Meteorological Development Laboratory (MDL)

Strategic Plan: 2015-2020

March 30, 2015

Foreword and Acknowledgements from the Director

Winston Churchill famously once said, “He who fails to plan is planning to fail”. While both the Meteorological Development Laboratory (MDL) and the National Weather Service (NWS) at large are performing our missions well and are in no danger of imminent failure, we face new challenges that require us to plan for the future in order to achieve our maximum potential.

NWS has set a course for several new strategic objectives as part of the Weather-Ready Nation Roadmap, which is complemented by the recently approved NWS Budget and Headquarters Restructuring Project, slated for initial implementation on April 1, 2015. MDL has several important roles to play in helping NWS achieve these objectives, and in order to fulfill these roles, MDL will need to evolve our current capabilities and take on exciting new challenges. This Strategic Plan is therefore intended to define the overall vision for the Lab and set the stage for more specific implementation activities that will follow.

The development of this Strategic Plan was a collaborative effort of MDL employees and management, and I am grateful for and extremely pleased with their valuable contributions. I would like to thank each of the following for their respective roles:

- Planning Team (led by **Tabitha Huntemann** and supported by **Jim Su** and **David Rudack**) for research, plan development, and incorporating employee and external feedback.
- Management Team (**Kathy Gilbert**, **Matt Peroutka**, **Dave Ruth** and **Steve Smith**) for expert input on strategy/content and working with their branches to maximize participation.
- MDL’s National Weather Service Employees Organization (NWSEO) steward (**Amy Fritz**) for her individual insights and helping ensure all employees’ voices were heard.
- Reviewers from NWS, partners, and other external organizations for their objective feedback and astute suggestions.
- And most importantly, the men and women of MDL, for their full participation and expert/constructive recommendations, ensuring that this plan is owned by all of MDL.

Speaking on behalf of all the members of MDL, we are proud to serve the Nation by helping the NWS achieve its mission of protecting life and property, and look forward to evolving our Lab in order to meet the current and emerging strategic challenges that face us.

Dr. Mike Farrar
Director, Meteorological Development Laboratory

Executive Summary

Since it was formed in 1964 under the original name of the Techniques Development Laboratory (TDL), the Meteorological Development Laboratory (MDL) has served the Nation by providing meteorological techniques, tools, applications, and products that have enabled the National Weather Service (NWS) to execute our vital mission to protect life and property. During those 50 years, MDL has developed and transitioned several fundamental capabilities that are central to NWS operations. *(See Appendix 1 for more on MDL's History.)*

While MDL continues to provide value-added capabilities to the forecasting enterprise, the NWS is undergoing fundamental change to meet the challenges of building a Weather-Ready Nation (WRN), and MDL needs to evolve along with the NWS. This Strategic Plan provides a strategic framework that will guide MDL's development and organizational priorities over the next several years, as we steadily evolve to meet the emerging challenges of the future.

Our Strategic Plan is aligned with the Strategic Plans of NWS, the National Oceanic and Atmospheric Administration (NOAA) and the Department of Commerce to ensure that our vision is in sync with our parent organizations. Our plan is the result of a collaborative effort by our employees and the NWS Employees Organization (NWSEO), NOAA and NWS management, and our external partners and customers. In collaboration with our key stakeholders, we have identified four fundamental areas in which MDL will focus our efforts over the next five years:

People: ***Our people are MDL's #1 resource***, and we need to recruit, retain, and develop a highly-skilled and competent workforce that aligns with our strategic goals, and provide them with the best possible environment in which they can flourish.
Science and Technology: While we to continue to improve the ***quality*** and ***resolution*** of our existing products, we must also transform our processes to be more ***efficient*** to enable us to redirect resources to development in ***new and emerging areas*** in support of WRN goals.
Infrastructure: We must enhance the ability of users to exploit MDL's capabilities to execute their mission and improve MDL's ***flexibility*** to meet future demands by ***modernizing*** MDL's hardware and software infrastructure and web presence.
Collaboration**:** We will improve engagement with MDL ***development partners*** and ***customers*** to ensure the ***value***, ***usability***, and ***relevance*** of MDL products and services.

