RESOURCES
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Space Commerce in the 21st Century

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Good morning, Mr. Chairman and Members of the Committee on Science, Subcommittee on Space and Aeronautics. I am Molly K. Macauley, a Senior Fellow at Resources for the Future (RFF), a research organization established in 1952 and located here in Washington, DC. RFF is independent and nonpartisan, and it shares the results of its policy analyses with members of all parties in the executive and legislative branches of government, as well as with business advocates, academics, members of the press, and interested citizens. My comments today represent my own views, it should be noted, and not those of RFF, which takes no institutional position on legislative or regulatory matters.

My training is in economics and I have worked as a space analyst for 20 years. I have written extensively about space economics and policy, serve on numerous NASA and National Academy of Science panels, and have had the opportunity to meet with your committee several times in past years. Thank you for the opportunity to meet with you today, Mr. Chairman. I am honored to be part of this distinguished panel. Moreover, I am grateful that you are seeking perspectives about the role of government in space commerce.

I've been asked to consider these topics: the kinds of activities included in "commercial space;" U.S. leadership in these activities and the outlook during the coming years for the industry; and the role of government, including what government should *not* do in encouraging commercial space.

My overall observation is that U.S. commercial space policy to date has been appropriately supportive of U.S. industry and sets a good precedent for the future. The interests of the taxpayer and industry are most likely to flourish mutually by way of a conservative approach to legislative and regulatory intervention, coupled with an innovative, incentive-oriented philosophy. I also recommend the usefulness of demonstration or pathfinder, experimental approaches to policy.

WHAT KINDS OF ACTIVITIES ARE INCLUDED IN "COMMERCIAL SPACE?"

Some of the promise of commercial space has been more than realized, accompanied by new and perhaps unexpected consumer markets. Some promise has been less successful, often for a variety of reasons independent of government actions.

Looking backward for just a moment is useful. A decade ago, the *Wall Street Journal* and *USA Today* had vastly expanded their geographic distribution by a new method: using satellites to transmit the papers to local printing presses across the country for early morning publication. The satellite distribution technology was so novel that the papers included at the top of their front page, "*Via Satellite,*" to impress upon readers that the news was hot off the press even if the news had originated thousands of miles away. A much more routine use of space by the commercial media were the satellite pictures of cloud cover and hurricanes on the daily TV news. In another routine use of space, telecommunications companies routed some long-distance telephone calls by way of satellite, although microwave or undersea fiber optic cable sent most calls. Satellites also enlarged the market for cable television. Sometimes to the dismay of neighbors, many consumers had erected large satellite dishes in their yards to receive cable TV. Reflecting the by-then wealth of experience of commercial satellite makers in serving these markets, *Fortune* magazine, in its list of "100 Things America Makes Best," included communications satellites by Boeing.

In another related market, the satellites supplying these services were commercially launched, fueling the commercial space transportation industry. In other markets, some bulky, expensive, and complex global positioning satellite (GPS) receivers were finding use in ground surveying and in navigation for civil aviation. The entrepreneurs proposing the first commercial remote sensing space system worked with policymakers to forge entirely new regulatory and legislative policy to obtain licenses for their service and were preparing for launch. There were also business plans for markets in space burials and for commercial materials processing on the shuttle and space station.

Today, just a decade later, the novelty of commercial communications satellites has worn off so that the newspaper covers don't remind readers of the transmission technology (although the technology is still

essential and new communication satellites are routinely launched for existing and new services). Residential satellite dishes are much smaller and hardly noticeable perched on apartment balconies and corners of rooftops. There are now some thirty-two commercial satellite operators around the world. They support 176 million Americans for whom cell phones, pagers, BlackBerrys and high-speed connection to the Internet are as essential as a morning cup of coffee. Most of these services use at least some satellite relays in addition to terrestrial network technologies. Backpackers and passenger cars carry lightweight, increasingly lower cost, and highly capable GPS receivers. Satellite radio receivers are in cars, homes, and boats and handheld satellite radios accompany joggers. XM Satellite and Sirius Satellite radio companies along with *SpaceShipOne* are the most prominent among new entrants in commercial space markets. XM has just announced that it is also joining with AOL for Internet radio service. Both XM and Sirius point out that after eighty years of AM radio and sixty years of FM radio technology, their digital technology offers the first new radio broadcast medium.

