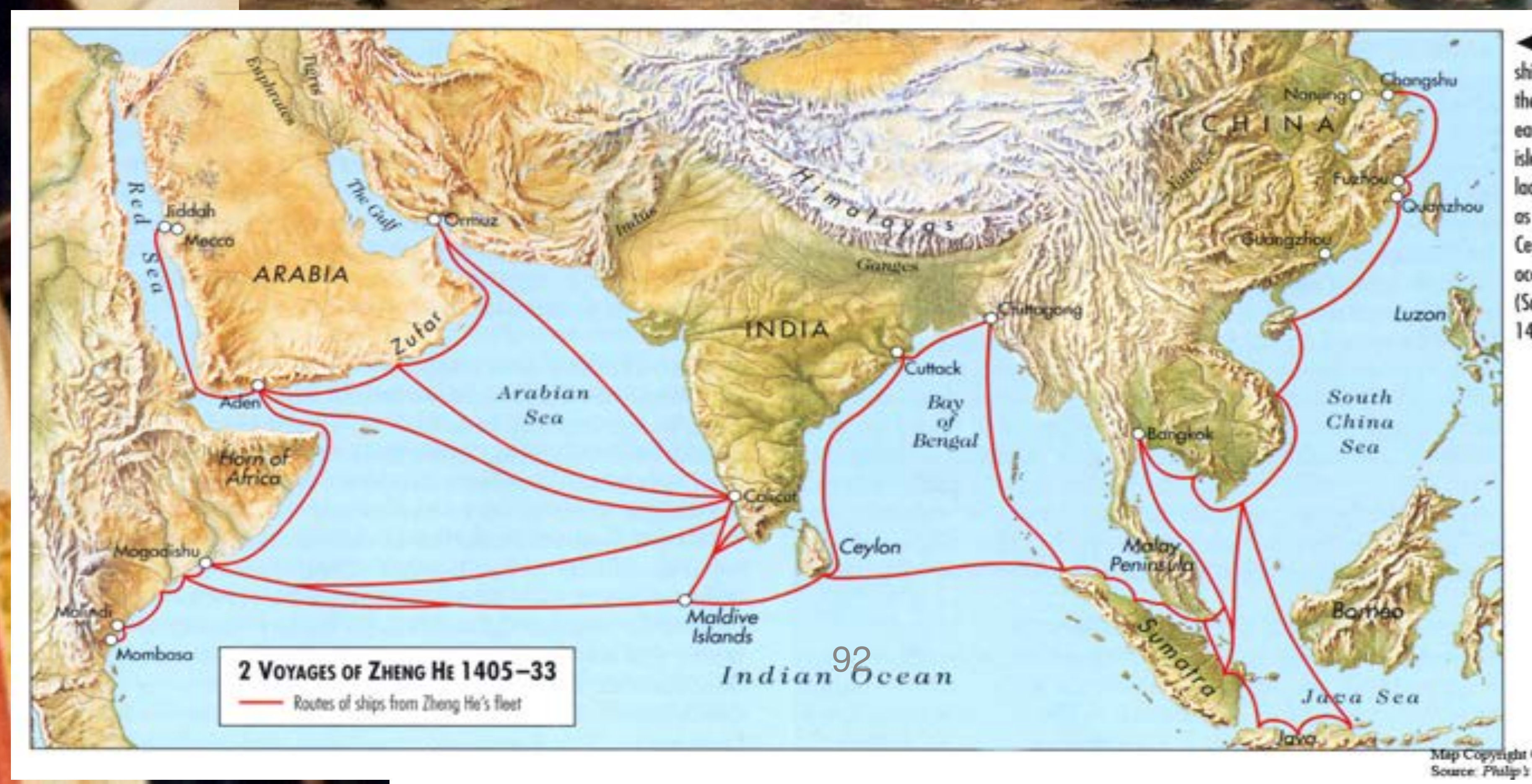
While not listed as billionaires (yet) by Forbes, the list of high net-worth individuals investing in space also includes Robert Bigelow (Bigelow Aerospace), Charles Simonyi (Planetary Resources), Richard Garriott (Visitor to ISS), Mark Shuttleworth (Visitor to ISS), Anousheh Ansari (X-Prize), Dennis Tito (Inspiration Mars), Bas Lansdorp (Mars One), Naveen Jain (Moon Express), Barney Pell (Moon Express), Tom Pickens (SpaceHab) and John Carmack (Armadillo Aerospace). The cumulative wealth of private space investors continues to grow.

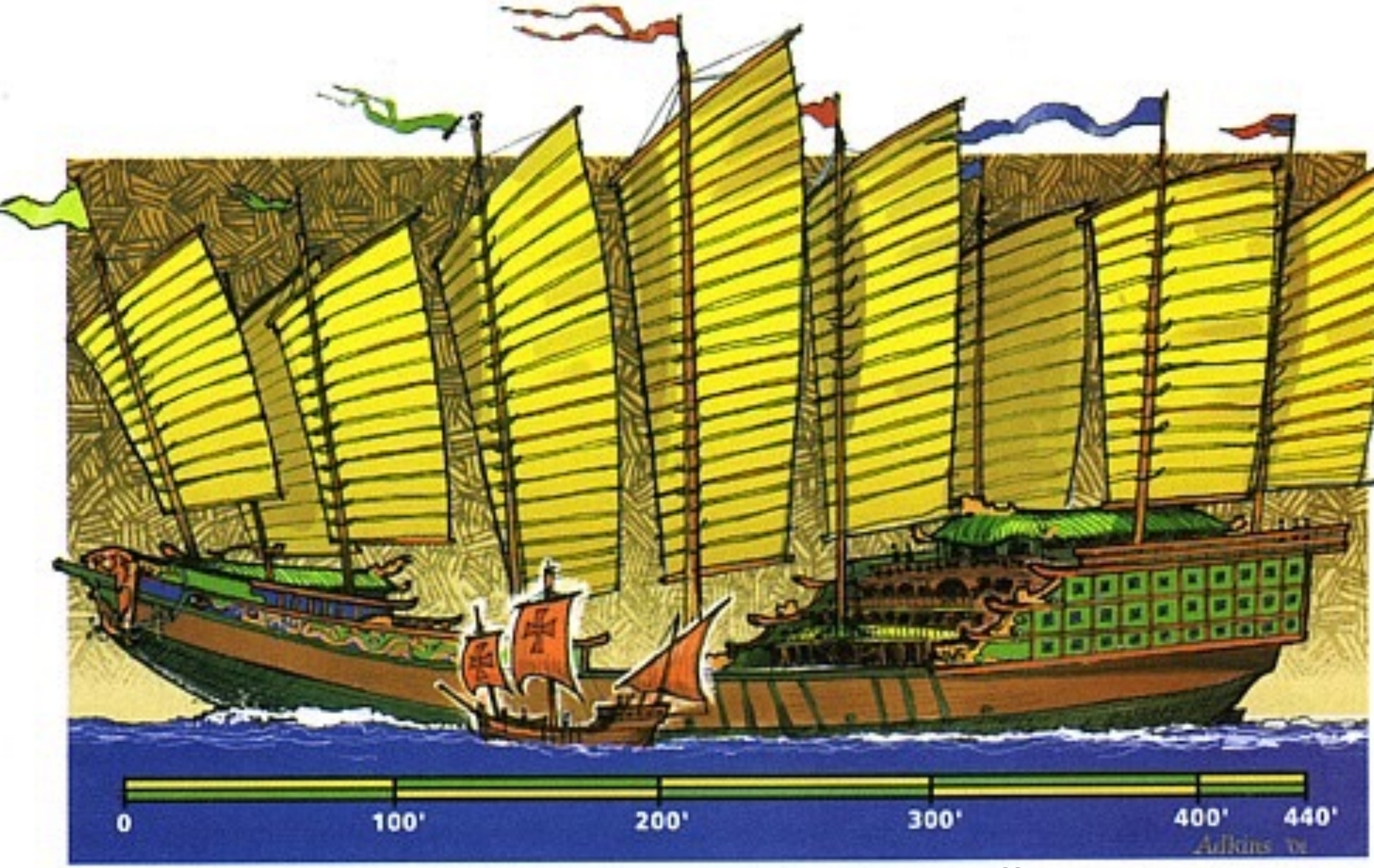


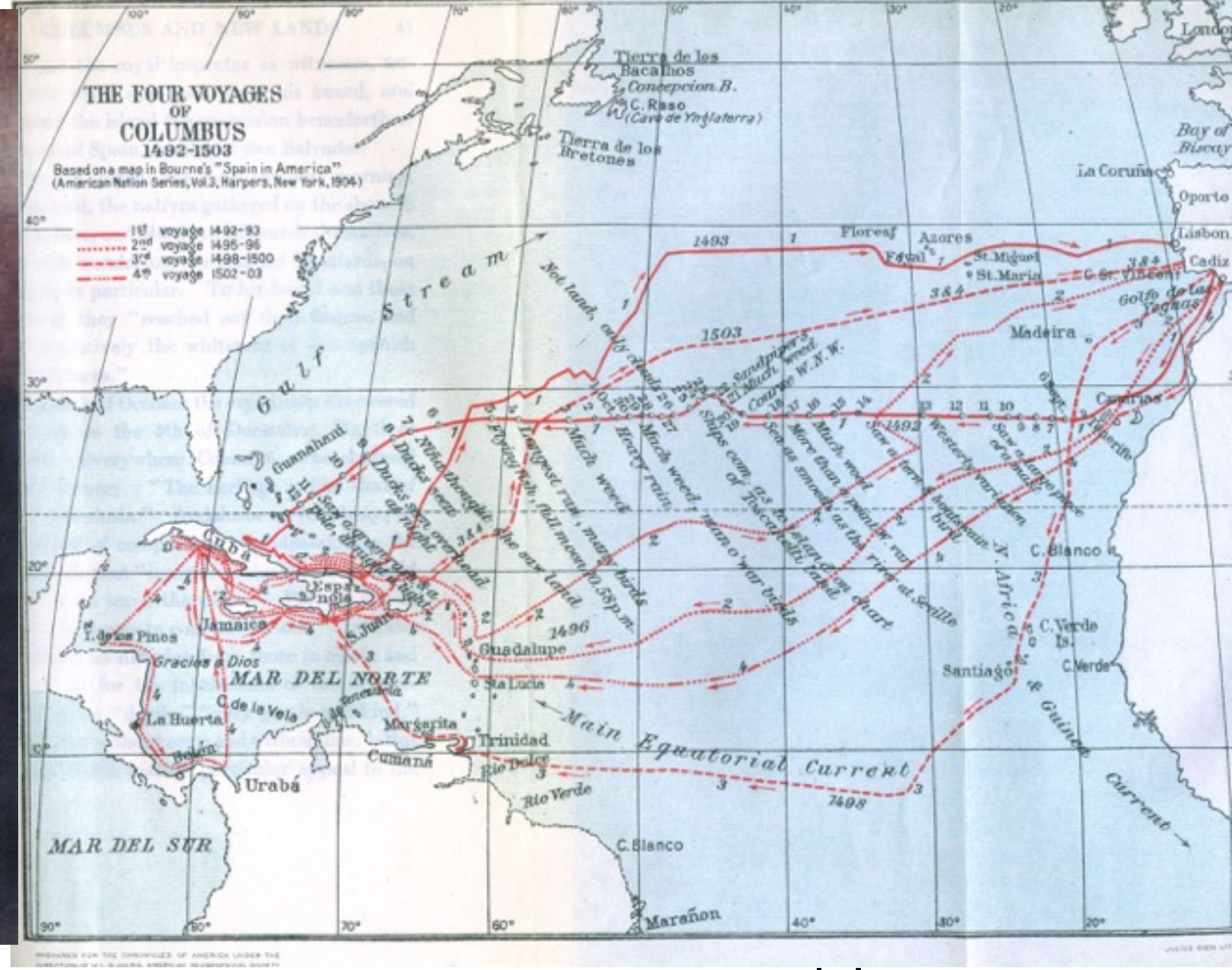
THE SPACE ECONOMY: A MODERN DAY GOLD RUSH
Asteroid Mining Will Create A Trillion-Dollar Industry
As our population grows we need to find a sustainable supply of natural resources to fuel exploration in space and prosperity on Earth.
PLATINUM-RICH ASTEROID
Could contain more Platinum Group Metals than what's been mined on Earth in all of history
USES OF PLATINUM GROUP METALS ON EARTH
REDUCE COST OF ELECTRONICS
ELECTRIFY TRANSPORTATION
DRIVE INNOVATION, AND CREATE A GREENER EARTH
MORE ASTEROIDS DISCOVERED NEAR EARTH EVERYDAY
1,500
EASIER TO REACH THAN MOON
8,800
DISCOVERED TO DATE
1000+
NEARLY 1K+ FOUND EVERY YEAR
NEAR-INFINITE SUPPLY OF PRECIOUS RESOURCES
WATER-RICH ASTEROID
One water-rich asteroid could produce enough fuel for every rocket launched in history
ONE SINGLE 500M platinum-rich asteroid
At current market prices one ounce of platinum is valued over $1,500
Worth $2.9 Trillion
174 times
more than the yearly world output of platinum
More than the known world-reserves of PGMs
USES OF WATER IN SPACE
ROCKET FUEL
BREATHABLE AIR
DRINKABLE WATER
ONE SINGLE 500M water-rich asteroid
$5 trillion
would produce over $5 trillion worth of water for use in space
It currently costs
to send a liter of water from Earth to Deep Space
Asteroid mining will open a trillion-dollar industry and provide a near-infinite supply of Platinum Group Metals and water to support our growth both on this planet and off.
PLANETARY RESOURCES

We would be wise to remember history; the last time we settled a new world.

