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

To Observe and Protect: How NOAA Procures Data for Weather Forecasting

Wednesday, March 28, 2012
2:00 p.m. to 4:00 p.m.
2318 Rayburn House Office Building

PURPOSE

On Wednesday, March 28, at 2:00 p.m. the Subcommittee Energy and Environment of the House Committee on Science, Space, and Technology Committee will hold a hearing to examine how the National Oceanic and Atmospheric Administration (NOAA) develops, evaluates, and executes plans to deliver the best and most cost effective data necessary to meet requirements for severe weather prediction and other observational needs.

WITNESSES

PANEL I

- **Ms. Mary Kicza,** Assistant Administrator, National Environmental Satellite, Data, and Information Service, National Oceanic and Atmospheric Administration (NOAA)
- **Dr. Alexander MacDonald**, Deputy Assistant Administrator for Research Laboratories and Cooperative Institutes, Office of Oceanic and Atmospheric Research, NOAA
- **Mr. John Murphy**, Chief, Programs and Plans Division, National Weather Service, NOAA

PANEL II

- **Mr. Eric Webster**, Vice President and Director, Weather Systems, ITT Exelis
- **Dr. David Crain,** Chief Executive Officer, GeoMetWatch
- **Mr. Bruce Lev,** Vice Chairman, AirDat LLC
- **Dr. Berrien Moore**, Dean, University of Oklahoma College of Atmospheric and Geographic Sciences, and Director, National Weather Center

BACKGROUND

The core mission of the National Weather Service (NWS) is to protect life and property and enhance the national economy through weather forecasts and warnings. Successful execution of this mission is primarily dependent on obtaining data necessary to generate accurate forecasts. This data is obtained through a mix of observing systems located in space (satellites), the atmosphere, on land, and in the ocean.

The FY2013 budget request for NOAA is \$5.1 billion. Of this amount, \$2.04 billion or 40 percent is designated for NESDIS (National Environmental Satellite, Data, and Information Service), which acquires and manages NOAA's operational satellites. Within the NESDIS budget, 84 percent, or \$1.7 billion is for two satellite programs, the Joint Polar Satellite System (JPSS) and the

Geostationary Operational Environmental Satellite R-Series (GOES-R).The percentage of NOAA's budget dedicated to satellites has grown substantially in recent years. The FY09 budget request for NESDIS represented 27 percent of NOAA's total budget. Procurements of large infrastructure such as satellites have a natural ramp-up and ramp-down cycles for appropriations. However, cost over-runs, poor management, technical problems and contractor mistakes associated with recent satellite programs have exacerbated these budget pressures. As a result, the amount of resources currently designated for satellite procurement is reducing funding available for—and in some cases forcing the elimination of—other worthwhile programs at NOAA.

For example, within the NWS budget, the Administration is proposing to eliminate funding for the NOAA Profiler Network currently installed in Tornado Alley[1] and the National Mesonet Network.[2] Although both of these observing systems have been the subject of a number of reports endorsing the value of the data they generate – including the National Academies of Science – the budget request still eliminates funding for them. This action brings into question the process NOAA is using to decide the value of data from different types of observing systems.

<u>Meeting Data Requirements</u>

To develop data requirements for weather forecasts, NOAA has created an intra-agency group called the NOAA Observing System Council (NOSC). Led by the Assistant Secretary of Commerce for Environmental Observation and Prediction, the NOSC has members from each of the line offices in NOAA as each service uses observations to provide information and products to the public. Within this framework, NOAA employs a system called Technology, Planning, and Integration for Observation (TPIO).

The TPIO system manages three major NOAA-wide capabilities, including: Observation System Architecture, Requirements and Planning, and Data Management Architecture. Observation System Architecture (OSA) includes developing and analyzing NOAA's integrated observation architecture. OSA works with the Requirements and Planning team to assess observation requirements against current, planned, and future observational capabilities. The Requirements and Planning (RAP) team is responsible for the collection, standardization, configuration, and assessment of all NOAA observation requirements. The Data Management Architecture (DMA) team is responsible for developing and analyzing integrated data management architecture.[3]

The process further involves TPIO working with NOAA program leaders and Subject Matter Experts (SMEs) to document observing requirements and labeling these requirements as mission critical, mission optimal, or mission enhancing. Those requirements garnering a mission critical designation are considered priority-1 importance, ensuring that these are the first requirements that are satisfied.[4] Once these requirements are documented and designated, they are subject to the Government Performance and Results Act (GPRA) and other NOAA-specific performance measures and then verified again by program managers and SMEs.[5]

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[1] The Profiler Network is a system of observing stations that measure the wind speed and direction providing a vertical profile of the atmosphere.

