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TRANSFORMATION OF THE NAS TO NEXTGEN AND THE FAA WEATHER ARCHITECTURE IMPACTS: AN UPDATE

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1.0 Introduction

Because of the profound adverse impact that weather has on aviation, the Next Generation Air Transportation System (NextGen) is focusing on a new direction in aviation weather information. The emphasis will be on capabilities to help stakeholders at all levels make better decisions to mitigate the impact of weather on operations. Safe and efficient NextGen operations will be dependent on enhanced weather capabilities based on three major tenets: [JPDO ConOps]

- A common view of the weather for all transportation decisions makers and aviation system users
- Weather directly integrated into sophisticated decision support capabilities to assist decision makers
- Utilization of Internet-like information dissemination to realize flexible and cost-efficient access to all necessary weather information

Weather impacts the National Airspace System (NAS), as approximately one-fourth of all aircraft accidents and one-third of fatal aircraft accidents are weather-related. Weather is also a major factor adversely affecting NAS capacity, contributing to approximately seventy percent of system delays greater than 15 minutes (OPSNET). To address the expectations of demand on capacity in 2025, weather impact mitigation becomes increasingly critical and current aviation weather capabilities must undergo major changes.

The Federal Aviation Administration (FAA) weather architecture fulfills an important role in enabling the agency to meet the increasing demand of air traffic on NAS capacity while maintaining existing high safety standards. To accommodate this increase in demand—expected to double and possibly triple by 2025—the FAA must transform the existing NAS weather architecture to support the tenets of NextGen to ensure the future NAS meets air transportation safety, security, mobility, and efficiency needs.

The approval of FAA's Mission Need Statement (MNS) #339 in June 2002 identified three primary gaps in weather information services—detection, prediction, and dissemination. NextGen adds an additional gap of weather integrated into Decision Support Tools (DSTs). New sensors on the ground, on aircraft, and on satellites, as well as enhanced algorithms on current ground-based sensors will provide significantly improved detection of hazardous or impacting weather. Aviation weather forecasting deficiencies must be resolved. Even though an accurate 2-hour forecast of convection is available, an 8-hour forecast is necessary for strategic planning and to enhance the efficiency of traffic flow management. Improved icing detection and forecasts are also necessary for general aviation safety, as well as, quality ceiling and visibility products. In addition, a seamless, consistent set of observations and analyses are necessary to support the needs of NextGen decision makers in a tactical situation, particularly at NAS super-density airports.

In addition, weather support in the NextGen era reveals emerging gaps in weather information support to Air Navigation Service Providers (ANSP) and Users decisionmaking, e.g., traffic flow mangers, dispatchers, and pilots. Weather information must be readily accessible to these decision makers, and in near-real time to support tactical situations. Also, weather information must be integrated into decision maker support tools to help mitigate the impact of weather on NAS operations. These additional weather support capabilities are absolutely essential to translate the weather information into an operational impacts by letting traffic specialists know where hazardous weather exists (for avoidance and routing/re-routing) or where weather constrains traffic flow (with estimates of reduced traffic throughput to maintain NAS system efficiency) so these impacts can be mitigated to the maximum extent.

Resolving these gaps will require additional funding for focused weather research, which is crucial to attaining needed NextGen weather capabilities. Moreover, the transformation of existing point-to-point communications to that of NextGen network-centric weather capabilities ensures service providers and users receive required weather information in real-time in a user specified format. Meeting the needs of NextGen requires resolving these gaps for both existing and emerging users.

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The transformation of the NAS weather architecture is documented in the NAS Enterprise Architecture (NASEA), which is updated and approved by the FAA's senior Vice-Presidents annually.

So, what is an Enterprise Architecture? In essence an Enterprise Architecture lays out the "form" of the enterprise; the form must align with the business strategy [of the FAA]. The NASEA enables the FAA to define, promote and enforce a common approach for describing, developing, presenting and integrating interoperable and interacting architectures. The Air Traffic Organization (ATO) implementation of the NASEA and Office of Management and Budget (OMB) governance guidance results in an OMB-compliant NASEA. As such it undergirds, constrains, conforms, and promotes constraint-and-compare concepts during ATO business processes throughout the three OMB-mandated lifecycle phases of the FAA Acquisition Management System (AMS), which include architecture development and evolution, budget and investment decisionmaking, and implementation.

Why is the NASEA needed?

- First, the 1996 Clinger-Cohen Act requires all Departments have an architecture
- Secondly, OMB Circulars direct compliance:
  - A-130 states Departments must use a Framework to guide the description of their architecture, and it must include specific items in the architecture description
  - A-11 specifies that capital planning must be related to Department architecture.
- In addition, the Government Accounting Office (GAO) may withhold funding if a Department doesn't have an adequate architecture or funding may be delayed until the architecture is updated.

Based on the recommendation from the NAS Chief Architect, the ATO Chief Operating Officer chose the NASEA Format (NASEAF) to implement the NASEA engineering (technical) functional model for the FAA. The value of this chosen framework is that it is "accepted and recognized" by OMB and GAO as an acceptable framework for real-time command and control architectures like the NAS.

In the NASEA, the term *architecture* is generally used both to refer to an *architecture description* and an *architecture implementation.* The former is a representation of a current or postulated future real-world configuration of resources, rules, and relationships. The latter is where the architecture description is transformed into a physical implementation of capabilities and assets. The NASEA addresses this transformation process by tightly coupling NASEA products (or Views) with the various Roadmaps that depict the FAA Acquisition Management System (AMS) policy and processes.

And, it's also the right thing to do to address:

- Communications: Provides documentation of agency enterprise communications transformation so that it can be understood by all concerned
- Analysis of Problem Areas: Helps uncover and flag problem areas to reduce risk and costs
- Budget: Helps the agency make cost-effective investment decisions
- Efficiency**:** Helps ensure that agency business processes are working optimally
- Use of Technology: Helps ensure that agency systems are actually the right ones

The NAS is a very complex system of systems and any transformation of the weather architecture cannot occur without consideration of likely interdependencies or interactions with other architectures including Airports, Surveillance, Air-Ground, Communications, Automation, Aircraft, Airspace & Procedures, and Enterprise Services. Thus, the NASEA is intended to ensure that each of the architecture descriptions can be related and compared across both organizational and capability boundaries of the FAA.

The weather architecture includes FAA weather system and communications, as well as weather information from the National Oceanic and Atmospheric Administration (NOAA) through its line offices—the National Weather Service (NWS) and the National Environmental Service, Data, and Information Services (NESDIS); the Department of Defense (DOD); and industry.

