



NewSpace: The Emerging Commercial Space Industry

Learning Outcomes

At the end of this lecture you should be able to:

- 1) Describe space regimes where commercial space is starting to take hold
- 2) Describe in what areas entrepreneurial companies are developing new markets
- 3) Name a few companies that are examples of the commercial space revolution
- 4) Discuss how governments can facilitate the birth of this new industry

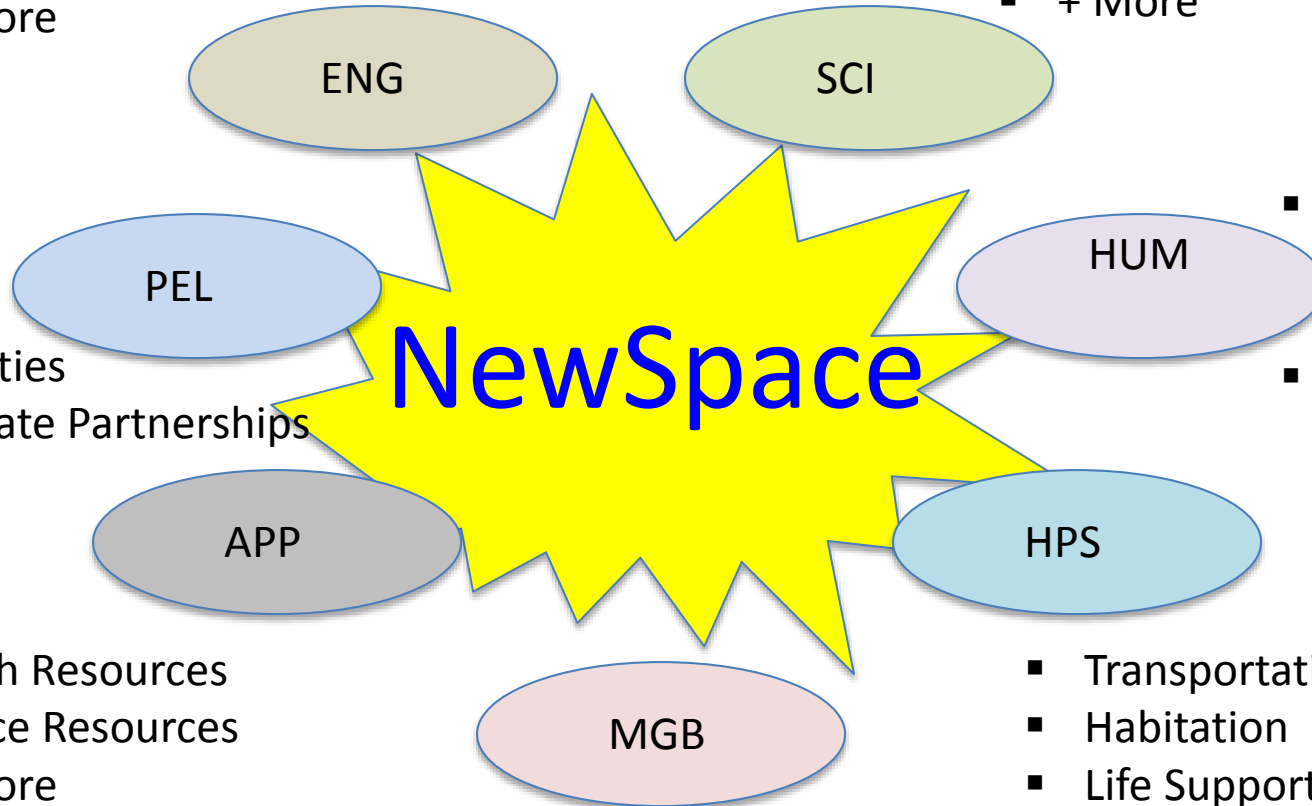
Why is this lecture important?

- We are at a turning point in the history of space exploration and development – the cusp of a revolution, new industries are being born that use space in many non-traditional ways
- The established military industrial space sector is no longer the only game in town
- Increased competition and new capabilities will change the marketplace forever
- Everyone interested in working in the space sector will be effected

3 – I Links

- Small Sats
- Disruptive Technology
- + More

- Explore the Moon and Mars
- Asteroids
- + More



- Historic Time Making Space Assessable
- + More

- Space Treaties
- Public-Private Partnerships
- + More

- Earth Resources
- Space Resources
- + More

- Transportation
- Habitation
- Life Support Systems
- + More

- Organizational
- Business Strategy
- + More

Outline

- **Regimes for NewSpace Opportunities**
 - Suborbital
 - Orbital
 - Deep Space
- **Example NewSpace Companies**
- **Government's Role in Promoting NewSpace**
- **Organizations Promoting NewSpace**



What is NewSpace?

- **HobbySpace.com**

“Alt.space, NewSpace, entrepreneurial space, and other labels have been used to describe approaches to space development that differ significantly from that taken by NASA and the mainstream aerospace industry.”

