Next Generation Air Transportation System (NextGen) Weather Requirements: An Update

Federal Aviation Administration

Presented to: Joint Interagency Weather Research Planning and Coordination Meeting

By: James Tauss

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Co-Authors: Cheryl Souders, Cecilia Miner, Ernie Dash, Steve Abelman, Jack May, Bob Showalter, Lorraine Leonard Tom Kay, Sue Spincic & Fran Bayne

Overview

- Purpose and Background
- Functional Requirements
- Performance Requirements
- Shifting Paradigms/Changing Requirements
- Next Steps
- Summary

Purpose

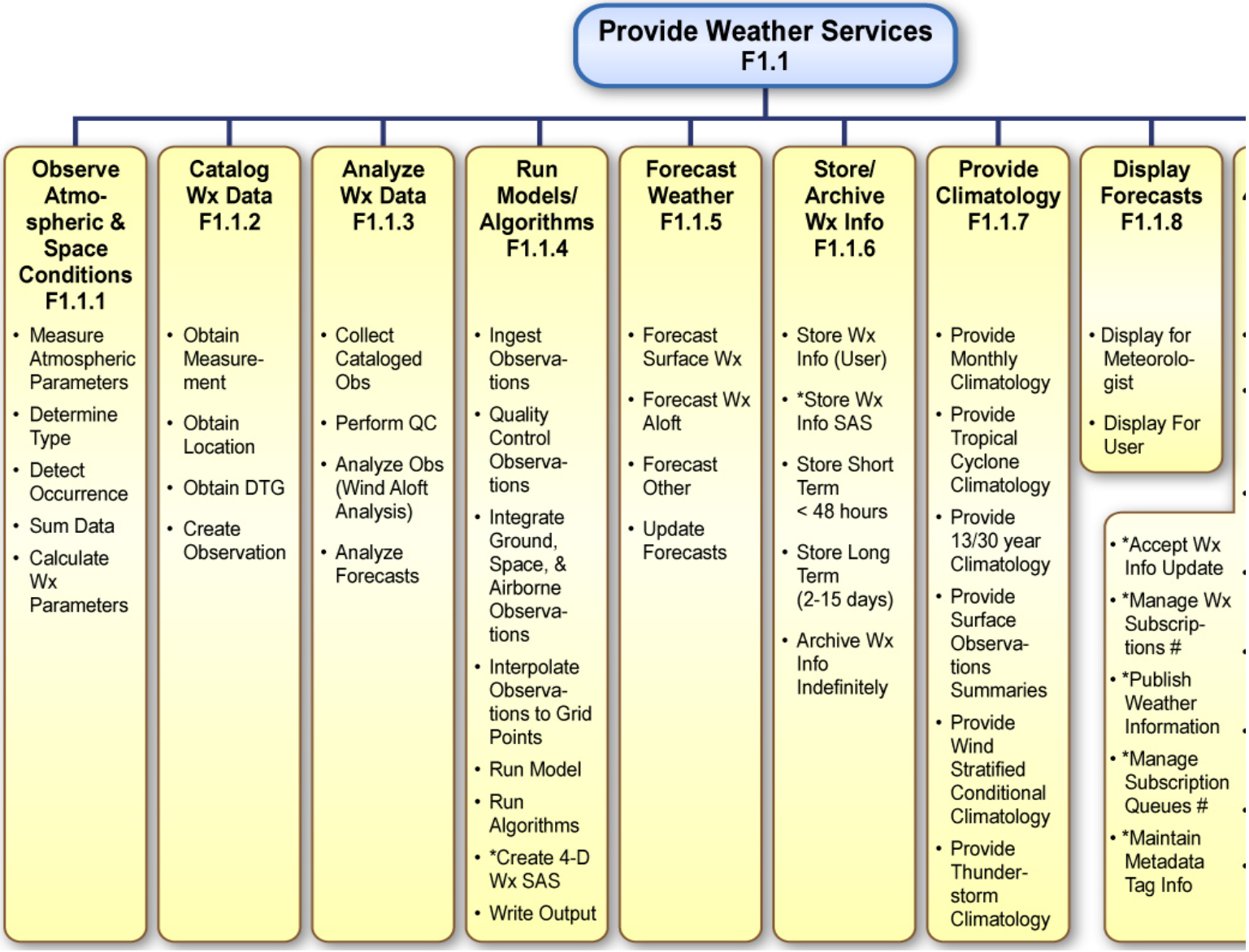
- **Performance requirements developed to support NextGen Business Cases (AMS process)**
  - NNEW = Functionality that provides network enabled access to the Cube and SAS via agency-specific infrastructures
  - NextGen Weather Processor that combines legacy processing and add new algorithms out of R&D
  - Forms the basis for determining viability of JPDO concepts and FAA Investment Packages: *Satisfaction of NextGen NAS aviation weather users requirements*
    - This task – Final Operating Capability (FOC) - 2025

