FAA NextGen Weather Systems

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

Presented to: ATIEC 2016

By: Alfred Moosakhanian, FAA

Date: 20 September 2016

Aviation Information World – Forecasting the Future

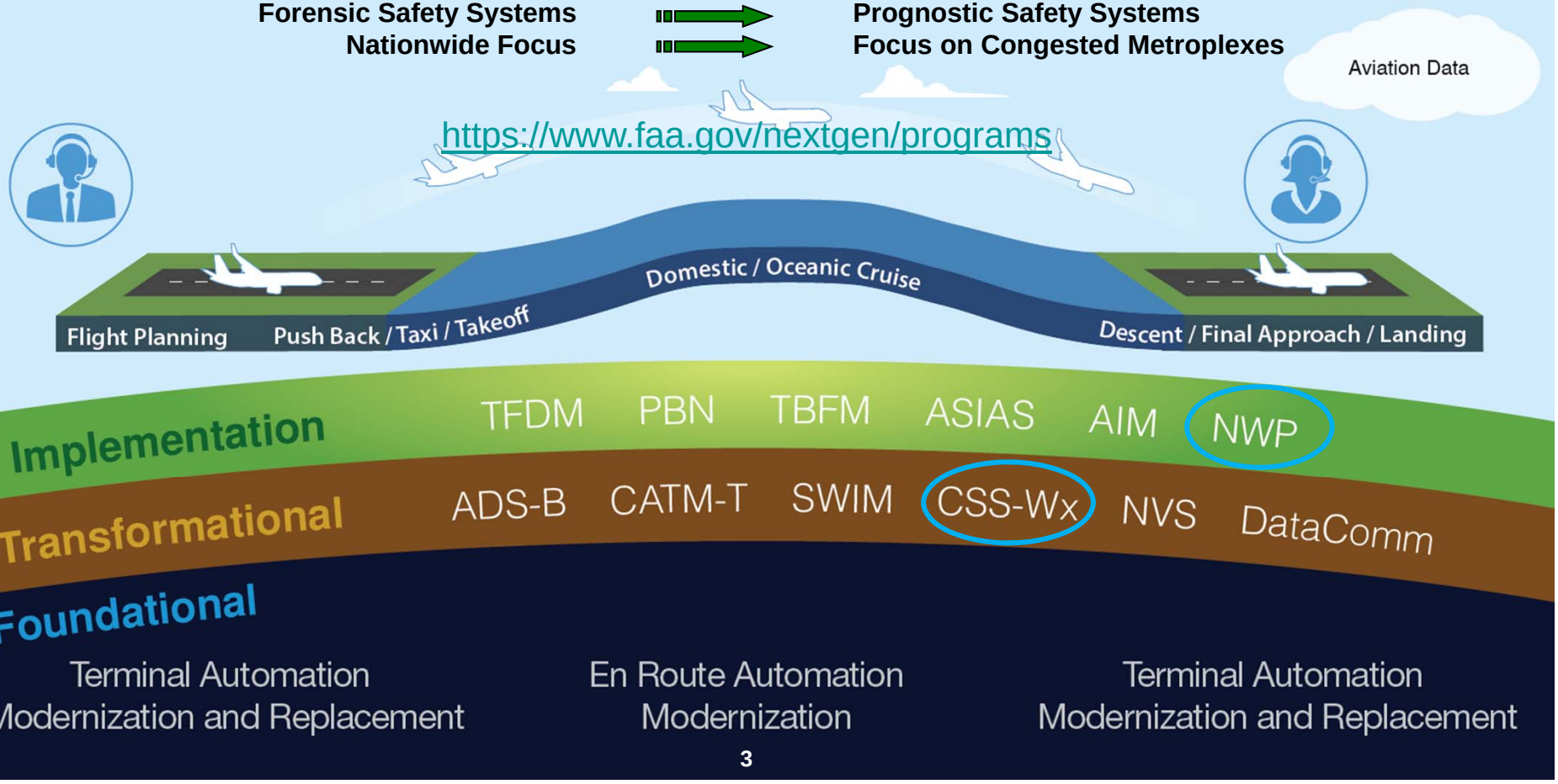
Purpose

- **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		NextGen
Radar	→	Satellite
Inefficient Routes	→	Performance Based Navigation (fuel savings)
Voice Communications	→	Voice & Digital Communications
Disparate Information	→	Automated Decision Support Tools
Fragmented Weather Forecasting	→	Integrated Weather Information
Weather Restricted Visibility	→	Improved Access in Low Visibility
Forensic Safety Systems	→	Prognostic Safety Systems
Nationwide Focus	→	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- *Decommission Outdated Systems*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*

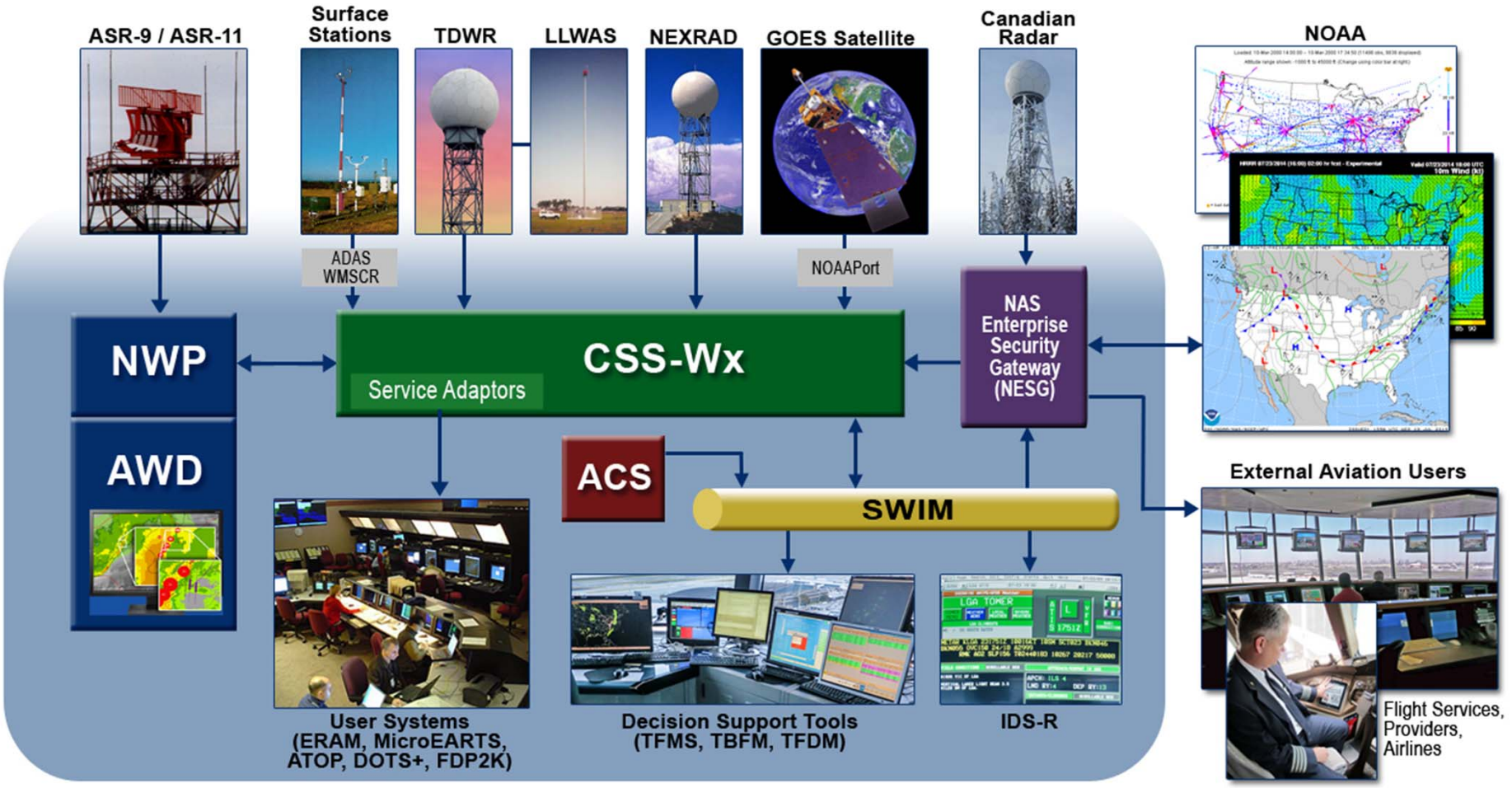
Improve Safety

- *Enhanced Weather Information*
- *Greater Access*
- *Common Situational Awareness*

