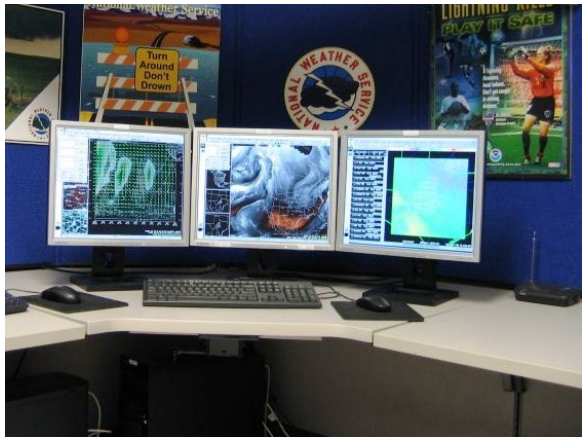
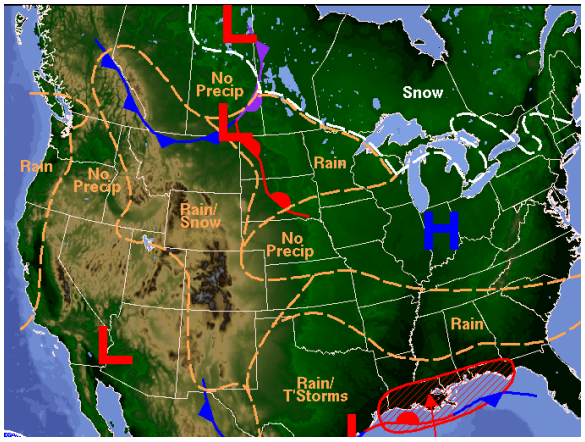
A Report by a Panel of the

NATIONAL ACADEMY OF PUBLIC ADMINISTRATION

for the U.S. Congress and the National Weather Service





FORECAST FOR THE FUTURE:

Assuring the Capacity of the National Weather Service

May 2013

National Academy of Public Administration ®

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Forecast for the Future

Assuring the Capacity of the National Weather Service

PANEL

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The views expressed in this report are those of the Panel. They do not necessarily reflect the views of the Academy as an institution.

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FOREWORD

"Everyone talks about the weather, but nobody does anything about it."
—Attributed to Mark Twain

While this may have been the case in the days of Mark Twain, modern weather forecasting techniques and analysis allow us, as a nation, to prepare for the worst thanks to the official watches, warnings, and advisories issued by the National Weather Service (NWS). From blizzards to hurricanes, floods to droughts, the products and services provided by the NWS serve as the foundation for critical public safety decisions. With 11 severe weather and climate events last year each incurring over $1 billion in damages and 144 such events since 1980, a strong NWS is a critical component of the services the federal government provides its citizens.

The decade-long modernization effort in the 1990s revamped and revitalized the NWS. Driven by technological advancements, this effort demonstrated the importance of keeping pace with changing public needs and expectations. In the 21st century, the appetite for weather information by the general public, emergency managers, and private industry has grown tremendously, as have the capabilities and capacities of the broader weather enterprise. As a result, these factors make it an ideal time to assess the lessons learned and evaluate how to best position the NWS for continued success in the future.

To inform policymakers and agency leaders about the impact of past investments and advise on next steps, Congress mandated two sets of studies. The first, conducted by the National Academy of Sciences, was focused on the lessons learned from modernization and how best to plan, deploy, and oversee investments to integrate science and technology into operations. This study by a Panel of the National Academy of Public Administration examines NWS operations and presents a change management framework for the future.

As a Congressionally chartered non-partisan and non-profit organization with over 750 distinguished Fellows, the Academy brings seasoned experts together to help public organizations address their most critical challenges. We are pleased to have had the opportunity to assist Congress and the NWS by conducting this review. NWS's leadership, union representatives, and stakeholders provided important insights and context throughout the study process. Also, I thank the members of the Academy Panel, chaired by Fellow Mort Downey, who provided invaluable expertise and thoughtful analysis to this undertaking, and the professional study team, headed by Project Director Stephanie Bailenson, that provided critical support to the Panel.

Dan G. Blair
President and CEO
National Academy of Public Administration

ACRONYMS AND ABBREVIATIONS

Academy	National Academy of Public Administration
AWIPS	Advanced Weather Interactive Processing System
CBA	Collective Bargaining Agreement
CWSU	Center Weather Service Units
DOC	Department of Commerce
DOD	Department of Defense
EISWG	Environmental Information Services Working Group of the NOAA Science Advisory Board
EM	Emergency Manager
FAA	Federal Aviation Administration
FACA	Federal Advisory Committee Act
FCI	Facilities Condition Index
FTE	Full Time Equivalent
FY	Fiscal Year
IAEM	International Association of Emergency Managers
IDSS	Impact-based Decision Support Services
IT	Information Technology
MAR	Modernization and Associated Restructuring
mbps	megabits per second
NAS	National Academy of Sciences
NASA	National Aeronautics and Space Administration
NCEP	National Centers for Environmental Prediction
NEXRAD	Next Generation Weather Radars
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
NWSEO	National Weather Service Employees Union
O2R	Operations to Research
OAR	Office of Ocean and Atmospheric Research
OCWWS	Office of Climate, Water, and Weather Services
OMB	Office of Management and Budget
OSIP	Operations and Services Improvement Process
OS&T	Office of Science and Technology
R&D	Research and Development
R2O	Research to Operations
RFC	River Forecast Center
SES	Senior Executive Service
S&T	Science and Technology
WFO	Weather Forecast Office
WSFO	Weather Service Forecasting Office
WSO	Weather Service Office

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EXECUTIVE SUMMARY

Panel Message

Throughout the course of this study the members of this Panel were struck by the level of commitment National Weather Service (NWS) employees have to the organization's mission. From top line leadership to support staff both in Washington, D.C. and the field, they expressed pride in the products and services the NWS provides the Nation. This was matched by statements of strong support from other federal, state, and local agencies, the private sector, and the academic community. It is clear to this Panel that weather, water, and climate products and services provided by the NWS are an important government function. However, despite their strong support, internal and external stakeholders alike stressed that while the advancements resulting from the modernization were significant, there is still room for meaningful improvement with reasonable additional investment. This Panel finds that investing in additional and ongoing change will improve the effectiveness and operational efficiency of the NWS.

The NWS has articulated a new vision—to build a Weather-Ready Nation. While this is a valid and important goal, and the NWS may make improvements to the products and services the organization provides, it cannot fully achieve the vision on its own. This will require a different approach and strong leadership by the NWS as well as considerable engagement and close collaboration with public and private sector partners. It is critical to improve clarity about the intent, the capabilities and capacities of all participants, and to secure commitments for action. The NWS runs the risk of over-promising and under-delivering without shared goals, commitments to collaborate, and sustained support. This clarity of capabilities and capacities will also enable the NWS to determine how to realign the NWS's resources, organization, and processes to achieve these mutual goals.

Whether the NWS is able to fully act on this new vision or not, additional and ongoing change will still be needed. The NWS finds itself operating in a changing environment with increasingly capable partners and a public with evolving expectations for weather information. The technology and infrastructure the NWS relies on is aging and will need periodic refreshment or replacement. This will require the NWS to make additional changes in order to avoid degradation of services.

It is a contradiction that change does not come easily to this highly innovative, mission-focused organization. This is partly because absent a known framework to guide change, the NWS has employed scatter-shot approaches to plan and implement change. It is also partly due to a labor-management relationship that struggles with organizational change. This Panel is hopeful that by re-framing this relationship and establishing a defined change management framework, the NWS can become the adaptive, agile organization essential for achieving the vision of a Weather-Ready Nation.

Basis for the Study

In the early 1990's the National Weather Service (NWS) embarked on a $4.5 billion program to modernize the suite of data collection assets and tools utilized by the NWS, reorganize the type and distribution of offices, and change the skill sets of the workforce. This decade-long

Modernization and Associated Restructuring (MAR) resulted in the structure and operations of the NWS as we know it today.

Since the MAR, much has changed. The capabilities and expectations of the weather enterprise, a term encompassing the public, private, non-profit, academic, media, and research sectors, have increased markedly. Great strides have also been made in science, technology, computing, telecommunications, and the Internet. In *A Retrospective Assessment*, the National Academy of Sciences (NAS) found that as a result of the improvements made during the MAR, forecasters are able to provide more timely and accurate forecasts and warnings. These developments combined have provided a tremendous increase in level of service to the public at a time when the impacts of severe weather have also evolved. There have been a total of 144 weather events that each exceeded $1 billion in impacts since 1980.

In 2010, Congress directed the NWS to work with the National Academy of Sciences to conduct an assessment of the completed modernization and provide recommendations to support future improvements to NWS capabilities. As a follow-up to that effort, Congress requested an independent assessment of the NWS for the purposes of evaluating efficiencies that can be made to NWS operations. The NWS selected the National Academy of Public Administration to conduct that assessment. Over the past seven months, the Panel has conducted extensive research and analysis, examining NWS's organizational structure, workforce, facilities and infrastructure, processes for infusing technology into its operations, and its methods for engaging its partners and other stakeholders. This report contains findings, recommendations, and implementation steps on how to advance the NWS organization.

The Need for Additional and Ongoing Change

The Panel found enormous support for the weather, water, and climate products and services provided by the NWS. However, both internal and external stakeholders see additional and ongoing change as necessary to continue to enhance NWS performance. To continue to provide the range and caliber of current products and services, the NWS, like any technologically dependent organization, will need to refresh or replace aging technology, infrastructure, and systems. <u>While most agree that the Modernization and Associated Restructuring transformed the structure and operations of the NWS for the better, the Panel recommends additional and ongoing change to improve the operations and services of the organization.</u>

The NWS is operating in a dynamic environment. The Panel finds that meeting the evolving expectations of core partners and members of the weather enterprise and keeping pace with technology may require additional resources or shifts in how resources are aligned. <u>The Panel recommends that the NWS improve its engagement with the weather enterprise and core partners to enhance the primary and secondary value-chains.</u>

Achieving a Weather-Ready Nation

During the course of this study, many stakeholders pointed to the tornado outbreaks of spring 2011 as having underscored the efforts underway to change the NWS strategy. Even though the NWS performed well, property was destroyed and lives were lost. The motive of reducing the impacts of severe events led to the vision of a Weather-Ready Nation: "Society is prepared for and responds to weather-dependent events." While many internal and external stakeholders were aware of this concept, they were not aware of the details of what it would actually entail.

To realize the vision of building a Weather-Ready Nation, the Panel recommends that the NWS engage both internal and external stakeholders to secure support for the concept and their commitments to collaborate to achieve mutual goals in the national interest.

NWS has various informal mechanisms for the engagement of external stakeholders and has benefited from the advice of NOAA's Science Advisory Board and its Environmental Information Services Working Group. However, the Panel finds that this is not sufficient to provide the range of advice needed to effectively guide change. To ensure the NWS receives advice from the range of external stakeholders, the Panel recommends the NWS establish a formal advisory committee under the procedures established by the Federal Advisory Committee Act.

Once decisions are made about what Weather-Ready Nation means in terms of outcomes and the NWS has clarified the capabilities it will need to contribute to the effort, the organization can better align its resources and operations to effectively and efficiently meet these needs. The NWS is evaluating an alternate budget construct that realigns program, project or activity lines by function to better support budget transparency and program delivery. The Panel finds that in reorganizing budget lines and the headquarters structure, it should consolidate responsibility around operational functions and service delivery, be forward thinking and anticipate the needs outlined in the *Weather-Ready Nation Roadmap*, and work towards forecast consistency and sharing of information and policies across regions and offices. The Panel recommends that the NWS better align its resources and operations to effectively and efficiently meet the emerging needs of the Weather-Ready Nation paradigm.

The Weather Workforce

The NWS has a very dedicated and engaged workforce that is valued by stakeholders. There has been no change in baseline staffing since the MAR and most agree the current staffing model is not optimal. There has not been sufficient analysis of the current and anticipated activities to resolve the differences in opinions about alternate staffing approaches. To guide and support the important changes needed to more effectively and efficiently deliver weather, water, and climate products and services, the Panel recommends that the NWS conduct additional zero-based analyses of staff alignment and functions. Such an analysis should be detailed, take into consideration the concerns of operating in the current fiscal environment, and include the National Weather Service Employees Organization.

According to the vision of a Weather-Ready Nation, the forecaster of the future will be more interactive and understand how people consume information to better enable them to use the information. The NWS recognizes the need to expand the skill sets of the workforce, yet recruitment strategies have yet to incorporate these skills. Not everyone in the NWS will require the full complement of these expanded skills, but the NWS needs to ensure the right blend of skills to meet the organization's strategic goals. The Panel recommends that the NWS expand its recruitment to include competencies needed for Weather-Ready Nation such as internal and external communication skills, problem-solving, collaboration, conflict management, and leadership.

In FY 2000, training was 1.6 percent of the NWS budget, and by FY 2012 it had declined to 0.7 percent. On-site classroom training has been curtailed due to shortage of travel dollars and the NWS has shifted to more web-based and self-directed training. Similarly, opportunities for

leadership development have been hampered by the suspension of leadership training programs. The Panel recommends that the NWS examine its training and development strategies and technology to build an improved training and development framework that marries the science, leadership, and decision support skills needed to ensure the success of Weather-Ready Nation.

The National Weather Service Employees Organization (NWSEO) represents slightly more than 3,700 NWS employees or 80 percent of the NWS national workforce. From the regional and local perspectives, management and NWSEO appear to be fairly satisfied with the formal labor-management relationship. However, the relationship strains when discussing potential changes to the organization and/or operations that may impact the workforce. Changes to the alignment and functions of employees will continue to occur over time as a result of advances in technology and evolving societal needs. NWSEO representatives express a strong desire to be more involved in pre-decisional issues. Managers agree in concept, but some are hesitant, citing the union's track record of circumventing negotiation and pre-empting decisions by going to Congress or the media with concerns. The Panel recommends that the NWS and NWSEO collaborate to re-frame the labor/management relationship in keeping with the true partnership spirit of Executive Order 13522, which will necessitate the pre-decisional involvement sought by the union and the increased organizational results sought by management within a climate of mutual trust.

Continuous Infusion of Science and Technology

Since its beginnings, the NWS has striven to adopt new science and technologies to optimize observations and forecasts. However, the NWS does not have an efficient and effective means for identifying science and technology requirements, researching and developing those to maturity, procuring the respective components or systems, and introducing them into operations. To ensure that NWS Research to Operations (R2O) and Operations to Research (O2R) receive appropriate priority and support, the Panel recommends that it consolidate the current distributed management of this function.

Absent a functional NWS process for R2O and O2R, many field operators who desire a new capability work on developing it themselves. There is no current means to prevent this activity. Many of these developments affect the Advanced Weather Interactive Processing System (AWIPS), the core forecasting system used throughout the NWS. The Panel finds that the practice of allowing ad hoc research and development both confounds system configuration management and poses a significant security threat that should be quickly remedied. The Panel also finds that the practice of developing local applications across the AWIPS network has resulted in a number of hidden costs, including diverted staff hours, network administration and systems engineering time, and schedule delay in rolling out new systems such as AWIPS II.
While NWS officials state that the organization is fully compliant with national information security requirements, the Panel finds that the NWS is assuming an inadvisable risk profile through the practice of allowing wholesale development of local applications. This has the potential for putting the organization in a position of greater vulnerability. The Panel recommends that the NWS establish Configuration Management and Security Risk Management over its information technology systems.

Infrastructure and Facilities

The MAR infrastructure is two decades old or more and is presenting an increasing cost liability. The NWS has struggled to keep pace with its technology refresh cycle, a risky endeavor that is starting to show as an operational concern. The Panel finds that the NWS is burdened with excessive amounts of information technology equipment that is not needed or supportable given current fiscal constraints. The Panel recommends that the NWS conduct an NWS-wide analysis of its enterprise architecture, dissemination systems, and telecommunications infrastructure and identify opportunities for consolidating, integrating, or eliminating hardware or systems given current or anticipated future operational scenarios.

The NWS is also supporting a large portfolio of deteriorating real estate. One hundred of the NWS's buildings are over 20 years old and 39 are over 40 years old. Forty-three buildings (18 percent) had a total of $21.1 million in deferred repairs and a condition index below 80 percent which according to NOAA guidelines is "unacceptable." Total deferred repairs on all properties were $42.5 million. The Panel recommends that the NWS conduct an NWS-wide requirements analysis of its facilities.

With the increasing demands for decision support, many of those interviewed said that the NWS will need to become more mobile and adaptable. The Panel finds that the ongoing NWS efforts at developing portable information technology applications have the capability of providing cost-effective tools that have proven effective to facilitate decision support. The Panel recommends that in keeping with its vision of a Weather-Ready Nation, the NWS prioritize and accelerate its efforts to develop mobile computing applications and the use of Virtual Private Networks and rapidly transition these technologies for use in mobile, forward-deployed, and remote applications.

Moving Forward

The Panel finds that due to the dynamic environment in which the NWS operates, it is essential that the organization have an adaptive and agile organization to enhance its ability to achieve the vision of a Weather-Ready Nation. In order to facilitate additional and ongoing change, the Panel finds that the NWS will need to address the diversity of opinions of internal and external stakeholders on what to change, how to change, and the appropriate rate of change. To facilitate additional and ongoing change the Panel recommends that the NWS, in conjunction with its partners, develop a process and structure to guide significant organizational and operational changes. This process and structure should be:

- defined;
- agile;
- collaborative;
- transparent;
- accountable;
- balanced; and
- must align the necessary resources.

There are a number of issues that will affect the potential for change:

- The need to define the undefined but widely cited concept "no degradation of service" if the NWS is going to have a reasonable chance of meeting stakeholder expectations.

- Finding solutions within a severely constrained budget environment. Over the last decade, the total NWS budget declined in constant FY 2004 dollars from $833.7 million to $815 million, a 2.2 percent decline in buying power.
- Improving internal and external communication as a gateway to improved collaboration.
- Strengthening service assessments through the inclusion of external participants to help further the Weather-Ready Nation goals of guiding community preparedness and response.

Conclusion

The NWS has long played a critical role in protecting the lives, property, and economy of the nation by providing valuable weather, water, and climate products and services. If realized, the bold NWS vision for a Weather-Ready Nation has the potential to significantly enhance our collective capabilities to make informed decisions about how to prepare for, and respond to, weather and climate events. This will require a new approach for the NWS that embraces collaboration and seeks new ways to create value beyond traditional forecasting activities. Once the NWS and partners determine the outcomes they seek to collectively achieve, clarify the capabilities and capacities of all participants, and commit to meeting these shared goals, then the NWS can decide how to align the resources of the organization to meet these common goals. This is not a finite transformation, rather a process of continual innovation and change.

CONSOLIDATED LIST OF RECOMMENDATIONS

1. While most agree that the Modernization and Associated Restructuring transformed the structure and operations of the NWS for the better, the Panel recommends additional and ongoing change to improve the operations and services of the organization.
2. The Panel recommends that the NWS improve its engagement with the weather enterprise and core partners to enhance the primary and secondary value-chains.
3. To realize the vision of building a Weather-Ready Nation, the Panel recommends that the NWS engage both internal and external stakeholders to secure support for the concept and their commitment to collaborate to achieve mutual goals in the national interest.
4. To ensure the NWS receives advice from the range of external stakeholders, the Panel recommends the NWS establish a formal advisory committee under the procedures established by the Federal Advisory Committee Act.
5. The Panel recommends that the NWS better align its resources and operations to effectively and efficiently meet the emerging needs of the Weather-Ready Nation paradigm.
6. To guide and support the important changes needed to more effectively and efficiently deliver weather, water, and climate products and services, the Panel recommends that the NWS conduct additional zero-based analyses of staff alignment and functions.
7. The Panel recommends that the NWS expand its recruitment to include competencies needed for Weather-Ready Nation such as internal and external communication skills, problem-solving, collaboration, conflict management, and leadership.
8. The Panel recommends that the NWS examine its training and development strategies and technology to build an improved training and development framework that marries the science, leadership, and decision support skills needed to ensure the success of Weather-Ready Nation.
9. The Panel recommends that the NWS and NWSEO collaborate to re-frame the labor/management relationship in keeping with the true partnership spirit of Executive Order 13522, which will necessitate the pre-decisional involvement sought by the union and the increased organizational results sought by management within a climate of mutual trust.
10. To ensure that NWS Research to Operations (R2O) and Operations to Research (O2R) receive appropriate priority and support, the Panel recommends that it consolidate the current distributed management of this function.
11. The Panel recommends that the NWS establish Configuration Management and Security Risk Management over its information technology systems.
12. The Panel recommends that the NWS conduct an NWS-wide analysis of its enterprise architecture, dissemination systems, and telecommunications infrastructure and identify opportunities for consolidating, integrating, or eliminating hardware or systems given current or anticipated future operational scenarios.
13. The Panel recommends that the NWS conduct an NWS-wide requirements analysis of its facilities.
14. The Panel recommends that in keeping with its vision of a Weather-Ready Nation, the NWS prioritize and accelerate its efforts to develop mobile computing applications and the use of Virtual Private Networks and rapidly transition these technologies for use in mobile, forward-deployed, and remote applications.

15. To facilitate additional and ongoing change the Panel recommends that the NWS, in conjunction with its partners, develop a process and structure to guide significant organizational and operational changes.

CHAPTER 1: INTRODUCTION

1.1 OVERVIEW OF THE NATIONAL WEATHER SERVICE

Weather has a direct and personal impact on Americans. Since America's early days, weather has had a profound influence on commerce, the military, the protection of property, and the safety of its people. The development of timely communications channels across the country in the early- to mid-1800s led to a growth in weather observation networks. Congress formalized these efforts within the U.S. Army Signal Service in 1870. The organization went through some transformations over time, becoming the U.S. Weather Bureau and moving to the U.S. Department of Agriculture in 1890, then to the U.S. Department of Commerce (DOC) in 1940, and becoming the National Weather Service (NWS) as part of the then newly-formed National Oceanic and Atmospheric Administration (NOAA) in 1970. As capabilities have improved, the duties of the NWS have grown to include issuing flood and hurricane warnings, international collaboration, upper air atmospheric observations and research, and seasonal climate outlooks.[1] While these duties have evolved, the current mission statement of the NWS would be familiar to its predecessors: "Provide weather, water, and climate data, forecasts and warnings for the protection of life and property and enhancement of the national economy."[2]

> ***NWS Mission***
> Provide weather, water, and climate data, forecasts and warnings for the protection of life and property and enhancement of the national economy

1.2 MODERNIZATION AND ASSOCIATED RESTRUCTURING

The Weather Service Modernization Act, enacted October 29, 1992, authorized a process whereby the NWS would implement new technologies; modify field office operations; change the quantity and/or skill set of field office personnel; commission or de-commission radars and equipment; and close, consolidate, automate, or relocate its field offices. The Modernization and Associated Restructuring (MAR) served to modernize the suite of data collection assets and tools utilized by the NWS workforce, reorganize the type and distribution of offices, and change the makeup of the workforce. Implemented between 1989 and 2000 at a cost of approximately $4.5 billion, the MAR created the structure and operations of the NWS as it exists today.[3]

Restructured Organization

The NWS currently has a distributed network of offices managed through a central headquarters led by the NOAA Assistant Administrator for Weather Services (also known as the Director of the National Weather Service).[4] The current distribution of NWS offices around the country can be seen in Figure 1.1.

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[1] Evolution of the National Weather Service, http://www.nws.noaa.gov/pa/history/timeline.php.
[2] National Weather Service. *Weather-Ready Nation: Strategic Plan 2011*.
[3] National Research Council. *The National Weather Service Modernization and Associated Restructuring: A Retrospective Assessment*.
[4] Descriptions of each office and an organization chart can be found in Appendix F.

Figure 1.1: Map of NWS Offices, Regions, and River Basins

NWS headquarters provides traditional program support through the Office of the Chief Financial Officer, Office of the Chief Information Officer, Office of Strategic Planning and Policy, and the Equal Employment Office. Additionally, there are offices that provide central research, services, and operations support and coordination: the International Activities Office; the Office of Hydrologic Development; the Office of Science and Technology; the Office of Operational Systems; and the Office of Climate, Water, and Weather Services.

The NWS field units are managed by 6 regional offices. Each region is led by a regional director. The regions provide administrative and operation support to the distributed field network, facilitating span of control over the Weather Forecast Offices, River Forecast Centers, Center Weather Service Units, and Weather Service Offices.

The MAR's biggest structural and functional change was made to the meteorology field structure. Before the MAR, the NWS had a two-tiered field structure of 52 Weather Service Forecast Offices (WSFO) and 204 Weather Service Offices (WSO). The larger WSFOs, approximately one per state, were staffed with approximately 1,000 professional Meteorologists while the smaller WSOs were staffed with approximately 2,000 observers and Meteorological Technicians. The WSOs served to collect weather data and feed that to the WSFOs for incorporation into the forecast. The WSOs also issued warnings for their respective local areas.[5]

The organizational restructuring pursuant to the MAR resulted in a field structure of 122 Weather Forecast Offices (WFO) and 21 Center Weather Service Units (CWSU). The 204 legacy WSOs were closed (with the exception of 18 in the Alaska and Pacific regions), and their observation duties were assumed by the WFOs. Before any existing field office could be affected, the Secretary of Commerce was to certify that such action would not result in "any degradation of service." Each such certification was to be preceded by publication of intent in the Federal Register and a 60-day public comment period. The WFOs are responsible for local forecasts and warnings and operate 24 hours a day, 7 days a week. A map showing the areas of responsibility for the WFOs can be found in Appendix F.

The 13 River Forecast Centers (RFC) are responsible for producing river and flood forecasts, warnings, and water resource information. They are aligned to the major river basins and were co-located with WFOs as part of the MAR in an effort to improve coordination between meteorology and hydrology activities. They work in partnership with other local, state, and federal water management agencies. A map showing the areas of responsibility for the RFCs can be found in Appendix F.

The National Centers for Environmental Prediction (NCEP) were also formed during the MAR. This reconfiguration consolidated and focused data assimilation and numerical weather prediction development and facilitated making new observation and forecast products available.[6] NCEP consists of nine National Centers located in five cities and is

[5] Friday Jr., Elbert W. The Modernization and Associated Restructuring of the National Weather Service: An Overview.

[6] Described in more detail in the National Research Council's report *Weather Services for the Nation: Becoming Second to None*.

managed centrally through the Office of the Director. The nine centers are the Aviation Weather Center, the Climate Prediction Center, the Environmental Modeling Center, NCEP Central Operations, the National Hurricane Center, the Ocean Prediction Center, the Space Weather Prediction Center, the Storm Prediction Center, and the Weather Prediction Center.