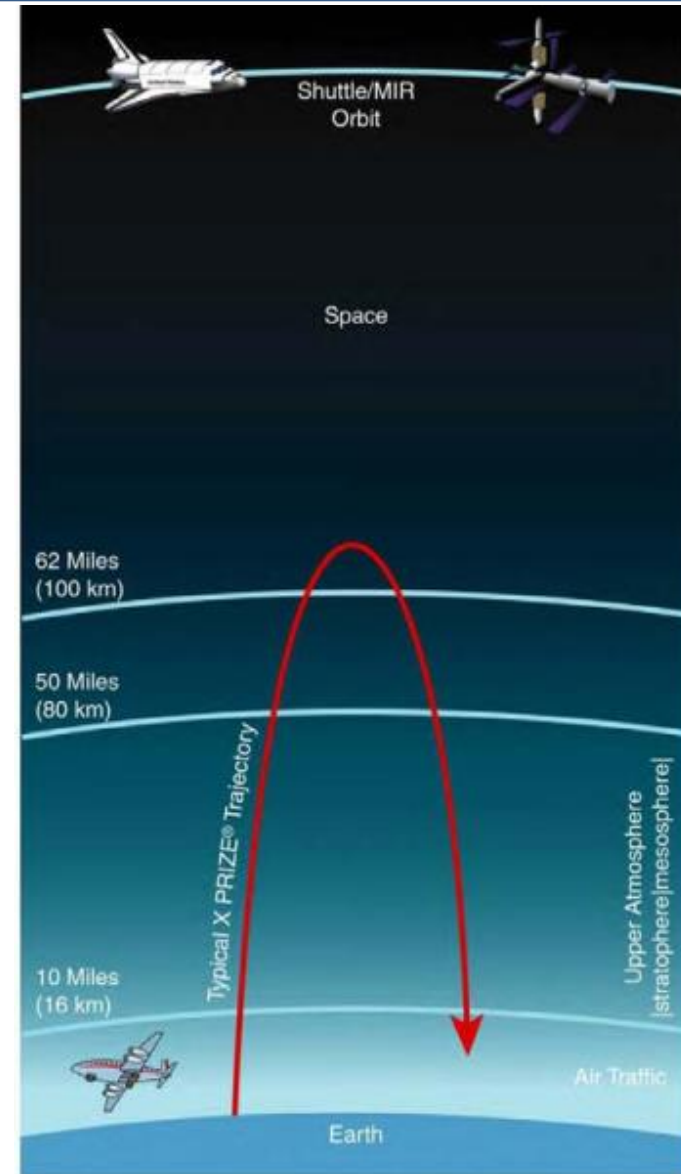
- **From Wikipedia:**

“NewSpace, alt.space, and entrepreneurial space are umbrella terms for a movement and philosophy often affiliated with, but not synonymous with, an emergent private spaceflight industry. Specifically, the terms are used to refer to a community of relatively new aerospace companies working to develop low-cost access to space or spaceflight technologies and advocates of low-cost spaceflight technology and policy.”

Regimes for NewSpace Opportunities

Suborbital

- **Description:**
 - Spacecraft reaches space 100 km (62 miles) or higher but does not have the forward velocity to go into orbit (e.g. 7.7km/s at 300 km)
- **Tourist Industry**
 - Companies are selling tickets for the suborbital experience, trips for \$250K Virgin Galactic to \$95K/\$100K XCOR per seat
- **Research**
 - Microgravity (around 4 minutes)
 - Upper atmospheric measurements
 - Technology demonstrations
 - Life Science experiments
- **Point-to-Point Travel**
 - Travel from one location on Earth to another through space
 - Challenging technical problems
 - Long-term goal not a current focus



Regimes for NewSpace Opportunities

Orbital

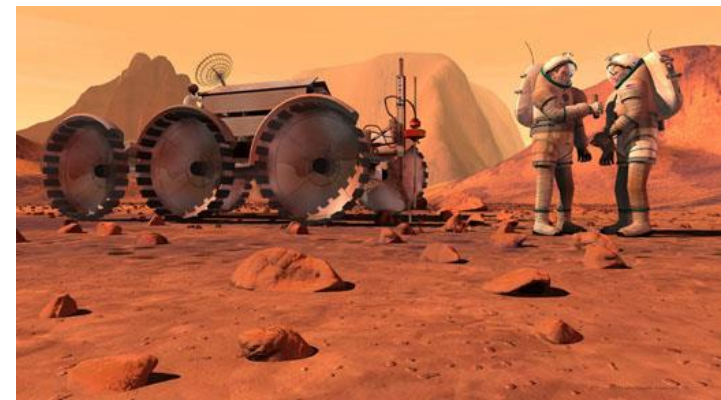
- **Description:**
 - Low Earth Orbit (LEO) between 180 – 3000 km
 - High Earth Orbit (HEO) – Geocentric 35,786 km
- **Tourist Industry**
 - Spend long periods of time in microgravity at ISS or on private space stations
 - Space Adventures: 7 private citizens to ISS (8 missions – \$20M – \$40M per trip)
- **Research/Applications**
 - Conduct experiments continuously in the orbital environment (microgravity and life sciences)
 - Launch small sats from ISS
- **Satellite Servicing**
 - Service satellites, put them in proper orbits, refuel, fix and upgrade systems



Regimes for NewSpace Opportunities

Deep Space

- **Description:**
 - Lagrange points, Moon, Asteroids, Mars and beyond
- **Tourist/ Explorers**
 - Ultimate in exotic experiences
 - The Inspiration Mars Foundation
 - \$750M per seat to the Moon; Golden Spike
- **Research**
 - Enabling Humans to be productive and happy in space; in-space economy
 - Developing new materials and processes to create new markets and improve life
- **Mining and In Situ Resource Utilization**
 - Examples: Propellants, metal & materials processing, and building materials
- **Servicing a space-based economy**
 - Examples: 3D printing in space, space manufacturing
- **Settlement**
 - Moving human civilization to Moon and Mars



