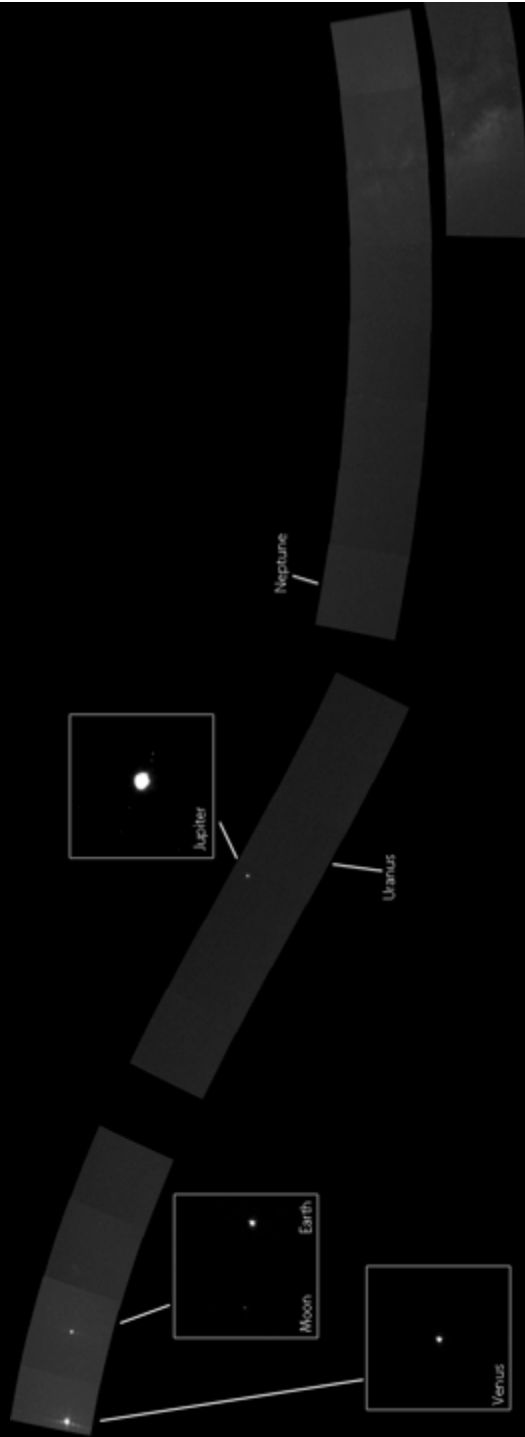


Expanding into the Solar System

Matt Daniels
Special Projects & Studies
NASA Ames Research Center

December 5, 2014



Science

Earth

Human
Expansion



Science

-Universe

-Life

Earth

Human
Expansion



A deep-field astronomical image, likely from the Hubble Space Telescope, showing a vast field of galaxies and stars. The background is black, and the foreground is filled with numerous galaxies of various shapes and sizes, including spiral, elliptical, and irregular forms. Some galaxies are bright and clear, while others are faint and distant. The overall scene conveys the immense scale and diversity of the universe.

Science

-Universe

-Life

Earth

Human
Expansion

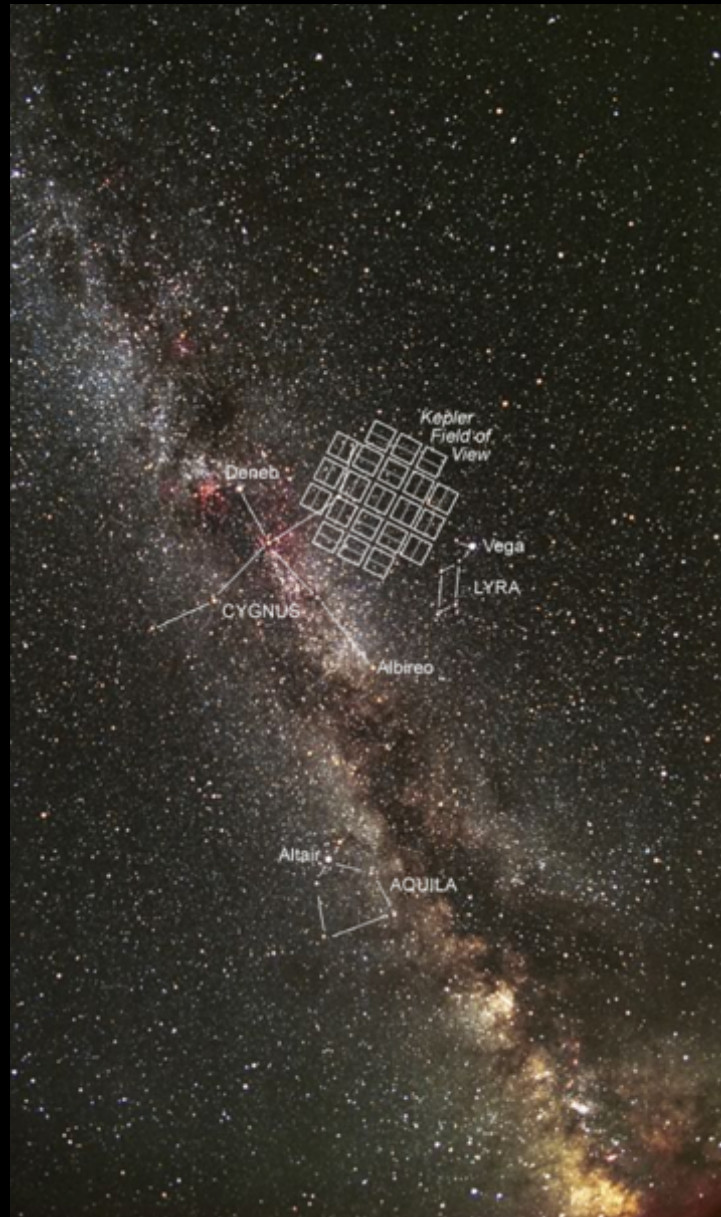
Science

-Universe

-Life

Earth

Human Expansion



Science

-Universe

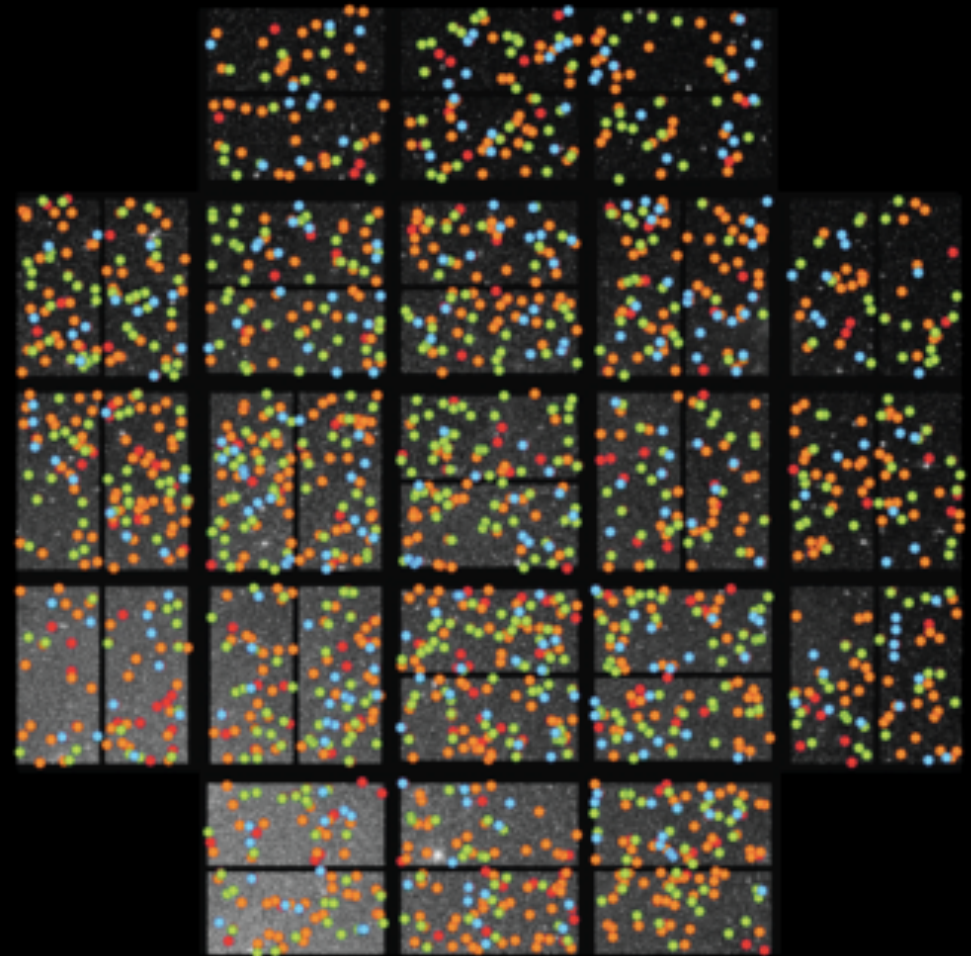
-Life

Earth

Human
Expansion

Locations of Kepler Planet Candidates as of January 7, 2013

- Earth-size
- Super-Earth size
1.25 - 2.0 Earth-size
- Neptune-size
2.0 - 6.0 Earth-size
- Giant-planet size
6.0 - 22 Earth-size