When integrating these four main areas together, we conclude that while MDL must continue to improve our legacy capabilities, we must expand beyond our traditional internal development role to one that ***collaborates*** with NWS and external partners to ***transition*** Research to Operations (R2O). As such, MDL will evolve to become the hub of the development component of the NWS' integrated field structure, which is captured in our new ***Vision Statement***:

MDL: The essential collaborative partner in developing and transitioning emergent forecast applications, interpretive model guidance, and digital forecast services into NWS operations.

Motivation and Approach

MDL has a 50-year legacy of developing meteorological techniques, tools, applications, and products to enhance the forecasting mission of the NWS and key partners. While MDL will continue to improve our existing capabilities and develop new capabilities, we must evolve to fulfill new roles posed by the evolution of the NWS, which is undergoing fundamental change to meet the challenges of building a Weather-Ready Nation (WRN).

One major component of the NWS Director's vision is to evolve the NWS to a more *integrated field structure*, whereby local field offices, National Centers, and the Headquarters work together as one integrated team to solve national problems. Under the NWS Budget and Headquarters Restructuring Project being implemented in 2015, the research and development (R&D) component of that new structure will be managed under the new Science and Technology Integration (STI) portfolio office. *(See Appendix 2 for MDL's organization under the STI office.)*

A central pillar of STI is to oversee R&D activities that advance weather and climate prediction, therefore the long-standing challenge of transition of research to operations (R2O) is one of STI's top priorities. In order to address that goal, MDL will build upon our core capabilities (which historically have mostly been used for internal development) to take a leadership role in a national collaborative development enterprise – i.e., the development component of NWS' integrated field structure. This will lead MDL to take on a greater role in R2O of capabilities developed elsewhere or developed collaboratively with external partners. Our new Vision and Mission statements articulate this shift in MDL's role.

Vision

MDL: The essential collaborative partner in developing and transitioning emergent forecast applications, interpretive model guidance, and digital forecast services into NWS operations.

Mission

MDL develops and transitions interpretive model guidance, decision support applications and digital forecast services that enable NWS forecasters and partners to be more effective in protecting life and property and enhancing the national economy.

To achieve this vision, MDL's core competencies of today (right) must adapt to be more *flexible*, *efficient*, and *collaborative* to meet the challenges of tomorrow. While this list of competencies will grow, the existing capabilities will also be used in new and innovative ways to meet emerging challenges. A prime example is to evolve our statistical post-processing expertise (largely used to develop Model Output Statistics [MOS] in the past) towards ensemble post-processing in order to enable forecasters to mine more usable intelligence from the growing volume of model ensemble data, including better representation of *forecast uncertainty* and *Probabilistic Hazards Information (PHI)*.