Example NewSpace Companies

	Masten Space Systems	Copenhagen Suborbital	Zero2Infinity	Xcore	Virgin Galactic	Blue Origin	Swiss Space Systems	Sierra Nevada Corporation	Nanoracks	Planet Labs	Bigelow Aerospace	Space Adventures	SpaceX	Space Adventures	Orbital Sciences	Moon Express	Golden Spike	Planetary Resources	Deep Space Industries
Sub-Orbital	Green	Green	Green	Green	Green	Green	Green	White	Green	White	White	White	Yellow	Green	White	White	White	Yellow	White
Orbital	White	White	White	White	White	White	Green	Green	Green	Green	Green	Green	Green	Green	Green	White	White	White	White
Moon	White	White	White	White	White	White	White	White	White	White	White	Green	White	Green	Green	Green	Green	White	White
Asteroids	White	White	White	White	White	White	White	White	White	White	White	White	White	White	Green	White	White	Green	Green
Mars	White	White	White	White	White	White	White	White	White	White	White	White	Green	White	White	White	White	White	White

Headquarters: Cerdanyola del Vallès, Spain

Founded: 2009 by Jose Mariano Lopez-Urdiales, CEO and Founder (ISU Masters)

Major Focus: Earth/Space observation, Atmospheric science, Drop testing and Technology demonstration

Implementation: Series of increasingly capable balloons fly to 36 km



Capacity: For Bloon: Four passengers and two crew

Cost: €110K (around \$149K) per seat

Major Partnerships: la Caixa, Large Spanish Bank

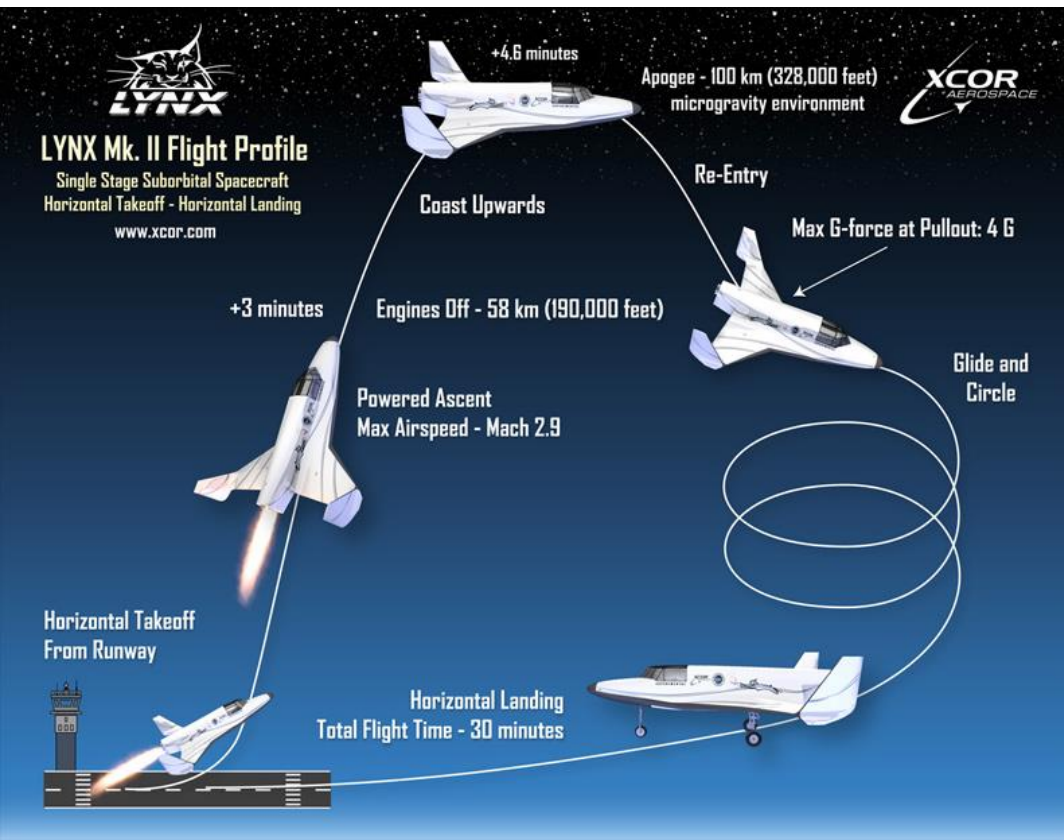
Suborbital - Companies

XCOR Aerospace

Headquarters: Mojave, California USA, with R&D Headquarters in Midland, Texas USA and operational base at Cape Canaveral, Florida.

Founded: 1999; Jeff Greason (President and Co-Founder)

Major Focus: Space tourism and research



Capacity: One passenger and one pilot per flight of the Lynx

Cost: \$95K (Mark I)/\$100K (Mark II) per Seat

Major Partnerships: January 2013 Unilever and Space Expedition Corporation (SXC) bought 22 flights for Global AXE Campaign. Citizens in Space has purchased 10 flights.



Suborbital - Companies

Virgin Galactic

Headquarters: Las Cruces, New Mexico USA

Founded: 2004 by Richard Branson (Virgin Group); George Whitesides (CEO)

Major Focus: Space tourism and research

Implementation: White Knight Two will air launch rocket powered SpaceShipTwo, reusable horizontal take off and landing.