Restructuring the Workforce

The MAR also resulted in a substantial reconfiguration and standardization of the NWS workforce. The automation of observations and closing of WSOs reduced the need for Meteorological Technicians. The increase in the forecast functions and responsibilities drove the need for additional Meteorologists. This resulted in an inversion of the workforce, increasing professional Meteorologists to approximately 2,000 and decreasing Meteorological Technicians to approximately 1,000. As part of the transition, incumbent technicians were provided the opportunity to complete courses of study to qualify them to serve in the new Meteorologist positions. The MAR established a standardized staffing model for field offices in an effort to provide more uniform services across the nation.[7] Although the standardized staffing template simplified acceptance and execution of the MAR, it created a very symmetrical staffing solution to an otherwise asymmetrical weather threat.

Results of Modernization

While public and congressional anxiety over the closing of individual offices caused concern about degradation of service, the net effect of the MAR was actually a marked improvement in service in several ways. In its retrospective assessment of the MAR, the National Academy of Sciences (NAS) found that the NWS has provided more uniform weather services and greater interaction with communities, specifically local media and emergency management. Moreover, the combination of scientific advancements, modernized technology, a more highly-skilled workforce, and a reorganized operational structure contributed to the improved accuracy and timeliness of forecasts and warnings.[8] These developments combined have provided a tremendous increase in level of service to the public.

Core Partners and the Weather Enterprise

Since the MAR, both the weather enterprise and the NWS's core partners have become increasingly important in the production and dissemination of weather information. As defined in the NWS's *Weather-Ready Nation Roadmap*:

> **Core Partners**—Government and nongovernment entities that are directly involved in preparation, dissemination, and discussions

[7] This is discussed in more detail in Chapter 4.

[8] See National Research Council's report *The National Weather Service Modernization and Associated Restructuring: A Retrospective Assessment* for a detailed discussion of the improvements to tornado and flash flood warnings, numerical weather prediction, and hurricane and extratropical storm predictions.

involving weather, water, and climate or other emergency information put out by NWS.

Weather Enterprise—All government agencies, private sector entities, nonprofit groups, and academic and research institutions contributing to the business and/or science of weather observing, forecasting, and warning.[9]

The public sector portion of the enterprise includes the NWS as well as other weather-related line offices within NOAA, other federal agencies such as the Navy, Air Force, and FAA weather components, and state and local governments.

The emergency management community and the electronic media depend upon the NWS and the rest of the enterprise for information, and the NWS depends on its core partners to disseminate the message. The inclusion of the media in the definition of core partners displays a recognition, echoed by many stakeholders interviewed, that an estimated 90 percent or more of the public receives its weather information from sources other than the NWS.[10]

1.3 Basis for the Study

In 2010, Congress directed the NWS to work with the National Academy of Sciences to conduct an assessment of the completed NWS modernization and provide recommendations to support future improvements to NWS capabilities.[11] As a follow-up to that effort, Congress requested an independent assessment of the NWS operations with recommendations on ways to improve organizational efficiency that would not result in any degradation of services to the communities served by local offices and River Forecast Centers or place the safety of the public at greater risk.[12] The NWS selected the National Academy of Public Administration (the Academy) to conduct this seven-month independent assessment. This report contains findings and recommendations on how to advance the NWS organization as needed to efficiently meet mission requirements within the evolving needs of the nation for weather, water, and climate services.[13]

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[9] The Academy will follow the convention used in the National Research Council's report, *Becoming Second to None*, and typically use "weather enterprise" to refer to those elements outside NOAA on which it can draw to fulfill its mission.

[10] Lazo, Jeffrey K., Rebecca E. Morss, and Julie L. Demuth. "300 Billion Served: Sources, Perceptions, Uses, and Values of Weather Forecasts."

[11] U.S. House of Representatives. *The Consolidated Appropriations Act.* House Report 111-366 of Public Law 111-117, 2010. The National Research Council's assessment resulted in two reports, *The National Weather Service Modernization and Associated Restructuring: A Retrospective Assessment* and *Weather Services for the Nation: Becoming Second to None*.

[12] U.S. House of Representatives. *The Consolidated and Continuing Appropriations Act*. House Report 112-284 of Public Law 112-55, 2012. For full text of this authorizing language, see Appendix B.

[13] The scope of this study does not include making recommendations about the internal structure of other weather-related parts of NOAA. A separate detailed assessment of financial management at the NWS was already underway and, therefore, was not a focus of this study.

1.4 Approach and Methodology

The Academy's research approach included extensive discussion and collaboration with NWS headquarters and field offices, including representatives from both management and the National Weather Service Employees Organization (NWSEO). The study team also interviewed the NWS's primary stakeholders including emergency managers, congressional staff, and other members of the weather enterprise including academics, professional organizations, and private corporations. Research for this study included interviews, multiple meetings with the NWS and the Panel and study team, data analysis, and a thorough review of the available literature. This review included the preceding assessment by the National Academy of Sciences and discussions with members of its Committee on the Assessment of the National Weather Service's Modernization Program.

Academy Panel

The Academy convened a five-member panel of Academy Fellows to review the NWS's structure and make recommendations to Congress and the NWS. The makeup of the Panel reflects the variety of stakeholders with whom the NWS interacts, including members with expertise and experience in federal and local governments, disaster management, emergency communications, finance, and workforce. Together they represent experience as senior executives, city managers, and academics in fields related to this topic. Appendix A contains information on Panel members and study team.

The Panel met four times over the course of the seven-month assessment, and individual members visited their local Weather Forecast Offices. A portion of each of the Panel's two informational meetings was open to the public, in which the NWS leaders, NWSEO representatives, and the Chair of the NAS Committee were invited to participate. Some portion of the Panel's meetings were reserved for deliberative executive sessions where the Panel worked with the study team to refine its work plan, direct research, formulate preliminary observations, and develop and approve the findings and recommendations contained in this final report.

Interviews

As directed by the congressional language authorizing this effort, the Panel and study team engaged with a wide variety of stakeholders to collect information about the current NWS structure, understand challenges and opportunities, and discuss proposals for change. The Panel and study team conducted interviews with NWS management and staff at headquarters and field offices, emergency managers, and external stakeholders including members of the weather enterprise. The Panel and study team interviewed or met with approximately 160 individuals over the course of this study. All interviews were conducted on a not-for-attribution basis. See Appendix D for a list of these participants.

Focus Groups

In order to better understand the range of weather-related issues of concern to emergency managers, the study team held two focus groups with state and local emergency managers.

The focus groups included 20 participants and were conducted on a not-for-attribution basis. For additional details see Appendix E.

Site Visits

Members of the Panel and study team visited several NWS offices to enhance understanding of the operational environment and challenges. These site visits included Weather Forecast Offices, a River Forecast Center, a Regional Office, the NWS Training Center, and several National Centers. The specific offices visited are listed in Appendix C.

Literature Review

The Panel and study team conducted an extensive review of the NWS operations and structure. Documents reviewed included congressional testimony and public law; U.S. Government Accountability Office reports; NAS reports; DOC/NOAA/NWS budgets, data, reports, directives, and guidance; the *NWS Strategic Plan* and *Weather-Ready Nation Roadmap*; stakeholder reports; and other secondary sources of information. See Appendix I for Information Sources.

CHAPTER 2: THE NEED FOR ADDITIONAL AND ONGOING CHANGE

2.1 THE CASE FOR ADDITIONAL CHANGE

During the course of this study, the Panel found enormous support for the products and services provided by the NWS. From emergency managers at the local, state, and federal levels to academics to private industry, all echoed the need for a strong NWS. Those individuals who collaborated with the NWS before the MAR highlighted the tremendous improvement it yielded in the reliability, timeliness, and accuracy of NWS products and services. Both internal and external stakeholders see additional and ongoing change as a way to continue to enhance the performance of the NWS.

Weather affects our lives on a daily basis. Timely, reliable, and accurate forecasts help shape decisions both large and small. From individual decisions, such as carrying an umbrella, to corporate decisions, such as determining the route to send shipments around a winter storm, we value weather, water, and climate information. It has been estimated that the American public receives $31.5 billion in benefits from the 301 billion forecasts we consume each year.[14] While some of this information comes to end users directly from the NWS, the public increasingly receives information that is packaged and delivered by other sources such as television and radio broadcasts, local emergency management alert systems, and mobile applications from private companies and media outlets.[15] When weather takes a turn for the worse, watches, warnings, and advisories can save lives and help minimize the impacts of these events. This is critical considering the U.S. experienced 11 weather and climate events that resulted in 349 deaths and exceeded $1 billion in damages and costs in 2012. There have been a total of 144 weather events that each exceeded $1 billion in impacts since 1980.[16] Reducing these devastating impacts is driving the need for change.

2.2 THE VALUE OF CONTINUOUS CHANGE

Some change is needed simply to maintain the status quo. In order to continue to provide the range and caliber of current products and services, the NWS, like any technologically dependent organization, will need to refresh or replace aging technology, infrastructure, and systems. Failure to provide for that refreshment or replacement will eventually lead to

[14] This includes active and passive exposure to forecasts and multiple exposures to individual forecasts. For a complete description of this survey of benefits see Lazo, Jeffrey K., Rebecca E. Morss, and Julie L. Demuth. "300 Billion Served: Sources, Perceptions, Uses, and Values of Weather Forecasts."

[15] This refinement and repackaging of weather information is described by the NAS report *Becoming Second to None* as being part of a secondary value-chain. As detailed in the 2009 Lazo, et al. study, local television was the most frequent source of weather forecasts, and internet-based sources were becoming more common. According to The Nielson Company's more recent *The Mobile Consumer* (2013), 48% of American smartphone owners use mobile weather applications.

[16] Information from NOAA's National Climatic Data Center website. http://www.ncdc.noaa.gov/billions/events.

a degradation of service.[17] However, no one the Panel and study team interviewed over the course of this study advocated for simply maintaining the status quo.

The NWS reflects this need for change in its guiding documents.[18] The advancements resulting from the MAR were significant, but there is still room for meaningful improvement with reasonable additional investment. The National Academy of Sciences highlighted a number of areas for science and technology enhancements including the need for improving the quality of foundational datasets, continued improvement to models and model ensembles, and a sustainable mesoscale observation system,[19] among others.[20] **The Panel finds that additional advancements have the potential to improve the weather, water, and climate products and services currently produced by both the NWS and the weather enterprise to save lives, protect property, and enhance the economy.** They also provide the NWS with opportunities to enhance or expand products and services to meet evolving societal needs.

Stakeholders pointed to efforts made since the end of the MAR as demonstrative of the types of improvements still to be made. The scale of these changes and their impacts vary. Some were technologically focused, such as the implementation of dual polarization radar, while others were driven by an interest in improving service delivery, such as the implementation of real-time chat systems. In each case, the changes enhanced the ability of the NWS workforce to fulfill mission requirements.

The Panel finds that the advantage of ongoing and incremental changes is that they result in less disruption to the organization, the workflow, and the provision of services than waiting to replace everything at once. They can also be redirected or reversed based on experience. While each change may have challenges in the development, testing, and implementation stages, these are likely to be less complex and less costly than a wholesale replacement of technology, systems, and workflow processes. Similarly, it makes it easier for core partners and members of the weather enterprise to contribute to, adapt to, and absorb these changes. The tradeoff is in having to merge new technology with old and ensuring system compatibility.

The NWS operates in a dynamic environment. Core partners and members of the weather enterprise indicated their expectations for access to more data; more information about the uncertainty of data used in weather, water, and climate products; and greater lead time. As detailed in the NAS report *Becoming Second to None*, keeping pace with technology and stakeholder expectations are key challenges faced by the organization. **The Panel finds**

[17] This "no degradation of service" standard is discussed in more detail in Chapter 7.
[18] See *NOAA's National Weather Service Strategic Plan: Building a Weather-Ready Nation* (2011); *NWS's Weather-Ready Nation Roadmap* (2012); and NOAA's FY 2013 Budget Summary.
[19] This generally refers to a system that allows for detection of more localized weather events with the use of sensors that operate over a smaller spatial scale and shorter timeframe.
[20] The National Research Council's 2012 report *Becoming Second to None* includes details about a range of science and technology-driven opportunities for improvement to weather, water, and climate products and services.

that meeting the evolving expectations of core partners and members of the weather enterprise and keeping pace with technology may require additional resources or shifts in how resources are aligned.

2.3 THE CONTEXT FOR CHANGE

Since the MAR, the weather enterprise has grown considerably. A 2007 survey of private sector meteorologists and meteorology companies concluded that of the approximately $5 billion spent on meteorological operations at the time, government agencies funded approximately $3.4 billion while industry contributed the balance. Recent estimates reveal that the private sector has continued to develop at a faster rate than government efforts; annual federal and non-federal enterprise investments are now estimated at $4 to $5 billion each.[21] This increasingly sophisticated and capable commercial presence has enhanced the exchange of information among various entities, as well as the potential for collaboration and partnerships. In addition, core partners expect the NWS to continue to deliver more timely, accurate, and reliable information—what they see as one of the most essential functions of the NWS mission—than ever before in order to serve their respective communities. A previous Academy Panel noted that as a result of significant investments in homeland security preparedness over the last decade, emergency management agencies have made significant improvements in their ability to save lives and protect property.[22] Many of these efforts have broader application than homeland security and apply to all hazards preparedness. The needs of core partners have evolved with their increased capacities and capabilities.

In *Becoming Second to None*, the "primary value-chain" was defined as the traditional channel through which the NWS delivers important weather information primarily to its core partners. There is also an important "secondary value-chain," through which others conduct value-added functions that improve the usability of NWS information. The secondary value-chain encompasses the commercial weather industry, as well as some governmental and non-governmental organizations.[23] Because of the significant impact weather can have on public and private sector activities, the use of in-house or contracted meteorologists and consultants by companies, organizers of major events, and state and local governments has become more common.

Today, many weather, water, and climate needs are not served by the NWS primary value-chain alone. As the capabilities of the private and public sectors increase, new opportunities for collaboration will occur. **Going forward, the Panel finds the NWS must focus on its core capabilities to effectively allocate its limited resources.** Prioritizing these core capabilities was a main recommendation in *Becoming Second to None* to ensure the NWS generates the products and services that serve as the foundation for the entire

[21] National Research Council. *Weather Services for the Nation: Becoming Second to None*.
[22] National Academy of Public Administration. *Improving the National Preparedness System: Developing More Meaningful Grant Performance Measures*.
[23] National Research Council. *Weather Services for the Nation: Becoming Second to None*.

weather enterprise.[24] Many stakeholders interviewed expressed the view that providing decision support to government emergency managers is an important government role in the interest of public safety. As the capabilities of the weather enterprise will continue to evolve, the NWS should seek advice from the federal advisory committee recommended in Chapter 3 when reviewing its core capabilities to determine how to effectively allocate resources in a manner that leverages the capabilities and capacities of public and private partners.

The Panel finds that while the NWS currently interacts regularly with a wide range of stakeholders, the entire weather enterprise would likely benefit from broader, more coordinated and consistent engagement that leverages all parties' capabilities while also meeting their needs. As the NWS's service activities increase, so will the risk of duplication of, or the perceived encroachment upon, the function of commercial interests within the secondary value-chain. Collaboration occurs when participants see an opportunity to do something together that they could not do alone. It is a process of working together to produce a better product or service. Removing barriers and more fully embracing collaboration with the weather enterprise could result in a significant force multiplier for the NWS.

Findings

Based on its research and evaluation, the Panel makes the following findings:

- Additional advancements have the potential to improve the weather, water, and climate products and services currently produced by both the NWS and the weather enterprise to save lives, protect property, and enhance the economy.
- The advantage of ongoing and incremental changes is that they result in less disruption to the organization, the workflow, and the provision of services than waiting to replace everything at once.
- Meeting the evolving expectations of core partners and members of the weather enterprise and keeping pace with technology may require additional resources or shifts in how resources are aligned.
- The NWS must focus on its core capabilities to effectively allocate its limited resources.
- While the NWS currently interacts regularly with a wide range of stakeholders, the entire weather enterprise would likely benefit from broader, more coordinated and consistent engagement that leverages all parties' capabilities while also meeting their needs.

[24] Ibid.

Recommendation 1

While most agree that the Modernization and Associated Restructuring transformed the structure and operations of the NWS for the better, the Panel recommends additional and ongoing change to improve the operations and services of the organization.

Recommendation 2

The Panel recommends that the NWS improve its engagement with the weather enterprise and core partners to enhance the primary and secondary value-chains.

To implement this recommendation, the NWS should:

- seek advice from the advisory committee recommended in Chapter 3 when reviewing core capabilities to prioritize them to effectively allocate its limited resources;
- identify opportunities to engage core partners to enhance mutual understanding of each other's needs, capabilities, capacities, and procedures to improve how weather, water, and climate information is translated into public action;
- identify opportunities to engage the commercial weather sector to better understand and leverage current and emerging capabilities and interests while avoiding duplication of effort; and
- invite private sector entities to furnish concepts on how to transition incrementally to a more open weather and climate service.

CHAPTER 3: ACHIEVING A WEATHER-READY NATION

3.1 VISION OF A WEATHER-READY NATION

Many NWS staff interviewed by the Panel and study team during the course of this study pointed to the tornado outbreaks of spring 2011 as having underscored the need to change the organization's strategy. During April and May of that year, five periods of high tornadic activity resulted in 545 deaths and an estimated $26.4-26.9 billion in damages.[25] By the NWS's performance standards, these were very well-forecasted events with higher than targeted probability of detection and lead time and lower than targeted false alarm rates. Notice had been given by the Storm Prediction Center days in advance that conditions were ripe for tornadic activity, and area WFOs conducted considerable outreach to emergency managers, the media, and the public.[26]

While these activities undoubtedly saved lives, people still perished. This occurred at a time when the NWS was already examining ways it could help reduce the impacts of weather events. The NWS articulated the concept of a Weather-Ready Nation in the *NWS Strategic Plan* that was released in June 2011. At the core of this concept is a shift from the more narrow performance focus on the weather, water, and climate products and services—the outputs of the NWS activities—to a broader performance focus on how these products and services translate into desired public actions—societal outcomes. The stated vision of a Weather-Ready Nation is that "Society is prepared for and responds to weather-dependent events."[27]

> ***NWS Vision***
> A Weather-Ready Nation: Society is prepared for and responds to weather-dependent events

This was not an entirely new concept for the NWS. It has its roots in the decision support that the organization has long provided to emergency managers and decision makers. Activities such as NWS staff deploying to emergency operations centers; incident meteorologists deploying on-site during wildfires; NWS staff participating in local, state, and federal preparedness exercises; and established the StormReady and TsunamiReady community preparedness programs serve as a foundation for the NWS to build upon. How to improve the communication of important weather information continued to be discussed within the enterprise and in a 2006 National Research Council study, *Completing the Forecast,* which examined how decision makers were faced with making weather-related decisions without a clear picture of the uncertainties associated with weather

[25] National Climatic Data Center. *Billion-Dollar Weather/Climate Disasters from 1980 to 2012*. http://www.ncdc.noaa.gov/billions/events.
[26] Service Assessment: The Historic Tornadoes of April 2011; NWS Central Region Service Assessment: Joplin, Missouri, Tornado – May 22, 2011.
[27] National Weather Service. *Weather-Ready Nation: Strategic Plan 2011*.

information. This was further explored through professional societies[28] and an international symposium.[29]

However, the *NWS Strategic Plan* takes these concepts several steps further by articulating six goals with "measures of success" that capture potential results (see Table 3.1). The NWS expanded upon these ideas in the *Weather-Ready Nation Roadmap*. This document was intended to "lay the foundation for future NWS Services."[30] With 90 percent of federally declared disasters being weather-related, building a Weather-Ready Nation could have enormous benefits for the Nation.[31] A key feature is a shift to Impact-based Decision Support Services (IDSS). This is the overarching paradigm from which the NWS will deliver weather, water, and climate related services. The six goals in the strategic vision either specifically mention service provision or involve tools for service provision. Many of those interviewed both inside and outside of the NWS, expressed the view that IDSS is the right path forward for the organization. With increasing IDSS demands, NWS field personnel will be called upon to engage customers in new ways on a more frequent basis, both in person and through technology, and to assist partners before, during, and after severe weather events.

[28] Final Report of Focus Groups Conducted at the 36th American Meteorological Society Conference on Broadcast Meteorology, Denver, CO: June 25-26, 2008.
[29] In 2007, the United Nations World Meteorological Organization held the International Symposium on Public Weather Services.
[30] National Weather Service. *Weather-Ready Nation Roadmap Version 1.0*.
[31] Information from NWS StormReady program, http://www.stormready.noaa.gov/. According to FEMA information for 2012, there were 47 major disaster declarations and 16 emergency declarations. All were related to weather and climate including hurricanes, tornado, flooding, and wildfire. http://www.fema.gov/disasters/grid/year/2012?field_disaster_type_term_tid_1=All.

Goal 1	Improve weather decision services for events that threaten lives and livelihoods
Measures for success	Improved community emergency preparedness leading to avoidance of fatalities from weather-dependent events; cost avoidance from unnecessary evacuations and property damage; and more rapid post-event recovery
Goal 2	Deliver a broad suite of improved water forecasting services to support management of the Nation's water supply
Measures for success	Reduced economic loss and property damage from flooding; more efficient management of municipal water supplies using integrated water forecasts and information; economic, ecological, and agricultural benefits realized from forecasting water temperature, soil moisture, and other parameters
Goal 3	Enhance climate services to help communities, businesses, and governments understand and adapt to climate-related risks
Measures for success	Economic benefits in areas such as agriculture, transportation, water, and energy as a result of impact-based climate services; improved preparation and response to weather dependent events based on climate forecasts; better management of environmental resources based on climate forecasts
Goal 4	Improve sector-relevant information in support of economic productivity
Measures for success	Economic benefits in weather sensitive sectors of the economy, including transportation (air, land, water), energy, and agriculture through efficiency gains, damage avoidance, and increased value from services provided by America's weather and climate industry
Goal 5	Enable integrated environmental forecast services supporting healthy communities and ecosystems
Measures for success	Reduced incidence of health impacts attributable to air pollution and extreme temperatures; reduced incidence of waterborne illnesses due to improved water and beach quality forecasts
Goal 6	Sustain a highly-skilled, professional workforce equipped with the training, tools, and infrastructure to meet our mission
Measures for success	Future workforce's skills and capabilities identified and aligned with training and recruitment; improved employee satisfaction, operational collaboration, and knowledge-sharing tools for NWS workforce; increased high performance computing capacity, expanded and sustained facilities, and infrastructure; expanded availability and interoperability of environmental data

Table 3.1: Goals and Measures of Success for a Weather-Ready Nation as identified in the *NWS Strategic Plan*.

3.2 The Challenges of Meeting the Vision of a Weather-Ready Nation

The Panel finds that taking a societal impact approach to weather, water, and climate represents a significant change in the way the NWS approaches its functions. The NWS can make a considerable contribution to achieving the anticipated results, but it cannot achieve them by acting alone. The *NWS Strategic Plan* recognizes that success "depends critically on teamwork—within the NWS and NOAA and with our partners in the public, private, and academic/research sectors." In this regard, it shares a similar philosophy to the Federal Emergency Management Agency's Whole Community concept.[32] **The Panel finds that achieving a Weather-Ready Nation will require strong leadership by the NWS as well as considerable engagement and close collaboration with public and private sector partners.** If the NWS does not make this clear in its communications with Congress, partners, and the public, it runs the risk of setting the organization up for perceived failure and undermining these efforts to help make a society that is prepared for, and responds to, weather-dependent events.

While the NWS's *Weather-Ready Nation Roadmap* is positioned as a "practical guide to making the vision of a Weather-Ready Nation a reality," based on numerous interviews with internal and external NWS stakeholders, it does not provide sufficient clarity of what the NWS intends to achieve or how to leverage the collective capacities and capabilities of the NWS, public and private sector partners, and the general public to fulfill this vision. Many core partners and members of the weather enterprise think the Weather-Ready Nation initiative holds great potential. For this to be successful, it must be a shared initiative with commitments to achieving mutual goals. **Without improved clarity about the intent of the initiative and about the capabilities and capacities of participants, as well as commitments to collaborate, the Panel finds that it will be difficult for the NWS to fully achieve the vision of a Weather-Ready Nation.** The Panel recognizes that capabilities and capacities of participants will change over time and, as a result, the nature of collaborations will also change. The NWS needs to expand upon the dialogue that resulted from the *Fair Weather* report,[33] to address the capacities and capabilities needed for this new societal outcome-based approach of Weather-Ready Nation. The dialogue should include a broad range of public agencies at the local, state, and federal levels as well as the private sector, non-profit organizations, and the general public.

While core partners and members of the weather enterprise had heard of the Weather-Ready Nation concept, they were familiar neither with the details nor with expectations of their involvement. All recognize that they have a part to play in having a country that is truly weather ready, but few have yet been sufficiently engaged to articulate shared goals or commit to specific activities. This must be addressed or the NWS will not be able to fulfill the vision of a Weather-Ready Nation.

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[32] Federal Emergency Management Agency. *A Whole Community Approach to Emergency Management: Principles, Themes, and Pathways for Action*.
[33] National Research Council, *Fair Weather: Effective Partnerships in Weather and Climate Services*.

Among those stakeholders less sure about the concept, some voiced apprehension about the possibility of false assurances and public confusion regarding what the NWS can and should do for the public. There are questions regarding whether this is consistent with or an expansion beyond the NWS's core mission to save lives and property. Others articulated concern that the government changes too slowly to accommodate such an ambitious plan. Some stakeholders worried that NWS activities under Weather-Ready Nation would encroach on other governmental agencies' missions, unnecessarily duplicating activities rather than leveraging complementary capabilities. Some question whether elements of Weather-Ready Nation will generate competition between government and industry, whereby government can offer at taxpayer expense that which industry provides for a fee, moving the NWS into the realm of the secondary value-chain.

