NWS Science and Technology Roadmap

Aviation

Aviation Team Composition

- Brian Gockel, OS&T – Team Co-Lead
- Steve Abelman, OS&T – Team Co-Lead
- Darien Davis, GSD – Contributor
- Celia Miner, OCWWS – Contributor
- Mark Moran, NCEP – Contributor
- Jamie Vavra, OS&T – Contributor

Aviation Vision/Benefits

- **Vision:**
  - Provide accurate, timely and consistent weather information in the NextGen era to reduce air traffic delays, improve the efficiency of the National Airspace System, enhance safety, and mitigate adverse economic impacts to the airline industry and the flying public.
- **Benefits:**
  - Effective management of the nation's airspace
  - Aviation service elevated to the 'next level,' through the creation of a comprehensive network-enabled weather information database with consistent information that fully supports NextGen weather decision-making
  - Aviation-driven consistency and accuracy requirements improve many NWS services
  - Realization of a 'system of systems,' linking major systems (e.g., AWIPS, MADIS, NDFD, satellite servers, radar servers and integrated environmental modeling systems) with common enterprise services* for internal and external users
  - Better integration of weather information into aviation decision-making

* "Common enterprise services" are defined here as services that are accepted and utilized across an organization. The services enable/facilitate machine-to-machine and human/machine access (and, thus, product access) across a network.

Impacts

- **Impacts:**
  - Potential cost savings from NextGen weather as high as $19.1 billion*
  - Reduced air traffic delays by 5% would reduce CO_2 emissions by approximately 350,000 metric tons*
  - Fewer weather-related (commercial/GA) accidents, fatalities and injuries
  - More timely and reliable air travel

* *Your Flight has been Delayed Again*, A Report by the US Senate Joint Economic Committee Majority Staff, May 2008. See expanded notes on final slide for details.

Goals/Targets: Customer Needs

Goal	Outstanding Issues
Provide an operational real-time 4-dimensional weather database, giving users access to aviation weather data and products	• Requirements still in formative stages (large and diverse stakeholder population, unanswered content questions, low-level CONOPS incompletely defined). • Process for assimilation of numerous data sources into single common weather picture is not yet well defined and could be very challenging to implement. • Incomplete definition and/or agreement on data formats, data exchange standards, and data/architecture models. Inter- and intra-agency data exchange challenges. • Legacy systems migration and the "virtualization" of pre-existing discrete systems into net-enabled single "system of systems"– technical and governance challenges.
Provide an operational real-time 4-dimensional weather database, giving users access to aviation weather data and products (*continued)*	• Supporting IT Infrastructure (hardware, software, communications) not yet in place. • Security. • Performance Requirements challenges (e.g., timeliness, latency, refresh). • Large diverse aviation community needs access. • Collaborative development (partnership challenges): need clear transition-to-operations pathway, bridging aviation research and NWS aviation operations. • Spatial/temporal resolution improvements needed
Aviation Product Consistency	• Today's multiple aviation products could be better aligned to minimize duplication and maximize product consistency and quality. • FAA regulations (e.g., Federal Aviation Regulations) must be adjusted to enable or accommodate more-consistent products.

Goals/Targets: Emerging Science & Technology

Goal/Target	Outstanding Issues
Improved and enhanced observation capabilities	• Need strategy for capturing observational research for new/improved sensor systems • Challenges in under-development sensor systems (GOES-R, NPOESS, MPAR, others) • Challenges in integrating observations into WIDB and models (assimilation/initialization) • Incorporation of mesonet (e.g., MADIS) • Need to develop techniques for assessing quality of new and third-party sensor systems • Require improved coverage over data-sparse regions
Improve numerical modeling capabilities to meet the FAA's emerging functional and performance requirements. These modeling improvements will have broader benefits throughout NOAA.	• Assimilation of information from new/improved sensors (e.g., NPOESS, GOES-R, MPAR); model initialization. • Improve spatial/temporal resolution • Refresh rate needs improvement (e.g., via HPC numerical analysis modifications, IT upgrades, and more-frequent observations for model initialization). • Uncertainty/probability/ensembles • Latency reduced (HPC/IT and numerical technique improvements) • Improved representation of physical processes • HPC expansion: complexity and facility issues

Goals/Targets: Emerging Science & Technology (cont.)