In the case of commercial space remote sensing, industry is struggling financially. For a variety of reasons, the industry has had trouble building a civilian consumer market and has instead relied heavily on sales to government, including contacts for data purchases by the National Geospatial Intelligence Agency and other national and foreign government security departments.

But Google's recent acquisition of Keyhole Corporation, a California-based digital mapping company, is a new and promising direction for remote sensing. Keyhole uses satellite and aerial maps and, most important, easy-to-use software. A person (untrained in the complexities of photogrammetry) can zoom-in for detail on satellite and aerial pictures by way of a personal or laptop computer and even simulate 3D maps to find hotels, parks, ATMs, and subway stops at home or when traveling. One reviewer noted that in some cases a consumer can even zoom in enough to see a neighbor's trashcans. In remote sensing, then, companies are finally treating the market not as "users" but as "consumers." Keyhole, together with the innovative software known as Ajax that manages the complexity of all of the data and interfaces between hardware and software components, simplifies and annotates otherwise complicated digital imagery.

In the commercial space transportation industry, ideas and technology have moved from conventional rockets to an innovation like *Sea Launch*, and from unmanned commercial vehicles to the promise of *SpaceShipOne* in serving payloads in the form of people not packages.

These examples of satellite radio, the Google–Keyhole arrangement, and innovations in space transportation technology and markets represent a particular and significant development relevant to Congressional and public policy perspectives on commercial space. This development is the hard work of industry in blending space-based technology with existing technologies and markets on earth, complete with having to comply with the regulations that govern *those* technologies and markets. In other words, commercial space is not a stand-alone industry and it can succeed or fail on market conditions and other public policy wholly independent of commercial space policy.

By way of illustration, satellite radio had to: obtain FCC licenses and frequency allocations; contract for commercial launch services and insurance; obtain permits for and then install and maintain an initial network of 800 terrestrial repeaters for ground coverage in drop-out areas; design and test radio, antenna, and in-car technology; attract GM, Honda, Sony, WalMart, Best Buy, Circuit City, and Radio Shack, among other companies, to build its supply and market chain; and sign up major league baseball, NASCAR, CNN, Fox News, Howard Stern, and other programming. No space technology has a stand-alone supply network or consumer market.

U.S. LEADERSHIP IN COMMERCIAL SPACE – STATUS AND OUTLOOK

Most experts contend that some of the best commercial space products as well as significant innovation continue to come from U.S. companies. But these observers also acknowledge that "U.S.-made" can be misleading. For instance, companies routinely employ foreign-born, U.S.-trained engineering talent. In addition, increasingly, and due in part to export restrictions, markets are typically larger for U.S.-made components rather than entire finished products.

Space-related markets are markedly more competitive than in past decades. Space transportation markets now include suppliers in Western Europe, China, Russia, Ukraine, Japan, and India—all now offer commercial launch services. Israel and Brazil also have their own launch capability. According to data maintained by the Office of Commercial Space Transportation in the Federal Aviation Administration, in the past ten years, the U.S. share of the worldwide commercial launch market has averaged about 30% to 40% of total launches and about a third of total revenue (of a $1 billion total market in 2004, the U.S. share was about $375 million). The total number of launches in the past five years has been smaller than in previous years, largely due to longer-lived satellites and a decline in the number of small satellites launched to nongeostationary orbit. For example, in 2004, U.S. companies launched 6 out of a total of 15 worldwide commercial launches.

Joint arrangements between U.S. and foreign companies are increasing. For instance, Boeing has a share of launch revenue from its partnership in *Sea Launch*, which had three launches valued at $210 million in 2004. In commercial remote sensing, U.S. companies have entered into distribution agreements to market foreign data from SPOT and Radarsat.