According to the NWS's *Weather-Ready Nation Roadmap*, the next step is to draft a plan to spell out the details of implementation: the capabilities needed, expectations, and goals. This provides an important opportunity for the NWS to clarify its intent and to better engage stakeholders in the initiative. Many of the "measures of success" included in the *Roadmap* are not actual performance measures (Table 3.1). The development of shared outcomes that partners can use to guide activities and investments would help build the clarity and commitment needed to achieve the desired results. These may be end outcome measures that are then supplemented by intermediate outcomes used by participants to track their own contributions to the effort.[34] Accountability to shared goals is a hallmark of high-performance partnerships.[35]

3.3 Formal Mechanism for Enhanced Engagement With NWS Stakeholders

As highlighted above, engagement will be critical to the success of building a Weather-Ready Nation. The NWS has various informal mechanisms for the engagement of external stakeholders. **The Panel finds that informal mechanisms have not been effective enough for the NWS to fully capitalize on the capabilities of its extraordinary grassroots network.**

Recent studies have found that the NWS needs to take a more collaborative approach when it comes to changing its operations and structure:

- The NWS conducts service assessments after severe weather events that have had a large impact on communities. Several of these service assessments have recommended that the NWS collaborate with external stakeholders on how to improve the communication of weather information to achieve better public safety results.[36]

[34] Hatry, Harry P. *Performance Measurements: Getting Results*.
[35] National Academy of Public Administration. *Powering the Future: High-Performance Partnerships*.
[36] National Weather Service. *Service Assessment: The Historic Tornadoes of April 2011*.; National Weather Service. *Service Assessment: Hurricane Irene, August 21-30, 2011*. National Weather Service. *Service Assessment: The Historic Derecho of June 29, 2012.*

- Government Accountability Office reports have been repeatedly critical of NWS proposals that have failed to adequately involve external stakeholders throughout their development.[37]
- The NAS report, *A Retrospective Assessment*, stated that advice and input from external stakeholders contributed to the success of the MAR.

In the federal government, the most common formal mechanism is the federal advisory committee, which allows government agencies to collaborate and engage with the public and outside experts.[38] The Panel recognizes that the NWS has not been completely without access to outside advice since the end of the MAR. The NOAA Science Advisory Board is an advisory committee focused on the science and technical aspects for the whole agency. The Environmental Information Services Working Group (EISWG) was created as a standing working group to "address environmental information services across NOAA with a focus on interactions with the NWS." The working group has been involved with reviews of NOAA and NWS strategic plans, NOAA's partnership policy, and produced *Towards Open Weather and Climate Services,* which recommends a new data and collaboration paradigm for NOAA and the NWS.[39] The members of the EISWG have advocated for its continuation and made recommendations on how it can be more effective, including expanding its focus to other NOAA line offices besides the NWS.[40]

Given that the EISWG is currently pursuing options to broaden its focus beyond the NWS at a time when the NWS is seeking to increase its level of external engagement, the Panel finds that a NWS-specific advisory committee is warranted. An advisory committee that is focused on weather-related issues and includes stakeholders from across the weather enterprise, core partners, and physical and social scientists will be better positioned to assist the NWS. In order to facilitate interactions on shared issues, the Panel proposes that the EISWG serve as a joint working group that includes representatives from the new NWS advisory committee and the NOAA Science Advisory Board.[41]

The Modernization Transition Committee that existed during the MAR contributed to the ultimate success of the MAR and was instrumental in the review of office closures,

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[37] Government Accountability Office. *Weather Forecasting: National Weather Service's Operations Prototype Needs More Rigorous Planning*; Government Accountability Office. *Aviation Weather: FAA and the National Weather Service are Considering Plans to Consolidate Weather Service Offices, but Face Significant Challenges*.
[38] Kamensky, John M. "Engaging Citizens v. Streamlining Bureaucracy."
[39] National Oceanic and Atmospheric Administration Science Advisory Board. Environmental Information Services Working Group. *Letter to Raymond J. Ban: Future Status of the EISWG*.; National Oceanic and Atmospheric Administration Science Advisory Board. Environmental Information Services Working Group. *Towards Open Weather and Climate Services*.
[40] National Oceanic and Atmospheric Administration Science Advisory Board. Environmental Information Services Working Group. *Letter to Raymond J. Ban: Future Status of the EISWG*.
[41] An example of a joint working group is the H1N1 Vaccine Safety Risk Assessment Working Group of the National Vaccine Advisory Committee. The membership of the working group is comprised of experts in related fields and five members from federal advisory committees that had a role in the H1N1 vaccination program. http://www.hhs.gov/nvpo/nvac/subgroups/h1n1risk.html

consolidations, and relocations.[42] Currently, the NWS is in need of an advisory committee that functions differently from the Modernization Transition Committee in that it will provide the NWS with advice rather than oversight. Any recommendations made to the NWS by an advisory committee will not obligate specific organization action—the NWS will still maintain the ability to evaluate and prioritize proposals. The NWS should make this advisory function clear in the advisory committee's charter.

A criticism of federal advisory committees is that they require funding and staff time, making it a less appealing option in a constrained budget climate.[43] In reviewing the NWS's past attempts at change, many required the NWS to spend considerable staff time and resources on a proposal's development only to see that proposal challenged by an outside force. The Panel notes that many of these efforts did not justify the need for a specific change or address mitigation of the impact of such change. Engaging external stakeholders through an advisory committee can help identify issues early for timely resolution of concerns. They also provide transparency and an avenue for critical review of the data supporting proposals to increase stakeholder confidence that implementation will not degrade services. The Panel recognizes that staff resources required for effective use of these committees is likely under-represented by the official tracking of specific staff assigned to them. **However, the Panel finds that the need for advice on the challenging issues facing the NWS in achieving a Weather-Ready Nation justifies the resources.**

Through the use of working groups under the advisory committee, the NWS will be able to obtain advice and recommendations on a range of issues. The NWS's vision of a Weather-Ready Nation requires the organization to facilitate greater involvement of external stakeholders on a variety of issues, not only those related to science and technology. Impact-based decision support will require the NWS to engage a wider range of stakeholders to determine what their needs and requirements are. The success of achieving a Weather-Ready Nation requires the NWS, in collaboration with its partners, to clarify the capabilities and capacities of participants. A federal advisory committee with working groups is a formal mechanism that will allow the NWS to solicit feedback on these pressing issues. Background and further analysis about the Federal Advisory Committee Act and implementation of committees can be found in Appendix H.

3.4 Align Resources

Once decisions are made about what Weather-Ready Nation means in terms of outcomes, and the NWS has clarified its own and partners' capabilities and capacities to contribute to the effort, the organization will be in a better position to align its resources and operations to effectively and efficiently meet these needs. The NWS has begun to set the groundwork as part of its ongoing effort to improve the organization's financial management. The NWS

[42] National Research Council. *The National Weather Service Modernization and Associated Restructuring: A Retrospective Assessment*.
[43] See Appendix H for more information on the resource requirements of the six current NOAA advisory committees.

is evaluating an alternate budget construct that realigns program, project or activity lines by function to better support budget transparency and program delivery. This is being conducted in conjunction with an internal evaluation of the organization of headquarters offices. The NWS has managed budget constraints, in part, by leaving headquarters positions unfilled. Over time, this has grown to an approximately 17 percent vacancy rate without the benefit of streamlining the structure or functions of these offices. This makes it a good candidate for near-term change.

While the financial management improvement process is a separate effort beyond the scope and duration of this study, the Panel offers the NWS the following guidance to assist in the reorganization of budget lines and headquarters structure:

Consolidate responsibility around operational function and service delivery. Currently, the NWS has many functions that are shared across offices and programs. For example, responsibility for maintaining operating systems is shared by the Office of Operational Systems in headquarters, the Systems and Facilities Divisions in the Regional Offices, and individual Electronics System Analysts in field offices. Another example is the shared setting and refinement of policies and procedures by the Office of Climate, Water, and Weather Services and the Office of Strategic Planning and Policy in headquarters; Regional Offices; and the National Centers for Environmental Prediction without overarching oversight for reconciliation of differences.[44]

Many interviewees indicated that these handoffs are problematic as they lead to incomplete accountability, fragmented efforts, and delays in activities. An approach aligned along operational functions and with regard to service delivery would provide more cohesion.

Be forward thinking. While the NWS is undertaking these activities to address current issues, it should be anticipating those opportunities with near-term potential within the *Weather-Ready Nation Roadmap*. The organization has spent considerable time developing and implementing pilot projects to test key concepts. Care should be taken not to constrain these efforts. Achieving the vision of a Weather-Ready Nation will take time. Phasing in changes is preferable to repetitive re-organizations that can create organizational chaos.[45]

Facilitate consistency and sharing of information. Core partners need to be able to translate the NWS's products and services into actions. Several indicated that inconsistencies and contradictions among products and services from different NWS offices impede their ability to do this. It has been cited as a problem in several

[44] A detailed discussion of the challenges of shared responsibilities for research and development can be found in Chapter 5.
[45] *Transforming Organizations*. Edited by Marc A. Abrahamson and Paul R. Lawrence.

service assessments following severe weather events.[46] NWS staff interviewed acknowledged this problem and have ideas to potentially address it but point to the lack of a responsible program or office with the resources, authority, and accountability to resolve this. Similar disconnects were articulated during interviews for policies, initiatives, or authorities being addressed by geographically-focused offices without a means to effectively coordinate across the organization.

Findings

Based on its research and evaluation, the Panel makes the following findings:

- Taking a societal impact approach to weather, water, and climate represents a significant change in the way the NWS approaches its functions.
- Achieving a Weather-Ready Nation will require strong leadership by the NWS as well as considerable engagement and close collaboration with public and private sector partners.
- Without improved clarity of the intent of the initiative and about the capabilities and capacities of participants, as well as commitments to collaborate, it will be difficult for the NWS to fully achieve the vision of a Weather-Ready Nation.
- Informal mechanisms have not been effective enough for the NWS to fully capitalize on the capabilities of its extraordinary grassroots network.
- Given that the EISWG is currently pursuing options to broaden its focus beyond the NWS at a time when the NWS is seeking to increase its level of external engagement, a NWS-specific advisory committee is warranted.
- The need for advice on the challenging issues facing the NWS in achieving a Weather-Ready Nation justifies the resources.

Recommendation 3

To realize the vision of building a Weather-Ready Nation, the Panel recommends that the NWS engage both internal and external stakeholders to secure support for the concept and their commitment to collaborate to achieve mutual goals in the national interest.

To implement this recommendation, the NWS should:

- define a process to engage the range of partners on an ongoing basis to secure acceptance of the concept, develop shared outcome goals, clarify capabilities and capacities, and evaluate progress;

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[46] National Weather Service. *Service Assessment: The Historic Tornadoes of April 2011*.; National Weather Service. *Service Assessment: Spring 2011 Middle and Lower Mississippi River Valley Floods*.; National Weather Service. *Service Assessment: Hurricane Irene, August 21-30, 2011*.

- proceed with developing a more detailed implementation plan that makes clear the specific activities and expected outcomes; and
- focus its implementation efforts on those activities that have the closest connection with its mission.

To implement this recommendation, Congress should:

- encourage participation of federal agencies in building a Weather-Ready Nation; and
- assist with the clarification of expectations and capabilities and capacities to participate.

Recommendation 4

To ensure the NWS receives advice from the range of external stakeholders, the Panel recommends the NWS establish a formal advisory committee under the procedures established by the Federal Advisory Committee Act.

To implement this recommendation the NWS should:

- establish a NWS Advisory Committee under the procedures of the Federal Advisory Committee Act;
- make clear the expectations for advice from the committee and how the NWS will consider the committee's recommendations in the committee charter;
- select members for the committee and any working groups with a diversity of expertise in physical and social sciences, emergency management, and business that is reflective of the diversity of NWS stakeholders; and
- establish a website with the membership, meeting schedule, committee products, and the NWS responses to committee products to facilitate broader engagement and transparency.

To implement this recommendation NOAA should:

- designate the Environmental Information Services Working Group as a joint working group of the NOAA Science Advisory Board and the NWS Advisory Committee; and
- designate additional joint working groups with other NOAA advisory committees as needed to address shared issues.

Recommendation 5

The Panel recommends that the NWS better align its resources and operations to effectively and efficiently meet the emerging needs of the Weather-Ready Nation paradigm.

To implement this recommendation, the NWS should:

- realign headquarters offices around operational functions and service delivery;
- improve consistency of products and services across the organization;
- determine the resources needed to meet Weather-Ready Nation commitments; and
- realign, over time, the organizational structure, functions, and resources to more effectively and efficiently meet the needs of a Weather-Ready Nation.

CHAPTER 4: THE WEATHER WORKFORCE

4.1 WORKFORCE OVERVIEW

The NWS has a very dedicated and engaged workforce that is valued by core partners and the weather enterprise. Emergency managers, commercial entities, and academics praise the professionalism and commitment of NWS employees. Nearly half of all NWS employees (2,148 in all) participated in the 2012 Federal Employee Viewpoint Survey.[47] The responses indicate that members of the NWS workforce are generally highly satisfied and believe that their work is valuable. Most scores exceed those in DOC, NOAA, and government-wide. Employee satisfaction and morale shows up in some key indicator questions in the 2012 Federal Employee Viewpoint Survey (Table 4.1).

Question	NWS	NOAA	Dept. of Commerce	Government-wide
My work gives me a feelings of personal accomplishment	**78.5%**	75.3%	73.8%	72.6%
I like the kind of work I do	**89.9%**	86.3%	82.5%	83.6%
The work I do is important	**93.7%**	90.7%	89.9%	90.8%

Table 4.1: 2012 Federal Employee Viewpoint Survey results indicate employee satisfaction.[48]

Employee satisfaction and commitment to the NWS mission is also demonstrated by the lengthy tenure of staff. The average length of service for an NWS employee is 17 years. As shown in Figures 4.1 and 4.2, nearly a quarter of the workforce will be eligible to retire within five years.[49]

As of the second quarter of 2013, the NWS had approximately 4,700 employees with an overall vacancy rate of 8 percent. Allowing positions to remain vacant or lapsed is a tool often used by agencies to contain personnel costs. The NWS lapse rate has been as high as 17 percent at headquarters and 5 percent in the field, demonstrating the priority the organization places on keeping operational units as fully staffed as possible. In addition to these vacant positions, it is common for the NWS to carry approximately 170 unfunded positions, generally used for temporary promotions to fill vacancies and place employees in longer-term detail assignments. Positions left unencumbered by temporary personnel moves may be backfilled by detail or temporary promotion if mission requirements dictate.

[47] This is administered by the U.S. Office of Personnel Management to obtain feedback from all permanent federal employees on the operating conditions of agencies. Sub-agencies such as the NWS are provided with results for their level of government and with information about how they compare to parent agencies and the entire government.
[48] Information provided to the Panel by the NWS.
[49] Ibid.

Otherwise, the position is left vacant until the incumbent returns. **The Panel finds that the NWS's practice of addressing vacancies has made it very difficult for management to determine its actual on-board count and has at times blurred the lines between funded and unfunded positions and permanent and temporary positions**. This presents workforce and financial management transparency challenges that should be addressed.

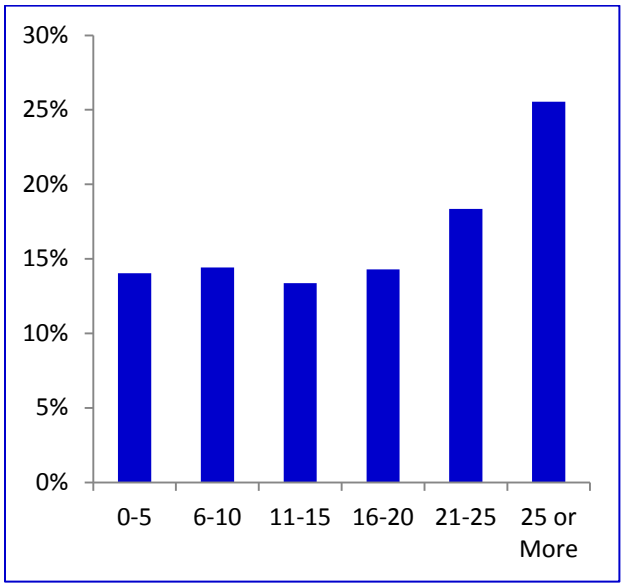

Figure 4.1: NWS employee years of service distribution in FY 2012.[50]

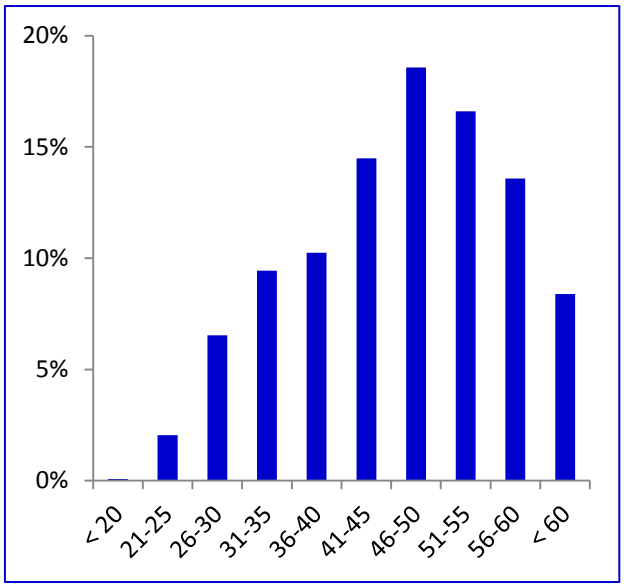

Figure 4.2: NWS employee age distribution in FY 2012.[51]

While staffing levels have been relatively constant over the past decade, in the last three years, the NWS has realized personnel losses at a greater rate than it has been hiring. If this trend continues, the NWS is in danger of losing a significant segment of the workforce and will not be able to renew itself at a sustainable rate unless it revises staff functions and allocations across programs and offices.

The NWS also has a highly educated workforce, with over 78 percent having earned a bachelor's degree or higher. Full performance levels for key occupations are at the GS-13 and 14 levels and grade distribution is reflective of a workforce comprised of scientists and skilled technicians. (See Figure 4.3)

[50] Information provided to the Panel by the NWS.
[51] Ibid.

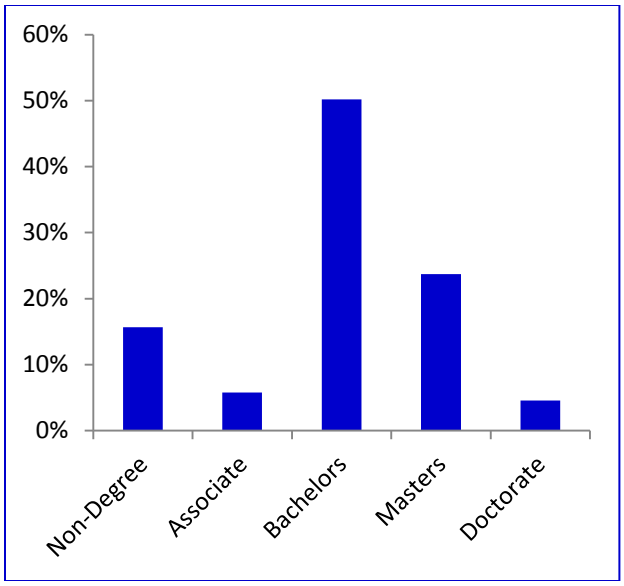

Figure 4.3: NWS employee education distribution in FY 2012. [52]

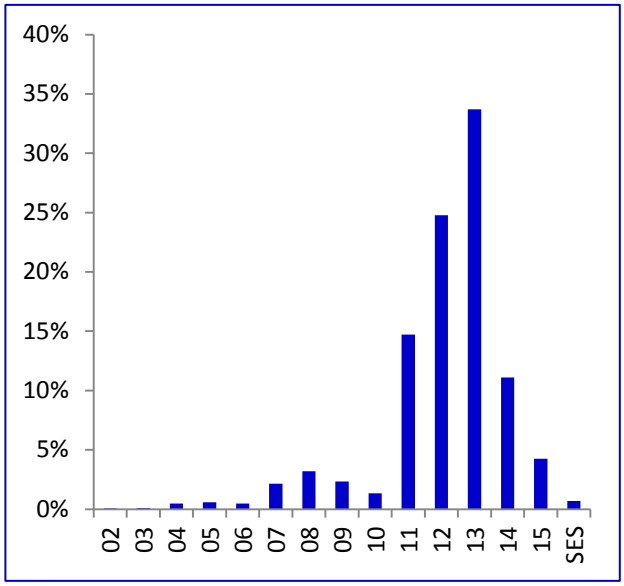

Figure 4.4: NWS employee grade distribution in FY 2012.[53]

4.2 Fair Weather Staffing

Since the MAR, the 122 WFOs have a "fair weather staffing" model, typically with 24 staff at each location. The staff consists of four managers: the Meteorologist-in-Charge, the Warning Coordination Meteorologist, the Electronics Systems Analyst, and the Science and Operations Officer. The remainder of the staff consists of meteorologists, service hydrologists, hydro/meteorological technicians and interns, electronic technicians, administrative support, and an information technology officer. Meteorologists make up the majority of the non-supervisory staff, which accommodates the 24 x 7 operations required to provide weather, water, and climate information to the serviced area. Eighty percent of the NWS population is in what is considered a field organization, inclusive of the National Centers. More than 62 percent of the workforce is in the WFOs.

While one of the goals of the MAR was to provide more uniform weather services across the nation, some managers currently feel constrained by the symmetrical approach to staffing the WFOs. Since the MAR, there has been no change in baseline staffing with technology improvements or enhanced decision support delivery expectations. Yet, while staffing levels have remained fairly constant over the last decade, personnel costs have risen by 6 percent when converted to constant dollars (see Figures 4.5 and 4.6 below). Salary, benefits, and event-driven overtime are “must pay” items, straining budgets in an already constrained fiscal environment. Additionally, some stakeholders and post-storm service assessments have noted that this standardized approach stresses offices during severe weather events. **While most agree that the current staffing model is not**

[52] Information provided to the Panel by the NWS.
[53] Ibid.

optimal, the Panel finds that there is little agreement across the NWS about how to better align its staff. Ideas range across a spectrum:

- add staff to augment current field capacity
- realign staff and functions within the current physical structure
- move, split, or consolidate field offices and/or staff to be near key stakeholders
- consolidate forecasting offices along jurisdictional or ecosystem/microclimate boundaries
- move the NWS and other NOAA weather-related programs out of NOAA to form a separate bureau within the Department of Commerce

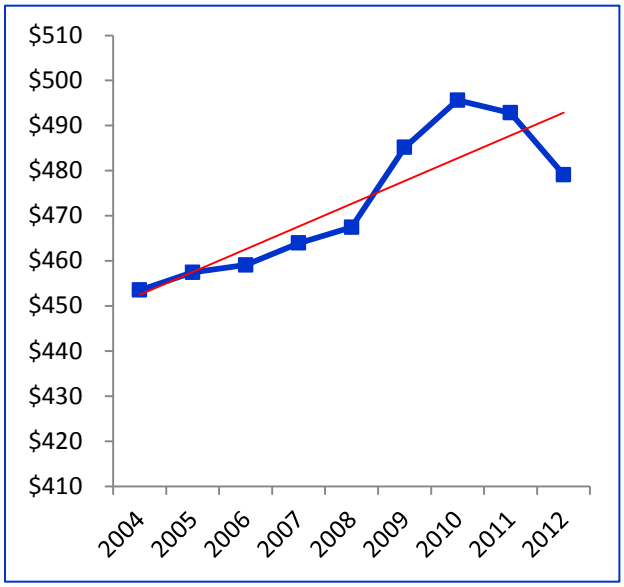

Figure 4.5: Total labor costs in millions per fiscal year in FY 2004 dollars. [55]

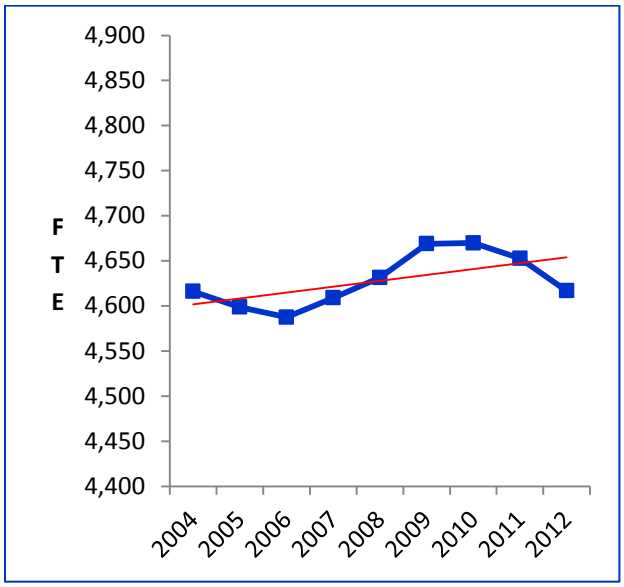

Figure 4.6: Total number of FTEs. [54]

The NAS *Becoming Second to None* report suggests that another look at the staffing model is warranted: "The NWS field office structure established during the MAR was designed to provide more nearly uniform coverage of service across the contiguous United States. In the broad sense, that goal has been accomplished reasonably well. Uniform service does not necessarily require uniform geographical office coverage."[56] The Panel agrees that the NWS needs to complete an analysis of its current staffing model. The organization needs to give weight to such factors as variations in types of weather, frequency and severity of severe weather events, and inclusion of major population centers, media markets, high impact targets, geography, and emergency management contacts. This will enable the NWS to develop a workforce planning model that identifies the human capital required to meet

[54] Information provided to the Panel by the NWS.
[55] Ibid.
[56] National Research Council. *Weather Services for the Nation: Becoming Second to None*.

organizational goals.[57] Such analysis is needed to improve the organization's approach to current products and services and to meet the emerging needs that will be identified in the to-be-developed Weather-Ready Nation implementation plan.

Managers have also commented that providing for standardized fair weather staffing levels limits opportunities at some offices for training, engagement with stakeholders, and participation in cross-agency teams. Overtime is used to cover staff shortages during significant weather events, but there has been no analysis to determine the nexus between geographic staffing and frequency, duration, and severity of weather events with overtime usage that would enable the NWS to develop alternate staff alignment. Temporary positions are being used to staff six pilot projects that test and evaluate key concepts of the Weather-Ready Nation initiative. These pilots are not yet mature enough to determine any future staffing impact under broader implementation.

Previous considerations of different staffing models—including realignment of functions without reductions in overall staffing—have met strong resistance from the union, core partners, and Congress. Past proposals were seen as leading to a decrease in staff and, by perceived extension, a degradation of service. The NWS has little data at this time that provides a direction on how to meet its mission with its existing and future resources. The NAS *Becoming Second to None* report recommends that the NWS evaluate its function and structure including individual NWS field offices, regional and national headquarters, and management, as well as the National Centers and the other weather-related parts of NOAA.[58]

The Panel finds that while change to the staffing model is warranted, the NWS has not completed sufficient analysis of the alignment and function of staff across the organization for effective and efficient delivery of weather, water, and climate products and services. Such an analysis should be detailed and take into consideration the realities of operating in the current constrained fiscal environment, as well as how to meet current and future needs. It is important to include the National Weather Service Employees Organization in this analysis process as discussed further in the report.

