Commercial Alternatives to Traditional NOAA Satellite Data Procurement

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Abstract

The National Oceanic and Atmospheric Administration (referred to as "NOAA" or "the Agency") provides operational weather data through its remote sensing satellites. Acquisition cost overruns of new systems, however, have led to an impending gap in satellite capabilities. While NOAA has developed strategies to mitigate the anticipated effects of this satellite coverage gap, the Agency's future success lies in utilizing commercial options to augment its large systems.

NOAA has the ability to purchase commercially operated remote sensing satellite data, secure hosted payloads on commercial satellites, and/or disaggregate its space systems by launching constellations of smaller satellites. In the near future, NOAA should pursue sources of commercially available operational weather data. Over time, the Agency should work to develop a diversified portfolio of satellite capabilities to include hosted payloads and smaller, disaggregated systems. Through this balanced approach, NOAA will be able to ensure its operational requirement of providing data to the United States for weather prediction.

Introduction

This paper investigates commercially available alternatives to NOAA's traditional means of procuring weather data via satellite. Acquisition cost overruns of new systems, however, have led to an impending gap in satellite capabilities. This situation is further described in the report below. As such, this paper does not address the gap directly. Rather, the paper looks at alternative options available on the commercial market in the short and long-term. Mitigating this gap in coverage, therefore, implicitly catalyzed this report.

The report begins with a section describing the operational background of NOAA. Then it describes the agency's current state of affairs and problems. The report then includes NOAA's current response to its problem and the project team's policy response. It then describes the short and long-term commercially viable options for satellite weather prediction data. The report concludes with an overview of the policy recommendations and the shortcomings of the project.

Background

NOAA is a vital government agency providing weather, water, and climate information for the public and private sectors. The Agency's strategic priorities include the following: enhancing its climate services; supporting coastal and marine spatial planning; ensuring sustainability of marine fisheries; sustaining satellite-based Earth observations; and strengthening Arctic science and service.[1]

[1] NOAA, "FY2013 Budget Summary," Accessed 1 April 2013, Available Online: http://www.corporateservices.noaa.gov/nbo/fy13_bluebook/noaaBlueBook_2013_Web_Full.pdf

While the Agency provides invaluable resources both domestically and internationally, it faces difficult decisions amidst fiscally constrained government operations. NOAA is housed under the Department of Commerce and is tied to the budget determination and the subsequent politics and hierarchy of the Department. NOAA has requested a budget of approximately $5.4 billion for Fiscal Year (FY) 2014 for its entire agency.[2]

It is important to distinguish NOAA is a separate agency from the National Aeronautics and Space Administration (NASA). NASA is a mission-based agency focused on research, development, and the launching of space-based instruments. NOAA is an operational agency concentrated on managing existing space-based operations and disseminating the acquired satellite data.[3] NASA and NOAA had a formal relationship for satellite development between 1973 and 1981 through the Operational Satellite Improvement Program (OSIP). This technology transfer and engineering knowledge between the federal agencies provided substantial assistance to NOAA's satellite programs. However, when it dissolved, NOAA lost access to most of NASA's satellite development processes. A 1997 Government Accountability Office (GAO) report cited the termination of OSIP as the one of the leading causes for NOAA's technical problems, cost overruns, and schedule delays.

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[2] NOAA, "Statement from Dr. Kathryn Sullivan on NOAA's FY 2014 Budget Request," 10 April 2013, Accessed 1 May 2013, Available Online: http://www.noaanews.noaa.gov/stories2013/20130410_budget_statement.html.

[3] National Research Council. "Assessment of Impediments to Interagency Collaboration on Space and Earth Science Missions," Washington, D.C.: National Academy of Sciences, (2011): 24-26.

This GAO report further comments that many of the technical problems currently faced by NOAA could be remedied with experimental precursor programs similar to OSIP.[4]

The National Environmental Satellite, Data, and Information Service (NESDIS) is the division of NOAA tasked with the responsibility of managing and operating weather and environmental monitoring satellites. NOAA is required by law to not privatize weather prediction data, and therefore uses the NESDIS satellites to provide data to the National Weather Service (NWS).[5] NESDIS "manages NOAA's operational environmental satellites; operates the NOAA National Data Centers; provides data and information services including Earth system monitoring; performs official assessments of the environment; and conducts related research."[6] NESDIS requested $2.186 million in the FY14 President's budget.[7] The following graphic shows the organizational structure of NOAA and NESDIS within this structure.

[4] *Ibid.*

[5] NOAA, "Policy on Partnerships in the Provision of Environmental Information, " Accessed 1 May 2013, Available online: http://www.noaa.gov/partnershippolicy/.

[6] The European Organization for the Exploitation of Meteorological Satellites, "EUMETSAT International Partners," Accessed 6 April 2013, Available Online: http://www.eumetsat.int/Home/Main/AboutEUMETSAT/InternationalRelations/InternationalAgreements/SP_2012013016305633?l=en.

[7] NOAA, "Mary Kicza's Remarks on FY2014 Budget," Accessed 1 May 2013, Available Online: http://www.nesdis.noaa.gov/pdf/FY_2014_PB_Mary_Kicza.pdf.