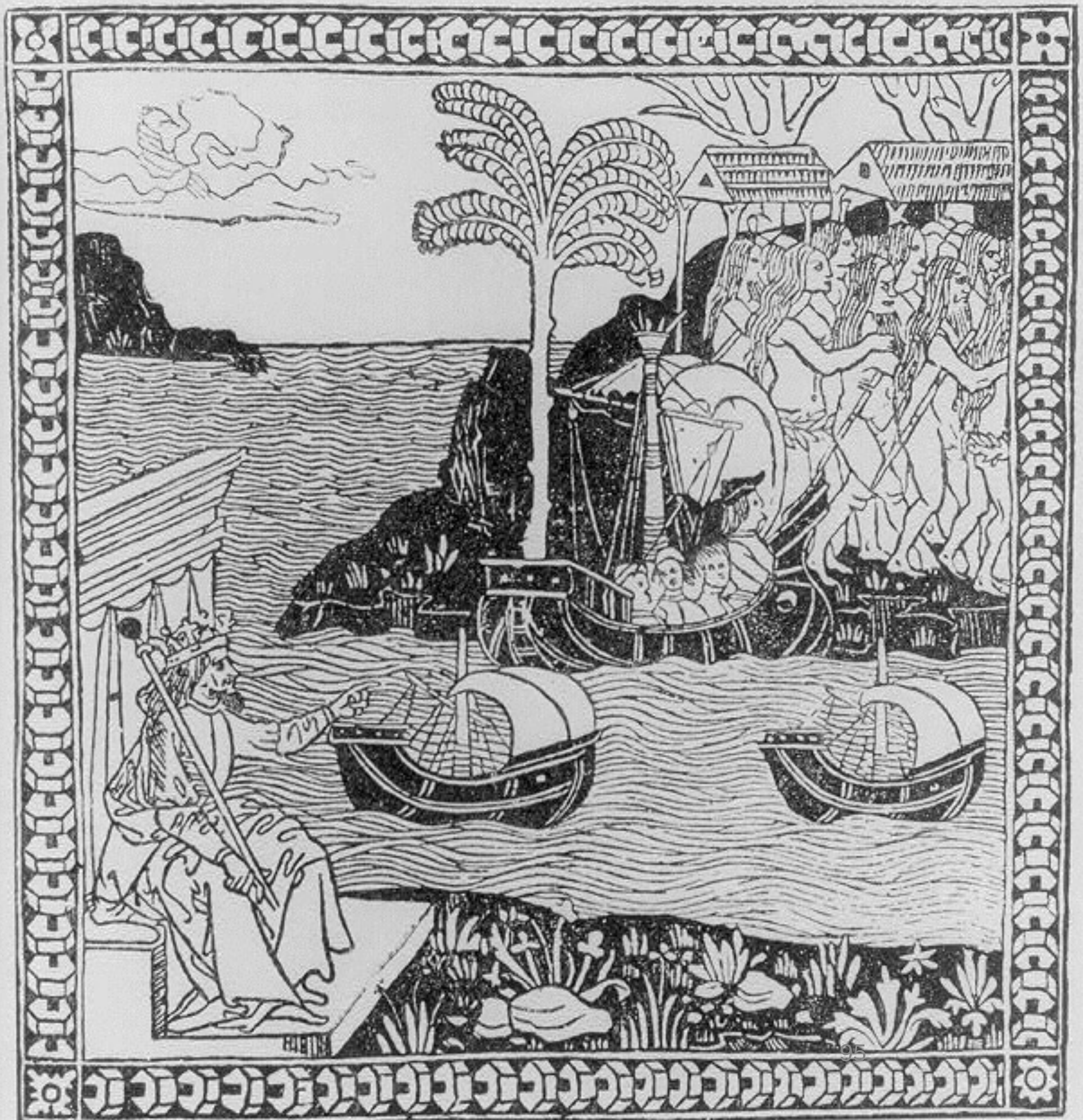
1421 -1520


2 VOYAGES OF ZHENG HE 1405–33
Routes of ships from Zheng He's fleet
Red Sea
Jiddah
Mecca
ARABIA
Euphrates
Tigris
The Gulf
Ormuz
Zufar
Aden
Horn of Africa
Arabian Sea
Mogadishu
Malindi
Mombasa
Maldive Islands
Indian Ocean
Indus
Himalayas
Ganges
INDIA
Calicut
Ceylon
Cuttack
Chittagong
Bay of Bengal
Bangkok
Malay Peninsula
Sumatra
Java
Java Sea
Borneo
South China Sea
Luzon
Guangzhou
Quanzhou
Fuzhou
CHINA
Nanjing
Changshu


0
100'
200'
300'
400'
440'
Adkins '06



Columbus was an entrepreneur seeking to find a way to Asia to by spices to sell to Europe. He was not an explorer seeking new lands. He thought he had been to Japan.

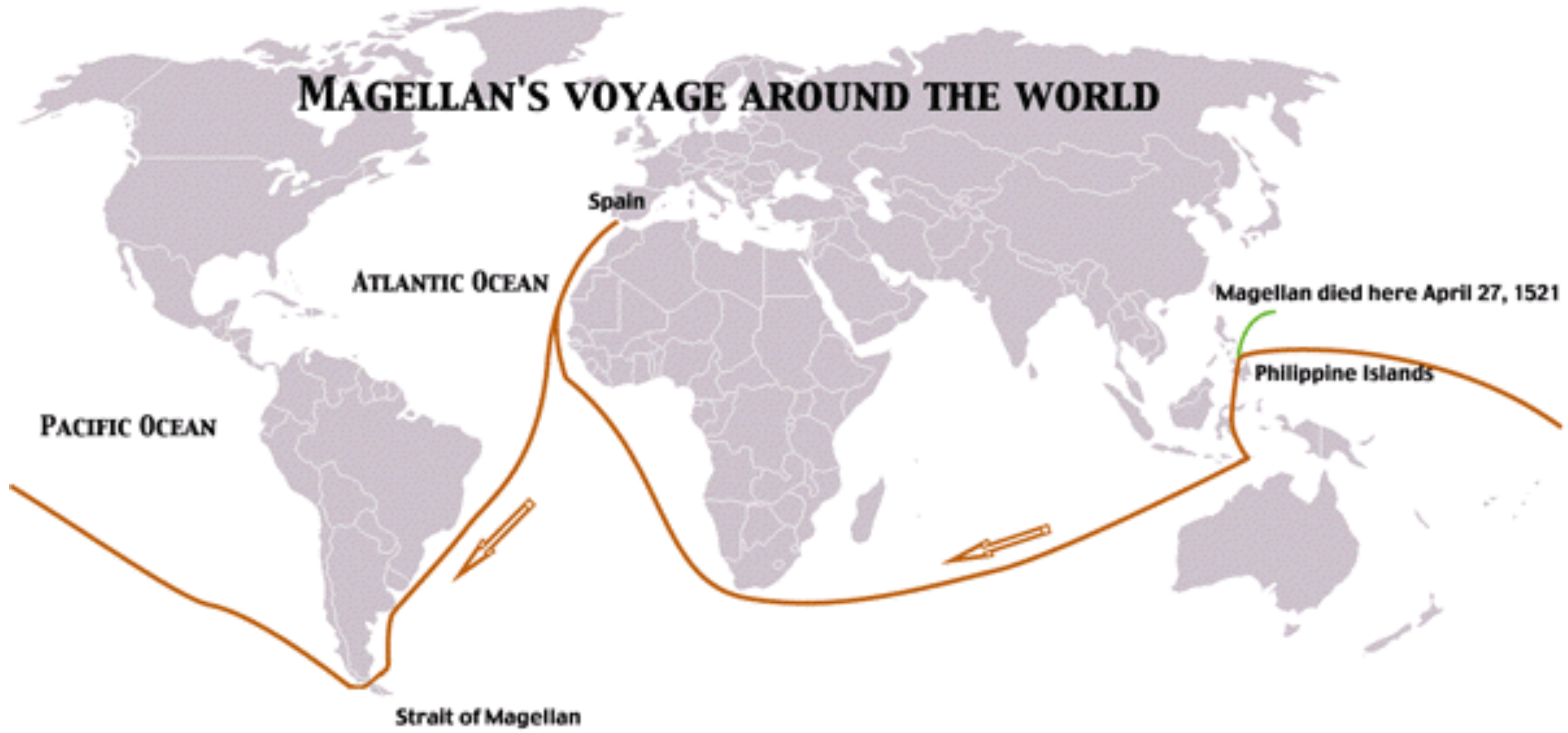


Business contact between the King of Spain and Columbus, April 17, 1492

"”That of all and every kind of merchandise, whether pearls, precious stones, gold, silver, spices, and other objects and merchandise whatsoever, of whatever kind, name and sort, which may be bought, bartered, discovered, acquired and obtained within the limits of the said Admiralty, Your Highnesses grant from now henceforth to the said Don Cristóbal [Christopher Columbus] ... the tenth part of the whole, after deducting all the expenses which may be incurred therein."

Following Columbus' discovery, Pope Alexander VI issued a May 4, 1493, papal bull granting official ownership of the New World to Ferdinand and Isabella. To these monarchs, the Pope declared:

"We of our own motion, and not at The solicitation, do give, concede, and assign for ever to you and your successors, all the islands, and main lands, discovered; and which may hereafter, be discovered, towards the west and south; whether they be situated towards India, or towards any other part whatsoever, and give you absolute power in them."



On March 22, 1518, King Charles approved Magellan's plan. Under the contract, Magellan and Faleiro, as joint captains-general, would receive one-twentieth of all profits and they and their heirs would gain the government of any lands discovered

18 members of the crew and one ship of the fleet returned to Spain in 1522, having circumnavigated the globe.

The expedition made a profit.

Summary

Zheng He (1405 - 1433)
48 to 317 ships
28,000 crew
Nonprofit government program.

Columbus (1492)
3 ships
90 crew
Commercial program. Success.

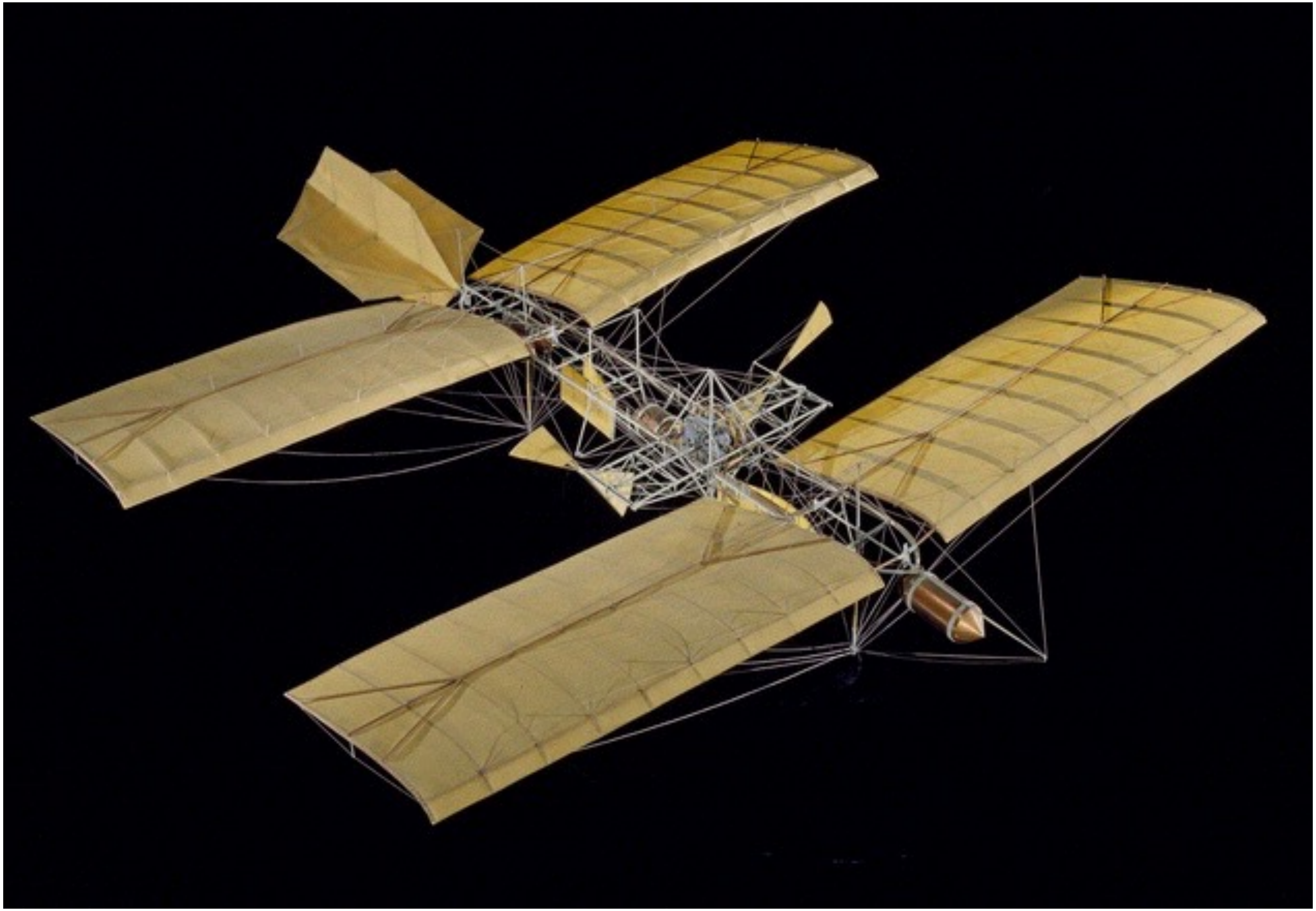
Magellan (1521)
5 ships
265 crew
Commercial program. Success.