[2] Surface-based observing networks owned and operated by non-Federal parties.

[3] https://www.nosc.noaa.gov/tpio/main/aboutrap.html

[4] https://www.nosc.noaa.gov/tpio/main/aboutrap.html#documenting

[5] https://www.nosc.noaa.gov/tpio/main/aboutrap.html#vv

Recently, NOAA has added a new element to this process called the NOAA Observation Systems Integrated Analysis Capability (NOSIA). According to NOAA, the NOSIA is a pilot study to "examine NOAA's upper air observing portfolio and ultimately will recommend a multi-year investment strategy/road map for upper air observing systems."[6]

Observing System Simulation Experiments

Another method that can be used to analyze the value of weather data from observing systems is called an Observing System Simulation Experiment (OSSE). OSSEs employ computer modeling used to investigate the potential impact of planned observing systems or to test current observational and data assimilation systems. Simulated data is used as an input into a data assimilation system, which in turn, is then used as the input for weather forecasting models. Different data types, whether inferred or direct measurements (explained below), can then be compared against one another, the measurement being the utility of these data streams to weather forecasting.

According to NOAA's Earth Systems Research Laboratory (ESRL), OSSE's provide an objective and quantitative manner through which to guide optimal development of observing systems. OSSE's "could play a critical role in…identifying future observation systems and data assimilation systems for improvement."[7] Additionally, ESRL plans "to build an OSSE or OSSEs helping NOAA to evaluate all potential future observation systems for all weather applications and identify improvement of data assimilation and forecast system." To date, however, NOAA's budgetary decisions for observing systems have not been based on information gleaned from OSSEs. Rather, decisions have been made using program managers and subject matter experts. The tools for NOAA to base decisions on impartial and independent information already exist, but are not part of NOAA's standard operating procedure to utilize them.

<u>History of Weather Observations</u>

The value of weather observations to society has been understood for centuries. However, it was not until the advent of the telegraph in the mid-1800s that allowed such observations to be useful in the creation of weather maps. In the U.S., the first official recognition of the utility of observations was established by a Joint Congressional Resolution in 1870 and signed by President Grant. It directed the Secretary of War to collect observations and transmit such data to DC. This first national policy on weather observation became the basis of the Cooperative Observer Program (COOP), a network of civilians who take daily observation from all areas of the U.S., which was formally created in the Organic Act of 1890 that established the Weather Bureau within the Department of Agriculture.[8]

In 1926, Congress passed the Air Commerce Act and directed the Weather Bureau to perform observations, warnings, and forecasts for weather impacting the safety of civil aviation and above the oceans. Congress expanded this role in 1938 with the Flood Control Act, delegating additional authority in the areas of hydrology and water resources.

In 1940, President Franklin Roosevelt transferred the Weather Bureau from the Department of Agriculture to the Department of Commerce, recognizing that the mission of weather observations

[6] https://www.nosc.noaa.gov/tpio/

[7] http://laps.noaa.gov/met/osse.html

[8] A weather and climate observing network consisting of more than 11,000 volunteers who take observations on farms, in urban and suburban areas, National Parks, seashores, and mountaintops.

and forecasting had grown beyond its initial role of supporting just agriculture and aviation. Around the same time, observational technology was revolutionized with the introduction of the radiosonde—an instrument package usually attached to weather balloons that measures temperature, relative humidity, and wind speed.

The 1950s and 1960s were marked by improvements in observational technologies such as satellites and operational radar. The National Weather Service was incorporated into NOAA in 1970 and technological developments continued throughout the 1980s within the Federal government and also throughout the private sector and university structure. In 1992, Congress passed the Weather Service Modernization Act to provide a new framework to implement technological advances made through research.

Categories of Observational Data

There are three major components driving advances in weather forecasting: improved observational data, data assimilation, and modeling (which includes processing speed). Although data assimilation and modeling are critically important to improvements in forecasting, the hearing will focus on the procurement of observational data.