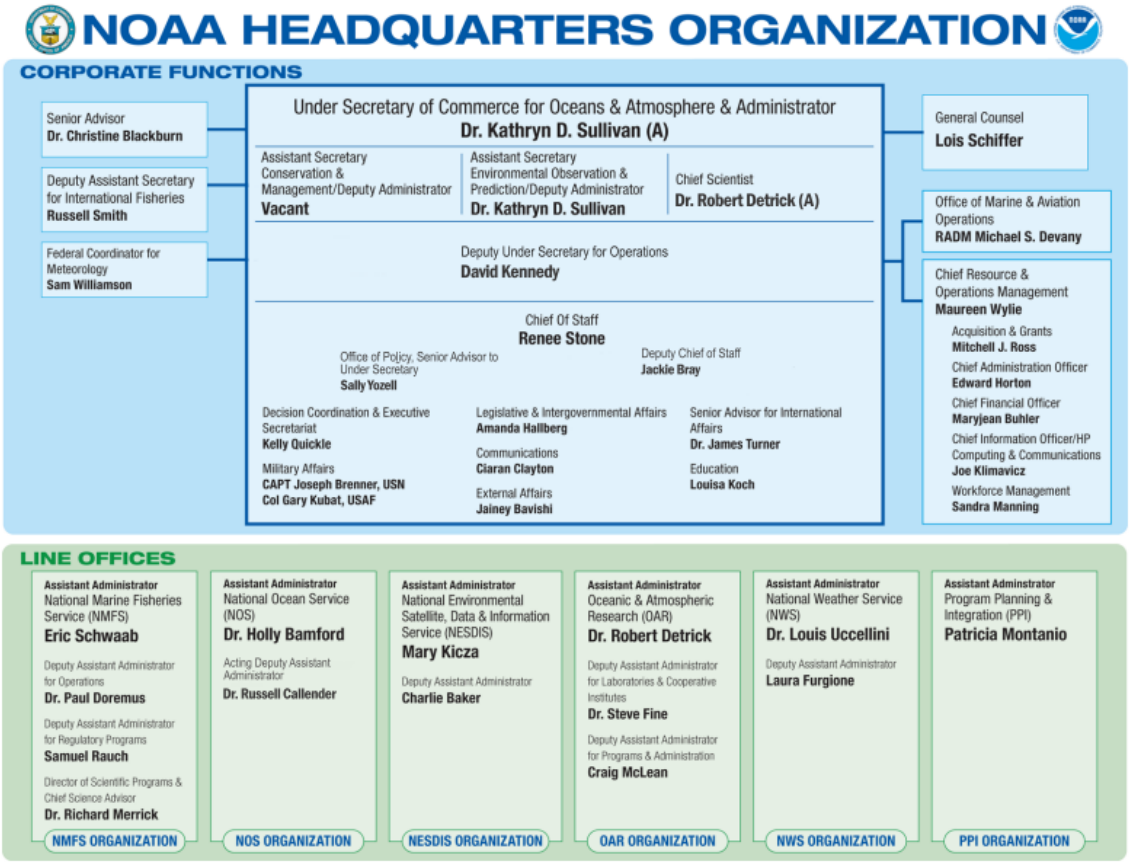

Figure 1: NOAA Organizational Chart (As of May 2013)[8]

NESDIS manages two groups of environmental satellites – Geostationary Operational Environmental Satellites (GOES) and Polar-orbiting Operational Environmental Satellites (POES). "Both types of satellites are necessary for providing a complete global weather monitoring system."[9]

[8] NOAA, "NOAA Headquarters Organization," Accessed 1 May 2013, Available Online: http://www.pco.noaa.gov/org/noaaOrganization.pdf.

[9] The European Organization for the Exploitation of Meteorological Satellites, "EUMETSAT International Partners," Accessed 6 April 2013, Available Online: http://www.eumetsat.int/Home/Main/AboutEUMETSAT/InternationalRelations/InternationalAgreements/SP_2012013016305633?l=en.

Geostationary satellites maintain a fixed position and orbit at the same speed as the Earth, thus allowing for continuous monitoring over time of the same geographic area of the planet. For example, GOES are used to track storms or assist in search and rescue operations. NOAA expects the next generation of these satellites, GOES-R, to be ready for launch in 2015 and to provide enhanced resolution and timelines of imagery.

Polar-orbiting satellites, on the other hand, provide global data by orbiting the Earth in a north-south orbit. These satellites are generally used to provide research data for longer-term forecasting such as ozone depletion and drought conditions relating to climate change. Moreover, polar satellites gather a broad range of data, which are used "for remotely determining information about the earth's atmosphere, land surface, oceans, and the space environment."[10]

NOAA currently maintains one operational POES, while the Department of Defense (DOD) through the Air Force manages two polar orbiting satellites. The U.S. also relies on a European satellite, Meteorological Operational (MetOp). These combined operations provide observational coverage for the early morning, midmorning, and early afternoon time periods. In addition, "six older satellites are

[10] Government Accountability Office, "GAO Report to the Committee on Science, Space, and Technology, House of Representatives, "Polar-Orbiting Environmental Satellites: Changing Requirements, Technical Issues, and Looming Data Gaps Require Focused Attention," (GAO, 2012). Accessed 1 May 2013, Available Online: http://www.gao.gov/assets/600/591643.pdf.

in orbit that still collect data and are available to provide limited backup to the operational satellites should they degrade or fail."[11]

Current State of Affairs/Problem

The most critical issue facing NOAA is the potential satellite coverage gap of the polar orbiting satellites in the afternoon orbit. This is caused by the expected service life of the current polar satellite and when its replacement will become fully operational. NOAA officials suggest that the anticipated gap in coverage between the retirement of the current polar orbiting satellites and the operation of the replacement Joint Polar Satellite System (JPSS) program could be anywhere between 12 to 24 months. According to GAO reports, the gap in coverage could be anywhere between 17 to 53 months depending of the survivability of the current satellite's operation and any postponement in launching or operating the replacement system.[12] The following chart shows the most recent schedule for launches of NOAA's polar satellites.

[11] *Ibid*

[12] US Department of Commerce – Office of the Inspector General, "National Oceanic and Atmospheric Administration: Audit of the Joint Polar Satellite System," Accessed 1 May 2013, Available Online: http://www.oig.doc.gov/OIGPublications/OIG-12-038-A.pdf.

