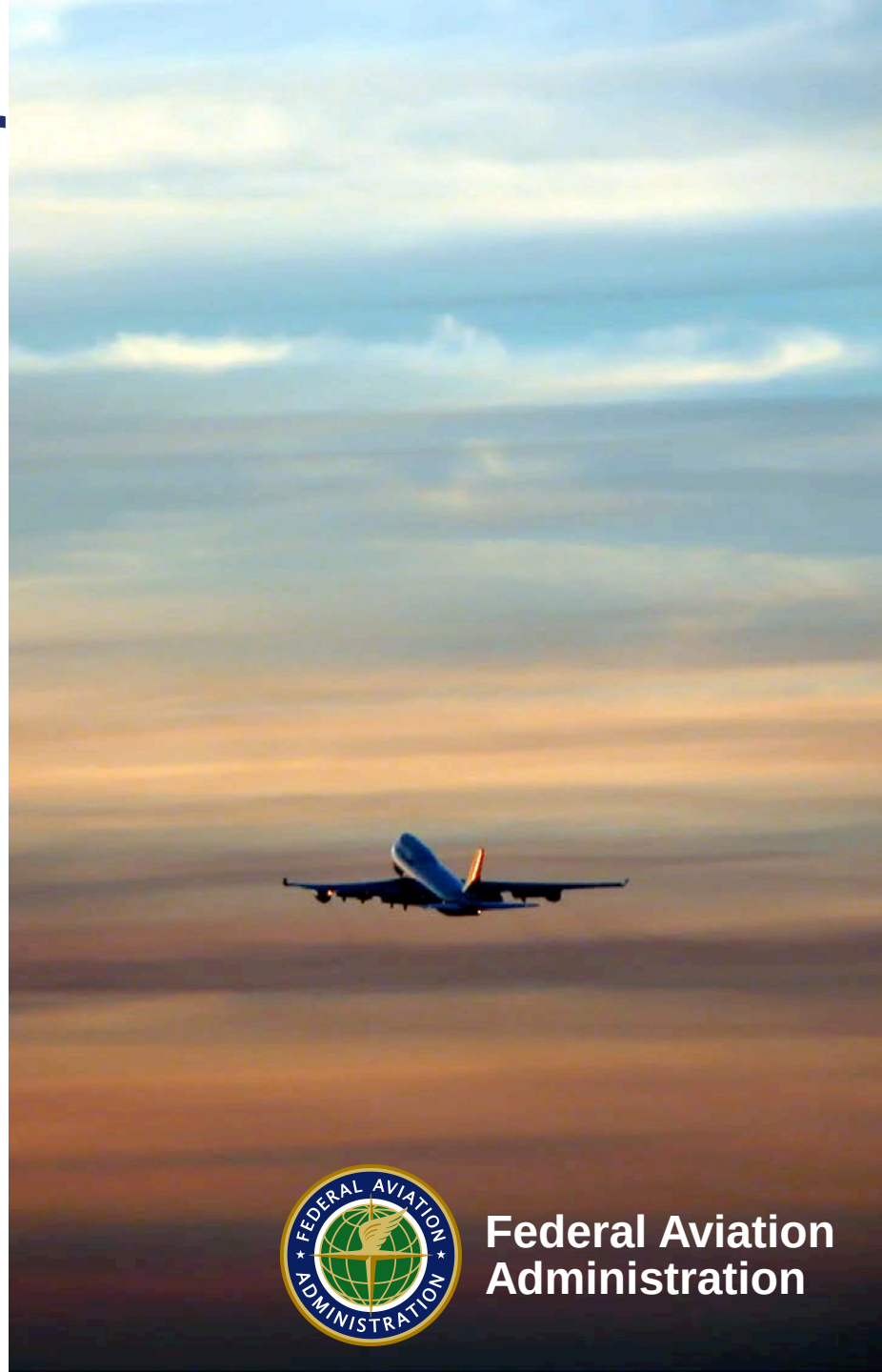
NextGen Weather Systems

CSS-Wx and NWP



Presented to: FPAW
By: PMO NextGen Wx Systems
Date: July 2018

Purpose

- **Provide NextGen Weather programs status**
  - Common Support Services- Weather (CSS-Wx)
  - NextGen Weather Processor (NWP)
- **Working with stakeholders to improve weather products from legacy to NextGen**
  - Building, delivering, and using digital weather information
  - Areas for further leveraging and collaboration

NextGen Weather Implementation

NextGen Wx Systems WP1 and WP2

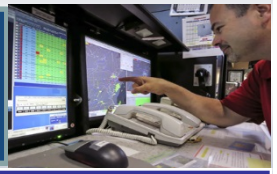
- **NextGen Weather Portfolio consists of two programs**
  - CSS-Wx for weather information dissemination
  - NWP for weather data processing
- **Work Packages 1 in solution implementation**
  - CSS-Wx contract awarded to Harris in April 2015
  - NWP contract awarded to Raytheon in April 2015
  - Three legacy weather systems will be decommissioned (ITWS, WARP, CIWS)
- **Work Packages 2 in progress**
  - CSS-Wx and NWP IARDs in 2019 Q4; planned FIDs in 2021 Q4
  - Continuing agile development approach
  - Four legacy weather systems will be subsumed (WMSCR, ADAS, WIFS, ALDARS)

CSS-Wx Program Overview

Common Support Services – Weather (CSS-Wx): ACAT 1

Improves weather information management and user access; provide new interface standards and formats

Reduces FAA cost by enabling decommissioning of legacy weather dissemination systems (e.g., WARP WINS, FBWTG, CDDS)



Capabilities	Benefits	Timeline

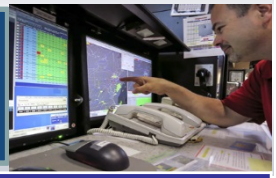
➢ **Single provider of weather data products within the NAS, using standards-based weather dissemination**
➢ **Makes weather products available from NOAA, NWP and other data sources for integration to air traffic systems**
➢ **Provides weather products via a set of common Web Services for weather, using international data access and data format standards**
	➢ **Reduces FAA costs**
	  ➢ Reduces infrastructure/bandwidth costs by optimizing weather dissemination
	  ➢ Reduces interface development costs by eliminating custom point-to-point interfaces
	➢ **Improves NAS information**
	  ➢ Facilitates consistent weather information using standard formats
	  ➢ Increases NAS access to common weather information
		➢ **Awarded to Harris in April 2015, executing base contract year 3**
		➢ **Incremental Agile Software design/development/test in progress**
		➢ **Conducted Critical Design Review (CDR): June 2016**
		➢ **Factory Acceptance Testing (FAT): March 2018**
		➢ **Initial Operational Capability (IOC): January 2019**