MDL's Core Competencies

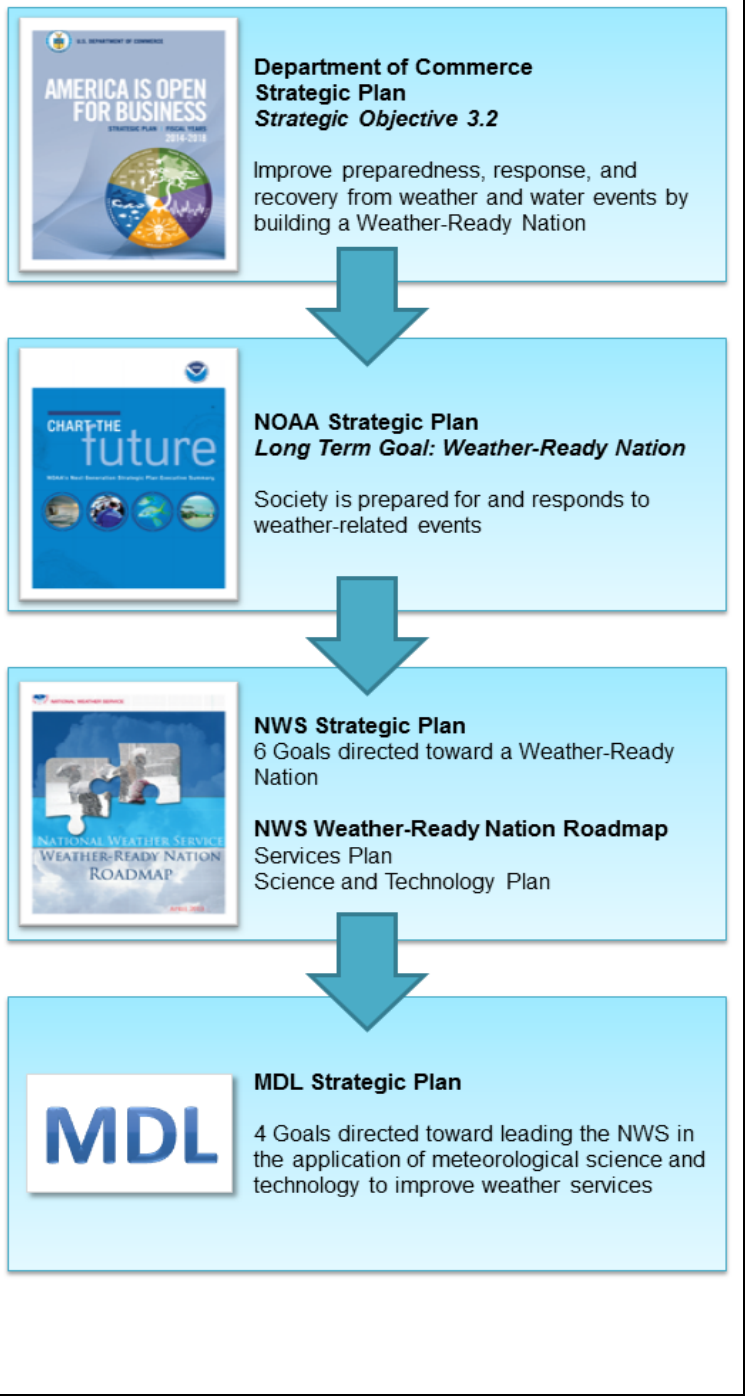
- Transition of R2O
- Digital forecast services
- Application of statistical methods to improve forecasts and services
- Verification of sensible weather forecasts and guidance
- Tools and applications for Decision Support Services
- Post-processing and user products
- Storm surge models and products

MDL's Role in Building a Weather-Ready Nation (WRN)

The Department of Commerce (DOC) Strategic Plan (FY 2014-2018) and the NOAA Next-Generation Strategic Plan each set long-term goals to improve preparedness, response, and recovery from weather and water events by building a weather-ready nation. In response, the NWS has developed a WRN Roadmap designed to facilitate community resilience to weather and water events. The WRN Roadmap communicates plans for evolving the NWS toward providing Impact-Based Decision Support Services (IDSS) that will help core partners understand the information NWS provides and allow these partners to make good decisions.

This MDL Strategic Plan, and Implementation Plans that will follow, are formulated to support the DOC, NOAA, and NWS plans through several key roles. For example, MDL will make key contributions towards providing foundational datasets, developing innovative guidance products, and facilitating R2O activities. These capabilities will aid our forecasters in more efficiently performing analysis and forecast functions, thereby enabling them to increase emphasis on IDSS. In addition, MDL will directly impact this goal through transition and development of IDSS tools and applications.

Linkage of MDL Strategic Goals to Parent Organizations



MDL will evolve our current capabilities and launch new efforts to support NWS' WRN goals:

- ***NWS will provide expanded IDSS to enable users to plan and take actions based on NWS' accurate forecasts and timely warnings, which will require high-quality data that are easily accessible, interoperable, and available anytime and anywhere.***
  - National Digital Forecast Database (NDFD): The NDFD, developed and improved by MDL, enables creation of several products needed for IDSS, including forecast text and images and digital data compatible with Geographic Information Systems (GIS).
  - IDSS tools: MDL, in collaboration with other NWS and external developers, will work with end users to develop IDSS tools and products to meet their specific needs.
  - Verification: Effective verification is critical to field execution of IDSS. MDL will therefore work to improve verification capabilities, and make them more *accessible* and *usable*.
- ***IDSS will require optimized use of probabilistic forecast guidance, in particular the use of ensemble prediction, associated reforecasts, and statistical post-processing techniques to produce, calibrate, and verify quantifiable forecast confidence.***
  - New and improved probabilistic products: MDL will adapt our critical mass of statistical post-processing expertise to develop new and improved probabilistic products to better mine valuable probabilistic information from the growing volume of model ensemble data. This includes better representation of *Probabilistic Hazards Information (PHI)* and improved methods of *communicating uncertainties* to forecasters and end users, consistent with the Forecasting a Continuum of Environmental Threats (FACETs) concept being championed by NOAA/OAR's National Severe Storms Laboratory.
  - National Blend of Models (NBM): The multi-model NBM, led by MDL with multiple NOAA partners, will leverage evolving state-of-the-science high-resolution analyses, multi-center deterministic and ensemble forecasts, and reforecasts for post-processing and verification. By using improved data and through the development of advanced post-processing techniques, the guidance will be substantially improved in quality and will *quantify the uncertainty* in the forecast. The NBM will produce a full set of NWS deterministic and probabilistic guidance products at a national scale, improving the *quality* and *consistency* of NDFD and making the forecast guidance more useful.
    - NBM will also serve as a foundation for providing PHI products and services.
- ***MDL will enable the infusion of science and technology into ops. Examples include:***
  - Impacts Catalog: MDL will lead a national team to develop Impacts Catalog and operationalize it within NCEP IT systems. This effort builds upon the Inter-Regional Integrated Services (IRIS) database of user-defined thresholds developed in the field.
  - Virtual Laboratory (VLab): MDL will continue to refine VLab to improve development of forecaster applications and enhance R2O activities. VLab is a key element STI's centralized development and testing environment strategy, whereby capabilities are *collaboratively developed in VLab* and then tested and evaluated in the *Operational Proving Ground (OPG)* with field users prior to operational implementation.
  - Advanced Weather Interactive Processing System (AWIPS): In partnership with the AWIPS program, NCEP, and external partners, MDL will reinvigorate our AWIPS development capabilities to collaboratively transition existing and develop new/improved tools and applications into the AWIPS II operational environment.

MDL's Strategic Goals and Objectives

MDL has identified four long-term goal areas that address MDL's role in achieving the NWS WRN vision: People, Science and Technology, Infrastructure, and Collaboration. Each goal has a number of objectives that describe a set of steps toward their respective goal. These objectives will flow down to individual and actionable development and implementation strategies, which will be separate documents that will be updated at least annually.

<u>People</u>: Sustain a workforce of experts in MDL's core competencies that are dedicated to advancing the NWS mission.

- *Recruit*, *retain*, and *develop* a highly-skilled and competent workforce (to include greater use of *external collaborative developers*) that aligns with the Lab's strategic goals.
- Maximize organizational performance by fostering a supportive work environment of mutual respect that *empowers* employees, and *recognize and reward* employees' efforts to advance science and technology infusion, teamwork, and innovation.
- Build a *sustainable critical mass of expertise* that eliminates single points of failure through a robust system for knowledge transfer and succession planning.
- *Training* and *technical interchanges* (e.g., scientific conferences) are key ingredients in building/maintaining scientific and technical expertise. MDL managers will work with employees to increase *equitable access* to these opportunities.

<u>Science and Technology</u>: Develop and facilitate the transition of critical and emerging science and technologies in support of a Weather-Ready Nation.

- Explore how to best use our *critical mass of statistical post-processing expertise* to meet the evolving challenges of the NWS.
    - Improve forecast *quality* and *consistency* through continued development of centrally-produced National Blend of Models.
    - Aid in extracting intelligence from reforecast, ensemble, and high-resolution analysis data through improved methods of post-processing and presenting ensemble output.
    - Improve value added to forecast operations of MDL's MOS product suite by improving efficiency and integrating emerging and adaptable statistical techniques.
- Support growing NWS mission of *Impact-based Decision Support Services* by continued development of decision support tools and meteorological techniques, providing sector-relevant information, and generating timely and actionable products, such as:
    - New tools that assess the *uncertainty* in NWS forecasts to strengthen informed decision making and risk management throughout the weather enterprise
    - Centralized database of weather-, water-, and climate-dependent *societal impact information* to allow the NWS to support data-driven decision-making.
    - Continued development of coastal impact products, including tropical/extratropical storm surge guidance, and diagnostic and forecast guidance for rip current hazards.
        - *Note: The future of storm surge modeling across NOAA (including MDL's role) will be worked under the NOAA Storm Surge Roadmap Team.*
- Improve the *quality* and *resolution* of analyses, objective forecast guidance, and verification by incorporating new observation types at the best feasible resolution.