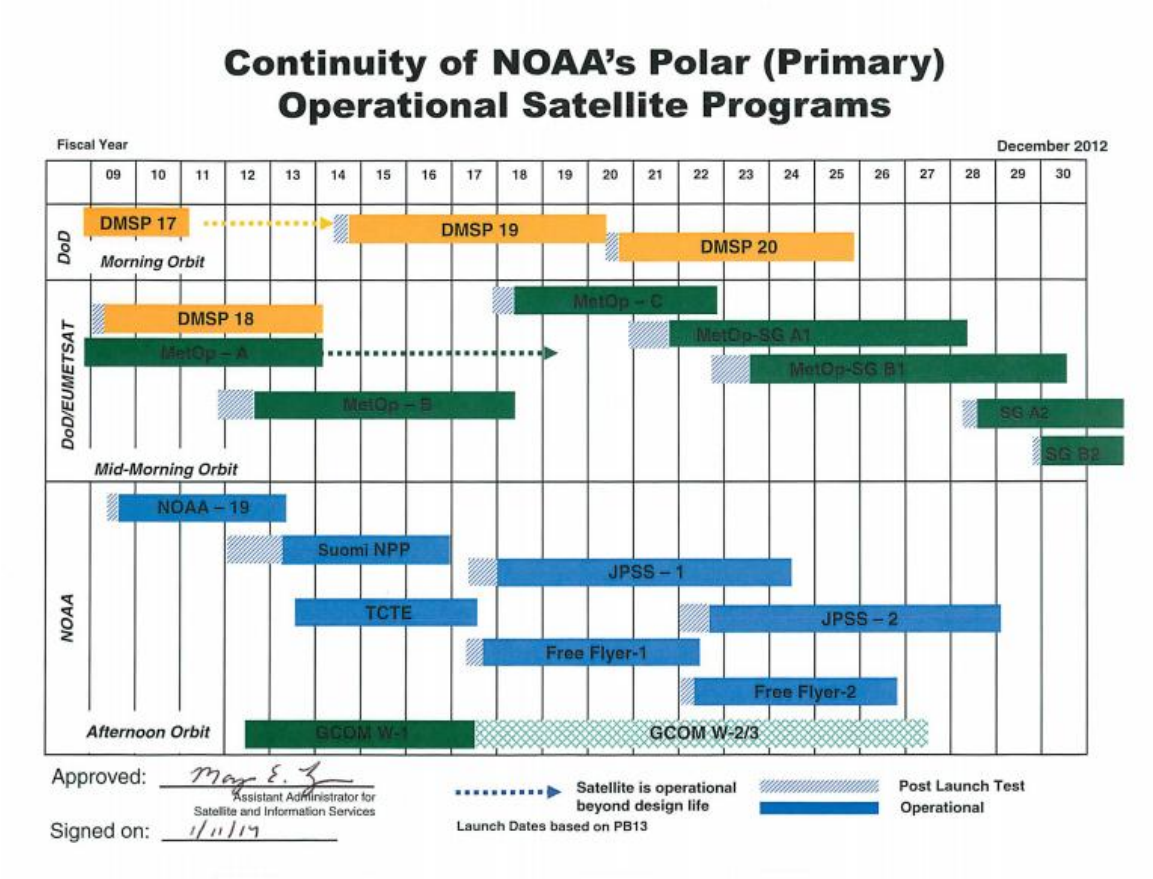

Figure 2: NOAA's Polar Satellite Operation Schedule[13]

NOAA faces this gap because its satellite acquisition strategy relied on the delivery of the failed National Polar-orbiting Operational Environmental Satellite System (NPOESS). A 1994 Presidential Decision Directive created NPOESS to merge NOAA's POES system and DOD's Defense Meteorological Satellite Program (DMSP). The goal was to create a combined DOD/NOAA satellite system for providing global weather and climate information for both civilian and military use. This effort was focused on reducing cost of satellite data by reducing redundancies in the national

[13] NOAA, "JPSS Fly Out," Accessed 1 May 2013, Available Online: http://www.jpss.noaa.gov/pdf/JPSS-flyout.pdf.

system through consolidation of the DOD and NOAA POES satellites.[14] The NPOESS program's cost of development was estimated at $6.5 billion in 2002; however, due to various technical and managerial issues, the total cost of the project inflated to $12 billion. As a result, NPOESS was forced to reduce it capacity from six satellites to four satellites. Prior to its dissolution, the official baseline life cycle cost estimate was $13.9 billion.[15]

As a result of cost overruns and setbacks in procurement, launch, and management of NPOESS, the President, with consultation from an Independent Review Team (IRT) and Congressional Committees, restructured the NPOESS project on February 1, 2010 separating the NOAA and DOD partnership. NOAA now has a continued reliance upon its existing JPSS system.

A report released by the Office of Inspector General of the Department of Commerce raised concerns about the lack of a clearly defined capacity for the JPSS satellites. Lack of specific capacity has led to uncertainty about the overall cost of the project, forcing numerous reconsiderations about the satellites' future capabilities. Major recommendations by the Office of Inspector General included the following: allocating enough resources within NOAA to completely develop the system requirements for JPSS-1 and 2; developing the cost-estimating structure of

[14] The White House, "Restructuring the National Polar-orbiting Operational Environmental Satellite System," 1 February 2010, Accessed 1 May 2013, Available Online: http://www.whitehouse.gov/sites/default/files/npoess_decision_fact_sheet_2-1-10.pdf.

[15] *Ibid.*

the satellites and associated support infrastructures; and documenting the program acquisition strategy for JPSS-3 and 4. The JPSS program has stalled due to "dysfunctional project management and budgetary limitations under the current fiscal situation."[16]

While NOAA is currently focused on mitigating the problems associated with this gap in weather satellite coverage, this policy assessment is geared towards future satellite acquisition strategies using commercially available alternatives. This analysis enables NOAA to operate into the future without finding itself in a similar conundrum.

Current Policy Response by NOAA

NOAA representatives have addressed the public about the risks and problems associated with a gap in satellite coverage. As of June 2012, NOAA reported its intent to maximize the use of existing satellites, stating there was no viable alternative to the JPSS program. GAO found NOAA's gap mitigation efforts insufficient and requested a more comprehensive plan to reduce or eliminate the satellite gap, including options to acquire supplemental data from other governmental, commercial, or foreign satellites.[17]

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[16] US Department of Commerce – Office of the Inspector General, "National Oceanic and Atmospheric Administration: Audit of the Joint Polar Satellite System," Accessed 1 May 2013, Available Online: http://www.oig.doc.gov/OIGPublications/OIG-12-038-A.pdf.

[17] *Ibid.*

In September 2012, NOAA released a report outlining several plans to reduce the satellite gap problem in response to the GAO inquiry. The action-plans included a comprehensive review of requirements and prioritization, an investigation on how to maximize the life of the Suomi-NPP satellite, options to accelerate the development of the second JPSS satellite, and the establishment of solutions for the coverage gap until the first JPSS satellite is launched.

Statement of Policy

Assuming NOAA's current GOES and POES Satellite Acquisitions (including the future Joint Polar Satellite System), we recommend the following with regards to commercial options to supplement/replace future satellite systems:

- In the short-term (1-5 years), NOAA should procure satellite imagery data from commercially available satellite sources.
- In the long-term (5-10 years), NOAA's future satellite acquisition strategy should include hosted payloads and a disaggregated satellite system.

Policy Assessment

NOAA NESDIS faces operational challenges amidst a tight budget, as a result of sequestration and satellite program cost overruns. The agency needs to have a comprehensive plan – a technological roadmap – for its future capabilities. Commercial options do exist, but NOAA does not yet know if they will ensure lower costs. Only through industry and government collaboration will the Agency be able to provide cost-effective weather data. The following recommendations, as a result, will enable NOAA's sustained ability to provide NWS with weather prediction data.