Science

-Universe

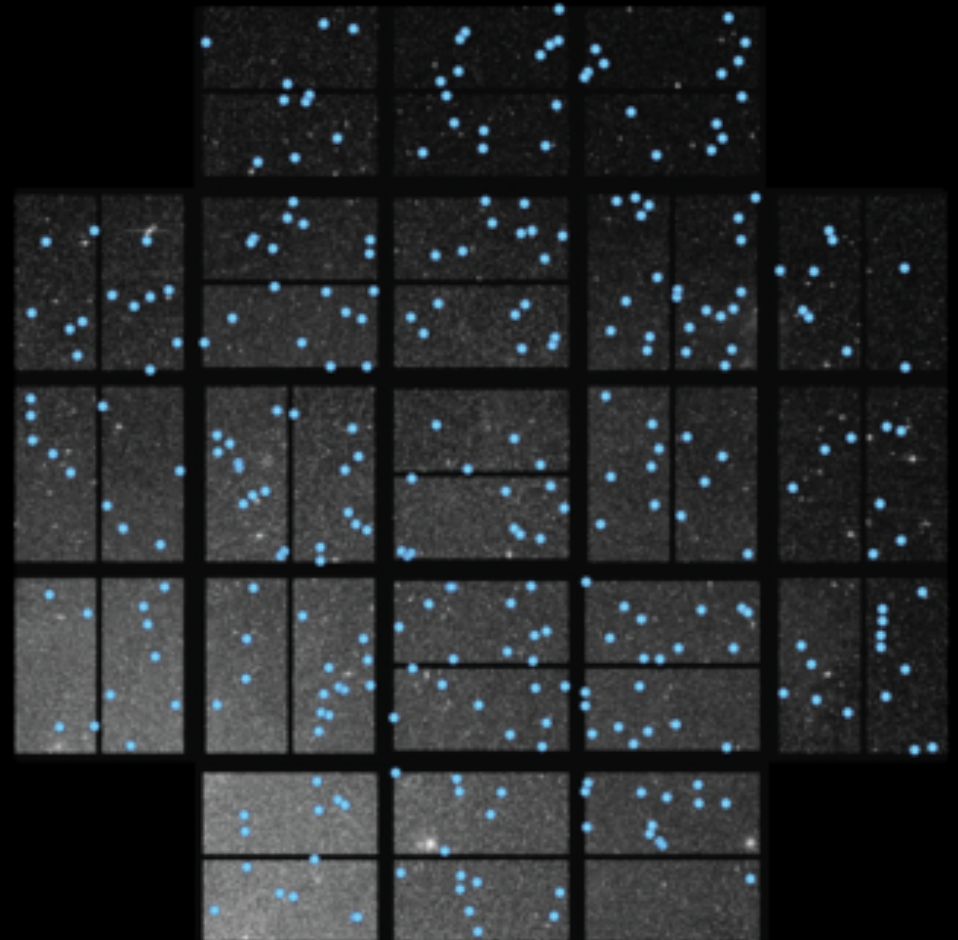
-Life

Earth

Human
Expansion

● Earth-size

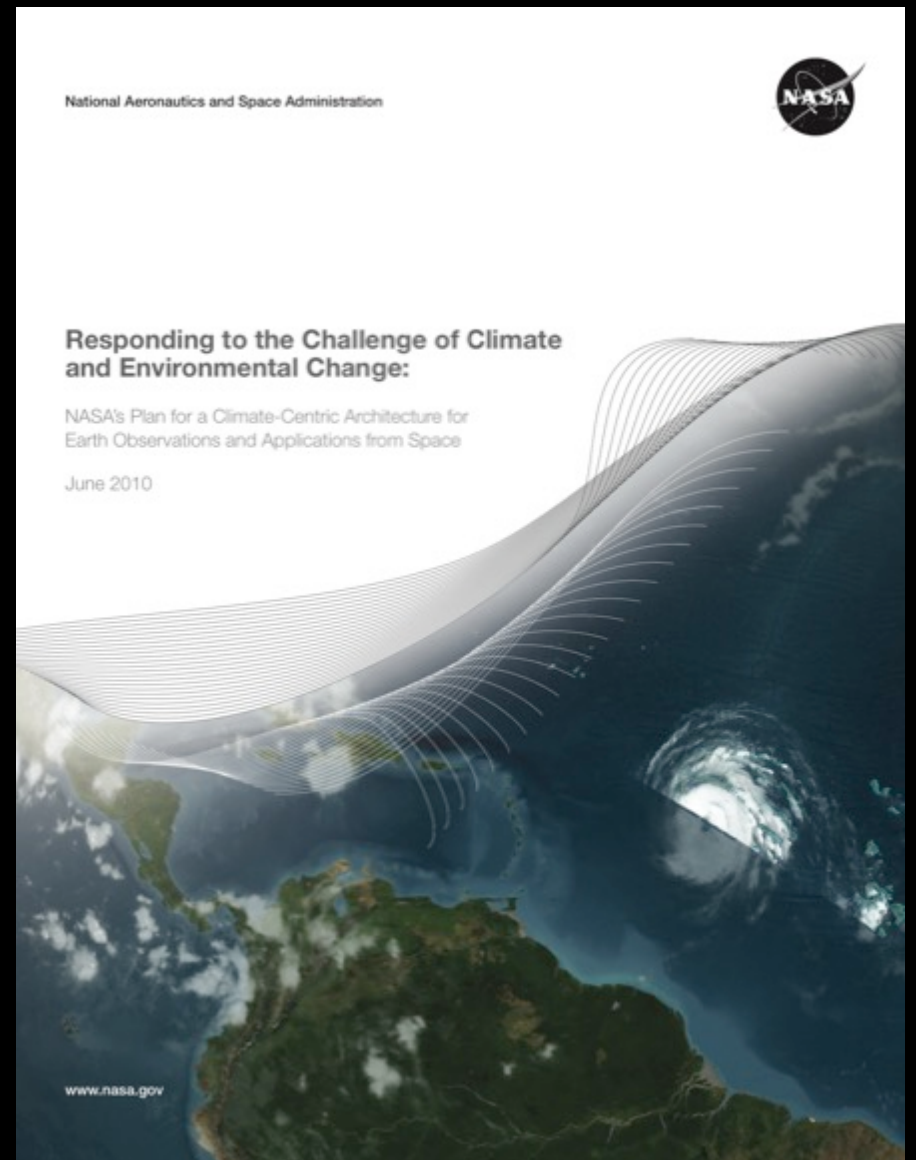
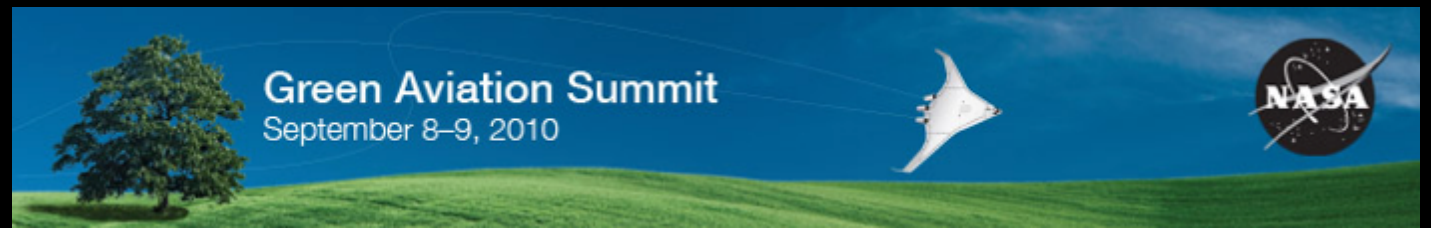
As of January 7, 2013



Science

Earth

Human
Expansion



An aerial photograph of a river delta, showing a complex network of channels and distributaries. The water is a deep blue-grey, contrasting with the light brown, silty banks. The land is characterized by a series of parallel ridges and valleys, creating a textured, almost sculptural appearance. The lighting is warm, suggesting a low sun, which casts long shadows and highlights the intricate details of the river's branching pattern.

Science

Earth

Human
Expansion

How do we think about the long future?