NWP Program Overview

NextGen Weather Processor (NWP): ACAT 2

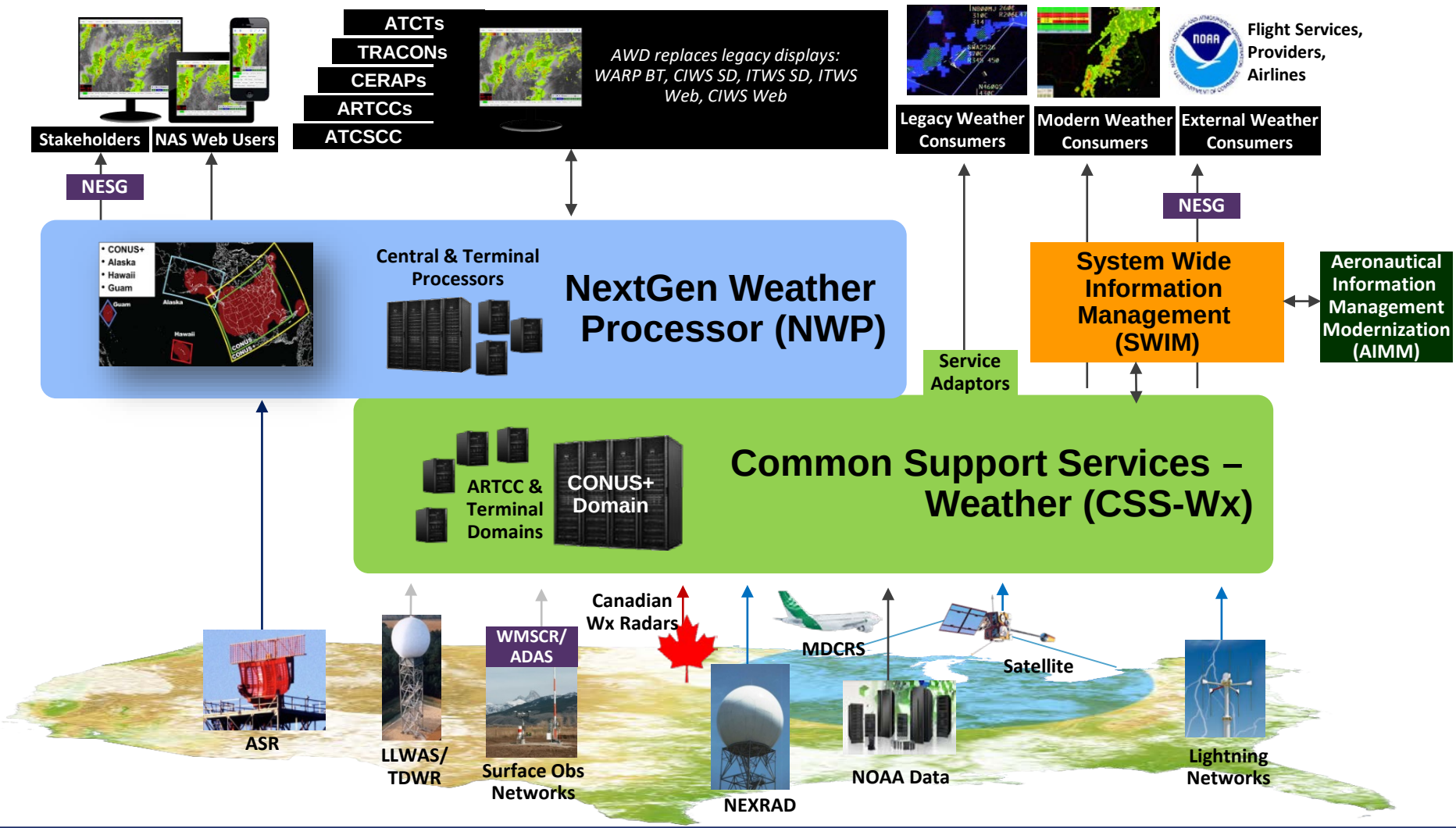
Increases NAS efficiency and safety by improving weather product generation, translation, and display for aviation weather users

Reduces FAA costs by enabling decommissioning of legacy weather processor systems (e.g., WARP, ITWS, CIWS)



Capabilities	Benefits	Timeline
➢ **Produces advanced aviation specific weather products** • Wind Shear alerts • Real-time weather radar information (e.g., ERAM) • 0 to 8 hour aviation weather products • Convective Weather Avoidance Fields ➢ **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 AT users**	➢ **Reduces operational costs** • Establishes weather processing platform • Consolidates legacy processors ➢ **Reduces air traffic delays** • Maximizes available runway and airspace usage • Improves accuracy, timeliness and look ahead (0-8 hour) of aviation-specific weather information to air traffic • Enhances weather algorithms	➢ **Awarded to Raytheon in April 2015, executing base contract year 3** ➢ **Incremental Agile Software design/development/test in progress** ➢ **Conducted Critical Design Review (CDR): November 2016** ➢ **Factory Acceptance Testing (FAT): February 2019** ➢ **Initial Operational Capability (IOC): August 2020**

NextGen Weather Architecture



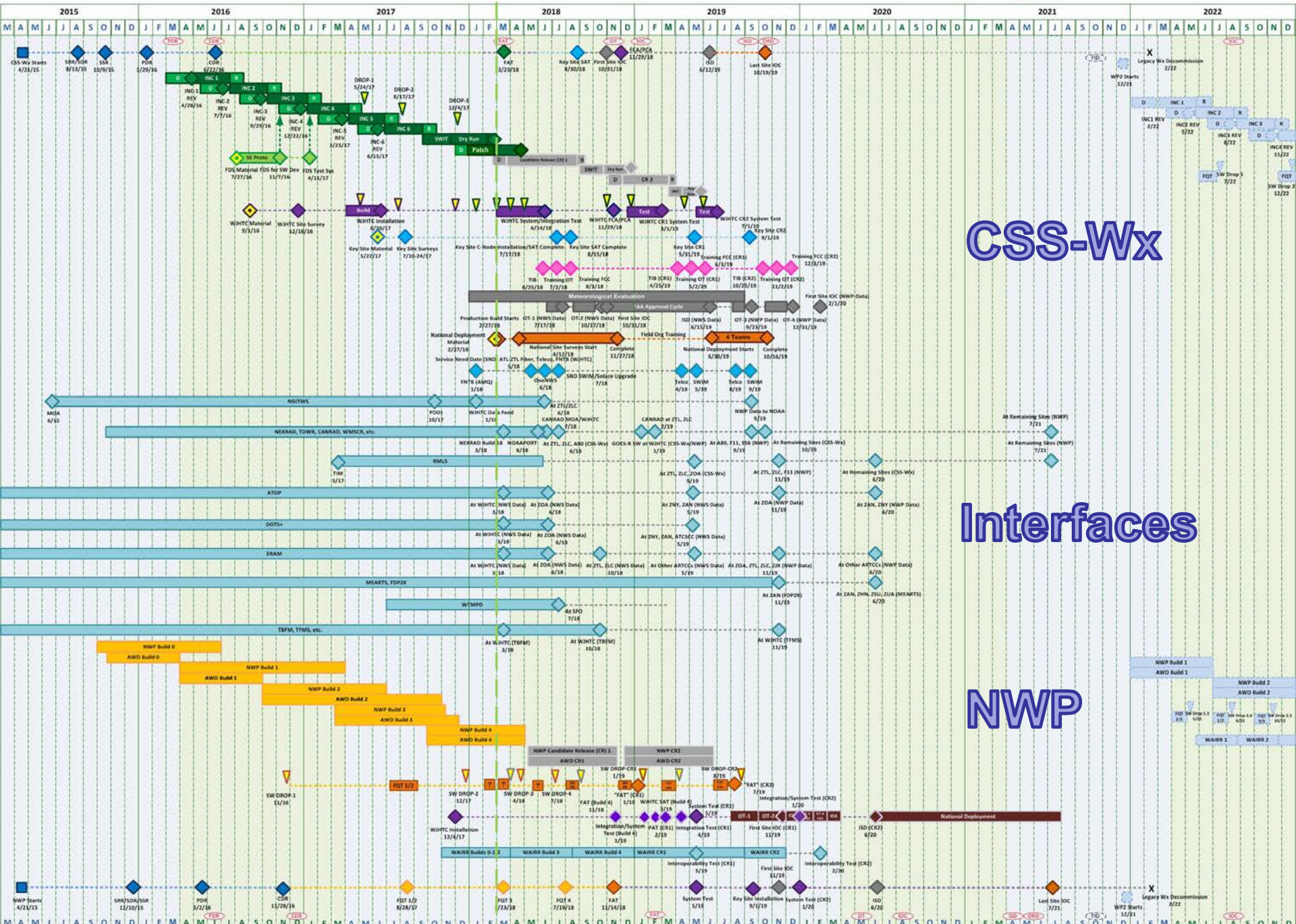
CSS-Wx/NWP APB Milestones

	Milestone	CSS-Wx	NWP
✓	Final Investment Decision (FID)	March 2015	March 2015
✓	Contract Award	June 2015	June 2015
✓	Preliminary Design Review (PDR)	March 2016	June 2016
✓	Critical Design Review (CDR)	September 2016	December 2016
✓	Factory Acceptance Test (FAT)	March 2018	February 2019
	Operational Test (OT)	November 2018	May 2020
	Key Site Initial Operational Capability (IOC)	January 2019	August 2020
	In Service Decision (ISD)	September 2019	April 2021
	First Site Operational Readiness Date (ORD)	October 2019	May 2021
	Last Site ORD	August 2022	August 2022