Short Term – Commercial Data Procurement

In the next 1-5 years, NOAA should purchase data from commercial satellite operators to supplement its current satellite constellation. NOAA has already investigated purchasing data, but it has not yet developed a formal plan to implement this process.

Commercial data can refer to any observations, whether in the visible spectrum or other sensory data (i.e. GPS Radio Occultation measurements), obtained from commercial. NOAA could benefit from purchasing commercial imagery data from private vendors, offering less expensive alternatives to government procured, government run satellite systems while delivering data meeting U.S. government standards.[18] Another alternative service proposed by the private sector is GPS Radio Occultation (GPS-RO) measurements – a process to significantly enhance weather prediction capabilities.

In a broad context, the utilization of private sector resources will benefit the American public in the long run by: (1) relieving pressure off the existing satellite projects, which are already complex, over budget, and behind schedule; (2) helping to mitigate the risks of gaps in coverage; (3) providing potentially lower cost

[18] U.S. Department of Commerce (Space Commerce), "Remote Sensing Data Buys," Space Commerce, Updated 14 March 2013, Accessed 30 April 2013, Available Online: http://www.space.commerce.gov/general/commercialpurchase/databuys.shtml

alternatives to traditional satellite systems by saving taxpayer money; and (4) creating new high-tech jobs in the private sector.[19]

NOAA's Existing Commercial Data Procurement Efforts

NOAA has taken steps to learn more about supplementing its satellite data with from commercial data sources. The first inquiry regarding commercial data buy was in FY 2008, when NOAA posted a Request for Information (RFI) titled, "Commercial Solutions to Meet Space-based Earth and Space Weather Requirements of the United States Government." This RFI was intended to identify commercial entities capable of providing NOAA with satellite data in accordance with US government requirements. The commercial options focused on hosted payloads of government sensors as well as purchasing satellite data for Earth and weather observations.

Subsequently, NOAA issued a Request for Quotation (RFQ) in 12 data collection requirements to establish price validation and technical feasibility studies, categorized into three levels, A, B, and C, in descending order of priority. Eight study contracts were awarded to five companies to review Set A RFQs in August 2008: GPS Radio Occultation measurements, Wind Speed and Direction

[19] Anne Hale Miglarese, "Statement of Ms. Anne Hale Miglarese: Addressing Program Overruns and the Looming Gap in Weather and Climate Data from Space Utilizing A Competitive, Commercial Data Purchase Approach: Hearing Before the Appropriations Subcommittee on Commerce, Justice, Science and Related Agencies, House of Representatives, 113th Congress," Accessed 1 May 2013, Available Online: http://www.planetiq.com/wp-content/uploads/2013/03/planetiq_testimony_march_2013.pdf.

measurements, Total Solar Irradiance measurements, Solar Wind measurements, and Coronal Mass Ejection measurements. Five U.S. companies – Iridium Satellite, LLC; Space Services Inc.; ORBCOMM Inc.; Sierra Nevada Corporation; and GeoOptics LLC – were awarded contracts totaling $200,000. NOAA received the evaluation for commercial approaches, but the contents of the final report was marked competition-sensitive and proprietary. However, NOAA does hold possession of the price estimates for Set A RFQs based on the submissions from the five companies, which can be used to calculate the cost of supplementing satellite data.[20]

Set B RFQs issued in March 2009 requested price validation and technical feasibility for Sea Surface Topography measurements, Earth Radiation Budget measurements, Geostationary Atmospheric Sounding measurements, and Ocean Color measurements. Study contracts totaled $250,000 and were distributed among seven private entities and one university. Set C RFQs received $100,000 for four study contracts. All reports for Set B and C were delivered to NOAA before the end of calendar year 2009. Similarly to Set A RFQs, the Set B and Set C reports are not publically available due to protection of proprietary information. The RFQ contained a price index for the available services from private sector companies. By comparing NOAA estimates for development and operation, NOAA will be able to assess if the utilization of commercial options can save the Agency money.[21]

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[20] U.S. Department of Commerce; National Oceanic and Atmospheric Administration; National Environmental Satellite, Data, and Information Service. "Acquisition of Space-based Scientific Data from Commercial Sources to Supplement NOAA's Weather and Climate Observation Requirements." Report to Congress, 2010.

[21] *Ibid.*

Available Commercial Imagery Data

NOAA can engage immediately procuring commercial satellite imagery data. Based on existing private sector satellite infrastructure, NOAA may be able to utilize commercially available multispectral sensors that deliver red and near infrared images, used to detect cloud and snow coverage. These passive observations can provide higher resolution data that could supplement existing weather data to deliver more accurate predictions.

According to LAND INFO Worldwide Mapping, an authorized image distributor for DigitalGlobe, GeoEye, and Astrium, there are several options for acquiring digital imagery. These companies offer both high resolution and medium resolution imagery.[22] Almost all satellites included in LAND INFO's service have multispectral sensors able to deliver images in the red and near infrared for weather prediction.[23]

For example, GeoEye-1, the highest-resolution commercial imaging satellite currently available, can collect as much as 350,000 km^2 of multispectral images.[24] The satellite's services can fulfill some of the pending coverage gap by delivering data for NOAA's weather forecasting efforts.

[22] LAND INFO Worldwide Mapping. "High-Resolution Satellite Imagery," Accessed 20 April 2013, Available Online: http://www.landinfo.com/products_satellite.htm

[23] *Ibid.*

[24] LAND INFO Worldwide Mapping. "GeoEye-1 High-Resolution Satellite Imagery," Accessed 21 April 2013, Available Online: http://www.landinfo.com/geo.htm

It is difficult to determine the cost of acquiring commercial data. Most current model satellite imagery data costs are considered to be proprietary company data; however, older pricing information from GeoEye OrbView-3's commercial satellite imagery product catalog and current imaging satellite models on LAND INFO Worldwide Mapping website are currently publically available.[25] OrbView-3 carried sensors capable of delivering one-meter resolution panchromatic images and four-meter resolution multispectral images.[26] While the resolution has improved over the past decade, with GeoEye-1 able to deliver 0.41-meter resolution for panchromatic and 1.65 meter resolution for multispectral images, the delivery of products has not changed.[27] Thus, using OrbView-3's prices and current model satellites (such as GeoEye-1 and WorldView-1), we were able to predict basic imagery costs.