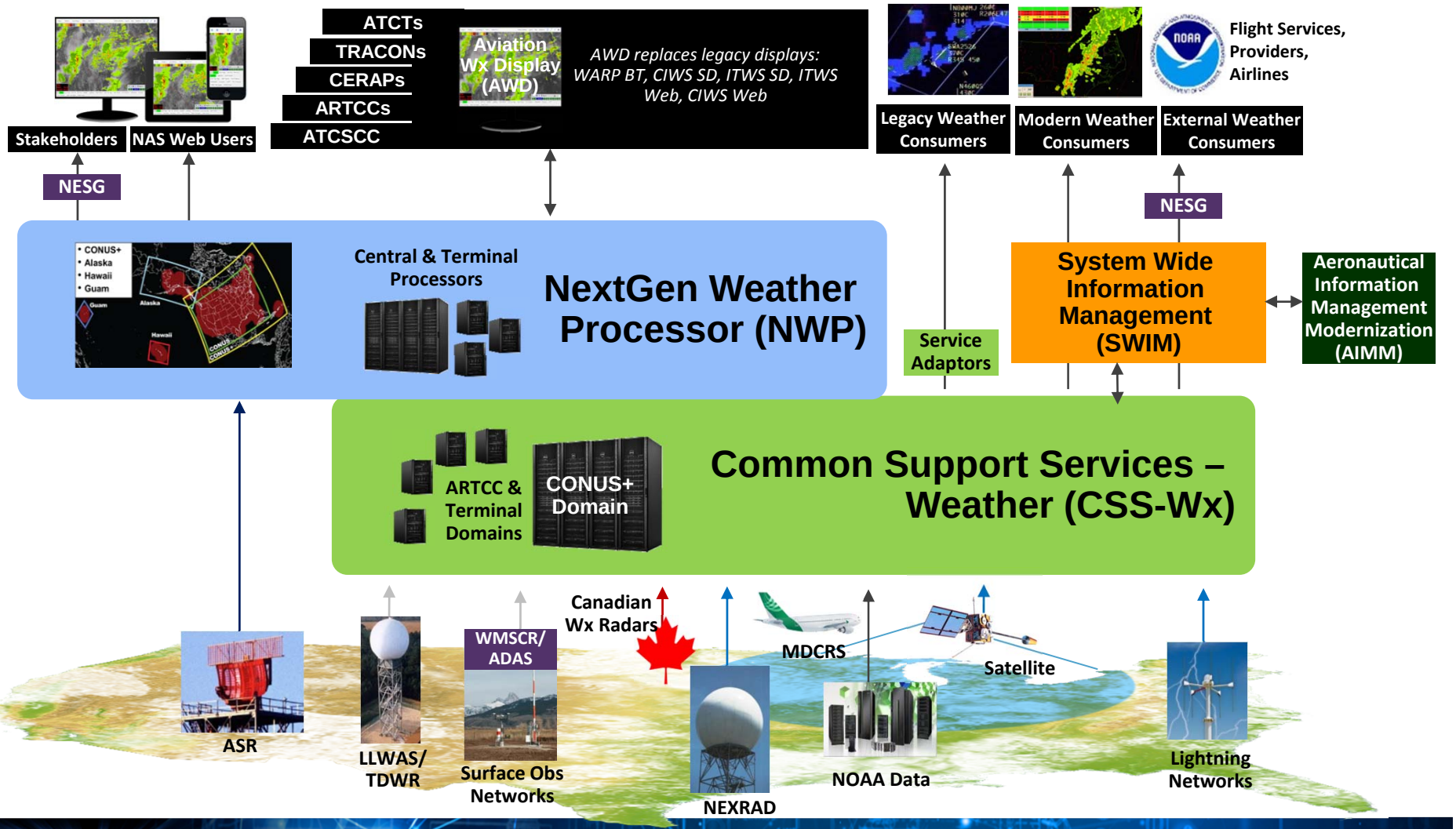
NextGen Weather Systems Scope

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

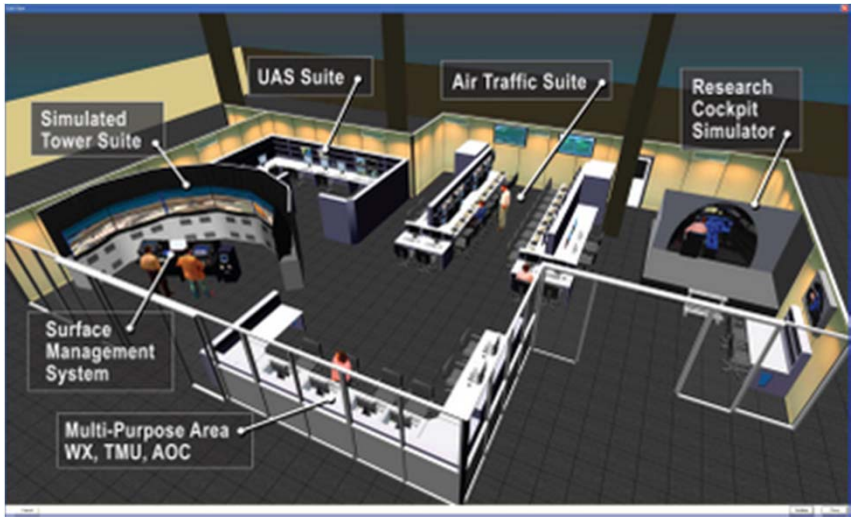


NextGen Wx Systems Architecture



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

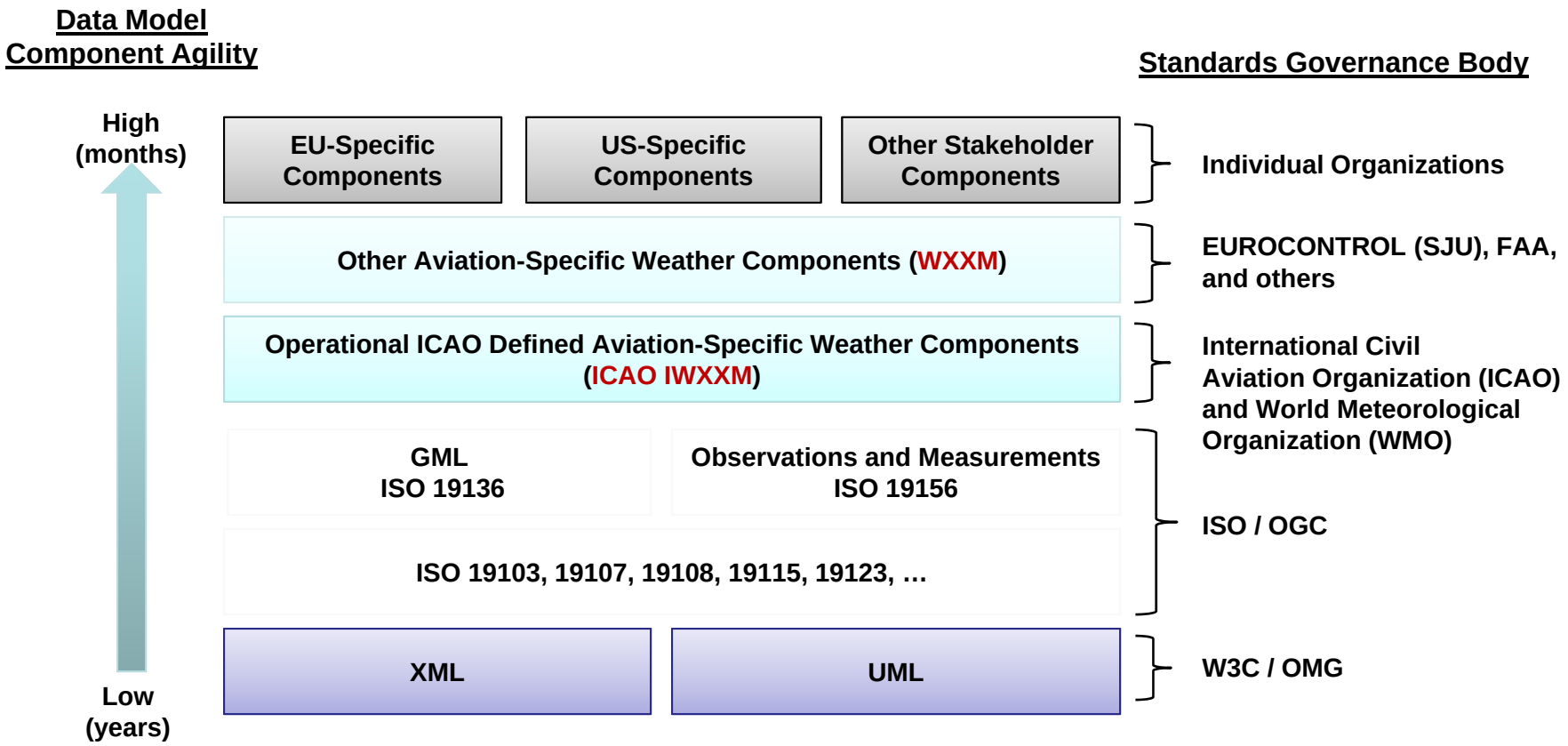
CSS-Wx Data Access Services

- **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

OGC® Open Geospatial Consortium

Web Coverage Service	Web Feature Service	Web Map Service
• Filters and transforms large gridded dataset • NetCDF format	• Filters and transforms non-gridded data sets • 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



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

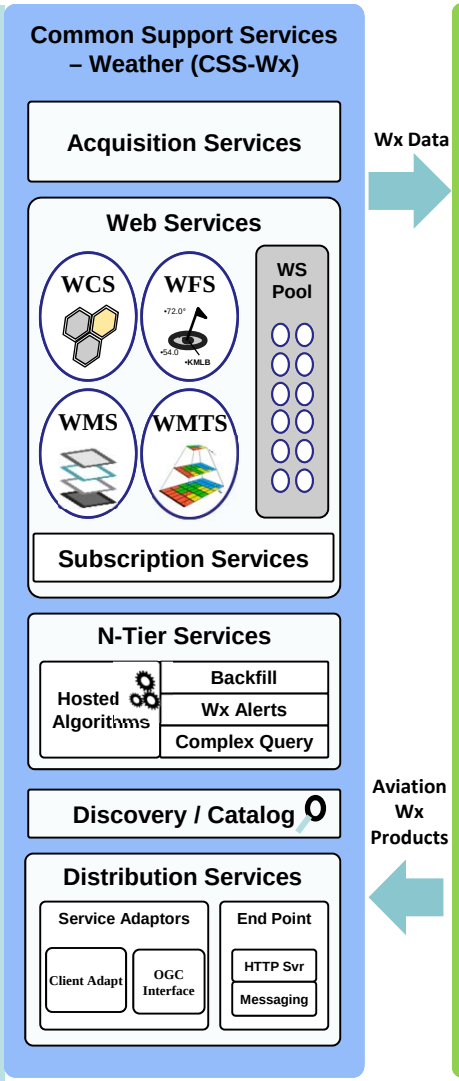
Decimation
- Decreased data resolutions with data interpolation methods