Background

- **Safe and efficient NextGen operations will be dependent on enhanced weather capabilities based on 3 major tenets:**
  - Common situational awareness of impacting weather for all aviation decision makers & aviation system users
  - Weather integrated directly into sophisticated ATM 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

NextGen Functional Weather Requirements - Approach

- **JPDO formed a Wx WG-sponsored study team with representatives from NASA, NWS, DOD and FAA**
  - Tasked to identify weather services (functions) in sufficient detail to support NextGen user needs
  - CONOPS identified NextGen Services; Enterprise Services; Weather Services (Ten functional areas) .
    - Study team performed functional de-composition on 'Observe Atmospheric and Space Conditions' and 'Forecast Weather' in preparation for PR work to follow.
- **Results documented in JPDO 4-D Wx Functional Requirements for NextGen Air Traffic Management report January 18, 2008**



- **Figure 2. NextGen Provide Weather Services Functions**

FAA NextGen Performance Requirements

- **Multi-disciplinary team (NWRPT): terminal, en route & system operations; aircraft certification & flight standards; flight services; aviation weather; system engineering and NWS**
- **Values for performance requirements developed based on understanding of NextGen CONOPS, functional analysis, functional requirements, and NAS EA operational needs**
  - Assumptions hard to validate against NextGen CONOPS
  - FAA has developed lower-level Midterm CONOPS to add required level of detail

Defined Five Airspaces

- **Super-Density Terminal Airspace** – a volume of airspace centered over super-density airports with a base at the surface, a radius of 180 km [Midterm ConOps], and an upper boundary at the top of the airport's terminal airspace
- **Designated En Route Terminal Airspace** – a volume of airspace centered over selected en route airports with a base at the surface, a radius of 40 km, and an upper boundary at the top of each airport's terminal airspace
- **En Route Airspace** – all domestic airspace outside Super-Density Terminal Airspace and Designated En Route Terminal Airspace, with a base at the surface and an upper boundary at the top of the NAS.
- **Designated Global Terminal Airspace** – a volume of airspace centered over selected global airports with a base at the surface, a radius of 50 km, and an upper boundary at the top of each airport's terminal airspace.
- **Global Airspace** – all non-domestic airspace outside Designated Global Terminal Airspace with a base at the surface and an upper boundary at the top of controlled airspace

FAA NextGen Performance Requirements (con't)

- **Reviewed spatial and temporal resolutions for surface and aloft within each air traffic domain as driven by envisioned NextGen operations**
- **Determined performance and accuracy values and tolerances for each domain based on SME experience**
  - Commonality across some domains (horizontal observation resolution the same in En Route airspace and designated En Route Terminal airspace)
- **Developed tables for observation PRs and forecast PRs**

Table N-2c. Forecast Horizontal Resolution and Accuracy						
	Super-Density Terminal Airspace		Designated En Route Terminal Airspace and En Route Airspace		Designated Global Terminal Airspace and Global Airspace	
	Convective Element	Other Wx	Convective Element	Other Wx	Convective Element	Other Wx
Horizontal Resolution	0.5 km		1 km	4 km	10 km	
Horizontal Accuracy						
0 to 15 min	± 0.25 km		± 0.5 km	± 2 km	± 5 km	
> 15 min to 45 min						
> 45 min to 2 h						
> 2 h to 4 h			± 1 km			
> 4 h to 10 h	± 0.5 km		± 2 km			
> 10 h to 24 h						
> 24 h to 60 h	± 1 km					
> 60 h to 7 d	± 2 km		± 4 km		± 8 km	