- Make *verification* data more *accessible* and *helpful* through the use of geospatial databases and improved web-based graphical user interfaces.
- Enhance the transition of *Research to Operations* through continued development and improvement of the Virtual Lab.
- Make NWS guidance and forecasts *more effective* and *easy to use* through continued improvements to the national databases of digital forecasts and guidance.

Infrastructure: Evolve hardware and software to meet current and future demands.

- Enhance the ability of users to exploit MDL's capabilities to execute their mission by *modernizing* MDL's hardware and software infrastructure and web presence.
- Enhance *leveraging* of other NWS computing resources (e.g., IDP and WCOSS).
- Work with NCEP to obtain the greater disk storage needed for expanded use of *reanalyses and reforecasts* needed to improve model statistical post-processing.
- Evaluate options for replacing or upgrading MDL's statistical interpretation system (MOS-2000). If retained, improve *software engineering practices* for MOS-2000 to incorporate best practices for software development.
- Improve IT capabilities to enable MDL developers to more effectively perform development activities (e.g., improve access to WCOSS over current VPN access)

Collaboration: Foster engagement with our development partners and customers to ensure the value, usability, and relevance of MDL products and services.

- Anticipate and address evolving partner and customer needs and requirements through the new STI portfolio process.
- Expand *collaborative development* with other NOAA developers (NWS Science Operations Officers, NOAA/OAR Labs, etc.) and external partners
- Build a *leadership* role in *transitioning* new capabilities into NWS operations.
- Improve *engagement* (site visits, training teleconferences, etc.) with NWS field offices and regions to foster better *mutual understanding* of field needs and MDL capabilities.
- Explore colocation at the National Center for Weather and Climate Prediction (NCWCP) to enable enhanced *collaboration* with NCEP and other NOAA development offices.

Application of MDL Strategic Plan to Follow-on Activities

This Strategic Plan is intended to lay out the overall vision and strategic approach for the direction of MDL over the next five years. It is not intended to map out the details of every project or activity that must happen to achieve that vision. Subsequent major projects will be outlined in specific Implementation Plans or Project Plans, developed separately.

Projects that are vital to achieving major NWS goals will be documented each year in the *NWS Annual Operating Plan (AOP)*, which outlines priorities, goals and milestones for each NWS Portfolio. While most MDL work will fall under the STI portfolio, some work may be funded though other portfolios (e.g., AWIPS projects from the Central Processing portfolio).

Appendix 1
History of MDL

The Techniques Development Laboratory (TDL) was formed in 1964 as part of the Weather Bureau under the Department of Commerce (DOC). Through a series of reorganizations, TDL was renamed the Meteorological Development Laboratory in 2001 and placed under the Office of Science and Technology of the National Weather Service (NWS) under the National Oceanic and Atmospheric Administration (NOAA).

Early MDL efforts focused on the development of techniques that had the potential of being implemented at the National Meteorological Center, since renamed NCEP. Among the earliest MDL products was Model Output Statistics (MOS) guidance, the subject of Bob Glahn and Dale Lowry's much-referenced 1972 article entitled "The Use of Model Output Statistics in Objective Weather Forecasting". The first operational product in 1969 was a 3-element Primitive Equation (PE) model-based message for 79 locations. The current products are for more than 20 elements and more than 11,000 sites across the U.S. and its territories. Recent additions to the MOS system include gridded guidance and the inclusion of ensemble model output.

MDL has applied MOS techniques to meet evolving forecast needs. This includes the system currently known as the Localized Aviation MOS Program (LAMP), which provides detailed short-range statistical weather forecasts and objective analysis of surface conditions. LAMP was designed in the early 1980s to run a MOS-like system locally by forecasters to provide short-term guidance of sensible weather for public and aviation forecasting. As the NWS modernized its operations in the mid-1990s with the development of the Advanced Weather Interactive Processing System (AWIPS), LAMP was implemented to run in AWIPS. By the mid-2000s, LAMP was redesigned again to run centrally on the NCEP supercomputing system with the official products disseminated centrally from NCEP. Today, there is gridded LAMP guidance available in support of NWS production of digital aviation products in addition to traditional station-based guidance.

