

# FAA NextGen Weather Systems

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

Presented to: ATIEC 2016

By: Alfred Moosakhanian, FAA

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*Aviation Information World - Forecasting the Future*



# 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



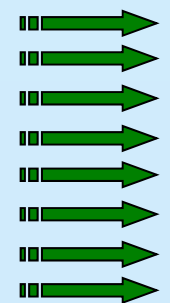
# Delivering NextGen Improvements

## Legacy System

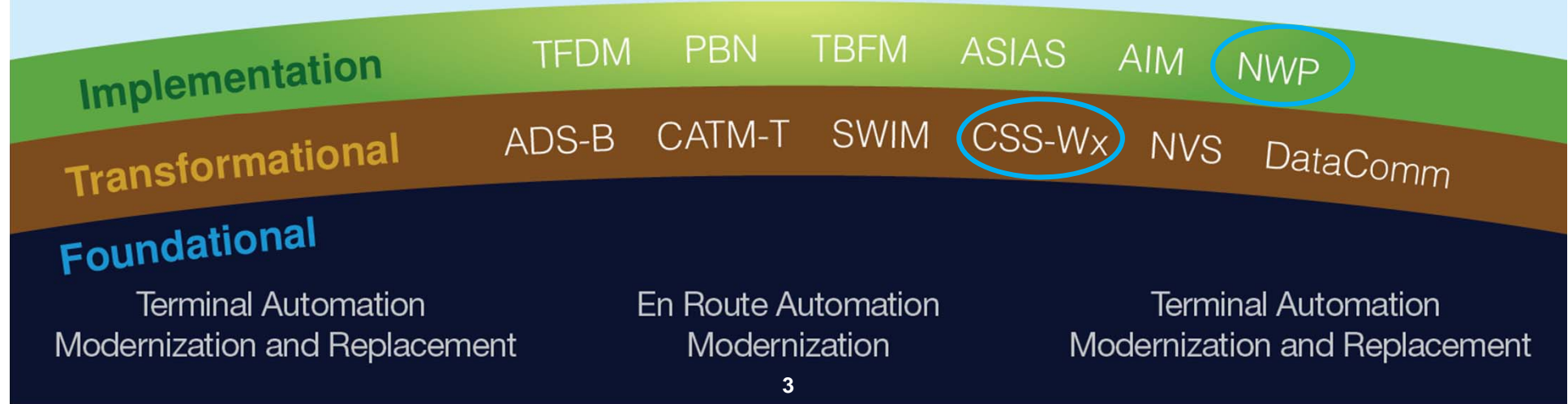
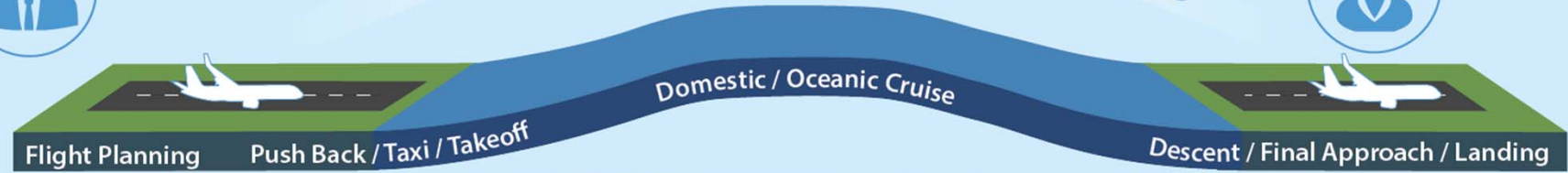
- Radar
- Inefficient Routes
- Voice Communications
- Disparate Information
- Fragmented Weather Forecasting
- Weather Restricted Visibility
- Forensic Safety Systems
- Nationwide Focus

## 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>





# 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***Decommission Outdated Systems Leveraging SWIM and FTI***  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)

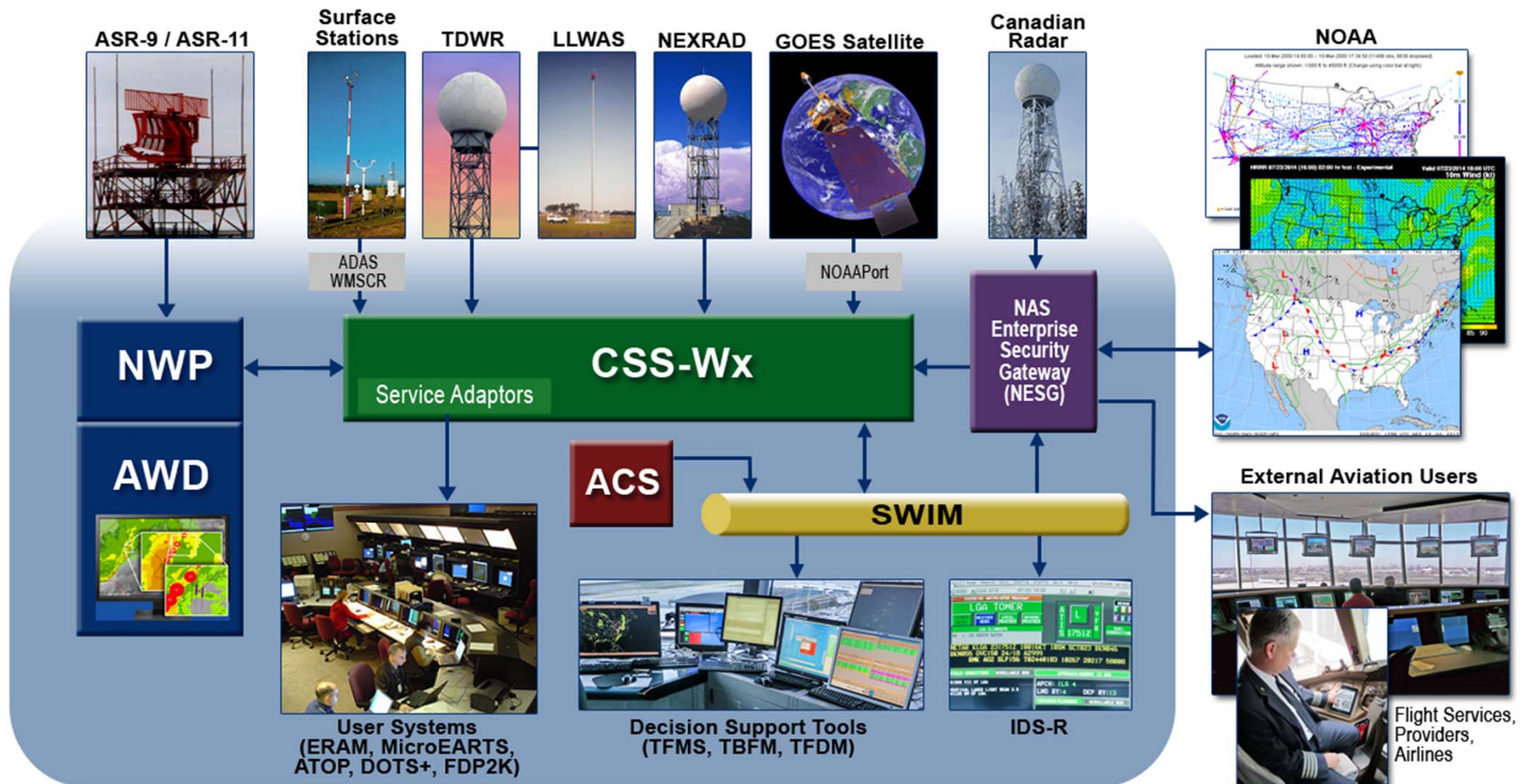
- Provides a single source for FAA weather information and establishes enterprise level common support services using SWIM
- Focuses on weather information management, publishing to support users, and providing new interface standards and formats
  - Consistent with global standards (e.g., WXXM)
  - 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)