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

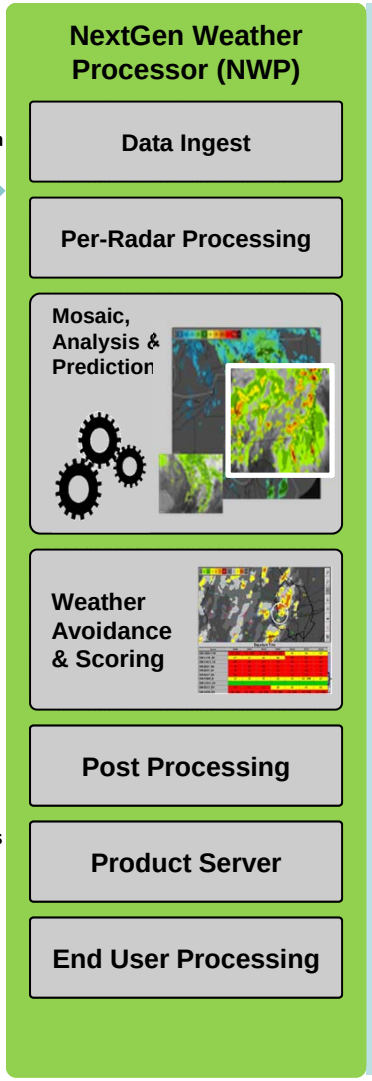
End-User Algorithms
- Composite Reflectivity with Flexible Floor
- Icing And Composite Icing Layer
- Composite Turbulence and Turbulence Layer
- Precipitation Altitude Mask
- CWAM Weather Avoidance Field

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



Wx Data

Aviation Wx Products



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

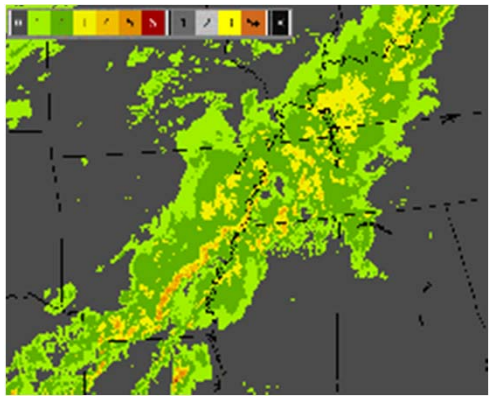
Domain Non- Gridded
- Precipitation (VIL) & Echo Tops (ET) Forecast Accuracy
- Aggregated Lightning Flashes & Tornado Detections
- Storm Information Hazard Texts, Leading Edges, & Motion Vectors
- Precipitation (VIL) & ET Contours
- Fronts, Trends & Wind Profiles
- Convective WAF Mosaic Polygons
- Jet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

