

FAA NextGen Weather Systems

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

To: FPAW Fall Forum

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November 19 , 2015



**Federal Aviation
Administration**



OVERVIEW

- **NextGen Wx Systems**

- Status
- Overview
- Examples

- **NWP Overview**

- **CSS-Wx Overview**

- **User Participation**

- **Summary / Q&A**

FAA/Alfred

Raytheon/Tom-Alan

Harris/Bob

FAA/Alfred

Panel



NextGen Weather Systems: Consolidation of NAS Operational Weather/Display



TDWR



•NextGen Weather Processor (NWP)



•Common Support Services-Weather (CSS-Wx)



•Aviation Weather Display (AWD)



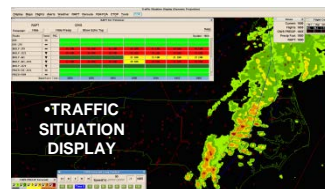
NEXRAD



ERAM



FLIGHT SERVICES



•TRAFFIC SITUATION DISPLAY

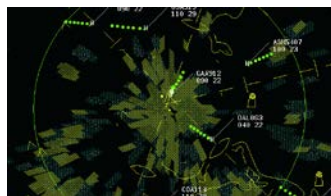
TFMS



PRIVATE VENDOR



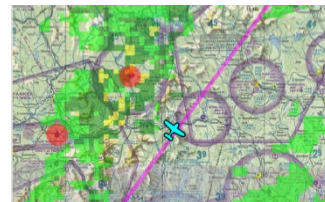
ASR



STARS



USER DISPLAY SYSTEM (ATOP, DOTS+)



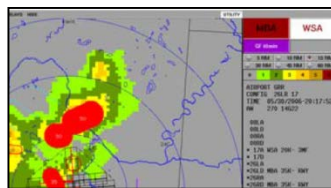
FIS - B



LLWAS



ASOS
AWOS
AWSS

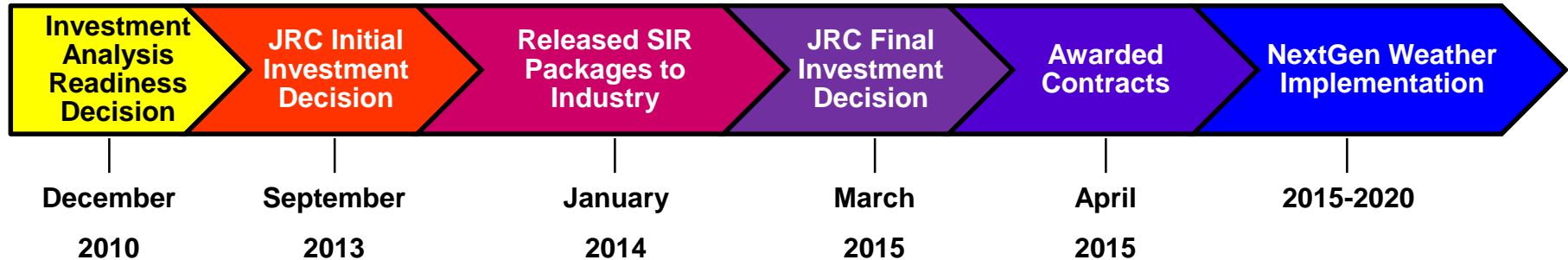


ASR - WSP



IDS - INTEGRATED DISPLAY SYSTEM

NextGen Weather Program Status



- **January 2014: SIR Packages released to industry**
 - NextGen Weather Processor (NWP)
 - Common Support Services – Weather (CSS-Wx)
- **March 2015: JRC Final Investment Decision**
- **April 2015: Contracts awarded**
- **2019/2020: Initial Operational Capabilities for Key Sites**

CSS-Wx: **HARRIS**

NWP: **Raytheon**

Good Source of Background Information

<http://www.faa.gov/nextgen/programs/weather/>

NextGen Weather → FAA Home • NextGen • NextGen Programs • NextGen Weather

NextGen Weather Processor
Common Support Services - Weather
NextGen Weather Architecture
Strategic Traffic Flow Management Support
FAQ: Weather Delay
Aviation Weather Research Program

NextGen Weather

The NextGen Weather Program is a critical part of NextGen as it helps reduce the impact of weather on aviation, resulting in safer, more efficient and predictable day-to-day National Airspace System (NAS) operations.

NextGen Weather harnesses massive computing power, unprecedented 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.

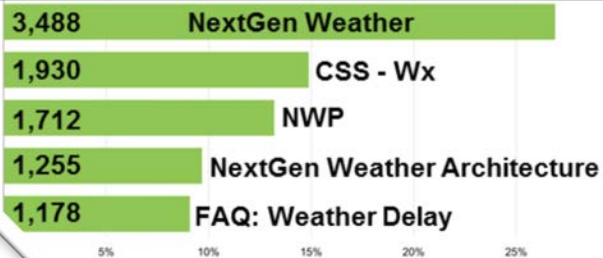
The flying public will experience less [weather delay](#), including fewer departure and arrival delays, reduced number of flight cancellations and refueling stops, and overall increased dependability in flight schedules.

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

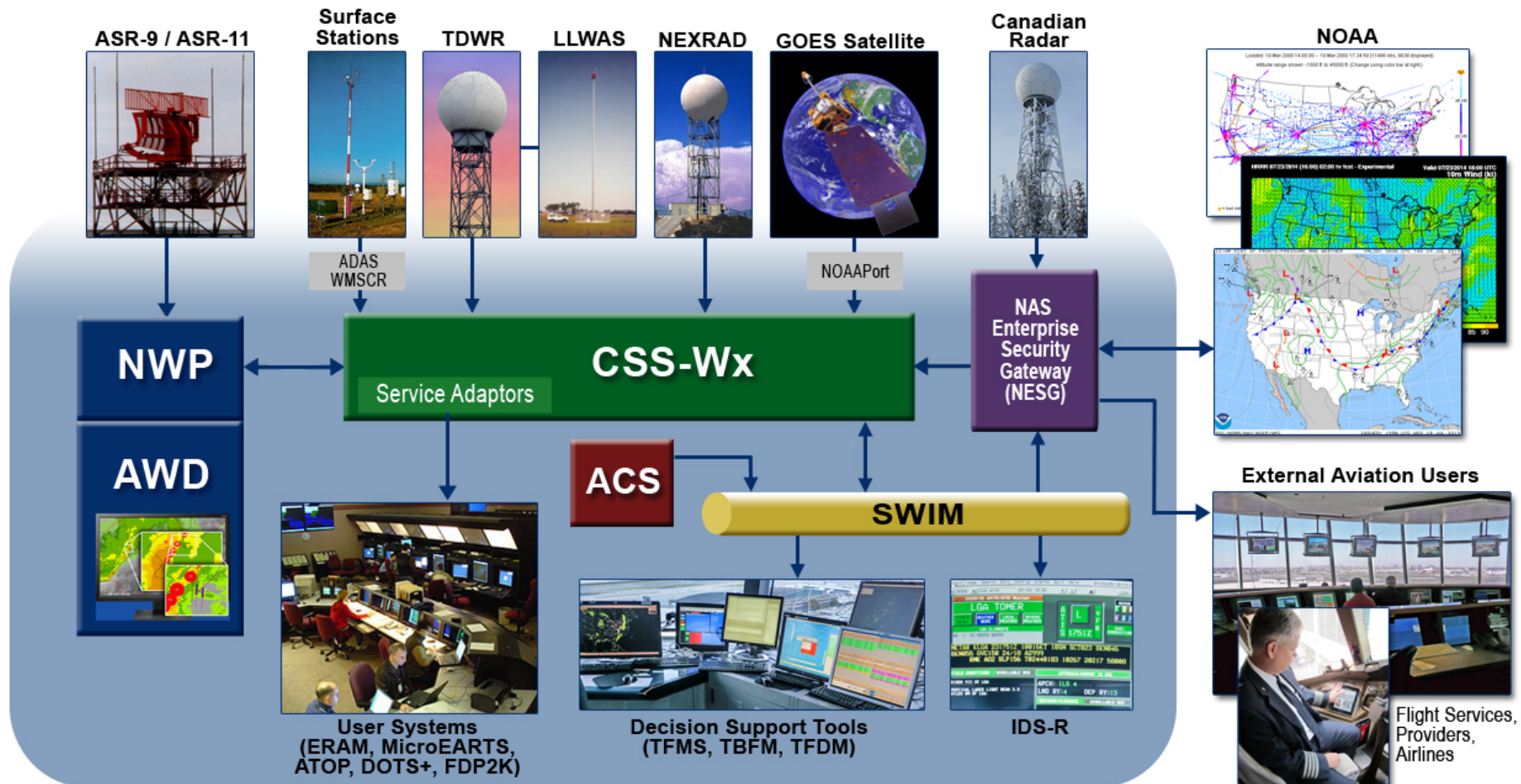
Print Share

Storm clouds over LaGuardia airport in New York. The New York area has some of the highest weather-related air traffic delays in the US. © Richard Ferris

Page View Statistics (Jan-Oct 2015)



NextGen Weather Architecture



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



Web Coverage Service

- Filters and transforms large gridded dataset
- NetCDF format

Web Feature Service

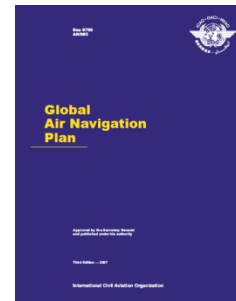
- Filters and transforms non-gridded data sets
- WXXM 2.0 XML format

Web Map Service

- Renders weather data as single large image or sets of tiled images for display
- JPEG, PNG, GIF, KML format

Weather Exchange Models

- **ICAO GANP: Projects a 15 year plan for implementing ICAO Doc 9854 concepts**
 - SWIM enables key ICAO GANP objective - Globally interoperable Systems
 - FAA NextGen Wx Systems leverages SWIM Services
- **Weather Information Exchange Model (WXXM):**
 - Address broad range of aviation weather information
 - Developed by FAA, EUROCONTROL and Others
- **ICAO WXXM (IWXXM):**
 - Addresses specific aviation weather products specified in ICAO Annex 3
 - Developed and Governed by ICAO and WMO
- **Global ICAO Exchange**
 - IWXXM (XML/GML) encoding increases the message volume beyond the AFTN capacity
 - XML exchange of OPMET products will transition to the ATS Message Handling System (AMHS) – SWIM