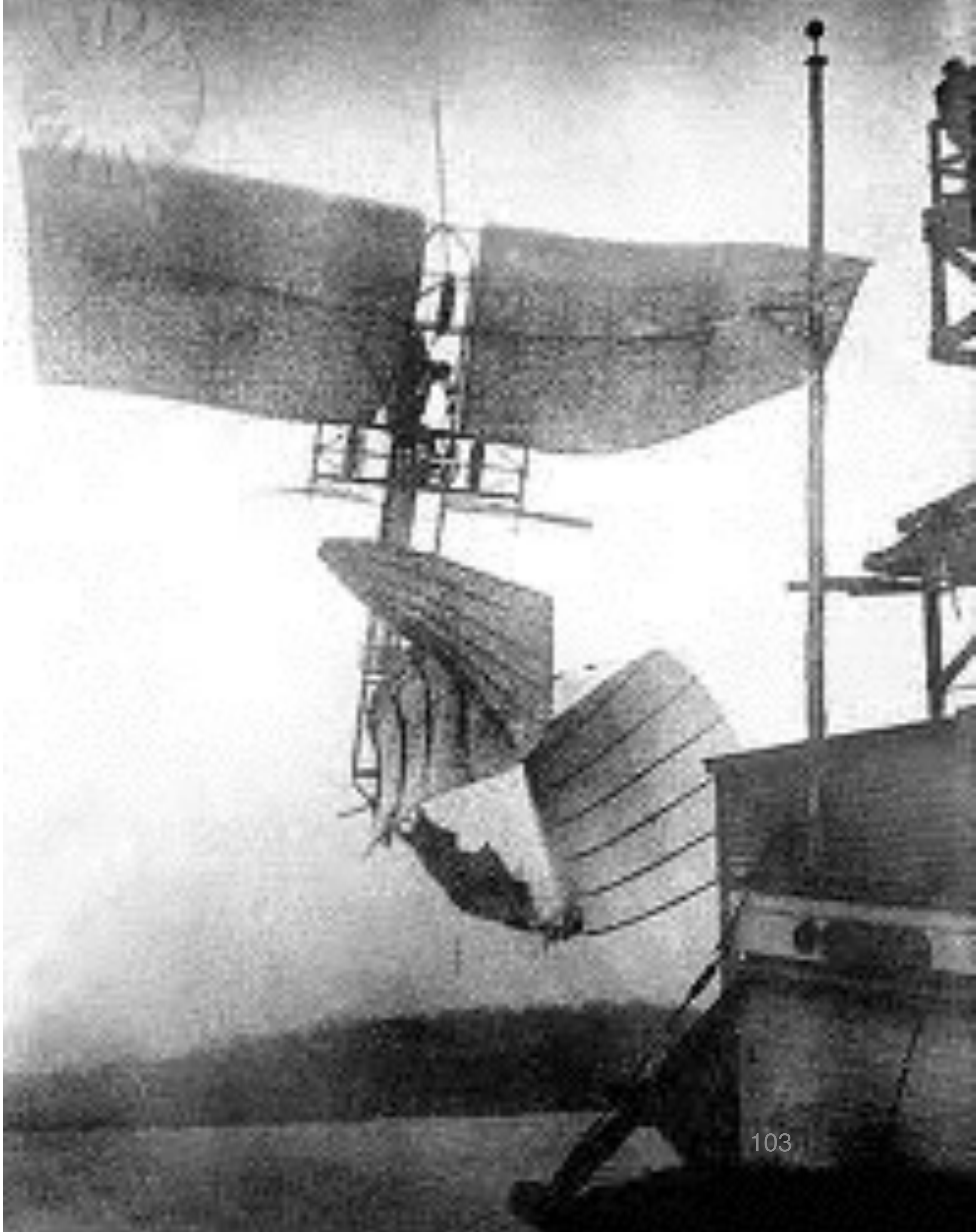
The invention of aircraft

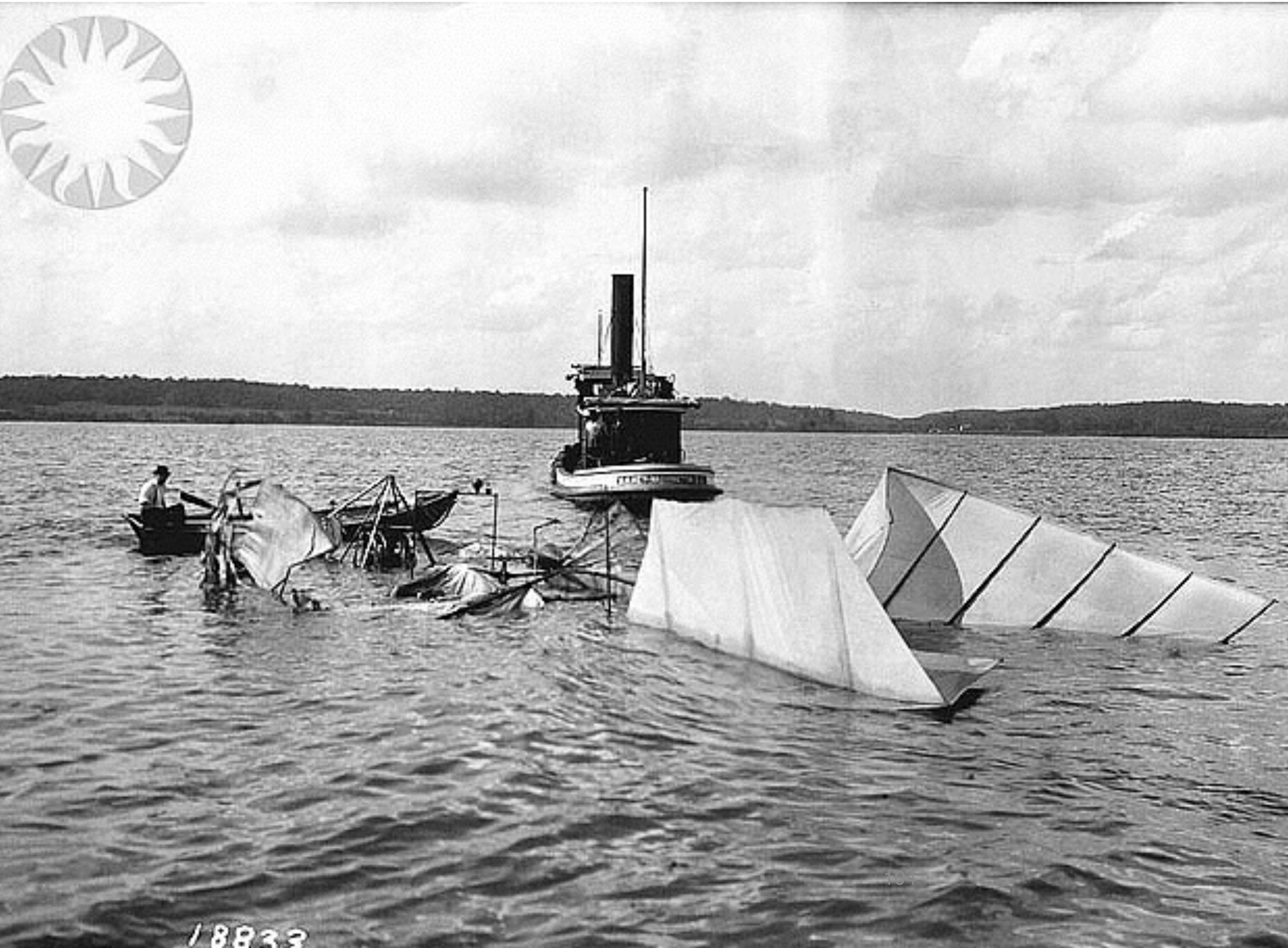
1900 - 1903

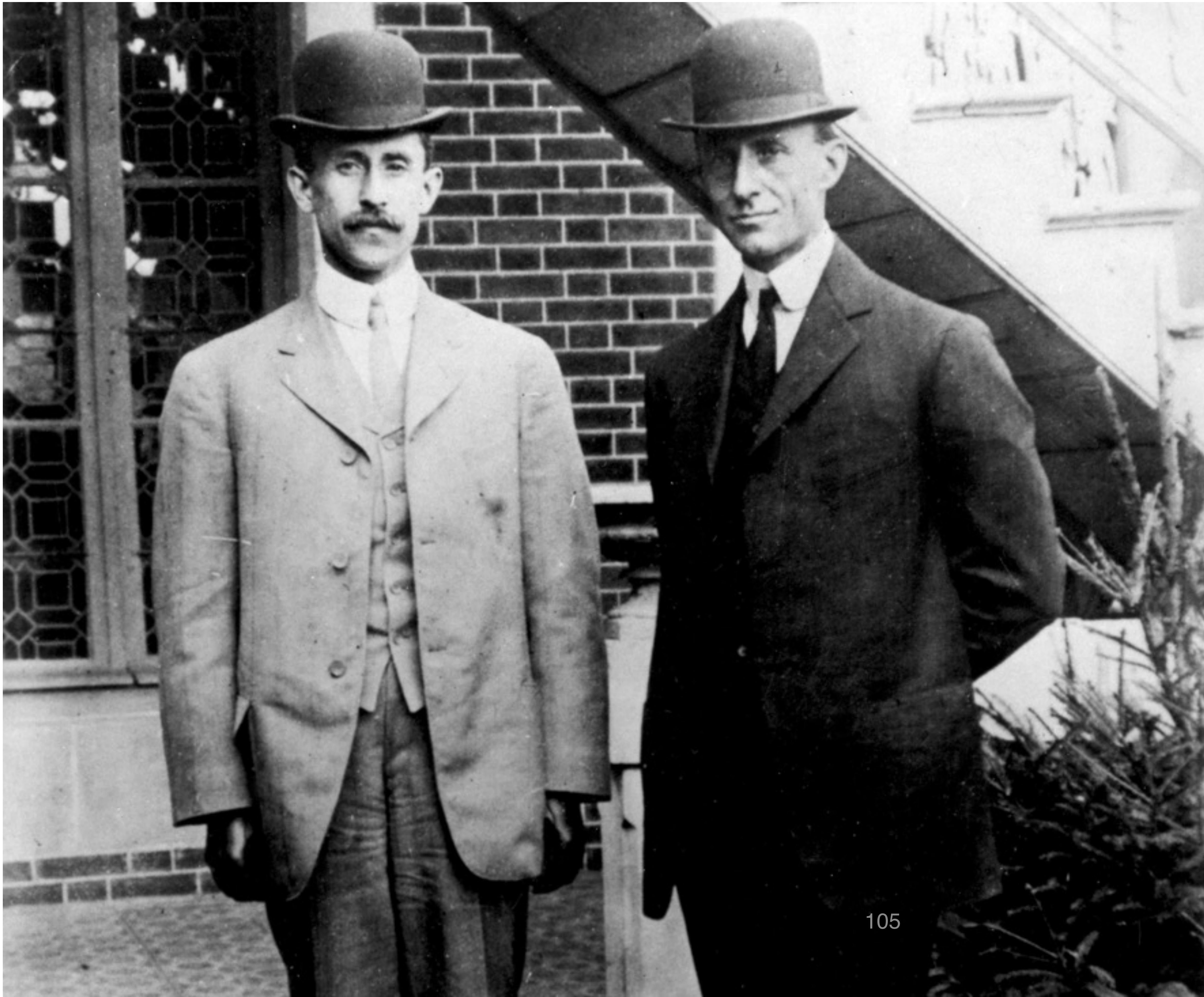
Became a trillion dollar world industry in one century

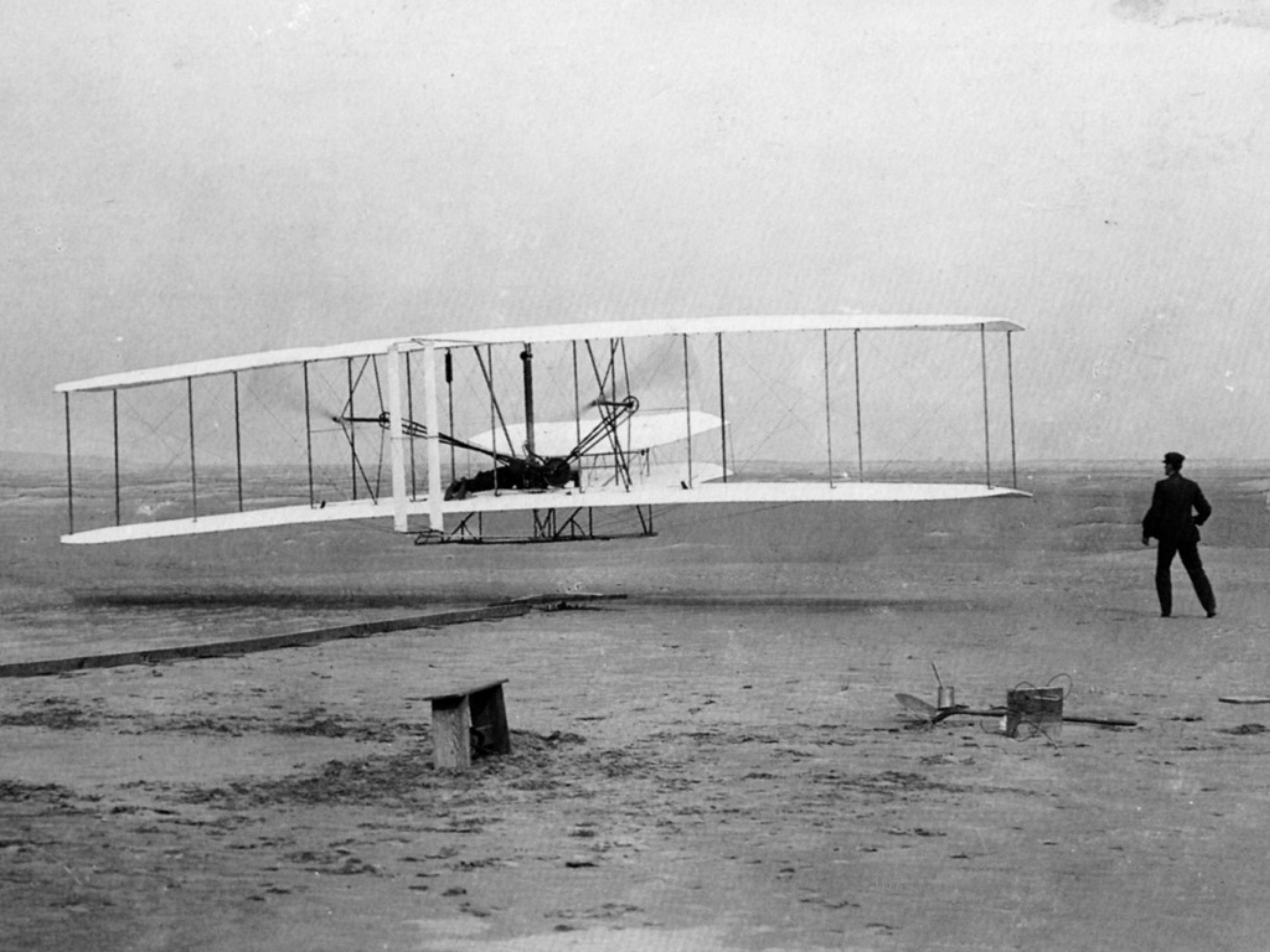
Langley's Full Scale Tunnel
NASA Langley Research Center 3/27/1990 Image # EL-1997-00145






18833





Where are we now?
&
What could we do with space resources?