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

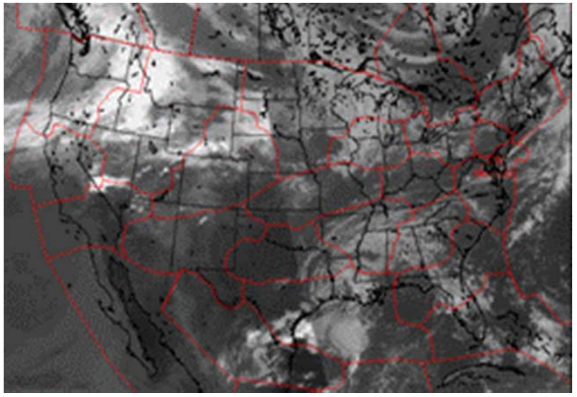
Terminal Products
- ASR Precipitation Mosaic and with AP Indicated
- Microburst and Gust Front TRACON Map
- Gust Front Estimated Time of Impact
- ATIS Panel Message
- Configured & Tornado Alerts
- Airport Lightning Warning
- Storm Information Motion Vectors, Leading Edges, & Hazard Texts (ASR)
- Runway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



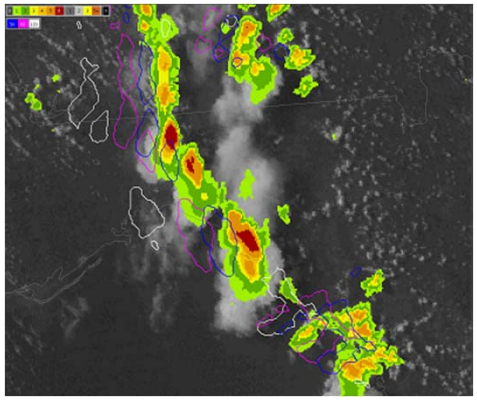
Satellite Mosaic

Terminal Winds

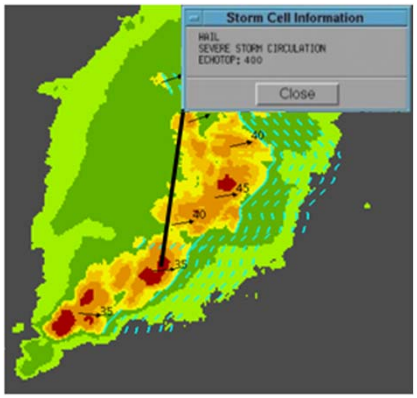
- **Mapping projection needed to map data grid to earth's surface**
  - Examples: Lambert Conic Conformal, Lambert Azimuthal Equal Area
- **Network Common Data format (NetCDF4) used to model gridded data products**

Non-Gridded Data Products

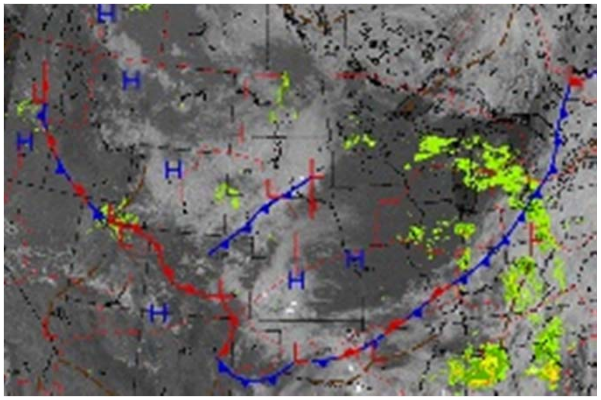
- **Non-gridded products express singular or sparsely distributed geospatial sets of observations or forecasts**
  - Contours, point products, text products



Precipitation Contours



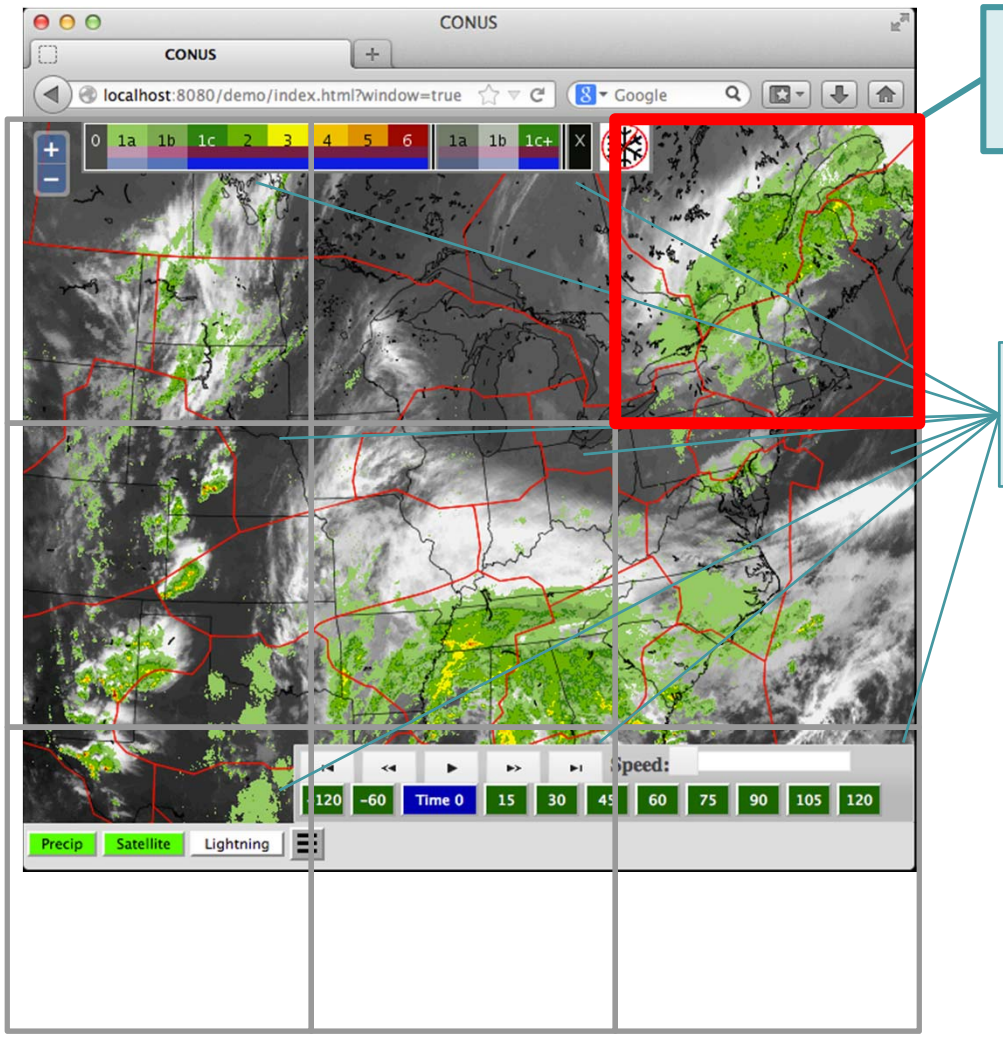
Storm Motion Vectors, Extrapolated Positions, Hazard Text



