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Becoming a Weather-Ready Nation

In this interview, Louis W. Uccellini, director of the US National Weather Service, discusses the organization's work to provide more accurate predictions and decision support for weather events.

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The United States National Weather Service (NWS), under the National Oceanic and Atmospheric Administration (NOAA), is one of the world's leading providers of weather, water, and climate observations. Its work in the study of atmospheric and hydrologic phenomena informs the public, promotes security, supports economic management, and fosters resilience to extreme weather events. Working with academic partners and federal agencies, the organization plays a vital role in predicting weather phenomena from severe storms and hurricanes to floods, droughts, wildfires, and tsunamis.

In 2010, the NWS launched a systematic effort, first to restructure its organization, budget, and communications, and then, via the "Evolve NWS" initiative, to adapt its strategy and develop a collaborative forecast process in support of its mission to protect life and property. A decade later, the organization has transformed from a weather-forecasting agency to a science-based service provider, meeting its mission through impact-based decision support services (IDSS) built from weather-forecasting data and expertise. This transformation has meant profound changes both for leadership and the public: NWS is now better able to serve the public by providing not only more consistently accurate predictions—which gives public-safety authorities the confidence to take action—but also recommendations and support on when and how to prepare for weather events. In a McKinsey interview, NWS Director Dr. Louis W. Uccellini discusses the transition and the NWS's plan to create a Weather-Ready Nation.

McKinsey: Thank you so much for speaking with us. Let's start off talking a little bit about the evolution of Weather-Ready Nation and the Evolve initiative.

Louis Uccellini: It started with the realization over the past two decades or so that our forecast products were becoming reliable enough to support a wide range of decision making, such as how to prepare for a major storm, days in advance. Previously, the level of forecast capabilities was not good enough to predict extreme events with the needed accuracy many days in advance. So, the NWS established a team in 2010 and started talking about establishing a strategic goal to provide forecast information on impending extreme events—accurate forecasts, which could be used by decision makers in the public-safety arena, that would give them enough confidence to make the decisions required to save lives and protect property. That's how we began thinking about extending beyond forecasts and warnings and how the idea of building a Weather-Ready Nation emerged. Furthermore, we quickly realized that this goal could be achieved through a holistic approach of providing impact-based decision support services, serving leaders in communities across the country to make better decisions based on weather, water, and climate information.

By 2013, a large part of the workforce embraced IDSS, even as we were still developing the concept. At the same time, we were reorganizing headquarters, restructuring the budget, and documenting a governance process to show how the new budget and HQ structures would work and could be directed toward addressing current and future field needs.

McKinsey: Once you had the concept in place, what did you do next?

Louis Uccellini: We went to work to evolve the operational side of things. This wouldn't be a forklift kind of change. It would be a much more systematic effort directed at changing many aspects of how a "one NWS" could be created through a more collaborative approach. At the same time, the effort would have to include a whole spectrum of changes related to IT renewal and the Integrated Dissemination program, interactive postprocessing of ensemble model data through a National Blend of Models, Regional Operations Centers—all would have to be brought together very carefully and moved through the workforce very slowly. It took a

Louis W. Uccellini

Education

Dr. Uccellini received his Ph.D., Master and Bachelor of Science degrees in meteorology from the University of Wisconsin-Madison.

Career highlights

National Oceanic and Atmospheric Administration
(2013–current)
NOAA's Assistant Administrator for Weather Services, and Director of NWS

National Centers for Environmental Prediction
(1999–2013)
Director

National Weather Service
(1994–1999)
Director

(1989–1994)
Chief of the National Weather Service's Meteorological Operations Division

Fast Facts

Has received many awards in recognition of his research and operational achievements including the U.S. Presidential Meritorious Executive Rank Award in 2001, he U.S. Presidential Distinguished Rank Award (2006; 2016), NASA Medal for Exceptional Scientific Achievement (1985), the AMS Cleveland Abbe Award (2017).

Served on many national and international research and field experiment programs involving the U.S. Weather Research Program and the WMO Commission for Atmospheric Science.

couple of years to put everything together and then start to make it work, with the workforce playing a key role in testing and evaluating the initiative at every step.

McKinsey: What were some of the highlights of the process and how much have things changed?