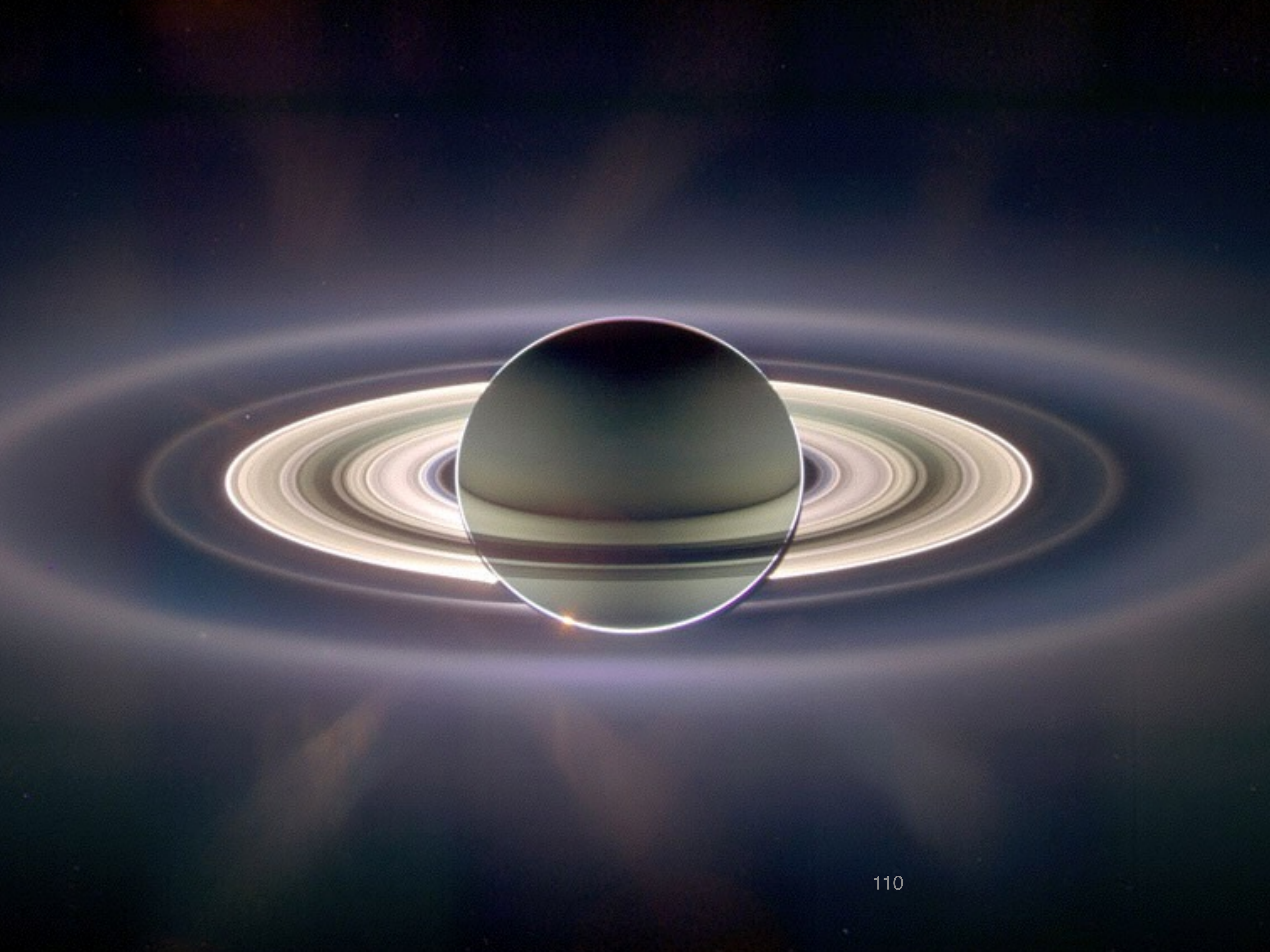
What is possible?

Any sufficiently advanced technology is indistinguishable from magic.

Arthur C. Clarke

One man's 'magic' is another man's engineering. 'Supernatural' is a null word.

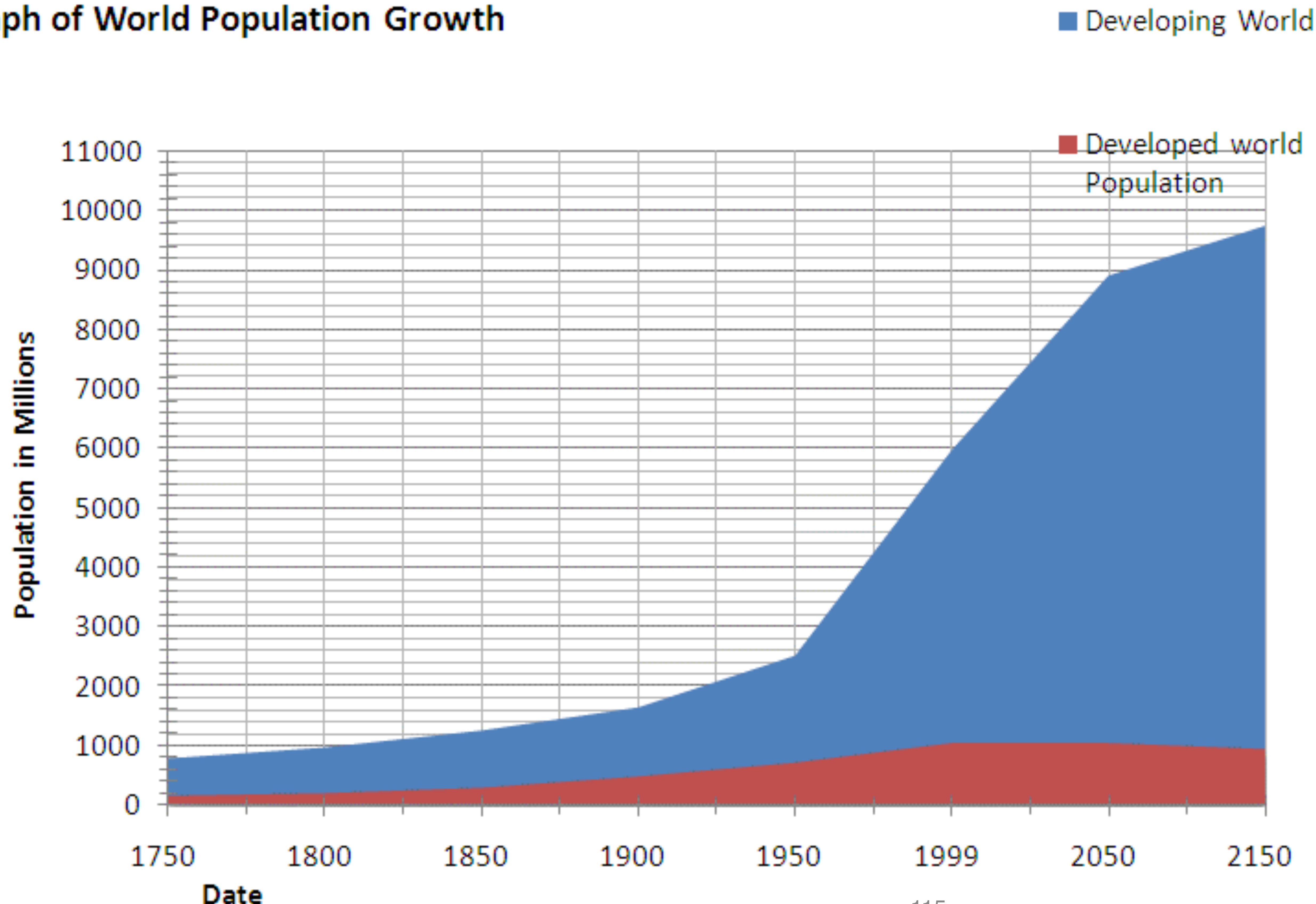
Robert A. Heinlein



Where do you want your grandchildren to be at the end of this century?


Why?

