FAA NextGen Weather Systems

Common Support Services-Weather (CSS-Wx) and NextGen Weather Processor (NWP)

Presented to: ATIEC 2016
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Purpose

• Provide information on FAA NextGen Weather Systems
  – NextGen Weather Processor (NWP)
  – Common Support Services Weather (CSS-Wx)

• Describe NextGen Weather products and models
  – IWXXM and WXXM
Delivering NextGen Improvements

**Legacy System**
- Radar
- Inefficient Routes
- Voice Communications
- Disparate Information
- Fragmented Weather Forecasting
- Weather Restricted Visibility
- Forensic Safety Systems
- Nationwide Focus

**NextGen**
- Satellite
- Performance Based Navigation (fuel savings)
- Voice & Digital Communications
- Automated Decision Support Tools
- Integrated Weather Information
- Improved Access in Low Visibility
- Prognostic Safety Systems
- Focus on Congested Metroplexes

[https://www.faa.gov/nextgen/programs](https://www.faa.gov/nextgen/programs)
Key Benefits of CSS-Wx and NWP

- **Reduce FAA Operations Costs**
  - $2.0B Cost Avoidance Over 25 Year Lifecycle Including $350M Ops Cost Savings
  - Eliminates Need for Legacy System Tech Refreshes

- **Modernize National Airspace System**
  - Decommission Outdated Systems
  - Leveraging SWIM and FTI
  - Cloud Compatibility
  - Global Data Standardization

- **Improve Efficiency**
  - Over $2.8B of User Benefits
  - Reduce Flight Delays
  - Enable Collaborative Decision-making

- **Improve Safety**
  - Enhanced Weather Information
  - Greater Access
  - Common Situational Awareness
## NextGen Weather Systems Scope

### Common Support Services – Weather (CSS-Wx)
- Provides a single source for FAA weather information and establishes enterprise level common support services using SWIM
- Focuses on weather information management, publishing to support users, and providing new interface standards and formats
  - Consistent with global standards (e.g., WXXM)
  - Provides geospatial data access services (WFS, WCS, WMS, WMTS)
- Enables decommissioning of legacy weather dissemination systems (e.g., WARP WINS, FBWTG, CDDS)

### NextGen Weather Processor (NWP)
- Produces advanced aviation specific weather products
  - 0 to 8 hour aviation weather products
  - Real-time weather radar information (e.g., ERAM)
  - Convective Weather Avoidance Fields
  - Wind Shear alerts
- Translates weather information into weather avoidance areas for integration into decision support tools (e.g., TFMS, TBFM)
- Provides Aviation Weather Display (AWD) of NextGen weather information for ATC users
- Enables decommissioning of legacy weather processor systems (e.g., WARP, ITWS, CIWS)
NextGen Wx Providers/Consumers

NWP
AWD

Service Adaptors

CSS-Wx

ADAS WMSCR

NOAA

NAS Enterprise Security Gateway (NESSG)

External Aviation Users

Flight Services, Providers, Airlines

User Systems (ERAM, MicroEARTS, ATOP, DOTS+, FDP2K)

Decision Support Tools (TFMS, TBFM, TFDM)

IDS-R

SWIM
NextGen Wx Systems Architecture

**Stakeholders**
- NAS Web Users
- NESG

**Central & Terminal Processors**

**NextGen Weather Processor (NWP)**
- ATCTs
- TRACONs
- CERAPs
- ARTCCs
- ATCSCC

**Common Support Services – Weather (CSS-Wx)**
- Canadian Wx Radars
- WMSCR/ADAS
- Surface Obs Networks
- MDCRS
- NOAA Data
- Lightning Networks
- NEXRAD

**AWD replaces legacy displays:**
- WARP BT, CIWS SD, ITWS SD, ITWS Web, CIWS Web

**Legacy Weather Consumers**

**Modern Weather Consumers**

**External Weather Consumers**

**Service Adaptors**

**System Wide Information Management (SWIM)**

**Aeronautical Information Management Modernization (AIMM)**

**Aviation Information World - Forecasting the Future**
NextGen Demonstrations

NextGen Integration and Evaluation Capability (NIEC)

Capability Evaluations (CE) – NIEC/FTB
- Evaluate SWIM data exchange
  - Ground: Between Systems / Users
  - Air-Ground: Via AAtS System
- Evaluate/Develop Wx Integration and New Applications

Global SWIM Demonstrations – FTB
- Mini Global II (MG II)
  - Global AIXM, IWXXM, & FIXM exchange
- Complex ATM Scenarios