Louis Uccellini: The change so far has been remarkable. We're much further ahead in this effort than I thought we would be at this point, especially in terms of evolving toward a collaborative forecast process (CFP), which involves all of the elements of the NWS forecast offices. When we launched the Evolve initiative, we were quite cautious, mainly due to a lack of resources. We prioritized projects that we could accomplish within our budget and address the low-hanging fruit, so to speak. We then set out to gain workforce acceptance of a more collaborative way to execute the forecast process within the NWS. That was important because our partners want a consistent forecast from us, not just an accurate one. We had to get away from the notional aspect of every office creating forecasts without enough

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concern about what other NWS offices and national centers were producing at the same time. We had to make sure the gridded forecast elements were not just created by individual offices and then cobbled together, which actually produced maps that had first-order discontinuities. We aimed for a CFP in which people across the NWS forecast offices worked together with national centers. This is a process supported by regional operation centers to produce one NWS forecast that we could distribute to decision makers across the federal, state, and local government levels, along with indigenous people in Alaska and governments in the Pacific, Puerto Rico, and Tribal Nations.

The second step was to create a single meteorologist career track and new competency models. This new career ladder helped establish the attributes associated with the CFP and career progression—while also attracting new employee recruits from the academic community who had the basics and willingness to embrace the full spectrum of sciences needed to sustain the CFP into the future. And our employees across the NWS started buying into the more collaborative approach: we were hearing them say they believed impact-based decision support services was an essential component of our mission delivery, and that the CFP became an important element to providing both accurate *and* consistent forecasts and warnings to decision makers at every government level.

Another important concept, which originated in the field, was the "whole office" concept— meaning that everyone working in our field offices plays an important role in providing decision support to our partners. This approach emphasizes the sense of belonging in our shared effort to build a Weather-Ready Nation and to meet our mission of saving lives and property. The main reason why we have exceeded where I thought we would be in this evolve effort at this time is that many of the NWS employees developed a sense of ownership of these changes to build a Weather-Ready Nation and realize our mission of saving lives. Combining these cultural changes within the NWS with partnerships—spanning all levels of government, private sector, and academia—is essential for us to succeed in this endeavor. While we have made progress in this area, we still have *a ways to go.*

McKinsey: Talk a little bit about the partner relationship, because that was another area where I know you worked to get more consistency.

Louis Uccellini: We're having tremendous success working in partnership with the emergency management community at the federal, state, and local levels (also with indigenous people in Alaska and governments in the Pacific, Puerto Rico, and Tribal Nations). Continually interacting with these partners helped all of us understand how the National Weather Service could support their decision making days ahead of an impending extreme event. The improved forecast skills, with greater lead times, have been critical, for example, to help us 1) predict the tropical storms that have impacted Florida over recent years, and then 2) provide useful information to our partners, which has allowed government officials at every level to work together to prepare for and react to complex weather events. We were able to help partners make decisions, for example, on whether they needed to deploy supplies and personnel a few days out, plan for evacuations starting many days before landfall, and position emergency teams and equipment to rapidly deal with electrical outages. Probably the biggest success story here was the governor of Florida declaring a state of emergency six and a half days before the landfall of Hurricane Irma in 2017, a storm that was forecast to impact the entire state (a correct forecast). We've had the same success in California with helping combat wildfires. We surged NWS personnel into state offices in California that were making decisions about how to combat the intense and destructive fires in 2018 and 2019, while also sending incident meteorologists to provide on-site weather support to the fire fighters battling the more destructive fires. We can cite examples like this across all 11 service areas in the NWS.

McKinsey: Can you describe where you have been innovating and the technology evolution?

Louis Uccellini: It all starts with observations. Everything builds out from that, toward decision making. It all starts with observations and technology, whether in support of the forecast process, issuance of warnings, or providing situational awareness during a weather or water event.

We have made significant advancements to the technology. We invested in a service life extension program for our Doppler radar network to ensure we would have a viable system, into the 2040s, with modern, internal components that would be more sustainable than the 1970s technology we were working with. Upgrading our radar technology allowed us to reduce the five-minute scan rates by two minutes, which has proven to be an essential tool to help forecasters track tornadic storm systems. We have also improved the NWS weather-forecast models by introducing a seamless suite of ensemble model systems that extend from short-range mesoscale predictions to medium-range weather predictions to sub-seasonal and seasonal forecasts. We have continued to upgrade the supercomputers needed to improve, reliably run, and deliver those model forecasts to the entire weather enterprise and the public.

But [these achievements alone are] not enough to realize the goals of the Weather-Ready initiative. We have to connect the technology advancements and the application of physical sciences, which improves the forecasts, to the application of social sciences and an understanding of human factors to use those forecasts in decision making. For me and for many others who studied the physical sciences to earn meteorology degrees, the social science, in some ways, is harder than the physical science. Social scientists are studying the human factors involved with the response to extreme events and trying to better understand what communication strategy best connects to a person's risk preference—so that we can actually provide the right information to influence [decision making so people can] to protect themselves during impactful weather events. We're just coming to grips with the social-science aspect as we extend the provision of IDSS required to make critical decisions ahead of extreme events. Each

event helps us learn, discover best practices, and improve.