NextGen Weather: Operational User Support

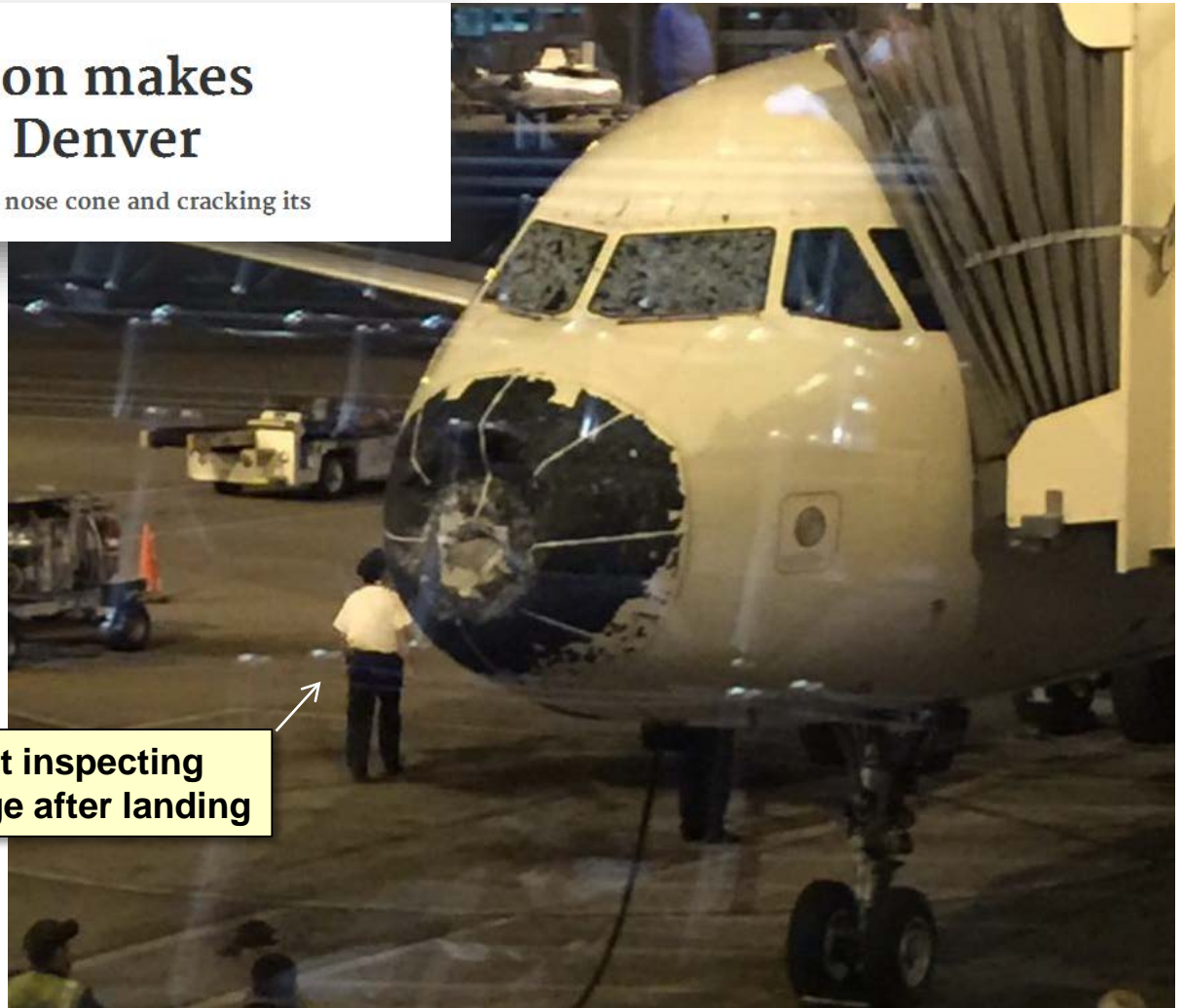
- **Traffic Flow Managers**
 - Terminal and enroute weather on same display
 - Weather translation into pilot avoidance areas
 - SWIM product delivery to Decision Support Tools
- **Enroute Air Traffic Controllers**
 - Timely, high resolution, flexible radar mosaics
- **Airlines and Commercial Providers**
 - 4-D aircraft trajectory through rapidly updating 3-D weather
- **Terminal Air Traffic Controllers**
 - Long range 25-sec update precip for large TRACONs
 - Integration of terminal safety products

Example Weather: Recent Hail Encounter

DENVER AND THE WEST

Delta flight from Boston makes emergency landing in Denver

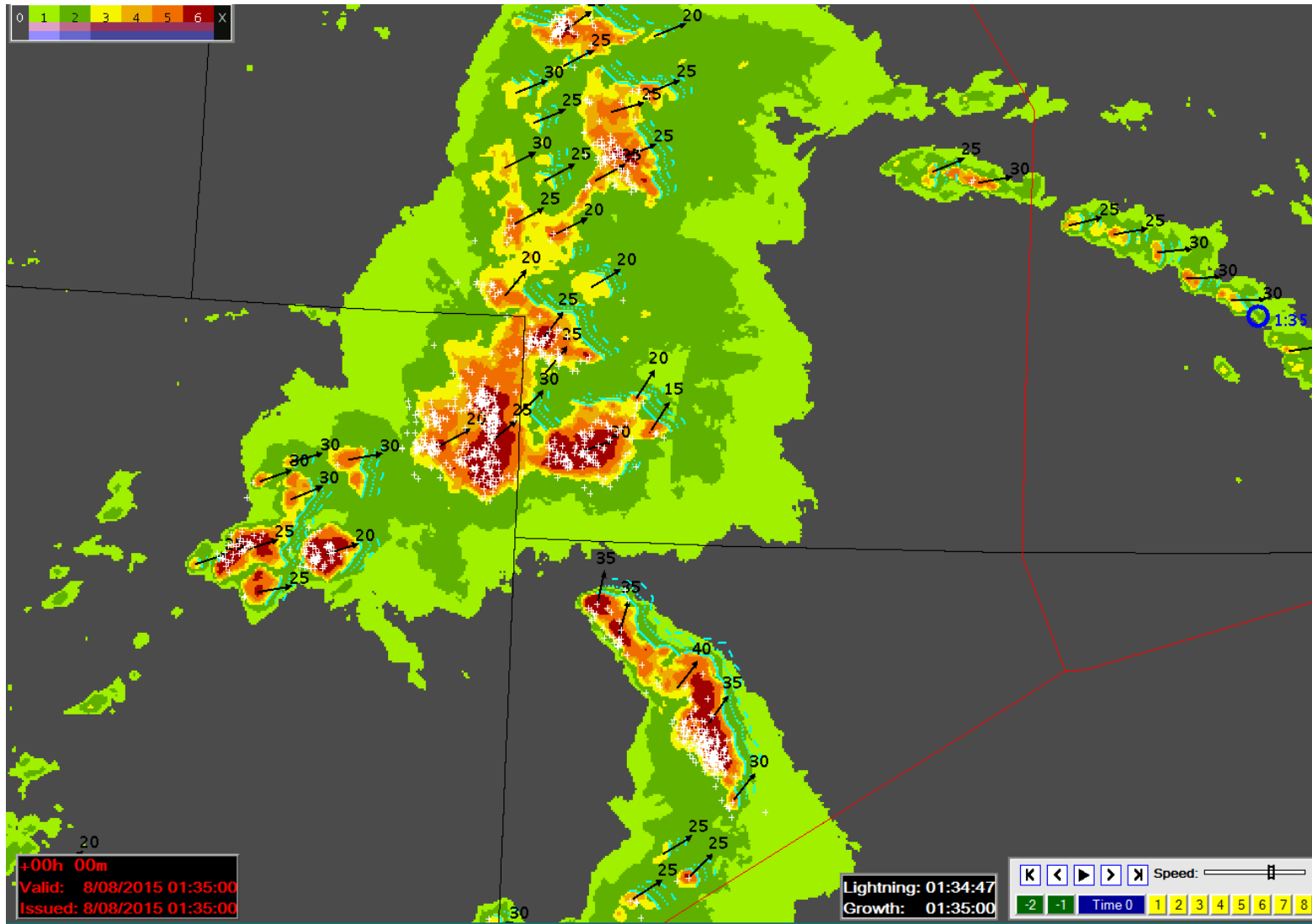
Jetliner pelted by hail, severely damaging plane's nose cone and cracking its windshield,