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

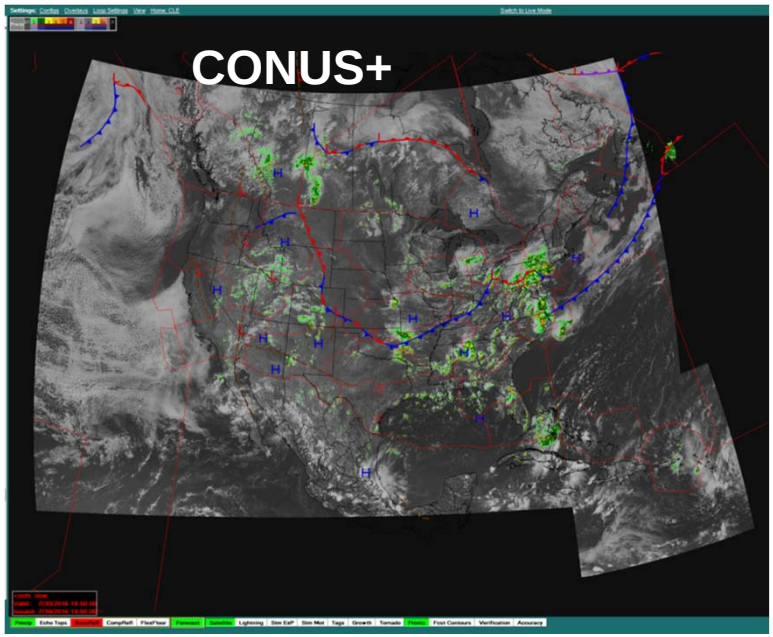


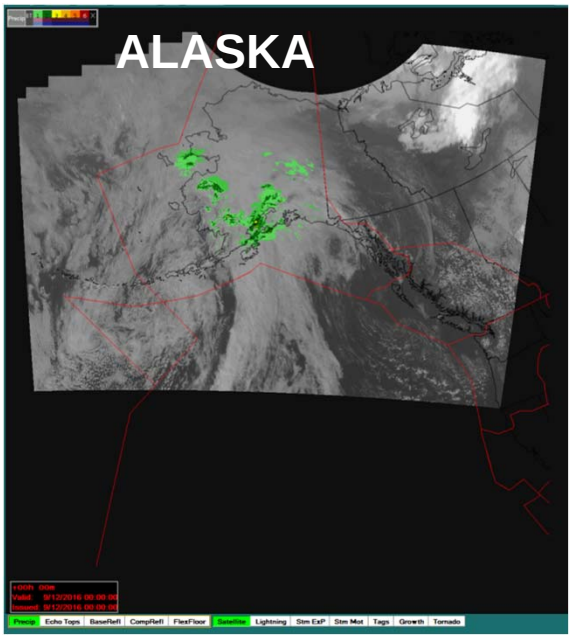
Individual Tile

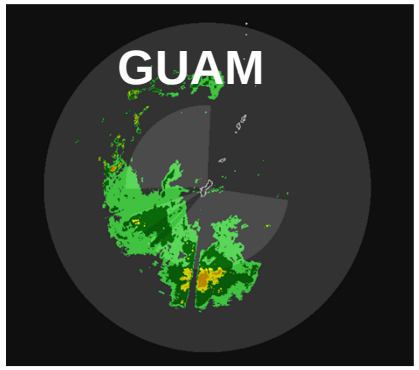
Set of Tiles

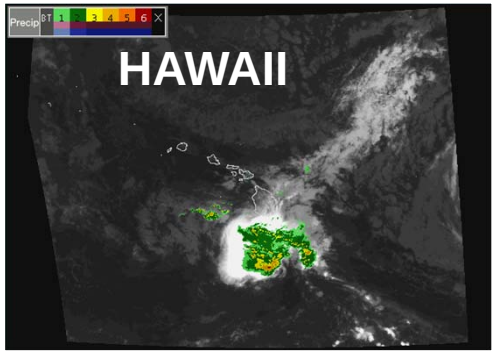
- **Image formats include**
  - **GIF**
  - **PNG**
  - **JPEG**
  - **TIFF**
  - **GEOTIFF**
- **Image data can be**
  - **Single tile**
  - **Set of tiles**
- **Allow specification of**
  - **Coverage**
  - **Map projection**
  - **Tile size(s)**
  - **Color palette**

