U.S. National Space Policy

- Recognizes three distinct sectors of space activity:
  - National Security (military, intelligence)
  - Commercial (satellite communication)
  - Civil (including both scientific research and services such as weather forecasting)

- The functions performed by each can be organized along a spectrum, depending on whether they are driven by government or markets
Space Surveillance & Orbital Debris

- Approximately 21,000 objects larger than 10 cm being tracked in 2012

- Collision Avoidance for the International Space Station and other major assets

- Surveillance of Asteroids & Comets for science and warning – “potentially hazardous objects”

- NASA estimated over 35,000 pieces of orbital debris larger than 1 cm from 2007 China ASAT test
Space and Cyber Contested Domains

Cross-Domain Integration

Cyber
- Networks: Computers, routers, cables, software...
- Network Monitoring & Information Assurance

Space
- Elements: Satellites, Ground Systems, Links
- Space Situational Awareness & Protection

Understanding the Overlap?

Virtual
- Space and Cyber are global in nature, very electronically focused
  - Some common elements, synergy when combined
  - Cyber has unique attributes regarding speed / range, and a psychological element of cyber (ever had your PC infected?)
- Perspectives
  - Cyber: space is just another transport medium
  - Space: cyber (IT) is just a tool to operate and maintain space systems
- Space and Cyber Situational Awareness
  - An attack on one domain can directly impact the other
  - Requires integrated methods for attack detection, characterization, and response (Ops Center collaboration)
- Mitigation
  - NSPD 49, NSTAC, HSPD 7
  - Designation as Critical Infrastructure / Key Resource (Communication and Information Technology Sectors)
  - Physical protection, redundancy, proliferation, reconstitution, path diversity

Physical

Natural
GPS enables a diverse array of applications

- Surveying & Mapping
- Power Grids
- Disease Control
- Trucking & Shipping
- Oil Exploration
- Fishing & Boating
- NextGen
- Precision Agriculture
- Intelligent Vehicles
- TeleComm
- Space Applications
- Transit Operations
The three foundations of C2 and how they are “changing the game” in an electronic battlespace: spectrum (communications media), yellow; computers (digital data), green; PNT (precise position and timing), blue.
Space Service Volume: Using GPS Beyond LEO and up to GeoSynchronous Altitude

**3,000 to 8,000 km Altitude**
- Four GPS signals usually available simultaneously, however poor geometry & coverage gaps cause harm
- 1 meter accuracies still feasible, however space GPS receivers have more difficulty processing signals
- GPS performance degrades with altitude due to geometry and classic near/far problem

**8,000 to 36,000 km Altitude**
- Users will experience periods when no GPS satellites are available – Point Positioning no longer available
- Nearly all GPS signals received over limb of the Earth – High variability in signal strength and beam paths
- Received power levels are weaker than those in TSV or MEO SSV – Side Lobe processing needed
- Specially designed receivers will be capable of maintaining accuracies ranging from 10-100 meters depending on receiver sensitivity and local oscillator stability
Why is the Space Service Volume Important?

**SSV specifications are crucial for providing real-time GNSS navigation solutions in High Earth Orbit**

- Supports increased satellite autonomy for missions, lowering mission operations costs
- Significantly improves vehicle navigation performance in these orbits
- Enables new/enhanced capabilities and better performance for future missions, such as:

  - **Improved Weather Prediction using Advanced Weather Satellites**
  - **Space Weather Observations**
  - **Astrophysics Observations**
  - **En-route Lunar Navigation Support**
  - **Formation Flying & Constellation Missions**
  - **Closer Spacing of Satellites in Geostationary Arc**
Key Governance Documents for NASA

National Aeronautics & Space Act of 1958
P.L. 85-568
July 1958

NASA Authorization Act of 2010
P.L. 111-267

Annual Appropriations

National Aeronautics Research and Development Policy
December 2006

National Space Policy
June 2010

Augustine Commission 2009

National Academy of Sciences Reports

New Worlds, New Horizons
In Astronomy and Astrophysics

2011 NASA Strategic Plan

Annual Budget Requests
NASA Enacted and President's Budget Requests

- Enacted Budgets
- FY2010 NASA Request
- FY2011 NASA Request
- FY2012 NASA Request
- FY2013 NASA Request
- FY2014 NASA Request
- FY2015 NASA Request
- FY2016 NASA Request