Before the
“aerospace era”

1800s - 1950

The
aerospace era

1950-2000

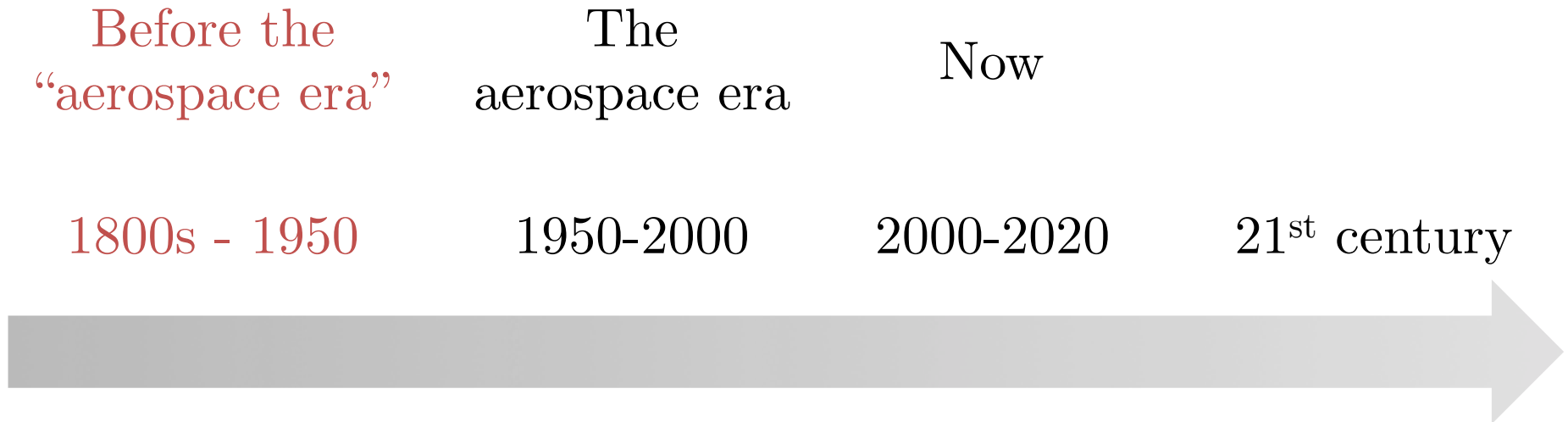
Now

2000-2020

21st century



How do we think about the long future?



“By 1958, private investments in over 40 U.S. observatories totaled about \$8 billion in 2012 dollars, and nationwide rocket clubs and test sites laid the first foundations of the American space community.”¹

¹ Source: MacDonald, Alexander, "The Long Space Age: An Economic Perspective on the History of American Space Exploration," (PhD dissertation, University of Oxford, 2012).

Lick Observatory
Private Endowment
1876



How do we think about the long future?

Before the
“aerospace era”

The
aerospace era

Now

1800s - 1950

1950-2000

2000-2020

21st century



Lick (1796-1876): \$1.2B (current USD) to Lick Observatory

Guggenheim (1856-1930) and family: \$36M (current USD) for Robert Goddard

Carnegie (1835-1919): \$630M (current USD) to Mount Wilson Solar Observatory

¹ Sources: MacDonald, Alexander, "The Long Space Age: An Economic Perspective on the History of American Space Exploration," (PhD dissertation, University of Oxford, 2012). NASA, "Emerging Space: the Evolving Landscape of 21st Century American Spaceflight, 2014.

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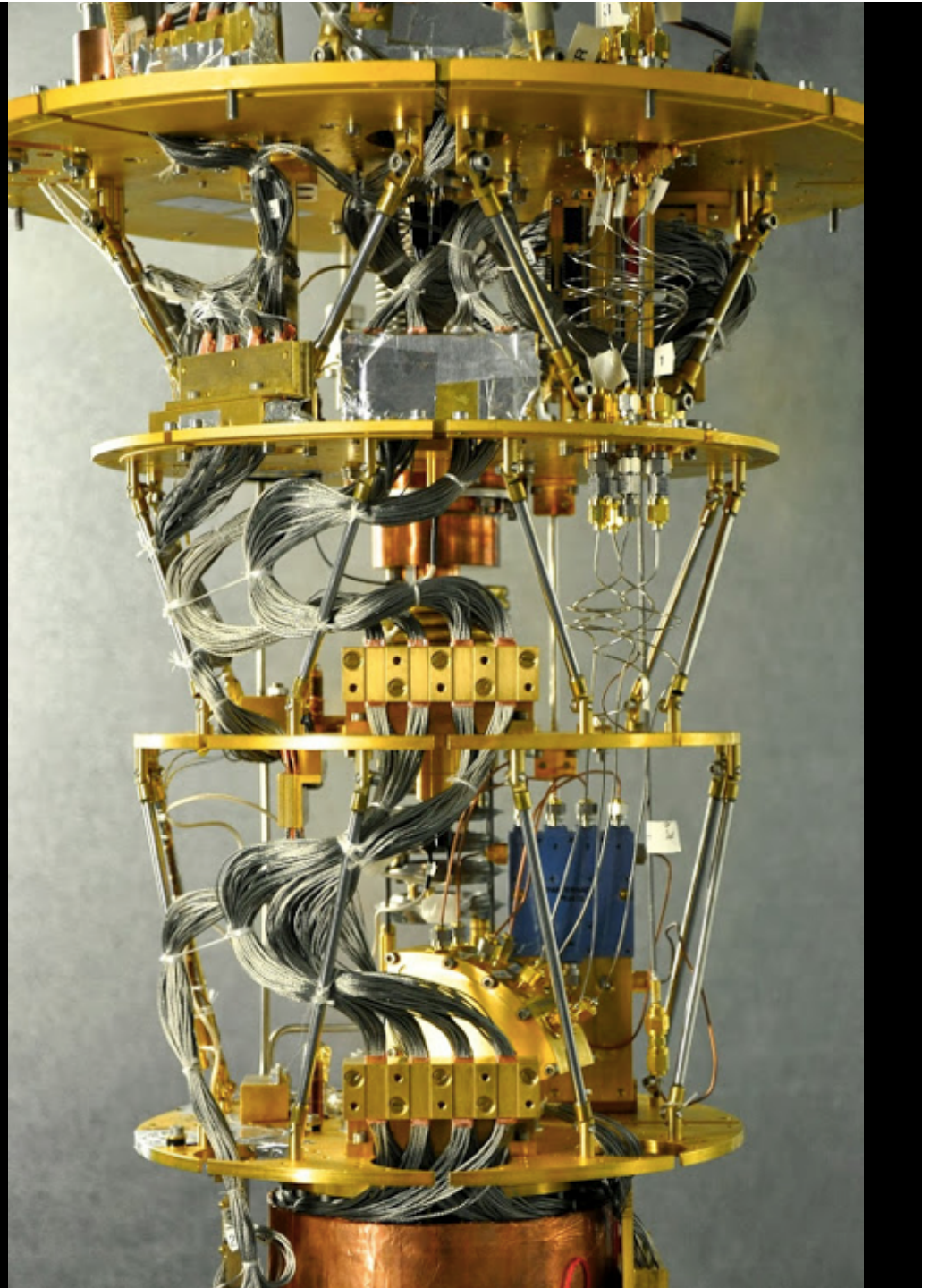