Pilot inspecting damage after landing

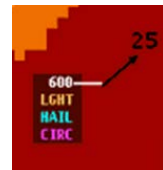
Occurred August 8, 2015
around 2:00 UTC

Today's Traffic Flow Management System Wx



New Storm Information: NextGen Weather

Benefits of Terminal & Enroute Wx Consolidation



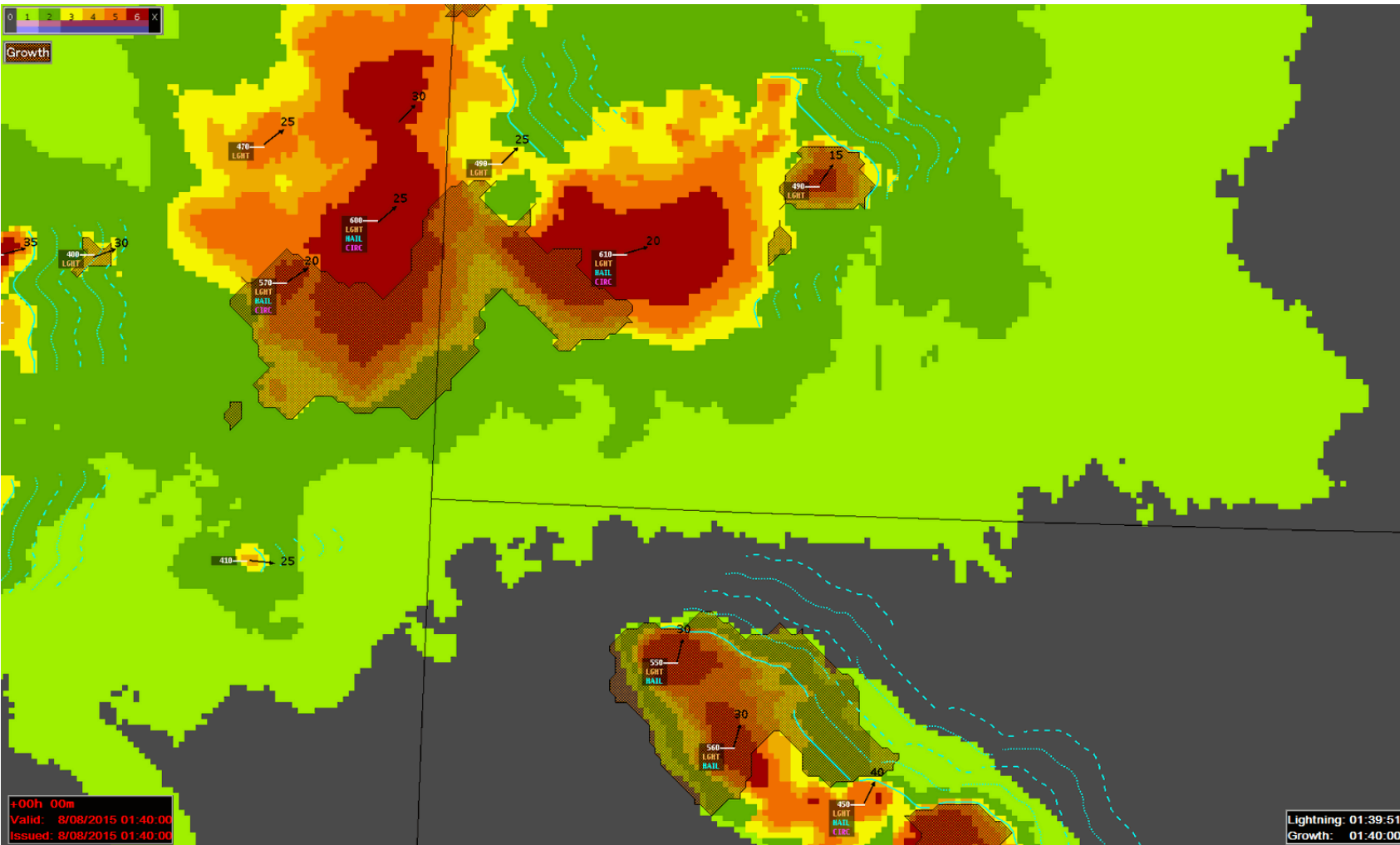
Storm Info Tags & Tornado Icon

- Terminal
- Safety



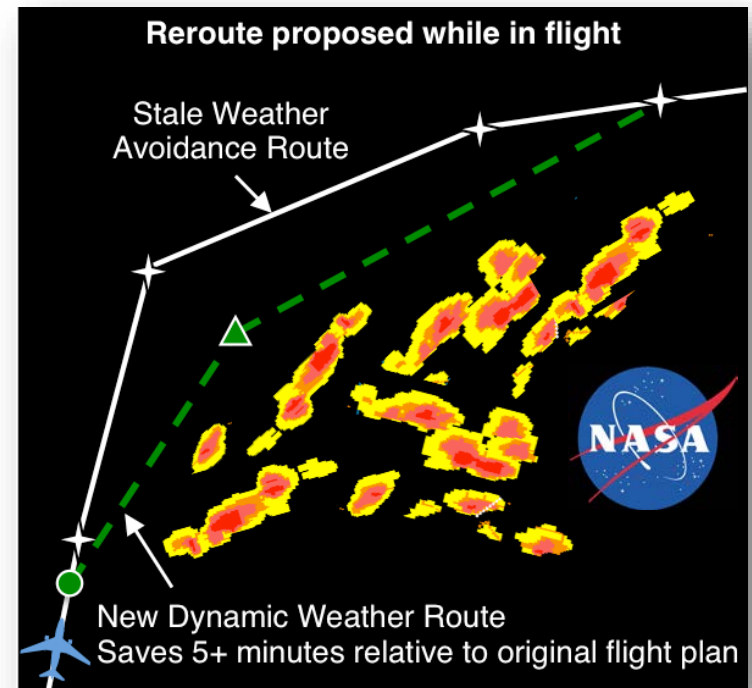
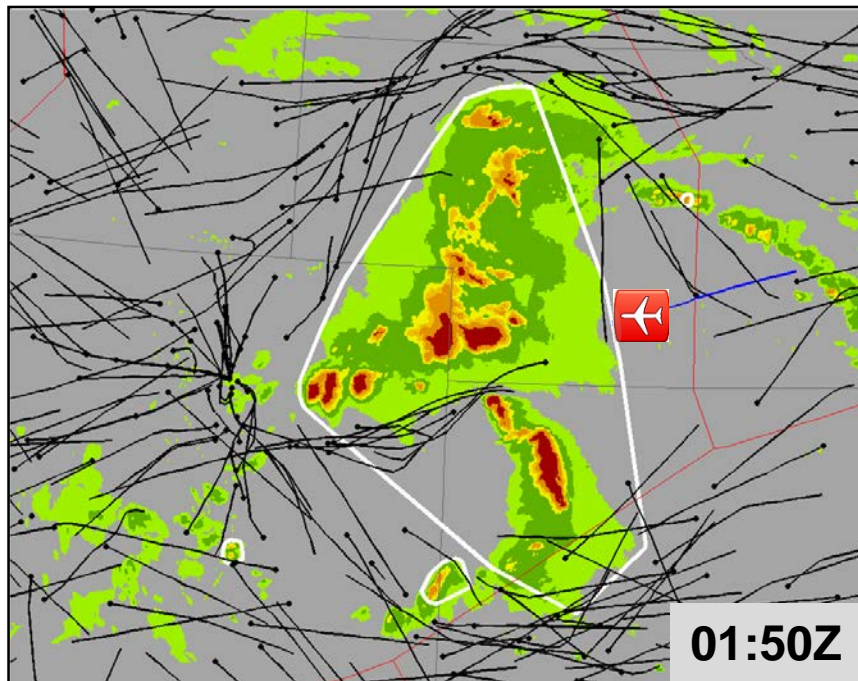
Growth Trends (rapid update)

- Enroute ATC
- 25 sec update

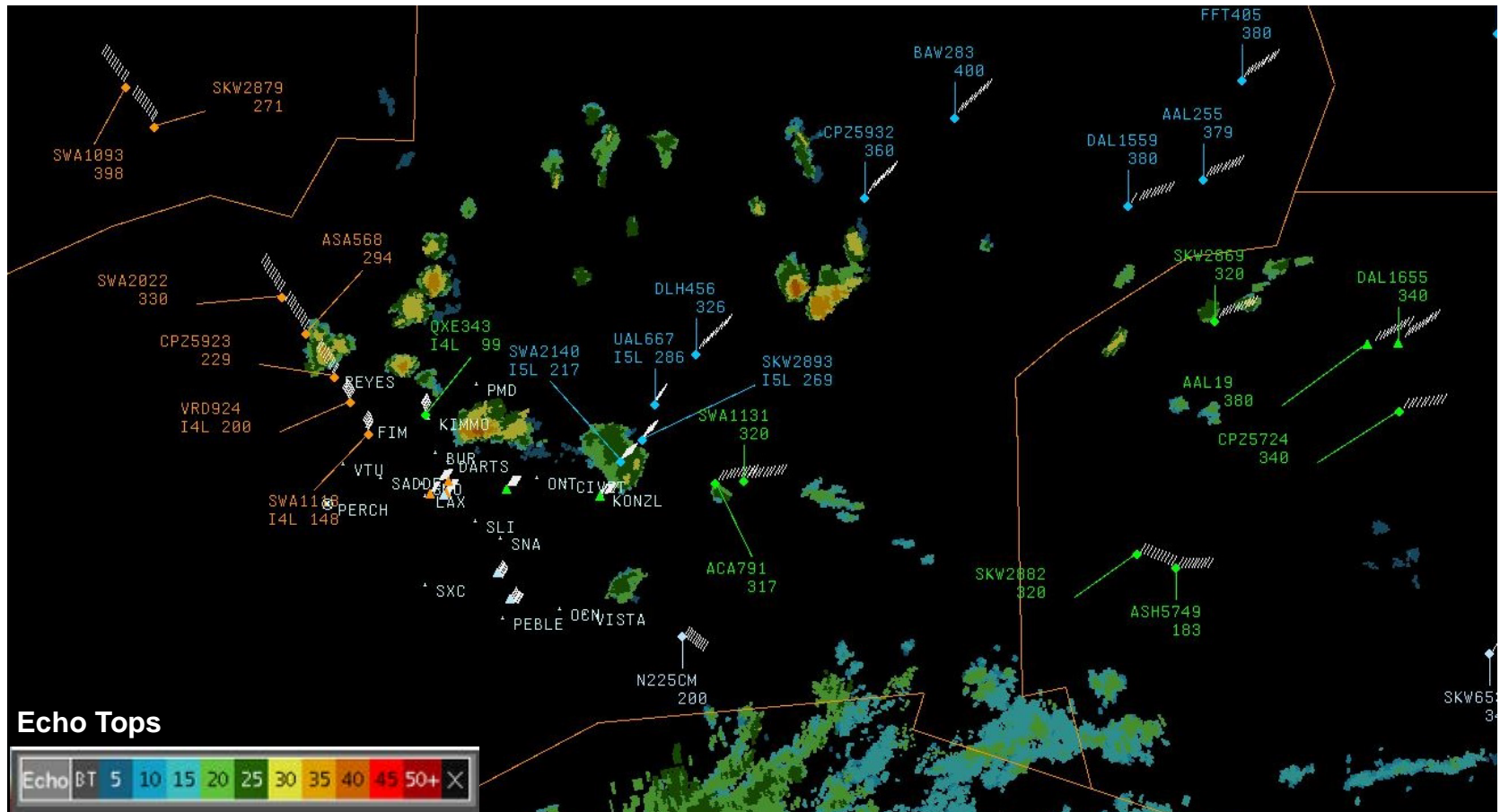


Convective Weather Avoidance Polygons (CWAP)

- NextGen Weather includes translation of convective weather into weather avoidance fields – areas pilots are likely to avoid
- Products include CWAP and CWAP forecasts out to 8 hours



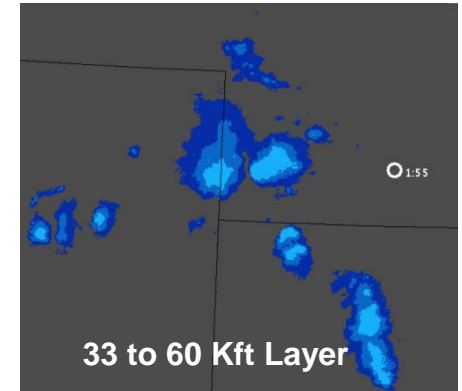
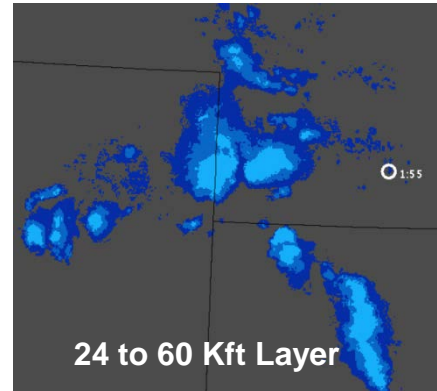
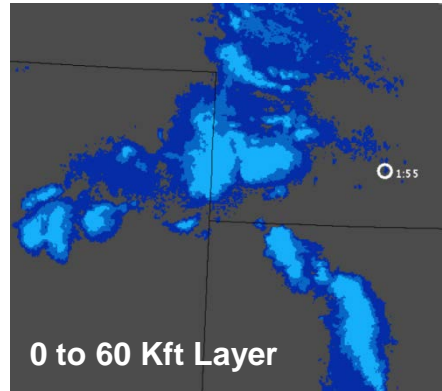
NextGen Weather on Time-Based Flow Management (TBFM) (Plan View Display - PGUI)



Enroute Automation Modernization (ERAM) System Wx

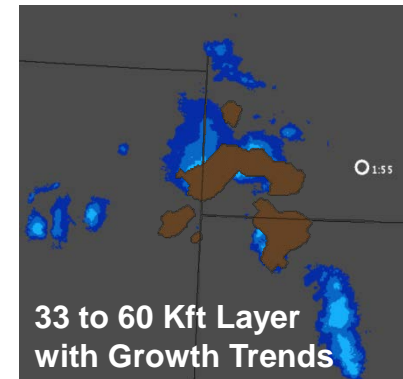
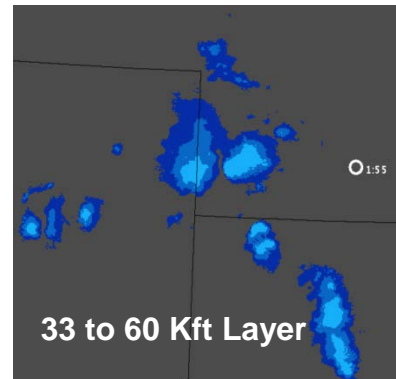
Current ERAM Composite Reflectivity – Levels 2, 3 and 5:

- Gap appears wider in uppermost layer – new storms are still below 33 Kft

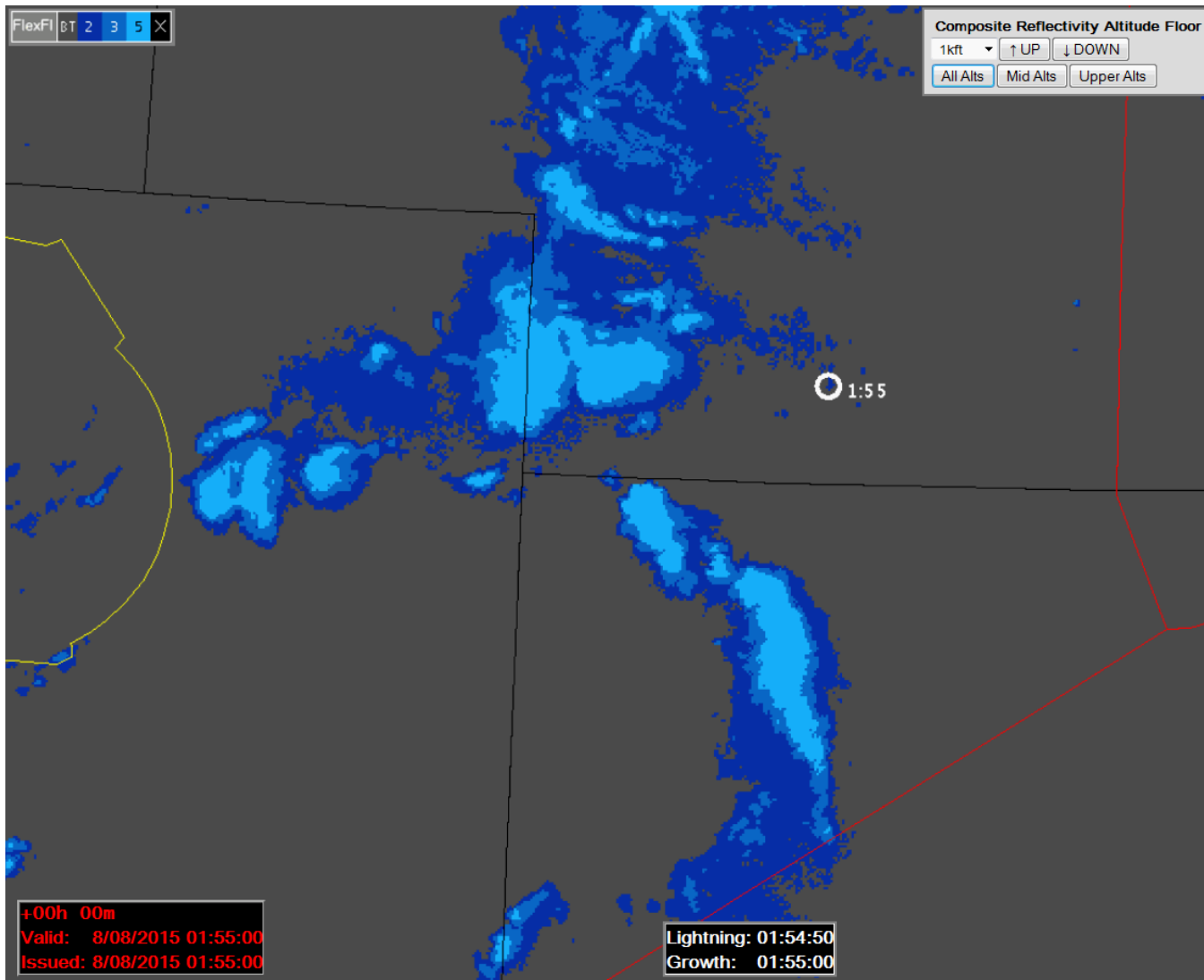


NWP Composite Reflectivity – Levels 2, 3 and 5:

- Growth Trends show growing storm hazard
- Could also consider HAIL tags and Storm Motion



NextGen Flexible Enroute Layer Mosaics



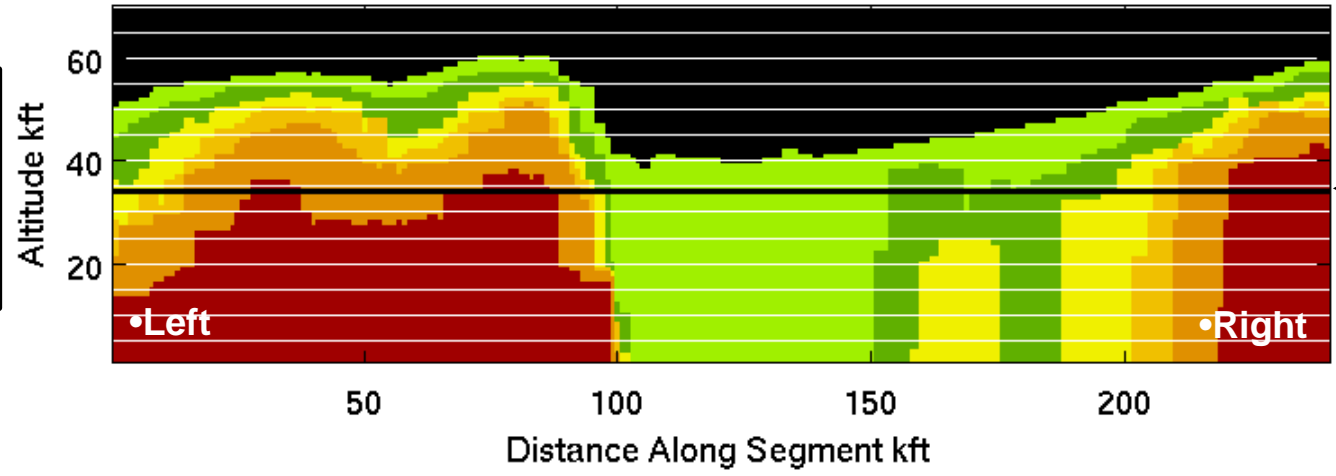
- Example shows Composite Reflectivity from “floor” to 60 Kft
- Layer bottom (“floor”) selectable in 1 Kft increments
- NextGen Weather radar mosaics contain fine-scale vertical storm structure
- Level 2 precip extends to 55 Kft!

4-D Trajectory Through Convective Weather

08/08/2015 01:52:30 UT Cross Section Composite from NWP Echo Tops

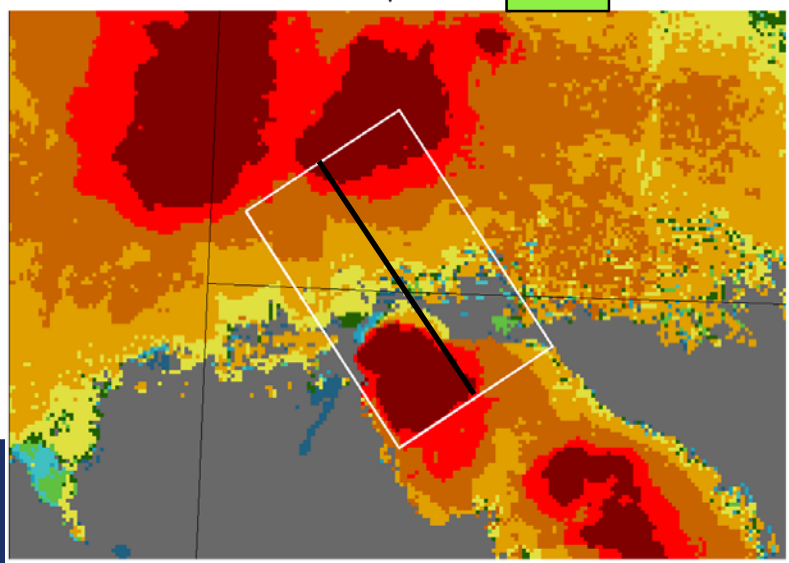
In cross section box

In storm



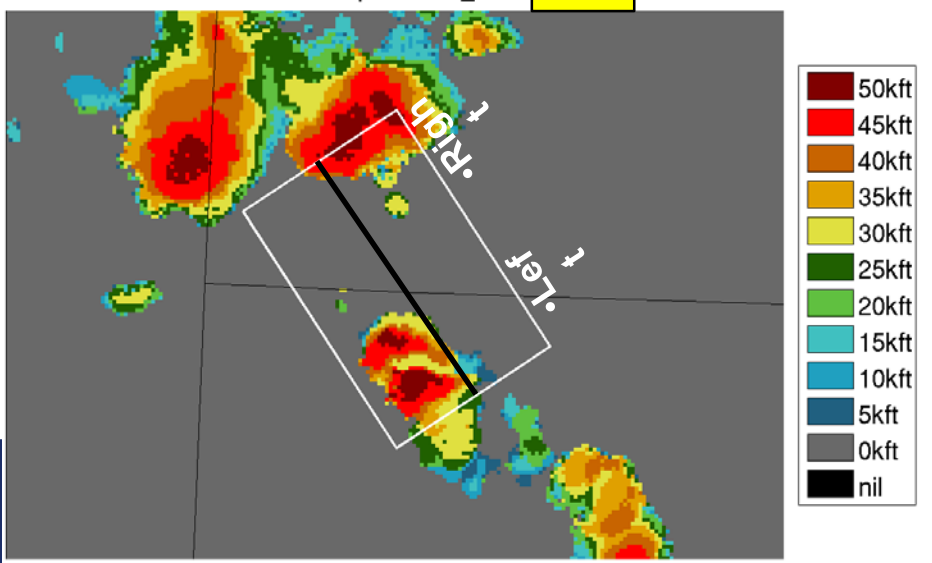
Flight altitude 34 Kft as approaching

EchoTopsMosaic **1**



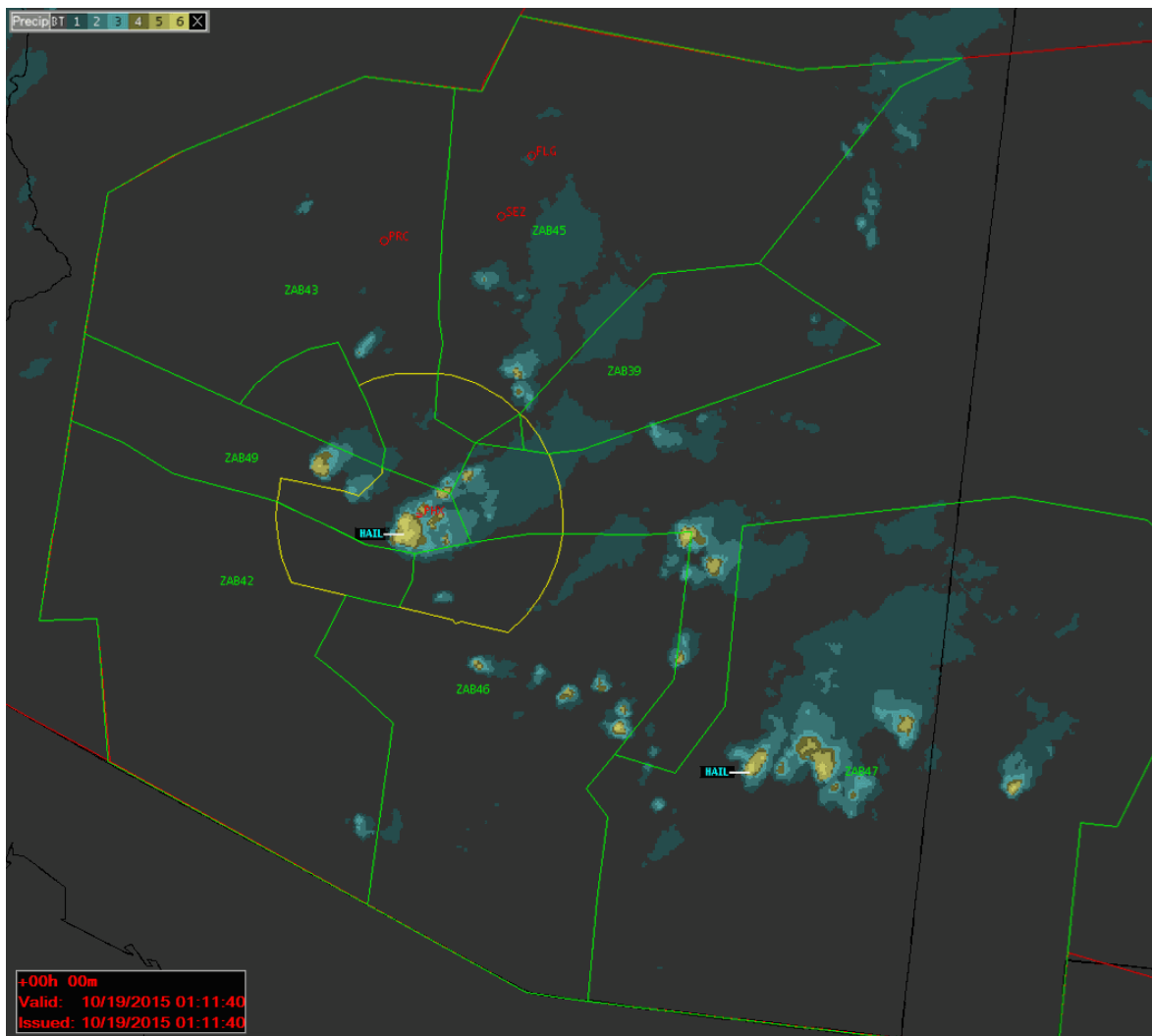
StopTime: 2015-08-08T01:53:20 | ValidTime: 2015-08-08T01:53:20