Goal/Target	Outstanding Issues
A network-enabled four dimensional Weather Information Data Base of observed, analyzed, and forecast weather information, with probabilistic attributes (where appropriate), integrated into NOAA operations and into NextGen operational decision-making, and satisfying all functional and performance requirements specified by the FAA. *Note: See next slide for sample of preliminary NextGen requirements related to aviation stretch goal.*	Same as Customer Needs (see Slide 5).
Data Storage (WIDB) & Communications (Customer Access)	• Existing deficiencies in data storage and/or network bandwidth (e.g., IT/hardware and dissemination systems) • Need to adopt common standards and practices for data exchange
Advanced processes for meteorologists to add value to highly automated model output	NextGen-era decision assistance tools needed. Optimized of mix of aviation meteorologist and automated processes.

Aviation Stretch Goal

"A network-enabled four dimensional Weather Information Data Base of observed, analyzed, and forecast weather information, **with probabilistic attributes (where appropriate),** integrated into NOAA operations and into NextGen operational decision-making, and satisfying all functional and performance requirements specified by the FAA."

Aviation Hazard	Today	2025	Forecast Accuracy (Time) (Begin/End times for <2 hr)*	Forecast Accuracy (location for < 2 hr)*	Vertical Resolution*	Horizontal Resolution*	Commercial Aviation Impact	General Aviation Impact
Turbulence	Subjective measure	Forecast Eddy Dissipation Rate (EDR)	15 min (5 min for terminal airspace)	2 km (0.25 km for terminal airspace)	500 ft	4 KM	Few passenger and flight attendant injuries, more efficient use of airspace in NextGen era	Fewer accidents, more accurate and detailed "SIGMET" type products
Icing	Mostly Subjective measure	Accretion rates	15 min (5 min for terminal airspace)	2 km (0.25 km for terminal airspace)	500 ft	4 KM	more efficient use of airspace in NextGen era	Fewer accidents, more accurate and detailed "SIGMET" type products
Convective Initiation	Model Data/ Various forecast processes	Meteorologist oversight (MOTL) and value add to automated model output	15 min (2.5 min for terminal airspace)	0.5 km (0.25 km for terminal airspace)	500 ft	1 KM	more efficient use of airspace and less delays in the NextGen era	Better "go" or "no go" decisions. Less exposure to "unexpected" convective development
Ceiling and Visibility	TAFS	Meteorologist oversight (MOTL) of C&V grids	15 min (5 min for terminal airspace)	250 feet (50 feet terminal, sfc to 4900 ft)	500 ft	4 KM	More efficient operations at major airports	Fewer accidents

* Resolution information based on Tables N-1 and N-2 of *Preliminary Performance Requirements – NextGen Four-Dimensional Weather Single Authoritative Source (4-D Wx SAS)*, Version. 0.2c, FAA, September 10, 2008. Forecast accuracy is for en route airspace unless otherwise noted. Note that these requirements are preliminary, still under review, and may be refined in the future.

Goals/Targets: Emerging Science & Technology (cont.)

Goal/Target	Outstanding Issues
Efficient, state-of-the-art verification and quality assurance (QA) methodology	• Feedback of verification results into process improvements. • Establish benchmarks for analyses used for product verification • Numerous verification schemes exist. Adopt verification best practices and use common approaches when appropriate. • Definition of requirements for the Network-Enabled Verification Service (NEVS), and its potential for integration with existing Stats on Demand (SOD) Verification System. • Regime- or phenomenon-based verification, which emphasizes high-air-traffic and high-impact areas.
Standard, secure, and robust architectural framework	• Legacy systems transition • Enterprise-wide adoption of SOA model/architecture (system of systems) • Multiple industry and federal standards, some inconsistent

Key Information Gaps

Gap	Solution Alternative	Impact
1. Observations for vertical water	1.1 Status Quo	1.1 High uncertainty in liquid water profiles; dangerous areas of fog & icing potential not well pinpointed
	1.2 Satellite-based radiometers (e.g., next generation AMSU and SSMI/S)	1.2 Improved water measurement, with good/widespread coverage. But with larger errors than in situ measurements. Coverage gaps from polar-orbiting satellites. Only moderate resolution from geostationary satellites.
	1.3 Ground and Aircraft-mounted radar	1.3 Improved water, but coverage gaps off-shore & where air traffic is limited.
	1.4 Higher density RAOB	1.4 Improved/accurate water measurements, but costly; generally ground-based only (few in marine & other remote areas)
	1.5 Improvement to MDCRS/TAMDAR	1.5 Improved water, but potential issues with consistency & standardization
	1.6 Addition of GPSmet Integrated Precip. Liquid (IPL)	1.6. Improved coverage
	1.7 RASS Profiler	1.7 Boundary Layer Moisture Profiles