The international mobility of engineering talent, increasing activity by other countries in commercial space launch markets, and joint arrangements such as those noted above are trends that are likely to continue in coming years. During 2004–2013, the Office of Commercial Space Transportation expects a total of about 23 commercial launches per year, on par with past years. Industry trends may include continuing coupling of space-based and ground-based technologies and markets—the "XM" model. Commercial companies have also proposed the first commercial deep space science mission and commercial space operations and telemetry, tracking, and control systems. In the case of earth observations, a major initiative impelled by the G-8 heads of state in June 2003 has led to a ten-year plan for an integrated global earth observation system (GEOSS) among the governments of more than 30 countries. A separately established organization is working closely with industry to identify opportunities to support GEOSS in the coming decade.

WHAT MIGHT GOVERNMENT DO (OR NOT DO) TO ENCOURAGE COMMERCIAL SPACE?

The Congress and executive branch have generally been extremely supportive of commercial space. The legacy of policy initiatives to nurture the industry is rich with examples. Table 1 lists key legislation, regulation, and policy directives that have included provisions specifically addressing commercial space. These initiatives have included (but not been limited to) a host of innovative, market-like approaches: vouchers to fund launch purchases by space science researchers, to enable them to choose a launch vehicle best tailored to their payload; government purchases of earth and space science data and launch services; and most recently in the 2004 Commercial Space Launch Amendments Act, initial steps toward allowing private and commercial passengers to undertake space travel.

The twenty-year legislative and regulatory history of commercial space has generally been responsive to industry concerns. To be sure, not all initiatives taken so far have worked in practice. For example, transferring the land remote sensing system (Landsat) to private operation or identifying a commercial company to build and operate a follow-on system (the Landsat Data Continuity Mission) did not work out for a variety of reasons. However, the policy emphasis on data buys has formed the basis for

Table 1. Key Legislation, Regulation, and Policy Addressing Commercial Space Activities*

Land Remote Sensing Commercialization Act of 1984
Established the process for the commercial operation of government- owned, civilian land remote sensing satellites

Commercial Space Launch Act of 1984
Granted to the US Department of Transportation (DoT) licensing authority and safety regulation for commercial space transportation and provided that DoT would prescribe insurance requirements

Commercial Space Launch Act Amendments of 1988
Established government indemnification of commercial space transportation third-party liability and other provisions for sharing certain space launch risks between government and industry through 1993; subsequent legislation extended the provisions through 2004

Launch Services Purchases Act of 1990
Required that launch services acquired for deployment of NASA and NASA-sponsored payloads take advantage of all reasonable sources of U.S. commercial launch services

NASA Authorization FY 1991
Codified space shuttle use policy initially promulgated after the Challenger shuttle accident in 1986 and limiting the shuttle system to activities requiring the presence of man or other unique capabilities of the shuttle; explicitly precludes shuttle launch of most commercial payloads; calls for no increase in space debris from U.S. space activities

Land Remote Sensing Policy Act of 1992
Transferred operation of the government-owned civilian land remote sensing satellites from industry back to the government

NASA Authorization FY 1993
Provided for a commercial space voucher demonstration program to award vouchers for the payment of commercial launch services for the purpose of launching small payloads funded by NASA

Commercial Space Act of 1998
Required the NASA Administrator to study feasibility of privatizing the space shuttle including consideration of ownership, operation, third-party liability indemnification, launch of commercial payloads, and potential cost savings; required NASA to acquire, where cost effective, space science data (such as data about the moon, planets, comets, solar storms) and earth science data from a commercial provider; continued space launch voucher demonstration program

U.S. Commercial Remote Sensing Policy 2003 (from NSPD-15)
Provided for the licensing and operation of U.S. commercial remote sensing space systems, U.S. government use of commercial remote sensing space capabilities, foreign access to U.S. commercial remote sensing space systems, and government-to-government relationships in U.S. commercial remote sensing space systems