NWP Test Reference System
- Generate NWP Test Data
- Could be provided to users for early development and demonstration
CSS-Wx Data Access Services

- Ingests weather sensor, NWP data and NOAA data (e.g. Satellite, models)
- Makes weather data available through Web Services
- Adheres to international standards for handling and representing geospatial data
- Consumers subscribe to CSS-Wx products through SWIM
  - Web Service Description Documents (WSDDs)
  - Product Description Documents (PDDs)
  - Sample data
  - Client Library / Software

<table>
<thead>
<tr>
<th>Web Coverage Service</th>
<th>Web Feature Service</th>
<th>Web Map Service</th>
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| - Filters and transforms large gridded dataset | - Filters and transforms non-gridded data sets  
| - NetCDF format            | - WXXM 2.0 XML format                        | - Renders weather data as single large image or sets of tiled images for display  
|                           |                                             | - JPEG, PNG, GIF, KML format                         |
Weather Data Models Used by CSS-Wx

### Data Model Component Agility

- **EU-Specific Components**
- **US-Specific Components**
- **Other Stakeholder Components**

**Other Aviation-Specific Weather Components (WXXM)**

**Operational ICAO Defined Aviation-Specific Weather Components (ICAO IWXXM)**

- **GML** ISO 19136
- **Observations and Measurements** ISO 19156
- ISO 19103, 19107, 19108, 19115, 19123, ...

- **XML**
- **UML**

### Standards Governance Body

- **Individual Organizations**
- **EUROCONTROL (SJU), FAA, and others**
- **International Civil Aviation Organization (ICAO) and World Meteorological Organization (WMO)**
- **ISO / OGC**
- **W3C / OMG**

Descriptions of US and International weather data models are available at [https://wiki.ucar.edu/display/CSSWX/Weather+Data+Models](https://wiki.ucar.edu/display/CSSWX/Weather+Data+Models)
NextGen Wx Services/Products

Conversions
- Conversion to/from spherical, NAD83 and WGS84 and unit conversions

Filtering
- Filter weather data based on user - selected field/layer names

Decimation
- Decreased data resolutions with data interpolation methods

Quantization
- Quantize data values of a user - specified weather product

Re-projections
- Re-projection for Lambert Conformal, Latitude/Longitude, Mercator, Stereographic, Cartesian, En Route, and Oceanic NAS Projection map projection coordinates and Tile Matrices

End-User Algorithms
- Composite Reflectivity with Flexible Floor
- Icing And Composite Icing Layer
- Composite Turbulence and Turbulence Layer
- Precipitation Altitude Mask
- CWAM Weather Avoidance Field

Display Algorithms
- Precipitation Grid Display
- Composite Reflectivity Grid Display
- Icing Grid Display
- Icing Contour Display
- Turbulence Grid Display
- Turbulence Contour Display
- Altitude - Masked Precipitation Grid Display

Web Services
- WCS
- WFS
- WMS
- WMTS

Subscription Services

Common Support Services – Weather (CSS-Wx)

Acquisition Services

NextGen Weather Processor (NWP)

Data Ingest

Per-Radar Processing

Mosaic, Analysis & Prediction

Weather Avoidance & Scoring

Post Processing

Product Server

End User Processing

NextGen Weather

Domain Mosaics
- Precipitation (VIL)
- Surface
- Precipitation Phase
- Echo Tops
- Composite Reflectivity
- Satellite
- Base Reflectivity
- Icing Tops & Bottoms

Domain Non- Gridded
- Precipitation (VIL) & Echo Tops (ET)
- Forecast Accuracy
- Aggregated Lightning Flashes & Tornado Detections
- Storm Information Hazard Texts, Leading Edges, & Motion Vectors
- Precipitation (VIL) & ET Contours
- Fronts, Trends & Wind Profiles
- Convective WAF Mosaic Polygons
- Jet Stream and Airport Status Summary

Weather Avoidance (Analysis and Forecast)
- Convective Wx Avoidance Field
- RAPT and ARSI Convective Wx Avoidance Field

Terminal Products
- ASR Precipitation Mosaic and with AP Indicated
- Microburst and Gust Front TRACON Map
- Gust Front Estimated Time of Impact
- ATIS Panel Message
- Configured & Tornado Alerts
- Airport Lightning Warning
- Storm Information Motion Vectors, Leading Edges, & Hazard Texts (ASR)
- Runway Configuration & AP Status
- Terminal Wx Information for Pilots