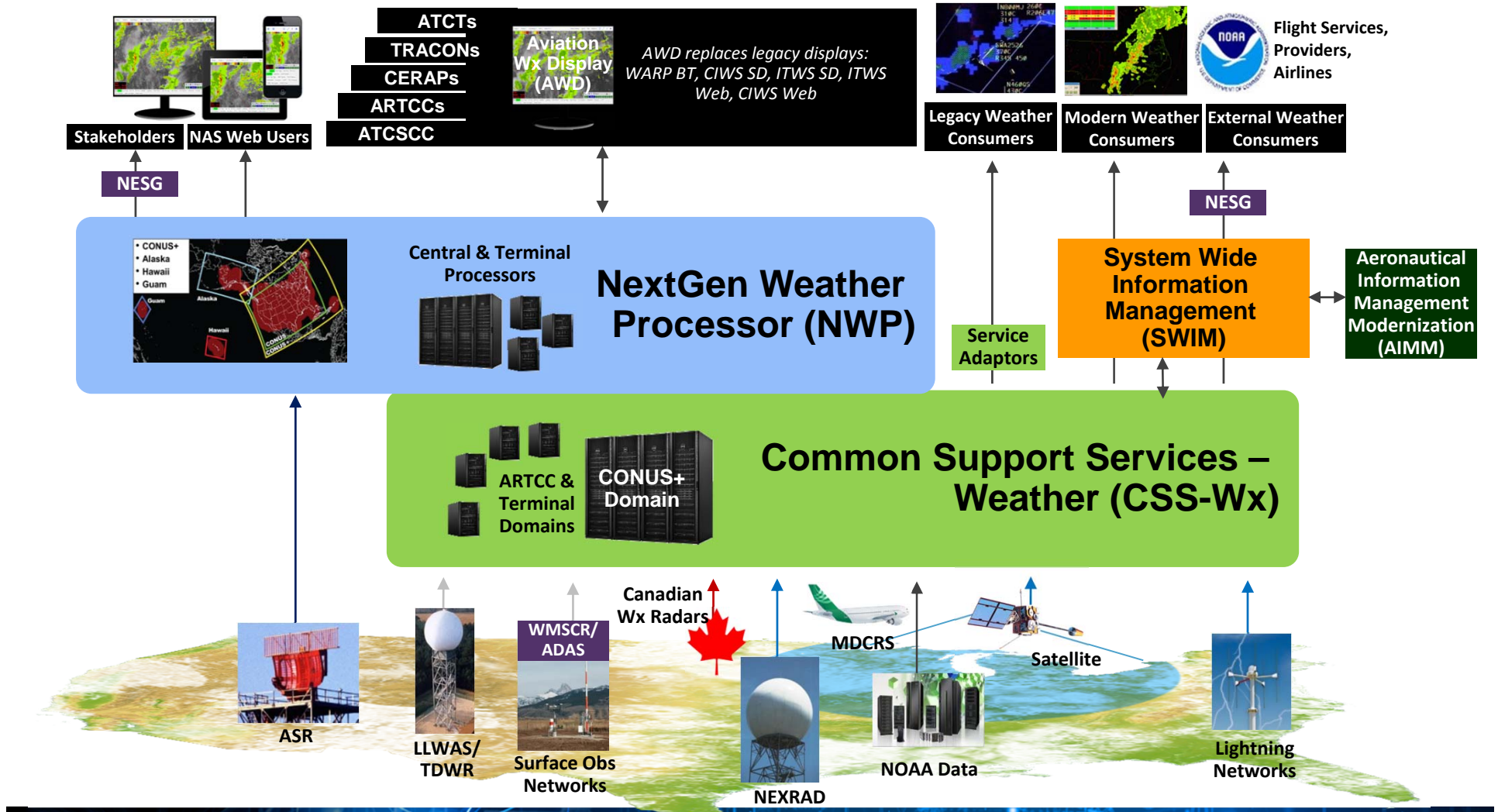


# NextGen Wx Providers/Consumers





# NextGen Wx Systems Architecture





# 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



## Web Coverage Service

- Filters and transforms large gridded dataset
- NetCDF format

## Web Feature Service

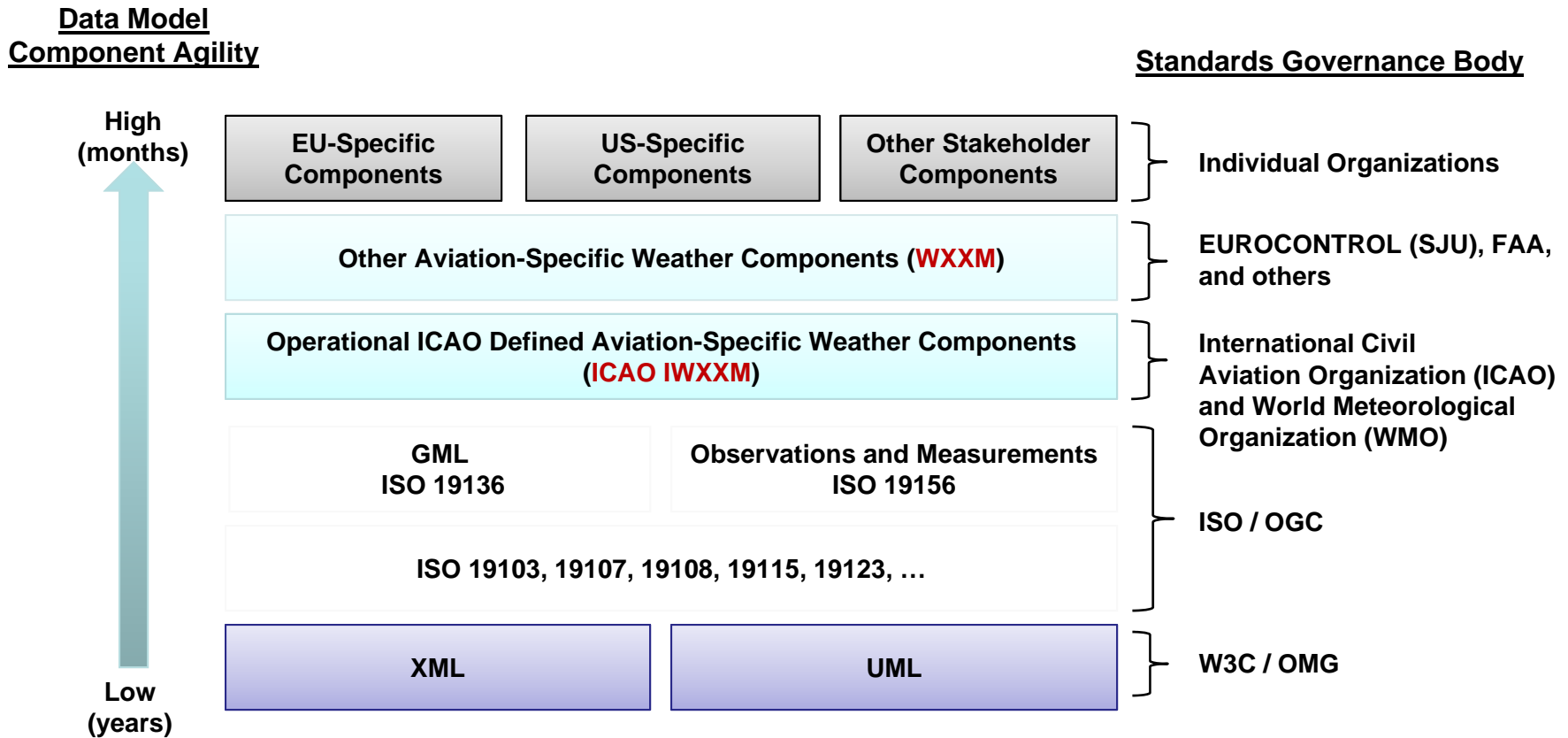
- Filters and transforms non-gridded data sets
- WXXM 2.0 XML format

## Web Map Service

- 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



Descriptions of US and International weather data models are available at <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

