Hearing of the House Committee on Science, Space, and Technology
Subcommittee on Environment
Subcommittee on Space

"Exploring Commercial Opportunities to Maximize Earth Science Investments"

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Thank you, Mr. Chairman, for providing an opportunity to discuss the important topic of how commercial capabilities could be used to benefit the nation's Earth Science investments.

From 1990 to 1993, I was a civil servant in the U.S. Department of Commerce and worked with the National Space Council on policy guidelines to encourage the growth of commercial space activities. We recognized the many different roles the government might play, not only as a customer and anchor tenant, but also as a regulator and supporter of research and development too risky for the private sector.

I had the privilege of working on Title II of the Land Remote Sensing Policy Act with Barry Beringer, the former chief counsel of the House Committee on Science. In the aftermath of the Cold War, Title II reformed the U.S. commercial remote sensing licensing process and removed regulatory barriers to space-based commercial remote sensing. This reform was successful beyond our somewhat modest expectations, leading to a more dynamic, information-driven global industry.

The idea of buying data from commercial sources for NASA needs is not new. In 1998, I testified to House Subcommittee on Basic Research on "Using Commercial Data Sources in the Earth Science Enterprise" and the development practical applications for remote sensing. At the time, I discussed the need for NASA to actively consider the needs of other civil agencies in the acquisition of commercial data for Earth science needs. The idea was that NASA's capabilities and buying power could be leveraged to support other public missions such as managing natural resources and responding to natural disasters. New applications of remote sensing data could be demonstrated to benefit the public and accelerate the growth of commercial applications.

The potential for small satellites to match the capabilities of traditional satellites was just emerging. Utilizing technologies developed under the Strategic Defense Initiative, there were conceptual industry designs for a "lightsat" version of Landsat in 1992. The Administration chose however to build a conventional satellite for

Landsat 6 instead. Unfortunately, the satellite failed to reach orbit. Its replacement, Landsat 7 was successfully launched in 1999. The original plans for Landsat 8 were for NASA to purchase data meeting its specifications from a commercially owned and operated satellite system. After evaluating industry proposals, NASA cancelled this approach in 2003 in favor of placing Landsat sensors on the National Polar-orbiting Operational Environmental Satellite System (NPOESS). This was a short-lived effort and the Administration again shifted to conventional satellite procurements, and Landsat 8 was launched in 2013.

Current Conditions and Global Trends

Access to space-based information capabilities and technologies is virtually ubiquitous, and access to space launch services is nearly so. The past decade has witnessed an increasing number of American entrepreneurial firms seeking non-traditional markets. The growth of Big Data and location-based services applications has created significant new demand for geospatial data. The fusion of data from multiple sources will allow motivated nations, multinational companies, and even small groups or individuals to improve their access to previously unavailable information that can have potential strategic implications.

The National Geospatial-Intelligence Agency (NGA), rather than NASA, became the dominant government purchaser of U.S. commercial remote sensing data. Information technologies have continued to advance rapidly so that more computer and sensing power can be packed into smaller packages. After almost twenty years, these information technology advances have led to small satellites emerging as the latest "overnight success." Concerns over access to adequate radiofrequency spectrum for remote sensing turned out to be partially correct. There is pressure on spectrum, but not so much from bandwidth demands for remote sensing but from competing demands by mobile terrestrial communications.

Market demands, deployed satellite technologies, and ground processing practices have all changed in the last decade. Rather than a few conventional satellites connecting to centralized data management systems, we are seeing potentially dozens of small satellites connecting to highly distributed networks in which even an iPad might be a ground station. Data processing is accomplished in highly diverse ways depending on specific applications rather than being driven by the space segment. In some cases, data files are so massive that moving them to the user is less efficient than creating a large "data cube" that users can query remotely. In other cases, targeted data are delivered to a user in the field to for remote processing.

The small satellite technologies and a rapidly evolving Internet have created major challenges to the regulatory structure created in the 1990s for commercial remote sensing. While perhaps more appropriate for a separate hearing, the ability of NASA to benefit from an innovative U.S. commercial remote sensing industry depends on an efficient and effective licensing and oversight process at the U.S. Department of

Commerce. That process is hard pressed to keep up with the changes occurring in the industry today.

The significance of private funding and development of new capabilities is coupled with the reality of globalization. Not only are modern space capabilities becoming ubiquitous but private funding also means that new and unexpected capabilities may be developed elsewhere in the world. To date, it has been to the advantage of the United States that innovative space activities have been concentrated in U.S. companies. This advantage is predicated on a timely and responsive domestic regulatory process and favorable economic conditions, but these cannot be assumed to be a given.