NWP Domains

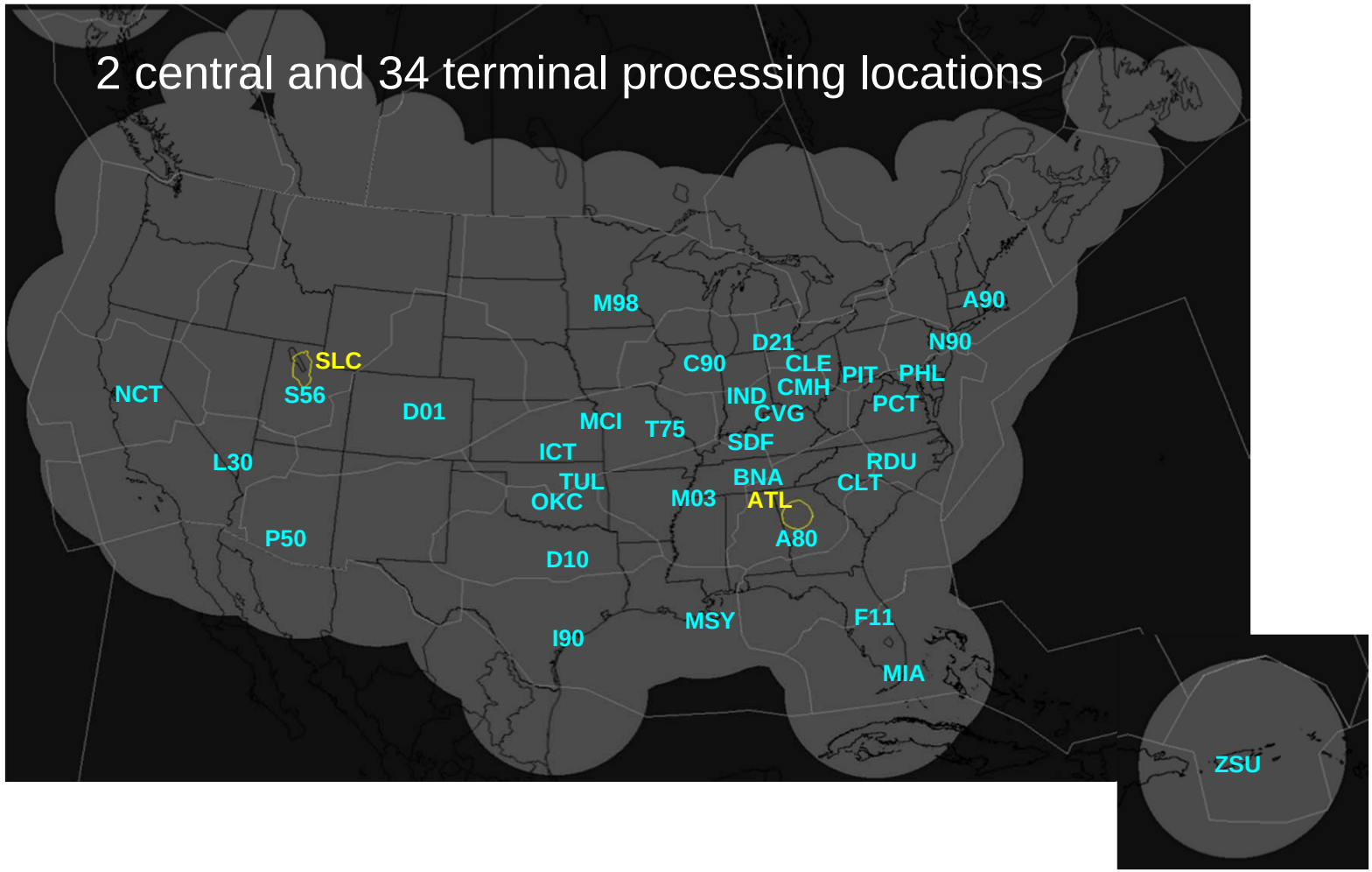




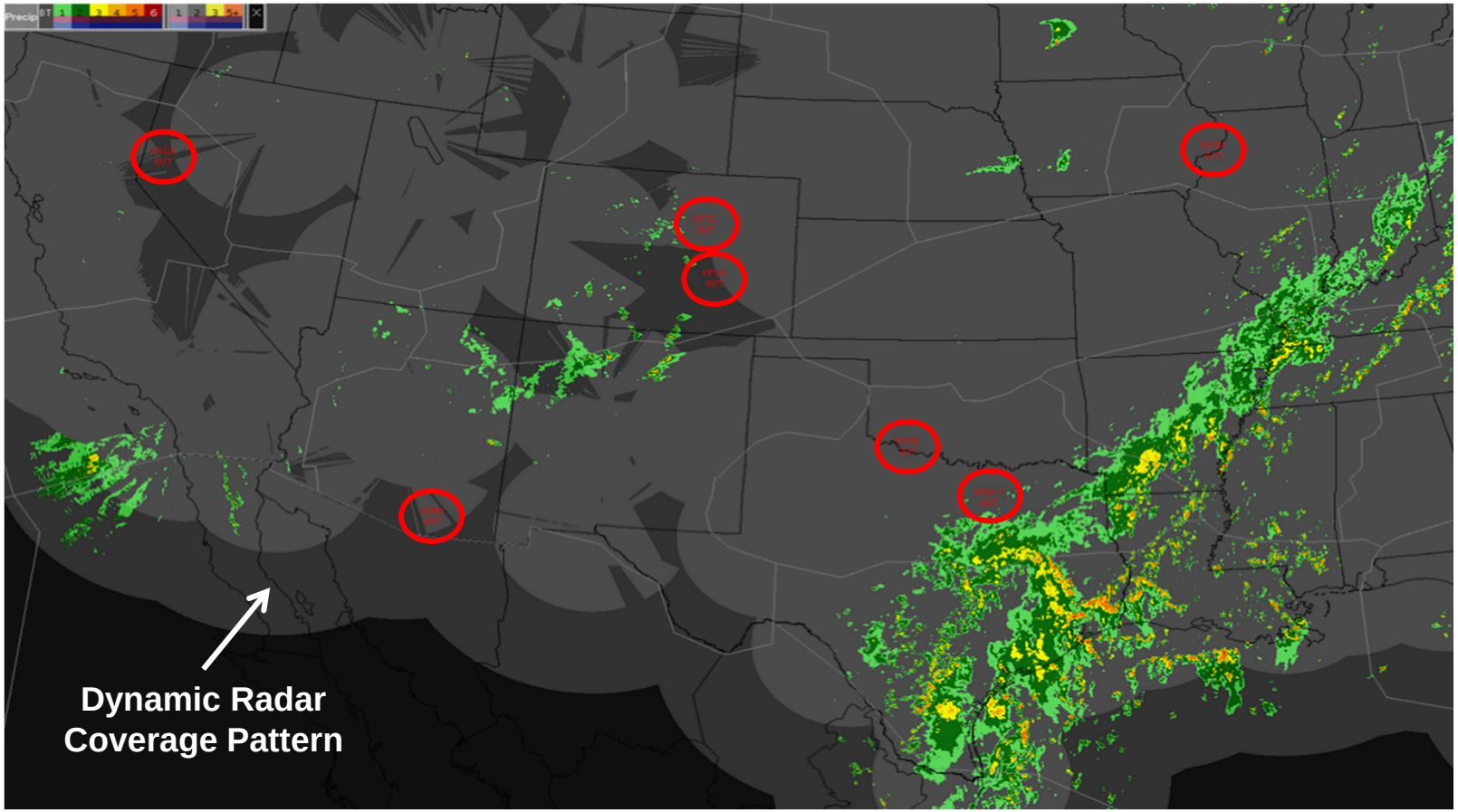




NextGen Wx Product Generation Locations



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/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: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>
```

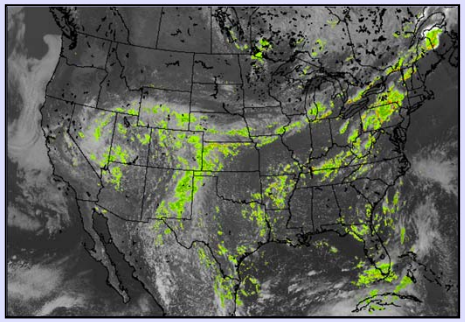
Regardless of nwp:status, the radar location is specified

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

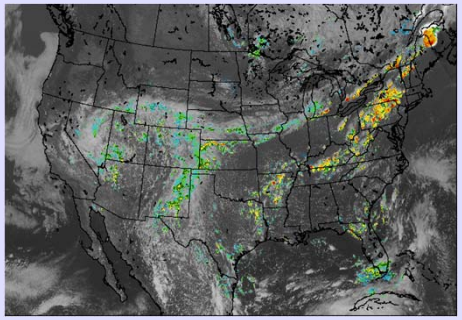
```
<nwp:Sensor type="NEXRAD" name="PAKC">
    <nwp:location srsName="http://www.opengis.net/def/crs/EPSG/0/4052" srsDimension="2"
axisLabels="latitude longitude">58.679444 -156.629444</nwp:location>
    <nwp:status>MISSING</nwp:status>
</nwp:Sensor>
```

Mosaic Examples

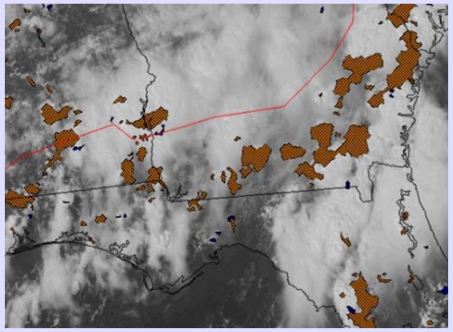
VIL Mosaic



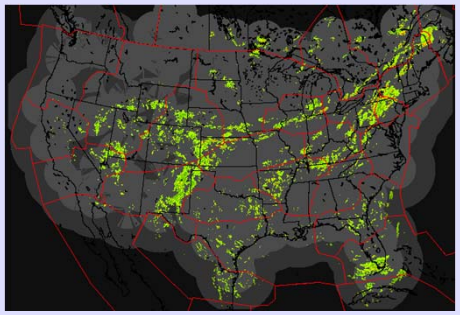
Echo Tops Mosaic



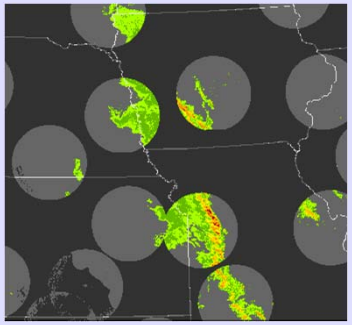
Growth Trends Mosaic



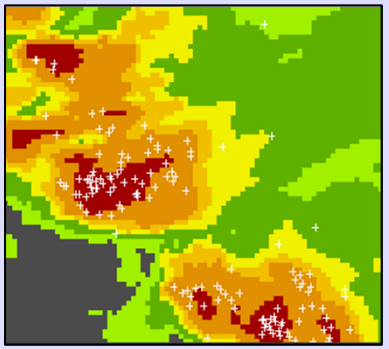
Comp Refl Mosaic



Base Refl Mosaic