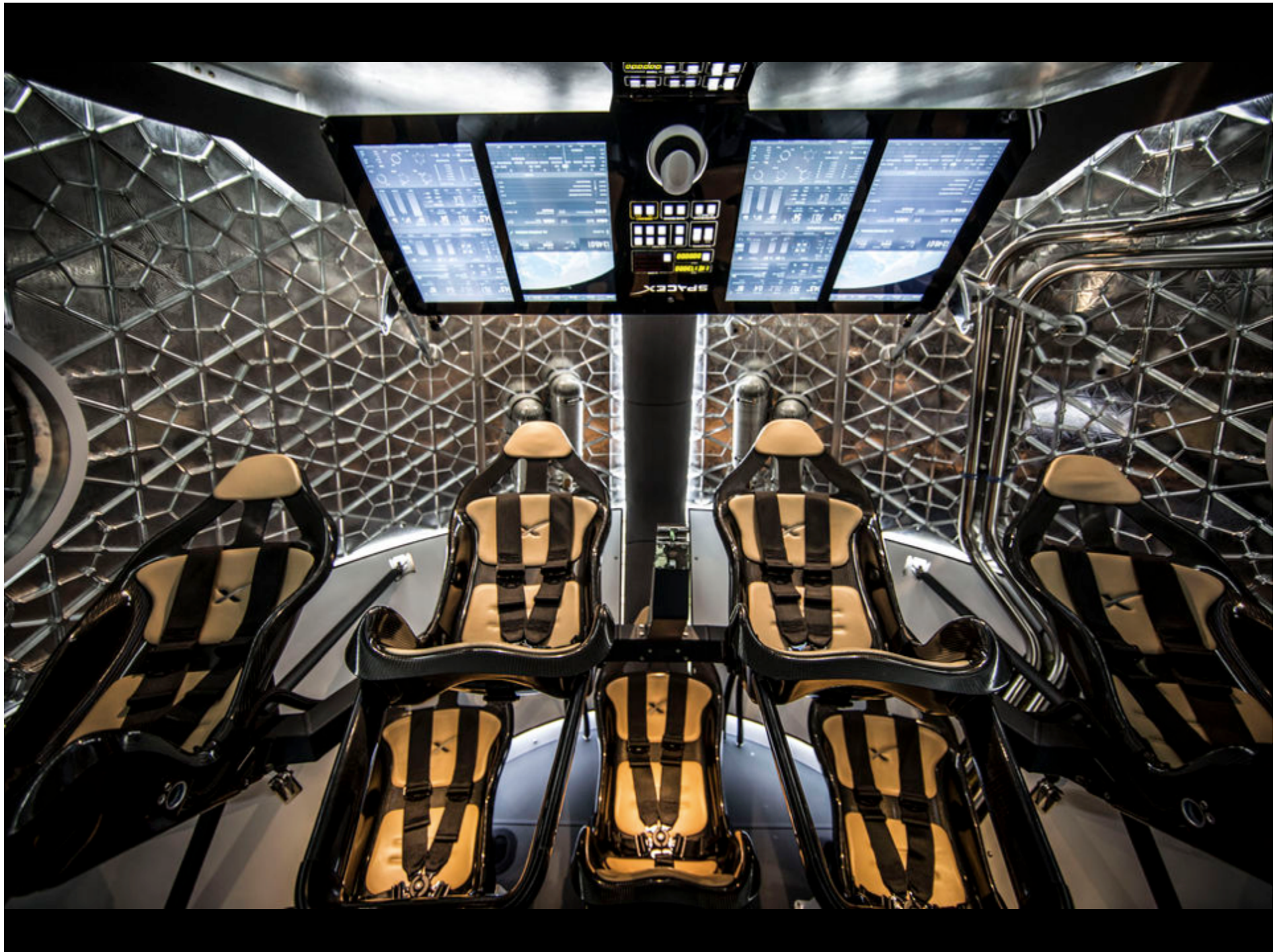
Creation of a Bacterial Cell Controlled by a Chemically Synthesized Genome

Daniel G. Gibson,¹ John I. Glass,¹ Carole Lartigue,¹ Vladimir N. Noskov,¹ Ray-Yuan Chuang,¹ Mikkel A. Algire,¹ Gwynedd A. Benders,² Michael G. Montague,¹ Li Ma,¹ Monzia M. Moodie,¹ Chuck Merryman,¹ Sanjay Vashee,¹ Radha Krishnakumar,¹ Nacyra Assad-Garcia,¹ Cynthia Andrews-Pfannkoch,¹ Evgeniya A. Denisova,¹ Lei Young,¹ Zhi-Qing Qi,¹ Thomas H. Segall-Shapiro,¹ Christopher H. Calvey,¹ Prashanth P. Parmar,¹ Clyde A. Hutchison III,² Hamilton O. Smith,² J. Craig Venter^{1,2*}



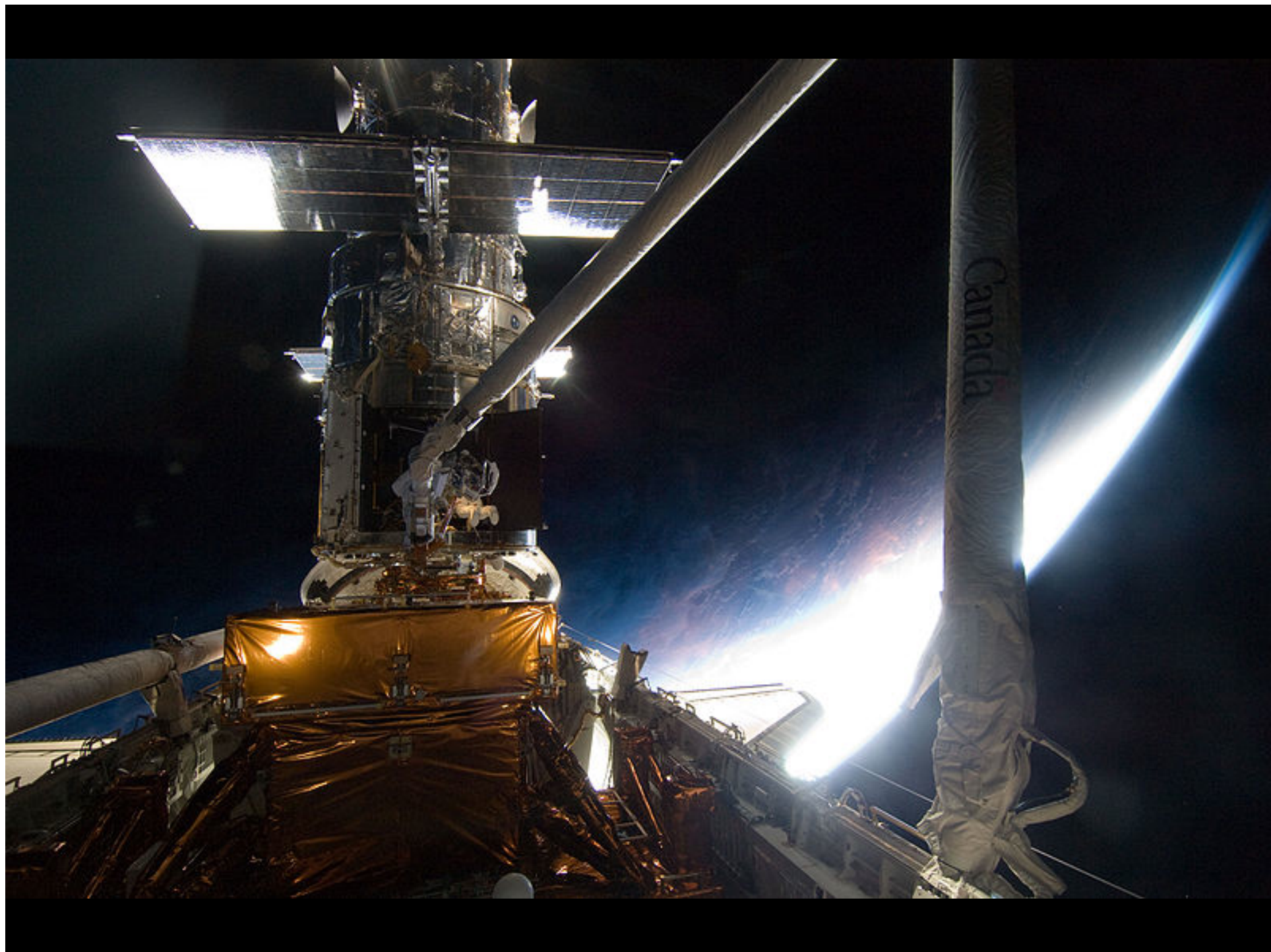
Quantum Artificial Intelligence Laboratory