Key Information Gaps (Continued)

Gap	Solution Alternative	Impact
2. Model resolution does not meet functional and emerging performance requirements; representation physical processes, in models, needs improvement	2.1 Status Quo	2.1 Failure to meet requirements; coarse low-res data products; small-scale, aviation-relevant features (e.g., turbulence) poorly represented
	2.2 HPC investment to improve model resolution and representation of physical processes	2.2 Hi res model products; improved representation of aviation-relevant features and hazards (e.g., turbulence). Improved analyses and forecasts for aviation users and systems/applications.
3. Forecasting initiation of convection	3.1 Status Quo (specific convective initiation not well forecasted today)	3.1. Breakouts of convection disrupt management of airspace, leads to amplified flight delays
	3.2 Research & development of mesoscale modeling, assimilation of high res radar (superRes) and satellite (e.g., GOES-R Advanced Baseline Imager), and the transition of these capabilities to operations	3.2 Critical to meeting NextGen customer requirements for ATM decisions. Facilitates/enables warn on forecast. Improved aviation forecast.
4. Production and use of probabilistic information – Need better integration into forecast process	4.1 Research, development, and evaluation of value of probabilistic information in forecast process.	4.1 Research for communicating uncertainty is still in planning stage. HPC augmentation necessary for expanded ensemble modeling.

Key Information Gaps (Continued)

Gap	Solution Alternative	Impact
5. Multiple aviation forecast products for the same parameters, today, yield competing/differing views of the weather.	5.1 Status Quo	5.1 Failure to meet NextGen requirement of a Single Authoritative Source of Weather Information
	5.2 Lead the development effort of a process to fuse or merge multiple products into a NWS single authoritative source of weather information with MITL oversight	5.2 NWS will meet customer NextGen customer requirement and continue to be the primary source of weather information for the FAA and the aviation community
	5.3 AWIPS Technology Infusion (Collaboration)	5.3 Collaboration intensifies forecaster interaction– leveraging local knowledge for improved national service
6. Incompletely-defined mix of meteorologist/automation mix, in NextGen era. (Need to develop optimized mix.)	6.1 Status quo	6.1 Cannot deliver consistent information at NextGen required resolutions
	6.2 Development of MITL/ MOTL techniques to maximize meteorologist-added value to automated model output	6.2 Better suited for WIDB/NextGen era but may require new forecast paradigm, new interfaces, and training

MITL *= Meteorologist in the loop,* ***MOTL*** *= Meteorologist over the loop*

Key Information Gaps (Continued)

Gap	Solution Alternative	Impact
7. Lack sources of analyses for gridded Aviation impact variable verification	7.1 Improve Real-Time Mesoscale Analysis	7.1 Good verification at all surface gridpoints, but additional research, objective quality assessment, and enhancements to RTMA to four dimensions is needed.
	7.2 Develop Analysis of Record for verification of Aviation impact variables	7.2 Excellent potential for gridded verification basis, but will require additional research and new observational data sources to meet goals for verification of selected aviation variables
	7.3 Use Observation data base at points (e.g., ASOS/METAR)	7.3 Good verification at points, but not adequate for entire gridded forecast domain.
8. Techniques for verification	8.1 Status quo	8.1 Limited capabilities for aviation verification and assessment of skill in Stats on Demand and Real Time Verification System
	8.2 Definition of requirements for the Network-Enabled Verification Service (NEVS) and the potential to integrate with the Stats on Demand (SOD).	8.2 Provides support for assessment of quality of aviation impact variable forecasts in addition to skill

Key Information Gaps (Continued)

Gap	Solution Alternative	Impact
9. NWS weather forecast products not well integrated into FAA decision-making processes	9.1 Status Quo	9.1 Potential for disconnects between NWS and aviation product users.
	9.2 Develop and finalize NextGen product/service requirements.	9.2 Establishes parallel/convergent implementation paths in NOAA and FAA NextGen development domains.
	9.3 Adopt common data standards & formats for agency-to-agency information exchange.	9.3 Facilitates and automates the integration of NOAA products into aviation decision-making processes.
	9.4 Strengthen collaboration between data and service providers, and users (e.g., via AWIPS Tech Infusion).	9.4 NWS service providers & NextGen users have enhanced understanding products/services, and of respective roles & responsibilities.
10. Stove-piped data access and dissemination	10.1 Status Quo (segmented product streams with multiple, unique interfaces for different NOAA products and service types).	10.1 Fragmented and inaccessible WIDB; multiple and inconsistent FAA/NOAA interfaces; high maintenance costs.
	10.2 New network-enabled Weather Information Database (4-D Cube) with a uniform/consistent interface for the broadest range of weather products/services, supported by an advanced NOAA Enterprise Infrastructure	10.2 Aviation and other communities provided with net-enabled access to NOAA's Weather Information Database

