U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON SPACE
SUBCOMMITTEE ON ENVIRONMENT

Exploring Commercial Opportunities to Maximize Earth Science Investments

HEARING CHARTER

Tuesday, November 17, 2015
10:00 a.m. – 12:00 p.m.
2318 Rayburn House Office Building

Purpose

The Subcommittees on Space and Environment will hold a joint hearing titled *Exploring Commercial Opportunities to Maximize Earth Science Investments* on Tuesday, November 17, 2015, starting at 10:00 a.m. in Room 2318 Rayburn House Office Building. The hearing will explore ways NASA can satisfy Earth science data requirements through public-private partnerships, including commercial capabilities.

Witnesses

- **Dr. Scott Pace**, Director of the Space Policy Institute, George Washington University
- **Dr. Walter Scott,** Founder and Chief Technical Officer, DigitalGlobe
- **Mr. Robbie Schingler,** Co-Founder and President, PlanetLabs
- **Dr. Samuel Goward,** Emeritus Professor of Geography, University of Maryland at College Park
- **Dr. Antonio Busalacchi,** Professor and Director of the Earth System Science Interdisciplinary Center, University of Maryland

Background

Overview of NASA Earth Science Program

NASA's Earth Science program is one of four program areas for NASA's Science Mission Directorate (SMD). The purpose of NASA's Earth Science program is to develop a scientific understanding of Earth's system and its response to natural or human-induced changes, and to improve prediction of climate, weather, and natural hazards.[1] The Earth Science Division (ESD) is responsible for coordinating satellite and suborbital missions for long-term global observation of the land surface, biosphere, atmosphere, and

[1] NASA Science Mission Directorate (SMD), Earth Science website available at <http://science.nasa.gov/earth-science/ >, last accessed on November 3rd, 2015.

oceans.[2] NASA missions have helped gain new knowledge and create new capabilities that have led to advances in weather forecasting, storm warnings, and the ability to more efficiently manage agricultural and natural resources. Capabilities and discoveries from NASA's program are often later incorporated into National Oceanic and Atmospheric Administration (NOAA) weather satellites or U.S. Geological Survey (USGS) land-imaging satellites.

NASA's Expanding Earth-Observation Responsibilities

Historically, new Earth remote sensing capabilities have been developed in a process whereby NASA develops first-of-a-kind instruments that, once proved, are considered for continuation by NOAA or the USGS.[3] NASA has viewed extended-phase operations for Earth science missions as "operational" and therefore the purview of NOAA.[4] However, recently NASA's Earth science portfolio has expanded to include new responsibilities for the continuation of several previously initiated measurements that were formerly assigned to other agencies, including data continuity and application focused satellite observation programs.[5] For example, the President's FY16 Budget Request redefines NASA and NOAA Earth-observing satellite responsibilities. Under the proposed framework, NOAA is responsible only for satellite missions that contribute directly to NOAA's ability to issue weather and space weather forecasts and warning to protect life and property. NASA is responsible for all other non-defense Earth-observing satellite missions. The near term impact of this revised framework includes the transfer of responsibility for TSIS-1 (Total and Spectral Solar Irradiance Sensor), Ozone Mapping & Profile Suite (OMPS), JPSS-2 Radiation Budget Instrument (RBI), and future ocean altimetry missions to NASA.[6]

Another example of increased NASA responsibilities is the Sustainable Land Imaging (SLI) program. The purpose of SLI is to provide data continuity to the Landsat missions. Landsat has provided 42 years of space-based medium resolution (15-30 meters) global land-remote sensing measurements. Landsat is a unique resource for those who work in agriculture, geology, forestry, regional planning, education, mapping, and global change research. Under SLI, NASA is responsible for development, launch, and check-out of Landsat 9, along with technology investments and detailed system engineering to design and building a full-capability Landsat 10 satellite.[7,8] However, in the past, both USGS and NOAA have been responsible for development and operation of Landsat satellites.[9]

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[2] Ibid.

[3] National Research Council, *Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond* (2007), at pg. xiii in the preamble.

[4] Ibid.

[5] National Academies of Sciences, *Continuity of NASA Earth Observations from Space: A Value Framework* (2015) at pg.1.

