NewSpace:
The Emerging Commercial Space Industry

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

1) Describe the areas in which entrepreneurial companies are developing new markets
2) Name a few companies that are examples of the commercial space revolution
3) Discuss how governments can facilitate the birth of this new industry
4) Describe a range of disruptive technologies in the space sector.
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
1. Regimes for NewSpace Opportunities
   - Suborbital
   - Orbital
   - Deep Space
2. Example NewSpace Companies
3. The Role of Government
4. The Role of Private Industry
5. Disruptive Technologies
WHAT IS NEWSPACE?

**HobbySpace.com:**
“Alt.space, NewSpace, entrepreneurial space, and other labels have been used to describe approaches to space development that different 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 selling tickets for the suborbital experience from $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) 180 – 3000km
- High Earth Orbit (HEO) – Geocentric 35,786km

**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:**
- Microgravity (around 4 minutes)
- 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
- Earth Imaging

**Servicing a space-based economy:**
- Examples: 3D printing in space, space manufacturing
Regimes for NewSpace Opportunities

DEEP SPACE

Description:
- Lagrange points, Moon, Asteroids, Mars and beyond

Tourist Industry:
- Ultimate in exotic experiences
- The Inspiration Mars Foundation

Research:
- Enabling Humans to be productive and happy in space; in-space economy
- 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

Earth Imaging:
- Natural resources, site development, crop monitoring, asset management ....

Broadband:
- Global internet connectivity

Settlement:
- Moving human civilization to Moon and Mars
Examples of NewSpace Companies

**Virgin Galactic**

**HQ:** Las Cruces, New Mexico

**Founded:** 2004 Richard Branson (Virgin Group)

**Focus:** Space Tourism & Research; Low-cost small satellite launch

**Cost:** $250K per seat, $10M per satellite

**Major Partnerships:** Spaceport America in New Mexico
Examples of NewSpace Companies

ORBITAL

HQ: Houston, TX

Founded: 2009 CEO Jeff Manber (MirCorp)

Focus: On-orbit research and smallsat launch

Cost: $30K-$60K for a 1U cubesat

Major Partnerships: XCOR for suborbital, Astrium for USS External Platform Program and Entropy Engineering (2010 NASA SBIR)
Examples of NewSpace Companies

**ORBITAL**

**HQ**: San Francisco, California

**Founded**: 2010 Will Marshall, Robbie Schingler, Chris Boshuizen

**Focus**: Applications, Earth Sensing

**Capacity**: Launched 73 smallsats, resolution: 10 square feet

**Major Partnerships**: Raised $183M in 5 years
Examples of NewSpace Companies

ORBITAL

HQ: North Las Vegas, NV

Founded: 1998 by Robert Bigelow

Focus: Orbital habitation

Capacity: BA330 has 330m³ of internal space

Cost: $25M for 110m³ for 60 days

Major Partnerships: Raised $183M in 5 years
Examples of NewSpace Companies

**HQ**: Hawthorne, California

**Founded**: 2002 Elon Musk

**Focus**: Transport to Low Earth Orbit (ISS), Geostationary Transfer Orbit (GTO), planetary missions

**Cost**: Falcon Heavy $84M for 6.4t to GTO

**Major Partnerships**: NASA Commercial Crew
Examples of NewSpace Companies

DEEP SPACE

**HQ:** NASA Research Park, Mountain View, CA

**Founded:** 2010 Bob Richards, Andy Aldrin

**Focus:** Lunar payloads, resource exploration, Google Lunar X Prize.

**Cost:** Initial cost ~$3M/kg

**Major Partnerships:** NASA innovative Lunar Demonstration Data (ILDD) program ($30M); Dynetics
Examples of NewSpace Companies

**DEEP SPACE**

**DEEP SPACE INDUSTRIES**

**HQ:** Mountain View, CA

**Founded:** 2013, Rick N. Tumlinson, Daniel Faber, David Gump et al.

**Focus:** Asteroid Mining: Water & Rare Metals

**Implementation:** Four stages: Prospect, Harvest, Process, Manufacture in space.

**Major Partnerships:** NASA Asteroid Initiative, ISISpace, Solid Prototype
The Role of Government

The Government’s Role in Commercializing Space

Key question:

“What role should the government play in the commercialization of space?”
The Role of Government

NATIONAL ADVISORY COUNCIL FOR AERONAUTICS (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
## CHANGES AT NASA

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<th>Program Characteristic</th>
<th>Early Space Age Approach</th>
<th>Commercial-Oriented Approach</th>
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<td>Owner</td>
<td>NASA</td>
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<td>Customer(s)</td>
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<td>Funding for Capability Demonstration</td>
<td>NASA procures capability</td>
<td>NASA provides investment via milestone payments</td>
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<td>NASA's Role in Capability Development</td>
<td>NASA defines “what” and “how”</td>
<td>NASA defines “what” Industry defines “how”</td>
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<tr>
<td>Requirements Definition</td>
<td>NASA defines detailed requirements</td>
<td>NASA defines top-level capabilities needed</td>
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<td>Cost Structure</td>
<td>NASA incurs total cost</td>
<td>NASA and Industry share cost</td>
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“Develop a robust and competitive U.S. commercial space sector”

&

“Energize competitive domestic industries to participate in global markets”

– NASA Act (as amended June 28, 2010)
NASA is to achieve this by:

- Purchasing and using **commercial space capabilities** and services to the maximum practical extent
- Actively exploring the use of **inventive, nontraditional arrangements** for acquiring commercial space goods and services
- **Refraining from** conducting U.S. Government space **activities that preclude, discourage, or compete with U.S. commercial space activities**
- Pursuing potential opportunities for **transferring routine, operational space functions to the commercial space sector** where beneficial and cost-effective.