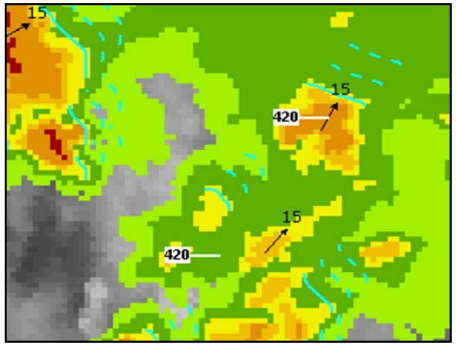


Lightning

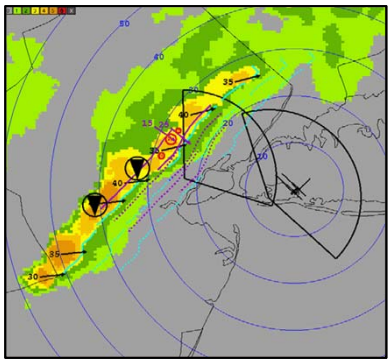


Analysis / Per-Terminal Examples

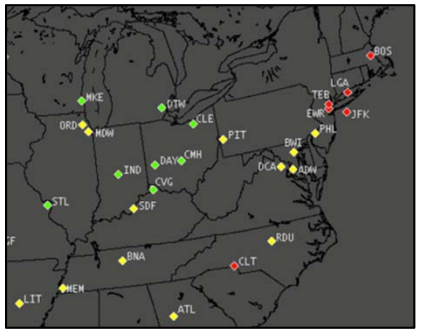
Storm Information



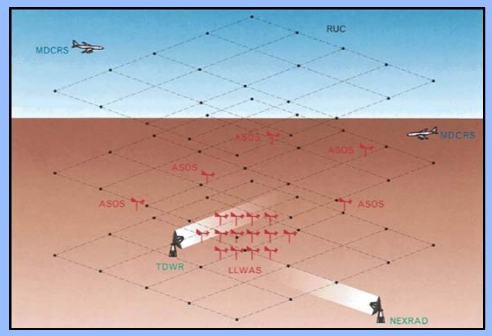
Tornado Aggregation



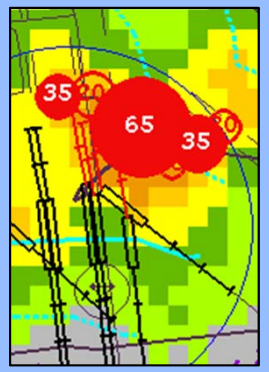
Airport Status Summary



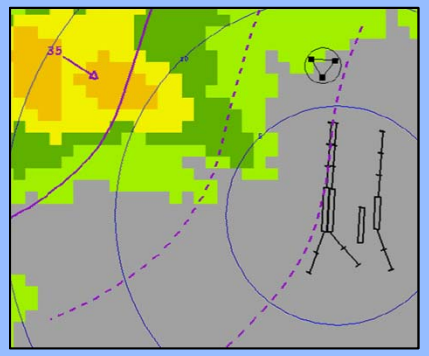
Terminal Winds



Microbursts & Wind Shear

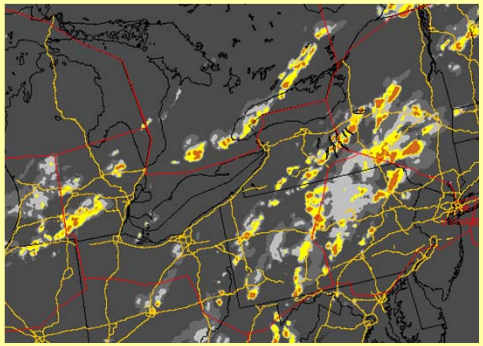


Gust Fronts

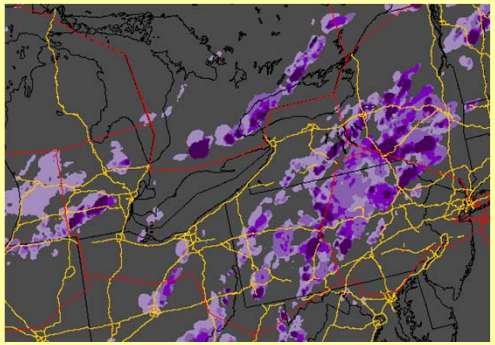


Predictions / Wx Avoidance Examples

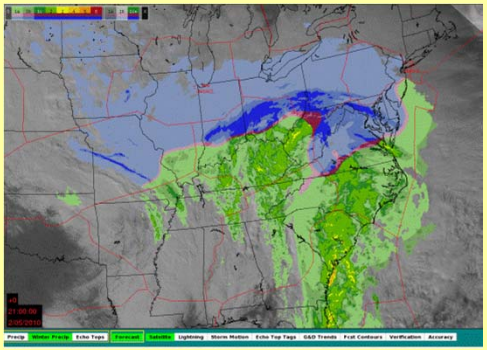
VIL Precipitation 0-8 Hr



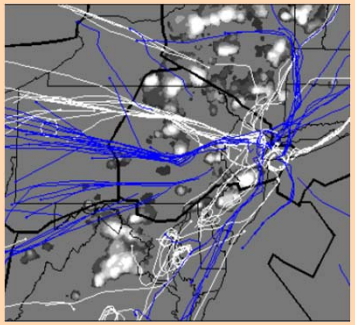
Echo Tops 0-8 Hr



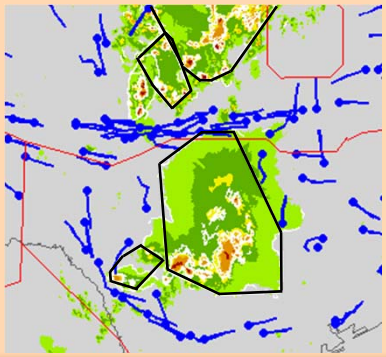
Precip. Phase 0-8 Hr



Convective Weather Avoidance Model (CWAM)



Convective Weather Avoidance Polygons (CWAP)



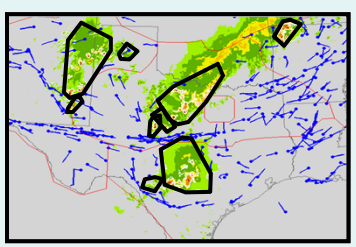
NWP WXXM Products

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

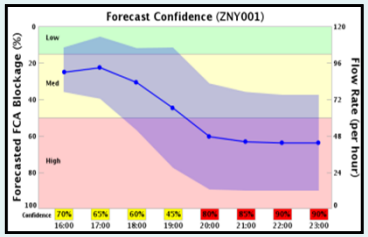
NWP Non-Gridded Terminal Products
Microburst TRACON Map