Capacity: Up to 6 passengers and two pilots or up to 600kg of payloads

Cost: \$250K per seat

Major Partnerships: Spaceport America in New Mexico;

Next Steps: First commercial operations planned for 2014



Photo by Marshall Space and Day Center Observatory



Suborbital and Orbital Companies

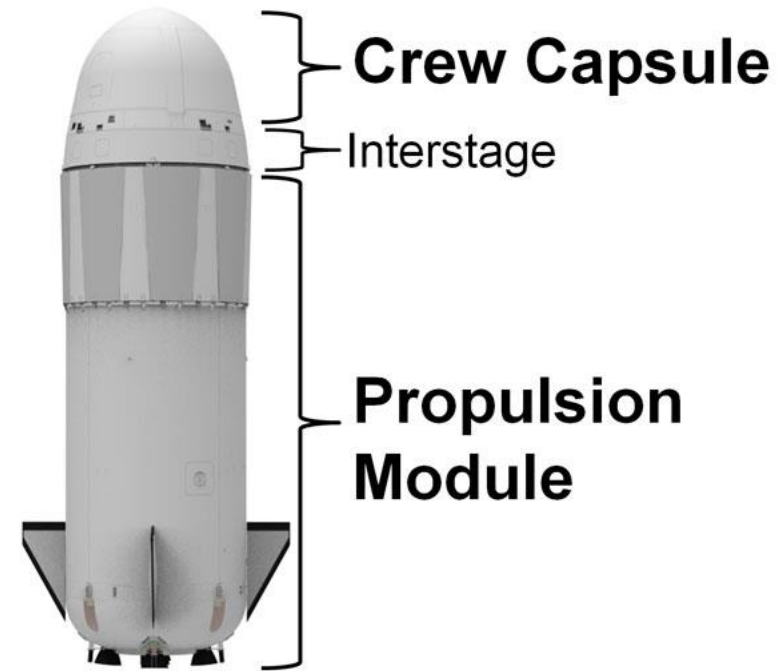
Blue Origin, LLC

Headquarters: Kent, Washington USA (launch site: Van Horn, Texas USA)

Founded: 2000 by Jeff Bezos (founder and CEO of Amazon.com)

Major Focus: Tourism and research

Implementation: New Shepard system, rocket powered vertical take off and vertical landing, reusable first stage and reusable capsule – suborbital and orbital



Capacity: Suborbital : New Shepard – 3 or more passengers

Cost: Unknown

Major Partnerships: NASA CCDev 1&2 (\$25.7M); ULA for Atlas V



Suborbital and Orbital Companies

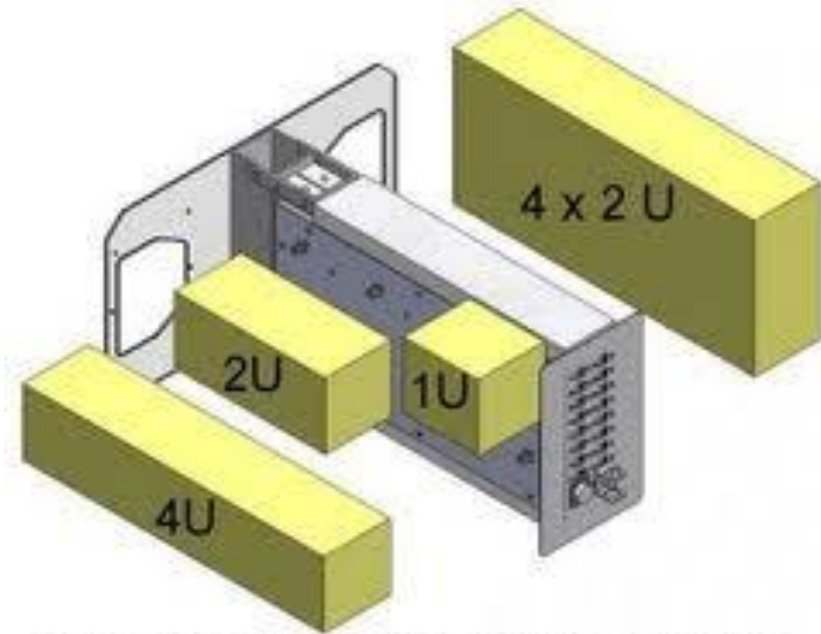
Nanoracks

Headquarters: Houston, Texas USA

Founded: 2009 CEO Jeff Manber (MirCorp)

Major Focus: On-orbit research and small sat launch

Implementation: Nanoracks research platforms on ISS follow cubesat form factor; cubesat launcher



Various sizes of CubeLab modules and a NanoRack platform



Capacity: Each platform has 32 payload slots.

Cost: Educational clients: payload (1U) can be as low as \$30K, 2U is \$60K. Commercial payloads start at \$60K per 1U, and non-US payloads are charged at a higher rate.