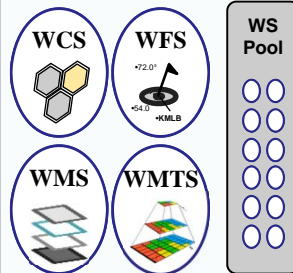
## Display Algorithms

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

## Common Support Services – Weather (CSS-Wx)

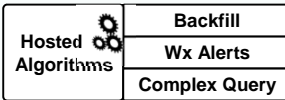
### Acquisition Services

### Web Services



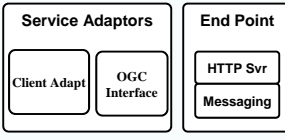
### Subscription Services

### N-Tier Services



### Discovery / Catalog

### Distribution Services



Wx Data

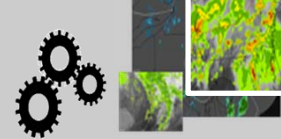
Aviation Wx Products

## NextGen Weather Processor (NWP)

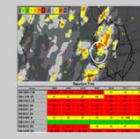
### Data Ingest

### Per-Radar Processing

### Mosaic, Analysis & Prediction



### Weather Avoidance & Scoring



### Post Processing

### Product Server

### End User Processing

## Domain Mosaics

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

## Domain Products

- Gridded Analyses
- Gridded Forecast (0-2hr)
- Gridded Forecast (2-8hr)
- Non-Gridded Analyses
- Non-Gridded Forecast

## 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)

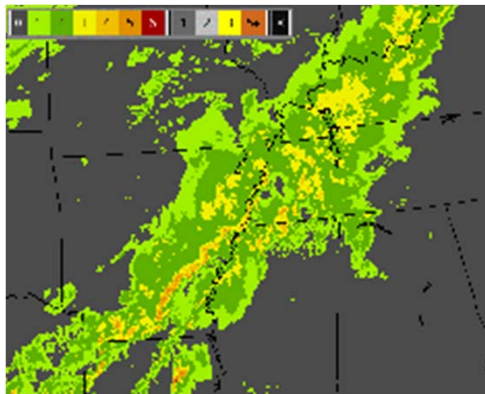
- Convective Wx Avoidance Field
- RAPT and ARSI Convective Wx Avoidance Field

## Terminal Products

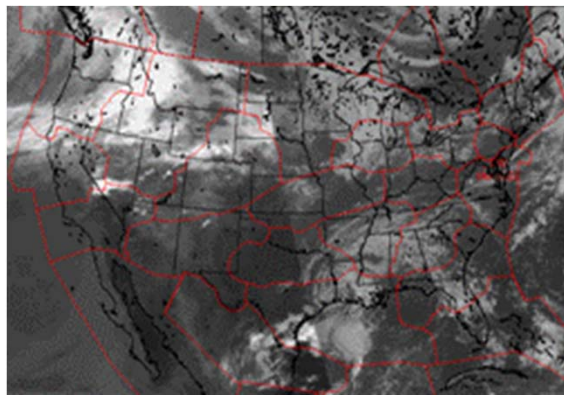
- ASR Precipitation Mosaic and with AP Indicated
- Microburst and Gust Front TRACON Map
- Gust Front Estimated Time of Impact
- ATIS Panel Message
- Configured & Tornado Alerts
- Airport Lightning Warning
- Storm Information Motion Vectors, Leading Edges, & Hazard Texts (ASR)
- Runway Configuration &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

# Gridded Data Products

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



Precipitation (VIL) Mosaic



Satellite Mosaic



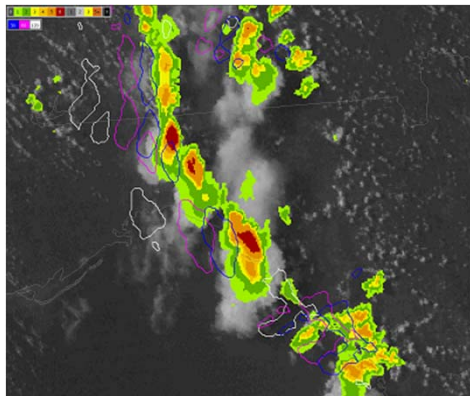
Terminal Winds

- 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

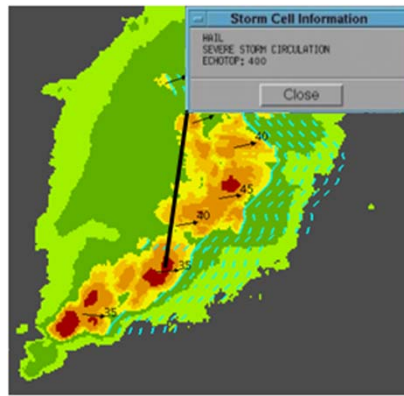


# Non-Gridded Data Products

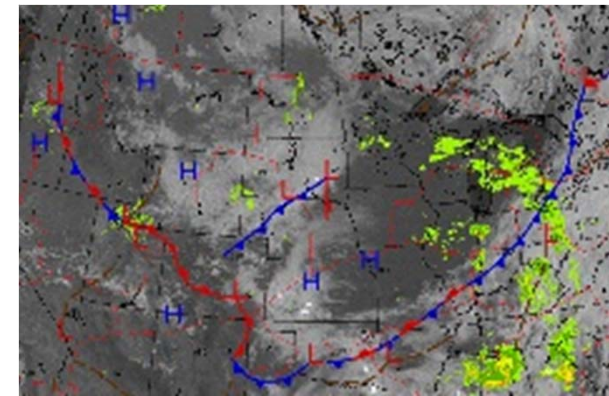
- **Non-gridded products express singular or sparsely distributed geospatial sets of observations or forecasts**
  - Contours, point products, text products



Precipitation Contours



Storm Motion Vectors,  
Extrapolated Positions,  
Hazard Text

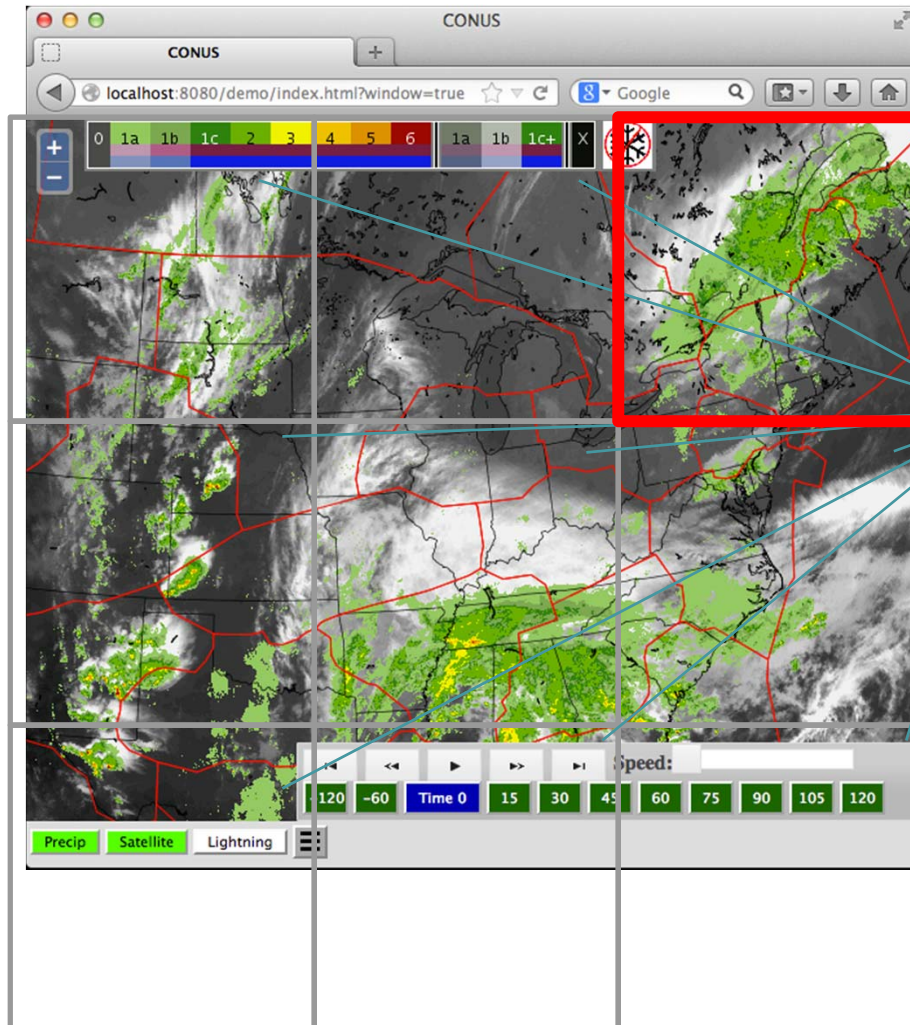


Fronts and Fronts Forecast

- **WXXM2 format and extensions (FAAWX) used to represent non-gridded data**
- **Geo-reference coordinates (latitude, longitude) used to represent data locations**