EchoTopsMosaic_L=3 **3**



StopTime: 2015-08-08T01:53:20 | ValidTime: 2015-08-08T01:53:20

NextGen Precip for Use in Terminal ATC



- **NextGen Weather precipitation product made from NEXRAD and TDWR radars**
- **Calibrated to match Terminal STARS ASR 6-level precipitation**
- **Range & update rate selectable**
 - Up to full CONUS, 25 sec
- **Web Map Service can convert digital product to graphic for display**
 - User-selected “styles” dictate colors and features

NextGen Weather on STARS

- Terminal safety products can easily be integrated on NAS user displays
 - Microbursts
 - Gust Fronts
 - Storm Motion
 - Storm Leading Edges
- Provides additional ATC safety margin
- Also provides common situational awareness
 - All users viewing same weather info



MISSION:

A WORLD OF INNOVATION

FPAW NWP Inputs

Tom Doyle



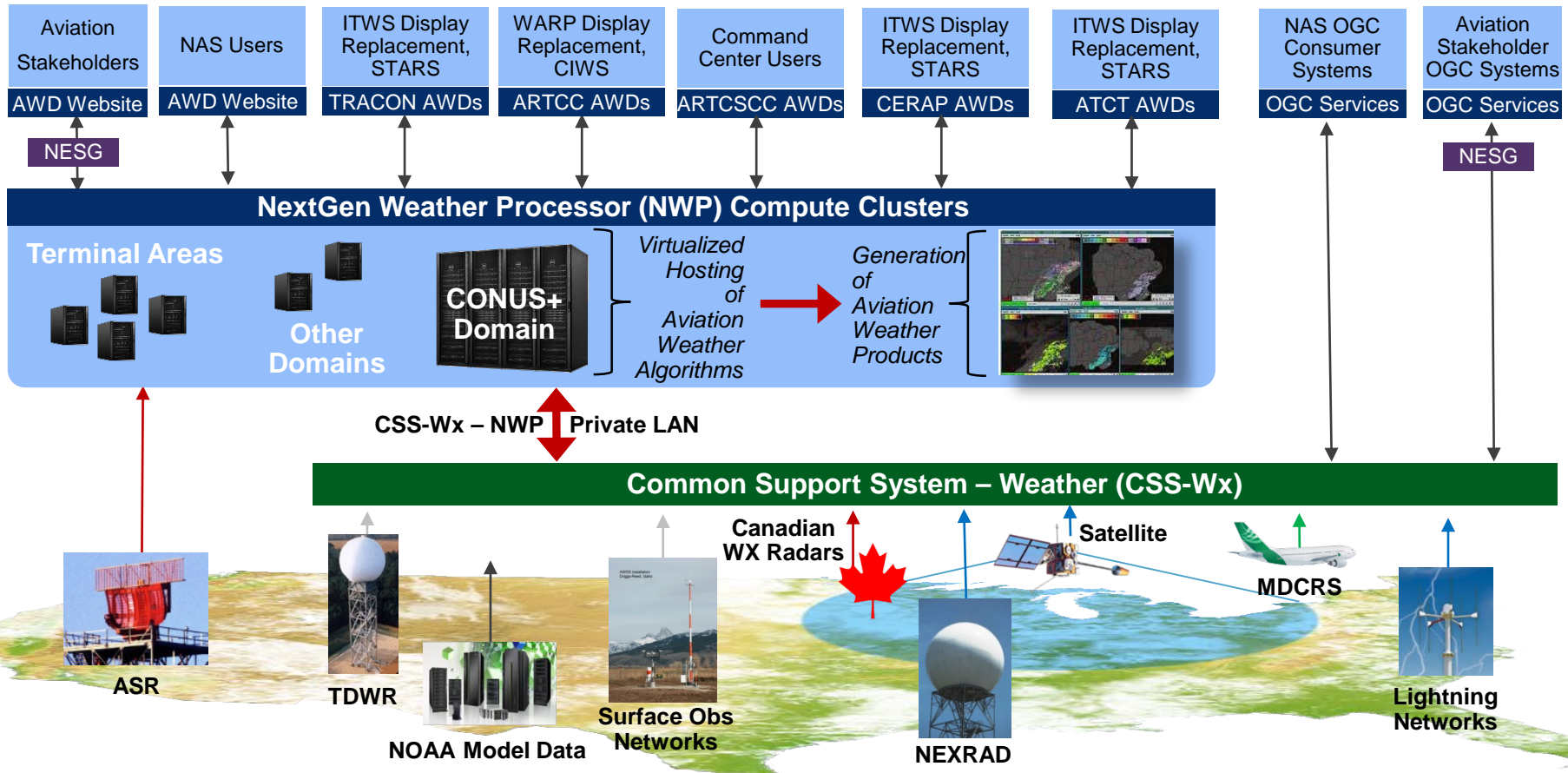
NextGen Weather Processor Overview

- **Aviation weather algorithms**
 - Ingest of real-time enhanced 4D weather and model data
 - Specialized to meet the needs of the aviation community
 - Integrated into a virtualized, scalable and flexible framework
- **Aviation Weather Display**
 - Common HTML 5 Web Application for all users
 - All operational and maintenance features via web browser user interface
 - AWD Website for NAS and External users
 - Hosted by redundant central compute clusters
 - Small Form Factor workstation (Dedicated AWD)
 - Each AWD hosts proxy website and local services (e.g. TDWR bypass)
- **Compute Cluster Infrastructure and Platform Services**
 - NWP software applications are hosted on a common platform
 - Virtualized, scalable, hardware independent
 - Directly connected to CSS-Wx via private LAN

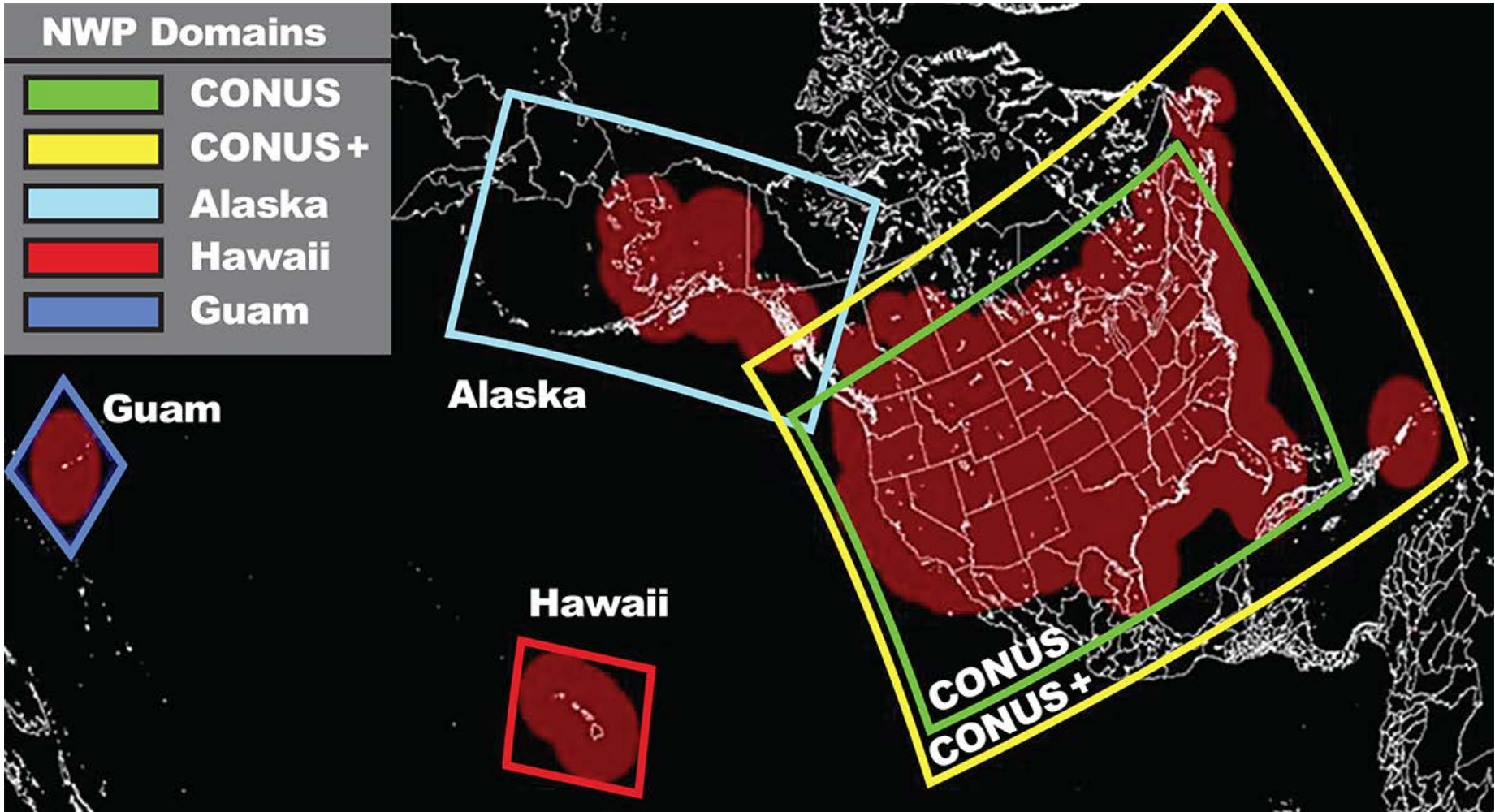
NextGen Weather Processor in the NAS

NWP Provides Access for NAS and External Users via Aviation Weather Displays (AWDs) and AWD Website