MDL also has a long-standing role in forecaster decision support. MDL has provided guidance forecasts for storm surges for over three decades, with the current NWS storm surge model, Sea, Lake, and Overland Surges from Hurricanes (SLOSH), evolved from earlier models developed at MDL in the late 1960s and early 1970s. To predict the surge accompanying an extratropical storm, MDL developed the Extra-Tropical Storm Surge (ETSS) model. This variation of the SLOSH model predicts storm surge flooding along U.S. coastlines, but does not predict the extent of overland flooding. In recent years, MDL has also developed Probabilistic Storm Surge (P-Surge) to predict the likelihood of various storm surge heights.

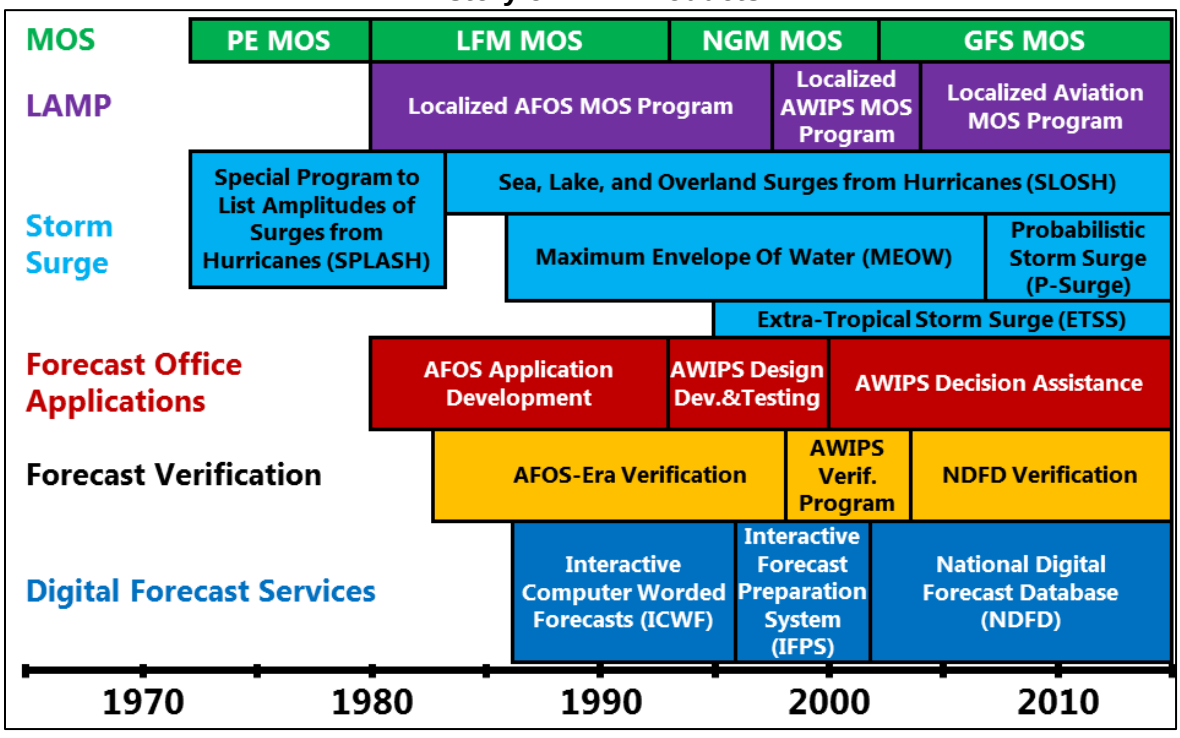
Since the 1980s, MDL has developed and evaluated techniques which enable the forecaster to interactively prepare digital forecasts of weather elements. Early efforts focused on the Interactive Computer Worded Forecast (ICWF) system, which allowed NWS forecasters to revise statistical guidance by adjusting values of forecast values displayed on an area map. The resulting digital forecasts were then used to produce products in several formats. In the mid-1990s, the Interactive Forecast Preparation System (IFPS) was implemented at Weather Forecast Offices (WFO). IFPS was developed by MDL and transitioned forecasters from manually typing hundreds of text forecasts to using graphical forecast editing techniques to more efficient, information-rich digital and graphical weather forecast products. These

advancements have culminated in the National Digital Forecast Database (NDFD) and complementary National Digital Guidance Database (NDGD). NDFD contains digital forecasts from WFOs working in collaboration with NCEP consistent with official NWS forecast products; NDGD contains digital forecasts, guidance, and observations from a variety of sources that relate to and supplement the NDFD. MDL routinely provides verification of NDFD in comparison with guidance. Long-term verifications show that while the skill of forecasts has improved with improvement in the dynamical models and MOS, the forecaster continues to add value, particularly at shorter-range projections.