June 28, 2010
The Role of Government

FAA Office of Commercial Space Transportation

Founded 1984, to:

- **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?**
  o Commercial companies must be competitive and governments have other priorities (safety, jobs, etc.)
  o 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**
  o US Congress focused on jobs in their districts
The Role of Government

NASA PROGRAMS TO STIMULATE COMMERCIAL SPACE

• **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
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

Crowdfunding
- Kickstarter: Lunar Space Elevator (Liftport Group), CubeSat Ambipolar Thruster (CAT) (UMich), Arkyd Telescope $1.5M (Planetary Resources) etc.
- Spire
The Role of Private Industry

NEWSPACE INVESTMENTS (NSG 50)

<table>
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<th>$200M-$2B</th>
<th>$20M-$200M</th>
<th>$2M-$20M</th>
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<tr>
<td>SpaceX</td>
<td>Skybox</td>
<td>Dauria Aerospace</td>
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<td>Virgin Galactic*</td>
<td>Spaceflight Industries</td>
<td>Planetary Resources</td>
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<td>Blue Origin*</td>
<td>MapBox</td>
<td>OmniEarth</td>
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<td>Vulcan Aerospace*</td>
<td>Spire</td>
<td>Satellogic</td>
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<td>O3B</td>
<td>Moon Express</td>
<td>Astroscale</td>
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<td>OneWeb</td>
<td>Spire</td>
<td>Nanoracks</td>
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<tr>
<td>Planet Labs</td>
<td>Moon Express</td>
<td>XCOR</td>
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<tr>
<td>Cloudera</td>
<td>SpaceIL</td>
<td>Rocket Lab</td>
</tr>
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</table>

(*) SVSC estimates

Crunchbase Data 2015

Source: Sean Casey (SVSC)

From 2015-2015 $12B in private investment  Source: Silicon Valley Space Center
Disruptive Technologies
"Moore's law" is the observation that, over the history of computing hardware, the number of transistors in a dense integrated circuit has doubled approximately every two years.
Computers are becoming exponentially more powerful – in accordance with Moore’s Law.

The advances in computing are allowing science and technology to follow suit.
Exponential Growth of Computing
Twentieth through twenty first century
SMALLSATS

Mass: 1kg-500kg

Cheap and quick

Lower cost of entry to the space market

Constellations of small satellites may replace single larger satellites

Small sats are technologically less advanced than conventional satellites. However, they provide a very useful test bed low-cost missions and for technology demonstrations.
DOES THIS LOOK LIKE A SATELLITE?
HOW ABOUT NOW?
SYNTHETIC BIOLOGY

Providing robust biological tools and technologies to sustain human activities across the solar system for the benefit of exploration, science and the economy.

Combining disciplines such as:

- Biotechnology
- Evolutionary biology
- Molecular biology
- Systems biology
- Biophysics
- Computer engineering
- Genetic engineering
The Potential of Synthetic Biology in Space

- Optimized Food Production
- Environmental Monitoring and Biosensors
- Cell-based Biomaterials Production
- Regolith and Bio-mining
- Multipurpose Microbial Bioreactors
- DNA Sequence Transceiver and in situ synthesis
- Bio-cementation
- Radiation Resistant Habitats
- Water Treatment
- Air Treatment
- Waste Management
- Bio-manufacturing and Programming Pattern Formation
3D printing or “additive manufacturing” offers a range of potential advantages:

- Crew in space can ‘print’ new or replacement items
- Spacecraft could be printed and assembled in orbit rather than launched
- In-situ resources could be used as feedstock, reducing mass that has to be delivered
In-Situ Resource Utilization (ISRU)

- Extraterrestrial resources are crucial for supporting human crews
- Oxygen, water, and inert gases are examples of high-value resources for life support.
- Metals, pure or alloyed, glass, ceramics and simple hydrocarbons are required to fabricate new parts or complete repairs for habitats and spacecraft.
What is the smallest number of machines and resources that future pioneers will need to create a self-sustaining settlement?
You should be able to:

1) List some examples of areas where entrepreneurial companies are developing new markets;
2) Name a few companies that are examples of the commercial space revolution;
3) Discuss how governments can facilitate the birth of this new industry; and
4) Describe a range of disruptive technologies in the space sector.
Organizations Promoting NewSpace

**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.
Emerging Commercial Space

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