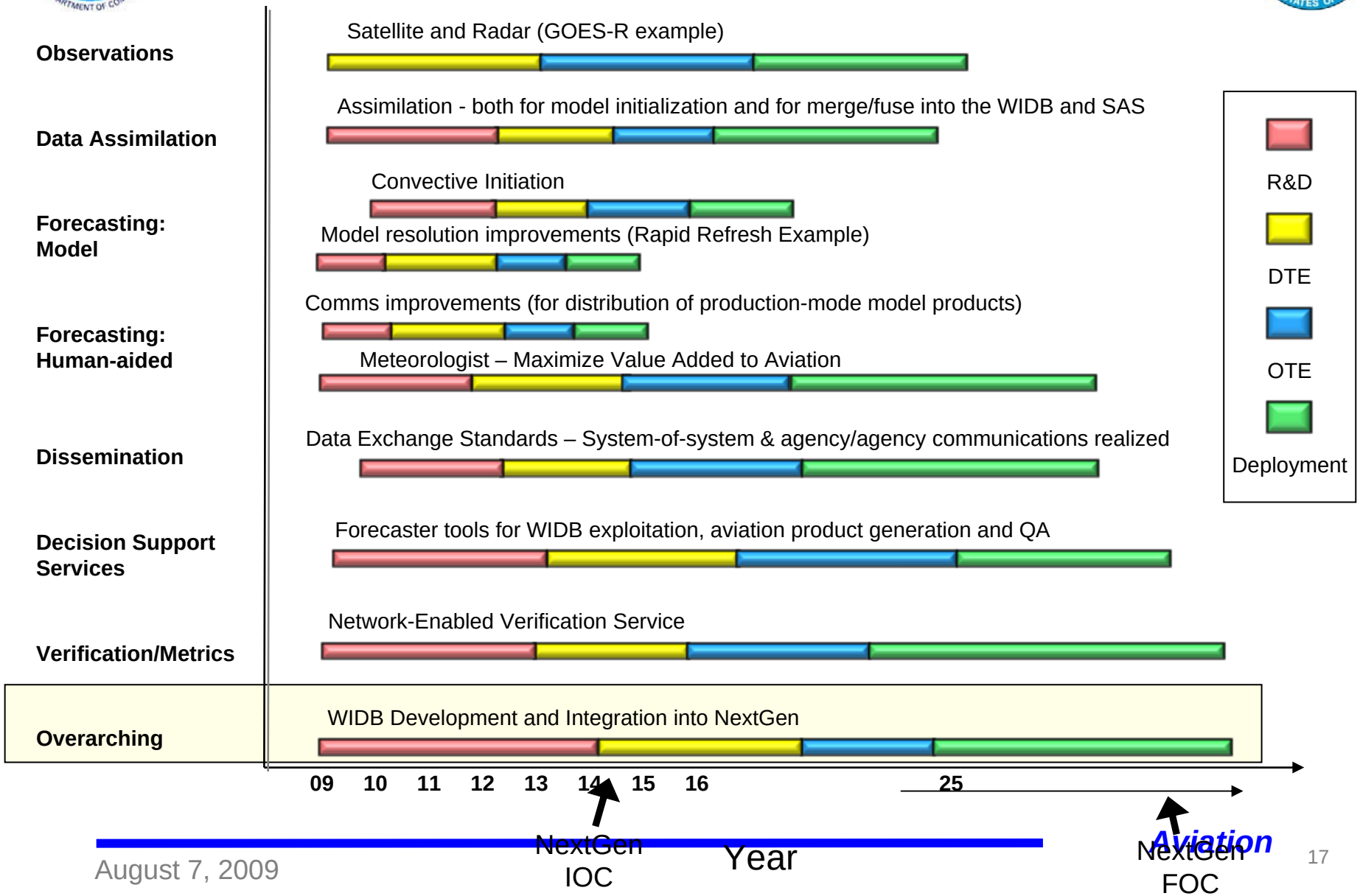
R&D Needs and Opportunities

- **Short-Term (through 2016)**
  - Improve analyses and forecasts of storm-scale convective initiation and evolution, ceiling, and visibility
  - Methods to develop a real-time single authoritative source of consistent weather information from multiple sets of forecasts and observational data
  - Generation of probabilistic weather forecasts (modeling, uncertainty, ensembling)
  - Flexible numerical weather prediction models to support the spatially-nested WIDB