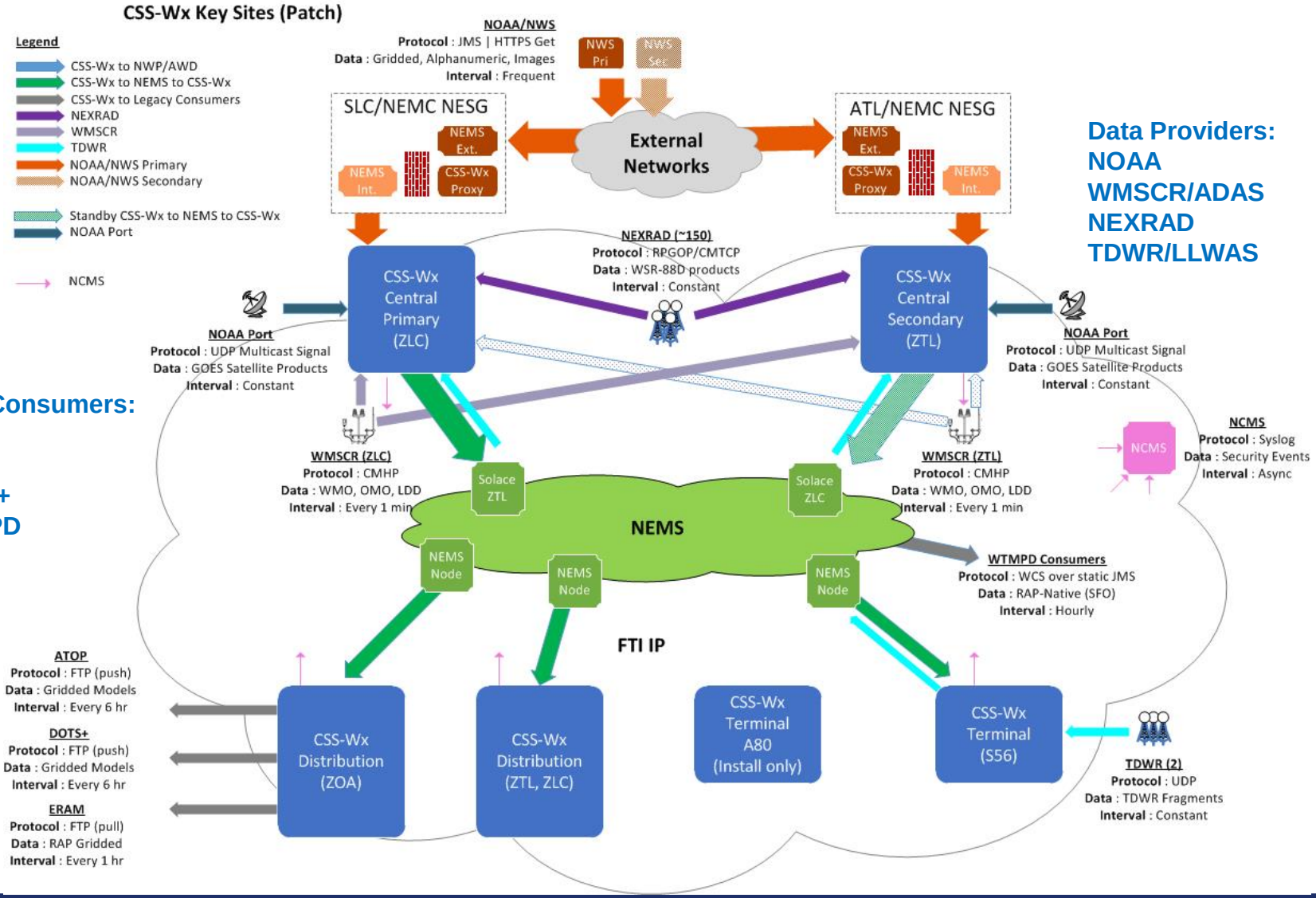
- Contract awarded April 2015
- Working schedule is ahead of APB