4.3 Competency Development for the Future

The Weather-Ready Nation concept envisions that NWS forecasters will be able to disseminate the impacts of the forecast along with the forecast data. This requires an understanding of potential impacts based on past events and modeling. Determining these

[57] A prior Academy Panel summarized lessons learned in federal workforce planning in a study conducted for NASA, *Balancing a Multisector Workforce to Achieve a Healthy Organization*. The NWS may find the information in Appendix C of this report useful as it conducts its own analysis.

[58] National Research Council. *Weather Services for the Nation: Becoming Second to None*. This includes recommendations for a range of workforce-related analyses that involve NWSEO early in the process and include an in-depth statistical evaluation of performance of the field-forecaster product compared to the numerical guidance; evaluate hydrologist skill-sets; examine other NOAA weather-related offices; and evaluate the flow of information to end users.

impacts is not the sole responsibility of the NWS and includes other federal, state, and local agencies. This underscores the need to clarify the capabilities and capacities of participants so that the NWS can determine what competency gaps exist within its workforce and develop strategies to address them.

The new paradigm merges the science of meteorology and an understanding of weather impacts with the art of communication. According to the vision, the forecaster of the future will be very interactive, understand how people consume information and help guide how the public uses the information. Most in the NWS acknowledge that although the workforce is extraordinarily dedicated, many longer-tenured forecasters are more comfortable working with science data and computers than interacting with communities. They prefer reflection to interaction, making decisions based on reason and logic. The IDSS approach calls for more reliance on the intangibles of human response to the data, putting the typical NWS forecaster outside his or her comfort zone. Many interviewees noted that, based on the Myers-Briggs Type Indicator instrument, the most frequent personality type for NWS employees is ISTJ (Introvert, Sensing, Thinking, and Judging), suggesting not only that there is an issue, but that they are very aware of the challenge it presents.

Weather-Ready Nation incorporates the skills included in the competency models that the NWS has built for its mission critical occupations—meteorologist and hydrologist—but has yet to fully realize. These skills, prominently featured throughout the *Weather-Ready Nation Roadmap*, go beyond the scientific and technical knowledge to include skills essential to the IDSS philosophy: creative thinking, customer service, communication, partnering, problem solving, judgment, and leadership.

The NWS recognizes the need to expand the skill sets of the workforce. Not everyone in the NWS will need the full complement of these expanded skills, but the NWS should ensure the right blend of skills to meet the organization's strategic goals. The position description of the Warning Coordination Meteorologist comes closest to the future mix of skills. While similar skills and functions are incorporated into the work of Service Coordination Hydrologists and Emergency Response Specialists, these have not been articulated through updated position descriptions. Moreover, recruitment strategies have yet to incorporate these skills. A search on the government's USAJOBS website showed NWS vacancy announcements requesting skills and abilities that focus on science and technology with little emphasis on the skills needed for decision support.

Moving the workforce into this new approach will require concentrated training and a culture shift that most managers and employees acknowledge will be a major challenge, particularly for those entrenched in technology. Academia is starting to take notice. At least one institution, the University of Georgia, recognizes the need for new skills, mixing essential core courses with communications, human dimension aspects, and perceptions, dispelling the notion that the next generation of meteorologists need only bring science to the forecast.

With very constrained budgets, the ability to address Goal 6 of the *NWS Strategic Plan*—"Sustain a highly-skilled, professional workforce equipped with the training, tools, and

infrastructure to meet our mission"—is being questioned by NWS managers and employees. **The Panel finds that the promise of a Weather-Ready Nation is in jeopardy without the right investment in communication skills and relationship building to deliver the concept effectively.**

In FY 2000, training was 1.6 percent of the NWS budget, and by FY 2012 it had declined to 0.7 percent. In FY 2012, the NWS base training budget was $3.64 million. If it had kept pace with the level allocated in FY 2000, the FY 2012 training budget would have been $9 million. Because on site and classroom training has been curtailed due to shortage of travel dollars, the NWS has shifted to web-based and self-directed training. This is reported to have had benefits of allowing personnel to train at their own pace and being implemented more quickly than classroom training, but managers lament that it does not allow for the same types of valuable instructor-student and face-to-face peer interactions that in-person training provides.

A recent Merit Systems Protection Board study, *Managing Public Employees in the Public Interest*, finds that many employees think that they are not receiving adequate training to perform their jobs with maximum effectiveness and that this impedes their ability to grow and advance. The report also states that there is a difference between training required to maintain technical competency and training in communications, leadership, and management that moves an agency to effective and efficient mission delivery:

> 'The Federal Government must spend public dollars judiciously, consistent with the merit principles requiring concern for the public interest and efficient and effective use of the workforce. Yet agencies and managers must also be wary of pursuing short-term savings (such as reductions in training budgets or time allotted for training and education) at the expense of long-term organizational capability and performance. Accordingly, agencies should take steps to accurately determine competency requirements and developmental needs, to assure that training activities are linked to (and can fulfill) those needs, to emphasize to managers and employees the importance of continued education and development, and to provide supporting resources and mechanisms."[59]

The NWS National Training Center in Kansas City has built an Operational Proving Ground to put employees into a simulated operating environment and conduct scenario-based training. This realistic operating environment allows for the testing of the full socio-technical system to evaluate the effectiveness of new concepts in terms of workflow, technology, and process. However, budget shortfalls have halted this effort. Many in the NWS have expressed serious concerns about its ability to reshape its workforce without the appropriate investment. While it is generally recognized that increasing the

[59] *Managing Public Employees in the Public Interest,* A Report to the President and the Congress of the United States by the U.S. Merit Systems Protection Board.

effectiveness of the workforce means that it must become more attuned to societal needs, there is an immediate need to develop and test activities that will facilitate greater use of decision support tools. Once proven, the workforce needs to be trained in the use of these tools.

4.4 Leadership Succession Challenges

Achieving the vision of a Weather-Ready Nation will require strong leadership. However, NWS employees tend to view their leaders less favorably than DOC or NOAA employees overall and only slightly better than employees government-wide (See Table 4.1).[60] In the 2012 Federal Employee Viewpoint Survey, the NWS workforce was more complimentary about the satisfaction of their work than they were about their leadership. These leadership-related scores declined sharply from the previous year[61] and indicate that the workforce feels disconnected from top leadership. A recent report from the Partnership for Public Service states that effective leadership is key to employee engagement. They cite the need for agency leaders to engage the workforce to improve the working environment, motivate employees, and enhance communication feedback loops.[62] These are critical factors for an organization trying to transform its approach to mission and should be addressed by the NWS. **The Panel finds that neglecting leadership development can have long-term consequences for the NWS's ability to improve products and service delivery.**

Question	NWS	NOAA	Dept. of Commerce	Government-wide
In my organization, leaders generate high levels of motivation and commitment in the workforce	**36.6%**	38.4%	48.0%	42.9%
My organization's leaders maintain high standards of honesty and integrity. (perceived positive)	**43.9%**	51.7%	60.8%	55.1%
I have a high level of respect for my organization's senior leaders	**34.1%**	44.0%	57.2%	54.1%
How satisfied are you with the information you receive from management on what's going on in your organization?	**40.6%**	43.7%	52.4%	48.4%

Table 4.2: 2012 Federal Employee Viewpoint Survey results show need for improved leadership and management of the organization. [63]

[60] Information provided to the Panel by the NWS.
[61] Ibid.
[62] Partnership for Public Service. *Federal Leadership on the Decline.*
[63] Ibid.

Many of those interviewed emphasized that in filling leadership positions throughout the NWS, leadership ability is not as highly valued as technical knowledge. This is common across government and the NWS is not alone in facing budget constraints that are impacting training dollars. A recent Merit Systems Protection Board report states:

> "Current selection of first-level supervisors is heavily based on technical expertise. The problems in supervisory selection reported over the past 30 years appear to persist. Supervisory selection is often based more heavily on technical expertise than on leadership competencies. Technical skills appear to be much more strongly emphasized than are supervisory skills in both job announcements and assessments."[64]

Opportunities for leadership development have been hampered by the suspension of leadership training programs across DOC, NOAA, and the NWS. The DOC Aspiring Leaders Development Program, the Careers in Motion Program, the Administrative Professionals Certificate Program, and the Project Management Certificate Program have all been defunded. DOC is continuing to hold its Executive Leadership Development Program (GS 13/14), and its Senior Executive Service Candidate Development Program (GS 14/15 programs), which is available to select employees annually. NOAA offered a five-day course specifically for new supervisors, but it has not been funded for over two years.

The NWS had a number of leadership training programs at the national and regional levels, most of which have been discontinued for fiscal reasons. Some have been replaced by distance learning courses, but most stakeholders agree that distance learning cannot duplicate the on-site experience and that distance learning for leaders produces suboptimal results. Most interviewed agreed that emerging leaders need the networking experience and the synergy that comes from being in a classroom setting with others, sharing experiences and building relationships. A further description of discontinued NWS leadership training programs can be found in Appendix G.

Preparing leaders at all levels is a challenge for every agency, especially in a constrained budget environment. However, the need for strong leadership is critical in an agency seeking to make ongoing and incremental changes to its operations, systems, and organization. The NWS faces daunting challenges in preparing the leadership cadre it will need to achieve its vision of a Weather-Ready Nation.

4.5 Labor-Management Relations

The National Weather Service Employees Organization (NWSEO) represents slightly more than 3,700 NWS employees or 80 percent of the national workforce. Approximately 1,200 employees (30 percent of covered employees) are dues-paying members. Representation extends to all members of the bargaining unit, regardless of whether they pay dues. Since

[64] Merit Systems Protection Board. *A Call to Action: Improving First Level Supervision of Federal Employees*.

2001, there has been a single Collective Bargaining Agreement (CBA) in place. Crafted largely under the terms of Executive Order 12871,[65] but ratified during the next administration which rescinded that Executive Order, the CBA still calls for both parties to commit to "pre-decisional involvement" and for management to solicit employee input through NWSEO prior to making final decisions.[66]

NWSEO has a president, a general counsel, regional and vice chairpersons, and local and vice stewards. The NWSEO president has held the office for seven years. Article 8 of the CBA established local office teams that negotiate at the local level, including all field offices, NCEP centers, regional headquarters, and national headquarters divisions. It also established Regional Labor Councils in each of the NWS regions as well as a National Labor Council.[67] NOAA and DOC have no official bargaining role with NWSEO. Article 8 lays the framework for a shared commitment to bilateral cooperation, building trust and respect, and the need to be involved in pre-decisional issues. The National Labor Council meets at least twice a year, co-chaired by the NWS Director and NWSEO President or their designees. Membership consists of up to three management officials, including a representative from the field, and up to three union officials. The NWS lead negotiator is a full-time position, currently vacant but temporarily filled with a manager with no prior labor-management relations experience. Regional Labor Councils meet semi-annually or more often as mutually agreed. Regional chairpersons sit at the table with the Regional Director or Deputy. Local impact and implementation bargaining occurs between the local stewards and local management officials. When the parties cannot reach agreement, the matter is elevated to the regional level.

From the regional and local perspectives, management and NWSEO appear to be fairly satisfied with the formal labor-management relationship. Interviewees indicated that negotiations generally go smoothly, and few grievances are filed. Management relationships with NWSEO vary by location, but the majority of managers in the field report productive relationships at their level. During interviews and site visits the Panel noted that local managers and local stewards define satisfaction in terms of how they are interacting on local issues, and these seem to be resolved quite effectively.

At the national level, success is defined in terms of what happens organizationally. The relationship strains when discussing potential changes to the organization and/or operations that may impact the workforce. Communication halts between labor and management and the trust factor declines. This has affected the perception of labor-management relations far beyond those at the negotiation table. Some think the bargaining process is too slow and impedes progress, and employees and managers alike are

[65] Clinton Administration Executive Order 12871. *Labor-Management Partnerships*. October 1, 1993. This was revoked by the Bush Administration Executive Order 13203, *Revocation of Executive Order and Presidential Memorandum Concerning Labor-Management Partnership*, February 17, 2001.
[66] The National Collective Bargaining Agreement Between the National Weather Service and the National Weather Service Employees Organization, Effective October 25, 2001.
[67] Ibid.

frustrated with delays in implementation of certain organization-level initiatives. This tension was also noted by external stakeholders who expressed concerns that the current tenor of the relationship is an impediment to change. NWSEO representatives feel they are left out of key discussions and express a strong desire to be more involved in pre-decisional issues, as stipulated under Article 8 of the CBA. Managers agree in concept, but some are hesitant to head in this direction citing the union's track record of circumventing negotiation and pre-empting decisions by going to Congress or the media with concerns.

NWSEO is engaged with members and keeps them informed of activities through routine emails, newsletters, and a website that is updated to reflect recent accomplishments.[68] They are very proud of their involvement in the conception and development of the current pilot programs under Weather-Ready Nation, all of which include a temporary increase in staff and resources to test ideas on top of normal operations. In its support of the pilots, the union strongly advocated for increased staffing to address new concept development and testing.

Both management and union officials think that the other would benefit from more training on the terms of the CBA. Training leaders at the NWS National Training Center report that no formal training is currently taking place to bring new managers up to speed on the CBA. Such training had been part of the new supervisor training, which has largely been curtailed due to funding constraints Previously-offered refresher training for seasoned managers is also no longer funded. NWSEO faces similar challenges. Training of new stewards is limited to those who can attend the annual NWSEO conference, sponsored each year by one of the regions. That region's stewards get priority for attending the conference. Approximately 25 stewards in the host region received training at the last conference. Regional chairs mentor and are very involved with new stewards. There may be overlap between incoming and outgoing stewards that facilitates knowledge transfer.

The Panel finds that the NWS needs to re-frame the labor-management relationship starting at the national level. This can be achieved under the terms of Executive Order 13522—Creating Labor-Management Forums to Improve Delivery of Government Services.[69] NWSEO involvement was crucial to the success of the MAR,[70] and continued involvement will be crucial to future NWS successes. Achieving the vision of a Weather-Ready Nation will require new approaches and different skill sets to deliver products and services. Changes to the alignment and functions of employees will continue to occur over time as a result of advances in technology and evolving societal needs. The sensitivity of future discussions will demand respectful and open communication; a mediator may be able to help each side agree on the tone and tenor of the communications.

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[68] National Weather Service Employees Organization. *NWSEO Working for You*.
[69] Obama Administration Executive Order issued on December 9, 2009.
[70] National Research Council. T*he National Weather Service Modernization and Associated Restructuring: A Retrospective Assessment*.

With a reinvigoration of the NWS National Labor Council, NWS leadership can create a forum for change and direct the organization into the future. This will be accomplished by communicating early and often with union officials and ensuring that the union understands they will be viewed as a partner in change. Both sides must commit to solidify the bilateral trust pact. This includes the opportunity to address issues or concerns together first before the process is prematurely aggravated by going to Congress or the media. Good faith efforts on both sides will go far to mitigate concerns about this renewed partnership. This is a culture shift that will take time and should be a priority.

Findings

Based on its research and evaluation, the Panel makes the following findings:

- The NWS's practice of addressing vacancies has made it very difficult for management to determine its actual on-board count and has at times blurred the lines between funded and unfunded positions and permanent and temporary positions.
- While most agree that the current staffing model is not optimal, there is little agreement across the NWS about how to better align its staff.
- While change to the staffing model is warranted, the NWS has not completed sufficient analysis of the alignment and function of staff across the organization for effective and efficient delivery of weather, water, and climate products and services.
- The promise of a Weather-Ready Nation is in jeopardy without the right investment in communication skills and relationship building to deliver the concept effectively.
- Neglecting leadership development can have long-term consequences for the NWS's ability to improve products and service delivery.
- The NWS needs to re-frame the labor-management relationship starting at the national level.

Recommendation 6

To guide and support the important changes needed to more effectively and efficiently deliver weather, water, and climate products and services, the Panel recommends that the NWS conduct additional zero-based analyses of staff alignment and functions.

To implement this recommendation, the NWS should:

- involve employees from across the organization, including through NWSEO, in the development of analyses and evaluation of results;
- consider current and emerging needs;
- identify gaps in capabilities and strategies to address them;
- evaluate the use of contractors; and
- consider fiscal constraints.

To implement this recommendation, the NWS and NOAA Workforce Management Office should coordinate to:

- take steps to establish and maintain an accurate count of both permanent and temporary encumbered positions;
- collaborate on a continuing basis to ensure that there is agreement on on-board counts; and
- purge expired temporary positions on a regular basis from the personnel data system.

Recommendation 7

The Panel recommends that the NWS expand its recruitment to include competencies needed for Weather-Ready Nation such as internal and external communication skills, problem-solving, collaboration, conflict management, and leadership.

To implement this recommendation, the NWS should:

- ensure that position descriptions, crediting plans, and interview protocols include the expanded skill sets for those employees that need these skill sets;
- leverage relationships and outreach to universities and communicate the competency model of the future to encourage them to expand curricula;
- build capacity for recruiters to search for the full spectrum of skills and competencies.

Recommendation 8

The Panel recommends that the NWS examine its training and development strategies and technology to build an improved training and development framework that marries the science, leadership, and decision support skills needed to ensure the success of Weather-Ready Nation.

To implement this recommendation, the NWS should:

- include input from across the organization, including NWSEO, in this review;
- engage the NWS advisory committee recommended in Chapter 3 and external stakeholders to get advice evaluating and framing workforce development needs;
- expand the use of technology necessary to create an environment for people to interact in a virtual setting for training and development when budget prevents on-site classroom training;
- consider what is the right mix of on-site and virtual learning, knowledge sharing, and knowledge transmission;
- assess current and emerging training needs to implement the NWS's contributions to Weather-Ready Nation and develop a plan to fulfill those needs;
- partner with other agencies at the state and local level for synergy in creating the best responses to weather emergencies; and
- form working groups of managers and employees (with NWSEO) to address the problems of workforce perceptions of leadership and propose short and long range actions aimed at improving those perceptions.

Recommendation 9

The Panel recommends that the NWS and NWSEO collaborate to re-frame the labor/management relationship in keeping with the true partnership spirit of Executive Order 13522, which will necessitate the pre-decisional involvement sought by the union and the increased organizational results sought by management within a climate of mutual trust.

To implement this recommendation, NWS and NWSEO should jointly:

- reinvigorate the Labor-Management Council in the spirit of EO 13522 and make it a true labor-management forum;
- conduct a baseline assessment of the state of labor-management relations and identify opportunities for improvement;
- establish a process to use committees at appropriate levels (local, regional, national) to identify opportunities, problems, and propose solutions;
- ensure that meetings are scheduled and on-going; and
- leverage their relationship to champion changes and advance the mission.

To implement this recommendation, the NWS should:

- involve NWSEO representatives in pre-decisional discussions on conditions of employment:
- ensure sufficient field perspective and representation in national negotiations;
- provide guidance from NWS leadership to regional and local leadership on how to work with union representation on proposed changes;
- fill the Lead Negotiator position with a qualified person as soon as possible; and
- work with NWSEO to provide sufficient training so that every supervisor, manager, and union official has sufficient training to ensure a good working knowledge of the CBA and Executive Order 13522.

To implement this recommendation, NWSEO should:

- poll its constituency on a recurring basis to ensure employee views and opinions are well-defined and accurately presented to NWS management;
- work with NWS management to ensure that pre-decisional information remains privileged; and
- work with the NWS to provide sufficient training to ensure that every supervisor, manager, and union official has sufficient training to ensure a good working knowledge of the CBA.

CHAPTER 5: CONTINUOUS INFUSION OF SCIENCE AND TECHNOLOGY

5.1 A TRADITION OF ADAPTING TO NEW SCIENCE AND TECHNOLOGY

Since its beginnings, the NWS has striven to adopt new science and technologies to optimize observations and forecasts. However, in its retrospective assessment of the MAR, the NAS found that the NWS had been unable to keep up with the pace of technological advances and had nearly become obsolete by the 1980s. The MAR was an ambitious and expensive effort on the part of the NWS to catch up to the state-of-the-art. However, during the MAR's 10-year implementation, the pace of technological advance exploded. Several individuals interviewed expressed the view that the NWS is now stuck in the 1980s—by the time the MAR was completed in 2000, the technology was already outdated. This is not a problem unique to the NWS and is experienced by many agencies that rely heavily on technology. In its report, *Becoming Second to None*, the NAS found that technology is still evolving more rapidly than the NWS can respond, particularly in the area of communications and applications.

5.2 RESEARCH TO OPERATIONS AND OPERATIONS TO RESEARCH

Both internal and external stakeholders said that the NWS does not have an efficient and effective means for identifying technology requirements, researching and developing those technologies to maturity, procuring the respective components or systems, and introducing them into operations. These issues have been raised by both the Government Accountability Office and the NAS in reports that have criticized NOAA and the NWS for poor contract management and inadequate acquisition policies particularly concerning the development of complex systems.[71] **The Panel finds that the processes of operationalizing technology development, known as Research to Operations (R2O), and the identification and communication of operational requirements, known as Operations to Research (O2R), are key to a science-based organization's ability to remain effective.**

Within the NWS, there is no single overseer of the O2R/R2O process with the authority to approve, fund, develop, procure, and field technological solutions to operational requirements. According to an NWS official, there is no single person or office with "cradle to grave" responsibility for the R2O process. The Office of Climate, Water, and Weather Services (OCWWS) oversees the forecast and warning services. Field user requirements come to the attention of OCWWS during the normal course of business. Once OCWWS has identified an operational requirement, the Office of Science and Technology (OS&T) is then responsible for responding to the requirement and planning, developing, and implementing new science and technology into operations. Once innovations are matured, they are to be transitioned from the entity conducting research or innovation to the

[71] Government Accountability Office. *NOAA; Next Steps to Strengthen Its Acquisition Function*: National Research Council. *Weather Services for the Nation: Becoming Second to None*. See also House Report 112-463; Senate Report 112-158.

eventual user (frequently the Office of Operational Systems) that will need to provide lifecycle operations and maintenance funding.

OCWWS manages a process called the Operations and Services Improvements Process (OSIP). The OSIP process is set out in NWS Policy Directive 10-1, dated April 16, 2010. The Directive defines the OSIP process as the "corporate NWS requirements-based management process for improving operations and services. The process establishes an OSIP Executive Oversight Committee, "ensures OSIP decisions are aligned with NWS mission priorities, and provides oversight to the OSIP Gates [or] key decision points." The directive specifically says it "applies to needs, opportunities and related projects potentially affecting the national baseline of operations and services when development or implementation affects the Advanced Weather Interactive Processing System (AWIPS)…"

OS&T oversees a process called Science Review and Approval to ensure all Science and Technology (S&T) activities have scientific merit and are aligned with the NWS mission. The Science Review and Approval process is set out in NWS Policy Directive 80-5. The Directive says that the policy ensures S&T related activities are evaluated for appropriate scientific merit and mission alignment and are approved or disapproved at appropriate levels within the NWS. Directive 80-5 lists two types of candidate activities that could enter the process. One type of candidate is proposals, plans and research and development related to S&T seeking new NWS financial support or endorsement. The second type involves the results of the S&T infusion process, as defined in the Directive 10-1 OSIP process.

Internal advocates of the OSIP process said it affords the opportunity to document requirements, make efforts visible from an organizational perspective, examine alternatives, assign priorities, and determine where to allocate resources. Moreover, they said it fulfills a NOAA mandate to have a Requirements Management Process. However, a number of internal stakeholders complained that the OSIP process involves too many handoffs, too much bureaucratic "red tape," and no promise of ongoing funding at the completion of research and development. They said that many projects make it through the process only to get stuck in a "parking lot" waiting for funding. As a result, many field users who desire a new capability would rather work on developing it themselves than submit to the OSIP approval gates. There is no current enforcement process to prevent them from doing so. **The Panel finds that the practice of allowing ad hoc research and development both confounds system configuration management, and poses a security threat that should be quickly remedied in a way that does not stifle innovation.** In defense of OSIP, one program manager with OSIP experience said the process was not overly burdensome or time consuming but qualified the comment by saying their particular program entered the OSIP process with its own source of funding. According to OSIP documents, the process has reviewed 331 projects since its inception in 2005. Of those, 238 projects have been implemented or approved for implementation, two projects have been rejected, and 91 remain idle in the process. Of the 91 projects awaiting further action, 51 require resources, and the balance are awaiting delivery or development of a prerequisite, such as AWIPS II, before implementation.

Another OS&T policy directive deals with "Transition of Innovation and Research to Operations."[72] Directive 80-8 defines "transition" as the transfer of research or innovation projects from the Financial Management Center conducting research or innovation to another Financial Management Center that will be providing operations and maintenance. Directive 80-8 establishes the NWS policy piece under the broader NOAA policy on Transition of Research to Application as set out in Administrative Order 216-105.[73] The policy applies to R2O activities with other NOAA line offices or other external research organizations. The directive appoints the OS&T Director as the Line Office Transition Manager to review programs and ensure transition to operations. Further, it tasks OS&T's Meteorological Development Laboratory Research and Innovation Transition Team to assist in the transition to operations. Directive 80-8 cites OCWWS as a partner in the process that collaborates through identification and validation of service needs requiring additional research, the O2R process.

5.3 Collaboration with the Office of Oceanic and Atmospheric Research

The Office of Oceanic and Atmospheric Research (OAR) is a NOAA line office that conducts research for the NWS, among others. OAR is responsible for providing a research foundation in: 1) climate; 2) oceans, Great Lakes, and coasts; and 3) weather and air quality.[74] A number of NWS stakeholder complaints about the R2O process were directed at OAR. Some interviewed said that OAR uses its dedicated research budget to pursue "ivory tower," and "big science" types of projects without sufficient consideration for the requirements of day-to-day operations. An often cited example was how OAR worked on a forecast model using its robust computing capacity but once completed, NWS did not have sufficient computing power in the operational environment to run it. This highlights the importance of taking into consideration operational success criteria before a project gets underway. Another criticism of OAR research was that scientists are often unwilling to share the results of their work before scientific publication, thus slowing the rate of assimilation into operations.

NOAA Research Council representatives cited two initiatives they hope will bring increased collaboration between the research and operational environments to facilitate R2O. The first is the creation of a virtual laboratory framework that allows researchers to work on common projects across geographical boundaries. The second is the establishment of a corporate research and development database that will provide information at the project level, including projected maturity. These should help to avoid duplication of efforts and facilitate planning for transition.

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[72] National Weather Service. Transition of Innovation and Research to Operations. Directive 80-8

[73] National Oceanic and Atmospheric Administration. . Policy on Transition of Research to Application. NAO 216-105.