Major Partnerships: XCOR for Suborbital, Astrium for ISS External Platform Program, and Entropy Engineering (2010 NASA SBIR)



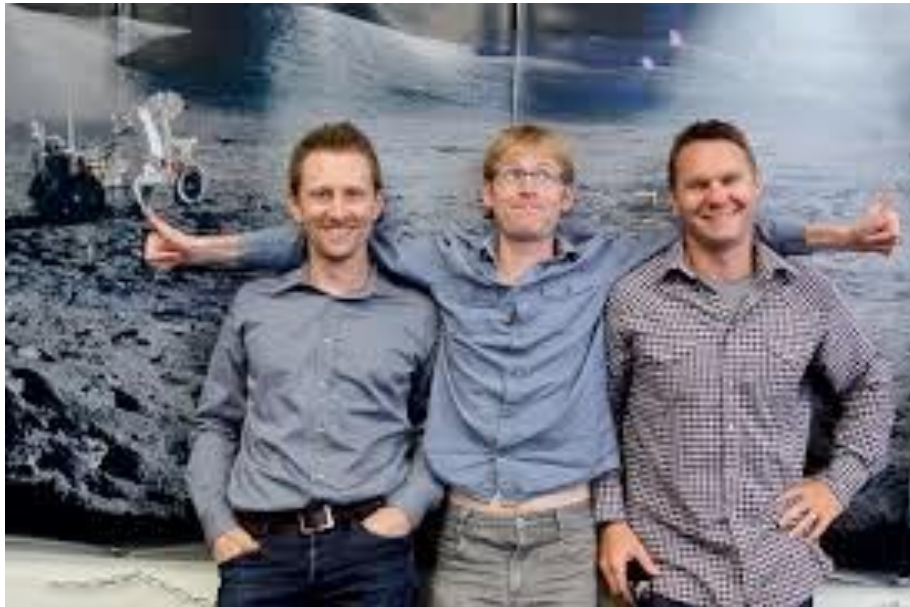
Orbital Planet Labs

Headquarters: San Francisco, CA USA

Founded: Will Marshall, Robbie Schingler, Chris Boshuizen

Major Focus: Applications; Earth Sensing

Implementation: Fleet of Small Sats called Doves; uses modern manufacturing methods, Flock 1 (28 satellites) launched Feb 2014



Capacity: +100 small sat; resolution 10 square feet. *The company **has clients** in a number of different industries, including mapping and agriculture, but sees plenty of room to expand.*

Major Partnerships: Raised \$160M in first 5 years, Draper Fisher Jurvetson (DFJ)



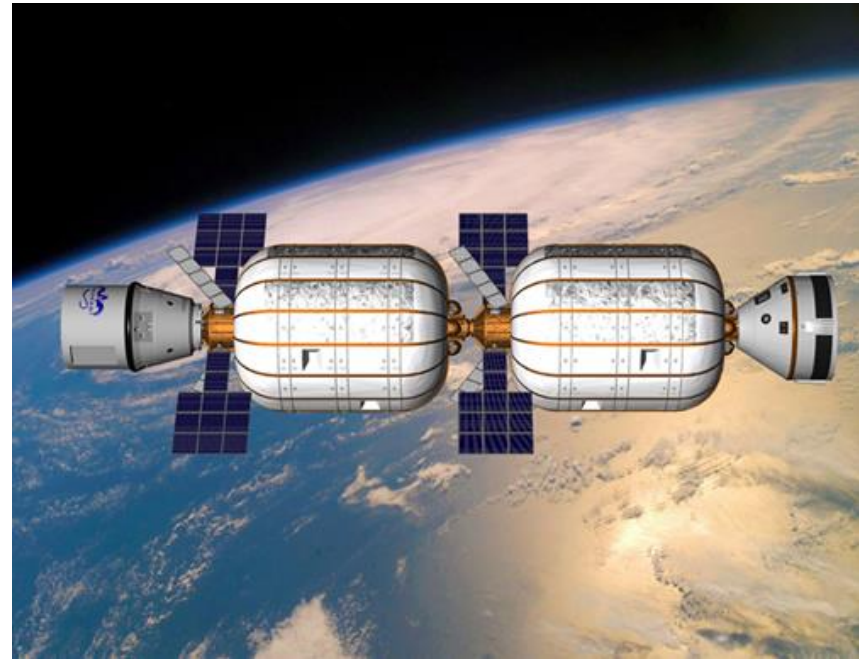
Orbital Bigelow Aerospace

Headquarters: North Las Vegas, Nevada USA

Founded: 1999 by Robert Bigelow, Founder and President (Budget Suites of America)

Major Focus: Commercial space stations, multiple uses, potential customers include nations without human spaceflight programs

Implementation: Expandable space habitat technology based on NASA Transhab design.



Cost: \$25M for 110 cubic meters for 2 months; trip cost \$26.25M (Dragon) or \$36.75M (CST-100)

Major Partnerships: SpaceX and Boeing/ULA

Orbital and Deep Space Companies

Space Exploration Technologies (SpaceX)

Headquarters: Hawthorne, California

Founded: 2002 by Elon Musk CEO and CTO (co-founder of PayPal); Gwynne Shotwell (President)

Major Focus: Cargo and passengers to LEO (ISS), Geostationary Transfer Orbit, and planetary missions

Implementation: Vertically organized, most development and manufacturing done in-house. Falcon launch vehicles and Dragon capsules.