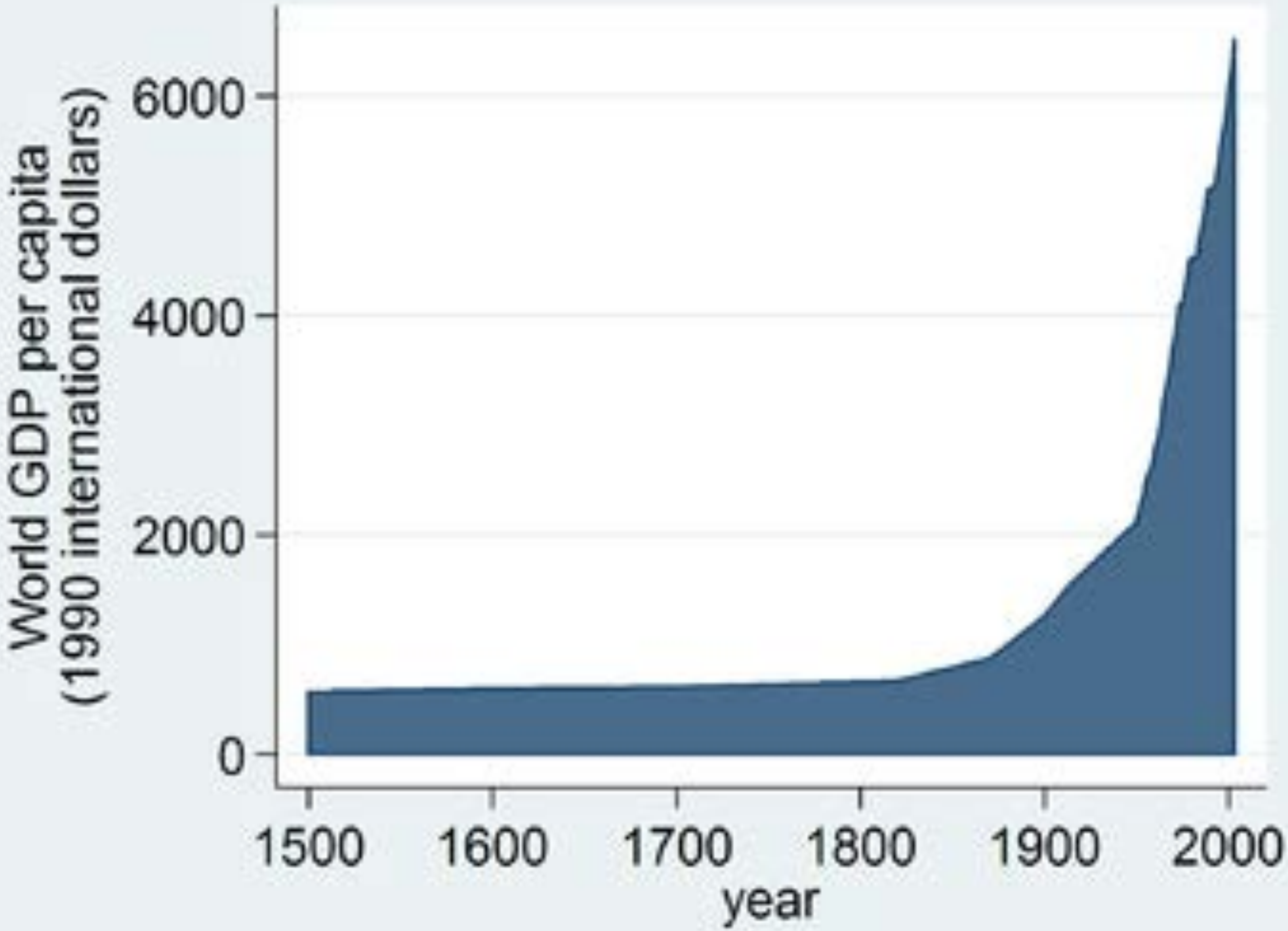
A Graph of World Population Growth

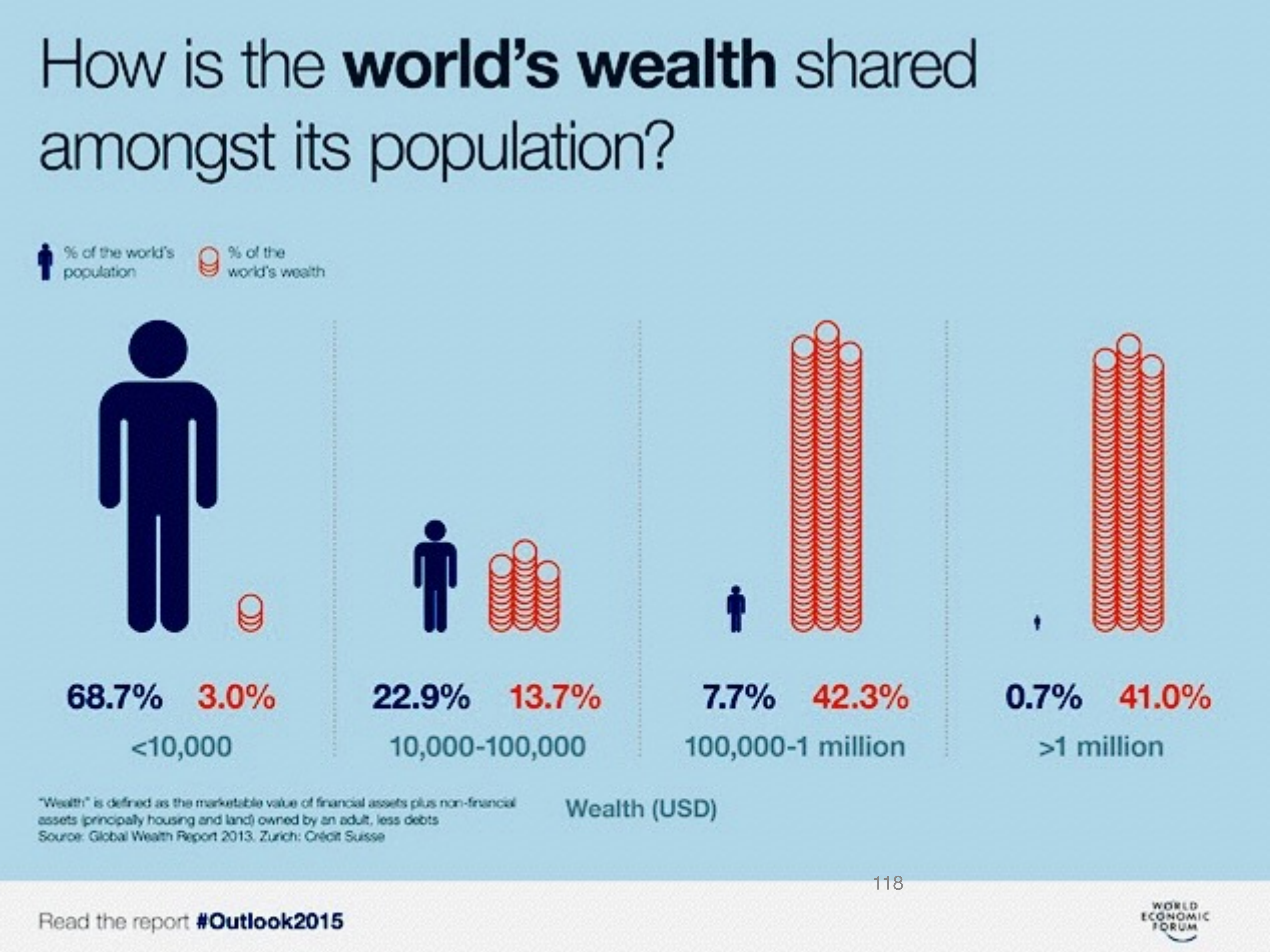


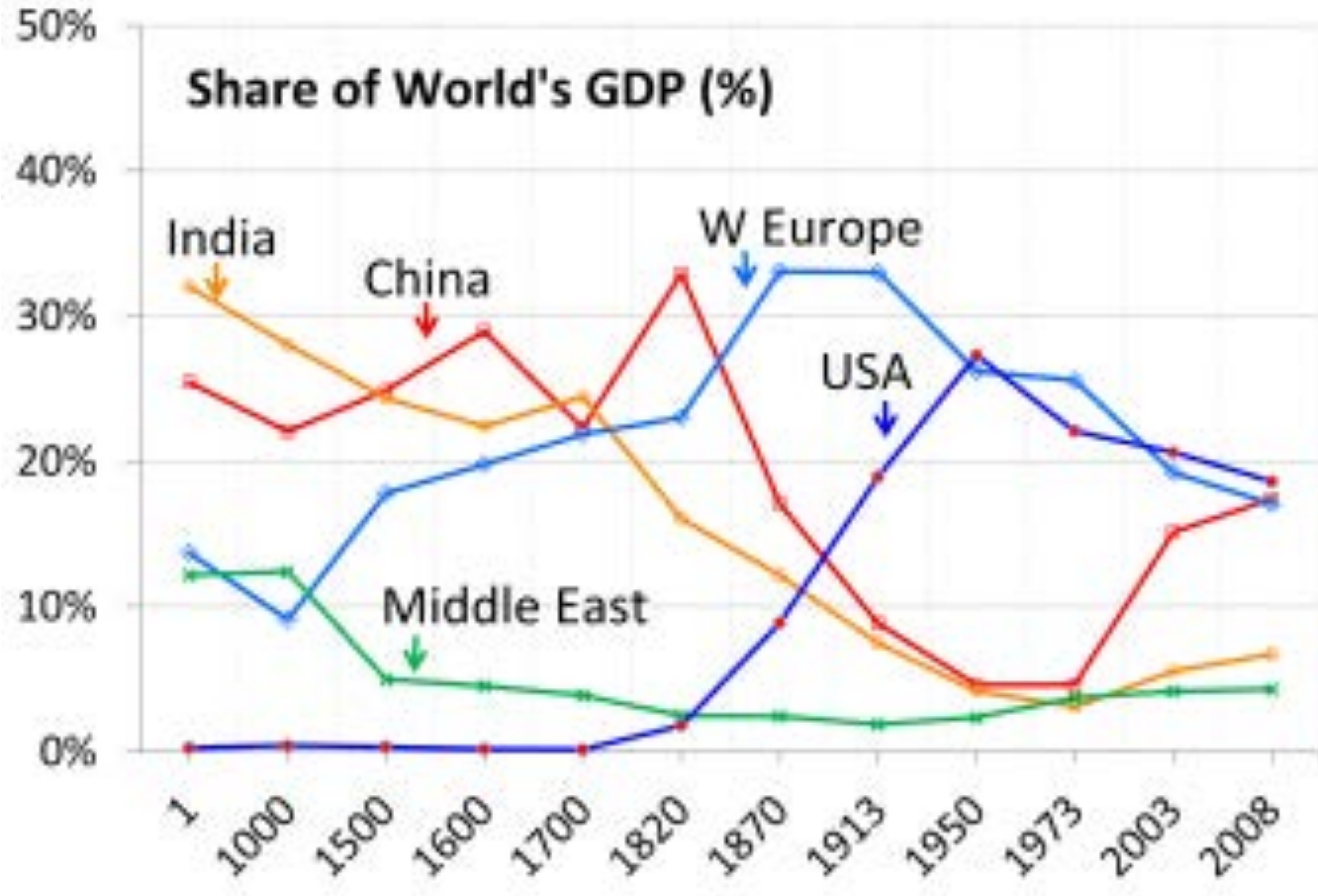
Since 1800 Wikipedia and the CIA World Factbook estimate that the Gross World Product (the combined product of all nations) has grown from U.S. $175 **b**illion to $84.97 **t**rillion.

A growth rate of 48,554%.

The population grew 725% during that same period


World GDP per capita
(1990 international dollars)
6000
4000
2000
0
1500
1600
1700
1800
1900
2000
year

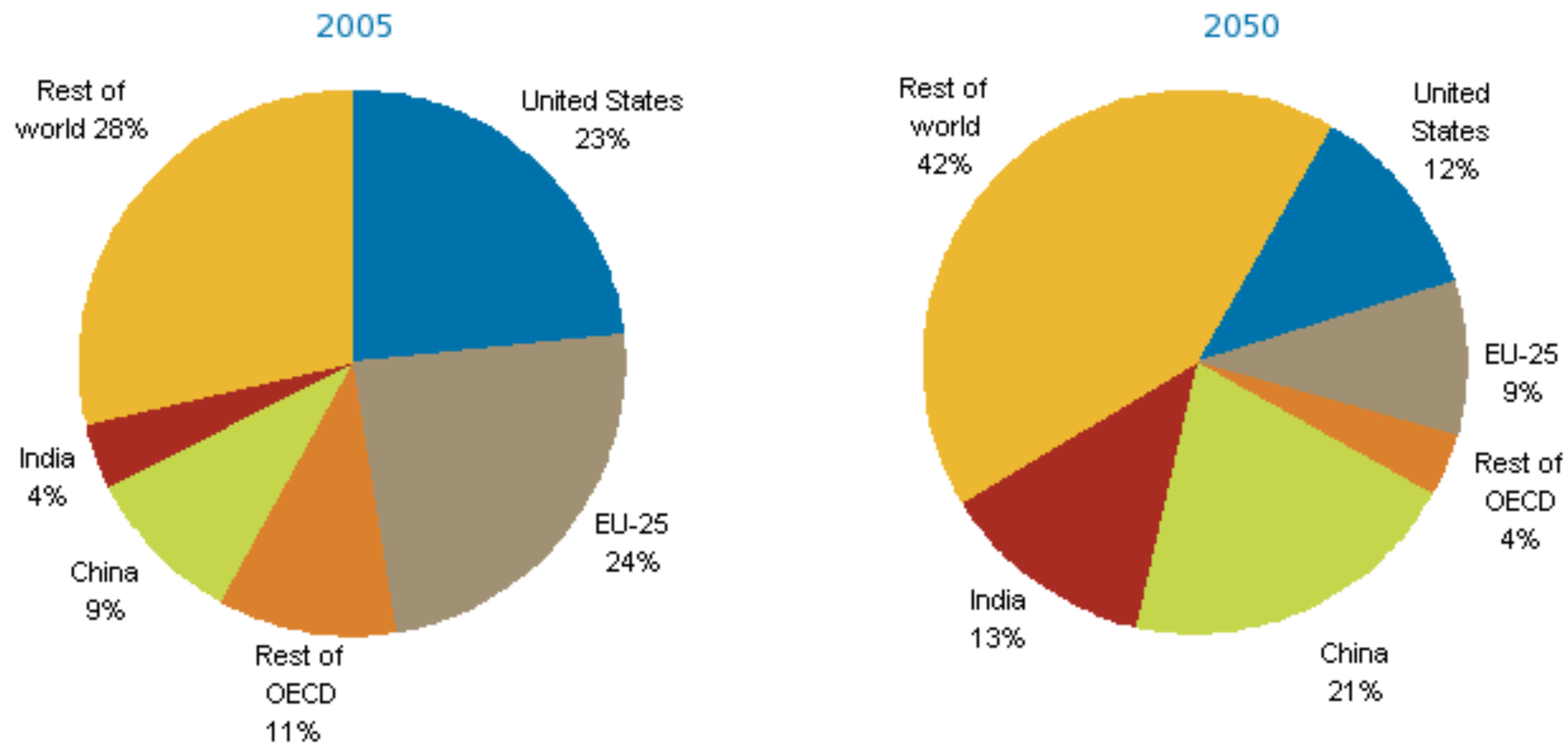

How is the world's wealth shared amongst its population?
% of the world's population
% of the world's wealth
68.7%
3.0%
<10,000
22.9%
13.7%
10,000-100,000
7.7%
42.3%
100,000-1 million
0.7%
41.0%
>1 million
"Wealth" is defined as the marketable value of financial assets plus non-financial assets (principally housing and land) owned by an adult, less debts
Source: Global Wealth Report 2013. Zurich: Crédit Suisse
Wealth (USD)
Read the report #Outlook2015
WORLD ECONOMIC FORUM



Share of World's GDP (%)
50%
40%
30%
20%
10%
0%
India
China
W Europe
USA
Middle East
1
1000
1500
1600
1700
1820
1870
1913
1950
1973
2003
2008

By 2021, China overtakes the United States as the world's largest economy; in 2083, India overtakes China, largely due to higher population growth. India's GDP reaches nearly US$34 trillion by 2050. By 2050, China, India and other currently developing economies comprise over 67 per cent of global GWP (Chart 3.11).

Chart 3.11: Distribution of gross world product



Source: Treasury projections.

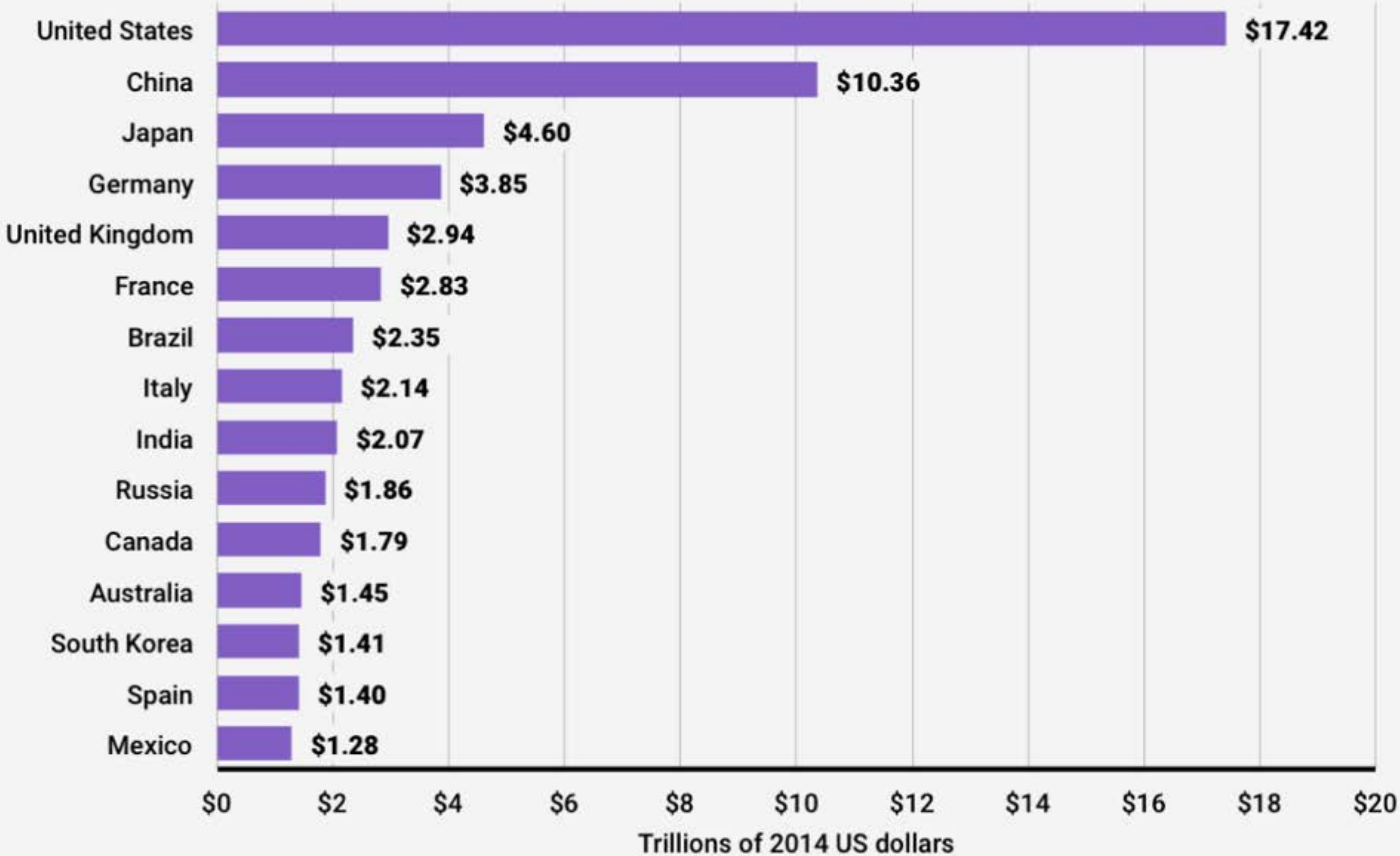
3.1.3 Sectoral analysis

As developing economies' living standards improve, the composition of their economies is expected to adjust. The share of GDP being derived from the services sectors will shift as more luxury goods appear in developing economies. This generally lowers the emission intensity of output, as the services sector is relatively low in emissions.

However, other trends push in the other direction. Adjustments occur in the types of goods in demand within sectors. For example, meat consumption, which is relatively more emission intensive, is expected to increase, while grain consumption is expected to fall in relative terms.