# Image Data Products

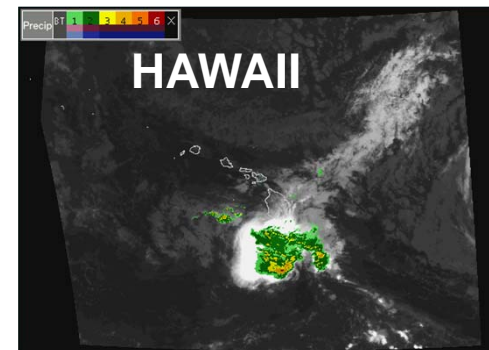
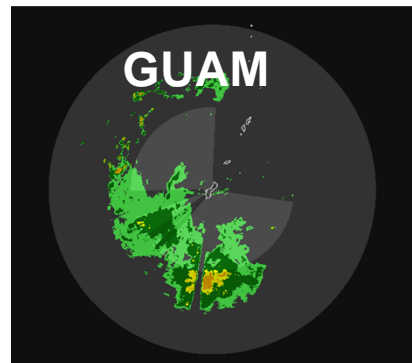
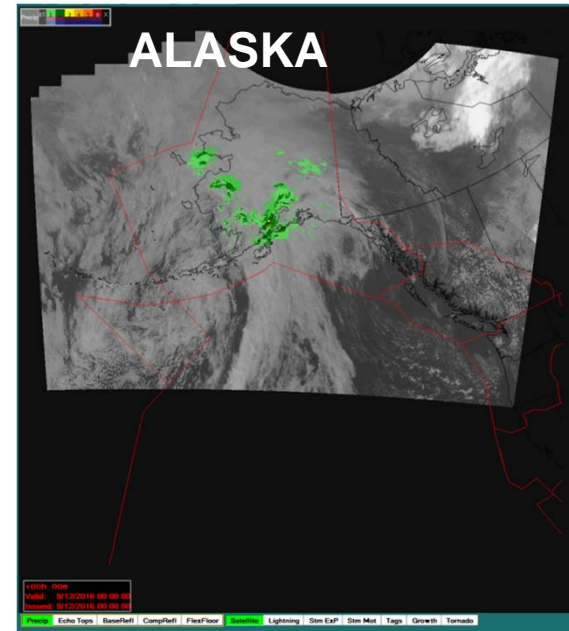
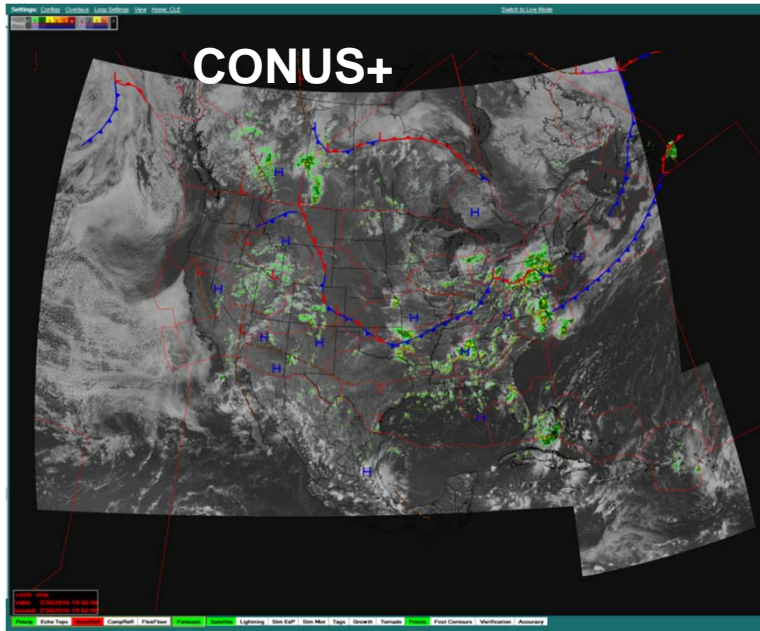


Individual Tile

Set of Tiles

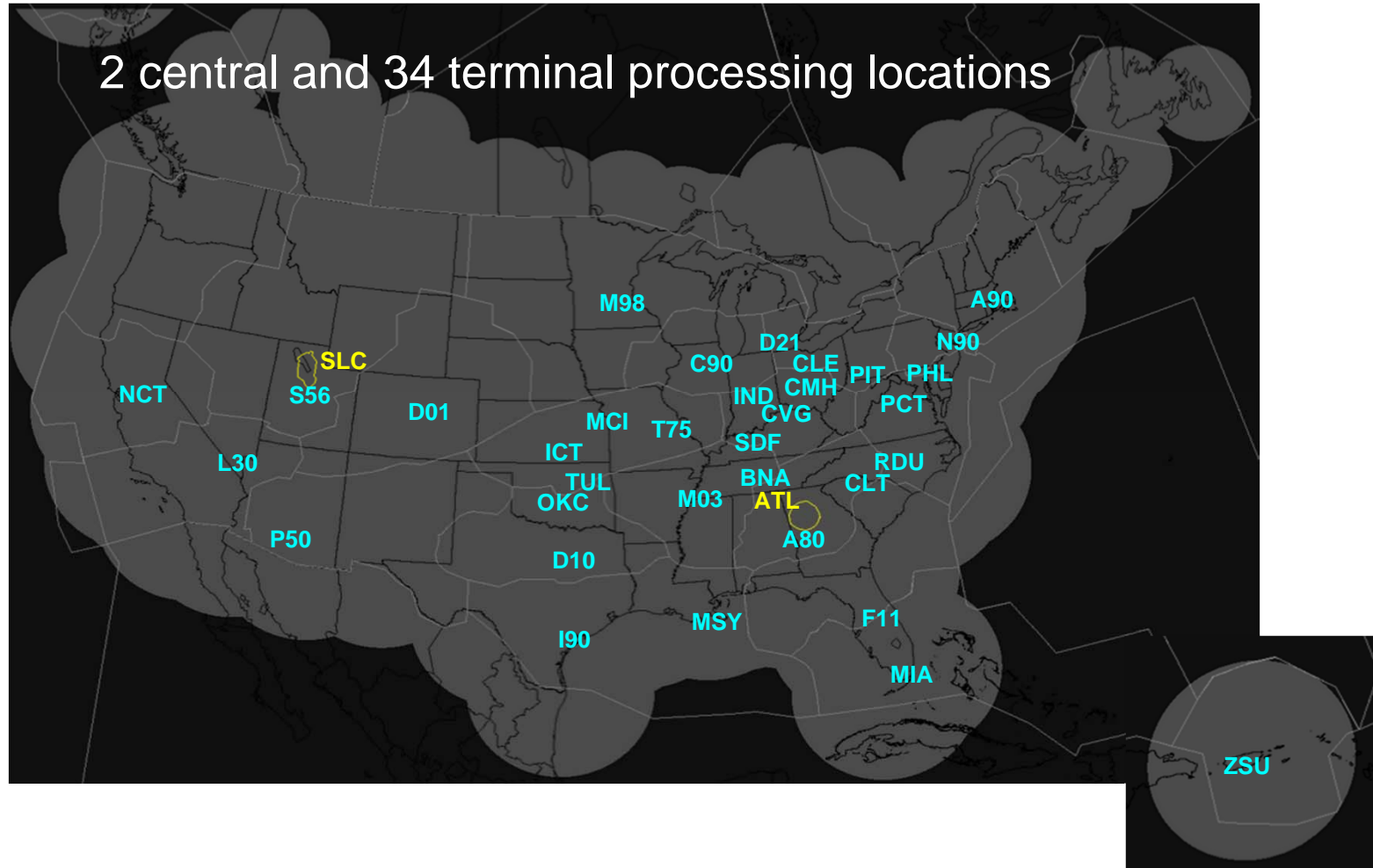
- Image formats include
  - GIF
  - PNG
  - JPEG
  - TIFF
  - GEOTIFF
- Image data can be
  - Single tile
  - Set of tiles
- Allow specification of
  - Coverage
  - Map projection
  - Tile size(s)
  - Color palette