Another challenge that has become more severe in recent decades has been the increasing pressure on non-defense discretionary budgets. It is not news to those here today that budget allocations have been flat or declining in real dollar terms. If NASA were to have the same buying power today that it had in Fiscal Year 1992, it would have a budget of about $24 billion dollars. At the same time, NASA is supporting more Earth science activities than just those of the decadal survey. In some cases, this is to support critical NOAA weather satellites or maintain the invaluable continuity of Landsat data. In other cases, the success of NASA missions in the A-train has created on-going demands for "operational" yet "exquisite" scientific data. This makes it difficult for NASA to fund new starts for decadal survey priorities.

Competing Public and Private Interests

In using tax dollars to acquire, process, and analyze data about the Earth, the United States seeks to serve multiple national interests. These include national security, economic competitiveness, and in the case of NASA, science and exploration. As discretionary budgets tighten and private sector capabilities grow, it is particularly appropriate to look at agency "make or buy" decisions. That is, in what situations is it best for an agency to develop, build, and operate its own space system and in what situations is it better for it to buy data licenses and value-added information products from a private provider?

Government is not a business, but business approaches can be helpful in thinking about the efficient use of public resources. A first concern is that agencies should not compete with the private sector unless there are compelling public safety or national security reasons. A second concern is that the unique needs of the public and private sector need to be understood.

One of my former students, Dr. Mariel Borowitz, is now an assistant professor at George Tech. She is writing a book on the international spread of open data policies for remote sensing archives, despite the attempts by many governments to monetize their databases through user fees. The United States tried to change user fees for Landsat data for many years with little success. With the Internet enabling virtually zero cost distribution, the United States dropped user fees for Landsat and other civil government data. Not surprising, this led to a dramatic increase in the use of Landsat data by businesses and universities. More importantly, it led to commercial and scientific results that have benefited the public through new information products and services.

The general policy principle for data sales should be simple. If data products are created by private funds, the private entity should own all the rights and can license them in response to markets. If public funds are used, then the data products should be provided at marginal cost – which is effectively free with today's IT systems. If a mixture of government and private funds are involved, the data rights need to be negotiated upfront between government and industry as a competitive consideration for partnership. If civil data are provided by a foreign system, the U.S. government should seek to get free data access in a manner reciprocal to how it provides similar data to the international community.

As I mentioned earlier, NGA is an anchor customer for the commercial remote sensing industry. NGA released a "Commercial GEOINT Strategy" in October that described agency intentions to shift its emphasis from the acquisition of raw data to analytical and contextual products. The growth of satellite constellations that can provide near persistent observation with increasingly sophisticated geospatial business applications means NGA may be able to meet the needs of its customer more quickly and at less expense. While defense needs and commercial needs are different and one cannot be substitute for the other, there are growing functional overlaps between the two that make for cooperative opportunities.

Like computer software and games, data products can come in multiple versions that can command different prices. For example, the most capable software may command a high price while less capable or older versions are provided for free. Unprocessed or lightly processed data can be made freely available for higher processing and value-added products may require payments. One can think of freely available Landsat data as not only providing a public good benefit for science but also fostering upgrades to more specialized, and expensive, commercial sources.

Talking about "data purchases" is often misleading, as what actually occurs is the purchase of a license to use the data. Similarly, when you buy a computer program, you are buying a software license, not the program itself. In a recent paper, Dr. Borowitz made the point that there are a wide variety of possible licensing arrangements.[1] These include providing license-free raw and processed data, as well as fee-based raw data and processed data. Depending on the specific data and

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[1] Borowitz, Mariel. "Examining Economic Models for Remote Sensing Satellite Data," paper presented to the International Astronautical Congress Symposium E6.1 *Case Studies and Prizes in Commercial Space* September 13, 2015 Jerusalem, Israel

who the potential customers are, providers will seek to spread their fixed costs over a wide base while recovering their variable costs. Data licenses can be open or restricted, with restrictions at many different scales, from individuals to companies, to countries. There is also a time-dependence to the value of the data licensee with the most commercially valuable data being the freshest, in near real-time, while science data (e.g. climate records) can be older with no loss in value.

One of the differences between data and value-added products is that the former are more like public goods and the latter are more like commodities. In general, government should provide data while industry provides value-added products, if there are also non-government customers. The last condition is perhaps the most significant for NASA missions. Decadal science priorities by their nature represent information that does not exist and for which there is no private demand at current technical and market conditions.