End-User Algorithms
- Weather (CSS-Wx)
- Processor (NWP)
- Subscription Services
- Hosted Algorithms

Display Algorithms
- Aviary Wx Display
- Composite Turbulence and Turbulence Display
- Turbulence Grid Display
- Turbulence Contour Display
- Altitude - Masked Precipitation Grid Display

Distribution Services

Discovery / Catalog

N-Tier Services
- Hosted Algorithms
- Wx Alerts
- Complex Query

Aviation Wx Products
Gridded Data Products

- Gridded products represented as uniformly spaced observations or computed values on rectangular arrays

- Mapping projection needed to map data grid to earth’s surface
  - Examples: Lambert Conic Conformal, Lambert Azimuthal Equal Area

- Network Common Data format (NetCDF4) used to model gridded data products
Non-Gridded Data Products

- Non-gridded products express singular or sparsely distributed geospatial sets of observations or forecasts
  - Contours, point products, text products

- WXXM2 format and extensions (FAAWX) used to represent non-gridded data

- Geo-reference coordinates (latitude, longitude) used to represent data locations
Image Data Products

• Image formats include
  – GIF
  – PNG
  – JPEG
  – TIFF
  – GEOTIFF

• Image data can be
  – Single tile
  – Set of tiles

• Allow specification of
  – Coverage
  – Map projection
  – Tile size(s)
  – Color palette
NWP Domains

CONUS+

ALASKA

GUAM

HAWAII
NextGen Wx Product Generation Locations

2 central and 34 terminal processing locations
List Reporting / Missing Radars in Mosaics

Dynamic Radar Coverage Pattern
NetCDF string variable `grid_metadata` contains the grid metadata.

When a radar is present in the mosaic the `nwp:status` value is “RECEIVED” and there is additional information in the `nwp:Sensor` XML block:

```xml
<nwp:Sensor type="NEXRAD" name="PAPD">
  <nwp:location srsName="http://www.opengis.net/def/crs/EPSG/0/4052" srsDimension="2" axisLabels="latitude longitude">65.035114 -147.501431</nwp:location>
  <nwp:status>RECEIVED</nwp:status>
  <nwp:dataTime>
    <gml:TimePeriod gml:id="id7">
    </gml:TimePeriod>
  </nwp:dataTime>
  <nwp:advection uom="s">21</nwp:advection>
</nwp:Sensor>
```

When a radar is not present the `nwp:status` value is “MISSING”:

```xml
<nwp:Sensor type="NEXRAD" name="PAKC">
  <nwp:location srsName="http://www.opengis.net/def/crs/EPSG/0/4052" srsDimension="2" axisLabels="latitude longitude">58.679444 -156.629444</nwp:location>
  <nwp:status>MISSING</nwp:status>
</nwp:Sensor>
```

Regardless of `nwp:status`, the radar location is specified.
Mosaic Examples

- ViL Mosaic
- Echo Tops Mosaic
- Growth Trends Mosaic
- Comp Refl Mosaic
- Base Refl Mosaic
- Lightning
Analysis / Per-Terminal Examples
Predictions / Wx Avoidance Examples

- VIL Precipitation 0-8 Hr
- Echo Tops 0-8 Hr
- Precip. Phase 0-8 Hr

- Convective Weather Avoidance Model (CWAM)
- Convective Weather Avoidance Polygons (CWAP)
# NWP WXXM Products

## NWP Non-Gridded Analysis Products
- Precipitation (VIL) Forecast Accuracy
- Echo Tops Forecast Accuracy
- Aggregated Lightning Flashes
- Aggregated Tornado Detections
- Storm Information Echo Tops
- Storm Information Hazard Texts
- Storm Information Leading Edges
- Storm Information Motion Vectors
- Storm Information Precipitation Cells
- Precipitation (VIL) Contours
- Echo Tops Contours
- Fronts
- Growth Trends
- Wind Profiles
- Convective WAF Mosaic Polygons
- Jet Stream
- Airport Status Summary

## NWP Non-Gridded Terminal Products
- Microburst TRACON Map
- ATIS Panel Message
- Gust Front TRACON Map
- Gust Front Estimated Time of Impact
- Configured Alerts
- Tornado Alert
- Airport Lightning Warning
- Storm Information Motion Vectors (ASR)
- Storm Information Leading Edges (ASR)
- Storm Information Hazard Texts (ASR)
- Runway Configuration
- AP Status
- Terminal Weather Information for Pilots