# NWP Domains



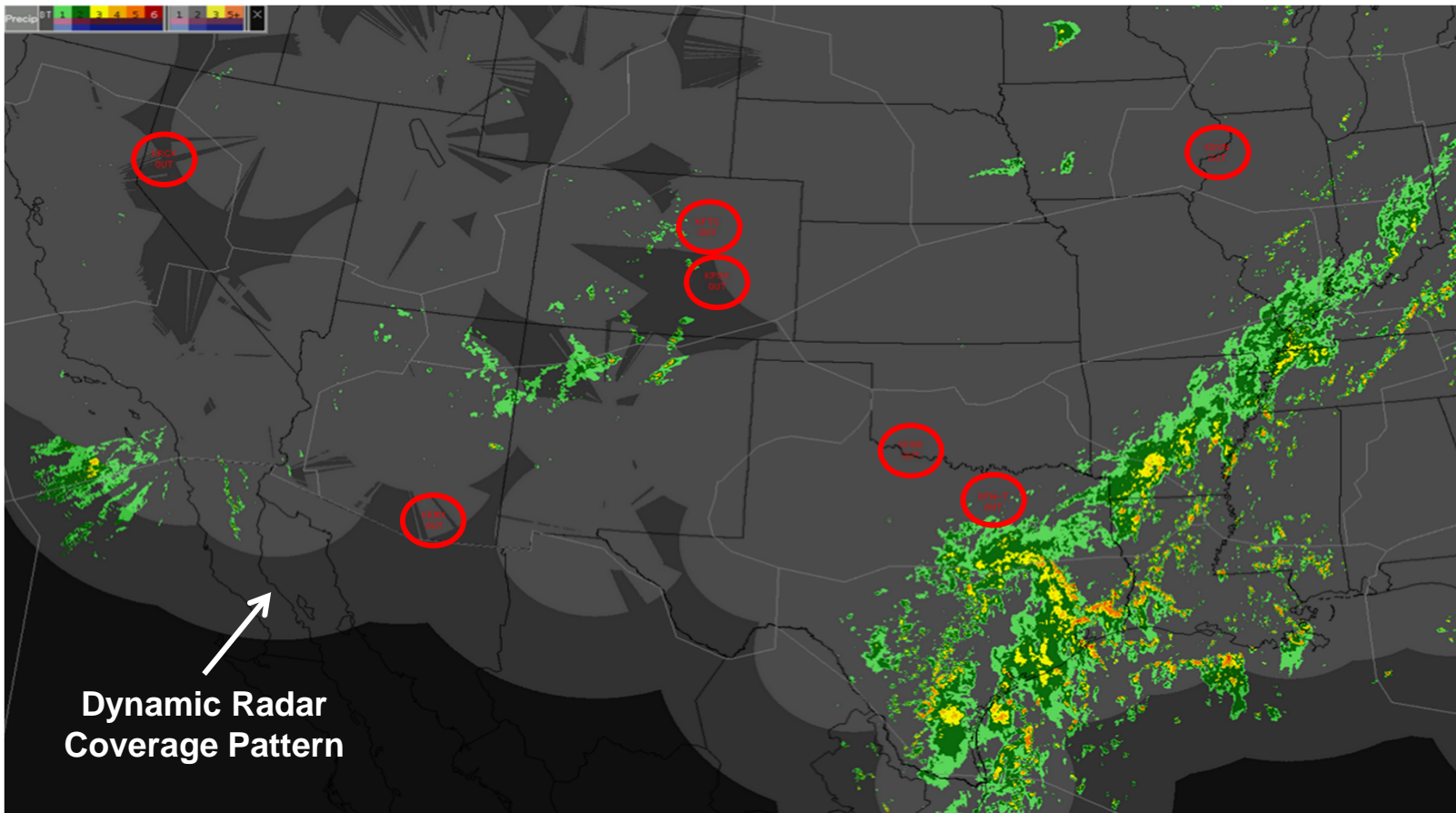


# NextGen Wx Product Generation Locations





# List Reporting / Missing Radars in Mosaics



# NetCDF4 Missing Radar Reporting

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:

```
<nwp:Sensor type="NEXRAD" name="PAPD">  
  <nwp:location srsName="http://www.opengis.net/def/crs/EPSSG/0/4052" srsDimension="2" axisLabels="latitude  
  longitude">55.035114 -147.501431</nwp:location>  
  <nwp:status>RECEIVED</nwp:status>  
  <nwp:dataTime>  
    <gml:TimePeriod gml:id="id7">  
      <gml:beginPosition>2016-07-09T23:58:15</gml:beginPosition>  
      <gml:endPosition>2016-07-10T00:02:09</gml:endPosition>  
    </gml:TimePeriod>  
  </nwp:dataTime>  
  <nwp:advection uom="s">21</nwp:advection>  
</nwp:Sensor>
```

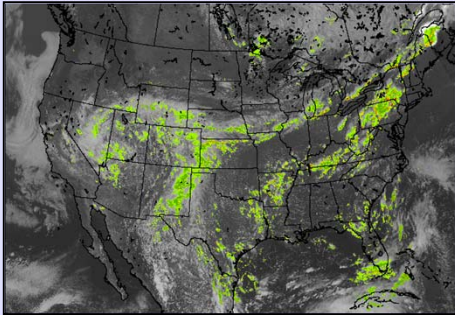
Regardless of  
`nwp:status`, the  
radar location is  
specified

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

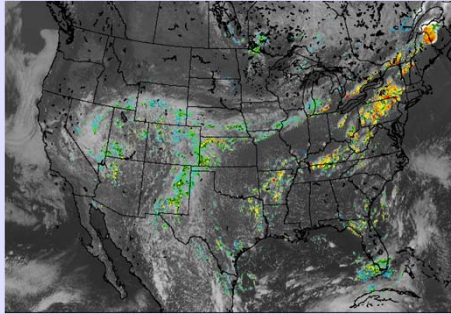
```
<nwp:Sensor type="NEXRAD" name="PAKC">  
  <nwp:location srsName="http://www.opengis.net/def/crs/EPSSG/0/4052" srsDimension="2"  
  axisLabels="latitude longitude">58.679444 -156.629444</nwp:location>  
  <nwp:status>MISSING</nwp:status>  
</nwp:Sensor>
```