Key: Complete | On Track

CSS-Wx and NWP System Implementation



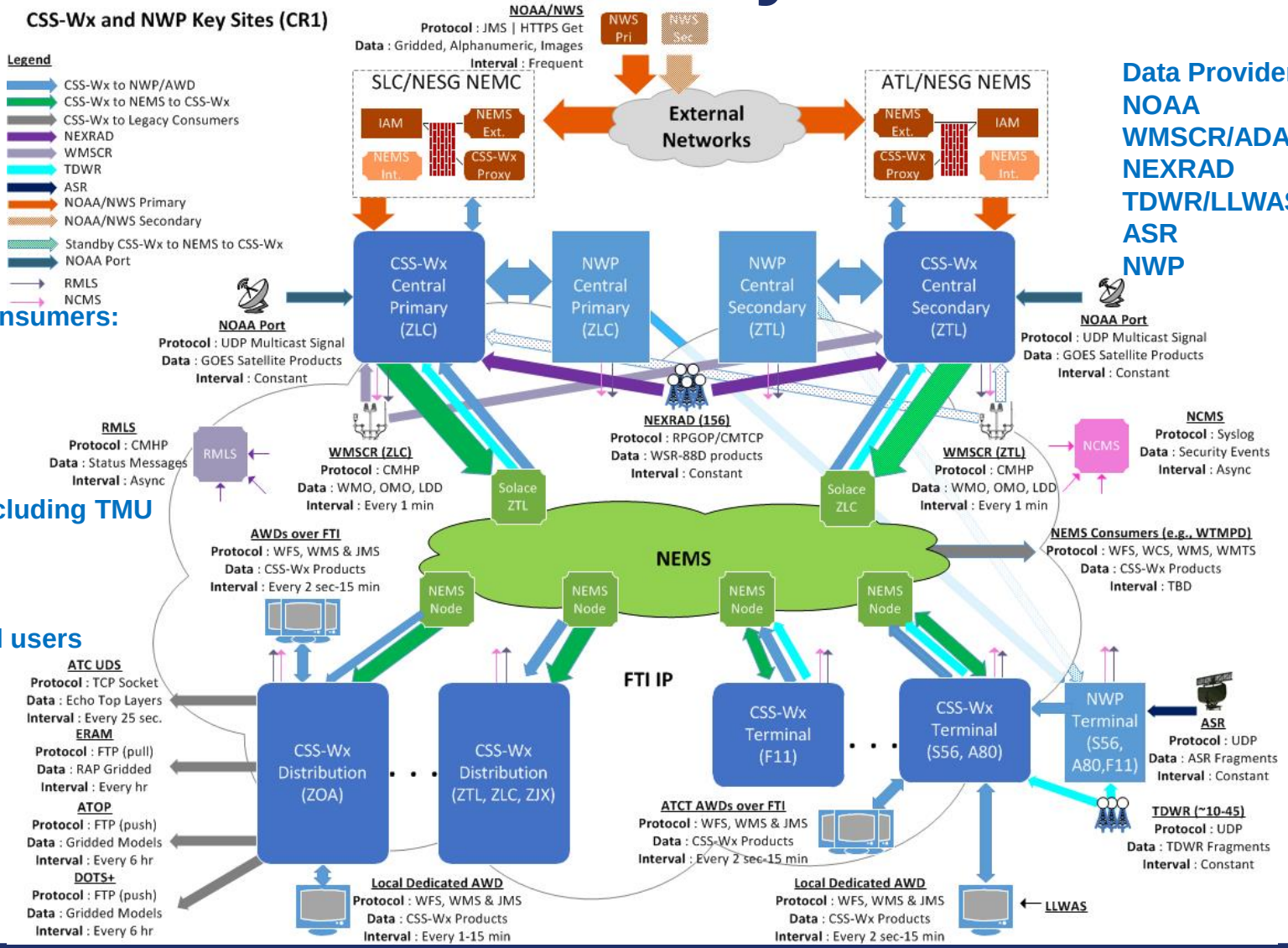
CSS-Wx Key Sites in FY19



Data Providers:
NOAA
WMSCR/ADAS
NEXRAD
TDWR/LLWAS

Data Consumers:
ERAM
ATOP
DOTS+
WTMPD
NCMS

CSS-Wx and NWP Key Sites in FY20



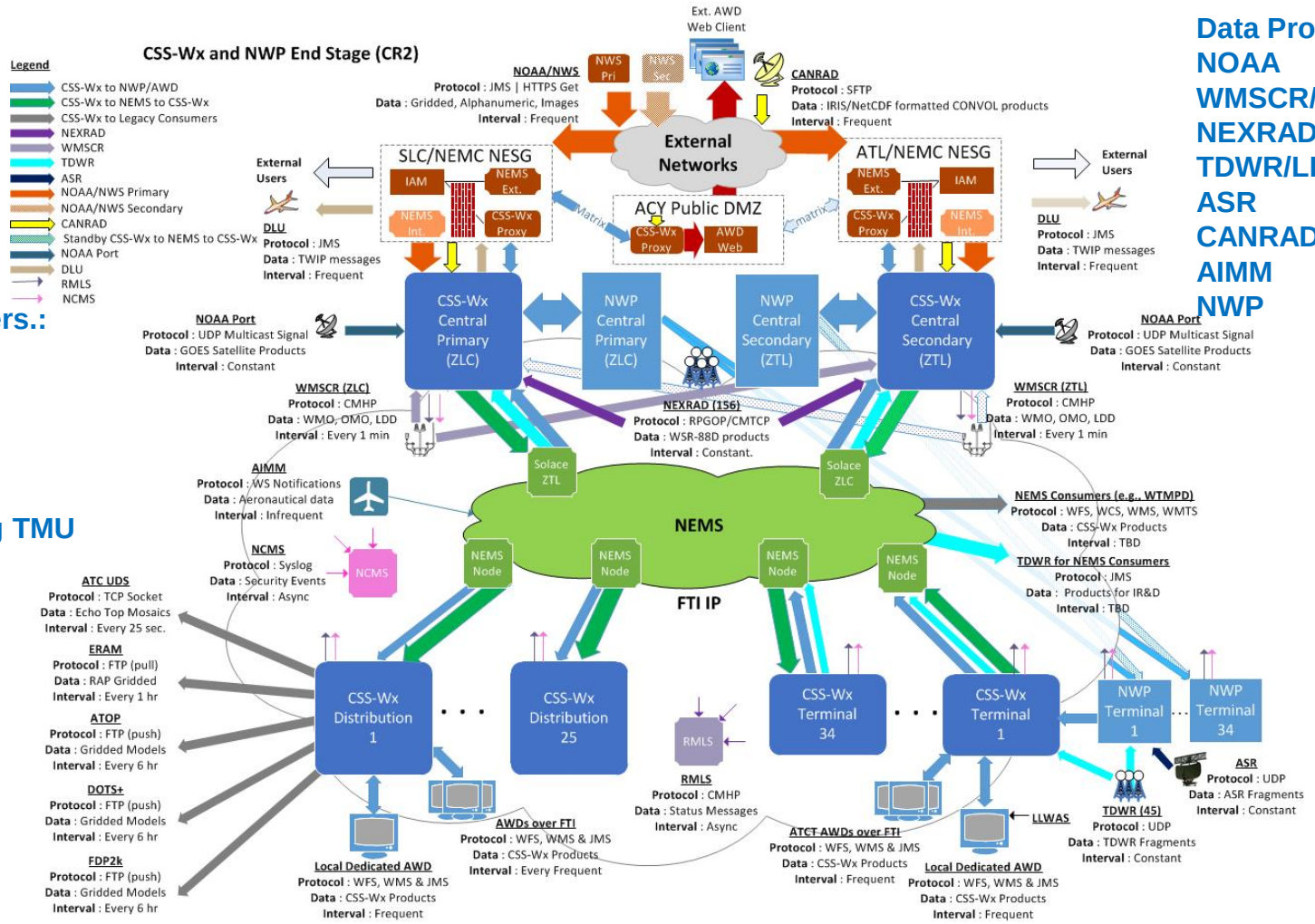
Data Providers:
NOAA
WMSCR/ADAS
NEXRAD
TDWR/LLWAS
ASR
NWP

Data Consumers:
ERAM
ATOP
DOTS+
WTMPD
NWP
AWD including TMU
TBFM
NCMS
RLMS
External users

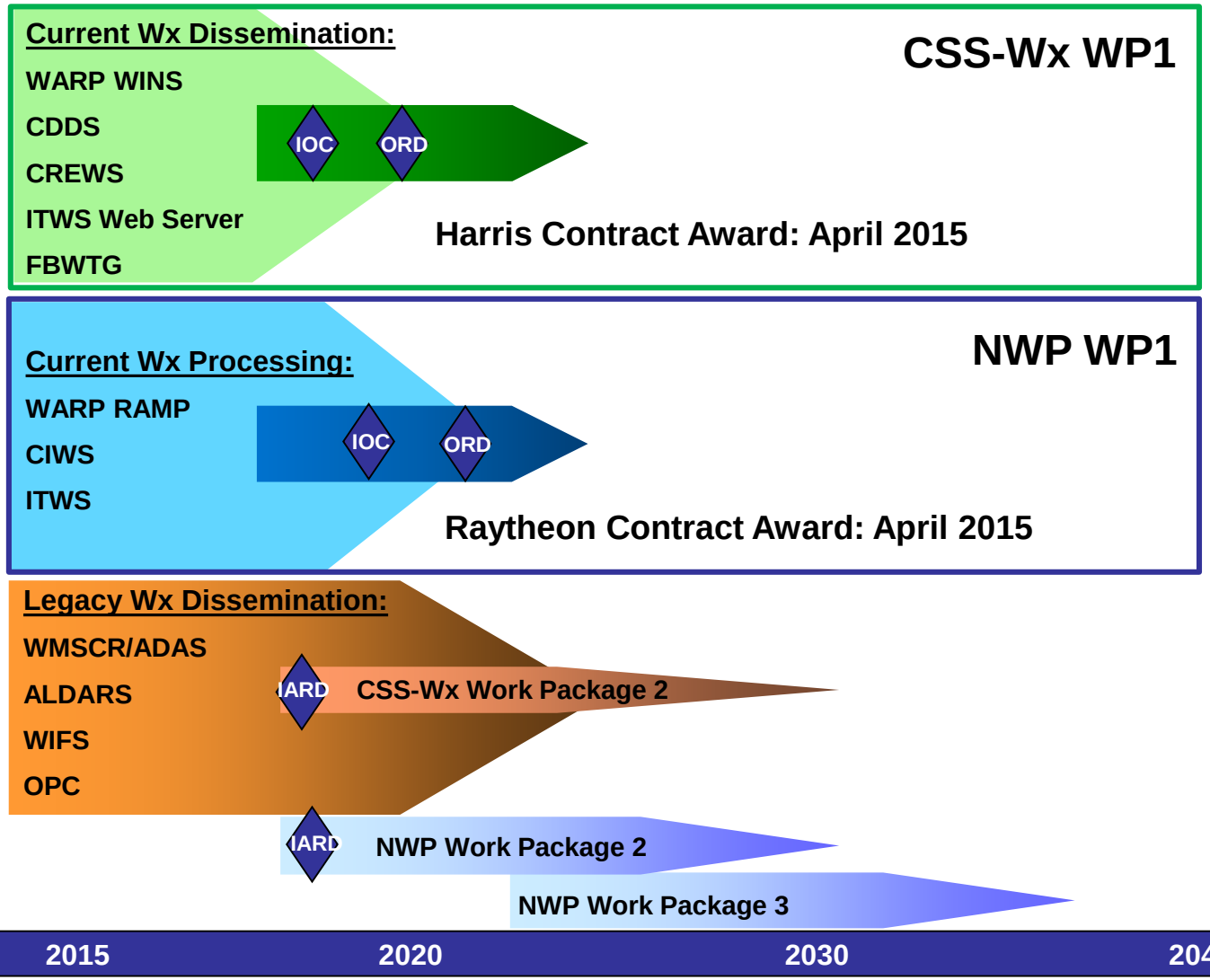
CSS-Wx and NWP Operational Systems

Data Providers:
NOAA
WMSCR/ADAS
NEXRAD
TDWR/LLWAS
ASR
CANRAD
AIMM
NWP

Data Consumers.:
ERAM
ATOP
DOTS+
WTMPD
NWP
AWD including TMU
NCMS
RLMS
FDP2K
Micro-EARTS
TBFM
TFMS
External users
Others (e.g.
NCR, FFSP,
SBS, E-IDS)