FAA NextGen Performance Requirements (con't)

- **Developed performance weather requirements from functional requirements for 'observe atmospheric and space conditions' and 'forecast weather'**
  - Developed ~ 2,500 observing performance requirements
  - Developed ~ 7,000 forecasting performance requirements
- **Requirements for super-density airspace sent out for review**
  - Just received NWS' 72 comments and NWPRT is performing reconciliation
  - 55 comments received to date; most accepted

Shifting Paradigms and Changing Requirements - Probability

- 4D probability forecasts will enable Air Navigation Service Providers' and flight operations DSTs to aid decision makers in managing operational risk
  - Determine most efficient 4DT & assess risk of deviations
  - Decision makers can apply their own operational thresholds
  - Developed ~ 2,500 probability forecast functional requirements
- Probabilistic forecasts to provide risk of occurrence and magnitude
  - Intensity is quantitative (i.e., in numerical values) not qualitative (e.g., "moderate", "severe", etc.) to facilitate integration

Shifting Paradigms and Changing Requirements - Probability (con't)

- Probabilistic forecasts to meet minimum measures of acceptability and provided in forms best suited for the DST application or phenomena
  - Straight probability for yes/no forecasts
  - Probability Distribution Forecasts (PDF) for continuous phenomena (e.g., temperature, pressure, etc.)
  - Probability Mass Functions (PMF) for discrete phenomena (e.g., type of precipitation, ceiling categories, etc.)
  - Cumulative Distribution Functions (CDF) of individual PDF or PMF curves: Relating non-weather aviation bias tolerance curves to forecasted weather

Shifting Paradigms and Changing Requirements - WEDSS

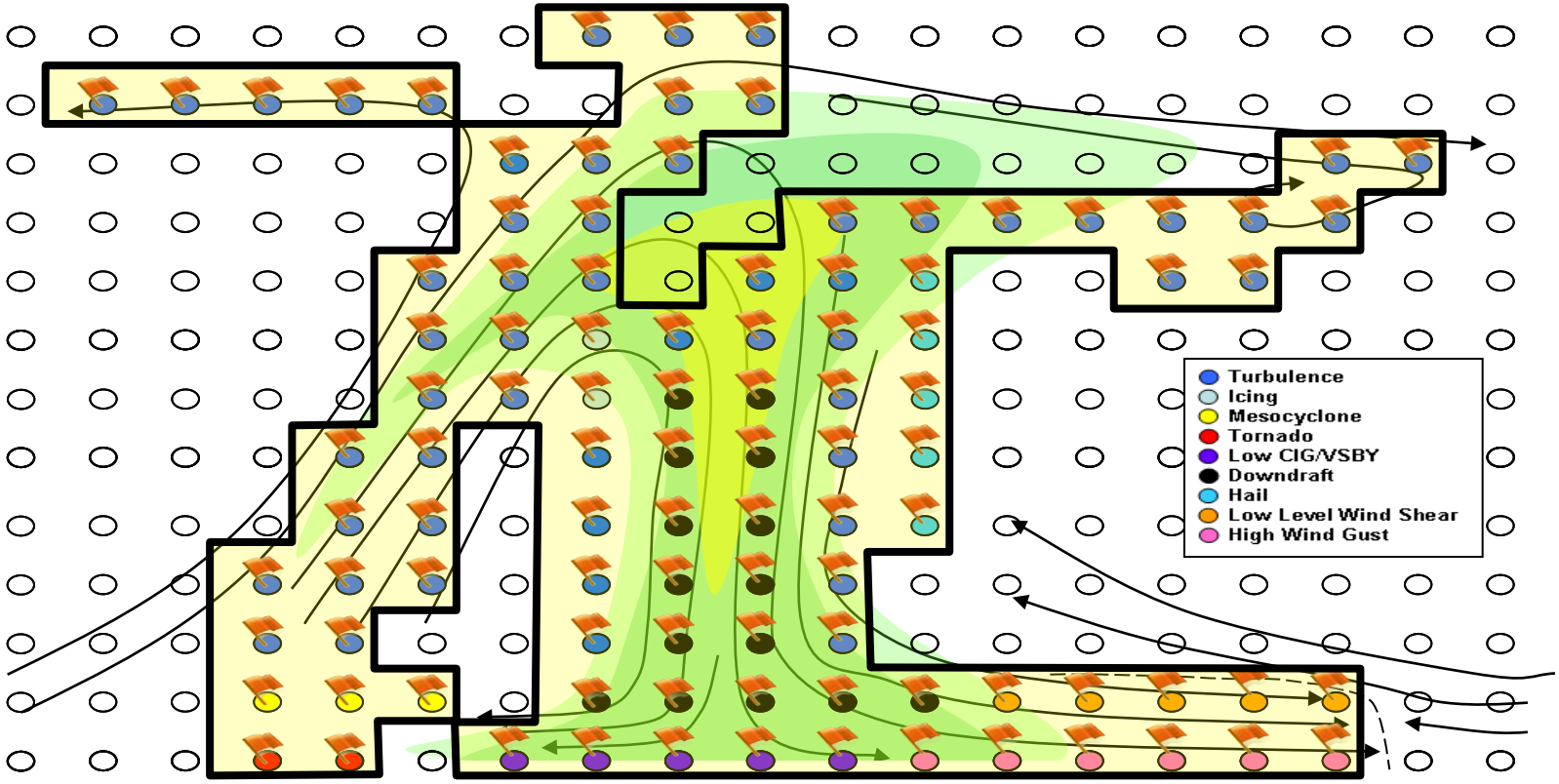
- Weather Enterprise Decision Support Services: Additional functions needed to provide users with information from the SAS not directly measured or forecast
  - “Determine” (e.g., vertical/horizontal extent, duration, etc.)
  - “Calculate” (e.g., altimeter, RH, etc.)
  - “Derive” (e.g., time of user-prescribed probability exceeded, highest probability of wind shift time, etc.)
  - “Construct” (e.g., 2D/3D objects that combine weather elements from many points at an instant or over a period of time: freezing level, fronts, etc.)
- Weather Enterprise Decision Support Service (WEDSS) performs these functions and resides beyond the Cube/SAS (to be allocated)