[74] See overview of the Office of Oceanic and Atmospheric Research website for additional detail of each research area, http://oar.noaa.gov/programs/

To improve Research and Development (R&D), NOAA issued an administrative order to establish the principles, policies, and responsibilities for planning, monitoring, evaluating, and reporting activities comprising the entire NOAA R&D enterprise.[75] As part of the process, the NOAA Research Council will conduct portfolio reviews to address the extent to which areas of NOAA's R&D are relevant to its mission and societal needs. The portfolio reviews will tie into the NOAA strategic planning and research planning process and will feed the Strategy Execution and Evaluation process. To further transparency, the portfolio reviews will be available to the public. A number of internal stakeholders were optimistic that this process will keep NOAA's R&D activities focused on the top agency priorities.

An internal NWS stakeholder said that in the current resource-constrained environment, NWS and OAR are working together to communicate early about operational shortfalls, assign technical readiness levels to projects, and more closely synchronize the operational budget with project maturity. The official said there needs to be a commitment to work with operational success criteria to set priorities.

In support of OAR-style "big science," some internal and external stakeholders expressed the view that some quantity of research and research dollars must be kept independent from, and outside of, the operational environment to ensure scientific progress. They said that if all the research dollars are under the control of operators, there is a risk those dollars would migrate into operations during times of constrained budgets. They said there must be a full spectrum of ongoing research—both basic and applied research programs are necessary.

5.4 Testbeds, Proving Grounds, and Pilot Projects

In *Becoming Second to None*, the NAS recommended that as an absolute necessary condition for success, the NWS should have an ongoing capacity for development and testing of its incremental technology upgrades. NWS's testbeds, proving grounds, and pilot projects aim to facilitate the orderly transition of research capabilities to operational implementation through development testing in testbeds, and pre-deployment testing and operational readiness/suitability evaluation in operational proving grounds and pilot projects. The eleven testbeds and proving grounds are overseen by the NOAA Testbed and Operational Proving Ground Coordinating Committee.[76]

The testbeds provide a means of testing new science and technology for the purpose of eventually producing better weather products and services. They provide a path to operational use for experimental products and services, invite the participation of third parties, provide a test environment for the purpose of refining and optimizing

[75] National Oceanic and Atmospheric Administration. *Strengthening NOAA's Research and Development Enterprise: Procedural Handbook and Appendices*.

[76] The eleven are: Aviation Weather Testbed, Climate Testbed, Coastal and Ocean Modeling Testbed, Developmental Testbed Center, Hazardous Weather Testbed, Hydro-meteorology Testbed, Joint Hurricane Testbed, Space Weather Prediction Testbed, Operations Proving Ground, GOES-R Proving Ground, and Joint Center for Satellite Data Assimilation.

experimental forecast tools, verify the scientific validity of experimental products, educate forecasters about experimental tools and the latest research related to forecasting, and educate researchers about operational forecast needs and constraints. By providing a quasi-operational environment, the goal is to accelerate the assessment and implementation of new technology, research results, and other scientific advancements from the research and development communities to enhance operations.

Many of those interviewed spoke positively about the testbed concept and the promise of assimilating new technologies. Internal stakeholders were particularly positive about the Operational Proving Ground sponsored by OCWWS and located at the NWS National Training Center in Kansas City, Missouri. According to its Charter, the Operational Proving Ground serves as a framework for advancing two important components of the *Weather-Ready Nation Roadmap*: services and science and technology. The Operational Proving Ground is described as the last step before implementation. According to an NWS official, the intent is to only accept those testbed experiments that are thought to be ready to transition to operations. The capability would be brought into a simulated workforce shift to test the human factors and how it would perform under pressure.

During FY 2012, two Operational Proving Ground exercises were held with 16 to 22 trainees at each exercise. Further exercises have been put on hold in FY 2013 due to funding constraints. Once resumed, the plan is to hold one or two per year. The goal is for the 30 or so new trainees to facilitate implementation of new concepts in the field.

The NWS has six pilot projects underway to test new approaches in line with building a Weather-Ready Nation. They primarily focus on improving decision support in varying environments (e.g. urban and coastal communities), at different scales (e.g. local, regional, and national), integrating non-traditional environmental forecasting, and use of emerging technologies. The NWS will evaluate the lessons learned from these pilots and how they may be applicable at a broader scale. The NWS has not identified specific plans for future pilot projects.

5.5 Research to Operations in the Department of Defense

Several persons interviewed cited the Department of Defense (DOD) process for funding and managing research as a more structured model that could benefit the NWS. DOD has a process for labeling and budgeting its Research, Development, Test and Evaluation funds according to stages of research.[77]

Those budget activities designated as 6.1, 6.2, and 6.3 (basic research, applied research, and advanced technology development, respectively) constitute what is called DOD's Science and Technology program and represent the more research-oriented part of the Research, Development, Test and Evaluation program. Basic Research is defined as scientific study for greater understanding of phenomena without specific applications in

[77] Congressional Research Service. *Federal Research and Development Funding: FY2013*. By John F. Sargent Jr.

mind. Applied Research is expansion and application of knowledge to understand the means to meet a specific need. Advanced Technology Development is development and integration of subsystems and components into model prototypes for field experiments and/or tests in a simulated environment. These categories are similar to the type of research carried out by OAR. Budget activities designated as 6.4 and 6.5 (advanced component development and systems development and demonstration) focus on the development of specific systems or components for which an operational need has been determined and an acquisition program established. This would be comparable to research carried out by OS&T and its Meteorological Development Laboratory on AWIPS or other systems.

The Fleet Numerical Meteorology and Oceanography Center is the U.S. Navy's weather service. It has operational locations at the Stennis Space Center in Bay St. Louis, Mississippi, and the Fleet Numerical Meteorology and Oceanography Center in Monterey, California. They have about 350 officers who are meteorologists and oceanographers plus the officers and sailors on ships and at the commands. All are supporting weather on command operations and "safety at sea."

According to a DOD official, R2O works in DOD because they have a clear research structure and a clear chain of command. Within the Navy, the 6.1 Basic Research and 6.2 Exploratory Development are done at the Office of Naval Research and the Naval Research Laboratory. The 6.4 Advanced Development weather work, goes to the Naval Research Laboratory remote locations at Bay St. Louis, Mississippi and Monterey, California. These are co-located with the Fleet Numerical Meteorology and Oceanography Center operational locations and the user community. This is seen as an important aid to coordination. When they get to the 6.4 level, they require a transition plan with milestones and timelines and a signed commitment from the end user.

The Navy has also instituted a Rapid Transition Process to accelerate the operational transition of maturing science and technology. The DOD official said that successful transition depends on: 1) frequent dialogue and coordination between researchers and operators, 2) periodic reviews to assess progress and risk, 3) strong advocacy at the identified user level, 4) reliable and consistent research funding, and 5) programmed operations funding to transition and sustain the delivered capability. Rapid Transition Process projects are held to a three-year development, testing, and transition cycle. An executive management panel is responsible for identifying resources to support development, transition, and sustainment and to protect those resources through to delivery.

Navy operational meteorology requirements will bubble up from the fleet users. Before an operational requirement can enter the research process, there must be a letter of validation which is signed by a fleet commander. This ensures that the customer and ultimate user stands behind the effort and also pledges to support the ultimate development with operations funding.

5.6 Advanced Weather Interactive Processing System – A Case Study

The Advanced Weather Interactive Processing System (AWIPS) is described as a high-speed, technologically-advanced processing, display, and telecommunication network that is the centerpiece of NWS operations. Since it became operational in 2000, AWIPS has been the subject of almost continuous technology infusion and is a core operational system used throughout the NWS. As such, it is a good case study of the R2O process in the NWS. AWIPS integrates all meteorological, hydrological, satellite, and radar data into one computer workstation and allows forecasters the interactive capability to view, analyze, combine, and manipulate large amounts of graphical and alphanumeric weather data. AWIPS is, therefore, the primary working environment and toolbox for meteorologists and others throughout the NWS. AWIPS is installed in all WFOs, RFCs, and in several National Centers. AWIPS is a wide area network, managed from a Network Control Facility in Silver Spring, Maryland with a Satellite Broadcast Network that broadcasts from Hauppauge, New York and downlinks to each WFO and RFC.[78]

> AWIPS has been the subject of almost continuous technology infusion and, as such, is a good case study of the R2O process in the NWS.

The development and implementation of AWIPS was a key component of the MAR. It replaced the previous Automation of Field Operations and Services that dated to the 1970s. During the early 1990s, AWIPS development went slower than expected. Like many large information technology procurement programs, the program was plagued by technical difficulties, cost growth, and schedule delays. According to an internal stakeholder, the contractor was given over 22,000 requirements, but their solutions did not always work in an operational environment. Some of this disconnect may have been in the way the user requirements were translated in the contract.

Because of delay in delivery of the AWIPS system, the program was restructured in 1994 to involve the government in development to a much higher degree. An internal manager said the government initially gave the contractor reams of requirements, but it did not look closely at operations. The contractor was attempting to faithfully implement the requirements as stated, but when it came to usability it did not initially work. The NWS then recognized the need to work with the forecasters. AWIPS versions were released into an operational testing environment with the Denver AWIPS Risk Reduction Research and Engineering program. As a result of the process of having developers and operators working side by side on requirements and solution development, the program was fielded in 2000.

At the time of fielding, the AWIPS software was a basic suite of tools, but according to NWS officials, it was missing a lot of capability, particularly to address local forecasting requirements. Since AWIPS became operational, system development has continued at

[78] Overview of the AWIPS System, http://www.crh.noaa.gov/lmk/?n=awipsoverview.

both the system-wide level and the field level. The AWIPS environment is unique in that the average user of the system is a trained scientist, often with advanced degrees and frequently with a second degree or a minor in computer science. AWIPS is their daily workspace, and they expect much from the system. Meteorologist vacancy announcements require candidates to have skills in several computer languages. During interviews and site visits, the Panel and study team learned of the existence of locally developed applications used to manipulate data, create a custom display, or publish a tailored customer product. Many of these locally developed applications bypassed the OSIP process and have occurred without the involvement or knowledge of the AWIPS Program Office or other headquarters entities. NWS headquarters is aware of the existence of these locally-developed applications and is attempting to identify and inventory them as the migration to the new AWIPS II system progresses.

Procurement and installation of AWIPS II is underway but behind schedule. It is now operational in eight WFOs. Some AWIPS II installations have been delayed because of compatibility issues with locally-developed applications. Field operators have insisted on assurance that their locally-developed applications will run on AWIPS II before migration. Within OS&T, a National Core Local Applications Development Team has been created to work on cataloging critical local applications that have been deemed operational by the respective regional directors and ensuring the infrastructure exists to be able to migrate them to AWIPS II. The team took an initial manual survey and came up with approximately 4,000 local applications. Subsequently, an automated scan was done of the system that discovered over 20,000 locally developed applications across the network.[79] **The Panel finds that the practice of developing local applications across the AWIPS network has resulted in a number of hidden costs, including diverted staff hours, network administration and systems engineering time, and schedule delay in rolling out new systems such as AWIPS II.**

There are over 20,000 locally developed applications across the AWIPS network.

The existence of so many locally developed applications raises a number of questions from a system security and configuration control perspective. A breach in AWIPS security has been categorized as potentially having a high impact on the organization, as outlined in the Standards for Security Categorization of Federal Information and Information Systems.[80] According to an internal stakeholder, AWIPS has to have "four nines" (99.99 percent) availability, meaning the percentage of time the system must be operational without failure. There have been numerous cases where locally developed applications have affected system operations and even "crashed" the system. In some cases, the Network

[79] Skoda, John and Harriett Loeb. *The AWIPS National Core Local Application Development Team: Collaboration is the Key.*

[80] National Institutes of Standards and Technology. *Standards for Security Categorization of Federal Information and Information Systems*.

Control Facility has had to restore a field office system from backup. One official said there is a different version of AWIPS at every WFO and RFC, and this causes problems with documentation, sustainability, and maintenance. **While NWS officials state that the organization is fully compliant with national information security requirements, the Panel finds that the NWS is assuming an inadvisable risk profile through the practice of allowing wholesale development of local applications.** This has the potential for putting the organization in a position of greater vulnerability. The Panel did not conduct a full review of the NWS's compliance with security requirements as outlined in the Federal Information Security Management Act,[81] but expects that the NWS will remain vigilant in its efforts to ensure the required security of its critical systems.

With AWIPS II, NWS officials said many of the system security and configuration control issues will disappear. Whereas AWIPS I started as proprietary software and transitioned to Linux open source operating software, every bit of AWIPS II is Free and Open Source Software. AWIPS II applications will be based on Java programming language, a ubiquitous programming language that has minimal impact on the operating system on which it is running. Java has security concerns when it runs on machines connected to the Internet. Although AWIPS is not connected to the Internet, security risks are still present if an unauthorized user gains access to a terminal or if highly vulnerable flash drives or other removable media are used to swap files from Internet-connected machines. According to an NWS official, Java is user/developer friendly and should lead to increased innovation. AWIPS II will be freely available to universities and laboratories to run on their own networks for teaching and research and development. They will have full flexibility to modify the software and develop new applications. Applications formulated in those development environments could subsequently be brought into the closed AWIPS operational system for use by the NWS. **The Panel finds that all NWS applications development should be done in a separate environment that allows for innovation and does not affect the security of the operational system.** Applications should only be brought into the operational system after they have been thoroughly tested, validated, and deemed secure.

5.7 Channeling Innovation

Both internal and external NWS stakeholders expressed the view that efforts to improve O2R/R2O should be done in a way that would not stifle innovation. NWS managers said that those closest to the customer needs have the best opportunity to discover requirements and innovate. One internal stakeholder said, "We have a world class workforce that has ideas that are broader than our corporate capability to deliver…we need to tap into that creativity." However, without coordination multiple offices could have developed duplicative applications. Also, there could be applications that have

> We have a world class workforce….we need to tap into that creativity.

[81] 44 U.S.C. § 3541, et sec.

broader applicability than one office but others might not be aware they already exist. This practice is costly and wasteful of NWS resources.

To harness local innovation and bring coordination and collaboration to the locally developed application phenomenon, OS&T has created a Virtual Laboratory that allows everyone with a need for a local application or innovation to document it and share ideas. This is an offline, cloud-based AWIPS research environment with 15 WFOs and laboratories participating. The goal is to allow them to build applications on a safe research and development "mirror image" of the operational system. Once something is matured, it can be pulled off the cloud and given to the contractor to include in the AWIPS system baseline.

Effective R2O and O2R processes, including effective procurement and project management, are critical for NWS to remain viable in an era of advancing science and technology with limited resources. Currently, the NWS's R2O and O2R processes are fractured and less effective than they should be. There are no cohesive processes for managing the vetting of operational requirements, the funding and assignment of R&D activities, the testing and transitioning of developments into operations, and the securing of life-cycle funding commitments. In the absence of effective NWS R2O and O2R processes, ad hoc research and development has proliferated across the organization, without the requisite configuration management. This hampers the fielding of new systems, and wastes scarce NWS budget resources. Further, development outside of a security framework has the potential to put NWS systems in jeopardy from increasingly menacing cyber threats.

A cohesive R2O and O2R process includes adequately resourcing not only research activities, but also the steps needed to transition research results into the operational environment. This includes evaluation through testbeds, proving grounds, and/or pilot projects. In a constrained budget environment this may require shifts in resources to accommodate transitioning research already underway or in the pipeline. Re-allocation should consider not just the research activities within the NWS budget, but weather-related research across NOAA.

Findings

Based on its research and evaluation, the Panel makes the following findings:

- The processes of operationalizing technology development, known as Research to Operations (R2O), and the identification and communication of operational requirements, known as Operations to Research (O2R), are key to a science-based organization's ability to remain effective.
- The practice of allowing ad hoc research and development both confounds system configuration management, and poses a significant security threat that should be quickly remedied in a way that does not stifle innovation.
- The practice of developing local applications across the AWIPS network has resulted in a number of hidden costs, including diverted staff hours, network administration

and systems engineering time, and schedule delay in rolling out new systems such as AWIPS II.

- While NWS officials state that the organization is fully compliant with national information security requirements, the NWS is assuming an inadvisable risk profile through the practice of allowing wholesale development of local applications.
- All NWS applications development should be done in a separate environment that allows for innovation and does not affect the security of the operational system.

Recommendation 10

To ensure that NWS Research to Operations (R2O) and Operations to Research (O2R) receive appropriate priority and support, the Panel recommends that it consolidate the current distributed management of this function.

To implement this recommendation, the NWS should:

- consolidate the R2O and O2R management functions within a single headquarters office;
- merge existing policy directives to establish one cohesive policy for identifying and vetting operational requirements, initiating research efforts, conducting developmental and operational testing, and transitioning technologies into operations;
- identify and consolidate NWS research and development funds under the control of the R2O office ensuring that the office has knowledge of, and purview over, all emerging requirements and all research efforts including at the regional and field office level;
- establish an executive R2O management committee to preside over the approval of operational requirements and the funding and assignment of research activities. The committee should be chaired by the director of the R2O office and populated on a rotating basis by representatives from the research and operational offices and programs;
- ensure that before any new research efforts are approved, commitments are made to fund not only the research portion but also, if warranted, the costs of: developmental testing through the appropriate testbeds; operational testing in proving ground environments and/or pilot projects; and system procurement and lifecycle operations and maintenance; and
- build NWS-wide support by clearly communicating the benefits to be gained by channeling O2R and R2O efforts through one integrated process.

To implement this recommendation, NOAA should:

- examine the need to re-allocate weather-related research resources to address the activities needed to transition this research into operations.

Recommendation 11

The Panel recommends that the NWS establish Configuration Management and Security Risk Management over its information technology systems.

To implement this recommendation, the NWS should:

- expedite the establishment of a NWS Configuration Management framework;
- transition the work of the National Core Local Applications Development Team to the Configuration Management framework;
- lock down network configuration across the AWIPS network and channel all applications experimentation to the Virtual Laboratory environment;
- ensure that any new developments that emerge from the Virtual Laboratory environment are thoroughly tested before incorporation into operational systems;
- ensure that the NWS O2R and R2O process is properly acknowledging, responding to, and channeling field innovation so as not to adversely impact Configuration Management; and
- ensure that computer security and cybersecurity risks are addressed in the development and operation of systems and institutionalized through policy and training.

CHAPTER 6: INFRASTRUCTURE AND FACILITIES

6.1 MAR STRUCTURE

The NWS field structure established pursuant to the MAR has been described as a technology-driven solution. The geographic array of WFOs was established primarily based on the radar footprint of the NEXRAD and the need for data processing to be co-located to mitigate data transmission costs. In *Becoming Second to None*, the NAS found that the infrastructure put in place during the MAR is now as much as two decades old and could present a cost liability because much of it requires replacement. The MAR infrastructure includes not only the technology systems but also the buildings housing these systems and the workforce.

6.2 TECHNOLOGY SYSTEMS

The NWS was described as a very technology-heavy organization. A NWS official said the NWS spends approximately $20,000 per capita on information technology (IT) annually. The official compared this to the spending of other federal agencies that reportedly ranges between $4,000 and $12,000 per capita annually.

A large portion of the NWS IT investment is in the AWIPS system. AWIPS is a distributed network with an extensive hardware footprint in each WFO and RFC as well as headquarters and the National Centers. According to NWS IT managers, there are three to five hardware racks for each AWIPS setup along with numerous servers and network storage devices. Each location has at least four AWIPS workstations consisting of multiple processors and monitors. An internal stakeholder estimated that the AWIPS hardware at a WFO, RFC, NCEP center, or other installation costs approximately $300,000 each. Extending that cost over approximately 150 installations results in a total AWIPS hardware investment of approximately $45 million.

NWS officials said technology refreshment is a constant challenge with AWIPS. The NWS's intent is to replace hardware components on a three to five year cycle, but that is unaffordable in the current fiscal climate. There are now key pieces of hardware that are out of warranty. This was described as risky and starting to show as an operational concern. There are a couple of components that should have been refreshed last year, that have since failed. One site was reportedly taken down for a week because of the failure. Had the NWS been able to refresh the technology, the failure would not have occurred. The internal stakeholder said that the hardware components are replicated at each field office, so once a component fails at one site, they can expect the same component to fail elsewhere, causing unplanned outages and operational disruptions. This shifts system management from a systematic approach of performing preventative maintenance and replacement into a firehouse response posture, having to quickly find solutions and the resources to fund them. **The Panel finds that the NWS is burdened with excessive information technology equipment that is not supportable given current fiscal constraints and rapid technological advancement.**

Field offices receive meteorological and hydrological data over the NWS Satellite Broadcast Network uplinked from a facility in Hauppauge, New York. The current bandwidth speed of the downlink is up to 30 megabits per second (mbps). By comparison, many residential users in the major markets have broadband Internet connections with speeds of 50 mbps. Residential service with as much as 300 mbps is available.[82] A mobile device, such as a tablet, with "4G" wireless connectivity can provide 9 mbps[83] download speed or almost one-third of the entire 30 mbps Satellite Broadcast Network downlink capability of a WFO or RFC. NWS officials said the current available bandwidth limits their ability to download forecast models and other raw data. As new weather satellites come online and the use of composite models increases, data requirements are expected to explode. A NWS official said they are limited now in their capacity and will not be able to afford the pipes to move the data of the future.

As a work-around for their limited NWS bandwidth, some field offices have implemented stand-alone computers with commercial Internet connections. NWS field forecasters said the Internet connection allows them to download data and models that they are unable to access over a Satellite Broadcast Network. NWS users said they access other NEXRAD data by using a commercial software product. One forecaster said, "All the really cool software is on the Internet." Although there is no direct connection between an office's Internet computer and AWIPS, staff uses removable storage to move data from Internet-connected machines. As mentioned earlier, this poses a security risk.

The Technology Demands of Decision Support

During the study, the Panel and study team heard about numerous occasions when NWS forecasters were forward-deployed to support decision makers during big events. According to the NWS, there were 163 deployments in FY 2012, a record for the NWS in both number and duration. Emergency managers and others were very supportive of NWS deployments and said they have come to rely on the presence of NWS personnel during key events.

A number of ongoing NWS technology developments are providing forecasters with mobile capability. The FX-NET system is part of an All Hazards Onsite Meteorological Support System developed to support NWS Incident Meteorologists at remote locations. According to NWS documents, FX-NET provides an AWIPS-like display on a laptop and delivers high-resolution satellite, radar, observational, and weather prediction model data from a server in either the Western, Southern, Pacific, or Alaska regions. Any type of network link can be used to access the server data.[84] The FX-NET system has become the "backbone" of fire weather forecasting in the field.

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[82] Verizon. *FiOS Fastest Plans available*.

[83] Sullivan, Mark. *3G and 4G Wireless Speed Showdown: Which Networks Are Fastest?*

[84] FX-Net Workstation 'Backbone' of Fire Weather Operations, http://www.esrl.noaa.gov/gsd/media/hotitems/2003/03Nov04.html

AWIPS Thin Client is a follow-on capability to FX-NET that will provide the capability to run the visualization component of AWIPS II. Thin Client is intended for Center Weather Service Units (CWSU) and for forecasters deployed to support incidents. It would be installed on a Windows or Linux workstation. A portable Thin Client currently provides display-only capability and is in field testing. Weather product generation capability is planned for the future. NWS officials also see this capability as a tool for Continuity of Operations, support to NCEP, RFC backup, and for remote WSOs in Alaska and the Pacific. Use of Thin Client is being tested as part of the New Orleans/Baton Rouge IDSS pilot project. It is being used by forecasters forward-deployed from the Aviation Weather Center in Kansas City, Missouri to FAA's Air Traffic Control Systems Command Center in Warrenton, Virginia. It was also used as part of a joint agency mobile support team at the 2013 Super Bowl.[85] NWS officials said all of these applications have been met with praise.

The Panel finds that the ongoing NWS efforts at developing portable information technology applications have the capability of providing cost-effective tools to facilitate decision support.

6.3 FACILITIES

In addition to its aging and unsupportable technology infrastructure, the NWS is supporting a large portfolio of deteriorating real estate. According to NOAA's FY 2011 Integrated Facilities Inspection Program tables, the NWS had 240 buildings with a total area of 2.5 million square feet at a total replacement cost of $632.2 million. Although the NAS report, *Becoming Second to None*, discussed MAR facilities that were as much as two decades old, 100 of the buildings—with a total replacement cost of $310.5 million—were over 20 years old, and thirty-nine of the buildings—with a total replacement cost of $166.8 million—were over 40 years old. It should be noted that the FY 2011 Integrated Facilities Inspection Program tables are the most recent data available because NOAA has since discontinued the Integrated Facilities Inspection Program due to "funding shortfalls."[86]

According to building descriptions in the FY 2011 NOAA facilities inventory, the NWS has an extensive assortment of building types and sizes. The buildings range from a standby power building of 159 square feet in Washington State to the National Logistics Support Center complex of 370,000 square feet in Kansas City. The majority (223) are less than 20,000 square feet. The building inventory includes offices, storage buildings, labs, shops, and housing.

Several of those interviewed said that many NWS buildings are in dire need of maintenance including heating, ventilation, and air conditioning systems; roofs; and plumbing repairs. Stories abound of broken toilets and buckets on top of computer racks to catch roof leaks.

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[85] Graham, Ken. *Importance of Technology as part of the NWS New Orleans/Baton Rouge Impact-Based Decision Support Pilot Project*.

[86] All information in this section from the NOAA FY 2011 Integrated Facilities Inspection Program was provided to the Panel by the NWS.

Interviewees also said many leases are nearing the end of their terms and will need to be renegotiated.

As part of NOAA's facilities inventory process, an estimate is made of the deferred repair costs and a Facilities Condition Index (FCI) is assessed. The FCI is calculated by dividing the total cost of deferred facility repairs by the current replacement value of a facility and subtracting the quotient from 1. For example, a building with a replacement value of $500,000 and deferred repairs of $250,000 would have an FCI of 0.50. An FCI below 0.85 is considered Poor and an FCI below 0.80 is considered Unacceptable, according to the NOAA guidelines.

Of the 240 NWS properties in the facilities inventory, 43 (18 percent) had an FCI below 0.80. Those properties had a total of $21.1 million in deferred repairs. Total deferred repairs on all properties were $42.5 million. The inventory identified five facilities that were not being utilized and nine that were under-utilized. The NWS provided a separate October 2012 schedule listing of $101 million of "unfunded NWS construction projects." These included 54 roof replacements, 50 Uninterruptable Power Supply upgrades, and 35 physical security upgrades, among others. It is unknown whether some of these projects, such as roof replacements, were included in the deferred repairs category on the facilities inventory.