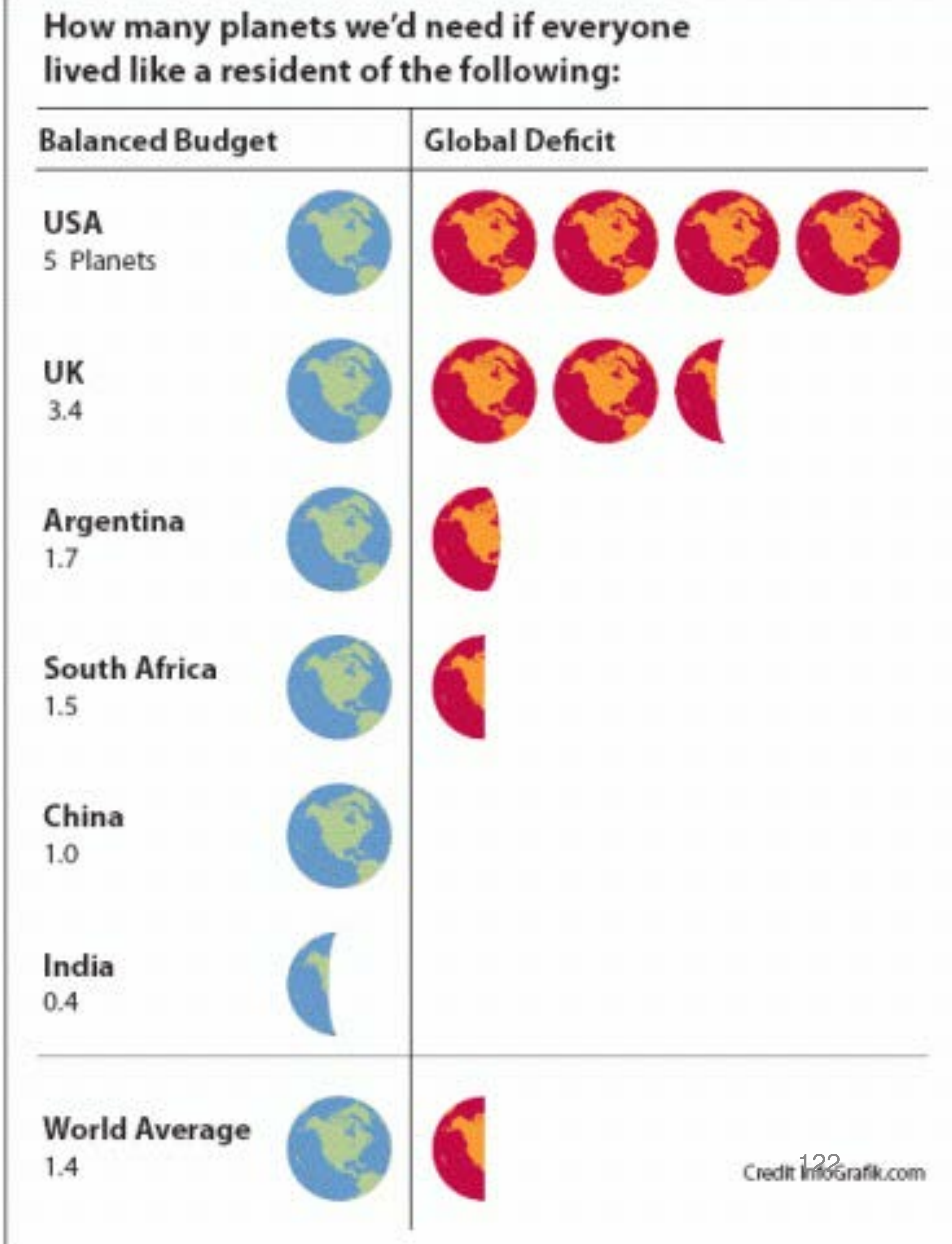
Developed economies continue the trend towards an increased share of the service sector (Chart 3.12). The United States service sector increases from around 63 per cent of total output in 2005 to over 68 per cent in 2050. At the same time, the share of other sectors such as manufacturing declines. A similar pattern occurs in developing regions, where the share of the service sector increases from around 32 per cent of total output in 2005 to 41 per cent by 2050.

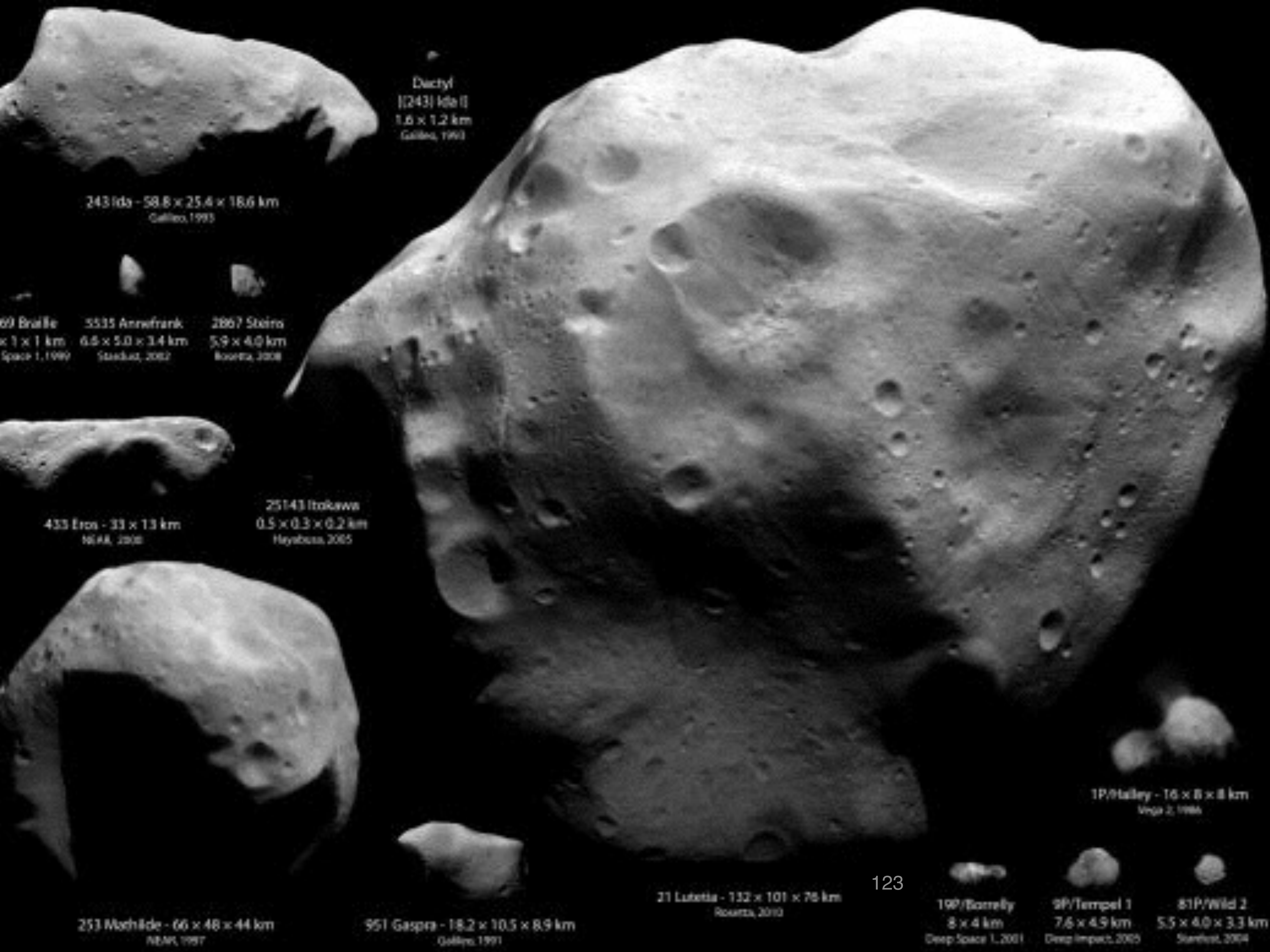
GROSS DOMESTIC PRODUCT, 2014



SOURCE: World Bank

BUSINESS INSIDER

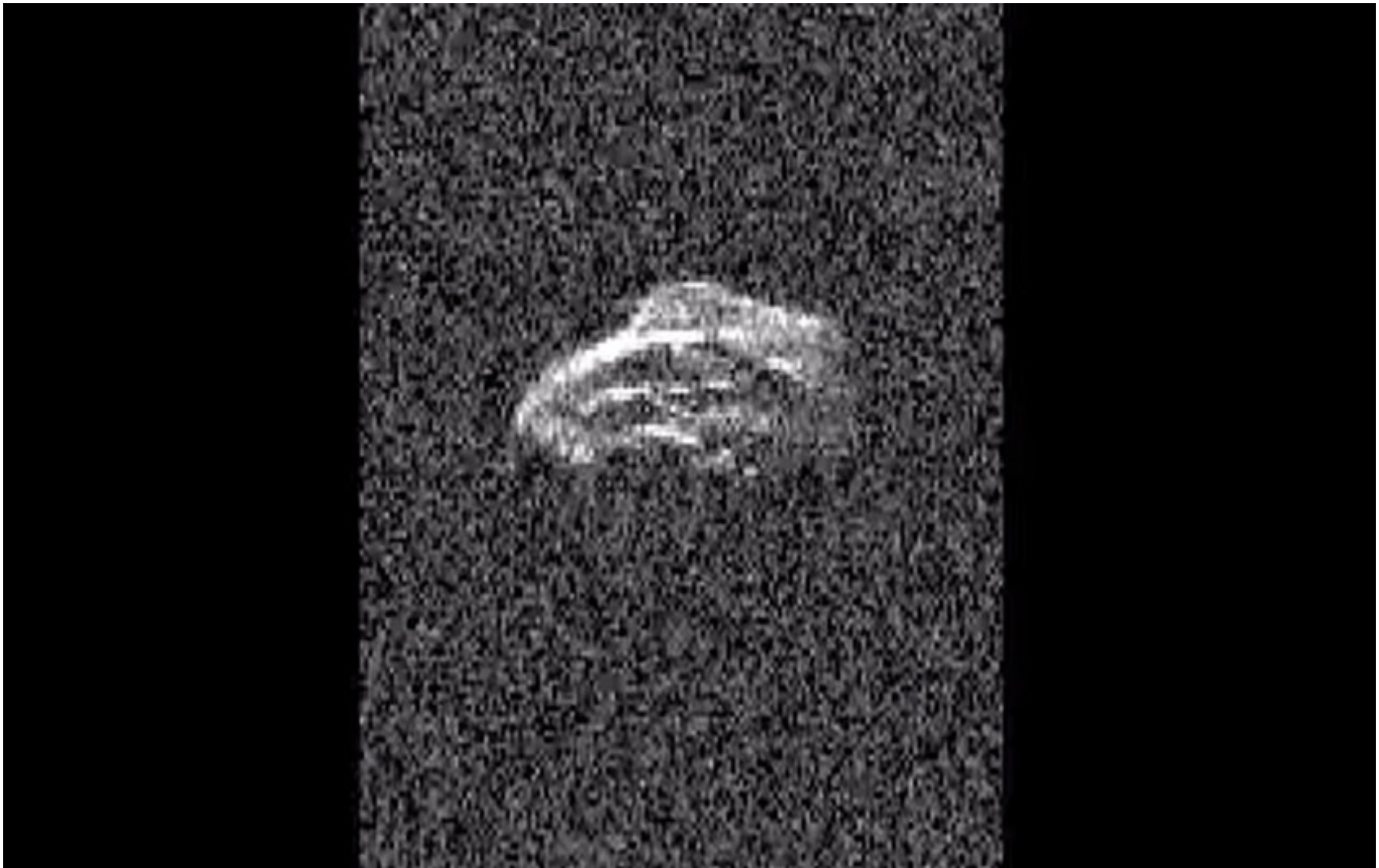

How many planets we'd need if everyone lived like a resident of the following:
Balanced Budget
Global Deficit
USA
5 Planets
UK
3.4
Argentina
1.7
South Africa
1.5
China
1.0
India
0.4
World Average
1.4
Credit InfoGrafik.com



Dactyl
[(243) Ida I]
1.6 × 1.2 km
Galileo, 1993
243 Ida - 58.8 × 25.4 × 18.6 km
Galileo, 1993
5535 Annefrank
6.6 × 5.0 × 3.4 km
Stardust, 2002
2867 Steins
5.9 × 4.0 km
Rosetta, 2008
25143 Itokawa
0.5 × 0.3 × 0.2 km
Hayabusa, 2005
433 Eros - 33 × 13 km
NEAR, 2000
1P/Halley - 16 × 8 × 8 km
Vega 2, 1986
253 Mathilde - 66 × 48 × 44 km
NEAR, 1997
951 Gaspra - 18.2 × 10.5 × 8.9 km
Galileo, 1991
21 Lutetia - 132 × 101 × 76 km
Rosetta, 2010
19P/Borrelly
8 × 4 km
Deep Space 1, 2001
9P/Tempel 1
7.6 × 4.9 km
Deep Impact, 2005
81P/Wild 2
5.5 × 4.0 × 3.3 km
Stardust, 2004