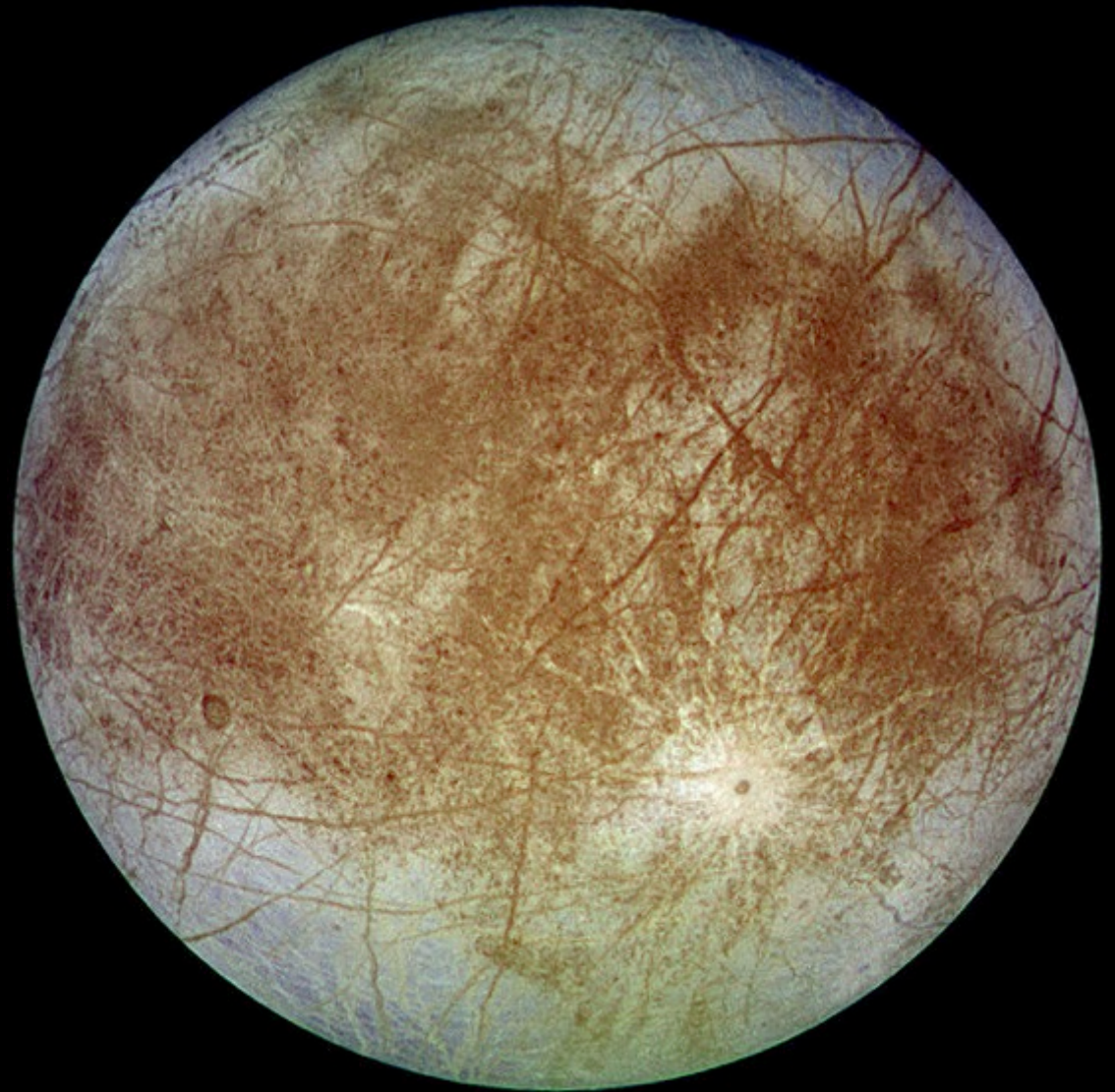
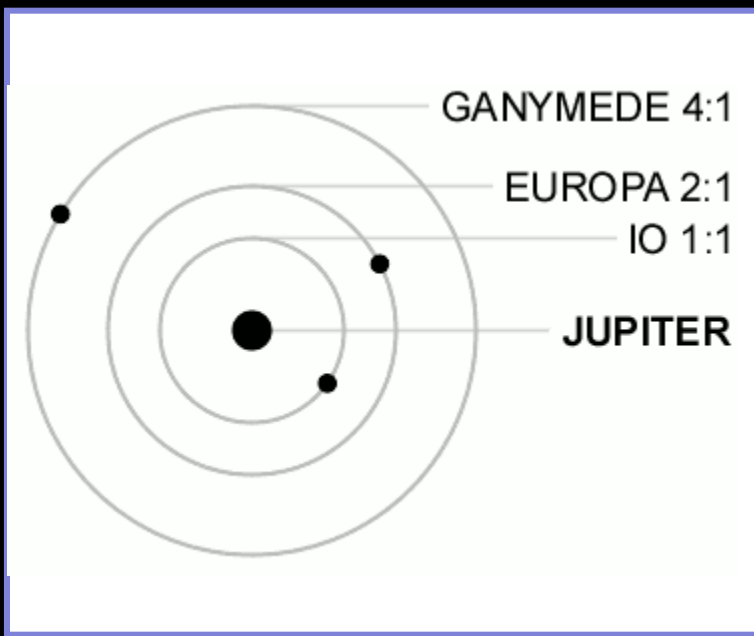




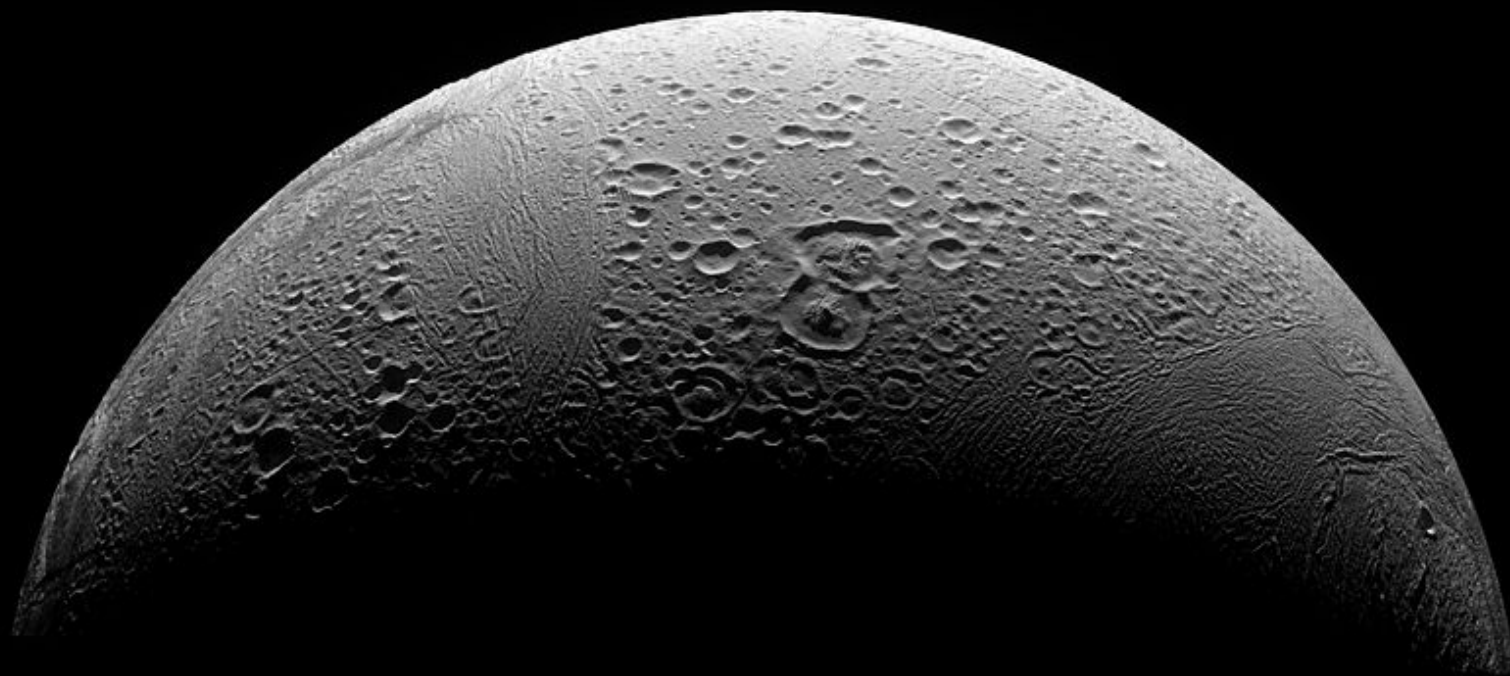




Europa



Enceladus



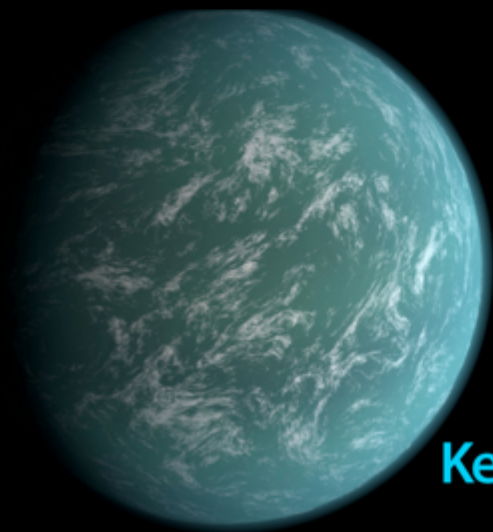
Water Jets From Enceladus as Observed by Cassini Probe