[6] President's Budget Request for NASA Fiscal Year 2016 for the Earth Science's Program at ES 37.

[7] President's Budget Request for NASA Fiscal Year 2016 at SCMD 5.

[8] Ibid.

[9] Under Presidential Directive/NSC-54 (Nov. 16, 1979) NOAA was assigned management responsibility for civil operational land remote sensing activities. However, operational management was not transferred

As stated in a recent National Academies report issued last month:

> *Starting in fiscal year 2014, the Administration directed NASA to assume responsibility for a suite of climate-relevant observations for the purpose of continuing a multi-decadal data record in ozone profiling, Earth radiation budget, and total solar irradiance. These measurements were to have been implemented by NOAA with the Radiation Budget Instrument (RBI) and the Ozone Mapping and Profiler Suite Limb profiler (OMPS-L) on NOAA's Joint Polar Satellite System 2 (JPSS-2) series, and the Total Solar Irradiance Instrument 2 (TSIS-2) instrument flown separately.* ***NASA received a one-time funding increment of $40 million in 2014 for these instruments; however, this is only a fraction of the estimated $200-$300 million cost for their implementation.*** *[emphasis added] Further, the Senate Appropriations Committee initiated a budget bill (not passed) that directed the development costs and responsibilities for the Deep Space Climate Observatory (DSCOVR) and Jason-3 to be transferred from NOAA to NASA ESD.…Pressures on the budget also come from a backlog of decadal survey-recommended missions (NRC, 2012) and an increasing demand for Earth observations to support societal applications (NSTC, 2014).* [10]

NASA Earth Science Program Budget

Table 1. NASA Science Mission Directorate Budget FY07-FY15[11]

Budget Authority ($ in Millions)	FY2007	FY2008	FY2009	FY2010	FY2011	FY2012	FY2013	FY2014	FY2015
NASA Total	16,285	17,309	17,782.4	18,724	18,448	17,770	16,879	17,647	18,010.2
Science Total	4,609.9	4,706.2	4,503.0	4,498	4,920	5,074	4,782	5,151	5,244.7
Earth Sciences	1,198.5	1,280.3	1,379.6	1,439	1,722	1,761	1,659	1,826	1773
Planetary Sciences	1,215.6	1,247.5	1,325.6	1,364	1,451	1,501	1,275	1,345	1438
Astrophysics	1,365.0	1,337.5	1,206.2	647	631	648	617	668	685
James Webb Telescope	N/A	N/A	N/A	439	477	519	628	658	645.4
Heliophysics	830.8	830.8	591.6	608	639	645	603	654	662

from NASA to NOAA until 1983. In 1998, the management of the Landsat 4 (and Landsat 5) operations contract was transferred from NOAA to the USGS; operations were continued by the private sector until mid-2001when Space Imaging (formerly EOSAT) returned the operations contract to the U.S. Government. See NASA Landsat Science website at <http://landsat.gsfc.nasa.gov/?p=3178>, last accessed on November 3rd, 2015.

[10] National Academies of Sciences, *Continuity of NASA Earth Observations from Space: A Value Framework* (2015) at pg.7.

[11] Note 1: These budget numbers reflect subsequent operating plan changes. Note 2: Both FY2008 and FY2009 appear to omit supplemental appropriations (including ARRA in FY2009, which was substantial: $400 million for SMD, of which $325 million for Earth Science).

NASA's Earth Sciences budget is the largest and fastest growing of all SMD budget line items. NASA's Earth Sciences budget has increased approximately 63 percent since 2007.[12]

Table 2. NASA Science Mission Directorate Appropriations, FY2015-FY2016, and Authorizations, FY 2016

Budget Authority ($ in millions)	FY2015 Enacted	FY2016 Requested	FY2016 House Approp.	FY2016 Senate Approp.	FY 2016 H.R.2039 Authorization	FY 2016 H.R. 2039 Authorization
NASA Total	18,010.2	18,529.1	18,529	18,290	18,529	18,010
Science Total	5,244.7	5,288.6	5,238	5,295	4,952	4,679
Earth Sciences	1,773	1,947	1,683	1,932	1,450	1,199
Planetary Science	1,438	1,361	1,557	1,321	1,500	1,500
Astrophysics	685	709	736	731	731	709
JWST	645	620	620	620	620	620
Heliophysics	662	651	642	650	651	651