Shifting Paradigms & Changing Requirements - WEDSS (con't)

- **Additional support services envisioned:**
  - Per User request extract Wx information from 4-D Wx SAS, e.g., by airspace, ICAO identifier, flight path, flight levels, time , or above a specified threshold
  - Format Wx information into ICAO formats
  - Convert Wx information between measurements systems
    - Celsius & Fahrenheit
    - Magnetic & True North
    - MSL & AGL
    - Radar coordinates and NAS coordinate system
- **WES-DST translation of weather information to impacts on aviation operations**

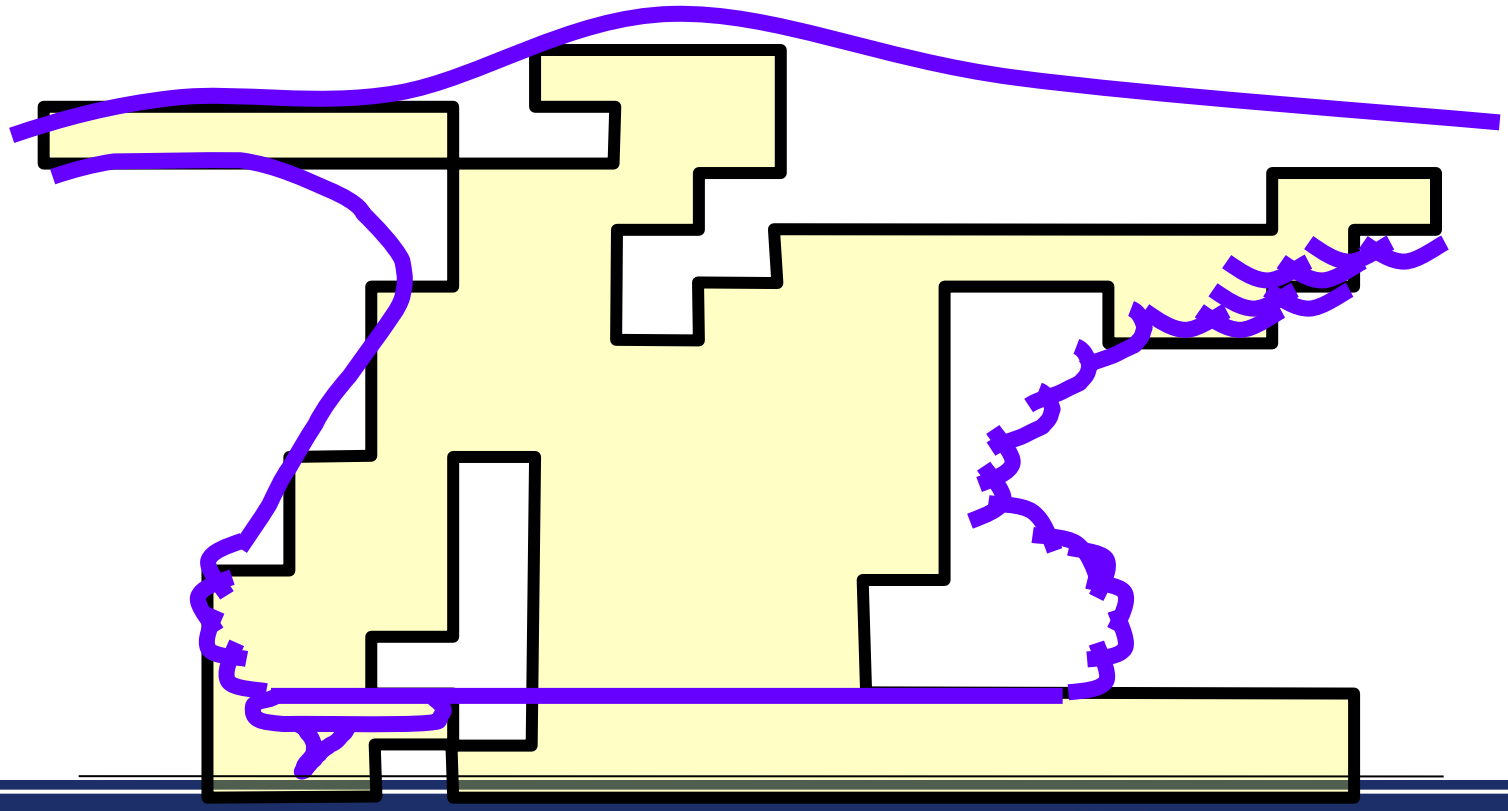
Shifting Paradigms & Changing Requirements (con't)

- **Forecast convective attributes w/probabilities**
  - e.g., lightning, turbulence, in-flight icing, low level wind shear & hail



Shifting Paradigms & Changing Requirements (cont'd)

- Users' Decision Support Tools apply user/aircraft performance thresholds to determine if forecast convective attribute constraints exist
- Area of future convection may be constructed by a decision support tool from forecast attributes for less sophisticated decision-makers



Next Steps

- **Reconcile all comments on ‘observe’ and ‘forecast’ performance requirements**
- **Develop performance requirements for other weather functions**
  - Analyze weather, run models and algorithms, create climatologies, etc.
- **Get agreement on weather information contained in the 4-D Wx SAS**
- **Complete probabilistic performance requirements after JPDO agencies agree to common framework for performance attributes**

Next Steps (cont'd)

- **Add performance requirements, methodology and basis for performance criteria to 4-D Functional Requirements for NextGen ATM document**
- **Validate weather performance requirements through modeling and simulation with users to ensure requirements are correct and sufficient**
- **JPDO to allocate weather requirements to agencies**
  - Agencies allocate requirements to current or near-term systems
  - If the current state of weather knowledge is insufficient, allocate to R&D

Summary

- **FAA NextGen Weather Performance Team reviewed work of JPDO study team**
  - New paradigms: forecast convection attributes rather than thunderstorms and forecast runway visual range
  - Added new functions
  - Some 4-D Wx SAS Wx information reallocated to 4-D Wx Data Cube
- **FAA NextGen Weather Performance Team developed ~10,000 NextGen performance requirements and 2,500 probabilistic forecast functional requirements**
- **JPDO distributed performance requirements for super-density airports for review**
- **NextGen probabilistic forecast performance requirements available for review by end of year**