Initiatives are underway across the federal government to achieve cost savings by limiting or downsizing real estate holdings. Pursuant to the Office of Management and Budget's March 2013 "Freeze the Footprint" policy memorandum, each agency is required to develop and submit a Revised Real Property Cost Savings and Innovation Plan. In future years, they are also required to prepare an Annual Agency Evaluation, which will describe the agency's overall approach in managing its real property usage and spending. Prior to this recent government-wide guidance, a NOAA strategic objective was already in place in its Facilities Program Business Model to improve the co-location of NOAA services and partners.[87]

The Panel finds that to reduce its physical footprint and exposure to growing building maintenance costs, the NWS could take advantage of opportunities to co-locate facilities with other NOAA line offices, other federal agencies, state or local emergency managers, water resource managers, or universities. In fact, the NWS has already co-located with other entities in certain situations. For example, the WFO in Norman, Oklahoma is co-located with the University of Oklahoma and the WFO in Honolulu, Hawaii is co-located with the University of Hawaii. The WFO in Seattle Washington is co-located at the NOAA Western Regional Center with the National Ocean Service, the National Marine Fisheries Service, the Pacific Marine Environmental Laboratory, the NOAA Diving Center, and the NOAA Seattle Library. In the early 2000s, the Houston/Galveston WFO co-located with the Galveston County Office of Emergency Management because their former location was susceptible to hurricane-induced surge.

[87] National Oceanic and Atmospheric Administration. *Business Operations Manual*. Version 6.2

6.4 A Mobile and Adaptable National Weather Service

During the course of the study, there was much discussion about transitioning the NWS from a static organization anchored by its physical infrastructure, to a more mobile and adaptable organization. Becoming *Second to None* cited "meeting expanding and evolving user needs of an increasingly information-centric society," as a key challenge for the NWS. Internal stakeholders said that the current structural model of the NWS does not optimize decision support services; the NWS needs more public outreach into the major metropolitan areas. The act of co-locating offices near the base of radars due to data transmission limits had the unintended effect of moving some offices and the workforce away from population centers and actually diminished in-person communication with decision makers. They said today's technology could free NWS personnel from the base of the radars and allow them to become more agile and effective.

Becoming more mobile and adaptable will likely also provide opportunities to ease budget pressures. Given budget realities, the operations and maintenance requirements of the current portfolio of real estate and technology infrastructure exceed the fiscal capabilities of the NWS. Portions of this infrastructure are outdated, beyond its useful life, out of warranty, or supporting anachronistic processes. A number of interviews revealed that possibilities exist for the NWS to downsize its costly infrastructure and to leverage the enterprise's capabilities for data collection. Fewer buildings means fewer hard-wired technology components needed to support those buildings.

The NWS could also reduce its information technology costs by doing more processing centrally, putting more capability in the cloud, and eliminating redundant servers and workstations. Some of these efforts are already underway. Many interviewees see a coming paradigm in which there will be intelligent pre-processing of weather data before it is transmitted to the local forecaster. This will result in better utilization of the communications infrastructure and reduce the need for computing power at the end point. NWS officials expressed optimism about the future of cloud computing and its ability to support the mobile forecaster. Some future thinking stakeholders described an environment of dispersed forecasters and IDSS specialists using mobile devices tethered through Virtual Private Networks to regional or central offices where ensemble weather models are being produced. **The Panel finds that the NWS is currently supporting more technology and facilities infrastructure than it can reasonably afford, and this will inhibit its ability to manage change and achieve its vision of a Weather-Ready Nation.**

Findings

Based on its research and evaluation, the Panel makes the following findings:

- The NWS is burdened with excessive information technology equipment that is not supportable given current fiscal constraints and rapid technological development.
- Ongoing NWS efforts at developing portable information technology applications have the capability of providing cost-effective tools to facilitate decision support.
- To reduce its physical footprint and exposure to growing building maintenance costs, the NWS could take advantage of opportunities to co-locate facilities with other NOAA line offices, other federal agencies, state or local emergency managers, water resource managers, or universities.
- The NWS is currently supporting more technology and facilities infrastructure than it can reasonably afford, and this will inhibit its ability to manage change and achieve its vision of a Weather-Ready Nation.

Recommendation 12

The Panel recommends that the NWS conduct an NWS-wide analysis of its enterprise architecture, dissemination systems, and telecommunications infrastructure and identify opportunities for consolidating, integrating, or eliminating hardware or systems given current or anticipated future operational scenarios.

To implement this recommendation, the NWS should:

- identify networks that could be merged and functions that could be satisfied using Service Oriented Architecture;
- conduct a system-wide review of server utilization and determine the feasibility of running virtual servers;
- conduct a system-wide review of dissemination systems and determine the feasibility of integrating isolated systems;
- examine the feasibility of using shared network data storage;
- explore ways to cost-effectively increase telecommunications bandwidth to field offices and to better utilize available bandwidth; and
- determine whether there are remote data collection sites with lease lines or downlinks that could be closed or moved to a cloud-based service.

Recommendation 13

The Panel recommends that the NWS conduct an NWS-wide requirements analysis of its facilities.

To implement this recommendation, the NWS should:

- determine whether there are buildings that are not being utilized, not cost-effective given their current physical condition, not operationally-efficient given their location, or have co-location opportunities within a reasonable proximity; and
- examine the feasibility, on a case-by-case basis, of moving, co-locating, or closing the offices and transferring their functionality, recognizing that this may entail concurrent organizational change.

Recommendation 14

The Panel recommends that in keeping with its vision of a Weather-Ready Nation, the NWS prioritize and accelerate its efforts to develop mobile computing applications and the use of Virtual Private Networks and rapidly transition these technologies for use in mobile, forward-deployed, and remote applications.

CHAPTER 7: MOVING FORWARD

7.1 FRAMEWORK FOR CHANGE

In order to facilitate additional and ongoing change, the Panel finds that the NWS will need to address the diversity of opinions of internal and external stakeholders on what to change, how to change, and the appropriate rate of change. As noted earlier, the MAR had a specific framework to address significant changes to the field structure. It had multiple layers that included evaluations by the NAS, the Modernization Transition Committee,[88] certifications by the Secretary of Commerce, and notification to Congress. While many stakeholders indicated that this was an extensive process that would not be appropriate for changes not as revolutionary or of the same magnitude as the MAR, the lack of a defined process has hampered change.

While there is much agreement that additional and ongoing change is needed, there is little agreement between stakeholders inside and outside the NWS on what change is needed. The Panel's research indicated this to be true for a variety of types of issues including change to the organizational structure, technology, workflow, staff alignment, and even for specific product and service offerings of the NWS.

Many stakeholders with whom the Panel and study team spoke indicated that the key obstacle to resolving the diversity of opinion about potential changes is the NWS's lack of a defined process to select and manage change. The MAR operated under a congressionally-directed framework for change. This framework was largely seen as successful for the scope and impact of changes encompassed by the MAR. This framework sunset at the end of the MAR, and nothing was put in place to help the NWS continue to evolve. Simply reinstating that framework was not favored as it is viewed as rigid and likely overly complex for more routine incremental changes.

The Panel finds that absent a known framework to guide change, the NWS has employed scatter-shot approaches to plan and implement change. These received mixed reviews both inside and outside the organization. A notable element the Panel has found in many of these efforts is the lack of clear justification of the need for the specific change and a complete understanding of its impact.[89] Given the operational nature of the NWS, the organization is held to a high standard of ensuring that change will not result in degradation of services.[90] Such justifications require both the interest and capability to

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[88] Established and operated under the procedures set forth in the Federal Advisory Committee Act.

[89] Government Accountability Office. *Weather Forecasting: National Weather Service's Operations Prototype Needs More Rigorous Planning*.; Government Accountability Office. *Aviation Weather: FAA and the National Weather Service are Considering Plans to Consolidate Weather Service Offices, but Face Significant Challenges*; House Report 112-463; Senate Report 112-158.

[90] The repeated use of this term by Congress in legislation has made it the standard. This term was not only included in the Weather Service Modernization Act that directed specific NWS activities, but also in the language authorizing this study to guide what potential recommendations the independent entity conducting the evaluation might consider. Public Law 102-567 and House Report 112-284 of Public Law 112-55.

develop them. **While NWS leadership expressed clear interest in providing adequate justification for potential changes, the Panel finds that the organization's capacity to do so has been constrained by the lack of a change management framework that provides for the time, capability, and budget required to develop, test, and analyze potential changes.**

The Panel finds that due to the dynamic environment in which the NWS operates, it is essential that the NWS have an adaptive and agile organization to enhance its ability to achieve the vision of a Weather-Ready Nation. The development of a process to guide significant organizational changes will facilitate not only successful implementation but also foster a culture of innovation within the NWS. To assist the NWS in its development, the Panel has outlined some attributes that the NWS should incorporate into its framework for change.

Defined
It should be clear to internal and external stakeholders what the process is, when it will be used, and how to participate as appropriate. Understanding the process for change is as important to stakeholders as the change itself.[91] The NWS is faced with decisions about a wide range of changes and so are all other agencies critical to achieving the vision of a Weather-Ready Nation. It will be important to establish and communicate the thresholds that would trigger the use of this change management framework. This process should consider factors such as the scale and scope of impact to the workforce, budget, new technology or systems, complexity, and risk.

Agile
The framework for change should help the organization be more nimble and improve operations. The NWS should use this framework to be both proactive and responsive to the evolving needs of its own workforce and programs, as well as core partners and the enterprise. Just as the organization can benefit from continuous change, the framework is likely to need adjustment over time.

Collaborative
The NWS has a tremendously talented workforce with a plethora of ideas of how to improve. Harnessing that collective capacity from the beginning will allow better connections among employees with differing expertise, between office types, and across geographies.[92] Similarly, leveraging the expertise of core partners and the enterprise can improve the ability to meet user needs in ways that the NWS could not do on its own. Employees across the organization communicated a wide variety of ideas to improve the effectiveness and efficiencies of the organization. A collaborative approach both inside the NWS and with respect to its partners can allow the NWS to develop a number of ideas simultaneously through teams, thus addressing more than a single cadre could.

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[91] Government Accountability Office. *Results Oriented Cultures: Implementation Steps to Assist Mergers & Organizational Transformations*.
[92] Cohen, Dan and John Kotter. "The Heart of Change."

As noted earlier, the importance of NWS products and services sometimes causes stakeholders concern that any change has the potential to have unintended consequences. A collaborative process surfaces concerns and allows them to be addressed early. This approach enables the NWS to build support that will help when it comes time to implement changes.

The emphasis on IDSS was described by many internal and external stakeholders as requiring a cultural shift for the NWS. The workforce has traditionally derived its sense of value in how everything comes together to produce a forecast.[93] As described in the *Weather-Ready Nation Roadmap*, the organization will be finding new ways to add value. Such cultural shifts take time and are facilitated by champions at all levels of the organization and external support. A collaborative framework helps develop champions and support.

Transparent

The likelihood of the NWS successfully developing and implementing change increases when those changes have been developed with internal and external stakeholder input. This requires a clear, understandable process so that stakeholders know when to engage and bring forward information or questions that can improve the deliberations. Given the timeframes involved in making significant changes within the federal government, being able to see where things are in the process can also help to sustain stakeholder support.

Accountable

The likelihood of successfully navigating a change management process increases when participants are held accountable for progress. Success does not mean that every concept identified to overcome a challenge or capitalize on an opportunity is implemented. Some concepts may turn out not to be implementable for a variety of valid reasons such as budget, staff, or infrastructure constraints or identification of a preferred alternative. It means that fidelity to the process is maintained and progress is measured and reported.

Balanced

The blend of systems across the distributed network of offices with the processes used by the highly-skilled workforce is needed to successfully produce the suite of products and services. This is a complex socio-technical system, and changes must recognize these connections. The *Weather-Ready Nation Roadmap* recognizes this complexity and appropriately highlights the need to connect service development, workforce evolution, science and technology development, and a sustainable business model. Over- or under-development in one area can lead to problems in another. To support an organization-wide

[93] National Research Council. *Completing the Forecast: Characterizing and Communicating Uncertainty for Better Decisions Using Weather and Climate Forecasts*.; Fine, Gary Allen. *Authors of the Storm: Meteorologists and the Culture of Prediction*.

culture of innovation where the entire workforce sees ideas translate into action, there must also be some balance across the various elements of the organization.

Align Resources
The framework must align the necessary resources to successfully implement changes. It is key to ensuring that the workforce has the skills, resources, and empowerment to execute changes. Processes may need to be re-engineered to ensure that workflow is appropriate and supported. Lifecycle costs should be anticipated and budget outlooks adjusted as needed. The organizational structure and physical footprint will need to be periodically evaluated and adapted.

7.2 Issues Affecting the Potential for Change

Change is rarely easy. A highly skilled workforce operating within a culture of innovation can yield tremendous improvement in the effectiveness and efficiency of an organization. Developing a joint understanding of the value of change to core partners who heavily rely on the products and services of the NWS to save lives and property is essential. Leveraging the full power of the weather enterprise can be a force multiplier and enhance the NWS's ability to truly build a Weather-Ready Nation. Achieving this will require strong leadership and constant communication of how these changes will enhance the NWS employees' ability to fulfill the organization's mission.[94] It will also require sustained commitment to the vision by the NWS, NOAA, and Congress. This is similar in many ways to the challenges identified by a previous Academy Panel in its work with NOAA on the reorganization of the agency to establish a NOAA Climate Service.[95]

No Degradation of Service Standard
The NWS is held to a very high standard by itself, Congress, core partners, and participants in the weather enterprise that changes not result in a degradation of services. **The Panel finds that the NWS must define the undefined but widely cited concept "no degradation of service" if the NWS is going to have a reasonable chance of meeting stakeholder expectations.** The NWS should work with internal and external stakeholders to develop a clear and common understanding of what does and does not constitute a degradation of services. This should be determined by setting an expected level of service to be met and against which performance can be measured. Various offices at times will undoubtedly exceed that level of service, especially as the NWS tests new concepts, but care should be taken to avoid shifting the baseline without also addressing allocation of resources. This effort should be conducted with input from a range of employees, including through NWSEO, and with advice from the NWS federal advisory committee recommended in Chapter 3. Left undefined, it will be a barrier to necessary change especially when there is not unanimity on a proposed change. As noted in Chapter 2, some change and

[94] General Accounting Office. *Results-Oriented Cultures: Implementation Steps to Assist Mergers and Organizational Transformations*.
[95] Chapter 5 of *Building Strong for Tomorrow: Recommendations for the Organizational Design of the NOAA Climate Service* focuses on change management challenges.

reinvestment will be necessary even to maintain the status quo and, absent the ability to make these changes, services can be expected to degrade.

As noted earlier, several prior attempts at organizational change have been contested due to lack of complete information about the problem or opportunity being addressed, the potential impact of the change, how those impacts have or can be mitigated, and the net value of the change. The change management process needs to include the appropriate steps to identify challenges and opportunities; develop, test, evaluate, and refine concepts; and prepare to implement successfully. This will take both time and resources. A cohesive verification program will help demonstrate the ability to take tested ideas to scale and allay concerns about the potential for impacts to service. The availability of base resources to fund each of these steps can minimize the time gap as concepts move through the process. If, at each step, funding and staff resources needed to complete that step first have to enter the planning and budget cycles, years will be added before any change could be fully implemented. Internal and external stakeholders discussed many potential enhancements to current NWS operations that hold great promise to also improve the efficiency of operations. However, these offsets will not be realized until full implementation is underway. **The Panel finds that investing in change has great potential to strengthen the effectiveness and operational efficiency of the NWS.**

Constrained Budget

The budget authority of the NWS is appropriated through two accounts: 1) Operations Research Facilities, and 2) Procurement, Acquisition and Construction. Both accounts are one-year appropriations with the exception of those funds in PAC that are provided for construction of facilities, which are no-year.

Since FY 2004, the total NWS budget had increased in current-year dollars from $833.7 million to $996 million in FY 2012. However, over the 9-year period, as shown in Figure 7.1, the NWS total budget declined in constant FY 2004 dollars from $833.7 million to $815 million, a 2.2 percent decline in buying power. Over the same period, personnel costs increased in constant FY 2004 dollars from $453.5 million to $479.1 million, a 5.6 percent increase. As a result, the NWS experienced an 11.6 percent decline in the buying power of the non-personnel portion of its budget. To manage to budget, the NWS has carried an increasing number of unfilled positions and has underfunded facilities maintenance, technology refresh, training, and travel.

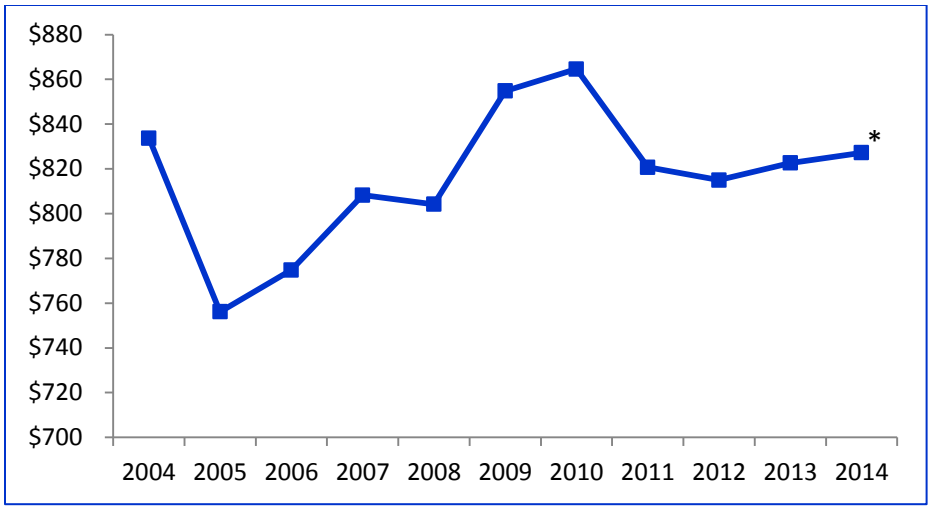

Figure 7.1: Total enacted budget per fiscal year in FY 2004 dollars. [96]
*: President's budget request is used for FY 2014.

Pursuant to the Consolidated and Further Continuing Appropriations Act, 2013, the NWS received $822.4 million in constant FY 2004 dollars, not including sequestration and other offsets, representing a 1.4 percent decrease in total buying power since FY 2004. The FY 2014 budget request includes $1,050 million, $827.18 million in constant FY 2004 dollars, which is 0.78 percent below the amount enacted in FY 2004.

A Culture Resistant to Change

Although the MAR created improved radar coverage and localized forecasting nationwide, an unintended consequence was the establishment of a culture of parochialism, anchored at the base of the radars with bricks and mortar and solidified with satellite downlinks and stationary computer systems.

In addition to the static "bricks and mortar" physical WFO structure, the MAR also created a static WFO staffing model. Described by many as "cookie cutter staffing," the structure is geared toward producing and disseminating the same message from the same suite of equipment with little flexibility to specialize or tailor staffing to fit differences in severe weather frequency, diversity of forecasting programs, population served, complexity of media markets, or decision support requirements.

[96] Information provided to the Panel by the NWS.

While the NWS is invested in this fixed field office configuration, the demands of customers such as emergency managers are evolving and increasing. In the words of one NWS field manager, "In the old Weather Service, the emphasis was on weather—in the new Weather Service, the emphasis is on service." This sentiment of a renewed emphasis on service was echoed by many. This requires a culture that embraces change as service needs will continue to evolve rapidly. NWS leadership should facilitate this cultural change through a compelling vision backed up with actions that motivate employees to embrace new approaches.[97] Engaging employees from the start can help build ownership of these new approaches and establish better connections across offices and programs.[98]

"In the old Weather Service, the emphasis was on weather—in the new Weather Service, the emphasis is on service."

Communication

A number of internal and external stakeholders described WFOs, RFCs, Regions, and National Centers as "islands," operating with independence, sometimes disseminating conflicting forecast information, and resistant to change. Considering that field offices have approximately 80 percent of the NWS workforce (62 percent in the WFOs), a large portion of the workforce is affected by this cultural phenomenon. Particular mention was made of conflicts at the edges of adjacent radars and their corresponding WFOs.

This "island" mindset is reinforced by the perceived paucity of communications from NWS headquarters. NWS field personnel said they do not receive enough information from headquarters about what is happening, what the leadership is thinking, and where the organization is going in the future. A number of NWS personnel said this isolation is exacerbated by budget constraints that inhibit travel to meetings, conferences, training, and other networking opportunities.

Interviews with the NWS staff at all levels indicated a strong desire for improved communication on organization priorities, activities, and promising practices. In addition to improved situational awareness, they see it as a gateway to improved collaboration. Each office has wisdom to impart on others, and NWS should exploit this internal resource. Current technology means that geography does not have to restrict communication as it once did. A reasonable investment to increase available bandwidth at offices to be able to use videoconferencing can provide "face-to-face" communication to build and maintain relationships in ways that phone calls and emails cannot. These tools will also assist offices in providing decision support to core partners. Then, limited travel funds can be better targeted to those conferences, meetings, and trainings that will meet the needs outlined in the to-be-developed Weather-Ready Nation implementation plan.

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[97] Cohen, Dan and John Kotter. "The Heart of Change."

[98] *Transforming Organizations*. Edited by Marc A. Abrahamson and Paul R. Lawrence, Lanham, MD. Rowman and Littlefield Publishers, 2001

Such an approach will foster relationship-building across the geographically dispersed organization. This creates an important feedback loop where problems are identified and addressed not in isolation but collaboratively, and the solutions are shared with colleagues. Successful change requires repeated, consistent communication through multiple channels to not only reinforce the value gained by the specific changes but also to address concerns and build support.[99]

Service Assessments

Another important feedback loop occurs after severe or high impact weather events through service assessments. These review the activities before, during, and after the event, including interactions with core partners. They identify best practices to be shared and make recommendations for improvements. Service assessments are intended to be constructively critical evaluations so that problems can be corrected, lives saved, and economic damages minimized. Internal and external stakeholders stressed the value of including external participants with expertise in areas not held by NWS employees. Inclusion of social scientists and emergency managers in the service assessment of the spring 2011 tornadoes was cited by several NWS staff interviewed as instrumental in demonstrating that the new Weather-Ready Nation approach was needed. The NWS has indicated that lack of a federal advisory committee has limited the organization's ability to include external non-governmental participants. The establishment of a NWS advisory committee, as recommended in Chapter 3, will facilitate this in the future.

In a Weather-Ready Nation context, these are exactly the kinds of recommendations which, if properly integrated and implemented, can lead to an increase in community resilience. Better information from assessments could help further the Weather-Ready Nation goals of guiding community preparedness and response, as well as decision support during future severe weather events. The NWS could take steps to enhance their core partners' understanding of the NWS's actions, policies, and limitations if additional stakeholders from various sectors were routinely involved in service assessments. This could enhance the dialogue among stakeholders and lead to improvements in operations. Additional evaluation of decision support during service assessments could result in product and service enhancements.

The NWS is to be commended for the inclusion of some external participants and for making major service assessments publicly available on its website.[100] A transparent feedback loop improves confidence that problems are being identified. Currently, as recommendations are addressed, they are tracked by OCWWS's Performance Branch but are not available to the public. Posting this information online as well will improve transparency and accountability.

[99] Cohen, Dan and John Kotter. "The Heart of Change."
[100] Service Assessments, http://www.nws.noaa.gov/om/assessments/index.shtml

Findings

Based on its research and evaluation, the Panel makes the following findings:

- In order to facilitate additional and ongoing change, the NWS will need to address the diversity of opinions of internal and external stakeholders on what to change, how to change, and the appropriate rate of change.
- Absent a known framework to guide change, the NWS has employed scatter-shot approaches to plan and implement change.
- While NWS leadership expressed clear interest in providing adequate justification for potential changes, the Panel finds that the organization's capacity to do so has been constrained by the lack of a change management framework that provides for the time, capability, and budget required to develop, test, and analyze potential changes.
- Due to the dynamic environment in which the NWS operates, it is essential that the NWS have an adaptive and agile organization to enhance its ability to achieve the vision of a Weather-Ready Nation.
- The NWS must define the undefined by widely cited concept "no degradation of service" if the NWS is going to have a reasonable chance of meeting stakeholder expectations.
- Investing in change has great potential to strengthen the effectiveness and operational efficiency of the NWS.

Recommendation 15

To facilitate additional and ongoing change the Panel recommends that the NWS, in conjunction with its partners, develop a process and structure to guide significant organizational and operational changes.

To implement this recommendation, the NWS should:

- use a team of staff from different NWS field and headquarters offices, including NWSEO, to develop a clearly defined process;
- seek advice from the NWS Advisory Committee on the development of the process;
- determine an expected level of service to form the basis of a definition of the "no degradation of service" standard. This should be done with input from a range of NWS field and headquarters staff, including NWSEO, with advice from the NWS federal advisory committee, and in conjunction with Congress;
- review and improve the process periodically based on input from internal and external stakeholders;
- ensure adequate avenues for participation by internal and external stakeholders in the process to ensure concerns are identified early and addressed;
- communicate regularly the status of concepts moving through the process; and

- identify base resources needed to develop, test, evaluate, and implement new concepts.

To implement this recommendation, Congress should:

- work with the NWS to clarify the level of service the organization is expected to provide; and
- support the development of a collaborative change management framework.

CONCLUSION

The NWS has long played a critical role in protecting the lives, property, and economy of the nation by providing valuable weather, water, and climate products and services. If realized, the bold NWS vision for a Weather-Ready Nation has the potential to significantly enhance our collective capabilities to make informed decisions about how to prepare for, and respond to, weather and climate events. This will require a new approach for the NWS that embraces collaboration and seeks new ways to create value beyond traditional forecasting activities. Once the NWS and partners determine the outcomes they seek to collectively achieve, clarify the capabilities and capacities of all participants, and commit to meeting these shared goals, then the NWS can decide how to align the resources of the organization to meet these common goals. This is not a finite transformation, rather a process of continual innovation and change.

Appendices

APPENDIX A: PANEL AND STUDY TEAM

PANEL

Mortimer Downey, *Chair**—President of Mort Downey Consulting, LLC and Senior Advisor, Parsons Brinckerhoff. Former Deputy Secretary, U.S. Department of Transportation. Former positions with Metropolitan Transportation Authority (New York): Assistant Executive Director for Management and Budget; Deputy Executive Director for Capital Programs; Executive Director; Chief Financial Officer. Former Assistant Secretary for Budget and Programs, U.S. Department of Transportation; Budget Priorities Analyst, Committee on the Budget, U.S. House of Representatives; increasingly responsible positions with the Port Authority of New York and New Jersey.