So the question becomes – *What are the implications of this transformation of the NAS Weather Architecture that are necessary for it to meet NextGen capabilities while complying with the tenets of the NASEA?*

2.0 Transformation

The FAA transformation of the NAS began several years ago. Figure 1 depicts the current NAS weather architecture. The movement of weather information across the NAS is from left-to-right. Sources of weather data/information are on the left side and consist of FAA sensors, airborne aircraft observations, weather information from NOAA (NWS and NESDIS), vendors, and global sensors. Alphanumeric (textual) weather information flows into weather communications systems such as Automated Weather Observing Systems Data Acquisition System (ADAS) and the Weather Message Switching Center Replacement (WMSCR), while the FAA Bulk Weather Telecommunications Gateway (FBWTG) receives various data types including gridded model output from NWS, aircraft observations, and products from the Aviation Weather Center. A variety of weather information types flow into weather processors, including the Weather and Radar Processor (WARP), the Integrated Terminal Weather System (ITWS), and

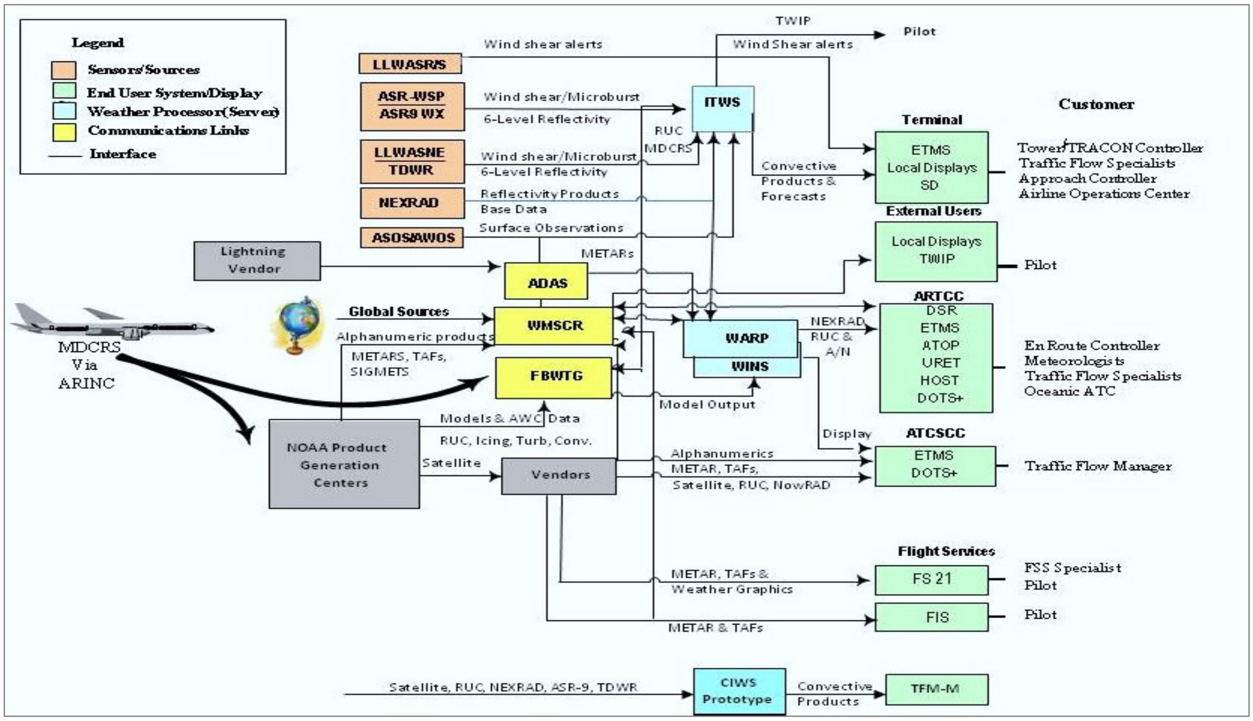

Figure 1 Current NAS Weather Architecture

the Corridor Integrated Weather System (CIWS) for processing and product generation of FAA required weather products, which are then sent to the User. On the far right side of Figure 1 are the Users (under the heading "Customer") and their systems that receive the weather information just to their left. The various types of weather data and products are also depicted along the lines representing a data flow pathway.

While Figure 1 seemed an adequate representation of the weather architecture at the time, it is only a 'snapshot' of the present day weather architecture. It is insufficient to depict the weather architecture in the context of the NASEA. Therefore a Roadmap was generated for each domain (e.g., weather, communication and aircraft). Portions of the Weather Roadmap are shown in Figure 3 (Sensors) and Figure 4 (Processors), which will be discussed later.

Collectively, the domain Roadmaps represent a blueprint of FAA and customer investment in the NAS out through the year 2025, when NextGen will be fully realized. Individually, each Roadmap provides the integrated decisions and synchronized investments that are needed, and do so by:

- Describing the technology/infrastructure to support changes in the NAS
- Projecting agency and customer investments in new technologies, training, and procedures
- Identifying transitions from the present to the near-term (2010-2012), mid-term (2013-2017), and the far-term (2018-2025)
- Being constrained in transition by current FAA and customer infrastructure, by agency budgets, and by projection of user equipage

But how does the weather Roadmap relate to the NASEA? The NASEA describes how the NAS will evolve to deliver NextGen by relating high level artifacts, such as Service Roadmaps. These Roadmaps identify the evolution of air traffic services that drive technology requirements and are supported by the lower level Infrastructure Roadmaps, which in turn identify interdependencies, e.g., technologies and schedules.

They show the evolution of major FAA investments and programs in today's NAS services to meet the future demand. These Roadmaps are updated as research and analyses more clearly define the evolution of NAS services. To illustrate, go online to the NAS Portal at https://nasea.faa.gov/ via a web browser (no 'user login' or 'password' are needed). Click on 'Service Roadmaps' and the following are available:

- Initiate Trajectory Based Operations
- Increase Arrivals/Departures at High Density Airports
- Increase Flexibility in the Terminal Environment
- Improve Collaborative ATM
- Reduce Weather Impact
- Increase Safety, Security, and Environmental Performance

Each NAS Service Roadmap consists of a Solution Set of Operational Improvements (OIs). For example, Click on Reduce Weather Impact (RWI), then Click on the blue text of "Reduce Weather Impact diagram; 1 of 1, to see the OIs listed with 'time bars' (in Figure 2) relating the beginning and ending of their projected implementation. Clicking on the 'Solution Set Report' tab provides a description of the following OIs:

- 103104 - Deploy FIS-B Nationally
- 103116 - Initial Improved Weather Information from Non-Ground Based Sensors
- 103119 – Initial Integration of Weather Information into NAS Automation and Decisionmaking
- 103121 - Full Improved Weather Information and Dissemination
- 103122 - Full Improved Weather Sensor Network
- 103123 - Full Integration of Weather Information into NAS Automation and Decisionmaking

forecasts of Convection, In-flight icing, and Turbulence

To realize each OI sub-capability of a Service Roadmap, a system on the supporting Infrastructure Roadmap is allocated the support function or capability. So a high level Service Roadmap, Reduced Weather Impact in this case, with Operational Improvements (e.g., 103116), can have sub-capabilities, which in turn are supported by system(s) on the Weather Infrastructure Roadmap. In the example for initial weather improvement of non-ground based sensing, aircraft (e.g., commercial, UAV, etc,) and satellite resources (NOAA, DOD) from the Weather Roadmap would be allocated support responsibilities. That allocation for support is seen in Figure 3 for the Non-FAA Sensor lane by the box labeled 'ACFT Wx Sensors' (ACFT is shortened version of Aircraft).

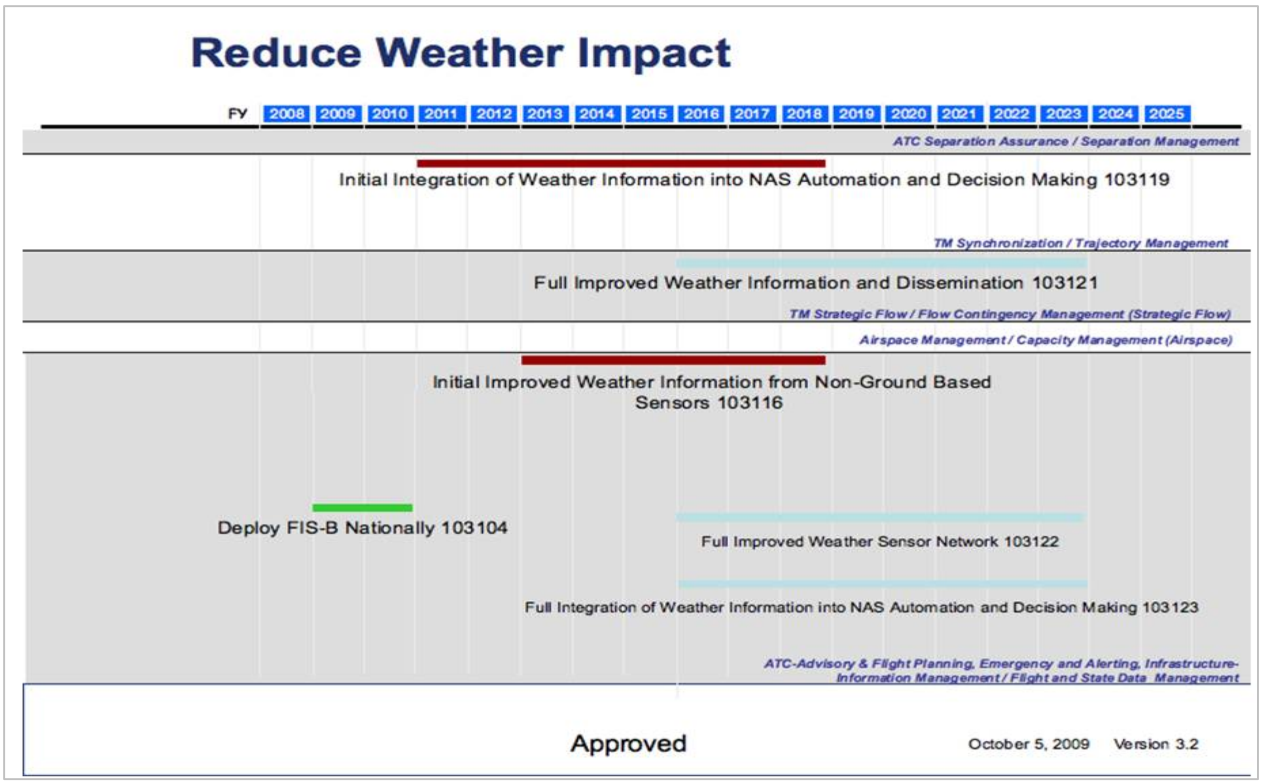

Figure 2 Reduce Weather Impact Service Roadmap

Note that OI 103116 has numerous sub-capabilities including:

- Improved aircraft & satellite data result in increased data density, which enhances situational awareness of impacting weather
- Data from aircraft during ascent/descent provides greater resolution for models in super-density airspace
- Addition of Humidity & Turbulence to Meteorological Data Collection and Reporting System (MDCRS) data stream enhances

Figure 3 is the Weather Roadmap for Sensors and contains numerous shapes and symbols. Unlike Figure 1, Enterprise Architecture Roadmaps depict the progression of time at the top of the Figure. Down the left side of Figure 3 the green boxes represent NAS systems, which exist today. Note the systems are grouped by function:

- FAA Wind Shear Service—Low Level Wind Shear Alert System (LLWAS), Light Detection and Ranging (LIDAR), Terminal Doppler Weather Radar (TDWR) and the Airport Surveillance Radar-Weather System Processor (ASR-WSP)

- FAA Sensors—Airport Surveillance Radar mod 8/9/11 weather channel and the multi-agency Next Generation Weather Radar (NEXRAD)
- FAA Surface Observing Systems—Automated Surface Observing System (ASOS), Automated Weather Observing System (AWOS), Automated Weather Sensors System (AWSS), and the Stand-Alone Weather Sensors (SAWS) system, etc.
- Near the bottom are Non-FAA sensors—Non-Federal AWOS, ACFT Weather Sensors, Pilot Reports (PIREPs), and Lightning data
- And at the very bottom are Supporting Activities, ranging from weather R&D product development, metrics development, evaluation of new multi-purpose aviation radars, and risk-reduction demonstrations of NextGen-related capabilities.

phase of the AMS process, etc. As before, going online to the NAS Portal (https://nasea.faa.gov) and a few clicks will readily pull up a great deal of information regarding not only the Weather Roadmaps, but other Roadmaps as well and about the FAA Enterprise Architecture.