MDL has also played a key role in transitioning innovative research into NWS operations. For example, in the late 1990s MDL collaborated with the National Severe Storms Laboratory (NSSL) and WFOs to develop both the System for Convection Analysis and Nowcasting (SCAN) and Flash Flood Monitoring and Prediction (FFMP) system. SCAN and FFMP were developed to provide an integrated suite of applications in AWIPS that generated short-term probabilistic forecast and warning guidance for severe weather and flash floods. In another partnership with the National Center for Atmospheric Research (NCAR) and NWS WFOs, MDL adapted NCAR's Thunderstorm Autonowcast (ANC) system for AWIPS. The ANC produces 0-1 hour thunderstorm nowcasting predictor fields derived from observation-based feature detections, numerical weather prediction model output, and human forecaster input. MDL's key role in transitioning innovative research into NWS operations is today manifested in the Virtual Lab (VLab), a service and IT framework that enables NOAA employees and their partners to share ideas, collaborate, engage in software development, and conduct applied research.

The interpretive model guidance, digital forecast services, and decision support applications provided by MDL meet the need of allowing NWS forecasters to work together to make fine-resolution, up-to-date forecasts available to the nation.

History of MDL Products

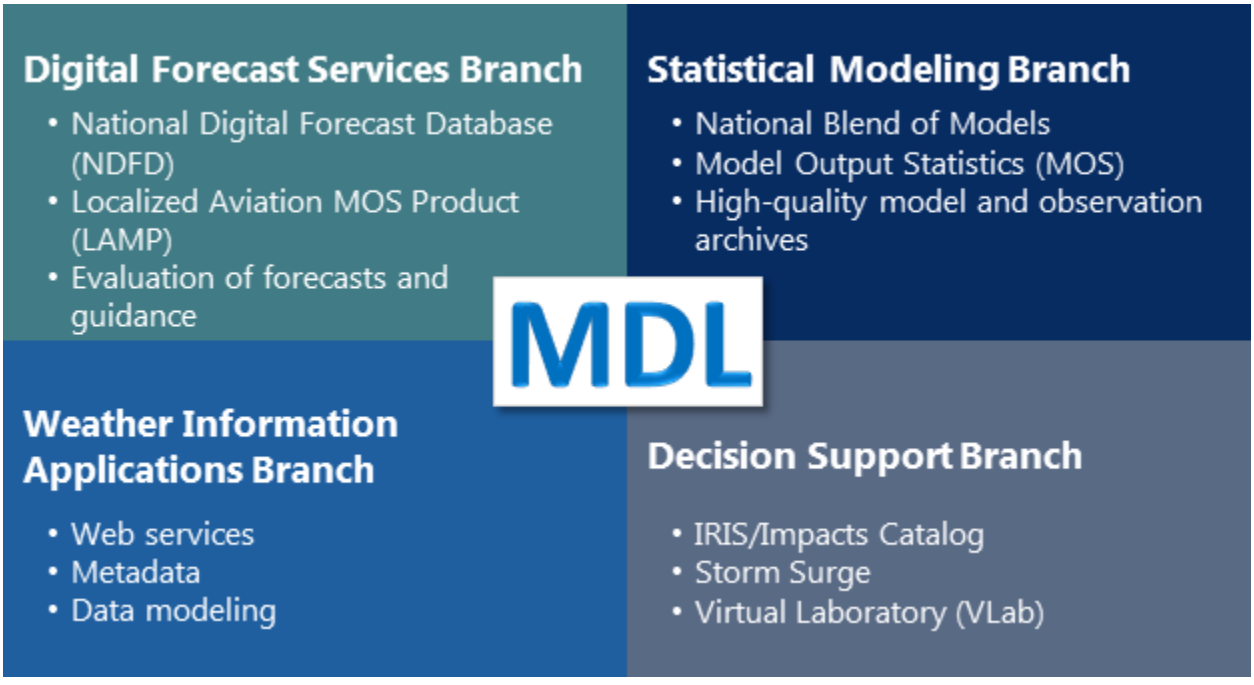


Appendix 2
MDL Organizational Structure

The Science and Technology Integration (STI) portfolio office was established in 2015 under the NWS Budget and Headquarters Restructuring Project. As the STI office manages the research and development (R&D) component of the NWS budget, MDL was aligned to report to the STI office. During that process, MDL elected to undergo a minor internal reorganization to coincide with the overall NWS Headquarters reorganization. In order to provide consistent size and scope to each of branch and to better consolidate like functionality, MDL realigned a subset of functions and personnel and eliminated one branch, reducing the number of branches to four and changing some branch names to more accurately reflect their mission space.

The major activities in each of MDL's four newly realigned branches are summarized in the figure below, which is a followed by a more detailed description of each branch. One familiar with MDL will note that the functions listed in the new branch structure are the same as in the old structure. *Therefore, it is important to note that while this strategic plan uses several methods to achieve fundamental changes for MDL, the limited administrative organizational alignment was not one of them. As such, the minimal change in organization should not be construed as a lack of change altogether; simply put, we are using other methods to achieve the desired strategic changes in focus and priorities, as described in the main body of the plan.*

Major Activities of the MDL Branches



The **Digital Forecast Services Branch** develops techniques to provide objective short-range (1-25 hour) forecast guidance for all weather elements in routine public and aviation products. In addition, the branch supports a National Digital Forecast Database (NDFD) offering products and geospatial data services that provide maximum flexibility to customers and partners. The branch also develops and maintains systems to assess the quality of operational and experimental NWS forecasts.