According to several price indexes, a square kilometer of image can range from 10 to 45 dollars. The price varies depending on several factors, such as the spectrum of the images, the resolution, and the delivery timeframe. The prices for government contracts are not disclosed on the website or the price index sheet for OrbView-3, thus it is hard to make full determination of the total cost for imagery

[25] GeoEye, "OrbView-3 Commercial Satellite Imagery Product Catalog," Accessed 20 April 2013. Available Online: http://glcf.umd.edu/library/guide/Orbview3_Product_Guide_25jan06.pdf

[26] *Ibid.*

[27] LAND INFO Worldwide Mapping. "GeoEye-1 High-Resolution Satellite Imagery."

procurement. Given a 30% price reduction for educational use, NOAA should be able to obtain competitive bulk pricing.[28]

Commercial GPS Radio Occultation Measurements

Another private sector service that NOAA could employ in the near future is the use of GPS Radio Occultation measurements. GPS-RO uses modified GPS receivers to track signals from GPS and determines the properties of the atmosphere as the signal passes through it. GPS-RO measurements can provide vital information about the atmospheric temperature, pressure, and contents, based on the refractivity of the signal. GPS-RO can provide extremely accurate data about the atmosphere, helping to improve the accuracy of weather predictions.[29]

NOAA currently has a partnership with the Taiwanese National Space Organization (NSPO) for a program called Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC), which has GPS-RO sensors on board. Unfortunately, most of the satellites in the constellation are failing or have stopped functioning, resulting in limited operations.[30] The successor program, COSMIC-2, a six satellite GPS-RO constellation, is planned for launch in early 2018.

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[28] *Ibid.*

[29] GeoOptics, LLC. "Technology," Accessed 24 April 2013. Available Online: http://geooptics.com/?page_id=35

[30] Constellation Observing System for Meteorology, Ionosphere, and Climate, "FORMOSAT-3/COSMIC (COSMIC-1) Science Mission," Accessed 27 April 2013. Available Online: http://www.cosmic.ucar.edu/satStatus/index.html

The contract includes an optional expansion for another six satellites.[31] NOAA's estimate for 10-year full life cycle for an operational constellation runs around $300 million for six satellites and $480 million for twelve satellites.[32]

Two private companies, PlanetIQ and GeoOptics have proposed commercial operations of GPS-RO satellites. PlanetIQ's CEO, Anne Hale Miglarese, spoke at a hearing of the House Appropriations Subcommittee on Commerce, Justice, Science and Related Agencies on March 21, 2013. During her speech, Ms. Miglarese testified that NOAA could utilize the private sector offerings such as the GPS-RO system her company plans to launch soon. While not suggesting that NOAA relinquish all of its government operated satellites, she suggested that the private sector could supplement data that NOAA needs for weather prediction services. PlanetIQ claims to have a complete constellation in service as little as 28 months, which suggests GPS-RO data could be available to NOAA as soon as 2016 if the contract was awarded next year.[33]

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[31] Constellation Observing System for Meteorology, Ionosphere, and Climate, "FORMOSAT-7/COSMIC-2 (COSMIC-2) Science Mission," Accessed 27 April 2013. Available Online: http://www.cosmic.ucar.edu/cosmic2/index.html

[32] Thomas Yunck, "A Brisk Tour of GPS Radio Occultation: Past, Present, and Future." Presentation given to NOAA, 17 May 2007. Accessed 21 April 2013. Available Online: http://www.jcsda.noaa.gov/documents/seminardocs/JCSDASeminarYunck051707.pdf

[33] Addressing Program Overruns: Hearing Before the Appropriations Subcommittee on Commerce, Justice, Science and Related Agencies, House of Representatives, 113th Congress. (Statement of Ms. Anne Hale Miglarese, CEO of PlanetIQ).

Another private vendor, GeoOptics, have presented similar set of GPS-RO satellites for commercial operation. GeoOptics also has plans to launch six satellites, possibly expanding to twelve satellites.[34] Its first launch is currently estimated for late 2014 and will likely to reach full operation within few years like PlanetIQ. GeoOptics constellation is called CICERO, Community Initiative for Continuous Earth Remote Observation. According to GeoOptics, they claim about 30% cost reduction compared to government-run projects; and previous NOAA estimates have shown economic savings by utilizing private sector resources.[35]

The cost structure for GPS-RO is still very uncertain. Companies like PlanetIQ and GeoOptics claim to have competitive pricing and can provide services quicker than NOAA or other government operated projects. COSMIC-2's GPS-RO system would cost NOAA approximately $300 million; thus observations could cost NOAA $20 per profile.[36] The private sector must present capacity and sound cost estimates to prove that private GPS-RO data costs significantly less than a government led project.

[34] GeoOptics, LLC. "The Constellation," Accessed 25 April 2013. Available Online: http://geooptics.com/?page_id=58

[35] *Ibid.*

[36] Thomas Yunck, "A Brisk Tour of GPS Radio Occultation," Accessed 1 May 2013, Available Online: http://www.jcsda.noaa.gov/documents/seminardocs/JCSDASeminarYunck051707.pdf

Problems NOAA Must Overcome to Enable Procurement of Commercial Data

NOAA must address the legal challenges facing using commercial data sources to supplement its own satellite data. The Office of Management and Budget's Circular No. A-130, the Management of Federal Information Resource policy, and the 2010 National Space Policy state that NOAA must sustain a full and open data policy. This open policy allows the full dissemination of NOAA's data and services for public safety and global environmental monitoring. NOAA must establish an amicable solution between protections of proprietary contents while still serving the public good. A potential solution is for NOAA to acquire entire services rather than just imagery, resolving any potential limitations on allowing NOAA to freely distribute data.

After evaluating set A RFQs, NOAA determined that there are indeed some areas where utilizing private sector data sources would be less expensive than by acquiring them through traditional means. Coronal mass ejection imagery measurements, solar wind data measurements, and GPS-RO are less expensive when using private sector data sources. PlanetIQ and GeoOptics can provide these services to complement NOAA's current satellites. Given available cost and data requirements, the team foresees that NOAA will benefit by utilize the private sector's data sources.