Another factor in the NASEA Weather Roadmap Sensors (Figure 3) warrants notice—that of consolidation of functionality. For the various wind shear systems (TDWR, ASR-WSP, LLWAS) and the weather radars (NEXRAD and the weather channel of the ASR-8/9/11 airport radars); note that with time the functionality of these individual systems are shown as 'merging' into a single system (more properly, one capability). The large green 'box' labeled, *NextGen Surveillance & Weather Radar Capability,* represents a combined functionality of wind shear and weather

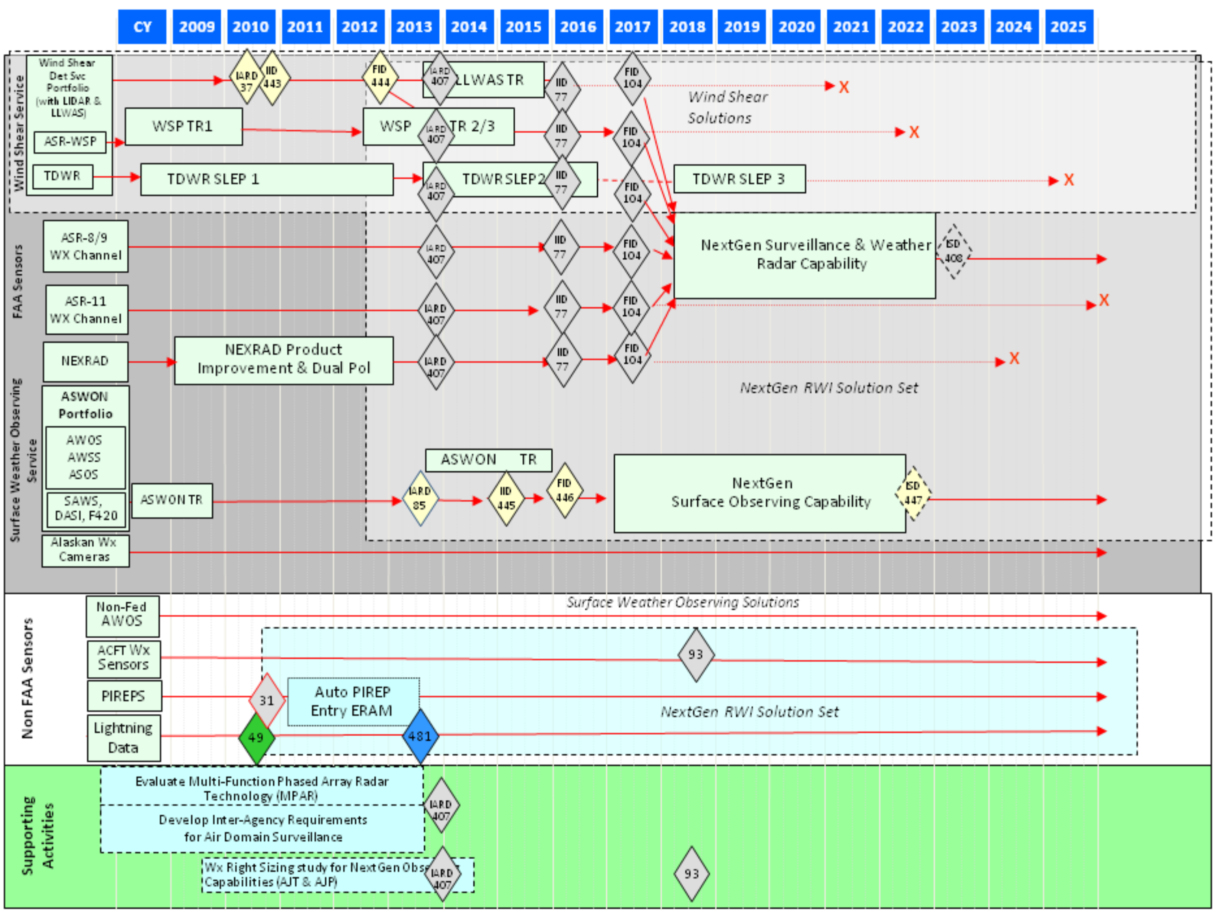

Figure 3 NAS Weather Roadmap to NextGen - Sensors

The diamond shapes associated with each system represent various phases of the FAA acquisition process as each is a FAA executive level decision. Their placement represents the year when the decision is projected to occur. The numbers within the diamonds simply serve to identify where to find additional information for each decision, e.g., description, which

radars with FAA aircraft surveillance radars! The grey color of the diamonds during 2013–2017 denotes 'cross domain' (weather and aircraft surveillance) decisions. There may be possible exceptions to this consolidation. For example, if a multi-functional (weather and aircraft) surveillance radar cannot meet FAA's wind ground-based shear requirements, then continued fielding of separate FAA wind shear radars would likely be fielded.

And like the radars, note [in Figure 3] that for the automated surface observing systems (ASOS, AWOS, AWSS, SAWS, etc.) a consolidation of functionality is also depicted. This consolidation culminates in a capability called, the *NextGen Surface Observing Capability*. The wording, C*apability* instead of S*ystem,* is by design as any reference to a 'system' infers a predetermined 'solution'. This would be premature and not in the interest of prudent system engineering practices. To that end, the FAA has begun 'right-sizing' studies to analyze future aviation weather sensing requirements for the mid-term and far-term of NextGen. As these studies also entail multi-agency (NOAA/NWS and DOD) systems, both they and the JPDO will be involved as well as appropriate.

Looking at Figure 4, one can see the transformation for weather processing and dissemination in incremental steps from now until NextGen is achieved. With the current FAA emphasis on reaching NextGen early, limited capabilities will be implemented by 2012. Between now and 2018, direct connections from weather sensors to users' systems will be minimized as data and/or products are available to end-users via a network-centric capability and the four-dimensional (4-D) Weather Data Cube (top half of Figure 4). Also, the communications path for weather information sent from processors to users' systems will be net-centric. This reduction of connections between sensors, users, and processors enables real-time dissemination throughout the NAS, as well as reduced time to implement new weather products into the NAS. More aircraft will have weather sensors and/or algorithms installed in the flight management system to provide weather information to other users directly and/or via the NextGen 4-D Weather Cube.