NASA proposes to spend about $1.947 billion on Earth Sciences in Fiscal Year (FY) 2016, an increase of about $174 million, or about 10 percent, from FY 2015.[13]

NASA Earth Science and Public-Private Partnerships

Public-Private partnerships "generally [are] recognized [to exist] wherever there is a contractual relationship between the public sector and a private sector company designed to deliver a project or service that traditionally is carried out by the public sector."[14] In practice, public-private partnerships can take a variety of forms.[15] Within the context of public-private partnerships for the production and delivery of satellite remote sensing data for scientific research, such forms could include redistributor-end user agreements and "anchor tenant" relationships in which the public sector guarantees that it will be a customer of commercial remote sensing enterprises.[16]

NASA's Earth observation program is the largest U.S. government civil remote sensing effort and largest civil remote sensing effort of any nation in the world. NASA currently operates 26 Earth observation satellites, with 12 currently under development.[17] NASA has partnerships with both government and non-government user-communities, domestic and international, to access NASA data provided by these satellites. It has a number of

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[12] In FY07, NASA's Earth Science program was appropriated about $1.198 billion. In 2015, the President's FY16 Budget Request for NASA's Earth Science program is about $1.947 billion, a 62.5% increase over FY 2008 appropriation. See NASA's Historical Budgets on NASA's webpage available at < http://www.nasa.gov/news/budget/index.html>, last accessed on November 3rd, 2105.
[13] President's Budget Request for NASA Fiscal Year 2016 for the Earth Sciences.
[14] Diane Howard, "Achieving a Level Playing Field in Space-Related Public-Private Partnerships: Can Sovereign Immunity Upset the Balance?" 73 J. Air L. & Com. 723 (2008)
[15] Ibid.
[16] National Research Council, *Toward New Partnerships in Remote Sensing* (2002) at pg.2.
[17] NASA Science Mission Directorate (SMD), Earth Science, Missions webpage available at http://science.nasa.gov/earth-science/, last accessed on November 3rd, 2015.

public-private partnerships on subjects such as data analytics, data visualization, and geospatial products.[18] However, none of NASA's Earth observation satellites, either in operation or under development, are public-private partnerships. NASA does have a program in place to procure commercial satellite Earth observation data under the 1998 Science Data Buy Program, but the program has not been used by NASA for over a decade (discussed in more detail below).

Examples of Government Acquisition of Earth Observation Data through Public-Private Partnerships

TerraSAR-X: TerraSAR-X is a radar Earth observation satellite that was funded jointly by government and industry and launched in 2007. The German space agency, DLR, placed the satellite contract, provided about 80 percent of the financing, and coordinates the scientific use of the satellite's Earth observation data. The remaining 20 percent of the funding was contributed by a company, Astrium, which built the satellite and markets the satellite data. This was first public-private partnership in the German Earth observation space sector. Prior to TerraSAR-X, remote-sensing and climate research satellites in Germany were funded entirely with public money. TerraSAR-X was proven as a successful public-private partnership model and was followed on in 2010 by TanDEM-X, a second almost identical spacecraft to TerraSAR-X.[19]

RADARSAT-2: Launched in December 2007, Canada's next-generation commercial radar satellite offers powerful technical advancements that enhance marine surveillance, ice monitoring, disaster management, environmental monitoring, resource management, and mapping in Canada and around the world. This project represents a public-private partnership between government and industry. MacDonald, Dettwiler and Associates Ltd. (MDA) owns and operates the satellite and ground segment. The Canadian Space Agency (CSA) helped fund the construction and launch of the satellite and recovers this investment through the supply of RADARSAT-2 data to the Government of Canada during the lifetime of the mission.[20]

Worldview: DigitalGlobe is an American commercial vendor of space imagery and geospatial content, and operator of civilian remote sensing spacecraft. It builds and operates a number of spacecraft, including Worldview-1, Worldview-2, and Worldview-3. Worldview-3 is the commercial remote sensing industry's first multi-payload, super-spectral, high-resolution commercial satellite and the most powerful commercial remote

[18] NASA Report, *Public-Private Partnerships for Space Capability Development, Driving Economic Growth and NASA's Mission* (April 2014), available online at <https://www.nasa.gov/sites/default/files/files/NASA_Partnership_Report_LR_20140429.pdf >, last accessed on November 3rd, 2015.