NextGen Weather Work Packages



NextGen Weather Capability

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

- **Filters and transforms large gridded dataset**
- **NetCDF format**

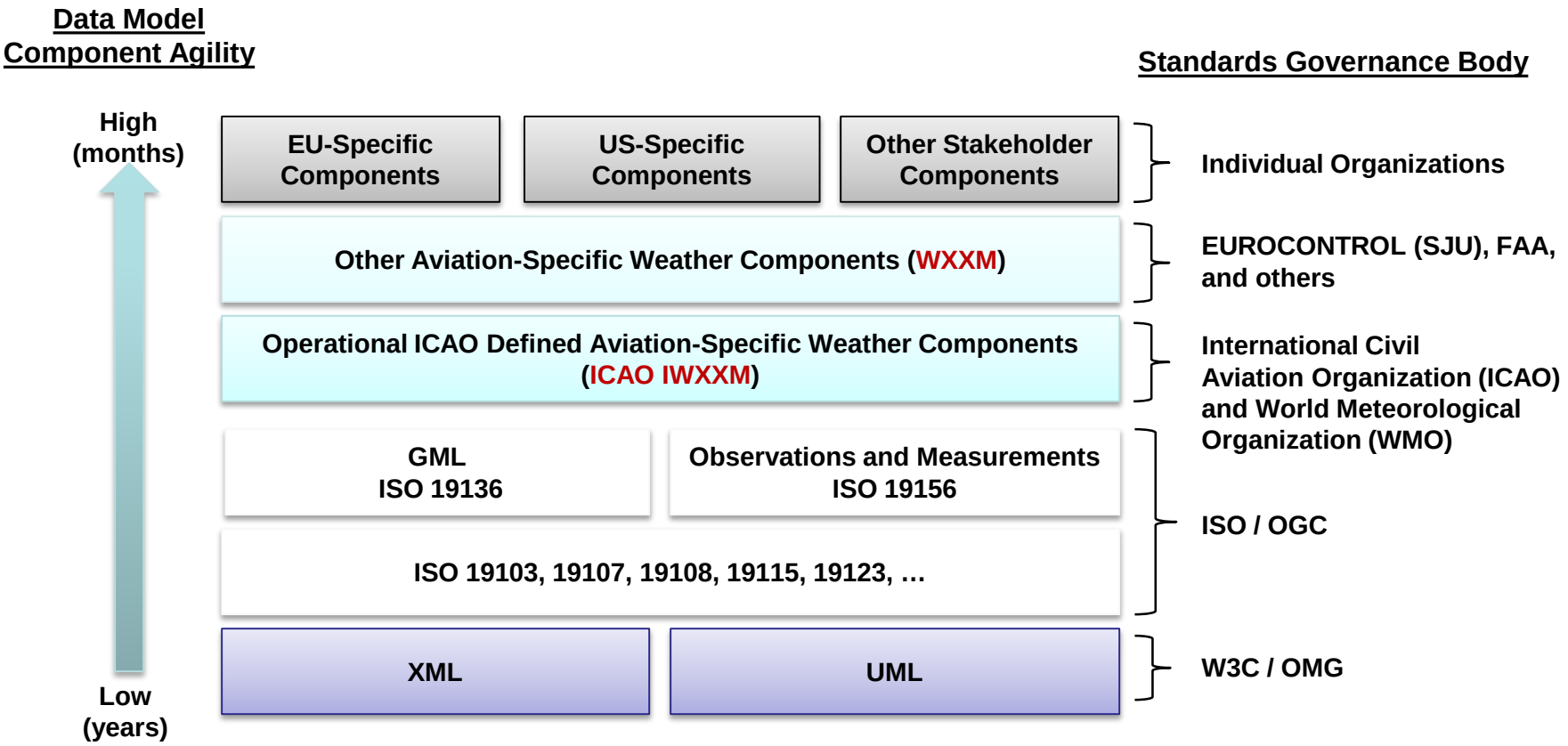
Web Feature Service

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

Web Map Service

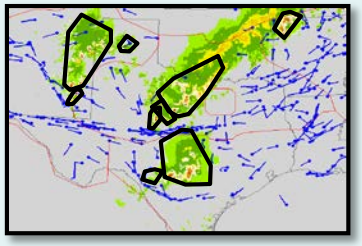
- **Renders weather data as single large image or sets of tiled images for display**
- **JPEG, PNG, GIF, KML format**

Weather Data Models Used by CSS-Wx

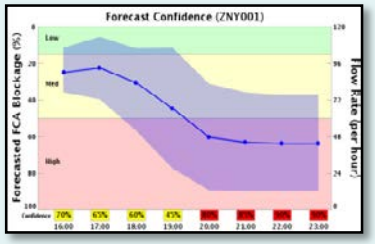


Descriptions of US and International weather data models are available at https://wiki.ucar.edu/display/CSSWX/Weather+Data+Models

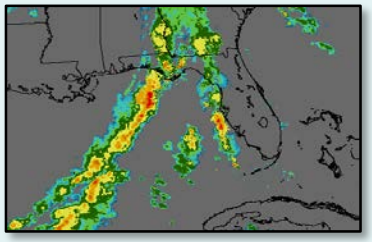
Current and Future NWP Products



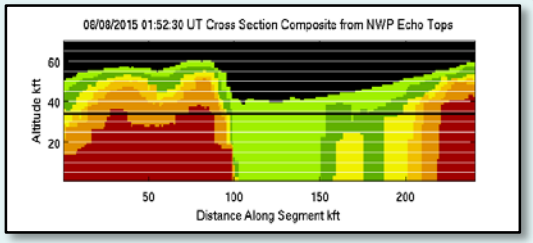
Convective Weather Avoidance Polygons



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 Wx Products- Gridded

Gridded Weather Data	
✓ Precipitation (VIL)	✓ Icing Bottoms
✓ Precipitation (VIL) with Mask	✓ Icing Bottoms Forecast
✓ Precipitation (VIL) Forecast	✓ Icing Layer
✓ Precipitation (VIL) Forecast with Mask	✓ Composite Icing
✓ Echo Tops	✓ Icing Layer Forecast
✓ Echo Tops Forecast	✓ Composite Icing Forecast
✓ Precipitation (Base Reflectivity)	✓ Turbulence Layer
✓ Precipitation (Composite Reflectivity)	✓ Turbulence Layer Forecast
✓ Precipitation (Composite Reflectivity) with Mask	✓ Composite Turbulence
✓ Surface Precipitation Phase	✓ Composite Turbulence Forecast
✓ Surface Precipitation Phase Forecast	✓ Convective Weather Avoidance Fields
✓ Precipitation (ASR)	✓ Convective Weather Avoidance Field Forecast
✓ Precipitation (ASR AP Flagged)	✓ Satellite
✓ Icing Tops	✓ Terminal Winds
✓ Icing Tops Forecast	✓ NOAA Model Data (RAP, HRRR, GFS)

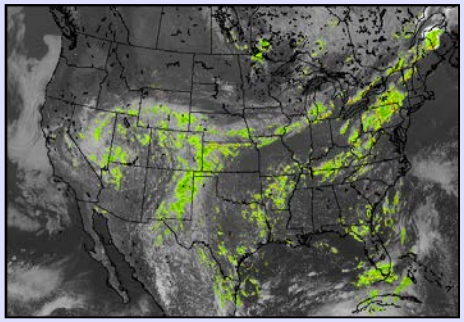
NextGen Wx Products- Non-Gridded

Non-Gridded Weather Data

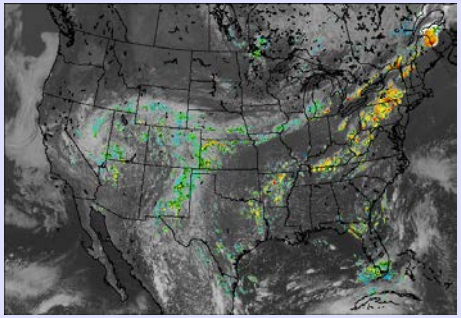
- ✓ Precipitation (VIL) Forecast Accuracy
- ✓ Precipitation (VIL) Forecast Contours
- ✓ Echo Tops Forecast Accuracy
- ✓ Echo Tops Forecast Contours
- ✓ Lightning
- ✓ Storm Information Hazard Text
- ✓ Storm Information Leading Edges
- ✓ Storm Information Motion Vectors
- ✓ Fronts Forecast
- ✓ Growth Trends
- ✓ Decay Trends
- ✓ Forecast Confidence
- ✓ Convective Weather Avoidance Polygons
- ✓ Wind Profiles
- ✓ Tornado Detections
- ✓ Airport Status Summary
- ✓ Microburst
- ✓ Gust Front
- ✓ Gust Front Estimated Time to Impact
- ✓ Tornado Alert
- ✓ Configured Alerts
- ✓ Wind Shear ATIS Timers – Microburst
- ✓ Wind Shear ATIS Timers – Wind Shear
- ✓ Terminal Weather Graphics
- ✓ Terminal Weather Text
- ✓ Airport Lightning Warning
- ✓ Icing Layer Contours
- ✓ Composite Icing Contours
- ✓ Turbulence Layer Contours
- ✓ Composite Turbulence Contours
- ✓ Pilot Report (PIREP)
- ✓ ICAO Aircraft Report
- ✓ Urgent Pilot Report (PIREP)
- ✓ Significant Meteorological Information (SIGMET)
- ✓ Convective Significant Meteorological Information (Convective SIGMET)
- ✓ Airmen's Meteorological Information Advisories (AIRMET)
- ✓ Winds Aloft Forecast
- ✓ Surface Weather Observations
- ✓ Aviation Watch Notification
- ✓ Tornado Warnings
- ✓ Tornado Watches
- ✓ Severe Thunderstorm Warnings
- ✓ Severe Thunderstorm Watches
- ✓ Volcanic Ash Advisory Statement (VAAS)
- ✓ Terminal Area Forecast (TAF)
- ✓ Center Weather Advisories
- ✓ Meteorological Impact Statements
- ✓ G-AIRMET