For the FAA, the network-centric System-Wide Information Management (SWIM) capability (note SWIM segments along the top of Figure 4) with the NextGen Network-Enabled Weather capability subsumes the functionality of several NAS weather communications systems. These systems include WMSCR, two subsystems of the WARP—the FBWTG and the Weather Information Network Server (WINS), and the communications portion of the ADAS. WMSCR is the primary NAS interface with the National Weather Service Telecommunications Gateway (NWSTG) for exchanging alphanumeric aviation weather products. WMSCR collects, processes, stores, and disseminates aviation weather products and information to various NAS systems, the airlines, commercial users, and international users. The FBWTG is the primary NAS interface with the NWSTG for receiving gridded forecast model data in situ airborne observations from the MDCRS and gridded aviation hazardous weather products (e.g., turbulence and icing) from the Aviation Weather Center. WARP disseminates weather products via WINS to NAS automation systems, including the

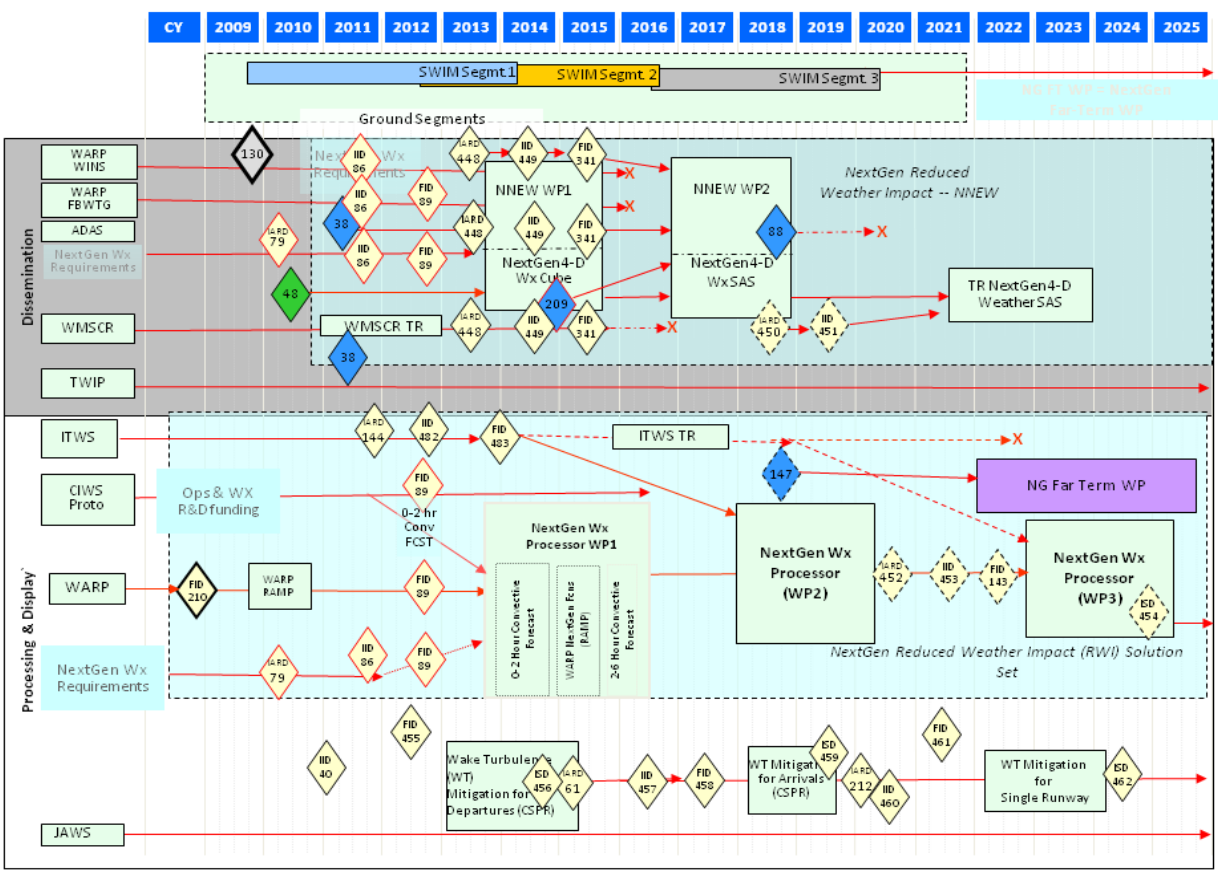

Figure 4 NAS Weather Roadmap to NextGen - Processors

User Request Evaluation Tool (URET). Dynamic Ocean Track System (DOTS Plus) and Advanced Technology and Oceanic Procedures (ATOP). URET uses three-dimensional wind and temperature forecasts to optimize trajectory algorithms for Conflict Probe to facilitate merging of air traffic by controllers, which increases airspace efficiency and capacity. ATOP and DOTS+ use 3-dimensional forecasts of wind fields to create flight tracks across oceanic airspace.

By 2015 FAA weather processors (Figure 4), currently optimized by domain (e.g., En route, Terminal, and Traffic Flow Management), begin consolidation of their functionality to the NextGen forecasting capability, which may ultimately be transferred out of the FAA. This convergence of weather processor functionality, WARP for En route, ITWS for Terminal, and CIWS for Traffic Management, reduces duplicative functions, as well as operations and maintenance costs. Initially, the WARP functionality that must be sustained into NextGen, the CIWS functionality and the 2 to 6-hour convective forecast will be incorporated into the NextGen Weather Processor (NWP). By 2012 CIWS will provide products for the entire CONUS via the network-centric capability of SWIM. Most ITWS functionality will be transferred to the NWP in either work package 2 or 3 depending on the extent and cost of the ITWS technical request. However, detection and alerts of microbursts and wind shear remain in the terminal until latency requirements to air traffic controllers can be assured for centralized processing.

The FAA needs to determine the sensor functionality that must be sustained or added to meet the vision of NextGen. The FAA's sensor roadmap back in Figure 2 depicts the planned transition to NextGen. The FAA will determine if the existing ground-based wind shear/microburst detection systems need replaced or if this functionality can be met through a combination of airborne systems, improved NEXRAD algorithms, and/or enhanced training. If not, the FAA will sustain these systems until convergence of the functionality has been completed. The FAA's 'right sizing' studies should greatly assist them in making acquisition decisions re sensor requirements well into the NextGen era.