Eric Anderson*—Former positions as City Manager, City of Tacoma, Washington; City Manager, City of Des Moines, Iowa; City Manager, City of Evanston, Indiana; City Manager, City of Eau Claire, Wisconsin; Town Manager, Town of Munster, Indiana; Assistant Town Manager, Town of Windsor, Connecticut; Assistant Director, Research and Development, International City/County Management Association.

Louise Comfort*—Director, Center for Disaster Management and Professor, Graduate School of Public and International Affairs; Associate Professor, School of Public and International Affairs, University of Pittsburgh. Former Visiting Professorships with Department of Geography, Ritsumeikan University, Kyoto, Japan; Center for Urban Safety and Security, School of Engineering, Kobe University, Japan; and Department of Public Administration, Leiden University, Netherlands.

Patricia Healy*—Executive Consultant, CGI. Former Deputy Chief Financial Officer, Acting Chief Financial Officer, and Director, Foundation Financial Information System Project Office, U.S. Department of Agriculture; National Director, Systems and Accounting Standards, Chief Office of Automation Support, Team Lead for Implementation of the Automated Financial System, and Staff Assistant, Systems Development Division, Internal Revenue Service; Librarian, National Library of Medicine.

Robert Tobias*—Director and Distinguished Adjunct Professor and Director, Key Executive Leadership Program, Institute for the Study of Public Policy Implementation, American University; Member, IRS Oversight Board. Former positions with National Treasury Employees Union: National President; Executive Vice President; General Counsel. Former Member, Commercial Activities Panel.

*Academy Fellow

ACADEMY STUDY TEAM

Joseph Mitchell, Ph.D., *Director of Project Development*—Manages the Academy's studies program and previously served as Project Director for past Academy studies for the Government Printing Office, USAID/Management Systems International, the National Park Service's Natural Resource Stewardship and Science Directorate, and the USDA Natural Resources Conservation Service. Served on the study team for past Academy studies for the Federal Emergency Management Agency, Office of National Drug Control Policy, Centers for Disease Control, National Aeronautics and Space Administration, and the Federal Bureau of Investigation, National Marine Fisheries Service, Patent and Trademark Office, National Institutes of Health, Department of the Interior, and Forest Service. Former Adjunct Professor at the Center for Public Administration and Public Policy, Virginia Polytechnic Institute and State University. Holds a Ph.D. from the Virginia Polytechnic Institute and State University, a Master of Public Administration from the University of North Carolina at Charlotte, and a BA in History from the University of North Carolina at Wilmington.

Stephanie Bailenson, *Project Director*—Served on past Academy studies for the National Oceanic and Atmospheric Administration, Government Printing Office, Office of Management and Budget, Federal Emergency Management Agency, National Coalition to End Childhood Lead Poisoning, and the Federal Bureau of Investigation, and the National Oceanic and Atmospheric Administration. Former Director, Office of Coastal and Aquatic Managed Areas, Florida Department of Environmental Protection; Senior Policy Advisor, National Oceanic and Atmospheric Administration; Professional Staff Member, U.S. Senate Committee on Commerce, Science, and Transportation, Research Assistant, University of Hawaii, Department of Zoology; and Teaching Fellow, Harvard University, Department of Government. Holds a Master of Public Administration from Harvard University, John F. Kennedy School of Government and a BA in Biology/Political Science from Duke University.

Diane Cochran, *Senior Advisor*—Former career Senior Executive with the Office of Personnel Management as a Deputy Associate Director, and the Department of Energy as a Deputy Assistant Secretary. Former senior human resources professional with twenty one years in the Department of Defense and nine years in non-Defense agencies. Holds a BS from the University of Maryland and MS from Air University, Air Command and Staff College.

Debbie Lehrich, *Senior Advisor*— Former Consultant, No Labels; Former Staff Writer, Active Voice; Former Director of Public Policy, Council of Parent Attorneys and Advocates; Former Consultant, Third Way; Former Counsel, Committee on Governmental Affairs, U.S. Senate. Holds a JD from Washington College of Law, American University and a BA in Political Science from the State University of New York at Binghamton.

Robert Pearre, *Senior Advisor*—Served on past Academy studies for the Office of National Drug Control Policy, and the Federal Bureau of Investigation. Project Director on past Academy study of the National Labor Relations Board. Former Director of Surveys and Investigations, U.S. House of Representatives, Committee on Appropriations; Former

Special Agent, Federal Bureau of Investigation; Certified Public Accountant; Holds a BS in Accounting from Towson University.

Amanda Mullan, *Research Associate*—Former American Government intern, the Congressional Research Service; Former Legislative Intern, the New York State Assembly. Holds a Master of Public Administration from Cornell University and a BA in Politic Science from the State University of New York at Cortland.

APPENDIX B: LEGISLATIVE LANGUAGE AUTHORIZING STUDY

House Report 112-284 of Public Law 112-55, the Consolidated and Continuing Appropriations Act, 2012

NWS Operations—NOAA shall enter into a contract with an independent organization with experience in assessing Federal agencies for the purposes of evaluating efficiencies that can be made to NWS operations. This review shall include consultations with emergency managers and other user groups as well as NWS employees. Any recommended efficiencies should not result in any degradation of service to the communities served by local forecast offices and River Forecast Centers, nor should such recommendations place the safety of the public at greater risk. This review shall not be undertaken until the National Academy of Sciences completes its review of the NWS modernization, which will include recommendations on the NWS workforce and composition and how NWS can improve current partnerships with Federal and non-Federal partners and incorporate new technologies for improved services. The findings and recommendations of the National Academy of Sciences review should inform this new independent assessment.

APPENDIX C: SITE VISITS

Baltimore/Washington Weather Forecast Office, Sterling, VA

Central Region Headquarters, Kansas City, MO

Kansas City/Pleasant Hill Weather Forecast Office, Pleasant Hill, MO

Milwaukee/Sullivan Weather Forecast Office, Dousman, WI

Missouri Basin River Forecast Center, Pleasant Hill, MO

National Centers for Environmental Prediction
- Aviation Weather Center, Kansas City, MO
- Central Operations, College Park, MD
- Climate Prediction Center, College Park, MD
- Environmental Modeling Center, College Park, MD
- Ocean Prediction Center, College Park, MD
- Weather Prediction Center, College Park, MD

National Weather Service Training Center, Kansas City, MO

Pittsburgh Weather Forecast Office, Moon Township, PA

APPENDIX D: PARTICIPATING INDIVIDUALS AND ORGANIZATIONS

The Panel and study team met with approximately 160 stakeholders through formal interviews, meetings, and focus groups to gain a thorough understanding of NWS's operations and structure. The Academy would like to thank these individuals for their contributions as well as the NWS staff who participated in site visits and fulfilling requests for information, but may not be listed here.

Albright, Leslie: Professional Staff Member, Committee on Appropriations, Subcommittee on Commerce, Justice, Science, and Related Agencies, U.S. House of Representatives

Alexander, Vicky: Chief, Administrative Services Division, Central Region, NWS

Adolphson, Julie: Meteorologist-In-Charge, Pleasant Hill Weather Forecast Office, NWS

Angle, Kelsey: Emergency Response Specialist and Union Steward, Central Region, NWS

Armstrong, John: Chair, Committee on the Assessment of the National Weather Service's Modernization Program, National Academy of Sciences; Retired Vice President for Science and Technology, IBM Corporation

Backlund, Curt: Electronics Systems Analyst, Sullivan Weather Forecast Office, NWS

Barrett, Catherine: Counsel, Committee on Commerce, Science, and Transportation, Subcommittee on Oceans, Atmosphere, Fisheries, and Coast Guard, U.S. Senate

Bailey, Andy: Warning Coordination Meteorologist, Pleasant Hill Weather Forecast Office, NWS

Becker, Joann: Senior Aviation Meteorologist and NWSEO NCEP Chair, Aviation Warning Center, National Centers for Environmental Prediction, NWS

Bleistein, Andrea: Weather-Ready Nation Roadmap Execution Manager, NWS

Bogdan, Thomas: President, University Corporation on Atmospheric Research

Bonner, Robert: Professional Staff Member, Committee on Appropriations, Subcommittee on Commerce, Justice, Science, and Related Agencies, U.S. House of Representatives

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Bray, Jackie: Deputy Chief of Staff, NOAA

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Bright, David: Aviation Support Branch Chief, Aviation Weather Center, National Centers for Environmental Prediction, NWS

Brown, Arthur: Electronics Systems Analyst, Pittsburgh Weather Forecast Office, NWS

Brown, Mickey: Deputy Director, Eastern Region, NWS; Former Chief Negotiator, NWS

Browning, Peter: Chief, Scientific Services Division, Central Region, NWS

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Duncan, Randall: Chair of the Government Affairs Committee, International Association of Emergency Managers-USA; Director of Emergency Management, Sedgwick County, Kansas

Edman, Andy: Chief, Scientific Services Division, Western Region, NWS

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Kapela, Rusty: Warning Coordination Meteorologist, Sullivan Weather Forecast Office, NWS

Kavinsky, Marc: Senior Forecaster, Sullivan Weather Forecast Office, NWS

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Kramer, Matthew: Science and Operations Officer, Pittsburgh Weather Forecast Office, NWS

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Sestre, Joe: Emergency Management Director, Groton, Connecticut

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Wallace, Clinton: Deputy Director, Aviation Weather Center, National Centers for Environmental Prediction, NWS

Walser, Maggie: Study Director, Committee on the Assessment of the National Weather Service's Modernization Program, National Academy of Sciences

Weirich, Jeremy: Professional Staff Member, Committee on Appropriations, Subcommittee on Commerce, Justice, Science and Related Agencies, U.S. Senate

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Wilz, Gregory: Director, North Dakota Homeland Security Division and State Security Advisor

Winokur, Robert: Deputy Oceanographer of the Navy, Deputy and Technical Director, Oceanography, Space, and Maritime Domain Awareness, U.S. Navy

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Young, Doug: Chief, Performance Branch, Office of Climate, Water, and Weather Services, NWS

Zubrick, Steven: Science and Operations Officer, Sterling Weather Forecast Office, NWS

APPENDIX E: EMERGENCY MANAGERS FOCUS GROUPS

State Emergency Manager Focus Group Summary

On December 12, 2012, The National Academy of Public Administration hosted a focus group with state emergency managers (EM). Below is a summary of key themes from that discussion.

Seven EMs representing six states plus a representative from the National Emergency Management Association participated:

- Alaska
- Arkansas
- Florida
- Georgia
- Minnesota
- North Dakota

These representatives identified a wide range of severe weather challenges related to sea storms, tsunamis, hurricanes, snow and ice, flooding, tornadoes, and rainfall.

Relationships

The focus group participants were very supportive of the NWS and see them as critical partners. Participants reported very good working relationships with their local Weather Forecast Offices (WFO), River Forecast Centers (RFC), and Regional Offices. The state EMs all reported that they coordinate with NWS before, during, and after weather events depending on their state's weather needs. Each state EM deals with multiple WFOs within and outside of their respective states. State EMs are in contact with NWS Regional Headquarters to coordinate the deployment of meteorologists during severe weather events. Depending on their requirements, some state EMs have relationships with some of the National Centers for Environmental Prediction including the National Hurricane Center, the Weather Prediction Center, and the Storm Prediction Center. The participating state EMs stated that NWS is responsive to their needs.

Decision Support

Most participants said they communicate with their local WFOs on a daily basis. Some state EMs stated that between events, their offices and NWS conduct joint training programs to prepare for severe weather. During events they said that they receive customized reports as well as conference calls and briefings as needed to translate forecasts and provide additional information about the level of uncertainty associated with the forecast. Some

EMs mentioned using NWSChat[101] during events for forecast clarification. For severe weather events, most state emergency operations centers receive some level of on-site decision support,[102] which was described as invaluable. Some state EMs said that they would appreciate having even more decision support from NWS during weather events, especially on-site. After weather events, some participants reported that NWS provides them with information for disaster relief assessments.

The focus group participants also identified some challenges in communicating with NWS. Some EMs said that it was difficult to find opportunities to discuss concerns they have with NWS. Others said they had expressed concerns, but the issues persist. They recognized that both communities have little time to assess post-event and that NWS does not have the luxury of taking a day off, as they are always preparing for the next forecast. There is also a limited amount of time to share best practices between NWS and the EM community.

Communication of Forecasts and Warnings

The state EMs identified several areas where improvements could be made in what and how information is communicated in a forecast. Some EMs reported instances where the language used in the forecasts had prompted the wrong response from the public. They recommended that forecasts be enhanced based on an understanding of how they translate into action by various users including EMs, the private sector, and the general public. Some participants suggested that NWS could improve its communications with the general public by using new technologies, social media, and by improving their website. Some EMs suggested that NWS could improve its forecasts by considering the "built environment" and how severe weather can impact certain areas differently than others.

Most of the EMs expressed concern that WFOs tend to overwarn, which can cause the public to become complacent about severe weather warnings. Some EMs thought that despite this, NWS does a good job of explaining the level of uncertainty to the emergency management community. Some participants thought that the two communities have different concepts of acceptable risk, which they might be able to overcome by working together and with more decision support and post-event assessments.

Another communication challenge was forecast and product inconsistency. The state EMs in the focus group all interact with multiple WFOs. Participants indicated that they receive inconsistent forecasts from the different WFOs. The EMs also said that they receive graphics in varying formats from different WFOs. Some EMs reported that occasionally WFOs had differing opinions on how severe an approaching weather event would be. These issues require EMs to reconcile the differences, which takes time and sometimes requires technical expertise they do not have. These differences impact the EMs' ability to prepare accordingly for upcoming weather events.

[101] This is a secure instant messaging system.
[102] One EM reported that his state chooses not to receive on-site support because his state has three meteorologists on staff.

National Weather Service's Approaches to Change

When asked about the NWS approach to change, state EMs said that, locally, they see WFOs as open to making changes as necessary and responsive to their requests. Some participants mentioned that changes to NWS products are very slow and methodical, but did not see that as a problem. Participants expressed an interest in having opportunities to help NWS develop new products, suggesting that involving EMs in the beta-testing could ensure that new products met their needs. Some EMs suggested that external forces, such as limited resources and multiple constituencies, have a negative impact on NWS's ability to change.

Challenges and Concerns

Limited Resources

The state EMs expressed concern that the current budget situation may require NWS to cut back, which could lead to a degradation of services. Limited resources also hinder NWS's ability to increase valuable outreach and decision support activities, as well as to have time to analyze the consequences of their forecasts. Some participants said that with more time to conduct further analysis, NWS would be able to improve the language they use. Some participants expressed concern that the current budget problems will lead to understaffing and exacerbate any issues associated with having meteorologists with less experience as members of the aging NWS workforce retire.

Aging Infrastructure and Technology

Some EMs acknowledged that the WFO infrastructure is aging to the point of concern. They also see some of NWS's technology becoming obsolete in the near future which could diminish NWS's ability to provide critical products and services. They do not want to see valuable products become outdated. Other participants cited examples of aging infrastructure and technology at their local WFOs, a growing problem identified as possibly affecting future forecast accuracy.

Local Emergency Managers Focus Group Summary

On January 10, 2013, the National Academy of Public Administration hosted a focus group with local emergency managers (EM) coordinated with the International Association of Emergency Managers (IAEM). Below is a summary of key themes from that discussion.

Eleven EMs representing 10 localities plus a representative of IAEM participated:

- Brier, Washington
- Burleigh County, North Dakota
- Fairfax, Virginia
- Galveston County, Texas
- Georgetown County, South Carolina
- Groton, Connecticut
- Huntsville-Madison County, Alabama
- Licking County, Ohio
- Sedgwick County, Kansas
- Volusia County, Florida

These representatives identified a wide range of severe weather challenges related to severe convective weather; tornadoes; winter storms; river, urban, and shoreline flooding; thunderstorms; wild fires; hurricanes; high winds; ice storms; nor'easters; and hazardous materials incidents.

Relationship with the National Weather Service

Focus group participants were extremely complimentary of the products and services they receive from the NWS. Each local EM said they worked directly with one WFO on a regular basis. Some participants reported daily contact with their local WFO and more frequent contact during severe weather events. Overall, local EMs said their relationship with their WFO was outstanding and extremely important for them in order to make decisions that save lives and property. They said that lives would be lost without NWS's providing critical forecasts and decision support. It was noted that 90 percent of Presidentially-declared disasters are weather related; underscoring the importance of the products and services provided to them by the NWS.

Their primary contacts at the WFOs varied, but overwhelmingly local EMs deal with the Warning Coordination Meteorologist, the Meteorologist-in-Charge, and the forecasters on duty. Some local EMs had relationships with the Science and Operations Officer, Emergency Response Specialists, and Incident Meteorologists.

Decision Support

The local EMs reported that they primarily have contact with one WFO enabling close working relationships to develop over time. Local EMs said they are in contact with their WFO before, during, and after severe weather events. EMs use a variety of methods to help translate forecasts into action, including telephone and conference calls, two-way radio, on-site briefings, WFO websites, NWS Chat, webinars, PowerPoint briefings, and social media outlets like Facebook and Twitter. EMs then disseminate this NWS-generated information to relevant stakeholders. These services were described by participants as "top shelf" and essential to the EMs' decision-making process, making it clear how indispensable the local EMs view these relationships. One participant indicated that he would not try to command a weather incident response without the NWS any more than he would go to a hospital without a doctor or to court without a lawyer. Upon request, local EMs are able to obtain spot forecasts which also enables them to make better decisions.

When asked if NWS's decision support capabilities could be improved by embedding forecasters in their local emergency management offices permanently, most participants were concerned about what, if any, value would be added compared to the potential cost of moving staff out of a WFO. They noted that NWS currently provides excellent decision support remotely or through temporary deployment during an event. The local EMs were concerned that forecasts at the WFOs could suffer if NWS was permanently deploying forecasters to the field. They want to ensure that the ability of the NWS to provide products and services is maintained across the entire WFO service area and seemed comfortable with the current locations of the offices with which they interact. Most participants indicated that if NWS was to provide more on-site decision support, it would require additional staffing.

Communication of Forecasts and Warnings

Unlike the state EMs, local EMs were not concerned with consistency of forecasts from multiple WFOs. This may be attributable to the fact that they routinely interact with one WFO. Some mentioned that on conference calls with state EMs with multiple WFOs providing briefings, they did not find the WFOs' forecasts to be inconsistent.

The participants said that communication with NWS was open and that the WFO staff was able to answer questions and further explain the forecast in ways they could understand. Many local EMs felt that NWS was able to anticipate their needs and provide information before the EMs had to ask. Some participants did note issues they had with NWS's communication of forecasts. A participant mentioned that sometimes the language used by NWS was confusing to the public. Now NWS is using "smartened text" with the common alert protocol which has improved the forecast. Another indicated that NWS's polygon method for tornado watches and warnings can make it difficult to respond when there are multiple warnings within a single county. This is especially problematic when listening to NOAA Weather Radio. A few local EMs receive information from the National Hurricane Center and expressed concern about the process used to issue hurricane watches and

warnings. There was some concern that NWS staff does not fully understand how EMs convert forecast information into action to protect lives.

NWS Organizational Structure and Staffing

The local EMs overwhelmingly agreed that the current arrangement of WFOs works. They recognize that the location of the WFOs is related to the placement of radar during modernization, and most were satisfied with their radar coverage. Many participants voiced concern about moving or consolidating WFOs to secondary centers. They felt that local knowledge would be diminished by moving forecasters further away from the locations for which they forecast. The local EMs agreed that local knowledge and having an emotional connection to the area greatly improved forecasts and decision support. They would not be satisfied with a forecaster from a remote office doing forecasting for their locality because they did not see how that forecaster could have appropriate local knowledge.

Most expressed concern about NWS's fair weather staffing model and its ability to supplement with additional staff during a severe weather event. Focus group participants were even more troubled about the increasing number of vacancies in the field, prompting concerns about overtime during severe weather events and the ability to provide adequate decision support under the current budgetary constraints.

The focus group participants were also asked about the potential to co-locate a WFO with an emergency management center. Some participants were concerned that given the number of emergency management departments covered by a single WFO, it would be difficult to choose a mutually agreeable location. They were also concerned about the possibility that services to other emergency management offices would be diminished if NWS was to co-locate with only one office. One participant's emergency management center currently co-located with the local WFO was enthusiastic about the arrangement seeing it as beneficial to their decision making process. Other participants indicated that decisions involving co-location should only be made on an individual basis, rather than a blanket approach across the country.

Challenges and Concerns

Limited Resources

The participants of the focus group expressed concern about the possibility of reduced services. Given the current budget atmosphere, the local EMs have already seen vacant position go unfilled and travel to participate in emergency management training and awareness events significantly reduced. They are worried that the next step is for NWS to reduce services the EMs see as vital to their decision making processes. With a reduction in resources, local EMs are worried about possible future consolidation of offices. They did not see how that could happen without a reduction in service to them and would strongly oppose any such proposals.

Degradation of Service

Participants were asked what would constitute a degradation of service. Some participants said that any reduction in services currently received would represent a degradation of service if it would impact their ability to make decisions. Other EMs were concerned about reductions in personnel and technology leading to degradation of service. A participant who had gone through modernization had experienced degradation of service when the Modernization Transition Committee approved the closing of the local Weather Service Office. After months of appealing the decision, the WFO was opened.

APPENDIX F: OVERVIEW OF NATIONAL WEATHER SERVICES OFFICES

Headquarters

Office of the Assistant Administrator for Weather Services (Headquarters)—is responsible for the overall management of the National Weather Service (NWS).[103]

Strategic Planning and Policy (SPP)—this office supports the Assistant Administrator by developing and implementing NWS policy and strategy. SPP is responsible for developing the NWS strategic plan, including the current Building a Weather-Ready Nation strategic plan, as well as other long-range policy objectives.[104]

Office of Equal Opportunity and Diversity Management (OEODM)—this office advises the Assistant Administrator in carrying out NWS responsibilities of Titles VI and VII of the Civil Rights Act of 1964, the Age Discrimination in Employment Act of 1967, the Rehabilitation Act of 1973, and other policies such as Equal Employment Opportunity (EEO) and affirmative action. OEODM provides policy guidance for EEO programs, monitors Affirmative Employment Program Plans, conducts studies on employment problems, and recommends solutions.[105]

International Affairs Office (IA)—this office coordinates all international cooperation for NWS. IA supports the Assistant Administrator, who serves as the Permanent Representative for the United States with the World Meteorological Organization. The office is also responsible for managing bilateral relations, implementation projects, overseeing the travel of NWS experts, and representing NWS at international meetings.[106]

Office of the Chief Information Officer (OCIO)—this office is responsible for managing NWS's information technology planning. OCIO coordinates and develops the annual IT Operating Plan, the IT Strategic Plan and implements all NWS IT security.[107]

Office of the Chief Financial Officer (OCFO)—this office includes the Chief Financial Officer and the Chief Administrative Officer for NWS. OFCO leads the formulation and execution of the NWS budget, provide accounting resources to the offices and the regions, as well as develops and manages the implementation of NWS human resources, labor management, and organizational development.[108]

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[103] National Weather Service. *Jet Stream - Online School for Weather*. http://www.srh.noaa.gov/jetstream/nws/regions.htm
[104] National Weather Service. *NWS Strategic Planning and Policy*. http://www.nws.noaa.gov/sp/
[105] National Weather Service. *Office of Equal Opportunity and Diversity Management*. http://www.nws.noaa.gov/eeo/
[106] National Weather Service. *International Activities Office*. http://www.nws.noaa.gov/iao/ia/hom/index.php
[107] National Weather Service. *Chief Information Office.* http://w1.weather.gov/cio/
[108] National Weather Service. *Chief Financial Officer and Chief Administrative Officer*. http://www.nws.noaa.gov/cfo/

Office of Climate, Water, and Weather Services (OCWWS)—this office is responsible for overseeing the forecast and warning operations by monitoring high impact events, assessing service and performance quality and accuracy, and measuring customer satisfaction. OCWWS develops and implements service policies and procedures. All training for the NWS workforce is managed by this office.[109]

Office of Operational Systems (OOS)—manages several different operational systems including field systems; radar operations; the National Data Buoy Center; maintenance, logistics, and acquisition activities; and telecommunications. OOS is responsible for providing engineering software management, facilities, communications, and logistical services as well as developing policy for operational weather systems.[110]

Office of Science and Technology (OST)—is the office responsible for integrating new science and technology into operations. The OST manages the execution of programs, assesses new technology options, and develops plans to integrate new technology into operations. OST also conducts applied research and coordinates collaboration amongst the different field offices to foster innovation.[111]

Office of Hydrological Development (OHD)—is the office responsible for providing Weather Forecast Offices and River Forecast Centers with support for stream flow forecasting. The office accomplishes this by collecting hydrologic observations, developing and implementing new technology, and producing hydrologic products to meet the needs of NWS customers.[112]

Regions

Regional Headquarters Offices—are the administrative and operational support centers for the local forecast offices, including Weather Forecast Offices (WFOs), River Forecast Centers (RFCs), Center Weather Forecast Units (CWSUs), and Weather Service Offices (WSOs). They provide meteorological and hydrological support for aviation weather, fire weather, marine weather, other forecasts, and severe weather. Regional Headquarters are responsible for supporting the field in the areas of professional development; budget support; communications, dissemination and information processing systems; systems maintenance; and facilities engineering. Each region is a little bit different from the rest because of their different weather patterns and the number and types of offices

[109] National Weather Service. *Office of Climate, Water, and Weather Services*. http://www.nws.noaa.gov/os/org.shtml
[110] National Weather Service. *Office of Operational Systems*. http://www.nws.noaa.gov/oos/
[111] National Weather Service. *Office of Science and Technology*. http://www.nws.noaa.gov/ost/; Information provided to the Panel by the NWS.
[112] National Weather Service. *Office of Hydrologic Development*. http://www.nws.noaa.gov/oh/; National Weather Service. *Laboratory Strategic Plan 2010*.

managed.[113] The list below describes the service areas for each region and the number and type of field offices it supports. [114]

- **Eastern**—the Eastern Region Headquarters is located in Bohemia, NY and includes the following states: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Rhode Island, South Carolina, Vermont, Virginia, Washington, D.C., and West Virginia. (23 WFOs, 3 RFCs, and 4 CWSUs)
- **Central**—the Central Region Headquarters is located in Kansas City, Missouri and includes the following states: Colorado, Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Nebraska, North Dakota, South Dakota, Wisconsin and Wyoming. (38 WFOs, 2 RFCs, and 3 CWSUs)
- **Southern**—the Southern Region Headquarters is located in Fort Worth, Texas and includes the following states: Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, New Mexico, Oklahoma, Puerto Rico, Tennessee, and Texas. (32 WFOs, 4 RFCs, and 7 CWSUs)
- **Western**—the Western Region Headquarters is located in Salt Lake City, Utah and includes the following states: Arizona, California, Idaho, Montana, Nevada, Oregon, Utah and Washington. (24 WFOs, 3 RFCs, and 4 CWSUs)
- **Alaska**—the Alaska Region Headquarters is located in Anchorage, Alaska. It is responsible for overseeing the states' WFOs, a Tsunami Warning Center, the Alaska Aviation Weather Unit and WSOs. (3 WFOs, 1 RFC, 1 CWSU, and 12 WSOs)[115]
- **Pacific**—the Pacific Region Headquarters is located in Honolulu, Hawaii. The region includes several WFOs and WSOs across the Pacific Ocean. It also includes the Pacific Tsunami Warning Center, the International Tsunami Information Center, and the Central Pacific Hurricane Center. (2 WFOs and 6 WSOs)[116]

Weather Forecast Offices (WFOs)—are the local forecast offices that are responsible for monitoring weather 24 hours a day, 7 days a week and issuing weather forecasts out to seven days. They are also responsible for issuing watches and warnings of severe weather. WFOs conduct outreach activities with local users and may at times provide remote or onsite decision support to emergency managers and decision makers.[117]

River Forecast Centers (RFCs)—are located based on major river systems and aquifers and are responsible for producing river and flood forecasts, warnings, and water resource information. The forecasts they produce are distributed by the Hydrology Program of the

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[113] National Weather Service. *Jet Stream - Online School for Weather.* 2010. http://www.srh.noaa.gov/jetstream/nws/regions.htm

[114] All regional descriptions are from *National Weather Service Organization*, http://www.weather.gov/organization

[115] The Alaska and Pacific Regions are structured differently than the other continuous United States Regional offices and were not subject to all of the changes that occurred during the NWS modernization.