OGC Service Consumers



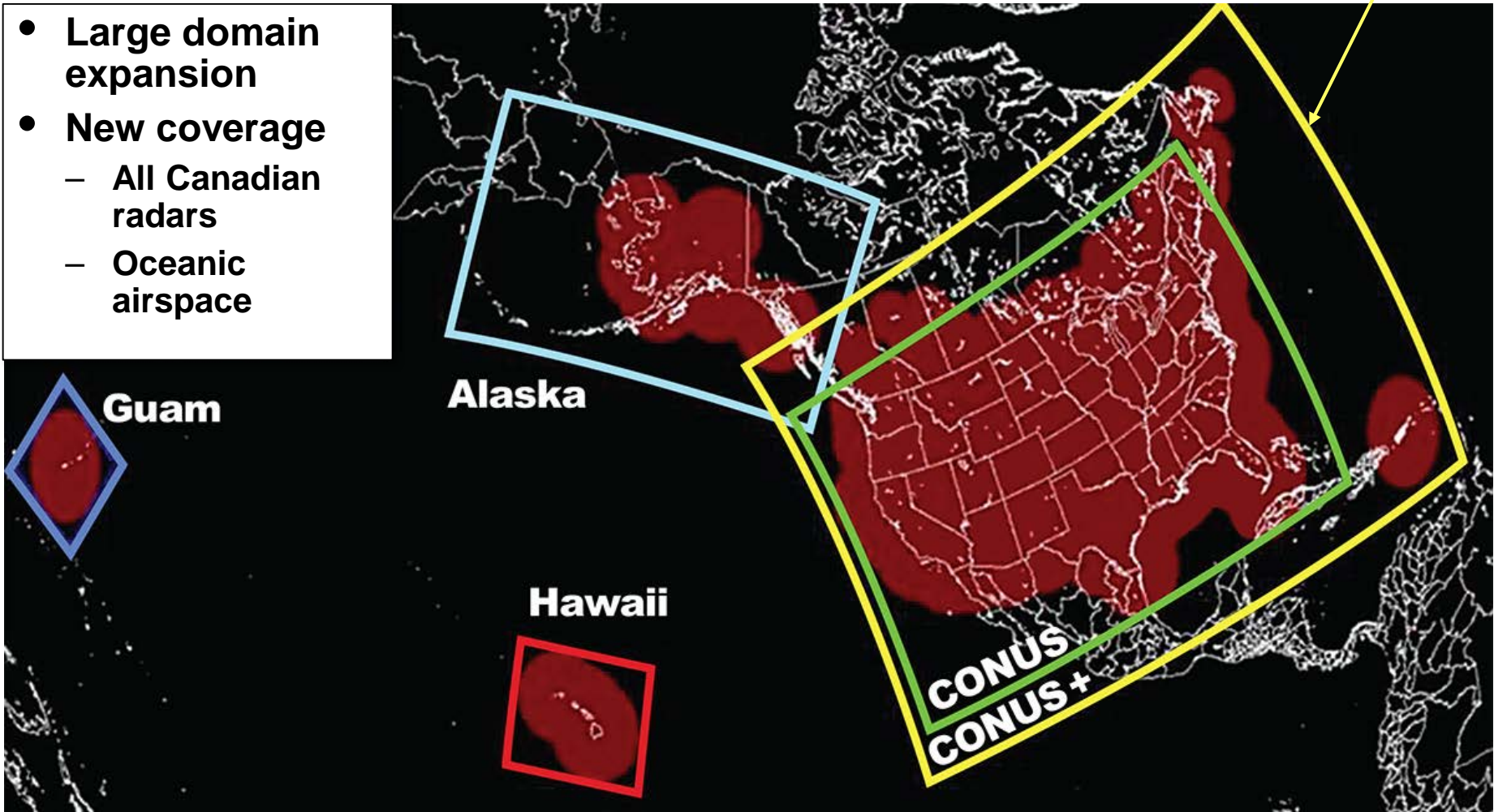
Coverage

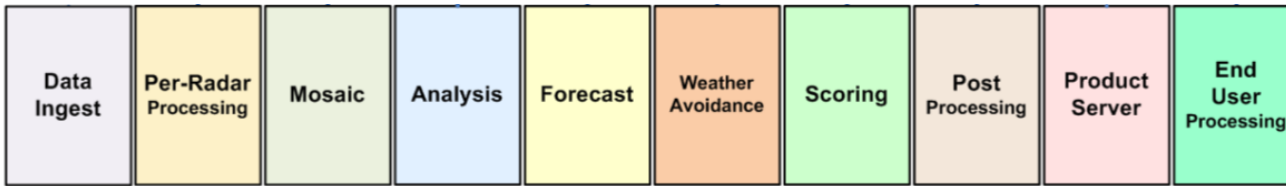


Coverage

- Large domain expansion
- New coverage
 - All Canadian radars
 - Oceanic airspace