[19] German Aerospace Center information sheet on TerraSAR-X, "TerraSAR-X – First Satellite Funded by Public and Private Sector," available at <http://www.dlr.de/en/Portaldata/28/Resources/dokumente/re/TerraSAR-X_PPP_engl.pdf>, last accessed on November 3rd, 2015.

[20] Canadian Space Agency webpage, Activities Sectors, RADARSAT-2, available at < http://www.asc-csa.gc.ca/eng/satellites/radarsat2/>, last accessed on November 3rd, 2015.

sensing satellite in-orbit.[21] DigitalGlobe has a public-private partnership through contracts with the National Geospatial Agency. The U.S. Government acts as an anchor tenant for DigitalGlobe, providing sufficient assurance of future revenues for the company to finance, build, own, and operate its commercial satellites. In return, DigitalGlobe provides Earth observation remote sensing data, products, and services that support Federal intelligence, military, and civil agency missions.

National Law and Policy Directing Commercial Use of Space

U.S. law and national policy directs NASA to advance the commercial space sector. Pursuant to the National Aeronautics and Space Act, NASA shall "seek and encourage, to the maximum extent possible, the fullest commercial use of space."[22] NASA is also directed "to the extent possible and while satisfying the scientific or educational requirements of the Administration, and where appropriate, of other Federal agencies and scientific researchers, acquire, where cost-effective, space based and airborne Earth remote sensing data, services, distribution, and applications from a commercial provider."[23] NASA is required to "develop a sustained relationship with the United States commercial remote sensing industry and, consistent with applicable policies and law, to the maximum practicable, rely on their services."[24]

A principle of United States National Space Policy is that "the United States is committed to encouraging and facilitating the growth of a U.S. commercial space sector that supports U.S. needs, is globally competitive, and advances U.S. leadership in the generation of new markets and innovation-driven entrepreneurship."[25]

The July 2014 National Plan for Civil Earth Observations, states the following policy: [26]

> *Federal agencies will identify and pursue cost-effective commercial solutions to encourage private-sector innovation while preserving the public-good nature of Earth observations. U.S. agencies will consider a variety of options for ownership, management, and utilization of Earth observation systems and data, including managed services (Government-Owned/Government-Operated, Government-Owned/Contractor-Operated, or Contractor-Owned/Contractor-Operated), commercially hosted payloads, commercial launch, commercial data buys, and commercial data management. In developing such options, agencies will preserve the principles of full and open data sharing, competitive sourcing, and best*

[21] Digital Globe, WorldView-3 Datasheet, available at < https://dg-cms-uploads-production.s3.amazonaws.com/uploads/document/file/95/DG_WorldView3_DS_forWeb_0.pdf>, last accessed on November 3rd, 2015.
[22] 51 USC § 20112(a)(4)
[23] 51 USC §50115(a)
[24] 51 U.S.C. §60302
[25] White House, U.S. National Space Policy (June 28, 2010)
[26] Executive Office of the President, Office of Science and Technology Policy, *National Plan for Civil Earth Observations*, July 2014, p. 26.

value in return for public investments within legal and financial constraints.

The 2015 National Space Weather Action Plan, as proposed by the Administration, directs Federal agencies to consider commercial solutions to sustain current operational satellite observing capabilities and recognizes that increased access to commercial space-weather observational infrastructure is of mutual benefit to the United States and its partners.[27]

1998 Science Data Buy Program

The passage of the Commercial Space Act of 1998 called on NASA to acquire, when cost-effective, space-based and airborne Earth remote sensing data, services, distribution, and applications from commercial providers.[28] Congress appropriated $50 million in FY1997 to procure a mix of products and services, and NASA proceeded to implement this activity through the Commercial Remote Sensing Program (CRSP) office at the NASA Stennis Space Center in Mississippi.[29] Under the aegis of an experimental Science Data Purchase Program (SDB), scientists received data obtained from commercial providers in support of NASA's Earth Sciences research programs. However, NASA has not requested and Congress did not appropriate additional funding to continue the program in subsequent fiscal years.[30]