  - Determine where meteorologists add maximum value to auto-generated WIDB information
  - Enhanced Ground, Airborne and Space Based Weather Sensors
  - Develop and augment use of test beds, especially the Aviation Weather Test bed, for expanding NextGen/aviation services

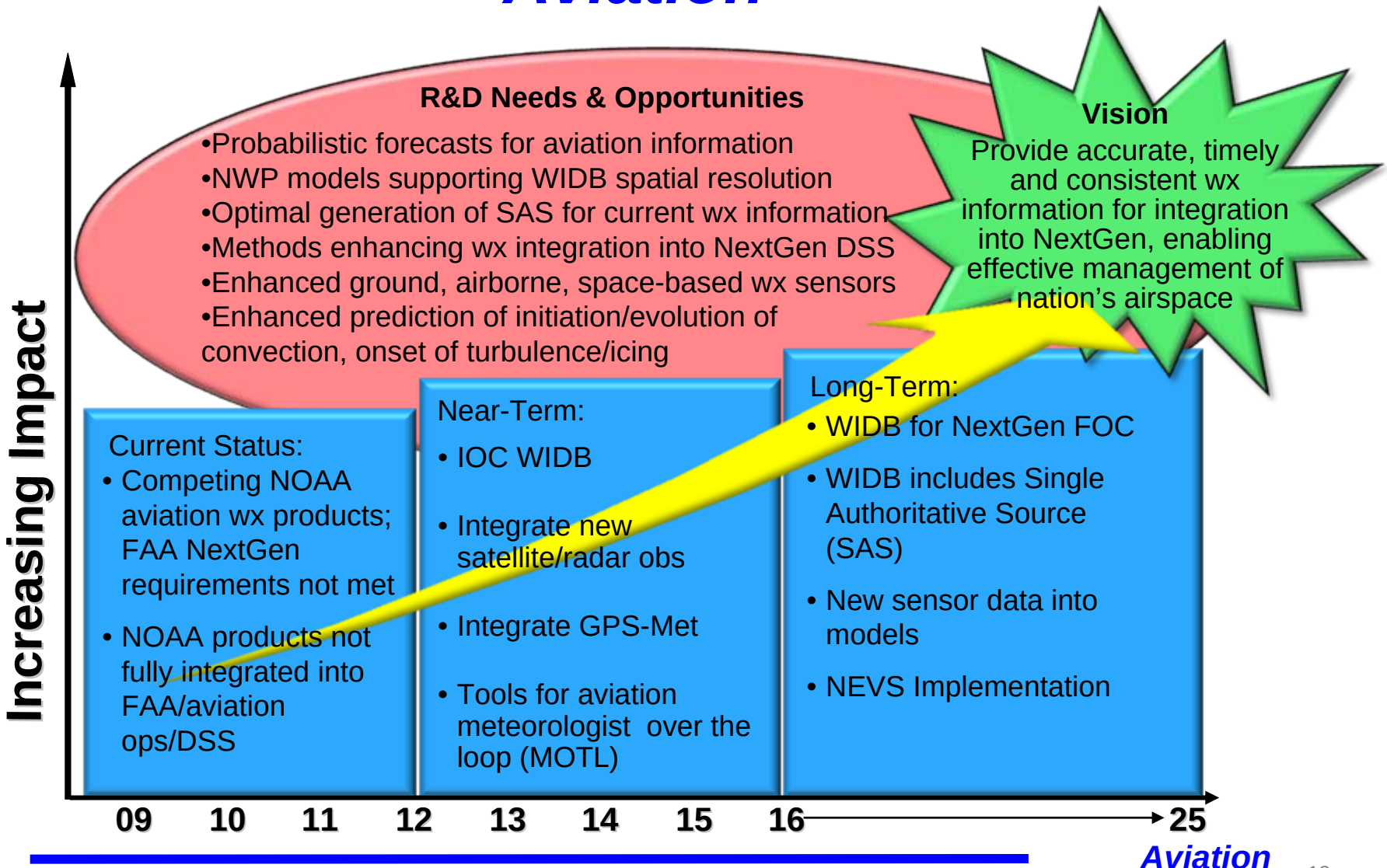
R&D Needs and Opportunities

- **Long-Term (2017 through *roughly* 2025)**
  - Improved Weather Sensing and Forecasting Models
  - Adaptive Weather Observation Capabilities
  - Forecast Process Enhancements (Optimum Human/Automation mix)