[116] Ibid.

[117] National Weather Service. *Weather Forecast Offices*. http://www.srh.noaa.gov/jetstream/nws/wfos.htm; Information provided to the Panel by the NWS.

WFOs. During floods, RFCs coordinate with water management agencies and during non-flood periods are focused on making daily streamflow forecasts and seasonal water supply forecasts that allow for preparation.[118]

Center Weather Service Units (CWSUs)—provide aviation weather forecasts to FAA traffic management personnel under a reimbursable agreement. CWSUs are located at each of the FAA's 21 en route centers and are operational 16 hours a day, 7 days a week. Staff usually consists of three meteorologists and a meteorologist-in-charge.[119]

Weather Service Offices (WSOs)—are located in the Alaska and Pacific regions. They are different from WFOs in that they do not issue forecasts and are responsible primarily for collecting observations. Before the last modernization, NWS had more WSOs that were staffed with meteorological technicians and observers.[120]

Tsunami Warning Centers (TWCs)—are located in Alaska and Hawaii. TWCs are responsible for issuing the official tsunami watches, warnings, and advisories. They monitor the tsunami warning system determine whether or not there is a risk of a tsunami, then issue the appropriate watches, warnings or advisories. TWCs are in charge of coordinating with other organizations to monitor seismic and sea level activity.[121]

National Centers

National Centers for Environmental Prediction (NCEP)—includes nine National Centers that generate products and services that support NWS field operations, private sector partners, other government agencies, and the public. NCEP aims to produce reliable, timely, and accurate analyses, guidance, forecasts, and warnings that enable NWS to achieve its mission of protecting life and property.[122]

- **Aviation Weather Center (AWC)**—is the part of NCEP that issues aviation forecasts and warnings impacting the flight conditions of domestic and international air space. AWC primarily works with FAA, but also coordinates activities with the NWS field offices including the WFOs and the Center Weather Service Units.[123]
- **Central Operations (NCO)**—is the part of NCEP that sustains and executes the supercomputer on which the numerical models from EMC are analyzed. They are

[118] National Weather Service. *NWRFC General Information*. http://www.nwrfc.noaa.gov/nwrfc/info.cgi
[119] Government Accountability Office. *Aviation Weather: Agencies Need to Improve Performance Measurement and Fully Address Key Challenges*.
[120] National Research Council. *The National Weather Service Modernization and Associated Restructuring: A Retrospective Assessment*.
[121] National Weather Service. Tsunami Warning Service. Directive 10-7.
[122] National Centers for Environmental Prediction. *Strategic Plan 2009-2013 "From the Sun to the Sea…Where America's Climate, Weather, Ocean, and Space Weather Service Begin."*
[123] Government Accountability Office. *Aviation Weather: Agencies Need to Improve Performance Measurement and Fully Address Key Challenges*; Information provided to the Panel by the NWS.

also responsible for preparing NCEP products for dissemination to the field, the private sector, and the public.[124]

- **Climate Prediction Center (CPC)**—is the part of NCEP that provides operational predications of climate variability, on time scales that vary from weeks to years. These include temperature, precipitation, and drought outlooks. CPC also conducts some climate research and manages the NOAA Climate Testbed.[125]
- **Environmental Modeling Center (EMC)**—is the part of NCEP that develops and improves numerical weather prediction using the NCEP model production suite. Their models are run 24 hours a day, 7 days a week on the NCEP supercomputer. EMC also interacts with the research community to facilitate the transition of research into operations.[126]
- **National Hurricane Center (NHC)**—is the part of NCEP that provides the official forecasts, watches, and warnings on tropical weather systems. In addition, NHC conducts analyses of hazardous tropical weather to increase understanding and improve forecasts.[127]
- **Ocean Prediction Center (OPC)**—is a part of NCEP that issues marine forecasts, warnings, and guidance for maritime users. OPC oversees the quality of marine observations globally from ship, buoy, and automated marine observations. The products issued by OPC fulfill the United States' responsibilities with the World Meteorological Organization regarding marine forecasting.[128]
- **Space Weather Prediction Center (SWPC)**—is the part of NCEP that issues the nation's official space weather alerts, watches, and warnings. It is the primary warning center for the International Space Environment Service. SWPC is responsible for monitoring and forecasting solar and geophysical events that may impact satellites, power grids, communications, navigation, and other technological systems. SWPC also explores new models and products to transition them into operations.[129]
- **Storm Prediction Center (SPC)**—is the part of NCEP that has responsibility for issuing forecasts and watches for the continental United States for tornadoes, thunderstorms, fire weather, severe snow storms, and other severe weather events. Their forecasts are disseminated to the weather forecast offices and the private sector. During severe storms they collaborate with the local forecast offices and the private sector to provide further guidance.[130]
- **Weather Prediction Center (WPC)**—is the part of NCEP that provides precipitation and weather forecast guidance out to seven days to the field offices. The information they disseminate is available to the private sector as well as the

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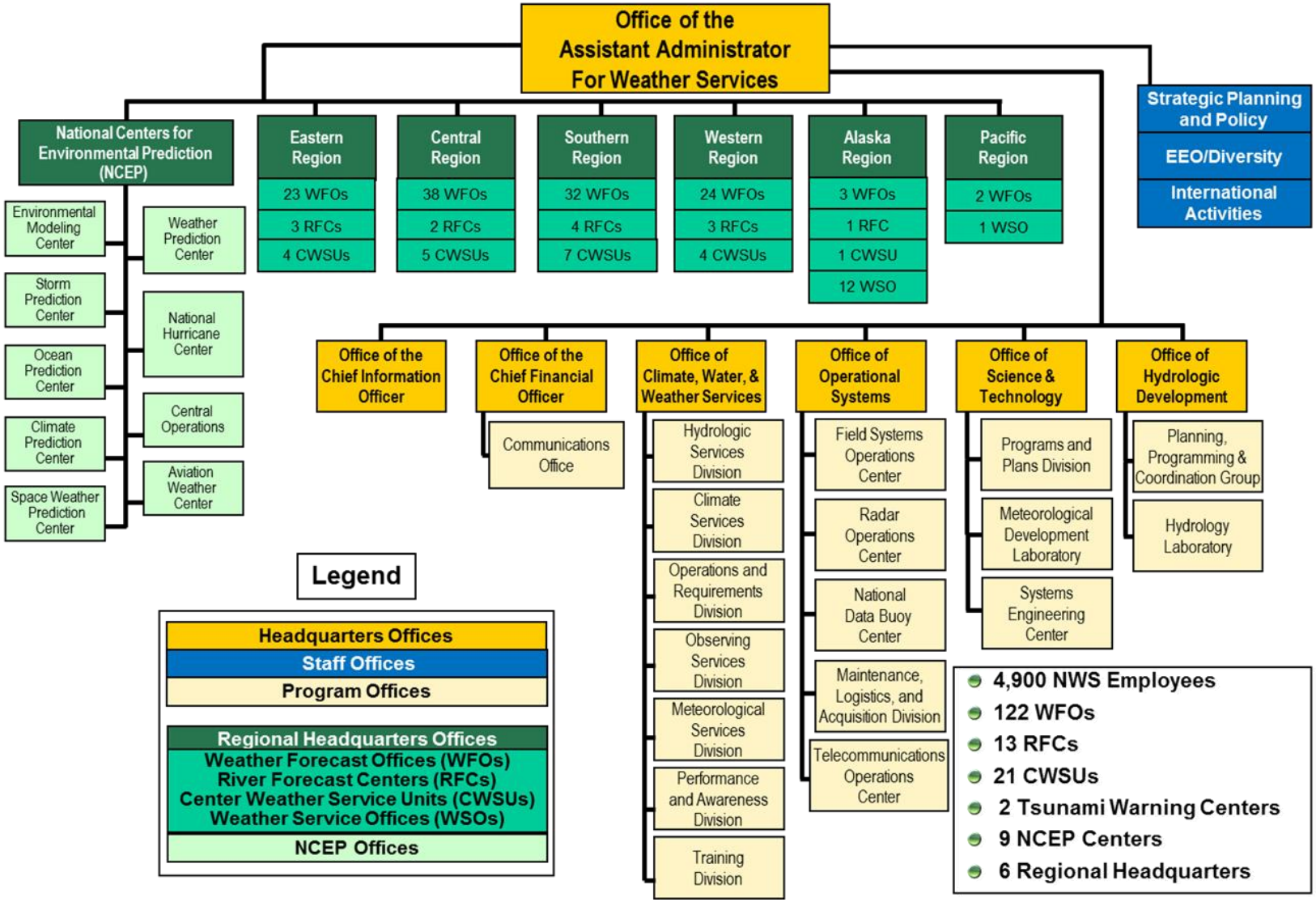
[124] National Weather Service. National Centers for Environmental Prediction. *Strategic Plan 2009-2013 "From the Sun to the Sea…Where America's Climate, Weather, Ocean, and Space Weather Service Begin."*.
[125] National Weather Service. *Climate Prediction Center.* http://www.cpc.ncep.noaa.gov/
[126] Information provided to the Panel by the NWS.
[127] National Weather Service. *National Hurricane Center*. http://www.nhc.noaa.gov/aboutintro.shtml
[128] National Weather Service. *Ocean Prediction Center*. http://www.opc.ncep.noaa.gov/about_us.shtml
[129] National Weather Service. *Space Weather Prediction Center*.
http://www.swpc.noaa.gov/AboutUs/index.html
[130] Information provided to the Panel by the NWS.

public. WPC collaborates with the field offices providing additional information and interactions on a daily basis.[131]

[131] Ibid.

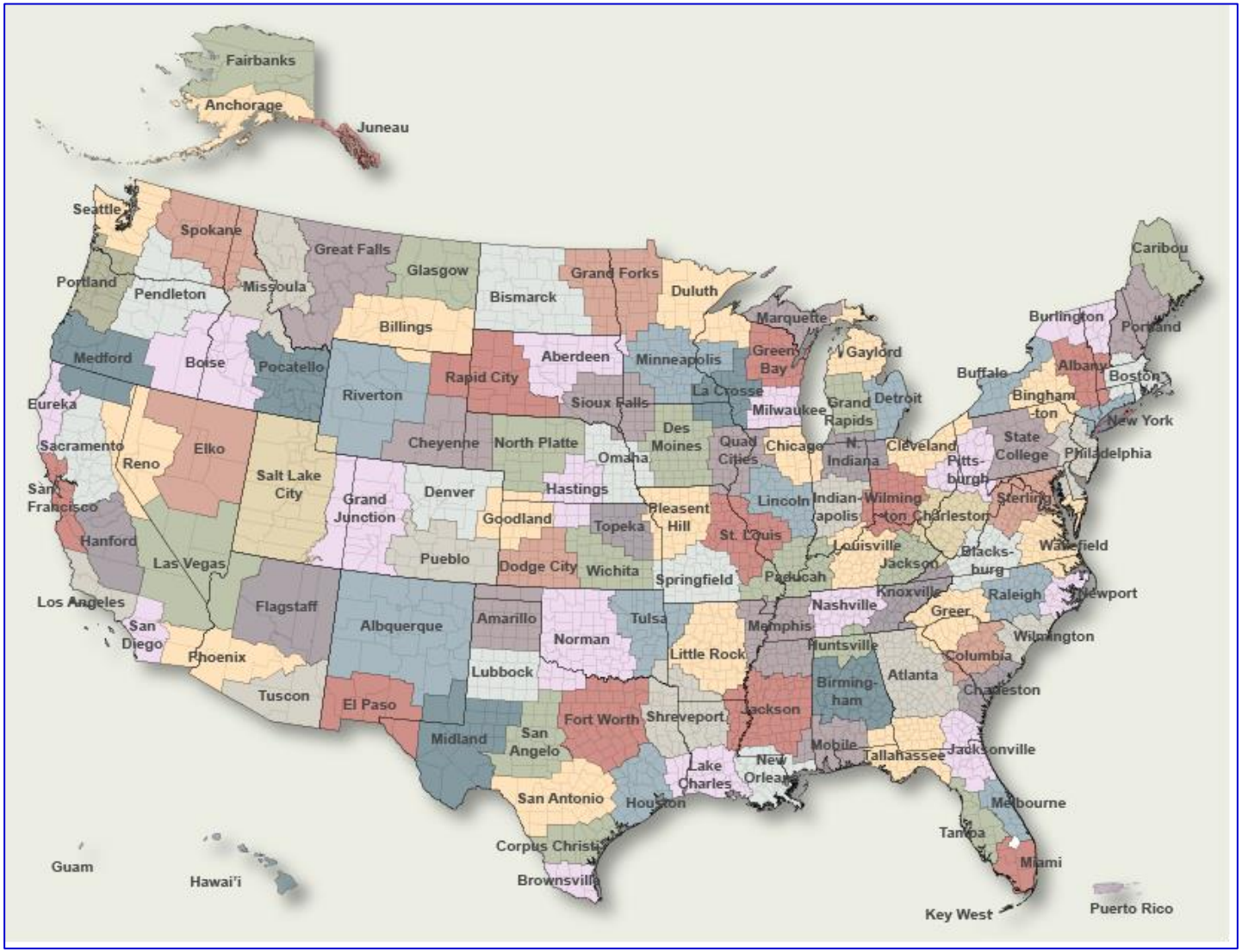
National Weather Service Organizational Structure

This chart depicts the current organizational structure of the National Weather Service



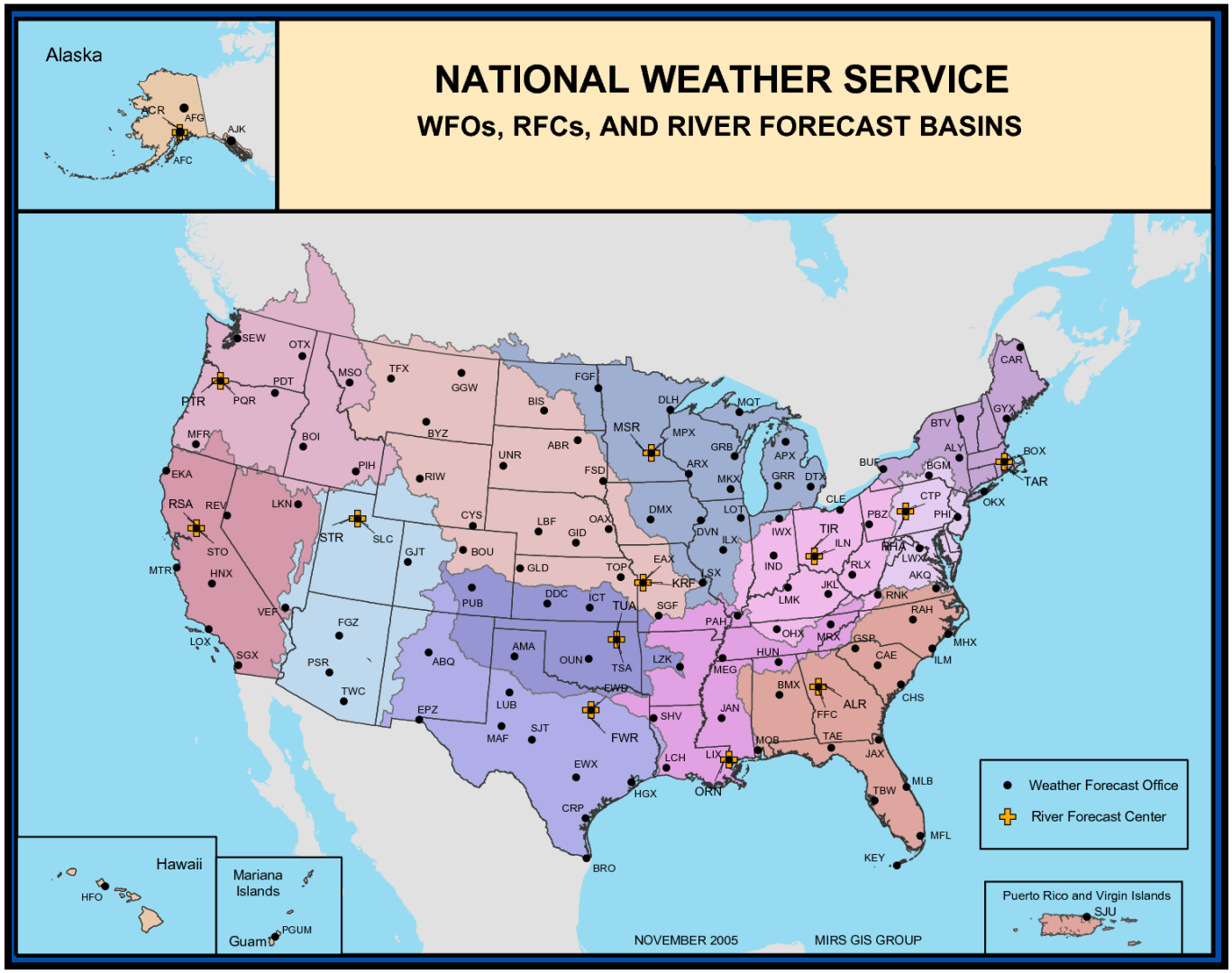
Weather Forecast Office Map

This map shows the areas of responsibility for the 122 Weather Forecast Offices



River Forecast Center Office Map

This map shows the river basin areas of responsibility for the 13 River Forecast Centers



NEXRAD Map

This map shows the NEXRAD coverage areas for the Continental United States.[132]

[132] Radar Operations Center. http://www.roc.noaa.gov/WSR88D/Images/WSR-88DCONUSCoverage1000.jpg

APPENDIX G: NATIONAL WEATHER SERVICE TRAINING PROGRAMS

The NWS National Training Center was home to robust leadership programs that built excellence in leadership. Courses were designed to distinguish between leadership and management. Instruction included leadership lessons to enable leaders to drive employee engagement and high performance, build listening and communication skills, manage stress, enable informed decision making, inspire creative problem solving, and teach techniques to implement effective change—all skills that are essential to leadership succession. Much of the on-site training for leadership has been curtailed and with a recent decision to freeze all management training, the NWS is facing a leadership succession crisis. The Executive Leadership Seminar was open to GS 12-15 managers/supervisors/team leaders with responsibility for supervising and directing the work of others. It was a 9-day residential course on the leader development experience, conducted two or three times per year, and accommodating between 15 and 20 employees at each class. The cost was about $1500 per attendee, inclusive of travel, per diem, and materials and was centrally funded. The last class was in 2010 and funding is no longer available. The NWS Training Portal posts no FY 2013 offerings for this course.

Fulfilling the requirement of 5 CFR Part 412, Management and Supervision training was an 80-hour class including an 8-day residential course that was mandatory for all new supervisors. It provided a foundation of knowledge and skills to successfully manage the people and operations of a federal agency. Key components included training on equal employment opportunity and diversity with instruction on associated regulations, law, and the application of diversity principles. Also included was training on labor and employee relations which instructed participants on management's role in conflict resolution, mediation, performance management, and recognition. The training had an on-site and a non-residence component that included independent and small group collaboration, online forum and webinar participation. The National Training Center conducted two or three sessions a year, attended by up to 15 new managers, costing approximately $1500 per attendee, including travel, per diem and materials. Due to funding issues, this format has not been in place for two years. The National Training Center has created a distance learning module for the course that covers some of the material.

The Forecaster Development Training Program was reportedly a well-received course of study for newly-hired meteorologists for their first two years. The 2-week residential course was discontinued a few years ago due to budget reductions. Team Leader Training (Field Operations Management) was 5-day training for team leads and senior forecasters who have shift leader responsibilities and provided knowledge and skills necessary to lead forecast offices, river forecast centers, or regional teams during shift work when a supervisor is not on the scene. Emphasis was placed on team situational leadership, communications, interactions with the public through the media, customer relations, personnel and administrative policies, basic labor relations, conflict mitigation and management, performance, and decision-making processes. This was also an important labor-management component that helped equip the shift manager to handle employee issues and work within the labor-management agreement. The class was held about twice a

year and the cost per participant was about $1000 including travel, per diem and materials. This course has not been funded for the past two years and the NWS Training Portal posts no FY 2013 offerings for this course.

Due to the vision and initiative of some key managers at the regional level, customized leadership programs for employees were created to partially fill the gap. Managers who were key to these initiatives all report that they recognized that leadership is not only required of management. Every employee has the opportunity, if not the need to exercise leadership. Each of the Regions created and funded programs for leadership development for non-supervisory employees. Even though singularly sponsored by each region, they were very similar in structure and purpose. Building Leaders for a Solid Tomorrow came out of the Southern Region and was the prototype for the programs developed by three other regions: Leadership Excellence and Development in the Central Region; Eastern Region Leadership and Development Program; and Leadership and Development for Tomorrow in the Western Region. Each of these programs was created in the absence of an organization-wide leadership program. They were the innovations of a few key leaders in the regions who said they recognized that "leadership is as much nurture as nature." The programs had similar features such as face-to-face kick offs, group projects, team building activities, selected readings, and mentorship. Each was funded at the regional level, generally selected about twenty participants for each cadre, and lasted between one to one and a half years. Costs were reported to be approximately $50,000 per class of 20 students per region per year, inclusive of travel to the on-site segments. Costs were contained in part by having regional leaders conduct and facilitate training sessions. These programs were innovative and excellent value but according to internal stakeholders, have been nearly all eliminated due to budget constraints.

APPENDIX H: ADDITIONAL INFORMATION ON FEDERAL ADVISORY COMMITTEES

The Federal Advisory Committee Act

The Federal Advisory Committee Act (FACA)[133] promotes transparency, requires public participation, and attempts to limit the influence of special interests by imposing membership restrictions. It also aims to preserve scarce federal resources by requiring the president and agencies to provide justifications to the General Services Administration (GSA) for the creation of a committee. Agencies are required to provide public notification through the Federal Register on the creation of an advisory committee, to solicit feedback on committee membership and post notification of meetings. Meetings are to be open to the public, unless the topics discussed are appropriate for exemption under the Government in the Sunshine Act.[134] FACA applies when the president or a government agency creates an entity that includes at least one individual who is a non-federal employee with multiple individuals who work as a group to provide advice and recommendations to the president or government agencies.

Additional Information on the Potential Benefits of Advisory Committees

Advisory committees can be a useful mechanism that allows agencies to solicit advice and recommendations from external stakeholders using a process that is transparent. Members of advisory committees should have expertise in a particular relevant subject matter or be representative of individuals and organizations that have an interest in the actions of the agency. By allowing individuals from both inside and outside of government to interact, problems can be discussed and solutions can be found in an environment that is collaborative.

Overview of NOAA Advisory Committees[135]

NOAA Advisory Committees	Number of Members	Number of Meetings	Total Cost	Number of FTEs
Advisory Committee on Commercial Remote Sensing	13	1	$6,653	0.1
Hydrographic Services Review Panel	19	2	$350,500	1.2
Marine Fisheries Advisory Committee	28	4	$221,000	1.3
NOAA Science Advisory Board	17	4	$385,000	0.75
National Sea Grant Advisory Board	12	3	$199,390	0.5
Marine Protected Areas Federal Advisory Committee	35	2	$230,000	0.5

[133] Public Law 92-463; 5 U.S.C. App
[134] Public Law 94-409; 5 U.S.C. § 552b
[135] General Services Administration. *Federal Advisory Committee Act Database*.

Additional Criticisms of Federal Advisory Committees

There has been some criticism of federal advisory committees as being procedurally burdensome. In a recent study by the Administrative Conference of the United States that interviewed Committee Management Officers, agency representatives, and FACA experts found that much of the procedural burden agencies associated with creating advisory committees stemmed from the belief that GSA's role constitutes an approval process rather than a consultation requirement with regards to the drafting of committee charters.[136]

Discretionary Advisory Committees

Following the issuance of Executive Order 12838[137], the Office of Management and Budget (OMB) issued OMB Circular A-135, which created a cap on the number of discretionary advisory committees agencies could create.[138] A discretionary advisory committee is an advisory committee that is not mandated by statute or Presidential Directive. According to GSA, DOC currently has a ceiling of 23 discretionary advisory committees and is now using 17. Therefore, DOC has room within their discretionary ceiling to establish this new committee.

[136] Administrative Conference of the United States. *Administrative Conference Recommendation 2011-7: The Federal Advisory Committee Act – Issues and Proposed Reforms*.

[137] This Executive Order was issued by the Clinton Administration on February 10, 1993.

[138] Currently, the cap on discretionary advisory committees is 534 for all federal agencies.

APPENDIX I: INFORMATION SOURCES

5 C.F.R. Section 412.202. Systematic training and development of supervisors, managers, and executives.

5 U.S.C. § 552b. Open Meetings.

15 USC 313-329. National Weather Service.

44 U.S.C. § 3541, et sec. Information Security.

Administrative Conference of the United States. *Administrative Conference Recommendation 2011-7: The Federal Advisory Committee Act – Issues and Proposed Reforms.* Washington, D.C.: December 9, 2011. http://www.acus.gov/sites/default/files/documents/Recommendation-2011-7-Federal-Advisory-Committee-Act.pdf

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