# Mosaic Examples

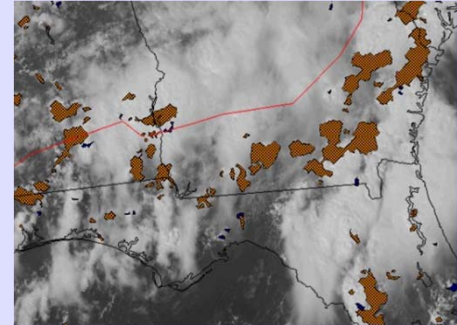
VIL Mosaic



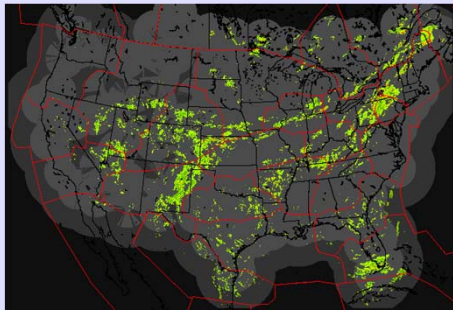
Echo Tops Mosaic



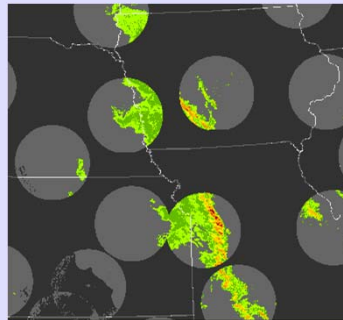
Growth Trends Mosaic



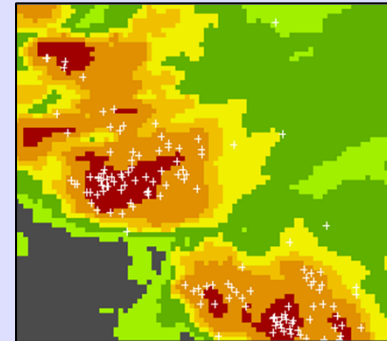
Comp Refl Mosaic



Base Refl Mosaic



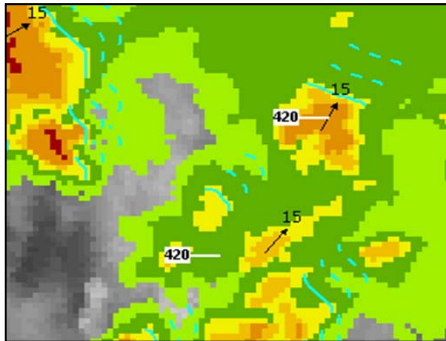
Lightning



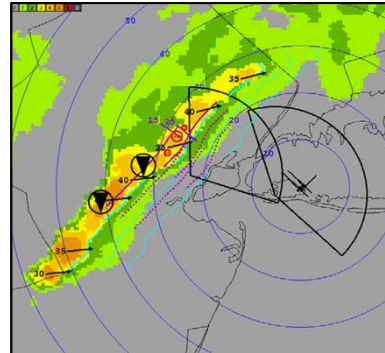


# Analysis / Per-Terminal Examples

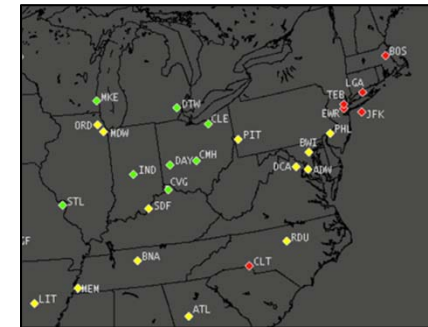
### Storm Information



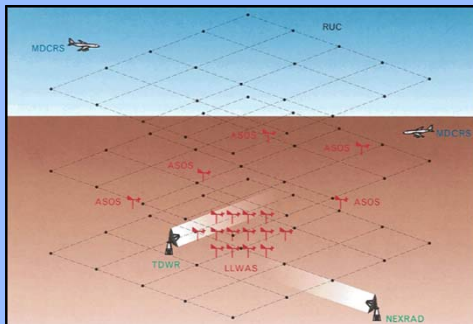
### Tornado Aggregation



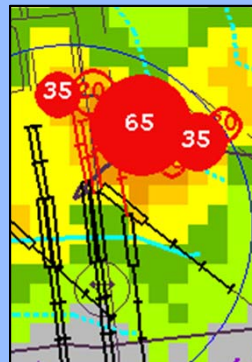
### Airport Status Summary



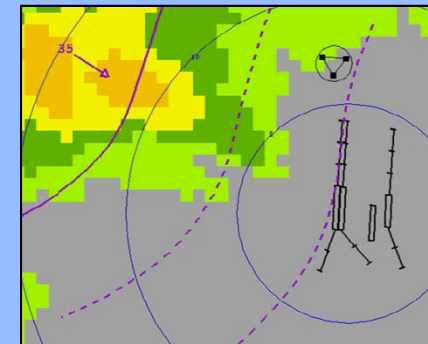
### Terminal Winds



### Microbursts & Wind Shear

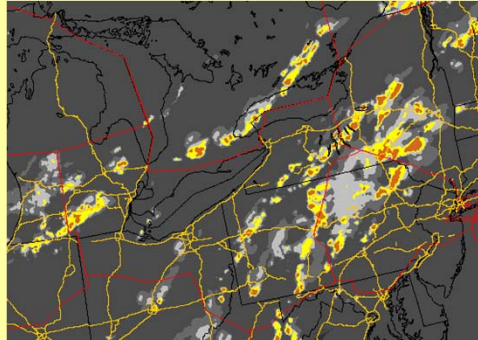


### Gust Fronts

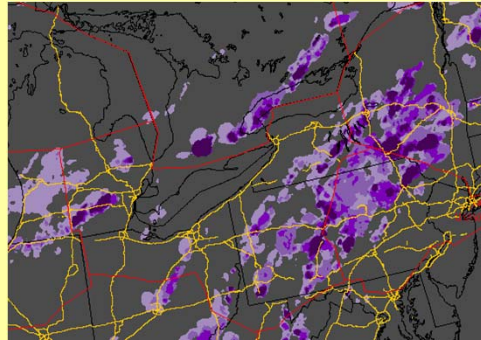


# Predictions / Wx Avoidance Examples

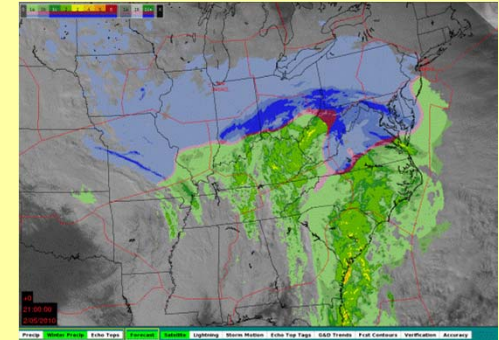
VIL Precipitation 0-8 Hr



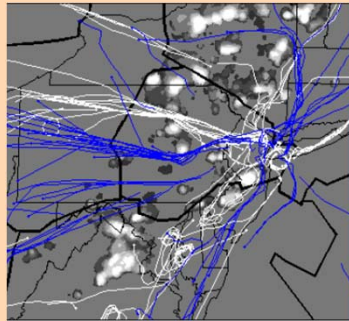
Echo Tops 0-8 Hr



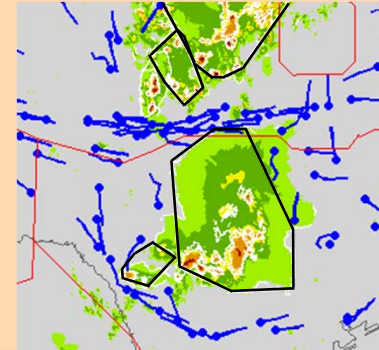
Precip. Phase 0-8 Hr



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

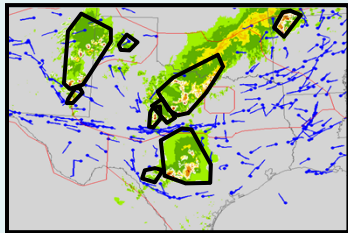




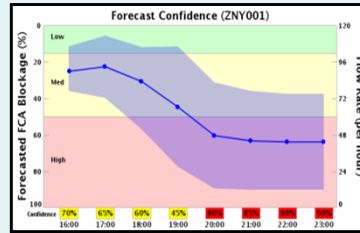
# Current and Future NWP Products



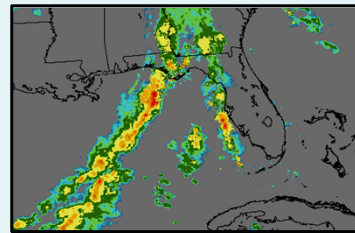
U.S. AIR FORCE