NASA Relevance

In principle, NASA has been open to buying (licensing) commercial data for a long time. The idea of promoting greater reliance on commercial goods and services is an old one, going back at least to the 1991 U.S. Commercial Space Policy Guidelines. Data purchases were part of the funded Space Act Agreements for commercial cargo support to the International Space Station. Commercial data purchases were considered for developing lunar landers in the Lunar Cargo Transportation and Landing by Soft Touchdown (Lunar CATALYST) effort using unfunded Space Act Agreements.

Today, NASA Earth Science Division researchers can propose to purchase commercial data using contract or grant funds when the purchased information "is required by, or would substantially enhance, their research activity." As a practical matter, if similar data or information were available in the public domain there would be no point in making the purchase. Some commercial data may already be available under all-government licenses such as those held by NGA. Such licenses exist, for example, for high-resolution commercial optical imagery through the NextView, EnhancedView, and ClearView contracts. Foreign data, particularly radar imagery, are available from Canada, Germany, Italy, and Japan.

If there are commercial data or products that could serve multiple NASA-funded communities and an all-government license does not already exist, NASA program managers can initiate such procurements. It is my understanding that as recently as August 2015, NASA issued a $310,000 contract to DigitalGlobe for procurement of high-resolution imagery from specifically tasked RADARSAT-2 (Canada) and other systems during disasters and other sensitive areas, to augment NASA uses of NGA-supported archived imagery.

Given the complexity of possible data licenses, NASA has to take special care in archiving and distributing commercial data. In accordance with national and international open data policies, NASA makes all non-commercial data freely and openly available through its data systems. When individual scientists (e.g., principal investigators) purchase commercial data products, they generally keep ownership and are governed by their purchase licenses regarding any sub-distribution. When NASA procures commercial data products, it attempts to negotiate the most open license possible, but must respect any contractual restrictions when data products are on NASA data systems.

From a NASA Earth science point of view, the mission is to advance Earth system science and to develop, test, and demonstrate applications for public benefit. The sources of data, value-added products, or other information is not of concern provided the data (and associate metadata) are stable, well-characterized, and of sufficient quality. This is largely similar to the view in the NGA Commercial GEOINT Strategy. If there are non-agency customers who might be able to bear some portion of fixed costs, then the agency can do a make or buy analysis. If the agency is the only customer, as is the case for almost all Decadal Survey Earth science data, then a government build is the only realistic choice. Looking beyond initial data acquisition, commercial providers could be part of data archiving, processing, and analysis functions where government-unique data resides on the same hosting infrastructure as commercial users.

In the case of Landsat, the technical risks in providing the data are well bounded and there are multiple non-NASA users. Given the right incentives, commercial entities could fund the development, test, and operation of systems to provide Landsat continuity data. However, the intent of Congress has been that NASA would develop a next-Landsat satellite, rather than examine the designs of innovative systems and partnerships as recommended by the Decadal Survey. The NASA Appropriations Conference Report for FY 2015 states: "The Committee [Conference] does not concur with various administration efforts to develop alternative ''out of the box'' approaches to this data collection —whether they are dependent on commercial or international partners."[2] In this case, as in 1992, innovation was less of a priority than reduced perceived risk of a gap in Landsat data continuity.

The current policy of free access to Landsat data is working well and I would not try to "commercialize" it. But I do think that innovation is possible in how the data are acquired. While proceeding with Congressional direction to purchase another Landsat satellite, there could be a parallel pilot program to buy Landsat continuity data specifically from a non-Landsat source to demonstrate feasibility. After having some experience, NASA could make a more informed decision about acquiring another spacecraft. Similarly, GPS radio occultation (RO) data were seen as potentially available from private U.S. sources almost two decades ago but partnerships with a foreign government were preferred. A pilot program to purchase GPS RO data to improve atmospheric modeling could enable a more

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[2] U.S. Congress, Omnibus Appropriation Bill and Conference Report for FY2015, H.R. 83, December 11, 2014, Washington, D.C.

informed decision about how and whether to expand the use of such data beyond the current successful partnership with Taiwan and COSMIC satellites.