According to the RAND Corporation report from 2000, "In terms of commercial response and quality of products and services, the SDB has been an experimental success in meeting its requirements—some observers were initially skeptical that industry could or would be able to respond in a useful way. However, NASA has not requested and Congress has not allocated any additional funds for the program to continue. NASA has said that it will purchase science data from commercial sources, rather than build new satellites, when these data sources meet Earth Science Enterprise science requirements and are cost effective."[31]

National Research Council Reports

NASA relies on the science community to identify and prioritize leading-edge scientific questions and the observations required to answer them. One principal means by which NASA's Science Mission Directorate engages the science community in this task is through the National Research Council (NRC). The NRC conducts studies that provide a science community consensus on key questions posed by NASA and other U.S. Government agencies. The broadest of these studies in NASA's areas of research are

[27] White House, National Space Weather Action Plan (October 2015)
[28] P.L. 105-303, Sec. 107 (Oct. 28th, 1998)
[29] Scott Pace, David Frelinger, Beth Lachman, Arthur Brooks, and Mark Gabriele (2000). *The Earth Below: Purchasing Science Data and the Role of Public-Private Partnerships*. DB-316-NASA/OSTP Science and Technology Policy Institute, p. vii.
[30] Congress did, however, under the NASA Authorization Act of 2000, Sec. 125, authorize for fiscal years 2001 and 2002 $25,000,000 for the Commercial Remote Sensing Program for commercial data purchases.
[31] Ibid.

decadal surveys. As the name implies, NASA and its partners ask the NRC once each decade to look out ten or more years into the future and prioritize research areas, observations, and notional missions to make those observations. The NRC completed its first decadal survey for Earth Science, *Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond* in January 2007 at the request of NASA, NOAA, and USGS. The next Earth science decadal survey is scheduled for 2017.

2007 Earth Science Decadal

The 2007 NRC decadal survey of Earth Science, *Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond*, found that:

> "An emerging source of data is the commercial sector. In the past, a program of Earth observations was associated almost exclusively with government-managed or government-sponsored projects. Today, commercial sources of Earth information are rapidly increasing in availability and scope. Commercial satellite systems are now reliable sources of high-resolution Earth imagery, and commercial remote-sensing companies have greatly expanded their offerings. An important example is evident in the emerging Internet geospatial browsers and Web portals, best exemplified by Google Earth and Microsoft Virtual Earth. The new technologies increase dramatically the ability to communicate Earth information to consumers, to share data and information among diverse groups, and to receive feedback from the end users of Earth information. Much of this capability is available for free. A long-term plan for Earth observations and information needs to account for the new sources; they promise to reduce the cost of Earth observation and to introduce new and different ways of looking at Earth.
>
> In reviewing the progress of commercial data providers in obtaining Earth observations and their potential applicability to the decadal plan, the committee sought input on providers of data from both space-based and airborne sources. The detailed and thoughtful responses of two groups indicated a clear expectation for rapidly evolving capabilities over the next decade, including imagery with increasingly fine spatial resolution and substantial improvements in geolocation accuracy. Prices are expected to drop as sources proliferate, and enhanced spectral capability is anticipated, with the possibility that hyperspectral data could become available from commercial sources. Constellations of imaging satellites, designed to reduce intervals between observations, are envisioned. Radar imagery would become widely available, with highly accurate global digital elevation models constituting one product. Much of the demand for such imagery will come from rapidly emerging consumer geospatial Internet applications, but the scientific community should also be able to take advantage of these data sets to complement those obtained with other observing systems."[32]

[32] National Research Council, *Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond* (2007), p. 70.