Kepler-22 System

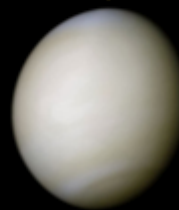
Solar System

Habitable Zone



Kepler-22b

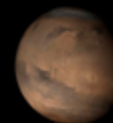
Mercury



Venus



Earth



Mars

Planets and orbits to scale

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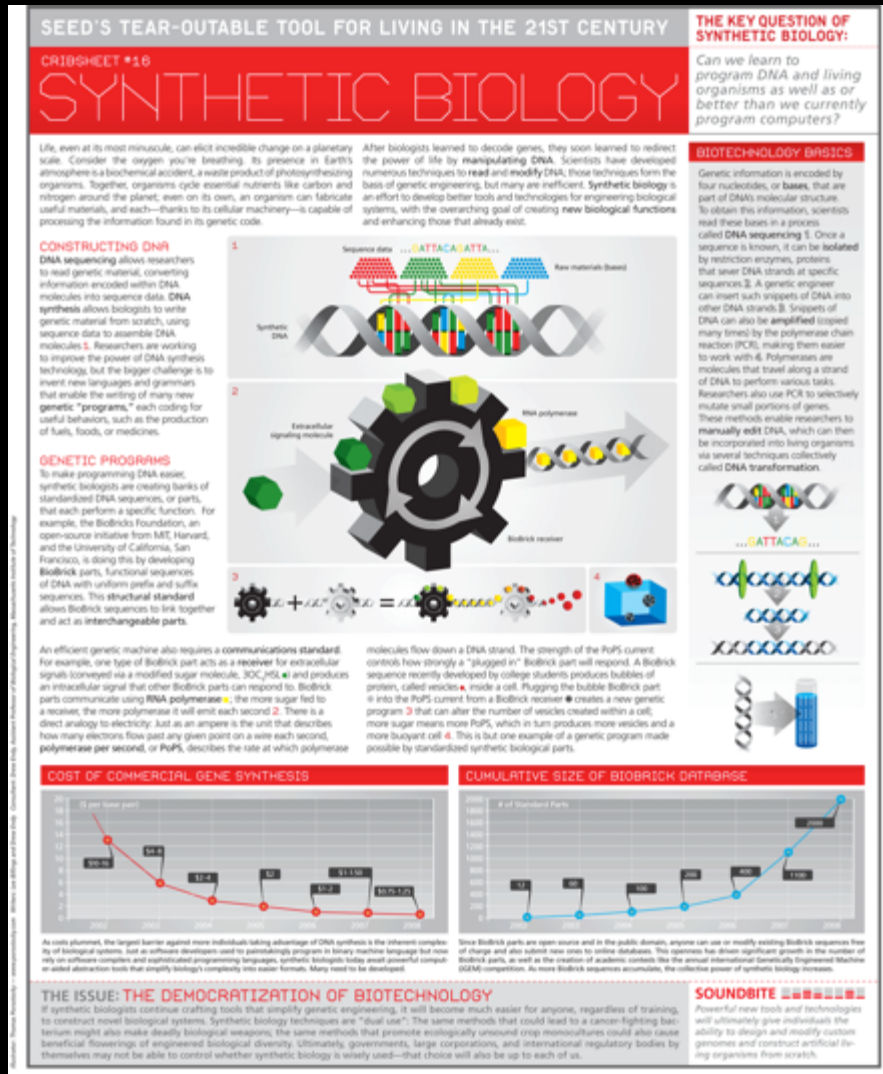
Now

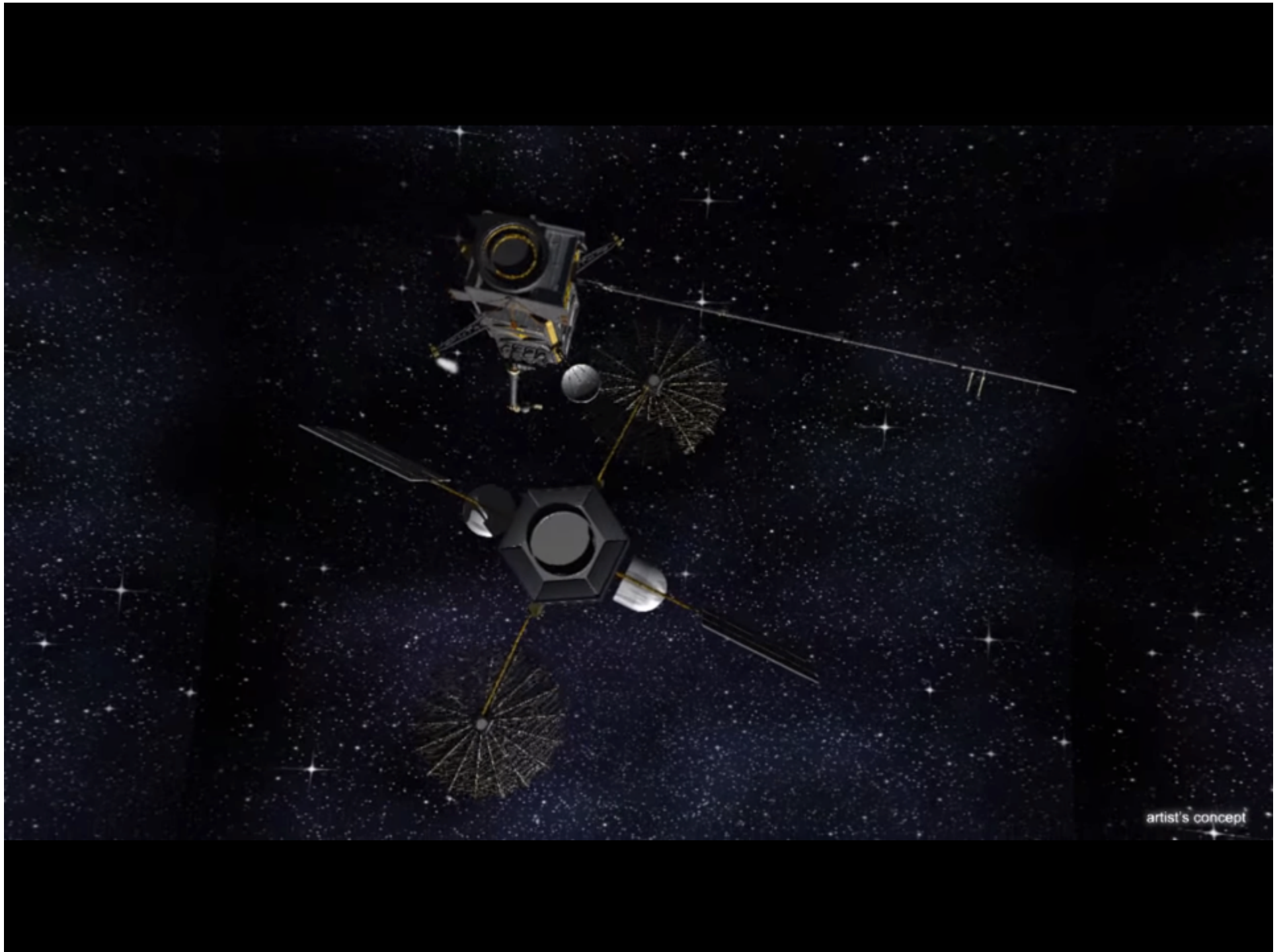
2000-2020

21st century



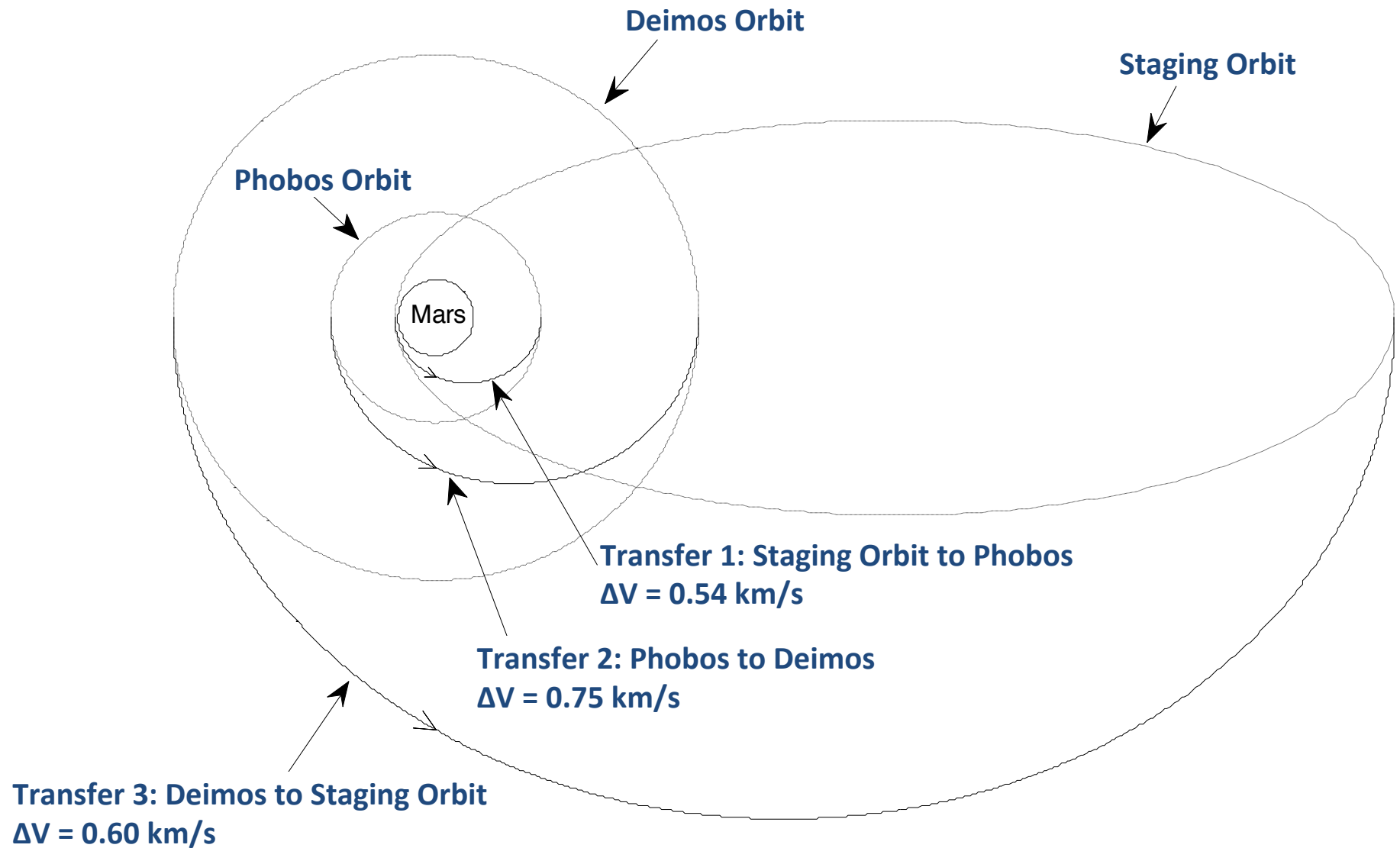
“Over the next 20 years, synthetic genomics is going to become the standard for making anything”
 - J. Craig Venter, 2007, Gibson et. al, Science 2010