In order for NOAA to utilize the private sector resources, it must use the cost information acquired through its past RFIs and RFQs as a starting point to engage in dialog with industry. NOAA should distribute some of its observation needs to private sector, provided the companies are able to deliver products demanded by

the U.S. government at a price lower than U.S. government itself. Past RFQs illustrate that the private sector companies are willing to provide this cost information. The private sector must not just discuss technological capabilities; it must demonstrate its feasibility to actually deliver upon these concepts. In terms of satellite imagery services, the industry is quite well established; and the key to using this information lies in establishing contracts that will allow for NOAA to freely process and redistribute its contents. NOAA may look at the DOD contracts for telecommunication satellites as a model to base its image acquisition program.

DOD uses commercial telecommunications satellites for secure communications, which enables DOD to utilize a commercial resource to supplement its own communications satellites. The Commercial Satellite Service in DOD's Defense Information Systems Agency uses a number of different satellite services to provide warfighters with worldwide communications services.[37] The organization leases global satellite bandwidth and provides limited monitoring and control of these satellite systems. This service is provided as part via General Services Administration's (GSA) Information Technology (IT) Schedule 70 Special Item Number 132-54.[38] This IT Schedule 70 arrangement includes transponded capacity, including a dedicated bandwidth on a commercial communications satellite, and subscription services, including subscriptions to pre-existing, pre-

[37] Defense Information Systems Agency, "Commercial Satellite Service," Department of Defense, Accessed 3 May 2013, Available Online: http://www.disa.mil/Services/Network-Services/Satellite/Commercial-Satellite-Service.

[38] *Ibid.*

engineered satellite solutions like service plans and terminals.[39] NOAA should contact GSA and DOD to further learn about this IT Schedule 70 arrangement to see how this can be used as a foundation for developing contract arrangements with the aforementioned remote sensing satellites companies.

Long Term – Hosted Payloads

Another option for NOAA is to utilize hosted payloads for gathering weather data. Hosted payloads are additional transponders, instruments, or other space bound items on commercial spacecraft already scheduled for launch (additionally referred to as ridesharing.)[40] These payloads enable test, demonstration, and validation of new space technologies prior to their operational deployment. These pieces of hardware will offer regular, reliable, and rapid access to space. [41]

The federal government has had some experience launching hosted payloads on commercial satellite platforms. The Federal Aviation Administration launched the Wide Area Augmentation System (WAAS) to enhance GPS signals for use in civil aviation. One WAAS payload was carried on Telesat's Anik F1R, built by Astrium, and was launched in September 2005. The other WAAS payload was placed on

[39] General Services Administration, "Satellite Communications," Accessed 4 May 2013, Available Online: http://www.gsa.gov/portal/content/105299?utm_source=FAS&utm_medium=print-radio&utm_term=satserv&utm_campaign=shortcuts.

[40] Department of Commerce – Office of Space Commercialization, "Hosted Payloads," US Department of Commerce, Accessed 11 April 2013, Available online: www.space.commerce.gov/general/commercialpurchase/hostedpayloads.shtml.

[41] *Ibid.*

Intelsat's Galaxy 15, a satellite built by Orbital Sciences; it was launched in October 2005.[42] DOD additionally has launched two hosted payload systems – the Internet Router in Space (IRIS) experiment hosted on Intelsat's Space Systems/Loral-built Intelsat 14 satellite, launched in November 2009, and the Commercially Hosted Infrared Payload (CHIRP) sensor, which was integrated on the SES WORLDSKIES' SES-2, launched in 2011.[43] CHIRP was the first hosted payload launched as a secondary payload on a commercial telecommunications satellite by the US Air Force. The figure below shows the CHIRP hosted payload.

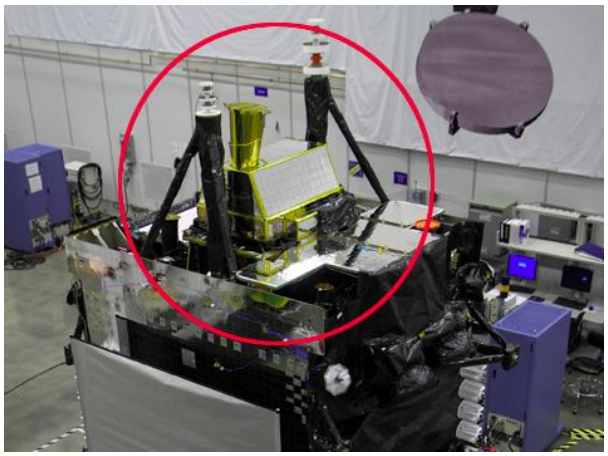

Figure 3: CHIRP Hosted Payload[44]

[42] *Ibid.*

[43] *Ibid.*

[44] Debra Werner, "Spotlight: Hosted Payload Alliance," *SpaceNews*, 25 February 2013, Accessed 30 April 2013, Available Online: http://www.spacenews.com/article/spotlight-hosted-payload-alliance#.UWhYcStNb48.

Since CHIRP's launch, DOD has strengthened their research in the hosted payload arena. The agency has established a Hosted Payloads office out of the Air Force's Space and Missile Command in California. This office has been sharing information with NASA and NOAA, but its research into the hosted payload arena is still in its preliminary stages. Richard McKinney, Deputy Under Secretary of the Air Force for Space, stated that the government must work to ensure that hosted payloads "are tied to what [the government] wants to do and the cost [of the operation]."[45] The Air Force is doing research on the best sensor candidates for hosted payloads, especially for weather prediction in order to supplement/replace their defense meteorological satellite. NOAA should work through the interagency process to acquire this information and work with DOD on a cost-sharing agreement to procure sensors together.

NOAA has the potential to use hosted payloads to supplement their current satellite portfolio. Future hosted payload missions could include hyper-spectral sounding, ocean color analysis, and ozone mapping. NOAA additionally intends to launch a spectral solar irradiance sensor as a standalone satellite, called a free flyer.[46] The recent de-manifesting (removal) of a number of sensors from NPOESS has led program managers to seriously consider flying them on commercial

[45] Richard McKinney, Remarks at the NDIA/AIAA Joint Luncheon, April 25, 2013, Lockheed Martin Global Vision Center – Arlington, VA.