Mosaic Examples

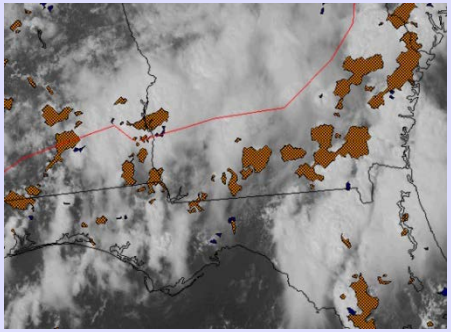
VIL Mosaic



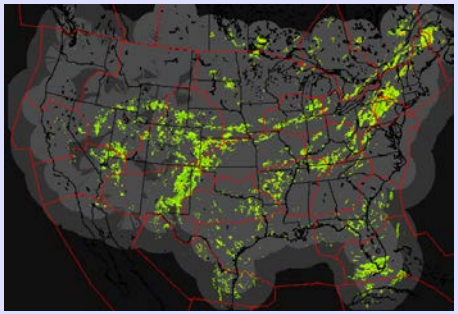
Echo Tops Mosaic



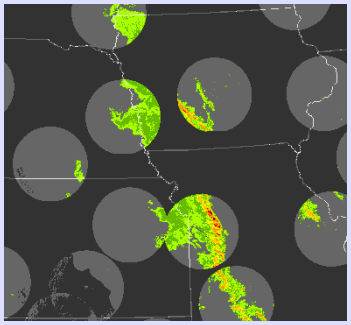
Growth Trends Mosaic



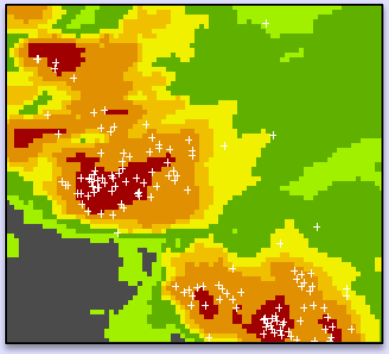
Comp Refl Mosaic



Base Refl Mosaic

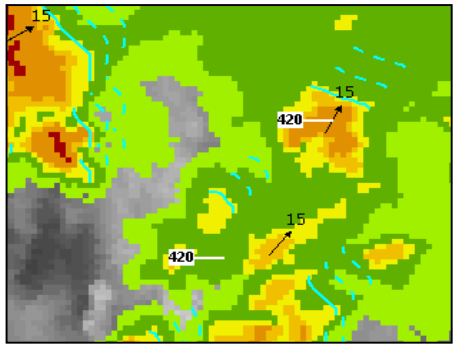


Lightning

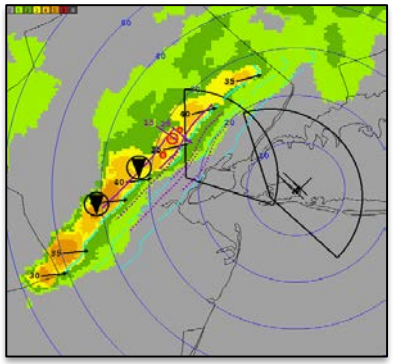


Analysis / Per-Terminal Examples

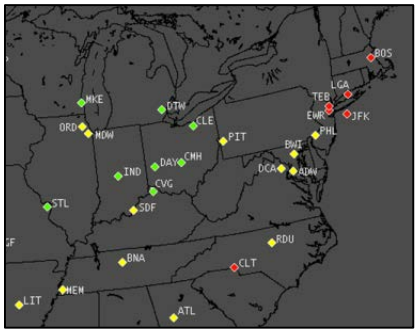
Storm Information



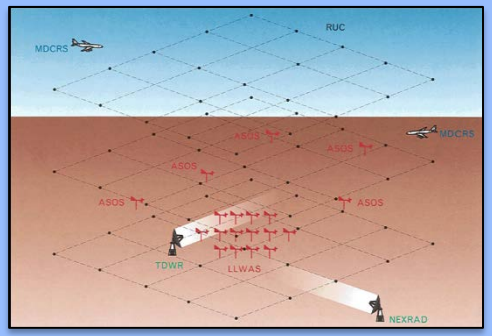
Tornado Aggregation



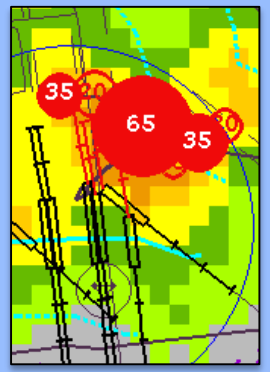
Airport Status Summary



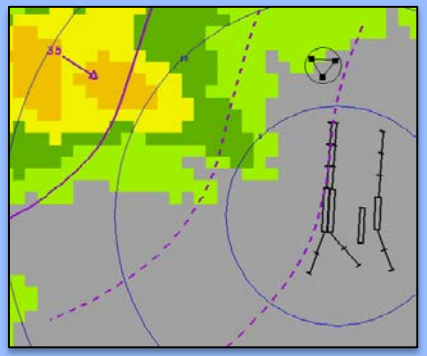
Terminal Winds



Microbursts & Wind Shear

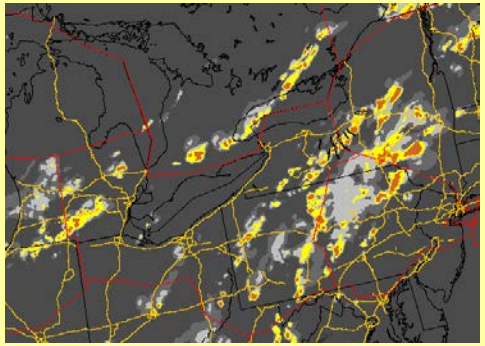


Gust Fronts

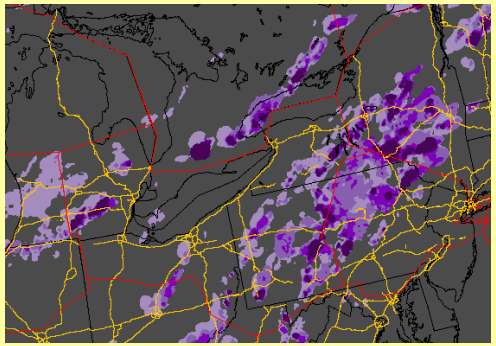


Predictions / Wx Avoidance Examples

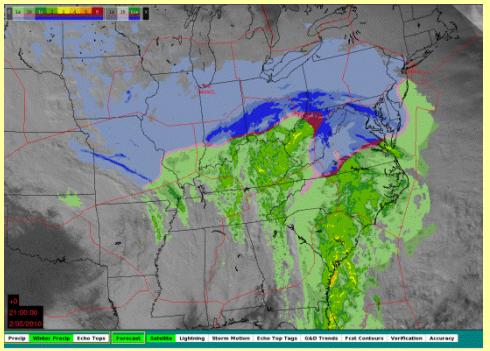
VIL Precipitation 0-8 Hr



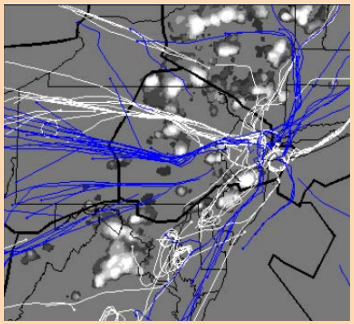
Echo Tops 0-8 Hr



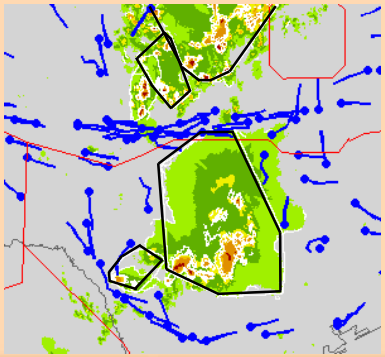
Precip. Phase 0-8 Hr



Convective Weather Avoidance Model (CWAM)