Capacity: Dragon – can support up to 7 crew

Cost: For Falcon Heavy - \$84M up to 6.4t to GTO; \$128M greater than 6.4t to GTO

Major Partnerships: NASA
Commercial Crew Development (CCDev 2)





Deep Space Moon Express

Headquarters: NASA Research Park, Moffett Field, California USA

Founded: 2010, Co-Founder and CEO, Bob Richards (ISU co-founder); Andy Aldrin, President (2014)

Major Focus: Delivering payloads to the Moon, Lunar resource exploration, Google Lunar X Prize Competition

Implementation: Deliver payloads, explore for valuable resources, and lunar sample return missions



Capacity: Developing series of increasing capable lander platforms, from ~50kg to 400+kg

Cost: For 'hard' payloads costs start around \$3M/kg and are expected to come down to around \$1M/kg over time

Major Partnerships: NASA Innovative Lunar Demonstration Data (ILDD) program (\$30M), Dynetics

Planetary Resources

Headquarters – Seattle, Washington USA

Founded: in 2010 as Arkyd Astronautics, reorganized and renamed in 2012.

Co-Chairmen: Pete Diamandis (ISU co-founder) and Eric Anderson (co-founder Space Adventures)

Major Focus: Mining asteroids: Water for fuel (in-space economy) and rare metals for Earth uses



Implementation: Series of small spacecraft with increasing capability. Initial space resource development will focus on water-rich asteroids

Capacity: N/A

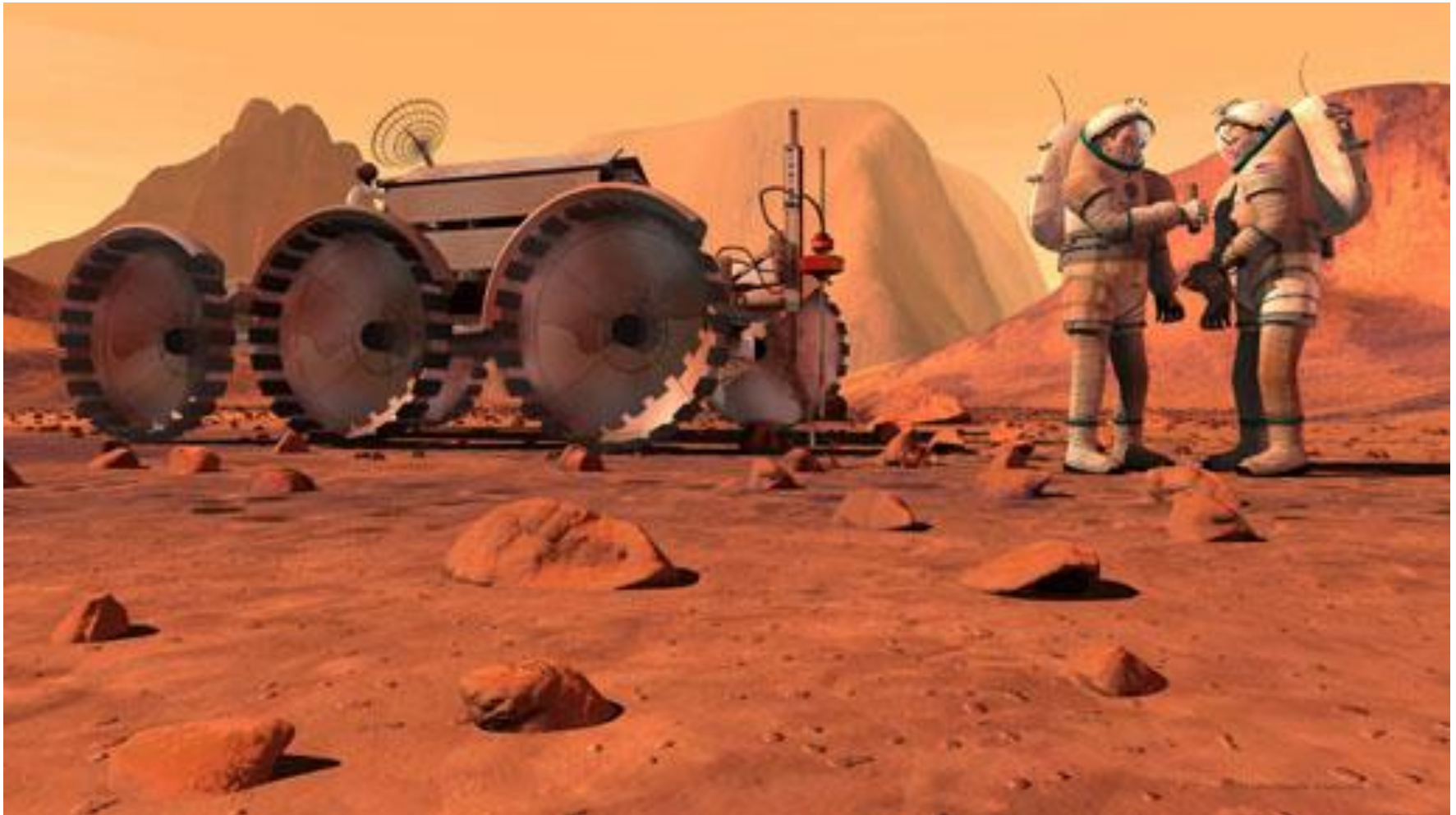
Cost: Unknown

Major Partnerships: NASA Funds

Investors include; Larry Page and Eric Schmidt (Google) and Ross Perot, Jr

Government's Role in Commercial Space

- **What should the role of government be in opening the space frontier?**



National Advisory Committee for Aeronautics (NACA)

- **Before NASA there was NACA:**

- Established in 1915 by Congress
- Developed key technologies to enabled air travel to become effective, economical and safe
- Studied the problems of flight to identify and resolve risks that kept air travel from being safe and commercially viable
- Government worked closely with industry to fund studies that retired technological risks and enabled private enterprise to successfully create a new industry