[46] Government Accountability Office, *2013 Annual Report: Actions Needed to Reduce Fragmentation, Overlap, and Duplication and Achieve Other Financial Benefits*, Washington D.C.: Government Accountability Office (April 2013), 189.

satellites.[47] NOAA has performed studies of cost-sharing opportunities, including through ride-sharing and hosted payloads, but has not yet committed to such options.[48]

Problems NOAA Must Address to use Hosted Payloads

The US Government, and NOAA in particular, must work with commercial operators to make hosted payloads easier to operate. The rapid rate of commercial satellite development is quite contrary to the long development cycles for government payloads. NOAA, therefore, must be able to develop sensors on a more rapid schedule to meet the rapidly to meet the huge commercial demand for satellite communications. Communications firms cannot afford to delay replenishment satellites to accommodate developmental problems with government payloads.[49] They must work side by side with commercial vendors to make their hosted payloads fit certain requirements for mass, volume, and power consumption. Additionally, these payloads must adhere to the strict procurement, construction,

[47] Department of Commerce – Office of Space Commercialization, "Hosted Payloads," US Department of Commerce, Accessed 11 April 2013, Available online: www.space.commerce.gov/general/commercialpurchase/hostedpayloads.shtml.

[48] Government Accountability Office, *2013 Annual Report: Actions Needed to Reduce Fragmentation, Overlap, and Duplication and Achieve Other Financial Benefits*, Washington D.C.: Government Accountability Office (April 2013), 189.

[49] Department of Commerce – Office of Space Commercialization, "Hosted Payloads," US Department of Commerce, Accessed 11 April 2013, Available online: www.space.commerce.gov/general/commercialpurchase/hostedpayloads.shtml.

and launch schedules for the commercial satellites. [50] In terms of NOAA observations and satellite orbits, the Futron Corporation has noted, "Although the number of commercial geostationary spacecraft launched in a particular year is quite large, each of them will occupy a fixed orbital slot with limited view of the Earth." This allows for multiple observations a day, but not a global view.[51] NOAA will have to plan extensively to ensure that different orbits are covered in low earth orbit as well as geostationary orbit.

Moreover, we recommend that NOAA work with other US governmental agencies to face the policy challenges surrounding hosted payloads. "Flying a payload for a U.S. Government agency on a commercial satellite can introduce a number of export control and other policy issues, including the ability to use a foreign launcher or satellite integrator, flying a payload that contains foreign components, and flying a U.S. Government payload on a satellite that is also hosting other non-U.S. payloads."[52] Additional problems include data-sharing agreements, intellectual property, operations, and liability (including but not limited to launch delay or failure, payload delay or failure, hosted payload or host satellite failure). Through the inter-agency process with DOD and NASA, NOAA should work to ensure that hosted payloads are easier to launch. Moreover, these agencies will be able to work with organizations like the Hosted Payload Alliance to forge stronger

[50] Futron Corporation, *Hosted Payload Guidebook: Prepared for NASA Langley Research Center*, Washington, D.C.: Futron Corporation (2010).

[51] *Ibid.*

[52] *Ibid.*

relationships between government and industry. The Hosted Payload Alliance is comprised of 18 commercial satellite companies including, Boeing, Intelsat, Iridium, Lockheed Martin, Orbital Sciences, SES, and Space Systems/Loral.[53] This industry organization's goal is to serve as a "bridge between government and private industry to foster open communication between potential users and providers of hosted payload capabilities."[54] By influencing policy and creating better ties with industry, NOAA will be able to leverage this commercial service and save money. Hosted payloads will also work well with disaggregated space systems, described in the following section.

Long Term – Disaggregation of Space Systems

NOAA could also employ the DOD concept of disaggregating their space systems. Disaggregating satellites refers to dispersing payload sets currently flown on large satellite platforms to smaller crafts. This concept is not new but has recently been nominated as a way to address critical challenges, particularly ongoing fiscal constraints.[55] The original intent for aggregating multiple capabilities

[53] Debra Werner, "Spotlight: Hosted Payload Alliance," *SpaceNews*, 25 February 2013, Accessed 12 April 2013, Available Online: http://www.spacenews.com/article/spotlight-hosted-payload-alliance#.UWhYcStNb48.

[54] Hosted Payload Alliance, "Home," Accessed 12 April 2013, Available Online: www.hostedpayloadalliance.org.

[55] Laura Delgado, "Benefits Weighed of 'Disaggregation for Military Space Systems," *SpacePolicyOnline.com*, 30 January 2013, Accessed 11 April 2013, Available online: www.spacepolicyonline.com/news/benefits-weighed-of-disaggregation-for-military-space-systems.

into a single large spacecraft was to reduce the inherent overhead, reduce the number of launches and therefore reduce system cost; disaggregation is the opposite.[56] While disaggregation is not inherently a commercially available option at this time, there are several companies now working to develop smaller satellites – thus allowing disaggregation to become a commercial option in the long term for NOAA.

Disaggregating NOAA's weather capabilities does have the ability to change the frequency of satellites launched into space. Helping to combat technology obsolescence, launching smaller satellites would require continuous production cycles and more realistic requirements than currently employed.[57] Today's satellites have been compared with the methodology behind walking into a restaurant with the idea that you were not going to eat for 15 days and then ordering everything on the menu.[58] Disaggregation, on the other hand, would enable smaller, more responsive satellites to be launched on a frequent basis. For instance, long-lived satellite systems do not enable satellite operators to know in

[56] James Wertz, "Reinventing Space: Dramatically Reducing Space Mission Costs – Programmatic Approaches," *SpaceNews*, 27 February 2013, Accessed 11 April 2013, Available Online: www.spacenews.com/reinventing-space-dramatically-reducing-space-mission-cost-—-programmatic-approaches#.UWbnAqtNb49.

[57] Laura Delgado, "Benefits Weighed of 'Disaggregation for Military Space Systems," *SpacePolicyOnline.com*, 30 January 2013, Accessed 11 April 2013, Available online: www.spacepolicyonline.com/news/benefits-weighed-of-disaggregation-for-military-space-systems.

[58] Mike Gruss, "Experts Divided on the Benefits of Disaggregating Military Systems," *SpaceNews*, 4 February 2013, Accessed 11 April 2013, Available Online: www.spacenews.com/article/experts-divided-on-benefits-of-disaggregating-military-space-missions#.UWbny6tNb48.

advance from what region of the world data will be important or what type of information will be needed. Currently, 70-80% of the acquisition cost of a satellite is spent during a satellite's development, and disaggregation lowers this cost substantially by having smaller platforms that do not require as much planning.[59] For instance, companies like Sierra Nevada Corporation are developing simpler satellite systems on a mass production scale that results in lower cost. Mark Sirangelo, Vice President for Space Systems at Sierra Nevada, calls this concept 'standardized customization,' allowing for a standard chassis in three or four weight categories and allowing the customer to customize it through a series of choices.[60] These satellites cost approximately a tenth of traditional satellite acquisition costs.[61] New satellite manufacturing concepts like this enable the US Government – NASA, NOAA, and DOD – to better plan for future satellite acquisition.