Supporting Activities for weather are very important, particularly as transforming the weather architecture into the NextGen era entails numerous risks. Figure 5 depicts just some of the many supporting activities for weather. For example, policy-related decisions concerning how the Federal Aviation Regulations (FARs) will address probabilistic forecasts, risk-reduction demonstrations for weather data exchange between the 4-D Wx Cube and NextGen Network-Enabled Weather (NNEW), developing or enhancing existing forecast algorithms for aviation impacting variables (ceiling/visibility, convection, in-flight icing, turbulence). Some demonstrations will entail new technology or innovative techniques to move large volumes of data in distributed networks or across net-centric communication environments. This is a departure from the present means of moving weather

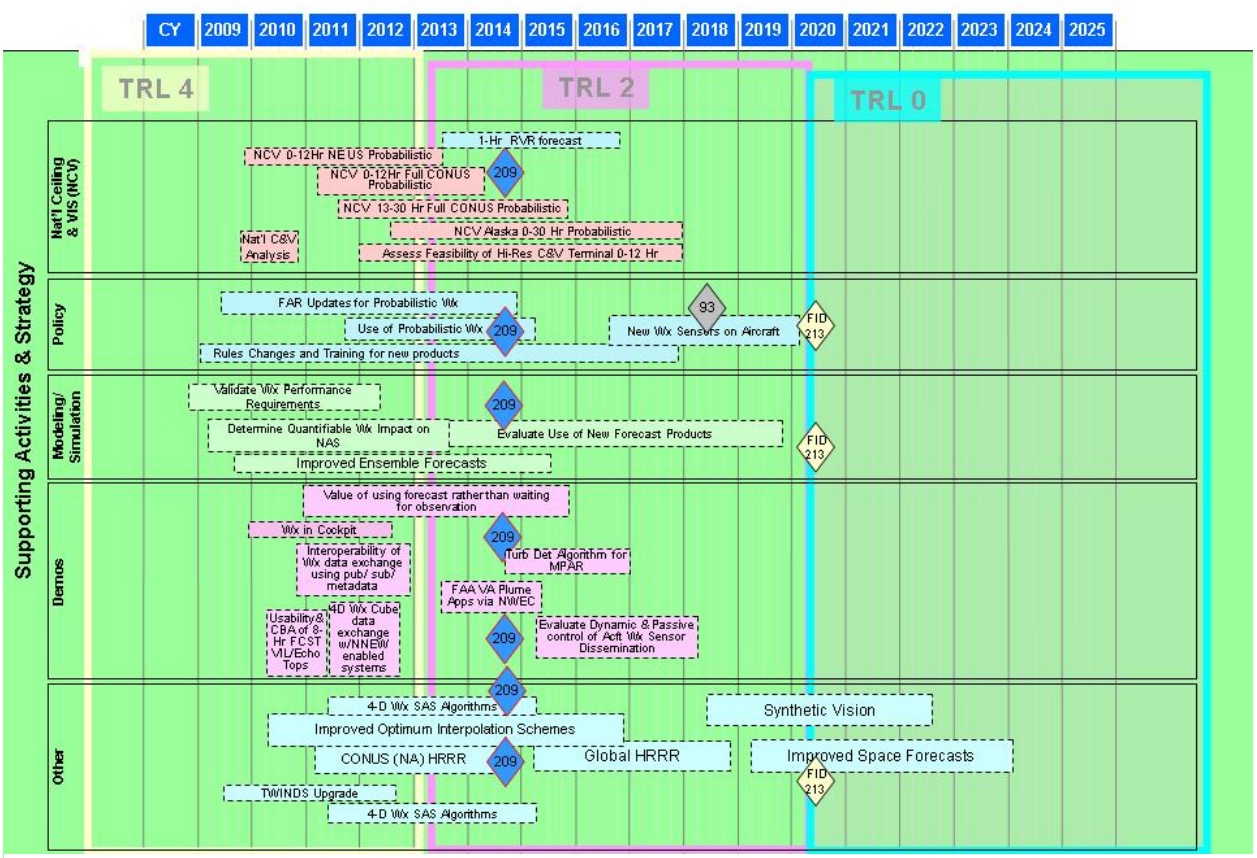

Figure 5 NAS Weather Roadmap Supporting Activities

data where direct connectivity is essential to ensuring both data latency and data reliability constraints are assured to the operational decision maker. Therefore, demonstrations of moving weather information from sensors to processors to ANSPs in a net-centric environment of distributed networks are absolutely necessary to aid in risk reduction strategies supporting acquisition decisions to transform the weather architecture to that of NextGen.

3.0 4-D Weather Data Cube and 4-D Weather Single Authoritative Source

The 4-D Wx Data Cube, which is defined as containing all unclassified weather information used directly and indirectly for making aviation decisions, contains all relevant aviation weather information (e.g., observations, automated gridded products, models, climatological data, and human produced forecasts from public and private sources). The 4-D Wx Data Cube is composed of text products, graphic products, and machine-readable products. It contains proprietary products and those in the public domain, as well as domestic and foreign weather information. The production of the 4-D Wx Data Cube and its utilization by NAS users' applications in an operational manner is the essence of NextGen weather capabilities.

However, a means is needed to arbitrate or merge 4-D Wx Data Cube information into a common weather picture upon which stakeholders, especially air traffic managers can rely. That common weather picture is the 4-D Wx SAS, which

- Fuses multiple weather observations and forecasts into a four-dimensional common weather picture available to all users.
- Facilitates decisionmaking by a diverse set of stakeholders making coordinated air traffic management decisions using a variety of applications, decision tools, and displays.

The purpose of the SAS is to provide a standardized source of aviation impacting weather elements (e.g., turbulence, icing, and probabilities of turbulence and icing) that is used for making air transportation management decisions. Because the SAS is created from data in the 4-D Wx Data Cube, the weather information is integrated (or as the NextGen ConOps cites it, "fused" or "merged") to obtain internal consistency before it becomes part of the SAS. Creating integrated information means that many information sets in the SAS are unique and may not reflect any one of the Cube sources that were used for merging.

The SAS represents the de-conflicted, machine-readable, network-enabled, geo- and time-referenced weather information available via network-enabled communications and has the following characteristics:

- Includes current observations, interpolated current conditions, and predictions of future conditions
- Supports probabilistic decision aids
- Provides a seamless, consistent common weather picture for integration into operational decision support tools available to all ATM decision makers

4.0 Assumptions

The following constitutes the assumptions for transforming the NAS weather architecture to that of NextGen:

- Requirements development may create Architecture perturbations
- Weather sensors sustained until NextGen replacement
- SWIM/NNEW subsumes weather communications
- Wake Vortex sensors installed and prediction capability developed
- Weather integrated into cockpit decision support tools
- Significant R&D and infrastructure changes are required
- FAA NextGen Weather Processor Work Package 3 most likely not be FAA system
- Ground-based wind shear detection continues
- Weather capability funded as Portfolio (data-driven business case) with likely consolidation of
  - Automated surface observing systems (ASOS, AWOS, AWSS, SAWS, etc.)
  - Weather, wind shear and aircraft surveillance radars (multi-agency use considered)
- Weather Information available at User-specified resolution with the operational impact of weather is determined by User DST

5.0 NextGen Issues Impacting Weather Architecture

The FAA annually updates the Enterprise Architecture roadmaps depicting the transformation from today to NextGen as an executive view of the NAS enterprise architecture. The latest approved weather roadmaps for Sensors and for Dissemination, Processing, and Display are depicted in Figures 3 and 4. The primary issues for determining the appropriate transition strategy are discussed in the following paragraphs.