artist's concept

Mars System: Phobos & Deimos Rendezvous





BLUE SUNSET - (MARS)

W A N D E R E R S
A SHORT FILM BY ERIK WERNQUIST

www.erikwernquist.com/wanderers

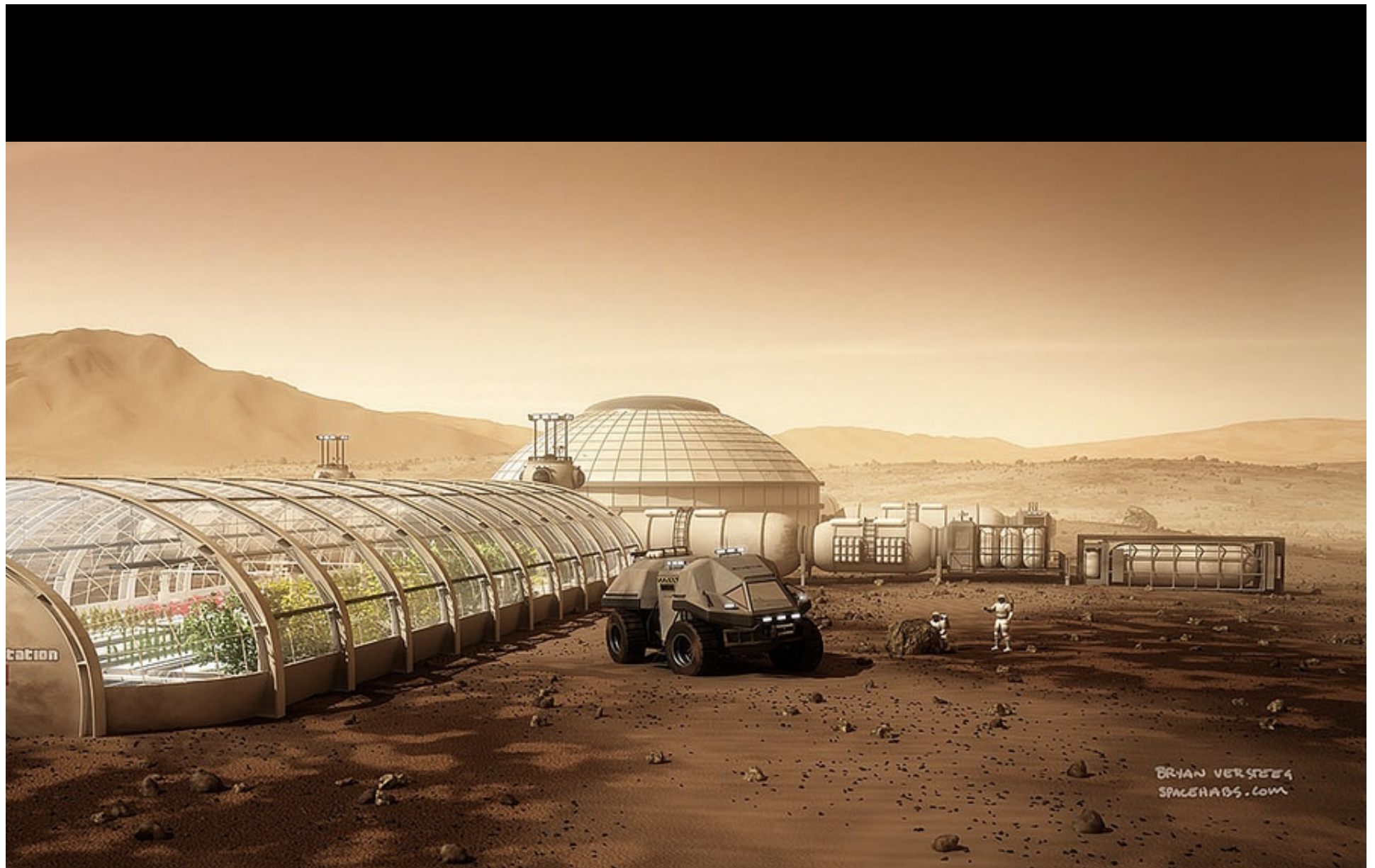
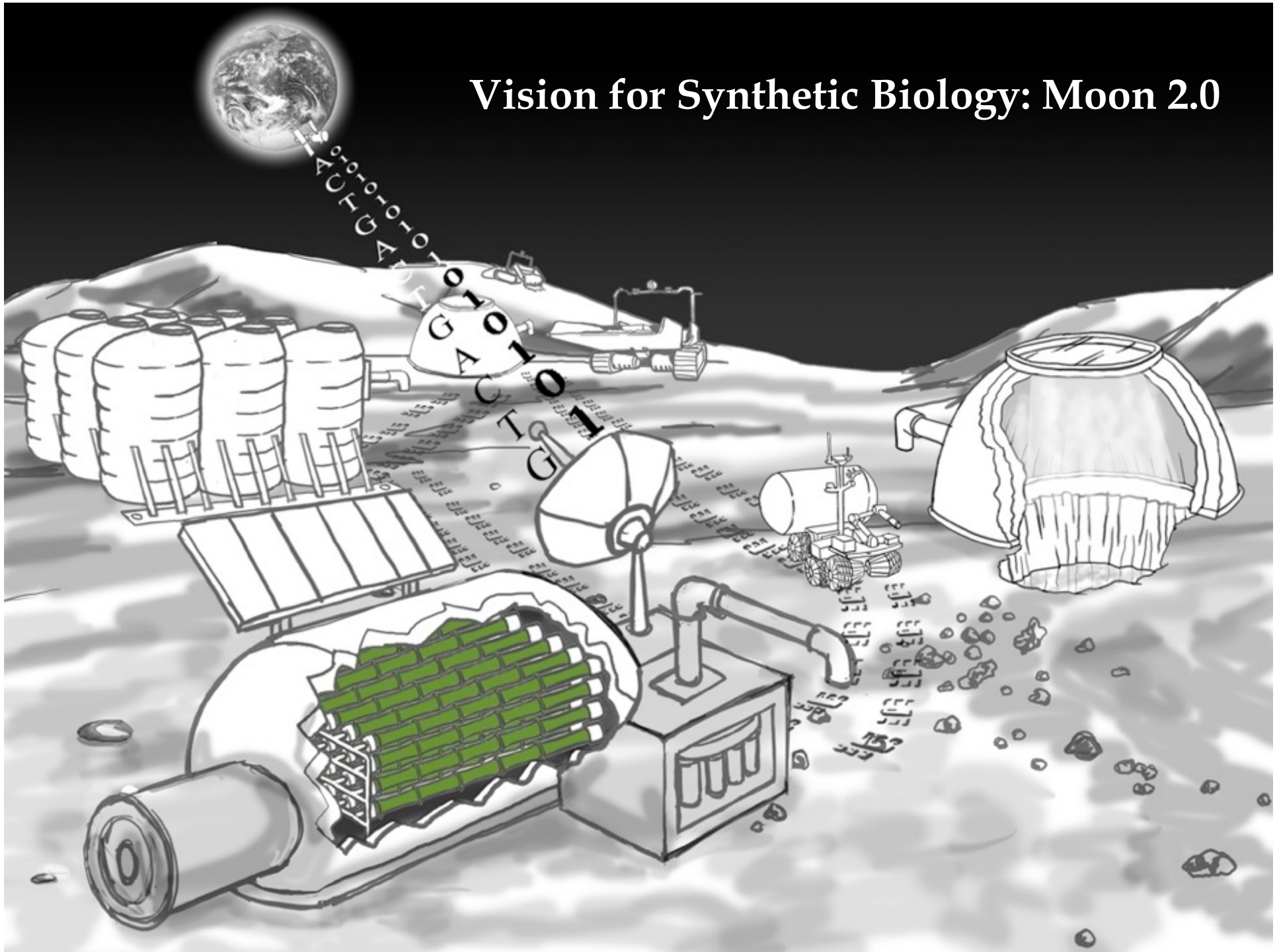