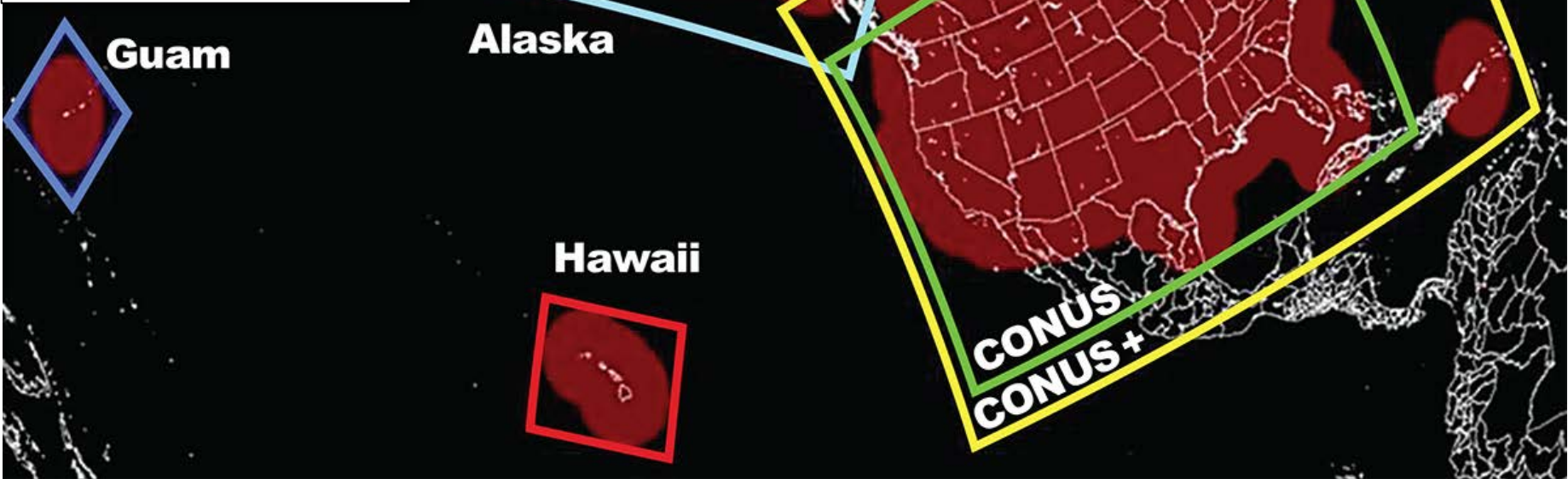
Large domain expansion



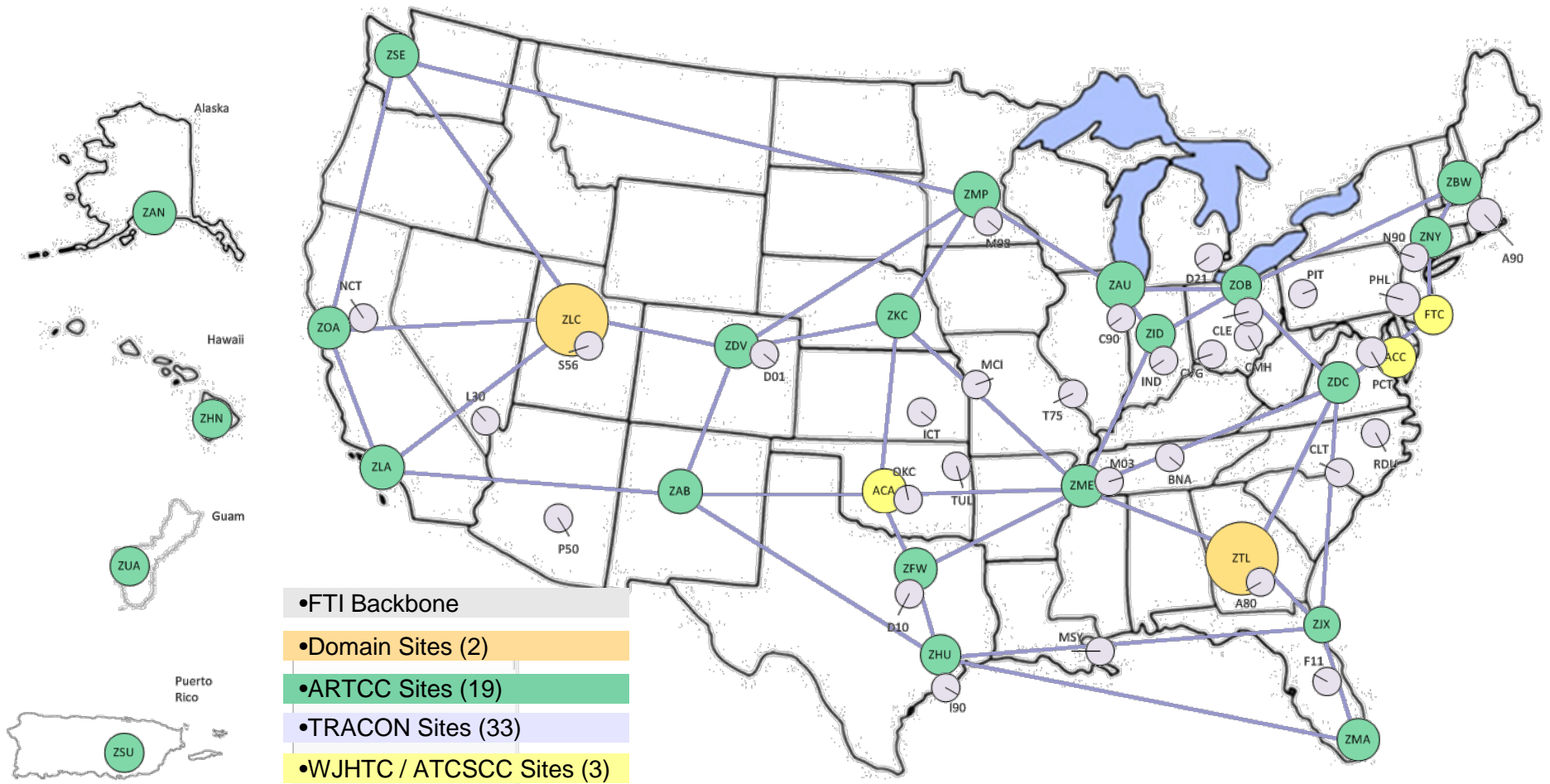


Large domain expansion

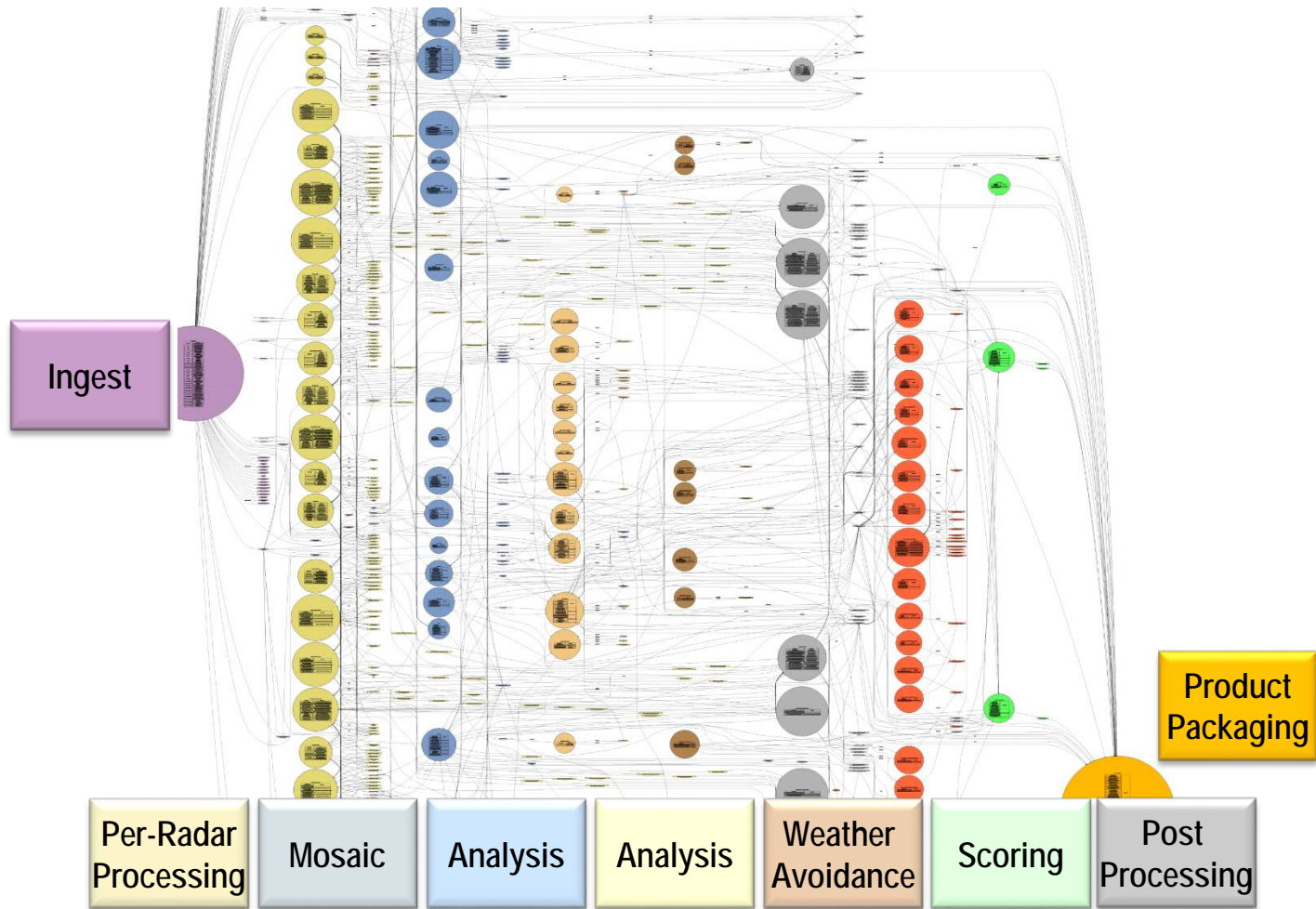
- Large domain expansion
- New coverage
 - All Canadian radars
 - Oceanic airspace



NWP Major Sites



NWP Domain Algorithms



Common Support Services – Weather (CSS-Wx)

Robert Carson, Harris

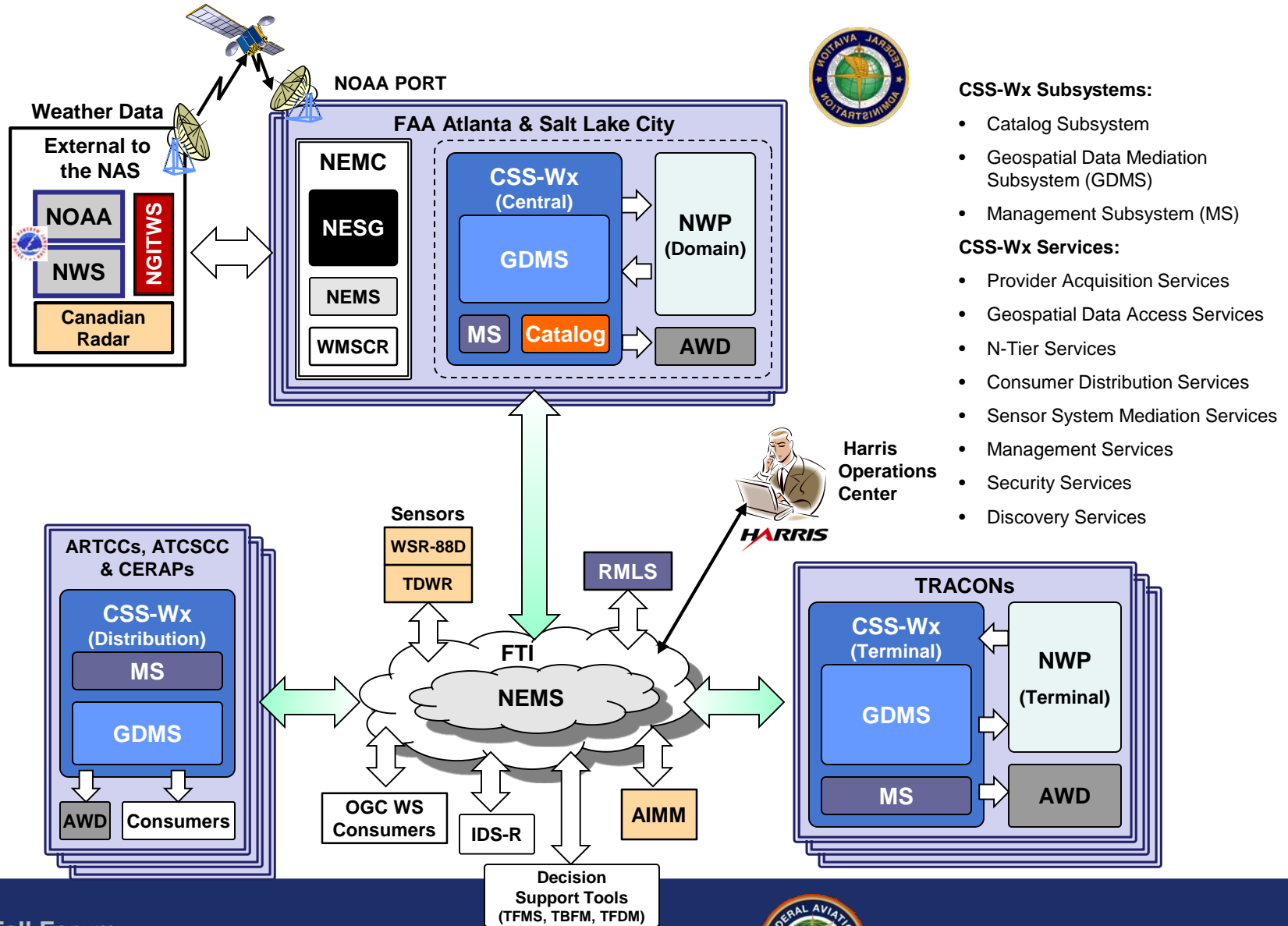


CSS-Wx CONOPS/Mission

- **Acquire weather information from FAA and other sources**
- **Provide data to systems that consume weather data**
- **Publish weather information in standardized formats for use by the FAA's ATO, commercial aviation, general aviation, and other Federal agencies**
- **Publish aviation weather products provided by the NWP, NOAA NextGen Web Services, other FAA weather data sources, and non-FAA weather data sources for aviation users**
- **High-level capabilities:**
 - Standardize weather information in common formats identified by the Open Geospatial Consortium (OGC);
 - Filter weather information geospatially and temporally based on a user's requirements;
 - Disseminate weather information via the SWIM system;
 - Perform weather data management; and
 - Store, archive, and retrieve weather information.



CSS-Wx Architecture within the NAS



- CSS-Wx Subsystems:**
- Catalog Subsystem
 - Geospatial Data Mediation Subsystem (GDMS)
 - Management Subsystem (MS)
- CSS-Wx Services:**
- Provider Acquisition Services
 - Geospatial Data Access Services
 - N-Tier Services
 - Consumer Distribution Services
 - Sensor System Mediation Services
 - Management Services
 - Security Services
 - Discovery Services



CSS-Wx Capabilities

- **Discovery/Catalog services**
- **Acquires aviation and weather products from**
 - NWP, NOAA Web services, AIMM Web services, WMSCR, Sensors (NEXRAD, TDWR, CANRAD, NOAAPORT GOES)
- **N-Tier services (Backfill, Hosted Algorithms)**
- **Subscription service**
- **Distributes aviation and weather products through**
 - Web services (WCS, WFS, WMS, WMTS)
 - Service Adaptors (SA) for legacy interfaces
 - Shared interface between CSS-Wx and NWP
 - FTI, NEMS and local LAN connections
- **System Management**
 - M&C and housekeeping
- **Located at 21 ARTCCs, ATCSCC, 34 TRACONs, 3 CERAPs, & WJHTC**



CSS-Wx Web Services

- **Web Coverage Service (WCS)**

- A coverage is digital geospatial information representing space-varying phenomena
- Distributes coverage/gridded data using the Open Geospatial Consortium (OGC) Web Coverage Service Implementation Standard (Example: NOAA gridded models, radar mosaics, etc.)
- Outputs gridded data in netCDF-4

- **Web Feature Service (WFS)**

- A feature is an abstraction of a real world phenomenon where a geographic feature is a feature associated with a location relative to the Earth
- Distributes feature/non-gridded data in WXXM format using the OGC OpenGIS Web Feature Service Interface Standard

- **Web Mapping Service (WMS)**

- WMS provides rendered maps as map image files using the OGC defined Web Map Service
- Obtains gridded and non-gridded products from the WCS-I and WFS-I through the cascade method to produce maps/images from those data and distribute the images to consumers
- Supports the output of PNG, JPG and GIF formats

- **Web Mapping Tile Service (WMTS)**

- Provides maps in the form of map tiles
- Uses predetermined maps to provide the capability to cache map tiles
- Supports the output of PNG, JPG, and GIF formats

CSS-Wx Web Service Capabilities

- **Conversions (WCS, WFS, WMS)**
 - Conversion to/from spherical, NAD83 and WGS84 and unit conversions
- **Filtering**
 - Filter weather data based on user-selected field/layer names
 - (WCS, WMS) Spatial extends using basic geometries (bounding box), temporal trajectory, and specified parameter value “above”, “below”, “equal to”
 - (WFS) Geospatial Points, Line Segments, 2-D Polygon, Circle, basic geometries (BB), user-specified trajectory-related geometries, by two specified times (For example, a forecast time and a dataset generation time)
 - (WMTS) TileMatrix, valid time, elevation
- **Decimation (WCS, WMS)**
 - Decreased data resolutions with data interpolation methods
- **Quantization (WCS, WMS)**
 - Quantize data values of a user-specified weather product
- **Re-projections (WCS, WMS, WMTS)**
 - Re-projection for Lambert Conformal, Latitude/Longitude, Mercator, Stereographic, Cartesian, En Route, and Oceanic NAS Projection map projection coordinates and Tile Matrices
- **Store Configuration Parameters**
 - Fields for coverages/features/layers, titles and unique IDs per coverage/feature/layer, quantization profiles, endpoints, coordinate reference system, etc.
 - (WMS) Styled Layer Descriptor (SLD) and Scalable Vector Graphic (SVG) files