Government's Role in Commercial Space

Changes at NASA

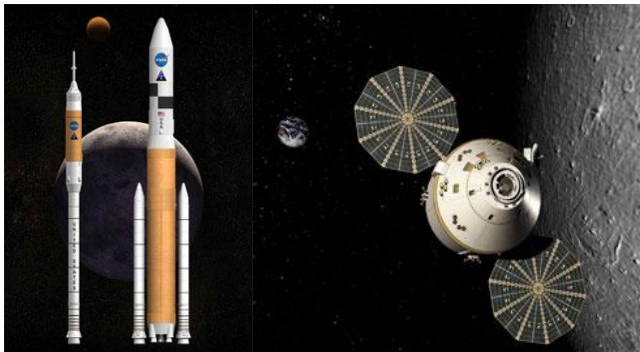
Program Characteristic	Early Space Age Approach	Commercial-Oriented Approach
Owner	NASA	Industry
Contract Fee-Type	Cost Plus	Fixed Price
Contract Management	Prime Contractor	Public-Private Partnership
Customer(s)	NASA	Government and Non-Government
Funding for Capability Demonstration	NASA procures capability	NASA provides investment via milestone payments
NASA's Role in Capability Development	NASA defines "what" and "how"	NASA only defines "what" (Industry defines "how")
Requirements Definition	NASA defines detailed requirements	NASA defines top-level capabilities needed
Cost Structure	NASA incurs total cost	NASA and Industry cost share

Government's Role in Commercial Space

Commercial Crew Approach

Traditional NASA Development

Goal: ISS Crew Mission
Extensive Government Involvement
No Cost Sharing
Government Owns IP
Detailed Design Requirements
Unlimited Data and Lots of Deliverables
Higher Costs



Non-Traditional Development

Goal: Commercial Human Transport
Limited Government Involvement
Cost Sharing
Commercial Partner Owns IP
Tailored Human-Rating Requirements
Pay-for-Performance Milestones
Lower Costs



Government's Role in Commercial Space
U.S. National Policy on Commercial Space
(June 28, 2010)

- Develop a robust and competitive U.S. commercial space sector
- Energize competitive domestic industries to participate in global markets
 - Purchase and use commercial space capabilities and services to the maximum practical extent
 - Actively explore the use of inventive, nontraditional arrangements for acquiring commercial space goods and services
 - Refrain from conducting U.S. Government space activities that preclude, discourage, or compete with U.S. commercial space activities
 - Pursue potential opportunities for transferring routine, operational space functions to the commercial space sector where beneficial and cost-effective.

Government's Role in Commercial Space

U.S. Federal Aviation Administration (FAA)

- Created Office of Commercial Space Transportation
 - Regulate the commercial space transportation industry, only to the extent necessary
 - Encourage, facilitate, and promote commercial space launches by the private sector
 - Recommend appropriate changes in Federal statutes, treaties, regulations, policies, plans, and procedures;
 - Facilitate the strengthening and expansion of the U.S. space transportation infrastructure

Why Commercial

- **Why Commercial?**
 - Commercial companies must be competitive and governments have other priorities (safety, jobs, etc.)
 - Example: comparison of SpaceX to NASA Development Costs
 - NASA initial estimates using its normal cost estimating software for Falcon 9 were 10 times more expensive than SpaceX actuals
 - Even when NASA made adjustments its estimates were still 4 times more
- **Conflicting goals**
 - US Congress focused on jobs in their districts

NASA Programs to Stimulate Commercial Space - Updated

- **Commercial Orbital Transportation Services (COTs) 2006**
 - NASA investment \$800M produced 2 new launchers 2 new ISS cargo carriers
- **Commercial Crew Development (CCDev) 2009 - 2011**
 - Stimulate development of privately operated crew vehicles
- **Commercial Crew Integrated Capability (CCiCap) 2012 – 2014**
 - Advance multiple integrated crew transportation systems
 - Develop a Commercial Transportation System capability to LEO
- **Commercial Resupply Services**
 - 12 missions for SpaceX and 8 missions for Orbital Sciences (\$3.5B)
- **Collaborations for Commercial Space Capabilities - SAAs**
 - Advance private sector development of emerging products and services commercially available to government and non-government customers
- **Flight Opportunities Program 2010 – Suborbital**
 - Commercial Reusable Suborbital Research Program (CRuSR) – supports commercial suborbital spaceflight by providing a steady, guaranteed market for research payloads.
 - Facilitated Access to Space Technology (FAST) – funding microgravity research

Alternatives to Government Funding (New)



- **Google Lunar X-Prize (GLXP) 2007 - 2016**
 - Eighteen teams currently in competition for \$30M in prizes
 - Land a robot on the Moon then travel more than 500m and transmits high definition images and video to Earth
- **NASA Innovative Lunar Demonstration Data - Indefinite delivery/indefinite quantity (IDIQ) contracts totaling up to \$30.1M**
 - Astrobotic Technology Inc., Pittsburgh, Pa.
 - The Charles Stark Draper Laboratory, Inc., Cambridge, Mass.
 - Dynetics Inc., Huntsville, Ala.
 - Earthrise Space Inc., Orlando, Fla.
 - Moon Express Inc., San Francisco
 - Team FREDNET, The Open Space Society, Inc., Huntsville, Ala.
- **Crowdfunding**
 - Kickstarter: Lunar Space Elevator (Liftport Group), CubeSat Ambipolar Thruster (CAT) (University of Michigan), Arkyd Telescope \$1.5M (Planetary Resources),...
 - Spire

Organizations Supporting New Space



- **Students for the Exploration and Development of Space (SEDS)**
 - 1980 founded by the same 3 founders as ISU, to promote space exploration and development.