The Pentagon has begun looking at weather observation as an early candidate for disaggregation.[62] According to Gen. William Shelton, Commander of Air Force Space Command, the U.S. Air Force expects to decide in 2015 whether to

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[59] Richard McKinney, Remarks at the NDIA/AIAA Joint Luncheon, April 25, 2013, Lockheed Martin Global Vision Center – Arlington, VA.

[60] Michael Belfore, "Affordable Space Flight Through Mass Production," *Moon and Back*, Accessed April 30, 2013, Available online: http://moonandback.com/2012/11/06/affordable-space-flight-through-mass-production/.

[61] *Ibid.*

[62] Frank Moring, "Sequestration May Push Milsat Disaggregation," in Aviation Week and Space Technology, 20 February 2013, Accessed 11 April 2013, Available Online: www.military.com/daily-news/2013/02/20/sequestration-may-push-milsat-disaggregation.html.

redesign some of its key space missions by dispersing payload sets currently flown aboard large satellite platforms to larger numbers of smaller craft.[63] Richard McKinney, Deputy Under Secretary for the Air Force for Space, has also stated that the Air Force is currently undergoing a review of possible options for their future defense weather satellites – noting that disaggregation is a large part of this concept. While the study has not yet emerged, McKinney said that the Air Force has "no answers yet to the problem but interesting concepts have emerged."[64]

Problems NOAA Must Address Regarding Disaggregation

NOAA must work to develop a plan for disaggregating its constellation of GOES and POES satellites. While smaller satellites are a novel concept, NOAA must determine if just using smaller satellites can truly provide their necessary weather data. Covering the world with every possible sensor is not economically feasible and substantial planning would be needed to figure out what sensors would be needed.[65] Additionally, disaggregation is not going to happen immediately. According to Josh Hartman, CEO of Horizons Strategy Group and a former deputy

[63] Titus Ledbetter, "Air Force Decision on Disaggregation Not Expected Until 2015," *SpaceNews*, 16 November 2012, Accessed 11 November 2013, Available Online: www.spacenews.com/article/air-force-decision-on-disaggregation-not-expected-until-2015#.UWbmrqtNb48.

[64] Richard McKinney, Remarks at the NDIA/AIAA Joint Luncheon, April 25, 2013, Lockheed Martin Global Vision Center – Arlington, VA.

[65] James Wertz, "Reinventing Space: Dramatically Reducing Space Mission Costs – Programmatic Approaches," *SpaceNews*, 27 February 2013, Accessed 11 April 2013, Available Online: www.spacenews.com/reinventing-space-dramatically-reducing-space-mission-cost-—-programmatic-approaches#.UWbnAqtNb49.

assistant secretary of defense for space and intelligence, "Research and development programs aimed at disaggregation in the $100 to $200 million range may be possible," but substantial research into the concept is needed.[66] This research process is more likely to take place over the next 10 to 15 years, and NOAA must coordinate its research with DOD and NASA. In this tough fiscal environment, sharing of research on future acquisition concepts like this is of the utmost importance. Richard McKinney has stated that the Air Force and NOAA need to determine how to measure the resilience of their satellite systems. The US Government needs to determine if "having more satellites and sensors increases resilience…more does not always equal better."[67]

In the long-term future, NOAA will need a balance of small satellites and hosted payloads to best provide on orbit weather data. Disaggregation of weather satellite constellations and hosted payloads theoretically provide options for lower cost satellite acquisitions. The main steps facing the Agency into the future are to study the cost/benefit of these systems and then to create a roadmap for future satellite systems. NOAA, NASA, and DOD should share information freely between each agency to determine the best ways to provide the American public with data for weather services. Industry should participate in these discussions – on hosted

[66] Frank Moring, "Sequestration May Push Milsat Disaggregation," in Aviation Week and Space Technology, 20 February 2013, Accessed 11 April 2013, Available Online: www.military.com/daily-news/2013/02/20/sequestration-may-push-milsat-disaggregation.html.

[67] Richard McKinney, Remarks at the NDIA/AIAA Joint Luncheon, April 25, 2013, Lockheed Martin Global Vision Center – Arlington, VA.

payloads and smaller satellites. As future concepts for space systems emerge, the US Government should work hand in hand with industry to better acquire satellite systems. Only through this cooperation will NOAA, NASA, and DOD have the ability to develop their future space architectures.

Conclusion

In conclusion, NOAA has the ability to utilize commercially available alternatives in the long and short-term future. Not only can NOAA procure commercial remote sensing data, it can utilize new architectures to further improve its weather prediction satellites.

As the nation's budgets tighten, utilizing commercially available alternatives to large satellite acquisition will enable NOAA to provide weather prediction services to the US public. NESDIS must work to develop a plan for its future space system architecture, taking lessons learned from the NPOESS program cuts and from GAO's recommendations. The report's aforementioned policy suggestions – using short and long-term objectives – will help the agency to develop a more cohesive plan for continuing to provide weather data.

Most importantly, NOAA must work with other space agencies – NASA and DOD – to learn more about the long-term alternatives to large satellite acquisitions strategies. DOD and NASA have also been studying disaggregated architectures and hosted payloads. The agencies must work together through the interagency process to share information on these future space system options. These agencies are all facing similar problems, and the duplication of efforts to study alternatives is a

waste of the American taxpayer's money. As such, the strongest policy recommendation of this paper is to urge NOAA to better utilize their partners in the federal government.

Shortcomings of the Report

As with any project, this report does have some minor shortcomings. The time spent on the project was limited, therefore not allowing the team to dive deep into specific areas. We believe that this report provides a good composite view of the various areas for commercial opportunities in the short and long-term, and we urge NOAA to continue its own research into these areas in the future. Additionally, we faced challenges in acquiring specific pricing data for all three of the policy recommended areas. However, NOAA as a federal agency should be able to acquire this information much more easily. The team also faced a learning-curve time delay since two of the team members did not have prior subject knowledge. While we did learn about the topic, this learning curve did limit our time to investigate other sources of data.

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