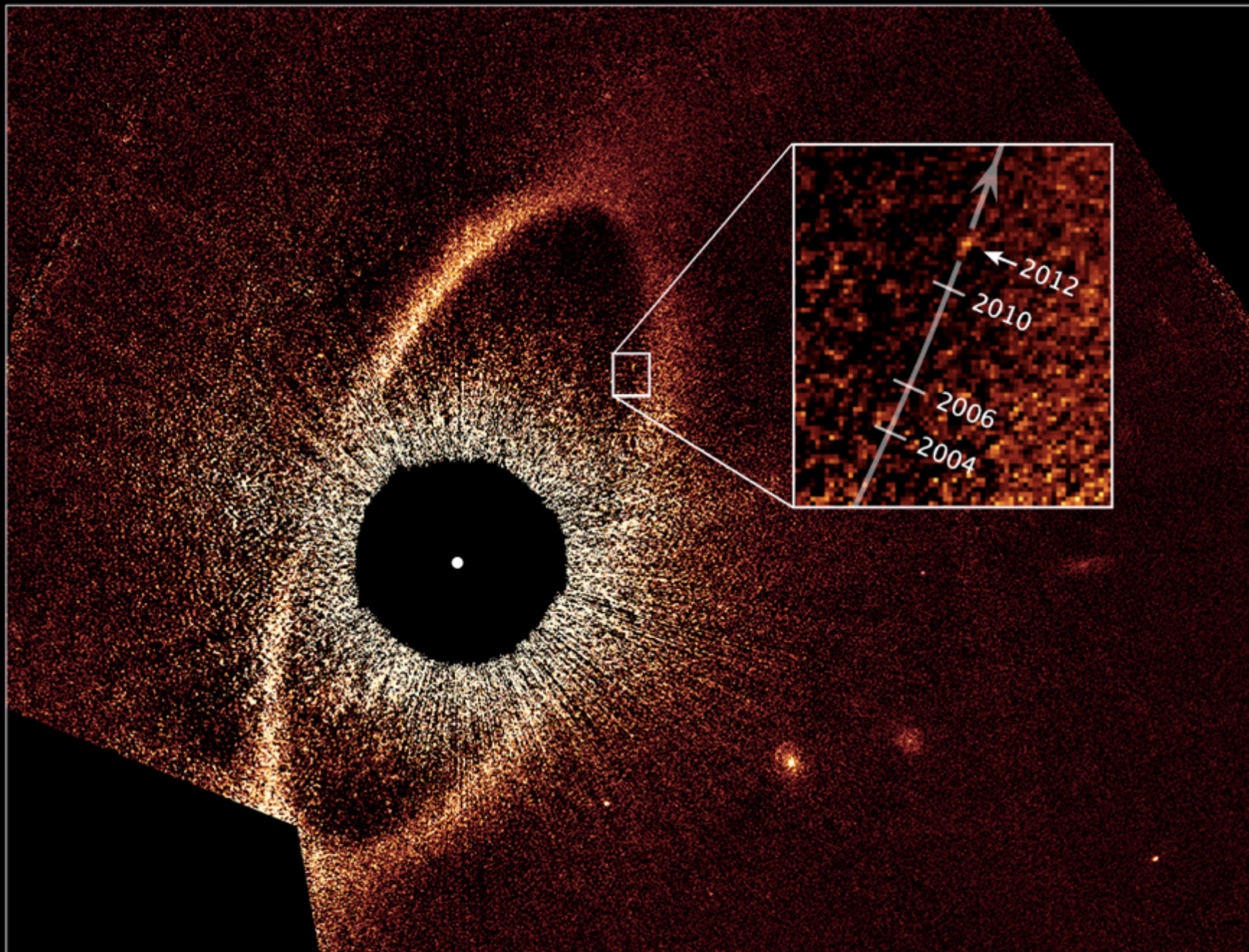
Image: Bryan Versteeg/Spacehabs.com

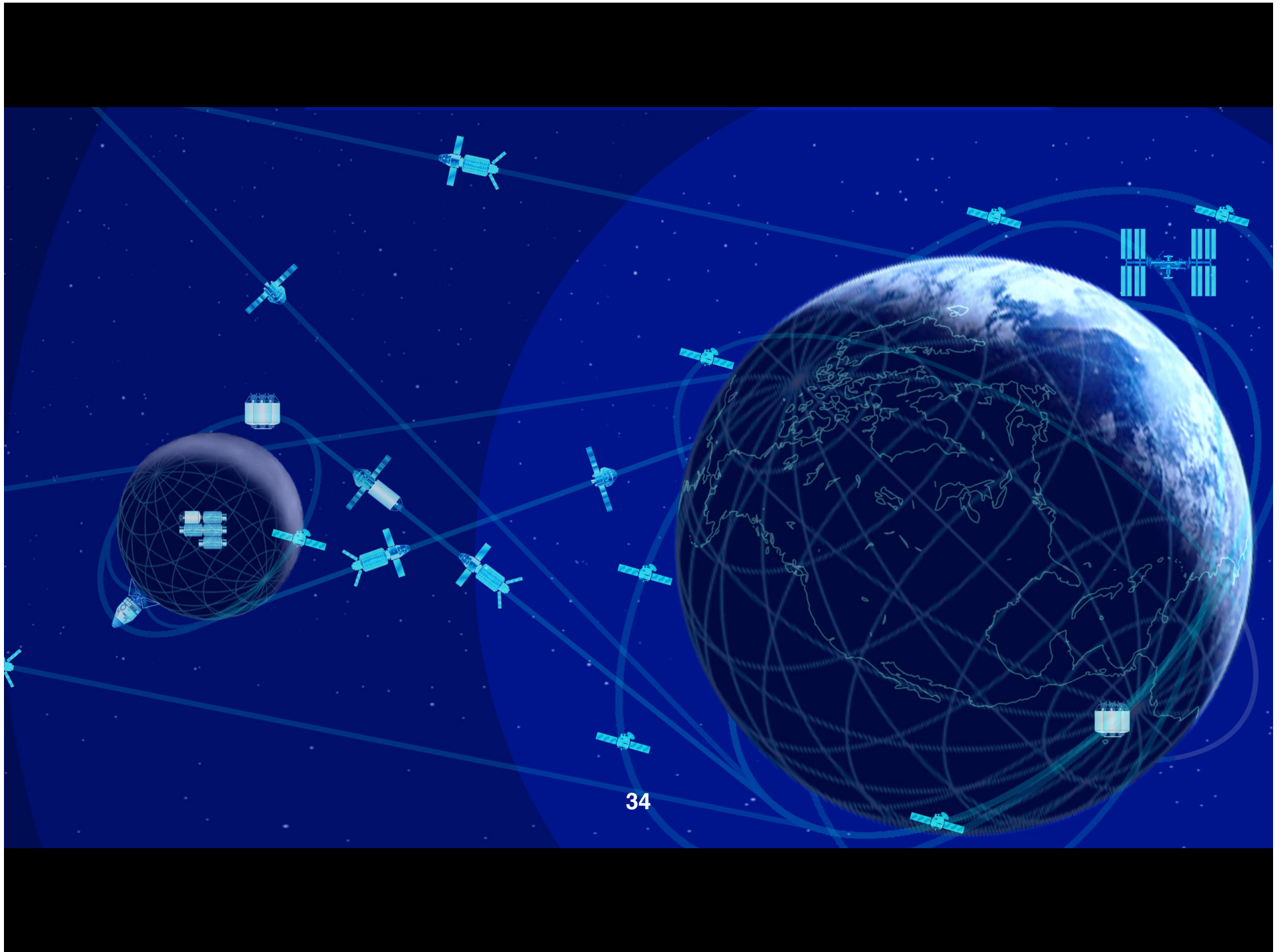


Image: ESA / Foster + Partners

Vision for Synthetic Biology: Moon 2.0







THE ECONOMICS OF NEOS

NASA RESEARCH PARK
MOFFETT FIELD, CA
SEPT 6 & 7, 2014

Workshop Summary