There are four general categories of observation systems: space-based remote sensing, atmospheric observations, surface observations, and ocean observations. Each of these categories play an important role in weather forecasting; no single observational system can supply all the necessary data for weather forecasts. Furthermore, not all data from the different categories are necessarily interchangeable. Atmospheric, surface, and ocean observations can include both direct measurements and passive sensing of atmospheric conditions. Space-based observations rely on a number of proxy parameters to infer atmospheric conditions. They are not direct observations, but rather the data is deduced through a series of mathematical equations based on radiated or reflected energy from the Earth.[9] NOAA uses information from over 100 observational networks. Several of these systems are highlighted below as examples of the types available.

Space-based remote sensing

For space-based observations, NOAA relies on two different satellite systems for weather forecasting. The Geostationary Operational Environmental Satellite (GOES) satellites sit 22,300 miles above the surface of the Earth. These satellites orbit the Earth at the same speed as the Earth's rotation, thereby allowing them to stay above the same fixed spot above the surface. GOES satellites work in tandem, with one providing observations over the eastern half of the continental U.S. and much of the Atlantic Ocean; and the second providing observations over the western half and much of the Pacific Ocean. Typically, NOAA maintains an on-orbit spare GOES satellite in the event that one of the existing operational satellites malfunctions. The on-orbit spare can be remotely maneuvered into position and begin providing observations. NOAA first began launching GOES satellites in 1975. Currently, GOES-13 covers the Eastern half of the country, and GOES-15 covers the Western half. The two most important instruments on the GOES satellites are the imager and the sounder. The imager is designed to sense radiant and solar reflected energy from the Earth. The sounder is designed to sense data that provides information about atmospheric temperature and moisture profiles, surface and cloud top temperatures, and ozone distribution.

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[9] National Research Council. *Observing Weather and Climate From the Ground Up: A Nationwide Network of Networks*. Washington, DC. 2009.

The Polar-orbiting Operational Environmental Satellites (POES) transverse the globe from pole to pole, with each orbit being defined by the time of day they pass over the equator: early morning, late morning, and afternoon. Each polar-orbiting satellite makes approximately 14 orbits per day and is able to view per day.[10] Currently, there is one operational POES satellite, two operational Defense Meteorological Satellite Program (DMSP) satellites, and a European satellite, called the Meteorological Operational (MetOp) satellite. In order to stream-line government functions and reduce duplication, in 1993 an Executive Order brought together the Department of Defense (DoD) program and the NOAA program, and created the National Polar-orbiting Operational Environmental Satellite System (NPOESS) program. In order to mitigate the risk of large advances in remote sensing technology, the National Aeronautics and Space Administration (NASA) was brought into the program to build the NPOESS Preparatory Project (NPP). NPP was intended to be a research satellite that would be launched in advance of the new NPOESS satellites and test the value of the data provided.

Originally designed to cost $6.5 billion for six satelites, the costs and difficulties of the NPOESS program grew substantially. In 2005, the program was subject to a Nunn-McCurdy[11] recertification and was substantially altered. By 2009, life-cycle costs of the program had grown to $14.9 billion for four satellites. A DoD-contracted Independent Review Team analyzed the program and concluded that it had an extraordinarily low probability of success.[12] In 2010, after working with NOAA, NASA, and the DoD, the Office of Science and Technology Policy (OSTP) announced that the NPOESS program would dissolve into two separate programs. NOAA and NASA would manage the Joint Polar Satellite Program (JPSS) responsible for the afternoon orbit, and DoD would manage the Defense Weather Satellite System (DWSS) responsible for the early morning orbit. The European satellite, MetOp would operate in the late morning orbit.

Given the extraordinary problems with this program, the launch schedule for NPP had slipped from May 2006 to October 2011. JPSS-1 (originally C-1 under the NPOESS program) was initially scheduled to fly in 2008. NOAA projects JPSS-1 will not launch until the first quarter of FY2017. Given these drastic shifts in schedule, NPP was re-designated an operational satellite in order to ensure working instruments in orbit when the previous POES series was retired. NOAA currently projects a near-certain data gap will occur, such that NPP will stop being operational before JPSS-1 is able to launch.

As part of the FY2013 budget request, NOAA has announced that it has capped the life-cycle costs of the JPSS program at $12.9 billion for two satellites.

Atmospheric Observations

Atmospheric data is measured in several ways. The oldest technology still in use is radiosondes attached to weather balloons. This instrument package measures temperature, relative humidity, and wind. The package is secured to a weather balloon and released in designated places around the country twice daily. The information provides a vertical profile of the current atmospheric

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[10] Committee on Science, Space and Technology. "From NPOESS to JPSS: An Update on the Nation's Restructured Polar Weather Satellite Program". September 23, 2011. Hearing Charter Subcommittee on Investigations and Oversight and Subcommittee on Energy and Environment.