We are doing a lot of work on the weather-water connection, working out how and where floods might strike, and how the connection between weather events, the water cycle, and the oceans plays out. These connections all play out in flood and drought forecasts and along coastal zones, where extreme storm events can wreak havoc along the coastline.

McKinsey: Could you tell us about the internal side of this? I am thinking about change management and how you've worked with the leadership team.

Louis Uccellini: As noted earlier, we started by changing the budget structure, going from 28 categories that nobody really understood to six categories: four are built on the forecast process, one improves the forecast process, and the last (facilities) houses the forecast process. These changes better tied our budget to the actual operational flow of our agency, through which we deliver products and services to our partners and the public. After we better organized the budget structure, we changed the whole headquarters' infrastructure to have a one-to-one relationship between the HQ offices and those six budget portfolios. This change allowed us to better meet the needs of operational forecasters and others throughout the agency's field-office structure. I'm absolutely convinced that without that budget and HQ structural change, along with putting a written governance in place, we would not have been able to evolve the organizational changes throughout the field structure noted above.

I should also note that this new management approach doesn't just support planning. We conduct quarterly reviews of all the portfolios, related administrative support functions, and related cross-cuts (training, international affairs, social science) to monitor how we are doing to meet our service needs and where we are falling short. Due to budget constraints, we can't do everything we want to do at once, so we go forward incrementally, with the hopes of getting there eventually. This is what I mean about the Evolve effort. It will take time, whether it's the technical aspect or whether it's breaking down the cultural barriers to help establish the CFP. The internal changes have allowed us to work collaboratively within the new budget structure, management structure, and governance document to harmonize and move the NWS forward within the planned deliverables and within the appropriated budget.

McKinsey: What advice would you give to students just starting out on their career journeys?

Louis Uccellini: I tell students that our agency is evolving to keep pace with society's modern demands and needs for weather, water, and climate information and forecasts. We are investing in the technology that will allow this evolution to continue as societal needs shift and newer tech advances become available. It's an exciting time to experience these changes. I also tell them that the job doesn't end with the forecast and warning—we fulfill our mission by providing the IDSS that decision makers need to keep people safe. Regarding their studies, I tell them that we are expanding our efforts beyond the atmosphere—that we are now taking a more "Earth system science" approach that includes the atmosphere, the hydrology, the land, the ocean, and the cryosphere as an interconnected system. I also tell students that it helps to have some understanding of social sciences when you're trying to influence decision making with forecasts that we know have an increasing level of uncertainty as we extend out in time. If you don't understand peoples' key decision points, and how they change their risk preference as we get closer to an extreme weather or water event, you're going to be a frustrated person on the forecast side of the process—as we were when we first initiated our Weather-Ready Nation strategic goal. So, I advise students that the social sciences are critical for advancing our effort.

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> –Louis Uccellini

McKinsey: And what are some of your biggest challenges?

Louis Uccellini: One of the biggest challenges is dealing with sustaining a level of predictability in our forecasts of extreme events. Let me explain that. When we make a great prediction for an extreme event many days in advance like the blizzard of [January] 2016, our partners, other users of weather information, and the general public are well prepared for that event. Seven to eight days in advance, models and forecasters started predicting the potential for that storm to impact the mid-Atlantic states. By the time we were three days ahead of the storm, states up and down the East Coast were announcing that the public better get ready for a dangerous winter storm. And by one and half days before the event, states were declaring states of emergency. There wasn't even any snow in the system yet; it was still a rainstorm along the Gulf Coast when states started calling states of emergency. Stunning—you know, it's stunning. Forecasters were using multi-model ensembles and various coastal models that predicted increasing waves and coastal flooding, while [blizzard conditions were predicted for] major metropolitan areas. And forecasters throughout the enterprise provided these forecasts and related IDSS with a high level of confidence [seven, five, and three days in advance and then one] day in advance. So now the expectation of the general public, elected officials, and perhaps even with our core partners, is that we can do this for every storm. But we can't. There are still storms that are approaching populated areas for which we are struggling with the forecast 12 to 24 hours in advance. And even today, it is not clear why one storm is predictable eight days in advance, while others are not predicted with the same level of accuracy even one day in advance.

McKinsey: And how does the NWS help support international operations?