The JPDO has developed several iterations on the NextGen Concept of Operations (ConOps) with the current approved as version 2.0, 13 June 2007 and a draft version 3.0 that is out for JPDO coordination. A JPDO-sponsored study team performed a weather functional analysis by extracting the operational functions requiring weather information to support decisionmaking from this ConOps. The weather functions required to support users' needs for weather information were then decomposed to the lowest level. These functions were then transformed into functional requirements. The next task, to develop the associated performance requirements, was completed with a preliminary set for super-density terminals only. Comments were solicited via JPDO distribution lists and are due back in February. After comment resolution, they will undergo validation by operational users. Once the validation is completed, a gap analysis between today's NAS and NextGen will be performed. Once the gaps are more clearly understood, the requirements are allocated to the infrastructure [system], and the Enterprise Architecture weather roadmap will be updated. However, the FAA's Concepts for Midterm have not been validated or translated into Midterm requirements, nor has a gap analysis been performed. Once these tasks have been completed, additional changes to the Weather roadmap may be necessary.

As NextGen aircraft must have specified capabilities to use super-density airspace, e.g. be fully capable, the NextGen Weather ConOps envisions that weather sensors and/or algorithms will be mandated for aircraft to use super-density airspace. There will be two standardized sets of data required from aircraft in situ observations, one for jetliners, and one for other aircraft. By NextGen, at a minimum, the jetliners will provide winds, temperature, relative humidity, turbulence, and icing information. To capture airborne in situ observations from the mid- and lower-levels of the troposphere, regional jets and some high-end general aviation aircraft will have a sensor set similar to jetliners. To meet the vision of NextGen and the required mitigation of weather hazards on the NAS, the NextGen critical path may require mandatory equipage of a similar, advanced sensor suite on smaller aircraft that wish to fly in highly congested airspace.

Another issue entails conducting Super Density Operations (SDO) at the nation's busiest airports. Today, in the most densely populated areas of the U.S., the air traffic system is barely keeping pace with demand. By 2020, even more major airports will become significantly congested as demand on the NAS approaches three times that of today. Conducting SDO entails matching land and airside throughput at an airport to meet 2025 NAS demand that will likely require reduced separation standards and less restrictive runway operations. A major factor impacting airport throughput is wake vortex (WV) considerations, which result in increased separation standards for arrivals and departures that lower airport acceptance rates. To ameliorate this reduction in airport capacity, the ability to provide wake vortex detection, and the predicted location and strength of WV is needed. Both these capabilities have been in research and development. NASA and FAA have data from an airport experiment using a commercial LIDAR to detect and characterize WV, which may lead to modifications to current procedures for aircraft separation standards at airports with closely spaced parallel runways. The FAA expects to have a wake vortex for departure capability implemented by 2015. Additional capability will be implemented through 2024, while further research on aircraft wake vortex mitigation systems is conducted.

However, a key question for the FAA is whether the convergence of its weather processing capability [depicted in Figure 3] should be a FAA system or integrated into a NextGen forecasting capability. This decision depends on several factors including the timeframe this capability is expected to emerge and to what extent it will be decentralized. The FAA still expects to extract model data from the NextGen 4-D Weather SAS and run aviation-unique applications, e.g., wind shear and microburst algorithms. This forecasting capability should be capable of incorporating all the current and planned functionality of WARP (except CWSU functionality), CIWS, and ITWS (except for microburst, wind shear, and possibly wake vortex detection maintained locally).

One continuing issue for users is the small number of PIREPs that are captured for transmission and assimilation into models. The FAA plans the addition of a nearly automated capability for controllers to easily enter PIREPs in post work package 3development of its En Route Automation Modernization (ERAM) system. At a minimum, this capability will be a part of the replacement NextGen Farterm Work Package (NFWP) for automation processors.

In the surveillance roadmap, the Terminal Service unit has determined the need for replacement terminal radars for aircraft and weather surveillance in the 2023 timeframe. With the transition to automatic dependent surveillance – broadcast (ADS-B) and satellite-based global positioning system (GPS), multi-lateration, and beacons; aircraft surveillance will no longer be ground based. However, it has been determine that a ground-based backup is necessary to maintain safety standards. The surveillance roadmap specifies a service life extension (SLE) for the ASR-9 to maintain a terminal weather radar capability. TDWR will also have a SLE. If it is determined that ground-based, low-level wind shear systems are no longer needed, the TDWR will be replaced with less expensive weather radar after 2023.

The JPDO will prioritize weather research and development (R&D) based on the selected NextGen critical path, which will be determined by the gap analysis and the requirements. Once the weather requirements have been validated, the JPDO will update their R&D plan and the FAA will aligns its sponsored aviation weather R&D efforts to attain envisioned improvements. Weather R&D provides improved safety with the emergence of new forecast products, such as enhanced in-flight icing and turbulence gridded products that include severity. In terms of capacity, as thunderstorms contribute the most to NAS weather-related delays, aviation weather research continues to develop longer-range thunderstorm forecasts enabling the FAA to meet traffic management needs for forecasts out to eight hours.

Initially, some new weather R&D products will be displayed on user workstations. However, after 2016, many of these products are integrated into decision support tools of both FAA service providers and users to optimize algorithm performance for trajectory calculations, capacity determination, etc. Subsequently, probabilistic forecasts are fully integrated into decision support tools to incorporate the uncertainty in weather forecasts and that of traffic demand to provide traffic managers with enhanced capacity forecasts that minimize the loss of usable airspace.

6.0 Summary

Mitigation of weather impacts on the NAS is crucial to meeting the NextGen vision. In transitioning the current weather architecture to support the enhanced capabilities of NextGen, there will be impacts to the weather architecture. However, before we can finalize the critical path of the Air Traffic System from today to 2025, the development of all NextGen requirements, not just weather, is needed in order to perform a complete gap analysis. In many cases, the functionality will not change, but the entity performing the function will change. Also, the performance requirement will become more constrained. Even when the gap analysis is completed, a number of studies are required to determine the optimal critical path.

The FAA has transformed the gaps determined in the analysis leading to MNS #339 and the associated functional analysis of the RTCA NAS Concept of Operations into a baseline set of today's weather functional and performance requirements. The NextGen performance requirements for the various weather parameters (e.g., accuracy of icing and turbulence forecasts) will be completed in 2010, which define the temporal and spatial resolution requirements of the 4-D Wx SAS, including refresh rates, reliability and availability. Then operational users must validate these requirements through modeling and simulations. These requirements will then be allocated to FAA systems or allocated to R&D as appropriate. The FAA Midterm requirements, when developed, will also be allocated appropriately. Once the gap analysis is completed for both NextGen and Midterm, a more detailed transition plan will be developed that looks not only at systems, but also at the functionally implemented on those systems.