[11] The Air Force managed the acquisition of the NPOESS satellites. The program was therefore subject to Department of Defense regulations for major defense programs. When such programs exceed approved baseline costs by more than 25 percent, recertification is required by 10 U.S.C. 2433 et seq.

[12] NPOESS Independent Review Team, Final Report. June 1, 2009.

conditions. Although highly reliable in terms of data quality, the discrete temporal and spatial data points provided limit the utility of these measurements.

Doppler radar is an active observing system that measures precipitation and is vital for detecting and tracking storms of all kinds.[13] Radar wind profilers are able to provide vertical profiles of wind speed and direction up to 50,000 feet above the Earth's surface. Mainly deployed in Tornado Alley, these wind profilers have substantially increased the warning time for tornado warnings during severe outbreaks.[14]

Another method for measuring atmospheric conditions include the use of sensors on commercial aircraft. The Tropospheric Aircraft Meteorological Data Relay (TAMDAR) system measures temperature, relative humidity, winds, icing, turbulence, and position. Another method being explored for additional aerial observations is the use of unmanned aircraft systems, or drones. These drones can be flown into hurricanes or other severe storms to collect vital data without endangering human life.

Surface Observations

Surface measurements typically consist of temperature, relative humidity, wind, precipitation, and air pressure.[15] Although the World Meteorological Organization defines the standards for such measurements (for example, wind measurements are taken at 10 meters above land), observations for specific industries may vary. Needs for transportation, energy sector, agriculture, and air quality will all have specific measurement needs that differ from the norm. Approximately 500 surface networks operate in the U.S., owned by the Federal government, States, universities, private sector and hobbyists. Despite the large number of systems, these networks are not evenly distributed, resulting in decreased utility in rural areas.[16]

Ocean Observations

Integrated ocean observations formally authorized as the Integrated Ocean Observation System (IOOS) as part of P.L. 111-11. IOOS is a national-regional partnership that supports over 1,500 instruments and platforms. Measurements include water temperature, wind, waves, currents, chlorophyll, and water chemistry. Thirty-nine surface buoys and subsurface recorders measuring water pressure are used as the backbone of the Deep-ocean Assessment and Reporting of Tsunamis (DART) program. In the last few years, unmanned marine vehicles such as wave gliders have revolutionized the concept of data collection. Using wave energy, these remote platforms can be placed in stationary locations, move if necessary, and return to base for maintenance, significantly reducing ship time needed to repair stationary buoys.

<u>Data Providers</u>

Much of the data utilized by NOAA is obtained from observing systems owned by the Federal government. However, much data is procured from privately-owned networks, universities, and other countries. Currently, ocean, surface, and atmospheric data is obtained from public and private observation networks.

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[13] NOAA is currently research the next generation of radars to replace Doppler radars with Multiphase Array Radar (MPAR).

[14] NOAA's FY13 budget request will zero out this program.

[15] National Research Council. *Observing Weather and Climate From the Ground Up: A Nationwide Network of Networks*. Washington, DC. 2009.

[16] National Research Council. *Observing Weather and Climate From the Ground Up: A Nationwide Network of Networks*. Washington, DC. 2009.

Space-based observations used in weather forecasting have thus far been the sole domain of government networks. NOAA uses data from satellites owned by NOAA, NASA, DoD, U.S. Geological Survey or foreign countries. In P.L. 102-555, Congress enacted the following provision:

Title VI – Prohibition of Commercialization of Weather Satellites
Sec. 601. Prohibition

> Neither the President nor any other official of the Government shall make any effort to lease, sell, or transfer to the private sector, or commercialize any portion of the weather satellite systems operated by the Department of Commerce or any successor agency.

Sec. 602. Future Considerations.

> Regardless of any change in circumstances subsequent to the enactment of this Act, even if such change makes it appear to be in the national interest to commercialize weather satellites, neither the President nor any official shall take any action prohibited by section 601 unless this title has first been repealed.

The interpretation of Title VI has led to the exclusive use of government owned satellite data. However, the language can be interpreted such that it does not prohibit the procurement of data from commercialized weather satellite systems, only the prohibition of commercializing existing weather satellite systems. The costs and problems that have plagued the NOAA weather satellite programs in the last decade indicate a new paradigm may be warranted.