## NWP Non-Gridded Prediction Products
- Forecast Confidence
- Precipitation (VIL) Forecast Contours
- Echo Tops Forecast Contours
- Fronts Forecast
- Convective WAF Forecast Polygons
Current and Future NWP Products

NextGen Weather Processor (NWP) Product Generation Platform

Per-Radar Processing
Mosaic
Analysis
0-8 hour Prediction
Weather Avoidance
Scoring
Post Processing

Convective Weather Avoidance Polygons
Forecast Confidence
Offshore Precipitation
4D Trajectory Weather

Forecast Confidence (Z9901)
NextGen Weather Systems T&E

1. Test Capability Accreditation
2. FAA Power Test
3. ROC NEXRAD Certification
4. Assessment Authorization Analysis
5. Regression Test
6. Regression Test
7. Regression Test
8. Regression Test
9. CSS-Wx and NWP Interoperability Test
10. Site Acceptance Test

Prime Contractor Activity
Contractor-Supported Activity
Integrated Facility Implementation

- ATCSCC
- 21 ARTCCs
- 33 TRACONs / 3 CERAPs
- ATCTs (Approx. 60)
- Harris
- Test Facilities
- MMAC/PSF

CSS-Wx
NWP

Salt Lake City
Atlanta

AWDs at all Sites

*ZSU Only (NWP)
CSS-Wx/NWP Implementation

**Current Wx Dissemination:**
- WARP WINS
- CDDS
- ITWS Web Server
- CREWS

**Legacy Wx Dissemination:**
- WMSCR
- ADAS
- ALDARS
- WIFS

**Current Wx Processing:**
- WARP RAMP
- CIWS
- ITWS

**Contract Award:** April 2015

**CSS-Wx Work Package 1**

**CSS-Wx Work Package 2**

**NWP Work Package 1**

**NWP Work Package 2**

**NWP Work Package 3**

**CY** 2015  2020  2030  2040

**ATHIEC** Aviation Information World - Forecasting the Future
FAA NextGen Weather programs are on contract for implementation
- NWP will generate advanced aviation weather products for NAS operations
- CSS-Wx will provide NWP and NOAA products along with other weather data to FAA and External users via SWIM
- IWXXM and WXXM are being implemented

Concept Evaluations and Global Demonstrations advance implementation of:
- FAA NextGen Wx Systems
- ICAO ATM and FAA NextGen concepts
Backup
Resources

https://www.faa.gov/nextgen/programs/
Key Acronyms

- ADAS: Automated Weather Observing System (AWOS) Data Acquisition System
- AIMM: Aeronautical Information Management Modernization
- APB: Acquisition Program Baseline
- ARTCC: Air Route Traffic Control Center
- ASR: Airport Surveillance Radar
- ATC: Air Traffic Control
- ATCSCC: Air Traffic Control System Command Center
- ATOP: Advanced Technologies and Oceanic Procedures
- AWD: Aviation Weather Display
- BT: Briefing Terminal (WARP)
- CDDS: CIWS Data Distribution Service
- CERAP: Combined Center Radar Approach Control
- CIWS: Corridor Integrated Weather System
- CREWS: CTAS Remote Weather System
- CSS-Wx: Common Support Services for Weather
- ERAM: En Route Automation Modernization
- FBWTG: FAA Bulk Weather Telecommunications Gateway
- IOC: Initial Operational Capability
- ITWS: Integrated Terminal Weather System
- LLWAS: Low-Level Windshear Alert System
- MDCRS: Meteorological Data Collection and Reporting System
- Micro-EARTS: Microprocessor En Route Automated Radar Tracking System
- NAS: National Airspace System
- NESG: NAS Enterprise Security Gateway
- NEXRAD: Next Generation Weather Radar (WSR-88D)
- NFU: NWS Filtering Unit
- NOAA: National Oceanic and Atmospheric Administration
- NWP: NextGen Weather Processor
- RAMP: Radar Acquisition and Mosaic Processor
- SD: Situation Display
- SWIM: System Wide Information Management
- TBFM: Time Based Flow Metering
- TDWR: Terminal Doppler Weather Radar
- TFMS: Traffic Flow Management System
- TRACON: Terminal Radar Approach Control
- WARP: Weather and Radar Processor
- WCS: Web Coverage Service
- WFS: Web Feature Service
- WINS: Weather Information Network Server
- WMS: Web Map Service
- WMSCR: Weather Message Switching Center Replacement
- WMTS: Web Map Tile Service
- WXXM: Weather Information Exchange Model
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