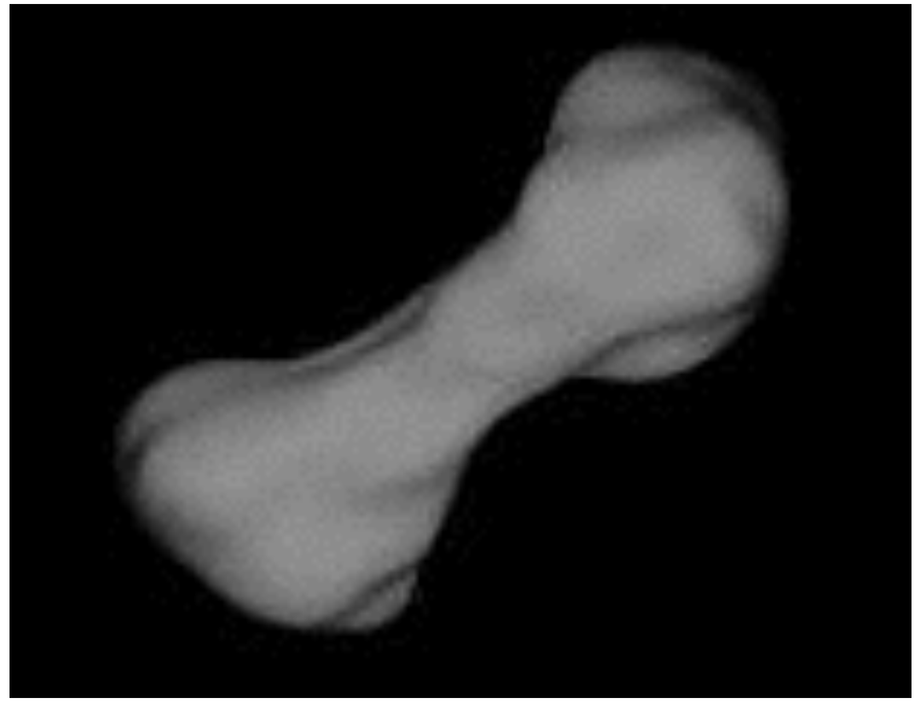

Toutatis
小行星间隔成像照片
CE-2卫星拍摄
@新华视
weibo.com/xinhuashidi

‘Platinum’ asteroid potentially worth $5.4 trillion to pass Earth on Sunday
Published time: 18 Jul, 2015 11:21



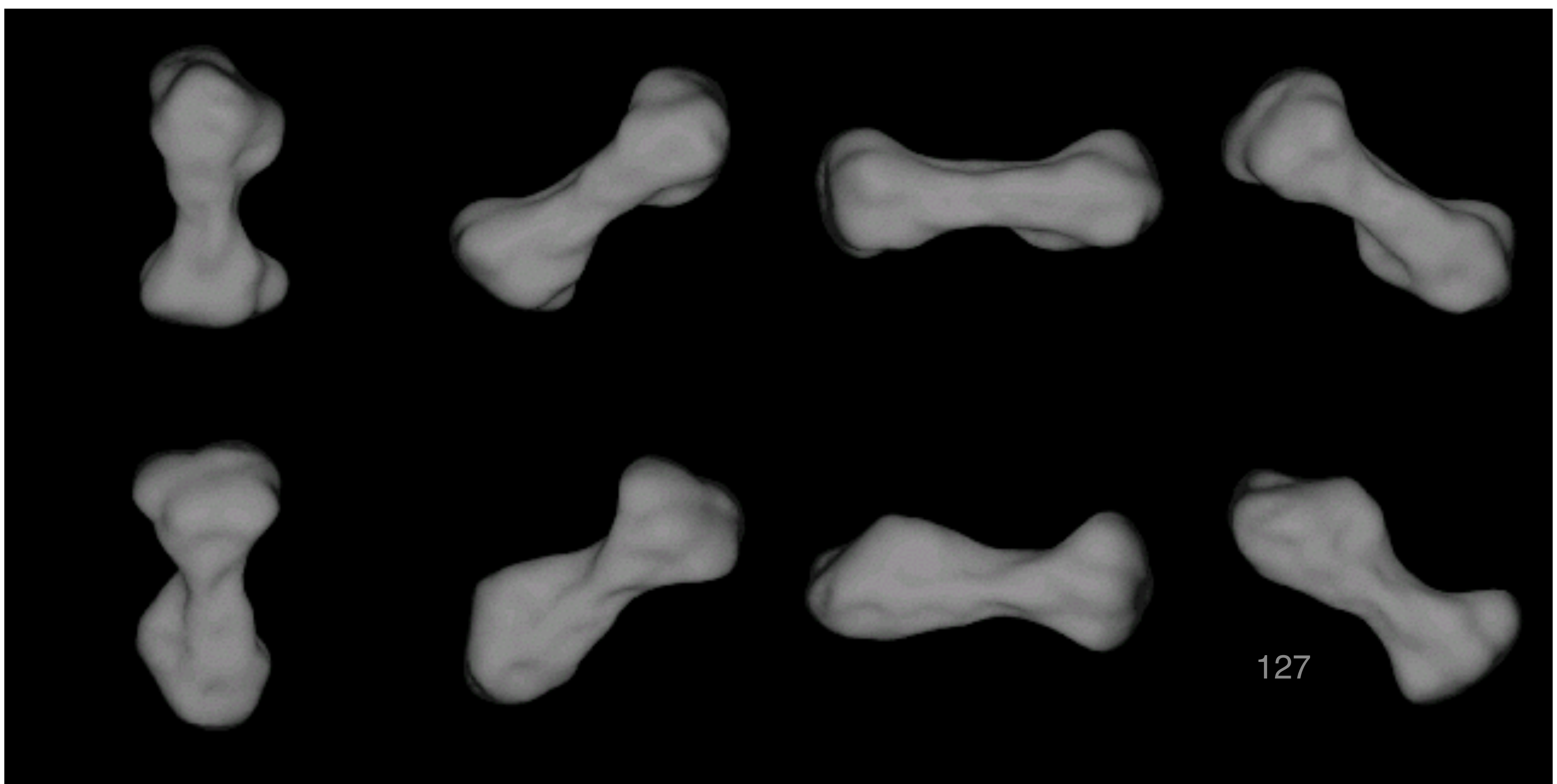
An asteroid believed to be carrying up to 90 million tons of platinum in its core, as well as other rare and precious materials, is about to swoosh past our planet. The news has left developers of asteroid-mining technologies intrigued.

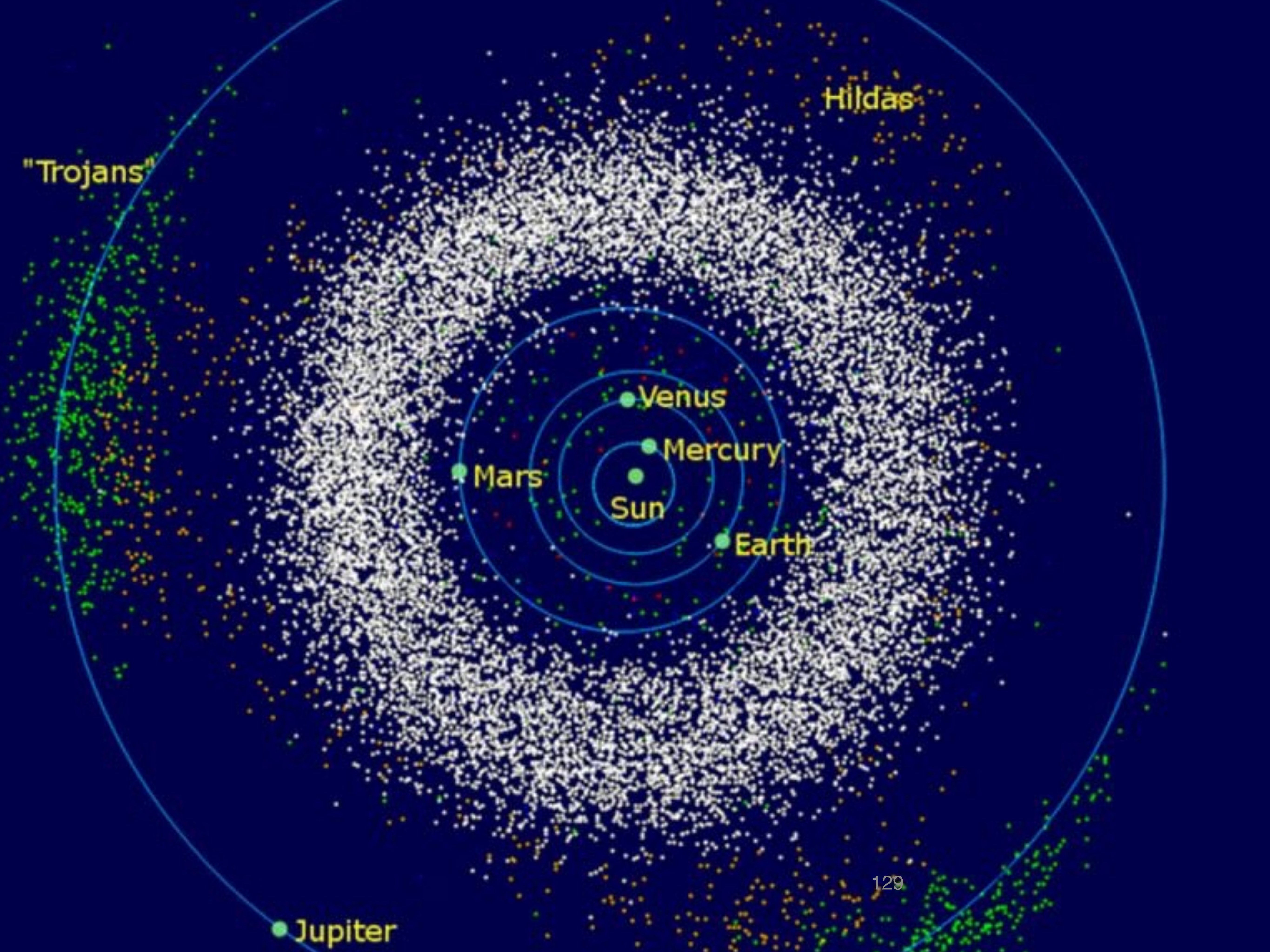
The platinum-rich asteroid officially named 2011 UW158, is 452 meters by 1,011 meters in size and will pass Earth at a distance of an estimated 2.4 million kilometers, according to the Goldstone Radar Observatory. It will be 30 times closer to Earth than the closest planet of the Solar system.