FY1992 NASA Budget in 2014 dollars
Evolvable Mars Campaign
A Pioneering Approach to Exploration

Earth Reliant
- International Space Station
- Commercial Cargo & Crew
- Low-Earth Orbit

Proving Ground
- Asteroid Redirect Vehicle
- Global Exploration Roadmap
- Robotic Lunar Surface
- Distant Retrograde Lunar Orbit

Earth Independent
- Exploration Augmentation Module Concept
- Odyssey
- Mars Surface
- MARS VICINITY
- PHOBOS DEIMOS
- Mars Cargo Pre-Deployment
- MAVEN
Multi-lateral Cooperation Examples

- Spectrum and GEO slots - ITU
- Weather prediction - WMO
- Environmental monitoring - GEO
- Missile proliferation and export controls - MTCR
- Orbital debris and long-term sustainability – COPUOS
- International Space Exploration – GES/ISECG/ISEF
- Space situational awareness - SDA?
- Space communications standards - CCSDS/IOAG

DTN contributes to science, security, commerce, international cooperation and public engagement
Space Entrepreneurs

SpaceX

Bigelow Aerospace

Planetary Resources

Virgin Galactic
Public and Private Sector Space Revenues

1. Ground terminal and Equipment
2. Direct-to-Home Television
3. U.S. DoD Space
4. Satellite Services (FSS & MSS)
5. NASA
6. ESA
7. Commercial Satellite Manufacturing
8. Russia
9. Japan
10. China
11. Satellite Radio
12. Earth Observation
13. Commercial Space Launch
14. India
15. NOAA

Space Foundation Report 2012
Global Space Trends

• Growing Private Sector Space Investments and Capabilities
  – Small satellites
  – IT and data drivers

• A Changing Space Industrial Base
  – Globalization

• Space Governance
  – Increasing number of State and non-State actors
  – Integration vs. Fragmentation

• Threats to Competitiveness
  – Supply Chain Dependencies
    • RD-180, Pu-238
  – Regulatory Burdens
    • Commercial licensing, esp. remote sensing
    • Space spectrum protection, esp. 1-3 GHz
    • Federal Acquisition Systems
  – Instability in Civil Space Cooperation
    • Post-ISS uncertainty

• Threats from Foreign Counterspace Capabilities
  – China, Russia, others?
International space cooperation, space commerce, and international space security discussions could be used to reinforce each other in ways that would advance U.S. interests in the sustainability and security of all space activities. At present, however, these activities are largely conducted on their individual merits and not as part of an integrated national strategy.

The next steps beyond low Earth orbit will require international partners for practical and political reasons. Therefore, it makes sense to ask what our partners would like to do, and what they are capable of doing in the future. The answer is the Moon – with Mars and other destinations in the distance. A U.S. commitment now, to lead a multinational program to explore the Moon would be a symbolic and practical first step as well as a means of creating a broader international framework for space cooperation. At the same time, the geopolitical benefits of improving relations with growing space powers through greater U.S. engagement could support more ambitious space exploration efforts than science alone might justify.

The United States is crucially reliant on space systems, and the future sustainability and governance of space activities are key strategic interests for us. If we are to have an effective American space strategy, we need to align our policies, programs, and budget priorities with enduring national interests. This means looking beyond individual missions and seeking to determine what future humanity might have beyond the Earth, and what values will be part of that future. I would like those values to include the things we value today – democracy, human rights, the rule of law, and free markets.
What is the Future of Humans in Space?

1. Can humans “live off the land” in space and function independently of Earth for long periods?

2. Are there economically useful activities in space that can sustain human communities in space?

<table>
<thead>
<tr>
<th>Live off the land</th>
<th>Nothing commercially useful</th>
<th>Commercially sustainable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antarctica</td>
<td></td>
<td>Settlements</td>
</tr>
<tr>
<td>Mt. Everest</td>
<td></td>
<td>North Sea oil platform</td>
</tr>
</tbody>
</table>

See also Harry L. Shipman "Humans in Space: 21st Century Frontiers"

• We don’t know which of these outcomes represents our long-term future. Advocates and skeptics may believe one outcome or another is most likely, but no one actually knows

• Determining the actual future of humans in space would be a watershed event for the United States and humanity