Convective Weather Avoidance Polygons (CWAP)

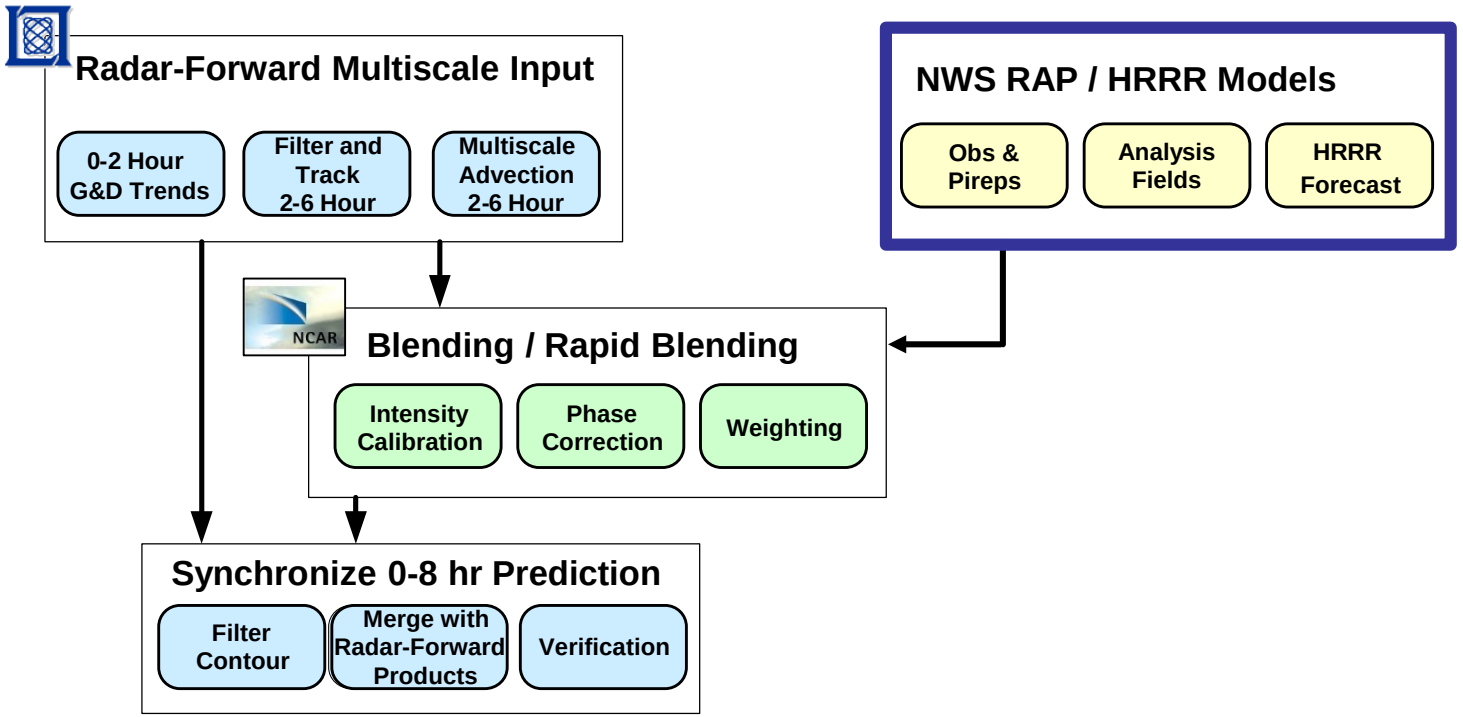


NextGen Weather Coordination

NextGen Weather Coordination

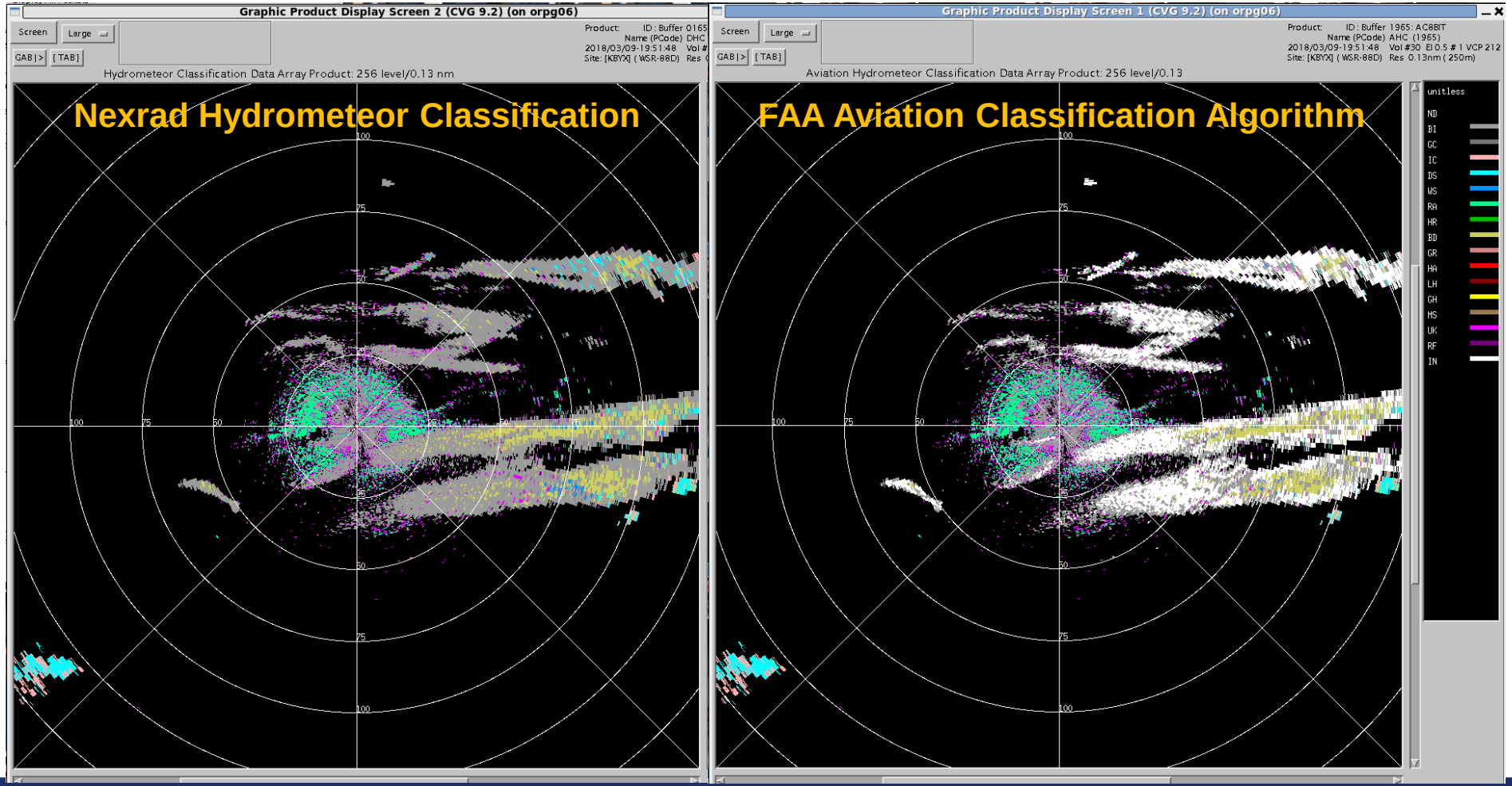
- **NextGen Weather Systems, NEXRAD and AWRP are working on further coordination**
  - Convective Weather Prediction effort is working well for NextGen Weather
  - Expect Icing improvements follow same pattern
  - NEXRAD program is contributing several products for NextGen Weather WP2