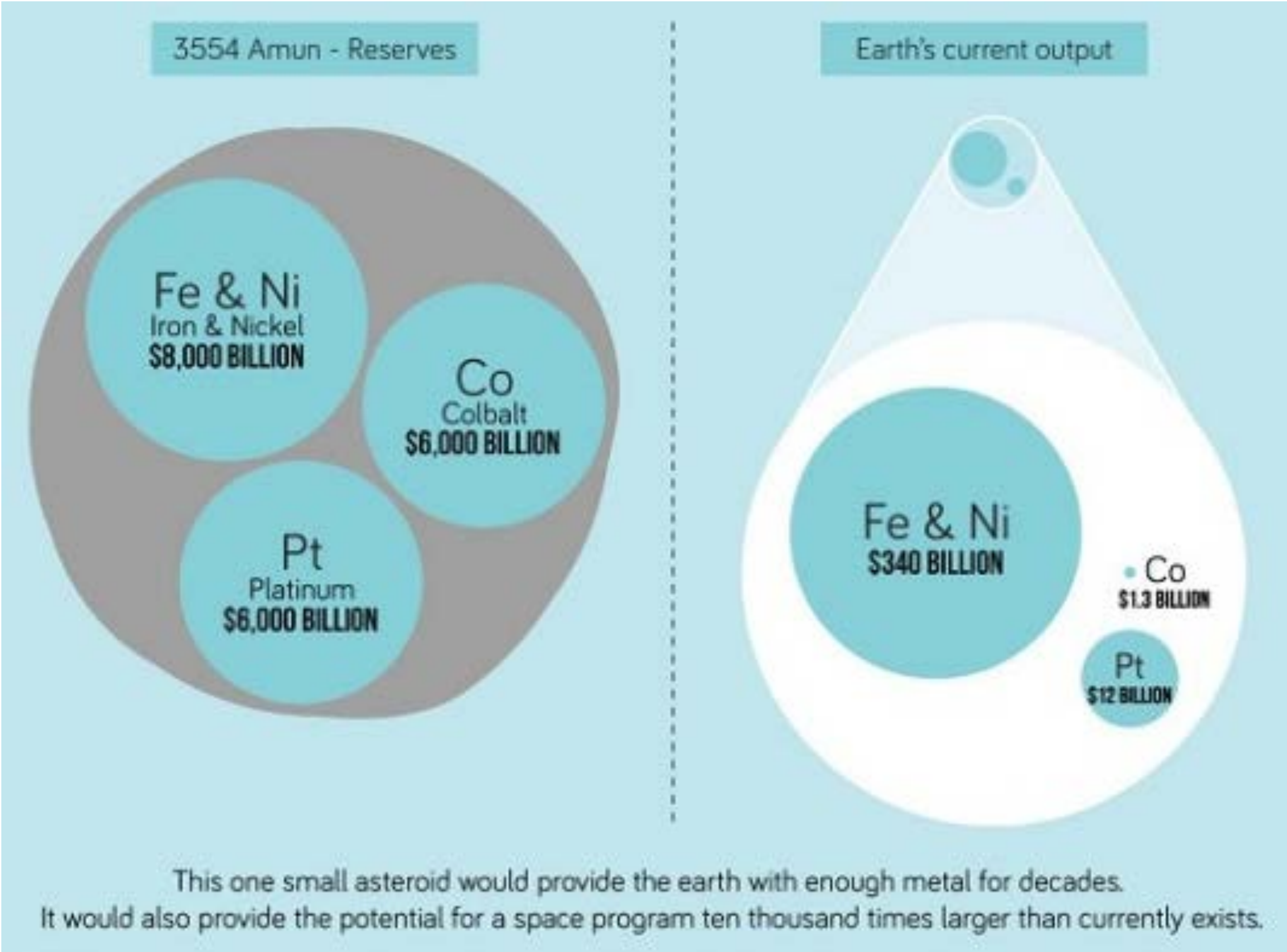


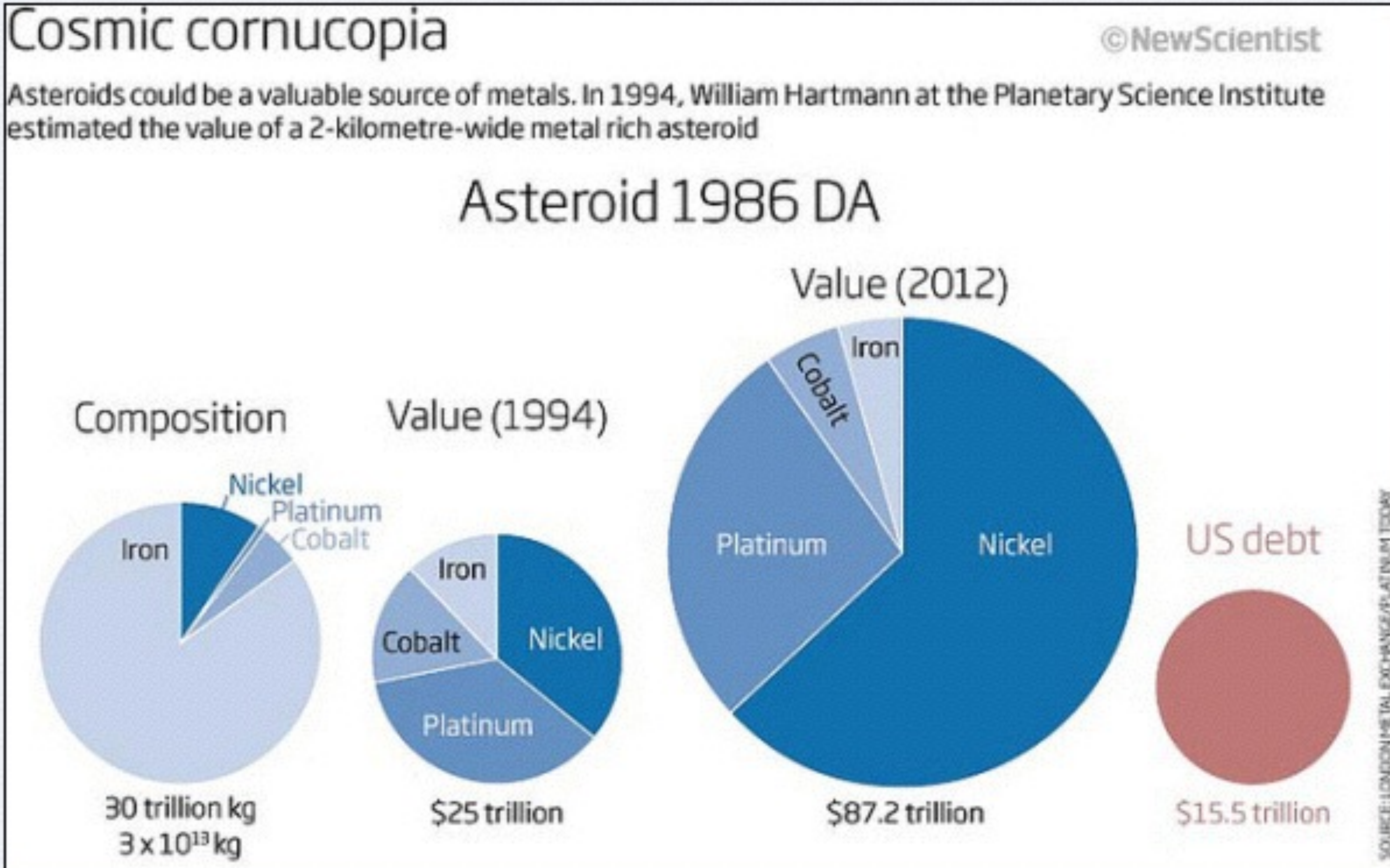
Dimensions 217 × 94 × 81 km

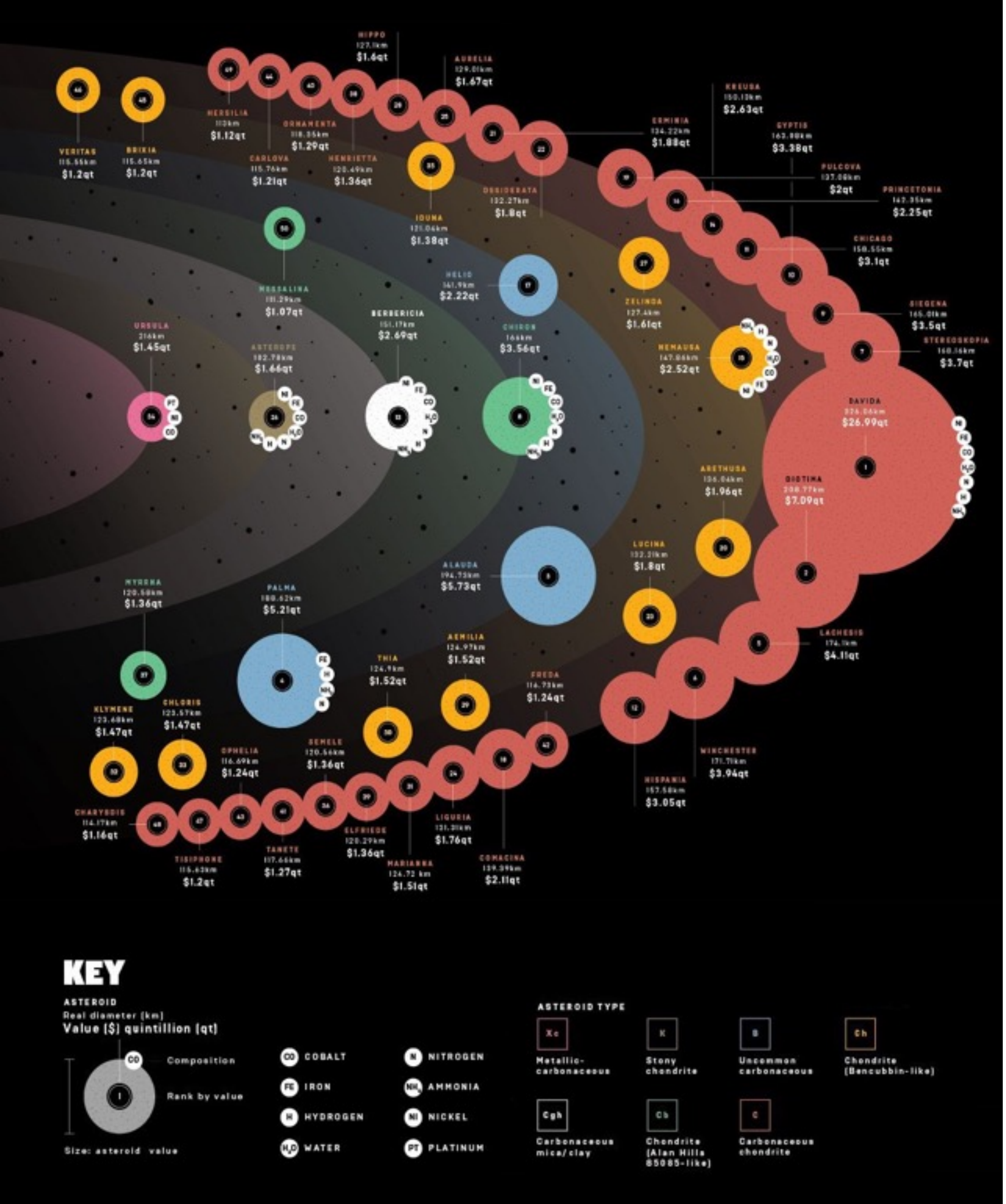
Mass 4.64 ± 0.02 × 10^15 mT




"Trojans"
Hildas
Venus
Mercury
Mars
Sun
Earth
Jupiter


3554 Amun - Reserves
Fe & Ni
Iron & Nickel
$8,000 BILLION
Co
Colbalt
$6,000 BILLION
Pt
Platinum
$6,000 BILLION
Earth's current output
Fe & Ni
$340 BILLION
Co
$1.3 BILLION
Pt
$12 BILLION
This one small asteroid would provide the earth with enough metal for decades.
It would also provide the potential for a space program ten thousand times larger than currently exists.


Cosmic cornucopia
©NewScientist
Asteroids could be a valuable source of metals. In 1994, William Hartmann at the Planetary Science Institute estimated the value of a 2-kilometre-wide metal rich asteroid
Asteroid 1986 DA
Composition
Nickel
Platinum
Cobalt
Iron
30 trillion kg
3 x 10¹³ kg
Value (1994)
Iron
Cobalt
Nickel
Platinum
$25 trillion
Value (2012)
Iron
Cobalt
Platinum
Nickel
$87.2 trillion
US debt
$15.5 trillion
SOURCE: LONDON METAL EXCHANGE/PLATINUM TODAY



The resources of our solar system are effectively infinite. The mineral wealth of just 50 asteroids would be enough to support a civilization of more than10 trillion people.

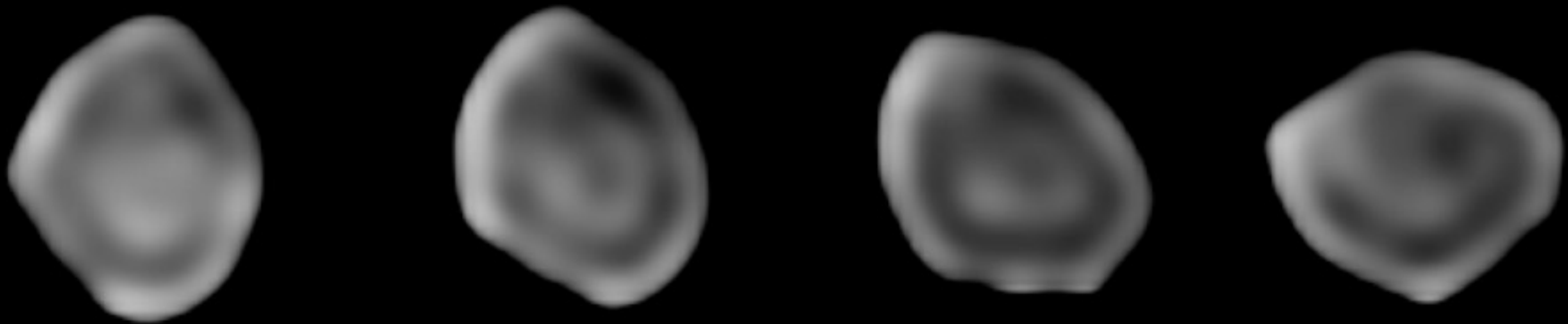
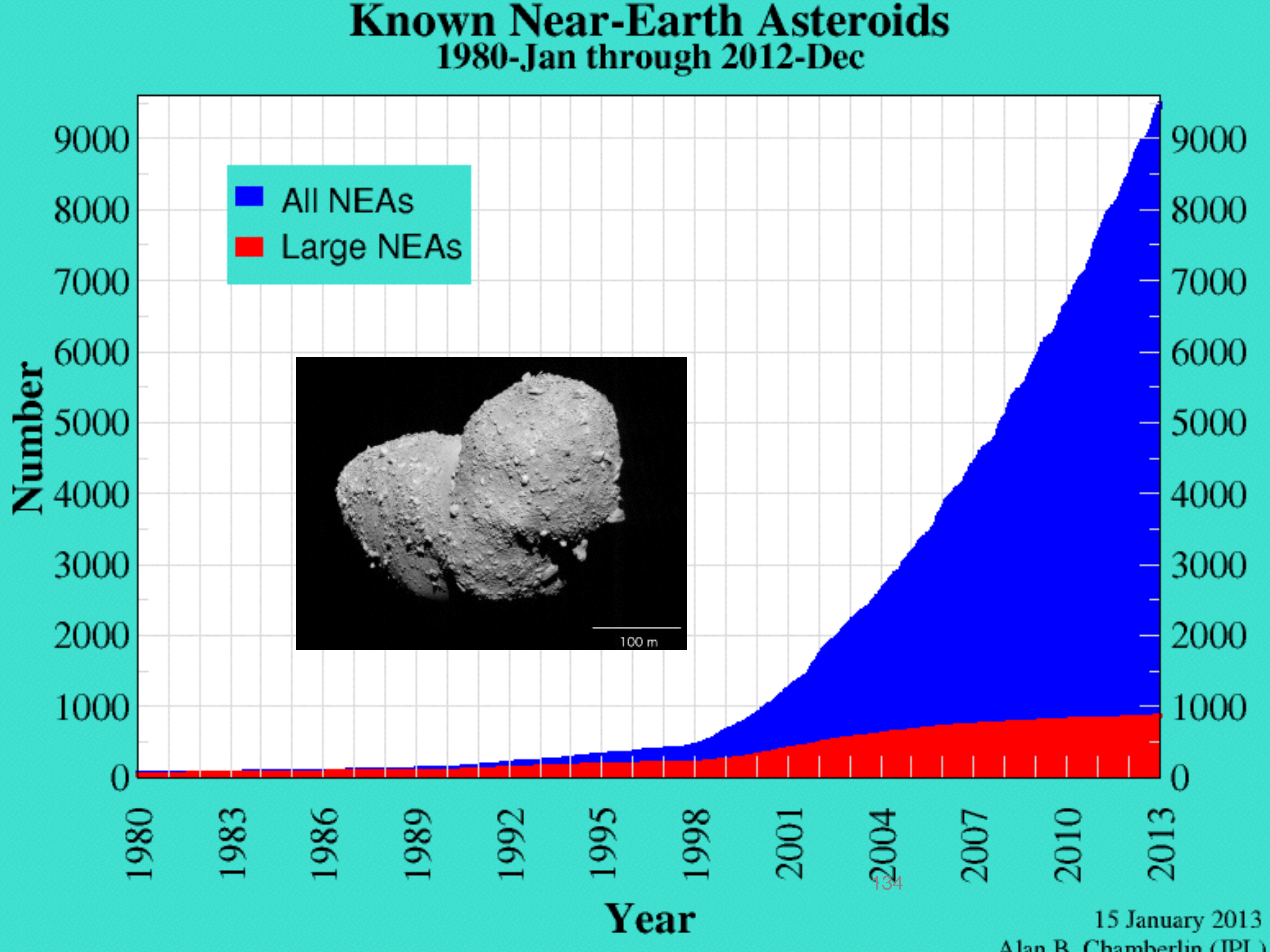


Photo: W.M. Keck Observatory

A sequence of images of asteroid (511) Davida, spanning slightly more than one hour, as it rotates on Dec. 26, 2002. In this view, the asteroid is seen from above its north pole, as it spins counter-clockwise, left to right. The features on the edges, such as the flat facets, show that the asteroid has rotated about one-quarter turn.

The W.M. Keck Observatory



Known Near-Earth Asteroids
1980-Jan through 2012-Dec
All NEAs
Large NEAs
Number
Year
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
1980
1983
1986
1989
1992
1995
1998
2001
2004
2007
2010
2013
100 m
15 January 2013
Alan B. Chamberlin (JPL)


If people aren't
laughing at
your dreams,
your dreams
aren't big enough.
Robin Sharma


NASA
Discovery

KOETKAN KOONLAPATKUNANON
THAILAND

8

Thank you for your attention. Please send me your questions.

Art Dula
art@dula.com