Commercial Space Launch Amendments Act of 2004
Allowed licensing of private spacecraft on experimental bases and established liability guidelines, provided legal basis for allowing private and commercial passengers to undertake space travel and established concept of informed risk for space passengers; also required study of whether to continue indemnification of commercial expendable launch vehicles

* Note: List is not comprehensive**.**

the purchases of commercial space remote sensing data under contracts worth about $1 billion with national security agencies. By way of the Centennial Challenges project, the National Aeronautics and Space Administration (NASA) is now offering prizes for space technology development. NASA also has funding in its FY 2006 budget request for commercial transportation of crew and cargo to the International Space Station.

In the future, consideration could be given to potentially strong incentive-oriented approaches when government oversight of commercial space activities is deemed necessary. These approaches include financial incentives, performance standards that nurture adoption of alternative technologies rather than requirements that specify technologies to achieve performance, rational pricing policy for access to government assets, and reliance on private markets for insurance when appropriate. Table 2 lists market-like policies that have been taken or are currently used or that might be used in the future in designing space policy. These approaches include performance standards, prizes, private market insurance, auctions, voucher, and government purchases of commercially produced goods and services. The objective of policy options such as these is to encourage flexibility, discourage government intervention when private institutions (such as insurance markets) could suffice, and ensure a "fair playing field" between government space and commercial space activities.

I know from Chairman Calvert's recent comments at the 21st National Space Symposium this month that there is concern about sectors of the U.S. space program working in isolation from the others. These sectors would include the civil, national security, and commercial space activities. This is a familiar problem. For instance, in the case of energy policy, the Department of Energy, the Federal Energy Regulatory Commission, the U.S. Nuclear Regulatory Commission, the National Highway Safety Administration, the Environmental Protection Agency, and the Minerals Management Service all have great influence on energy markets. These agencies' decisions affect what fuels are used to generate electricity, what fuel efficiency targets cars must meet, what mixtures of gasoline may be sold, and where oil and natural gas can be produced.

Our space and space-related agencies now range from the national security complex to NASA, the Department of Interior and the U.S. Geologic Service, the Department of Commerce and the National Oceanic and Atmospheric Administration, the Federal Aviation Administration, and the Federal Communications Commission. The Departments of State and Energy, together with the Department of Commerce, are key champions of the GEOSS program (described above). The Department of Energy also plays a role in space power systems.

To some extent, our space sectors have mutually benefited from this mix. For instance, GPS is owned and operated on the defense side but routinely used by the civil and commercial sectors. Remote sensing/earth observation information was championed by NASA and the infrastructure, data, R&D, data validation, and information products from NASA's earth science activities over four decades are routinely used by the defense and commercial sectors. Commercial satellite telecommunications were advanced markedly by industry but are routinely used by the defense and civil sectors.

Some steps could be taken to better integrate the large scale and scope of government space and space-related activity. For instance, establishing prizes for innovation of use to all three space sectors—civil, commercial, and national security—makes sense provided all three sectors have at least a few desirable innovations in common. These requirements could range from space transportation to space-based navigation for on-orbit activities that may include autonomous refueling and repair. They may also include developments in earth science in mapping and meteorology, for which prizes could be offered for new and faster algorithms to turn data into actual information products for the battlefield or the oil field (for geologic exploration). These prizes could be jointly funded and developed by the civil and national security sectors with input from the commercial community.

Another step, and one that has been taken in the past, is establishment of a space-dedicated cabinet council. In the past, such an effort has been inadequate to overcome differences in goals, leadership, and decisionmaking. Nor did previous interagency efforts adequately include provision for industry