CSS-Wx Web Service Message Exchange Patterns

- **Ad-hoc Request/Response MEP (WCS, WFS, WMS, WMTS)**
 - Consumer identifies the raster dataset along with filtering parameters using the GetCapabilities operation
 - Available datasets are defined by service metadata which may be retrieved by the GetCoverage/Feature/Map/Tile operation
- **Static and On-Demand Persistent Query subscriptions (WCS, WFS, WMS)**
 - Static: Design time stored subscriptions with products published to a JMS endpoint
 - On-Demand: Run time OGC client processed subscriptions with products published to a JMS endpoint
- **Static and On-demand Notification subscriptions (WCS)**
 - Static: Design time store subscriptions
 - On-Demand: Run time OGC client processed subscriptions
 - Consumer receives notification that published information is available through the subscription
 - Consumer may then retrieve the data through a Request/Response exchange

CSS-Wx N-Tier Services

- **Hosted Algorithm Services**

- Hosted Algorithms integrate weather data with user-specified and/or site-adaptable information to generate products for immediate use
- Hosted Algorithms by a Web service acting on behalf of a consumer application
- Hosted processing reduces bandwidth and latency costs associated with transporting large data sets over telecommunication circuits

- **Model Data Backfill**

- In the event of missing model data, the CSS-Wx System will provide the capability to replace the missing data with valid forecast information from previous model runs

Hosted Algorithms

- **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

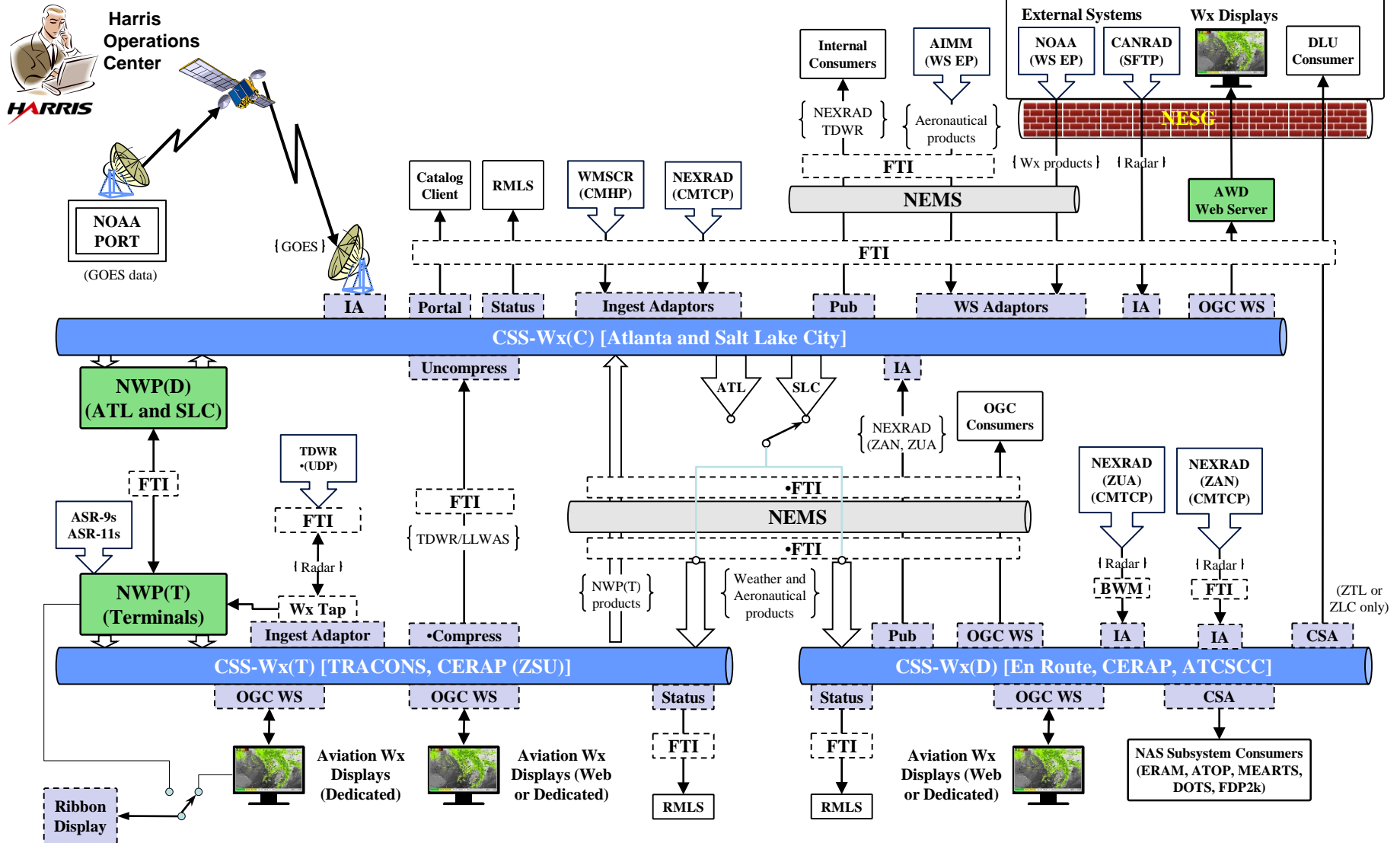
- **Display Algorithms**

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

CSS-Wx Products

- **NOAA**
 - Model Products
 - Alphanumeric
 - Gridded & Graphic
- **Aeronautical – AIMM**
 - Geopolitical Boundaries
 - Geopolitical Features
 - NAS Boundaries
 - NAS Routes
 - NAS Features
 - System & Sensor Locations
- **Sensor Product Sets**
 - NEXRAD Level III
 - TDWR Base Data
 - NavCanada Weather Radar
 - GOES (E/W) Satellite Data
- **NWP Domain Products**
 - Gridded Analyses
 - Gridded Forecasts (0-2 hours)
 - Gridded Forecasts (2-8 hours)
 - Non-Gridded Analyses
 - Non-Gridded Forecasts
 - System Information Messages
- **NWP Terminal Products**
 - Gridded Products
 - Non-Gridded Products
 - System Information Messages
- **WMSCR (Source) Products**
 - Lightning Detection Data
 - Surface Wx Obs (OMO)
 - Pilot Reports (PIREPs)

NEXTGEN Wx Data Flow

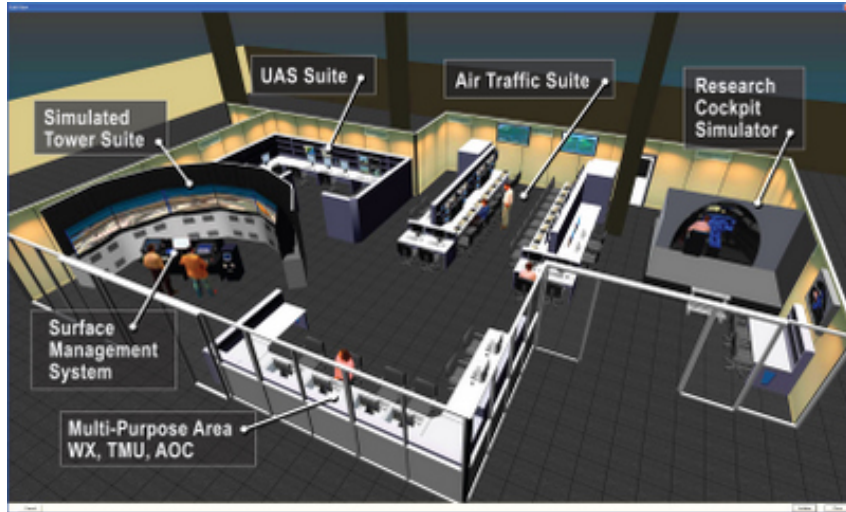


NAS User Participation

- **CSS-Wx provides access to common source – FAA and External Users**
 - FAA ATC/ATM Controllers
 - Airline AOCs
 - LM Flight Service
 - Weather Vendors
 - Others ...
- **Enhances access to timely updates and new products**
- **Provides opportunity for new support concepts and procedures**

Demonstration – User Participation

NextGen Integration and Evaluation Capability (NIEC)



Global SWIM Demonstrations – FTB

- Mini Global II (MG II)
 - Global AIXM, IWXXM, & FIXM exchange
 - Complex ATM Scenarios
- Mar-Apr 2016

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

NWP Test Reference System

- Generate NWP Test Data
- Could be provided to users for early development and demonstration

NextGen Weather Summary

- **CSS-Wx and NWP 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
- **Concept Evaluations and Global Demonstrations will advance implementation of:**
 - NextGen Wx Systems
 - ICAO ATM and FAA NextGen concepts

Resources

- **NextGen Weather:**

- <https://www.faa.gov/nextgen/programs/>

- **CSS-Wx Wiki at NCAR:**

- <https://wiki.ucar.edu/display/CSSWX/CSS-Wx+Home>

- **Program contact information:**

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alfred.moosakhanian@faa.gov

Key Acronyms

- ADAS: Automated Weather Observing System (AWOS) Data Acquisition System
- ARTCC: Air Route Traffic Control Center
- ASOS: Automated Surface Observing System
- ASR: Airport Surveillance Radar
- ATOP: Advanced Technologies and Oceanic Procedures
- AWD: Aviation Weather Display
- AWOS: Automated Weather Observing System
- AWSS: Automated Weather Sensor System
- CDDS: CIWS Data Distribution Service
- CIWS: Corridor Integrated Weather System
- CREWS: CTAS Remote Weather System
- CSS-Wx: Common Support Services for Weather
- DHS: Department of Homeland Security
- DoD: Department of Defense
- DOTS+: Dynamic Oceanic Tracking System Plus
- DST: Decision Support Tools
- ERAM: En Route Automation Modernization
- EWD: Enhanced WINS Dissemination (WARP)
- FBWTG: FAA Bulk Weather Telecommunications Gateway
- FDP2K: Flight Data Processing 2000 System
- FTI: FAA Telecommunications Infrastructure
- IDS-R: Information Display System Replacement
- ITWS: Integrated Terminal Weather System
- LLWAS: Low-Level Windshear Alert System
- MEARTS: 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
- NEMC: National Enterprise Management Center
- NWP: NextGen Weather Processor
- OGC: Open Geospatial Consortium
- RAMP: Radar Acquisition and Mosaic Processor
- SWIM: System Wide Information Management
- TBFM: Time Based Flow Metering
- TDWR: Terminal Doppler Weather Radar
- TFDM: Terminal Flight Data Manager
- TFMS: Traffic Flow Management System
- TMU: Traffic Management Unit
- TRACON: Terminal Radar Approach Control
- VOLPE: National Transportation Systems Center (ITWS Web Services Provider)
- WARP: Weather and Radar Processor
- WINS: Weather Information Network Server
- WMSCR: Weather Message Switching Center Replacement