Public-Private Partnerships

The phrase "public-private partnership" is an increasingly popular one for space activities. Unfortunately, what the term means in any particular case is often hard to discern. It can represent agency hopes that private capital will pay for developments for which it does not have the budget. On the industry side, there may be expectations that the government will reduce potential market and financial risks to enable an otherwise unprofitable venture to proceed. This is not to say that mutually beneficial public-private partnerships cannot exist but rather a clear understanding is needed of the allocation of costs, risks, and benefits on both sides.

In policy, it is instructive to compare the 1991 definition of commercial space activity with the current national space policy:

Compare and Contrast Definitions

U.S. Commercial Space Policy Guidelines
February 11, 1991

Commercial space sector activities are characterized by the provision of products and services such that:

- private capital is at risk;
- there are existing, or potential, nongovernmental customers for the activity;
- the commercial market ultimately determines the viability of the activity; and
- primary responsibility and management initiative for the activity resides with the private sector.

U.S. National Space Policy
June 28, 2010

Commercial Space Guidelines

The term "commercial," for the purposes of this policy, refers to space goods, services, or activities provided by private sector enterprises that

- bear a reasonable portion of the investment risk and responsibility for the activity,
- operate in accordance with typical market-based incentives for controlling cost and optimizing return on investment, and
- have the legal capacity to offer these goods or services to existing or potential nongovernmental customers.

The 1991 definition is stricter in its emphasis on market forces while the 2010 definition is looser to allow for government supports and mixing of public and private goods. In the case of commercial remote sensing, there are a variety of potential benefits, costs and risks to NASA or any government agency. The agency can save development costs and reduce its portion of sustaining fixed costs if a private sector partners has multiple non-agency customers, preferably outside the U.S. government. The private sector need not follow the constraints of federal acquisition regulations and thus may able to operate more efficiently and rapidly. For companies, reliable agency purchases can lower financial and market risks although this depends on the type of contract mechanism.[3]

For both agencies and companies, it is common to find that each wants only to pay the marginal cost of having a capability rather than the average cost. Each will want the other to bear the fixed costs and risks. If the dominant market demand is for a public good, then the burden rightly falls on the government. If the dominant market demand is from the private customers, the burden should be borne by the private sector. In many cases of civil remote sensing, like Landsat, the roughly even balance of public and private demand makes a clear partnership more difficult, not easier.

A notional agency perspective on public-private partnership (PPP) is shown in the strengths-weaknesses-opportunities-threat (SWOT) chart below.

Agency SWOT Perspectives on PPP

Strengths	**Weaknesses**
Potential for cost and schedule efficiencies (costs factors of 3-7x) Attraction of non-government stakeholders to support the partnership	Less opportunity to build in-house expertise Unrealistic or optimistic expectations that misread cost, schedule, and demand and create implicit risks Fewer accountability mechanisms for performance and insight
Opportunities	**Threats**
Allows agency to reallocate attention and resources to higher priority objectives Attraction of private investment that aligns with government missions Allows for more innovative experiments	Policy and budget instability Private investment fails to occur, private providers fail to perform, and public missions placed at risk Becoming captive to a monopoly supplier, lack of government IPR

[3] Either cost-plus or fixed price contracts can work depending on the conditions and allowable margins. Neither is intrinsically better than the other.

The purchase of data as opposed to ownership of a satellite system means a subtle shift in the role of the agency toward being a consumer of what industry chooses to provide rather than a customer who specifies what is to be provided. For agencies, including NASA, there are strengths, weaknesses, opportunities, and threats associated with the use of commercial data and public-private partnerships to meet their mission needs. Among the strengths and opportunities are the potential for cost savings, more rapid innovation, and the alignment of private investment with public good needs. Among the weaknesses and threats are a loss of in-house expertise, dependency on private resources for the performance of public missions, and fewer mechanisms for agency control of cost, schedule, and performance.

Choices for Government Uses of Commercial Data

If the government needs certain kinds of data, an independent and objective "make versus buy" analysis can help decide whether it should own and operate its own system or buy the data from an outside supplier. In some cases, the rights to access and distribute privately owned data for scientific research might simply need to be purchased. The government has no right to free access to other forms of private intellectual property even for purposes of scientific research.

On the other hand, as the experience with Landsat shows, efforts to sell many kinds of space-derived data may make no economic sense. Free distribution of data can result in greater public and private benefits if users are not initially deterred by prices, even low ones. The promotion of commercial remote sensing is sometimes seen as being in competition with the open exchange of scientific data, as defined by the data sharing principles of the Group on Earth Observations. This need not be the case and a "one size fits all" policy should be avoided that either infringes on private property rights or encourages governments to act like for-profit firms.