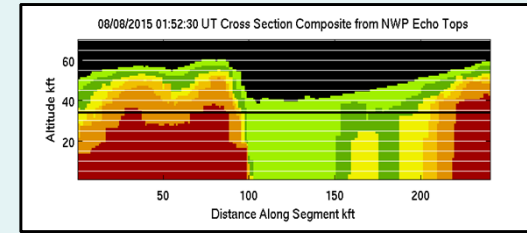
Convective Weather Avoidance Polygons



Forecast Confidence



Offshore Precipitation



4D Trajectory Weather

Per-Radar Processing

Mosaic

Analysis

0-8 hour Prediction

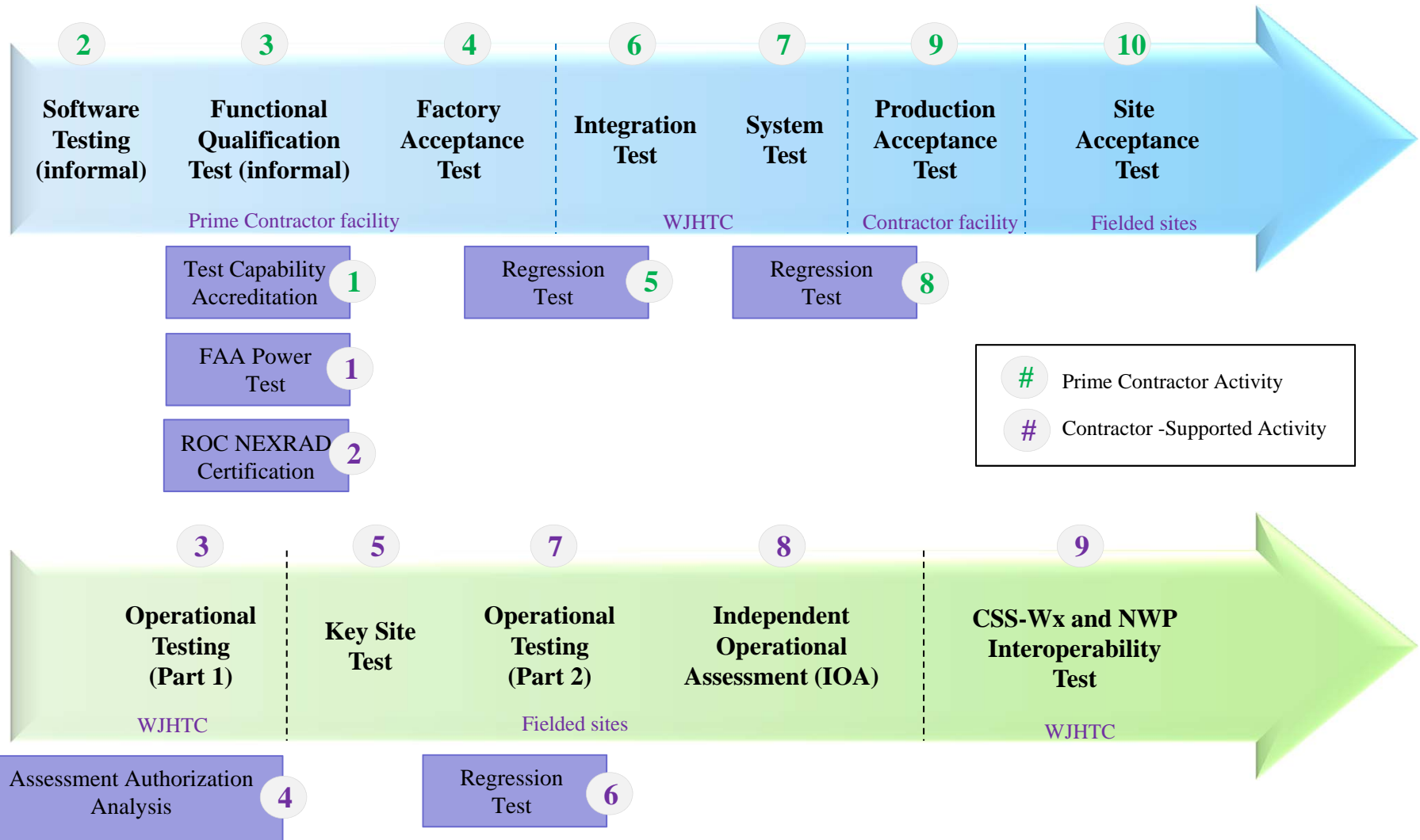
Weather Avoidance

Scoring

Post Processing

NextGen Weather Processor (NWP) Product Generation Platform

# NextGen Weather Systems T&E

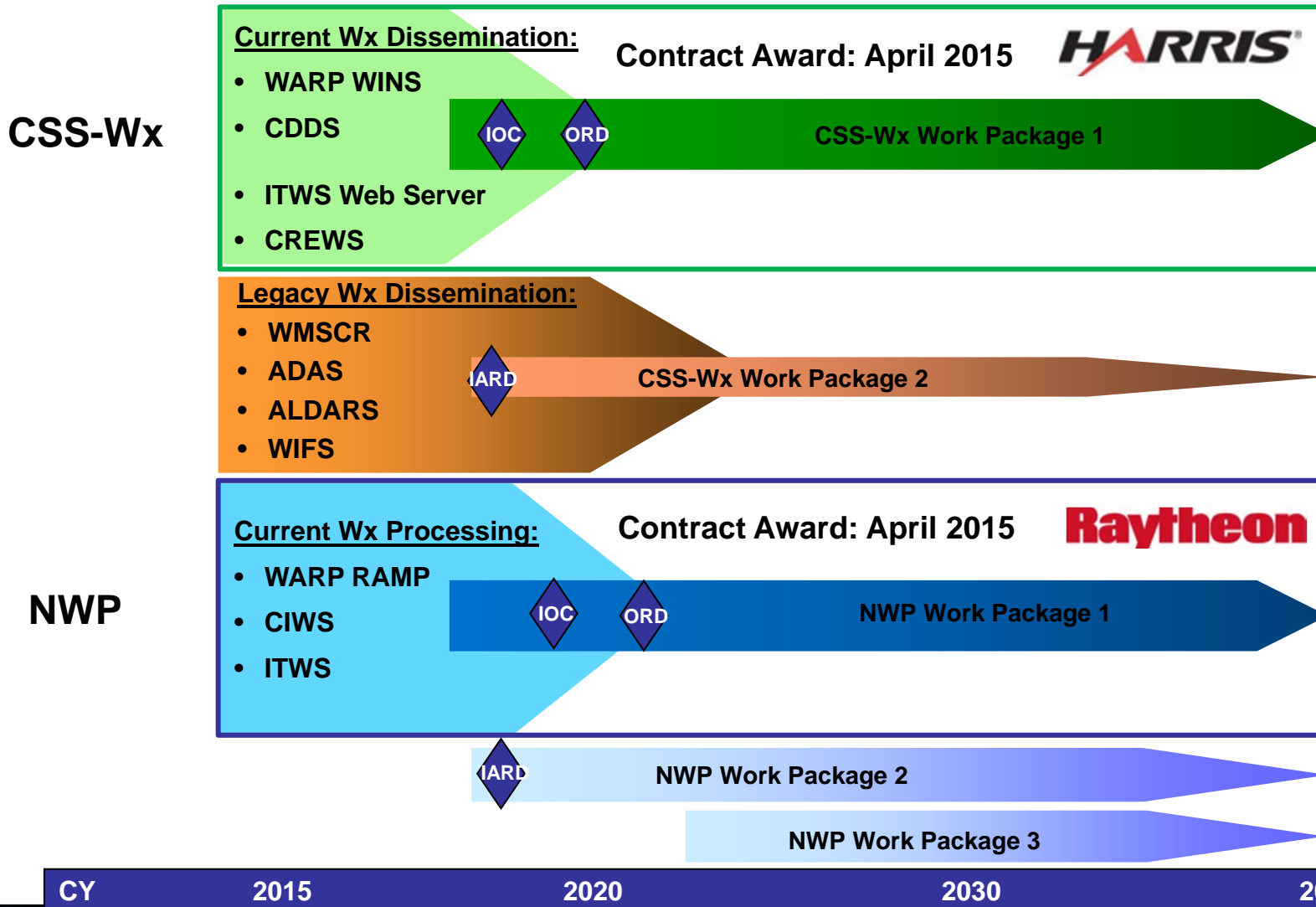


# Integrated Facility Implementation





# CSS-Wx/NWP Implementation



# NextGen Weather Summary

- **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/>

**NextGEN WEATHER**  
Improving Safety and Efficiency in the National Airspace System

**AWD AVIATION WEATHER DISPLAY**  
Decision makers in the National Airspace System (NAS) require a clear, consistent presentation of weather information to ensure efficient and safe air traffic operations in the current environment. Multiple weather displays from the Weather and Radar Processor (WRP) are integrated into the Terminal Weather System (TWS) to present different information – even when meteorologically displaying the same product. Those who manually display the weather information on some operational decision support tools, users still require a stand-alone, dedicated weather display.