- **National Space Society**
 - 1987 promotes living in and working in space. The organization is located in many countries.



- **Space Frontier Foundation**
 - 1988, dedicated to free enterprise and human settlement of the Solar System



- **Space Access Society**
 - 1992, dedicated to reducing the cost for commercial access to space.

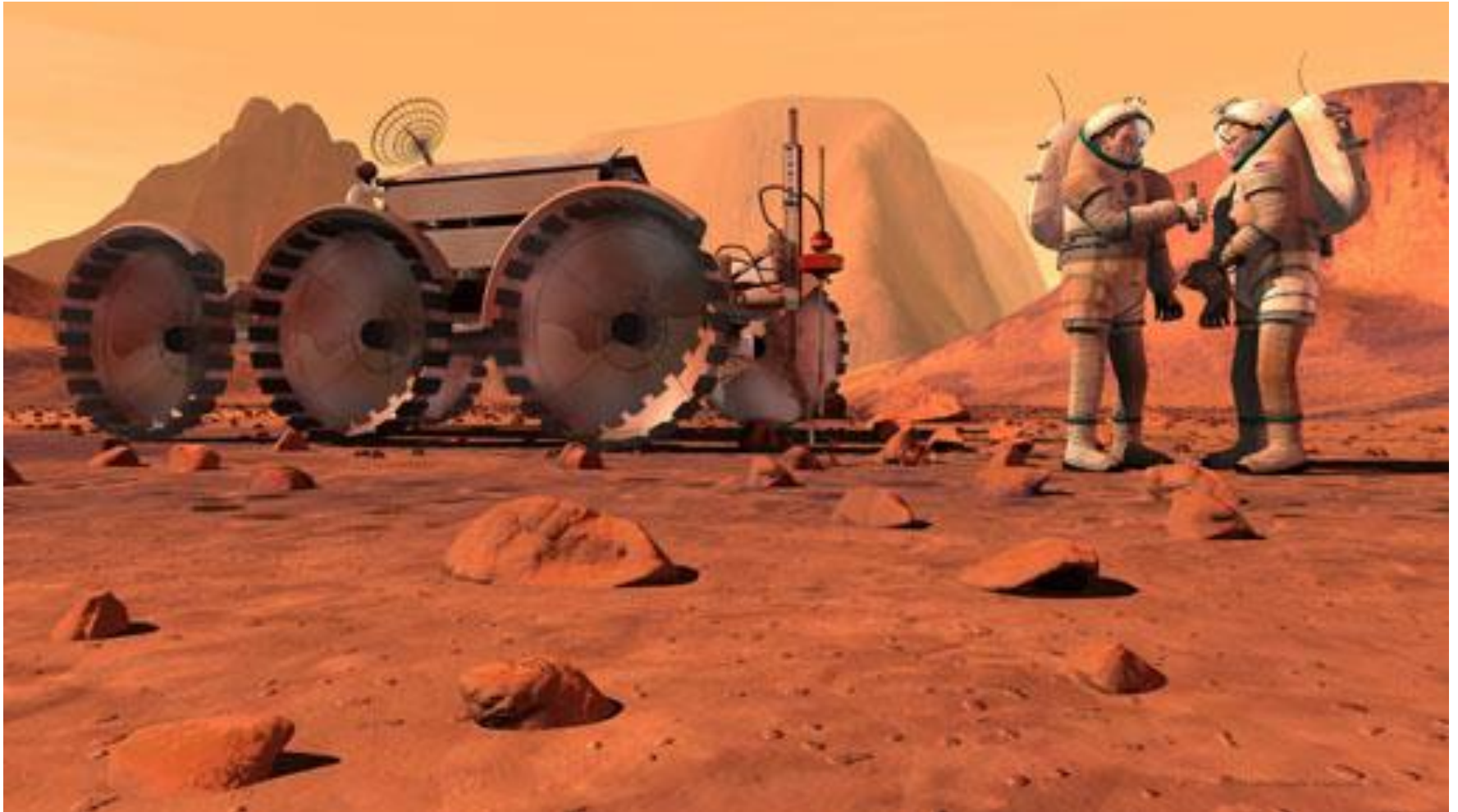


- **Commercial Spaceflight Federation**
 - 2005, promotes commercial human spaceflight, high levels of safety, and shares best practices and expertise throughout the industry.

Wrap Up

- 1) You can now describe the different regimes where commercial space is starting to take hold
- 2) You can list some examples of areas where entrepreneurial companies are developing new markets
- 3) You can name a few companies that are examples of the commercial space revolution
- 4) You can discuss how governments can facilitate the birth of this new industry

Back-Up



Technical and Policy Issues to Consider

- **Outer Space Treaty - 1967**

- Precludes sovereignty over off-world territory by nations
- Principle of property rights in space is not clearly defined
- Most likely world governments would not recognize any claims of rights - serious risk that investments would be challenged under the current framework

- **Moon Treaty 1979**

- Not ratified by nations who could reach the Moon on their own
- Bans any ownership of any extraterrestrial property by any organization or person, unless that organization is international and governmental.
- Requires all resource extraction and allocation be made by an international regime.

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