Toward New Partnerships in Remote Sensing: Government, the Private Sector, and Earth Science Research (2002)

In 2002, the NRC published *Toward New Partnerships in Remote Sensing: Government, the Private Sector, and Earth Science Research*.[33] This report identified several approaches to public-private partnerships and other commercial involvement in Earth science. It also reviewed lessons learned from the commercial data purchase program and the SeaWiFS instrument. It made a number of recommendations, including:

- The government partner in a public-private partnership should negotiate in its contract for open scientific distribution and reuse of data obtained under the partnership.
- NASA should permit any academic scientist to compete for data under the Science Data Buy or successor programs.
- Existing remote sensing data series—for example, the Landsat series—within current or anticipated public-private partnerships should be maintained to provide comparable data for scientific research over time. Support should also be made available for research in either the scientific community or the private sector or both on how to generate seamless transitions from one data source to another as new sensor replace past or current sensors.
- Data produced by the private sector in a public-private partnership should be archived for subsequent redistribution to scientists and for creating long time series of data. The government partner should negotiate for permission to do this.
- Public-private partnerships to acquire data for scientific research should ensure that the partnership agreement specifies who has responsibility for calibrating and validating the data, what the scope of the calibration and validation processes is, and what resources (financial, technical, and personnel) will be made available for these purposes.
- In the process of negotiating a public-private sector data partnership, the parties should agree to use commonly accepted standards for metadata, data formats, and data portability.
- The government should facilitate direct communication between members of the scientific community and the private sector, including communication during the early stages of planning for public-private remote sensing programs.
- Representatives of government agencies and commercial firms involved in public-private partnerships, together with scientists who use the data in these programs, should define performance measures at the time the public-private partnership is established. These performance measures should be taken into account in formal program evaluations.

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[33] National Research Council, *Toward New Partnerships In Remote Sensing: Government, the Private Sector, and Earth Science Research* (2002).

- Public-private partnerships for producing scientific data should practice realistic cost accounting, making all the costs of the partnership transparent and open to negotiation.

Other Agency Approaches to Commercial Public-Private Partnerships

National Geospatial Agency

In October 2015, the National Geospatial-Intelligence Agency (NGA) released a *Commercial GEOINT Strategy*. According to the NGA, "the remote-sensing industry's evolving global coverage, rapid revisit rates, diverse spectral content, aggregation of open source venues, and growing analytical capabilities will allow NGA to embrace emergent commercial capabilities with the same dynamism that they embraced National Technical Means decades ago."[34] This strategy recognizes two realities that are in dynamic tensions: (1) real innovation is fueled by diversity, and (2) fiscal resources have become more constrained and will remain so.[35] NGA's strategy articulates both customer-focused objectives and a set of implementation imperatives that guide the actions necessary to achieve these objectives. Among these are to explore, experiment, and evaluate commercial data and products, acquire mission relevant commercial capabilities, and adopt and institutionalize commercial capabilities as a core component of their mission.[36] The strategy also lays out key milestones with timelines, objectives, and outcomes sought.

National Oceanic and Atmospheric Administration

In September 2015, the National Oceanic and Atmospheric Administration (NOAA) released a draft commercial space policy for review. According to NOAA, "The policy seeks to establish broad principles for the use of commercial space-based approaches for NOAA's observational requirements, and to potentially open a pathway for new industry to join the space-based Earth observation process.[37] Public comments on this draft policy were due on October 1st, 2015, and NOAA is currently in the process of reviewing comments and preparing a final policy.

Issues

In light of NASA's increasing responsibilities for the continuation of several previously initiated measurements that were formerly assigned to other agencies, how can NASA leverage public-private partnerships to maximize its existing funding levels to satisfy its primary Earth science mission?

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[34] National Geospatial-Intelligence Agency (NGA), *Commercial Geoint Strategy*, October 2015.
[35] Ibid.
[36] Ibid.
[37] NOAA press released on release of draft commercial space policy, posted online at NOAA's Office of Space Commercialization website (September 1, 2015), available at <http://www.space.commerce.gov/noaa-releases-draft-commercial-space-policy/>, last accessed on November 3rd, 2015.

How have technological advancements impacted the viability of commercial public-private partnerships for the provision of space-based Earth observation data to meet NASA program requirements?

What steps should be taken to initiate constructive dialogue between NASA and the private sector on developing alternatives to NASA procurement of Earth observation satellites?

Is there a viable public-private partnership alternative to the proposed Landsat 9 upgraded rebuild of Landsat 8?

What lessons can be learned from NASA's Scientific Data Purchase (SDP) program?