The FAA's transition to the NextGen 4-D Weather SAS began in 2009 with the system engineering necessary to provide a minimal set of weather information that will be available in 2015. The FAA will fully coordinate and collaborate with the NWS and DOD as well as the JPDO.

In order for weather organizations to obtain the required funding, data-driven business cases must be developed. Classes of studies needed include (1) available benefits, (2) integration of weather into decision support tools (DST), and (3) how does weather really impact the NAS. More importantly, these studies need to be conducted to determine what portions of available benefits can be allocated to weather systems. With the emphasis on improving NAS capacity to meet a demand three times that of today, caution must be exercised to not attribute capacity benefits to weather that may not be realistic. For example, what portion of the airspace that is currently 'lost' due to inadequate convective forecasts can actually be 'used' in the future with a weather product that permits capabilities such as over-the-top routing, or depicts high-resolution convection spacing that enables safe passage, or has an accurate 8-hour forecast? And, full integration of weather into DSTs is a must for improved trajectory-based operations to become a reality.

In the final analysis, benefits must be based on metrics that improve NAS safety, efficiency and capacity. For example, if research can improve in-flight icing forecast accuracy by 12% or turbulence forecasts by 8% due to limited funding, it must be determined which one has the greatest positive impact on the NAS. It may be that the 8% improvement in turbulence has more impact on NAS capacity, but may not be as great of a safety improvement as that of in-flight icing.

The FAA's NAS enterprise architecture roadmaps will be updated annually, incorporating changes needed based on maturing R&D and operational studies, as well as any updates to the NextGen Concept of Operations or the FAA's Midterm concepts. While these changes may be considered revolutionary by some, they are absolutely essential to meet the challenges of mitigating weather impact to NextGen. The real challenge for the FAA – ensure that sound system engineering principles are adhered to in transforming the NAS weather architecture to the NextGen vision.

7.0 Acronyms

AMS = Acquisition Management System

A/N = Alphanumeric (or textual) Data

4-D = Four dimensional (space and time)

ADAS = AWOS Data Acquisition System

ADS-B = Automatic Dependent Surveillance - Broadcast

ANSP = Air Navigation Service Provider

ARTCC = Air Route Traffic Control Center

ASOS = Automated Surface Observing System

ASR-9 = Airport Surveillance Radar, Model 9

ASR-11 = Airport Surveillance Radar, Model 11

ASR-WSP = Airport Surveillance Radar-Weather System Processor

ASWON = Aviation Surface Weather Observation Network

ATC = Air Traffic Control

ATCSCC = Air Traffic Control System Command Center

ATO = Air Traffic Organization

ATOP = Advanced Technologies and Oceanic Procedures

ATM = Air Traffic Management

AWOS = Automated Weather Observing System

AWSS = Automated Weather Sensor System

CIWS = Corridor Integrated Weather System

ConOps = Concept of Operations

CONUS = Continental United States

CSPR = Closely Spaced Parallel Runways

CWSU = Center Weather Service Unit

DASI = Digital Altimeter Setting Indicator

DOD = Department of Defense

DOTS = Dynamic Ocean Track System

DSR = Display System Replacement

DST = Decision Support Tool

ERAM = En Route Automation Modernization

ETMS = Enhanced Traffic Management System

FAR = Federal Aviation Regulation

FBWTG = FAA Bulk Weather Telecommunications Gateway

FIS = Flight Information System

FAA = Federal Aviation Administration

GA = General Aviation

GAO = Government Accounting Office

GPS = Global Positioning Satellite

HRRR = High Resolution Rapid Refresh

HOST = Host Computer System

ITWS = Integrated Terminal Weather System

JAWS = Juneau (Alaska) Airport Wind System

JPDO = Joint Program and Development Office

LIDAR = Light Detection and Ranging

LLWAS = Low-Level Wind-Shear Alert System

LLWAS-NE = Low-Level Wind-shear Alert System-Network Expansion

LLWAS-RS = LLWAS Replace/Sustainment

M1FC = Model 1 Full Capacity

MDCRS = Meteorological Data Collection and Reporting System

METAR = Aerodrome Aviation Meteorological Report

MIAWS = Medium Intensity Airport Weather System

MNS = Mission Need Statement

MPAR = Multifunction Phased Array Radar

NAP = NextGen Automation Processor

NAS = National Airspace System

NASA = National Aeronautics and Space Administration

NASEA = NAS Enterprise Architecture

NASEAF = NAS Enterprise Architecture Framework

NCV = National Ceiling and Visibility

NCWF = National Convective Weather Forecast

NESDIS = National Environmental Service, Data, and Information Services

NEXRAD = Next Generation Weather Radar

NextGen = Next Generation Air Transportation System

NLDN = National Lightning Detection Network

NNEW = NextGen Network-Enabled Weather

NOAA = National Ocean and Atmospheric Administration

NWP = NextGen Weather Processor

NWS = National Weather Service

NWSTG = NWS Telecommunications Gateway

OASIS = Operational and Suitability Implementation System

OMB = Office of Management and Budget

OPSNET = Operations Network

PIREP = Pilot Report

R&D = Research and Development

RUC = Rapid Update Cycle

RVR = Runway Visual Range

RWI = Reduce Weather Impact

SAS = Single Authorative Source

SD = Situation Display

SDO = Super Density Operations

SLE = Service Life Extension

SWIM = System Wide Information Management

TAF = Terminal Aerodrome Forecast

TDWR = Terminal Doppler Weather Radar

TRM-M = Traffic Flow Management Modernization

TR = Technical Refresh

TRACON = Terminal Approach Control

TWINDS = Terminal Winds

TWIP = Terminal Weather Information for Pilots

UAS = Unmanned Aircraft System

UAV = Unmanned Aerial Vehicle

URET = User Request Evaluation Tool

VIL = Vertically Integrated Liquid

WARP = Weather and Radar Processor

WINS = Weather Information Network Server

WMSCR = Weather Message Switching Center Replacement

WS = Wind shear

WSP = Weather System Processor

WT = Wake Turbulence

WV = Wake Vortex (or Wake Vortices)

Wx = Weather

8.0 References

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NOTE: The views expressed herein reflect the personal views of the author(s) and do not purport the views or position of the Federal Aviation Administration or any other component of the Federal Government.