ATIS Panel Message
Gust Front TRACON Map
Gust Front Estimated Time of Impact
Configured Alerts
Tornado Alert
Airport Lightning Warning
Storm Information Motion Vectors (ASR)
Storm Information Leading Edges (ASR)
Storm Information Hazard Texts (ASR)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

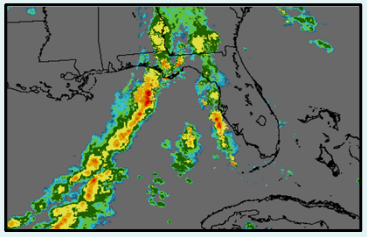
Current and Future NWP Products



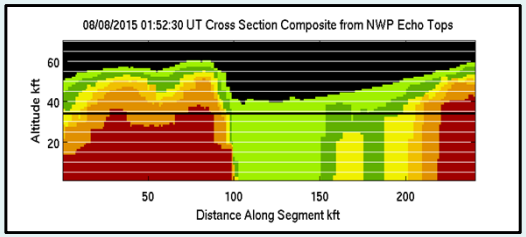
Convective Weather Avoidance Polygons



Forecast Confidence



Offshore Precipitation

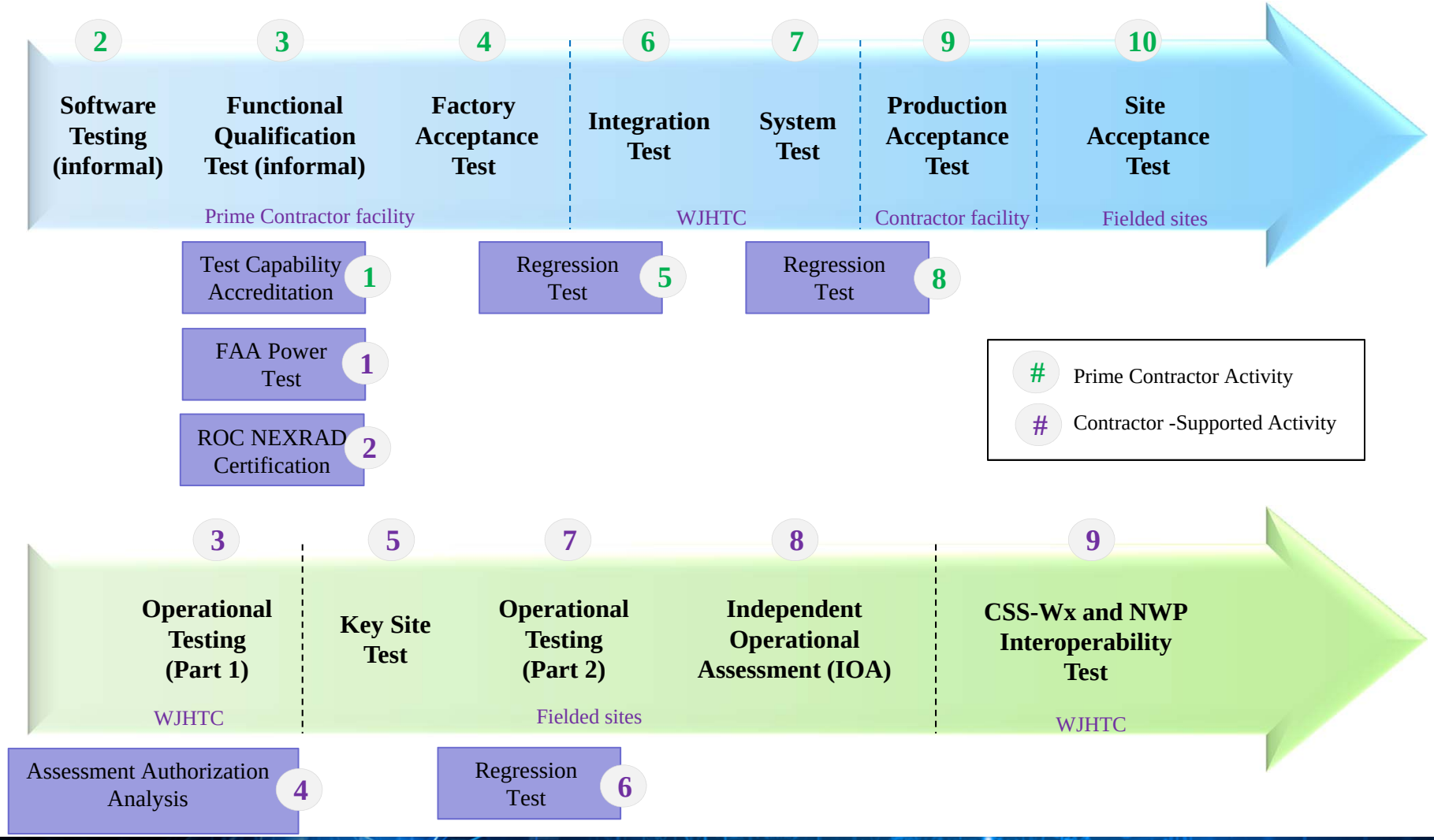


4D Trajectory Weather

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

Salt Lake City

CSS-Wx
NWP

Atlanta

CSS-Wx

ATCSCC

AWDs at all Sites

ATCTs
(Approx. 60)

CSS-Wx
(1 per site)

21 ARTCCs

CSS-Wx
NWP

33 TRACONs / 3 CERAPs* *ZSU Only (NWP)

Test Facilities

NWP

MMAC/PSF

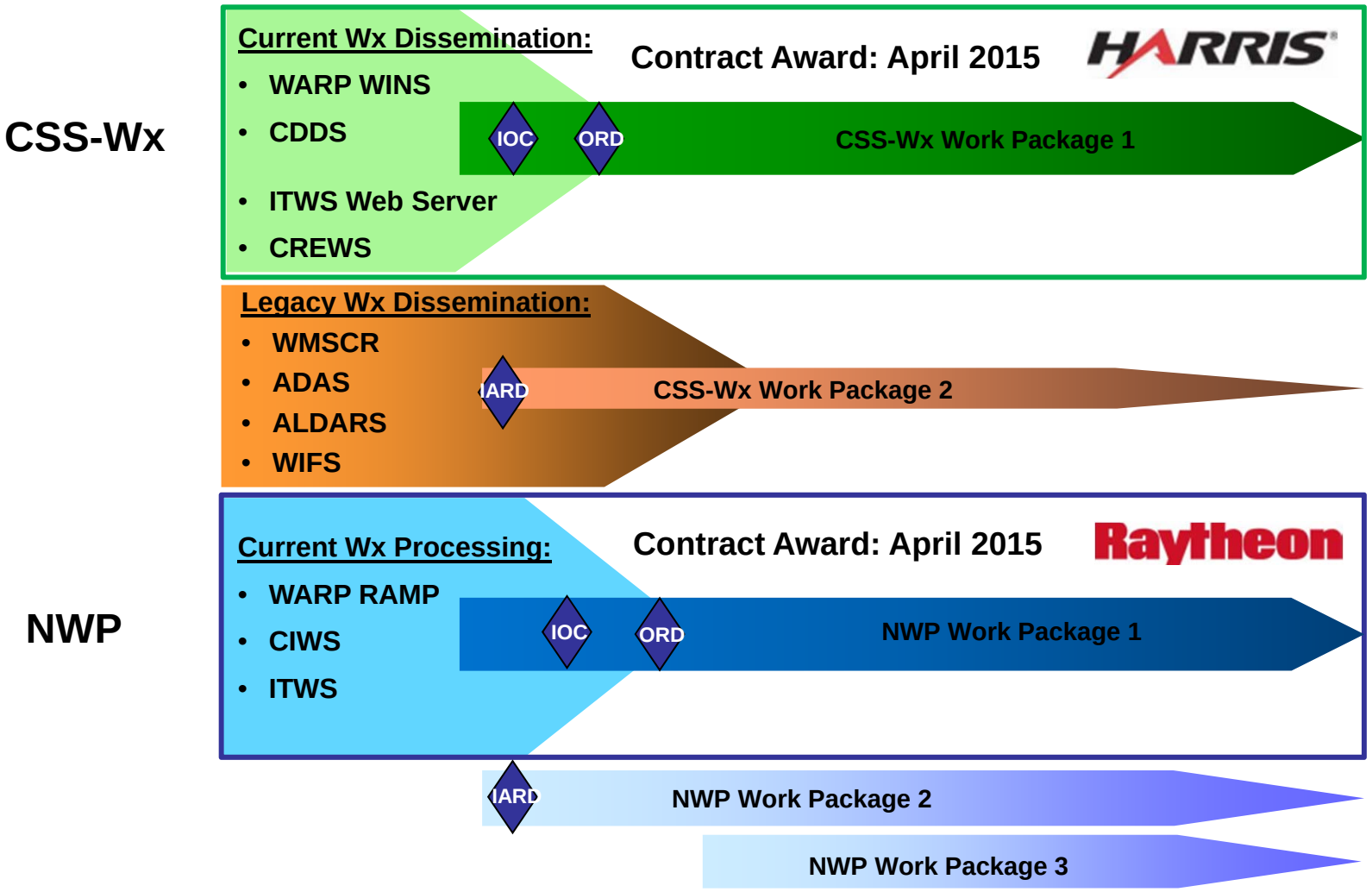
CSS-Wx
(1st Article)

Harris

CSS-Wx
NWP

NWP
(1st Article)

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/

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