The **Statistical Modeling Branch** develops and implements statistically calibrated objective guidance products from numerical weather prediction models for weather elements contained in public and aviation forecasts for use at Weather Forecast Offices (WFO), River Forecast Centers (RFC), National Centers, and public and private customers. The branch investigates innovative scientific approaches to produce interpretive model guidance less sensitive to model changes, and to quantify uncertainty of weather guidance to improve weather decision services for events that threaten lives and livelihoods. The branch also maintains a high-quality archive of observations and model data to support the development of statistical forecast guidance.

The **Decision Support Branch** develops and implements techniques to synthesize, display, and manipulate data and guidance from various sources to aid WFOs, RFCs, and National Centers forecasters and other users in interpreting the wealth of information available at the WFOs. Prototyping of promising techniques in an operational setting is done to identify those best suited for implementation. The branch also develops and improves techniques for producing forecasts for the coastal marine environment. To improve the research-to-operations (R2O) and operations-to-research (O2R) functions in NOAA, the Decision Support Branch leads the design, development, and maintenance of the Virtual Laboratory (VLab).

The **Weather Information Applications Branch** develops and implements techniques that generate products and services that enhance the value of NWS forecast products (especially NDFD). Techniques emphasize information on forecast uncertainty that can enhance decision making throughout the weather enterprise. Techniques include data modeling, metadata, and web services that support NOAA's dissemination needs. Prototyping of promising techniques is done to identify those best for implementation. All such techniques are implemented in software on NWS operational platforms and maintained as those systems evolve.

Appendix 3
Acronym Reference List

AWIPS	Advanced Weather Interactive Processing System
DOC	Department of Commerce
IDP	Integrated Dissemination Program
IDSS	Impact-based Decision Support Services
IRIS	Inter-Regional Integrated Services
LAMP	Localized Aviation MOS Program
MDL	Meteorological Development Laboratory
MOS	Model Output Statistics
NBM	National Blend of Models
NCEP	National Centers for Environmental Prediction
NDFD	National Digital Forecast Database
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
NWSEO	National Weather Service Employees Organization
OAR	Office of Oceanic and Atmospheric Research
R2O	Research to Operations
R&D	Research and development
RFC	River Forecast Center
SLOSH	Sea, Lake, and Overland Surges from Hurricanes (model)
STI	Science and Technology Integration
TDL	Techniques Development Laboratory
VLab	Virtual Laboratory
WCOSS	Weather and Climate Operational Supercomputing System
WFO	Weather Forecast Office
WRN	Weather-Ready Nation