Louis Uccellini: First, we are a strong participant in the World Meteorological Organization within the United Nations, and through that we have had a long partnership with many of the modeling efforts around the globe over the past 70 years. Today, the United States provides one of four major modeling centers around the globe that are continuing to collaborate as we move forward, and we all share observations with one another. Another important contribution is our support of training desks for operational meteorologists around the globe. And we have developed a new hurricane model that is embedded within our global system. With that capability, we can now run model forecasts for seven storm systems at any one time; we make sure that there's room there for extreme typhoons and cyclones that affect other parts of the globe. For example, we can use the new hurricane model over the Indian Ocean and then interact with our meteorological colleagues in India even as the storm is approaching.

Many have said that we cannot make a local forecast without a global observation system and global partnerships, and that's absolutely true. And with our partnerships, we continue to learn. For example, we're learning from the European modeling effort about better approaches to the data quality control and data assimilation (that is the first step in a numerical modeling system) as we focus our efforts to improve our models across a whole spectrum of forecast applications—from space weather, to medium-range forecasts, to short-range predictions of severe thunderstorms and flooding rains.

And the learning can go both ways on the training desks I mentioned earlier, like the African training desk hosted at our National Center for Weather and Climate Prediction. We have helped them with the extension of seasonal predictions for the African continent. But they and others have been very proactive in extending these forecast advances to the prediction of disease vectors and extreme heat. Today, they're the ones providing a real focus on advancing the forecasts for extreme heat over Africa days in advance. We have also worked with India on their monsoon prediction system. And in doing so, we learn from them as we advance the prediction of our own Southwest monsoon.

McKinsey: So maybe the last question on the "human factor" point would be, do you have advice for other leaders, whether that's in government or beyond to manage this scale of change?

Louis Uccellini: First, you need to have the vision. And for us it was not just about improving models but the whole societal focus around becoming a Weather-Ready Nation. Planning is a bit more difficult because you've got to broaden the circle, even in the planning domain space. And that includes keeping key stakeholders in the executive branch and the House and Senate informed every step of the way. So, you have to start incorporating a diverse group of people into that planning process. And then there's the follow-through, which is always the hard part (and it will take longer than you originally planned). You need to sustain the support of your stakeholders. You've got to be tenacious in the follow-through. You've got to do it in a disciplined way, and you really have to continue to broaden the circle outside your agency to include your partners—who help advance your role in the overall effort as they become users of the information you are providing. Last but not least, the employees play a key role in these stages of planning and execution to make the change work.

I think the success we had in the headquarters reorganization, and now the ongoing Evolve effort, is that we all internalized the need to break down the cultural barriers to allow the flexibility for many in the field to take the Evolve effort and make it their own. It became an almost natural thing—it wasn't forced: people internalized the need for change and saw how it would work for them. I

began hearing about the "national blend of models," the "whole office concept," and the "collaborative forecast process" from people during field-office visits. As I made these visits, I could see whole offices start to understand how the changes associated with the Evolve effort are needed for the NWS to succeed in working with our partners across the enterprise to build a Weather-Ready Nation. I think it will take another 10 years to really nail this down, because evolution is a slow and deliberate process. But our workforce in the field is leading the way, and our core partners see the value we are bringing to their efforts to prepare communities before and during extreme weather and water events, so I believe we will continue to advance with no turning back.

Finally, we are always working with the larger science communities. And it's not just in the modeling arena now. There is a lot of buzz about the importance of artificial intelligence and machine learning to extract and apply the most useful data across every step of the forecast process and to provide our best information to our core partners. We need to tap into the spectrum of AI activities throughout the research, academic, and technology communities. Doing so will ensure we can extract the most useful information from our observational and modeling systems and bring this information to the fingertips of our forecasters more effectively. The end goal is for us to always be there to assist our partners in their decision-making processes and keep them ahead of the storm as we work together to save lives and property.

McKinsey: I guess we could summarize by saying that over time a lot has changed?

Louis Uccellini: Yes. Looking back to when I started as a student, I never would have thought that we'd be affecting decision making the way we are today. Back in the '70s and '80s, the observations and forecasts were a matter of interest, but people didn't use these forecasts to make the kinds of decisions that they're making now for public safety, business, energy, agriculture, transportation, water and air quality, and now disease vectors—nearly everything required to support societal needs. This has been the trajectory—to improve the fundamental understanding, associated observations systems, and predictive capabilities, and now connect all that information with decision making that actually saves lives and property. It has been an amazing journey.

Louis W. Uccellini is director of the US National Weather Service. **Nora Gardner** is a senior partner in McKinsey's Washington, DC, office where **Sarah Tucker-Ray** is a partner.

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