For policy-makers and industry, a primary task is getting an objective market analysis. Privatization is when industry provides goods and services previously provided by governments. Commercialization is a more difficult task in that industry has to serve private demand in addition to government demand. Meeting private market demand with competing private providers using private capital at risk is the essence of commercialization. It can be difficult to assess the size of addressable markets for new data products and judge the amount of capital required to come to market. Yet doing so is a necessity in deciding whether commercial data buys are viable and sustainable.

For agency leaders, they need to conduct their own analyses of alternatives in how to best meet their mission requirements. In deciding whether to "make" data with their own system or to "buy" data from others, NASA needs to decide how to allocate risks between what it provides and what it expects others to provide, to assess the regret costs if a private provider fails to perform as expected, and what fallback options exist. Most critically, NASA needs to gain and retain in-house expertise to ensure due diligence and oversight of public funds, whether used for traditional acquisitions, public-private partnerships, or commercial purchases.

Concluding Thoughts

Today, NASA is facing both opportunities and challenges in taking advantage of an increasingly sophisticated, innovative commercial remote sensing industry to meet mission needs. Industry capabilities are greater than ever before, but so are the budget pressures and expectations placed on NASA Earth Science to meet the nation's needs for everything from cutting edge science to the sustainment of climate monitoring capabilities and practical social benefits from Earth science.

Agencies are in an extended process of sorting out which roles and responsibilities they are best at performing. Major elements of NASA's Earth science programs will likely remain government-led due to the lack of commercial demand for specialized scientific data. Commercial providers will not soon replace unique platforms, such as those in the A-Train. On the other hand, where NASA needs can be met by commercial data sources, cooperation with other agencies like NGA can increase the government's buying power. Similarly, NASA already acquires weather satellites on behalf of NOAA as it has the internal expertise to do so more efficiently.

In acquiring commercial data, NASA should ensure it gets sufficient rights so that data sets can be shared for scientific, non-commercial purposes. It should also ensure that it has sufficient insight into how the data were generated so that scientific peer review can independently assess conclusions based on those data.

There should be procurement "on-ramps" to enable experimentation and large-scale innovation in parallel with current government systems and international partnerships. In its own self-interest, NASA should be open to alternatives as industry develops. In the long term, it will be more risky to pursue only traditional acquisitions without a mixed portfolio that includes non-traditional and commercial procurements.

Finally, NASA should continue to be a strong domestic and international advocate of preventing interference to the radio spectrum upon which remote sensing relies. Spectrum protection is and will continue to be challenging due to commercial terrestrial communications demand for more spectrum.[4]

Thank you for your attention. I would be happy to answer any questions you might have.

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[4] This particularly includes the Earth Exploration Satellite Service (EESS) used for remote sensing, and the Radionavigation Satellite Service (RNSS) used by GPS.

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Prior to NASA, Dr. Pace was the Assistant Director for Space and Aeronautics in the White House Office of Science and Technology Policy (OSTP). From 1993-2000, Dr. Pace worked for the RAND Corporation's Science and Technology Policy Institute (STPI). From 1990 to 1993, Dr. Pace served as the Deputy Director and Acting Director of the Office of Space Commerce, in the Office of the Deputy Secretary of the Department of Commerce. He received a Bachelor of Science degree in Physics from Harvey Mudd College in 1980; Masters degrees in Aeronautics & Astronautics and Technology & Policy from the Massachusetts Institute of Technology in 1982; and a Doctorate in Policy Analysis from the RAND Graduate School in 1989.

Dr. Pace received the NASA Outstanding Leadership Medal in 2008, the US Department of State's Group Superior Honor Award, *GPS Interagency Team*, in 2005, and the NASA Group Achievement Award, *Columbia Accident Rapid Reaction Team*, in 2004. He has been a member of the US Delegation to the World Radiocommunication Conferences in 1997, 2000, 2003, and 2007. He was also a member of the US Delegation to the Asia-Pacific Economic Cooperation Telecommunications Working Group, 1997-2000. More recently, he has served as a member of the U.S. Delegation to the UN Committee on the Peaceful Uses of Outer Space in 2009, and 2011-15. Dr. Pace has been a member of the NOAA Advisory Committee on Commercial Remote Sensing (ACCRES) since 2012. Dr. Pace is a former member of the Board of Trustees, Universities Space Research Association, a Member of the International Academy of Astronautics, an Associate Fellow of the American Institute of Aeronautics and Astronautics, and a member of the Board of Governors of the National Space Society.