Aviation Alternative Solutions



Focus Area Team Summary: Aviation



NWS Science and Technology Roadmap

Aviation Team Additional Information

Target Performance Measures:* Aviation

Proposed	Current (2009)	FY 2016 Target Example	FY 2025 Target Example*
Turbulence	Subjective/Qualitative Measures @ 3000 feet vertical resolution: – Light - Severe – Moderate - Extreme	Quantitative Forecast of Eddy Dissipation Rate at resolutions: • vertical: 2000 feet • horizontal: 8 km	Quantitative Forecast of Eddy Dissipation Rate at resolutions: • vertical: 500 feet • horizontal: 4 km Accuracy: 2 km (space) and 15 min (time) (<2 hr begin/end time)
Icing	Subjective/Qualitative Measures (e.g., grids and AIRMETs), some at at 1000 ft vertical resolution: – Light – Moderate – Severe	Quantitative Forecast of Ice Accretion Rates at resolutions: • vertical: 2000 feet • horizontal: 8 km	Quantitative Forecast of Ice Accretion Rates at resolutions: • vertical: 500 feet • horizontal: 4 km Accuracy: 2 km (space) and 15 min (time) (<2 hr begin/end time)
Convective Initiation	Model Data and Various Forecast Processes/Products (e.g., SIGMETs, CCFP, NCWF, TAFs, NDFD gridded Convective Hazard Outlook)	Meteorologist oversight (MOTL) and value added to automated model output at resolutions: • vertical: 2000 feet • horizontal: 8 km	Meteorologist oversight (MOTL) and value added to automated model output at resolutions: • vertical: 500 feet • horizontal: 1 km Accuracy: 0.5 km (space) and 15 min (time) (<2 hr begin/end time)
Ceiling/ Visibility	TAFS Gridded Model-Based Visibility (e.g., 12km horizontal resolution)	Meteorologist oversight (MOTL) of C&V grids at resolutions: • vertical: 2000 ft • horizontal: 8 km	Meteorologist oversight (MOTL) of C&V grids at resolutions: • vertical: 500 ft • horizontal: 4 km Accuracy: 250 feet en route
Low Level Winds	TAFS and meteorologist oversight of NDFD wind speed/direction/gust grids at 2.5-5km resolution: 10mph (speed) & 20 degrees (direction) 0-3 hrs 15mph and 30 degrees 3-12 hour forecast	Meteorologist oversight (MOTL) of wind grids at resolutions: • horizontal: 2.5 km • temporal: 30 min • 10mph and 15 degrees	Meteorologist oversight (MOTL) of wind grids at resolutions: • horizontal: 2.5 km • temporal: 30 min • 5mph and 10 degrees at 0-12 hrs

** See table notes on next slide.*

Target Performance Measures: Aviation (continued)

Table Notes (from previous slide)

1. The FAA/JPDO (in coordination with NWS) is in the process of identifying and documenting the NextGen Weather-Related Performance Requirements. Content from the associated soon-to-be-released reports and studies will be added on previous slide, where appropriate.

2. FY2025 Target examples (right column of table) are gridded deterministic and probabilistic products.

Expanded Notes on Impacts (Slide 3)

In its May 2008 report on the cost of flight delays to passengers, the airline industry and the economy, ("*Your Flight Has Been Delayed Again*"), the Congressional Joint Economic Committee quantified the total cost of air traffic delays for 2007 at $41B. Federal Aviation Administration (FAA) records indicate that on average, weather is a factor in 70 percent of delays, amounting to roughly $29B of this cost. The FAA estimates that 2/3rds of those delays may be avoided with more accurate, timely and consistent weather information with better integration into FAA's Air Traffic Management (ATM) Decision Support Systems. These figures indicate that the potential savings from NextGen weather could be as much as $19.1B.

The total excess jet fuel consumed during airline delays resulted in the output of an estimated 7.07 million metric tons of CO_2, in 2007. A reduction in delays by 5% would cut CO_2 emissions by an estimated 350,000 metric tons.