Table 2. Commercial Space: Flexible Approaches to Government Oversight

Approach	Examples	
	Previous/Current Use	**Prospective Use**
Auctions	Some regions of electromagnetic spectrum (FCC)	Access to/use of some operational assets; access to congested resources (e.g., tracking networks)
Government purchase of commercial services and products	Earth observation data buys; launch services	Space science data buys; space transportation
Performance standards	Commercial launch licensing safety requirements (FAA/AST)	Safety requirements; space transportation; earth observations science requirements
Pricing policy	Access to government launch facilities; access to ISS-like resources; government earth observation and science data	Access to/use of government facilities
Non-deterrence of commercial sector in pricing and disposal of tooling, equipment, and residual hardware, etc., at completion of government programs	Excess ballistic missiles	
Private market insurance	Commercial space transportation; payloads	Commercial space transportation; payloads including persons
Prizes	Centennial Challenge (NASA)	Innovation in technology development and testing
Tradable permits	Pollution mitigation (EPA)	Debris mitigation
Voluntary measures	Debris mitigation	Informed consent for private, first-party risk taking; GEOSS-like institutional arrangements
Vouchers	NASA-funded researchers' purchases of launch services	NASA-funded researchers' purchases of earth science data

representation, which if optimally designed would include representatives from “other than the usual suspects” by seeking participation of non-space companies (perhaps WalMart, Microsoft).

SUMMARY OBSERVATIONS

Some of the alternatives outlined in Table 2 address different types of risk (financial and safety), export issues, and other topics not addressed at length in this testimony. With these omissions in mind, some general guidelines for public policy and commercial space include:

–Balance financial risk taken by industry compared with asking the public to underwrite risk (for example, in the case of upcoming deliberations on continuation of commercial launch indemnification)

–Balance personal risk taken by crew, passengers, and third parties in commercial space transportation

–Maintain familiarity with the non-space commercial markets upon which commercial space relies (for example, computing hardware, software, wireless connectivity, telecommunications capacity enhancements and cost reductions, consumer retail markets)

–Routinely seek out the opinions of non-space industry leaders in information technology, telecommunications technology, entertainment, automobiles, education, retail services, and other consumer markets to appreciate the larger context in which commercial space operates

–Intervene when necessary and appropriate in legislative and regulatory policy in non-space commercial markets upon which commercial space relies (for instance, spectrum and orbital access, environmental and occupational safety/health regulation)

–Balance export policy, national security concerns, and other restrictions on international trade in space goods and services

–Build or build on interagency relationships among the myriad government offices that are involved directly or indirectly in space technology, policy, and operations

–Acknowledge that commercial space success depends at least as much if not more on normal business challenges (business strategy, customer relations) as on challenges that are space-unique or that pertain to government commercial space policy

–Accept that some commercial ventures will fail independently of supportive legislative, regulatory, or other policy

In conclusion, the supportive legacy of U.S. commercial space policy has set a good precedent for the future. The interests of the taxpayer and U.S. industry are most likely to flourish mutually by way of a conservative approach to legislative and regulatory intervention, coupled with an innovative, incentive-oriented philosophy amenable to demonstration or pathfinder, experimental approaches to policy.

Biography

Dr. Molly K. Macauley

Dr. Macauley is a Senior Fellow at Resources for the Future in Washington, DC. Her research focuses on economics of and policy issues in space transportation, earth science and remote sensing, space risk, space debris, space power technology, and the roles of the government and private sectors in space. She has published over 50 articles, lectured widely, and testified before Congress on these topics. Dr. Macauley also chairs the Board of Advisors of the Thomas Jefferson Public Policy Program at the College of William and Mary and has served on the Board of Directors of Women in Aerospace. She is a member of the International Academy of Astronautics and the Aeronautics and Space Engineering Board of the National Academy of Sciences, and has been honored by the National Space Society as one of the nation's "Rising Stars" in space policy. She has also received commendation from the National Aeronautics and Space Administration for contributions to development of commercial space remote sensing. In addition, Dr. Macauley spearheaded the space shuttle flight of replica of a standard of George Washington; that standard is now on display at Mount Vernon. Dr. Macauley has taught for many years in the Department of Economics at Johns Hopkins University and consults for a variety of aerospace and other companies. She has a bachelor's degree in economics from the College of William and Mary and master's and doctoral degrees from Johns Hopkins University.