**REDUCE WEATHER IMPACT**  
NextGen Weather harnesses massive computing power, unproven technologies, and operational advances in numerical weather forecasting, integration of weather information into airspace constraints, and modernized information management services.

**AWD Architecture**  
GIS: The AWD is designed as a Geographical Information System (GIS). Digital weather data is both geospatial and non-geospatial, but is especially heavy weather.

**Dedicated and Web Versions:** Operational use is via a web browser with nearly identical function.

**ViewSU portal:** The AWD enables access to the Center Weather Service Unit (CWSU) products by users via the ViewSU web portal within the NAS. Users can configure the CWSU alert for automatic viewing on their AWD, and set up alerts so they are notified when content there is updated.

**In the future as FAA weather-aware systems and decision support tools are implemented, the AWD-based graphical layers can be accessed directly to support display users.**

**NWP NEXTGEN WEATHER PROCESSOR**  
The fully-automated NextGen Weather Processor identifies terminal and enroute safety hazards and provides translated weather information needed to predict route blockage and airspace capacity constraints up to eight hours in advance.

**REDUCE WEATHER IMPACT**  
NextGen Weather is a central part of the NextGen Air Transportation System, designed to improve the management and operation of how we fly. It helps reduce weather impact, resulting in safer, more efficient and predictable day-to-day NAS operations.

**NextGen Weather harnesses massive computing power, unproven technologies, and operational advances in numerical weather forecasting, integration of weather information into airspace constraints, and modernized information management services.**

**With this powerful combination, NextGen Weather can provide tailored aviation weather products within the NAS, helping controllers and operators develop reliable flight plans, make better decisions, and improve on-time performance.**

**NextGen Weather is accomplished through collaboration between FAA, NOAA, and NASA.**

**Improvements with AWD**

- Consolidates legacy weather display or view
- Establishes new stand-alone weather center
- Designed as Geographical Information System
- Includes dedicated and web browser
- Supports Long Range and TRACON view
- Alerts from all TRACONs available on AWD
- Long & turbulence products integrated
- Provides display for new NextGen Weather

**Improvements with NWP**

- Rapidly updating radar products
- Fast-forward predictive products
- Products tailored to meet aviation requirements for enroute and weather decision-making
- Improves collaborative planning
- Enables safe, timely, efficient operation of the National Airspace System (NAS)
- Reduces congestion and delays
- Increases flight schedule reliability
- Consolidates FAA weather programs
- Replaces legacy weather processors (NRP, TWS, CWS)

**TRANSLATION PRODUCTS**

- 6-8 hour Convective Weather (CWF)
- Convective Weather Avoidance (CWA)
- Convective Weather Avoidance (CWA)
- 0-2 hour CWF for Route
- Microbursts, Gust Fronts, and Turbulence (MGT)
- 0-2 hour Accuracy scores
- Fronts (misaligned)

**PREDICTIVE PRODUCTS**

- 0-2 hour Precipitation
- Precipitation Phase
- Log-Temp
- Clouds
- 0-2 hour Accuracy scores
- Fronts (misaligned)

**MOSSAC PRODUCTS**

- Forecast: TWS and CWSU
- Precipitation
- Convective Intensity
- Turbulence (100 ft level)
- Base Turbulence
- Log-Temp (Convex, L&B)

**Air Surveillance Radars**

- Enroute Terminal
- Enroute 1.9 miles
- Convective Intensity
- Turbulence

**GOES Satellite**

- Convective Intensity
- Turbulence

**FAA | CSS-WX | NWP | AWD**  
**NOAA | RAP | HRRR | LAPS**  
**NASA | CIWAP | SATCAST | DWR**

**NextGEN WEATHER**  
Improving Safety and Efficiency in the National Airspace System

**REDUCE WEATHER IMPACT**  
NextGen Weather is a critical part of the NextGen Air Transportation System, designed to improve the management and operation of how we fly. It helps reduce weather impact, resulting in safer, more efficient and predictable day-to-day NAS operations.

**CSS-Wx COMMON SUPPORT SERVICES - WEATHER**  
NextGen Weather is the single provider of weather data, products, and imagery within the National Airspace System (NAS), using standards-based weather dissemination via System Wide Information Management (SWIM). CSS-Wx makes available enhanced weather products for integration into air traffic decision support tools, improving the quality of traffic management decisions and reducing controller workload during severe weather.

**NextGen Weather harnesses massive computing power, unproven technologies, and operational advances in numerical weather forecasting, translation of weather information into airspace constraints, and modernized information management services.**

**With this powerful combination, NextGen Weather can provide tailored aviation weather products within the NAS, helping controllers and operators develop reliable flight plans, make better decisions, and improve on-time performance.**

**NextGen Weather is accomplished through collaboration between FAA, NOAA, and NASA.**

**High level view of NextGen Weather architecture, showing the relationship between CSS-Wx, the NextGen Weather Processor (NWP) and its Aviation Weather Display (AWD). Weather sensor inputs are shown across the top, where "Surface Stations" includes ASOS, AWOS, AWSS and Lightning. Consumers of weather information within the NAS are shown along the bottom. Incoming weather products from NOAA pass through the NESG, as do outgoing products for all external consumers.**

**CSS-Wx Weather Product Categories**

NOAA	Numerical Forecasts Models	Aviation Forecasts	Alphanumeric Products	Imagery
RAP, HRRR, LAMP, SREF, NAM, etc.	Turbulence, Icing, etc.	METAR, FROTH, TAF, PIREPA, etc.	Asaka and Guam Satellite, etc.	
NWP	Mosaic Products	Analysis Products	Predictive Products	Translation Products
Precipitation, Echo Tops, Satellite, etc.	Microbursts, Terminal winds, Gust Fronts, etc.	8-hour Precipitation, Phase, Contouring, 2-hour Fronts, etc.	8-hour Convective weather avoidance Fields, etc.	

**CSS-Wx Web Services**  
The CSS-Wx system makes access and format standard (OGC). The services provide:

- WCS (Web Coverage Service)**
  - Disseminates gridded weather products in NetCDF4 format
  - Filters and transforms large gridded data sets such as weather radar and satellite mosaics, upper level winds, icing and turbulence forecasts, etc.
- WFS (Web Feature Service)**
  - Disseminates non-gridded weather products in WMOX XML format
  - Filters and transforms non-gridded data sets such as wind shear alerts, storm cell information, terminal aerodrome forecasts, etc.
- WMS (Web Map Service)**
  - Disseminates weather product imagery in variety of formats (e.g., JPEG, PNG, GIF, KML)
  - Renders digital weather data as single large image or as sets of tiled images
  - Enables weather product consumption by modernized displays and mobile applications
  - Permits geographical overlay of information from multiple domains

**FAA | CSS-WX | NWP | AWD**  
**NOAA | RAP | HRRR | LAPS**  
**NASA | CIWAP | SATCAST | DWR**

# 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
- ATCT: Airport Traffic Control Tower
- 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





# Contact Information

**Alfred Moosakhanian, FAA  
Program Manager  
FAA NextGen Weather Systems  
(202) 267-0792  
[alfred.moosakhanian@faa.gov](mailto:alfred.moosakhanian@faa.gov)**