Convective Weather Predictions



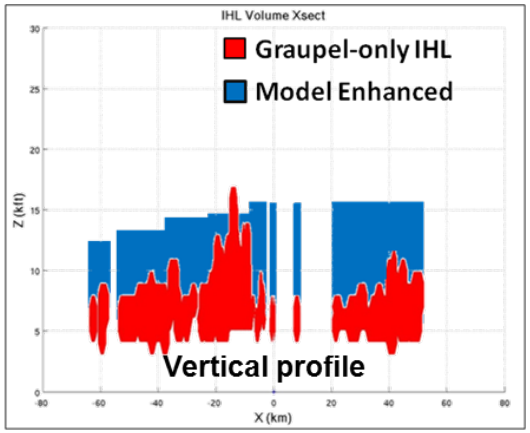
FAA Aviation Classification Algorithm

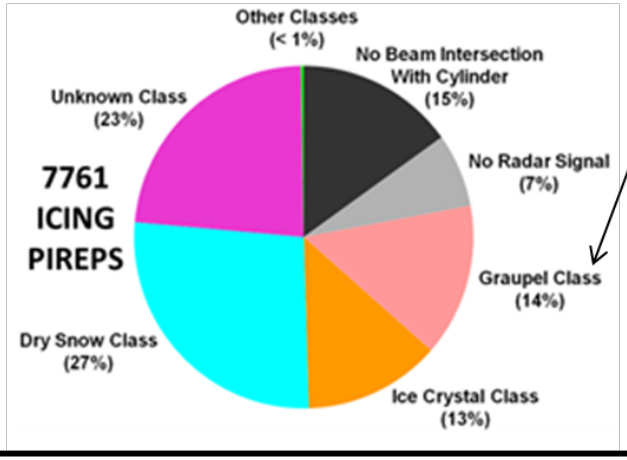
“Inanimate” class (white) for Chaff detection – Key West, FL



FAA NEXRAD Icing Hazard Levels (IHL) Product

Current Product

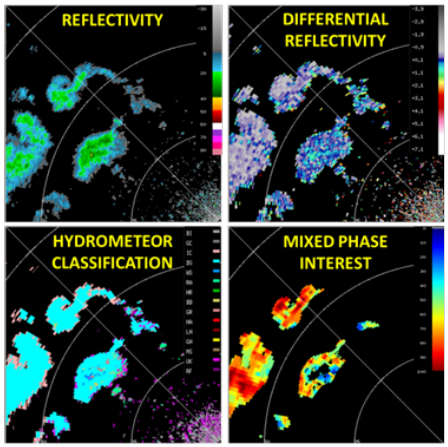




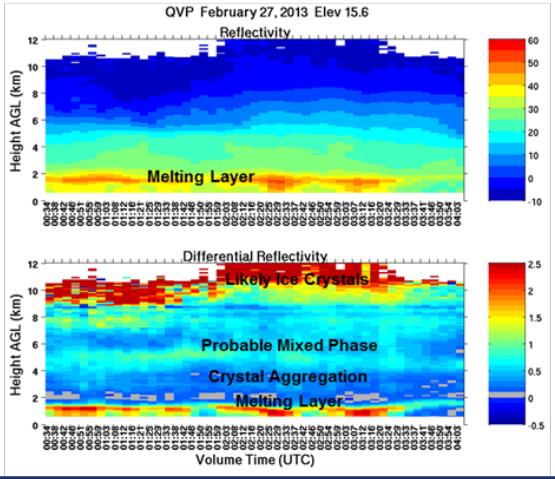
IHL Performance
POD = 78%
FAR = 5%

Graupel-model IHL captures only part of the radar potential for icing detection

Further Algorithm Development



Use mixed phase interest field to identify additional icing hazard conditions



Develop automated interpretation of 4D radar data to identify icing potential

PIREPS = Pilot Reports; QVP = Quasi-Vertical Profile
POD = Probability of Detection; FAR = False Alarm Rate

Sample CSS-Wx/NWP WP1 Products

- **In-Flight Icing**
  - CIP & FIP
  - Flexible Layers via Hosted Algorithms
  - Icing Tops & Bottoms via NWP Product Generator
  - No radar
- **Airport Icing**
  - Rain/Mix/Snow 0-8 hr Forecast (5 min update rate)
- **Convective Turbulence**
  - 0-8 hr Convective Weather Avoidance Polygons
  - Separate Growth Trends product (25 sec update rate – no forecast)
    - Very strong predictor of Convective Weather Avoidance
- **Turbulence**
  - GTG3 – Clear Air Turbulence only
  - Mountain Wave sub-partition - not deemed critical by ATC users
  - “TAM” – linear shift of turbulence scale - also not deemed important

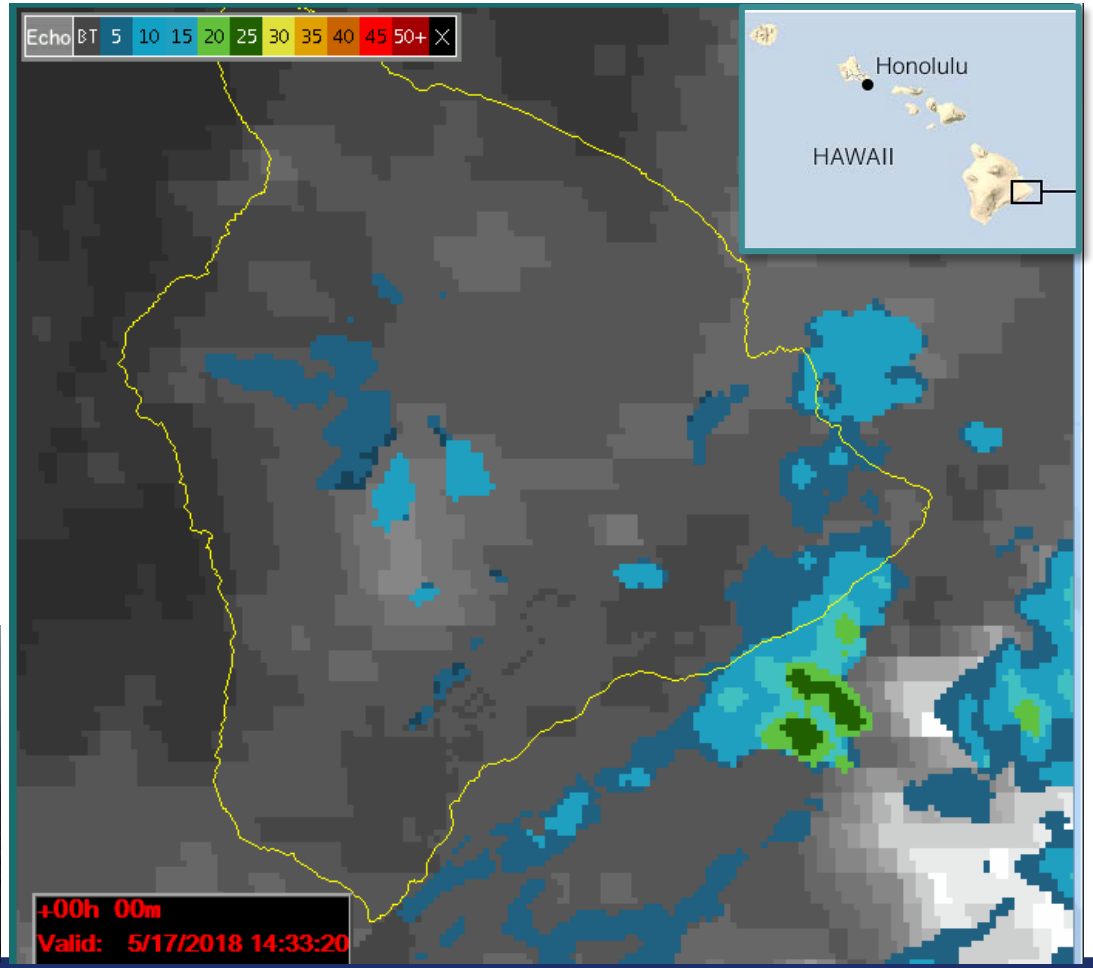
Sample CSS-Wx/NWP WP2 Products

- **National Weather Service (NWS) inputs**
  - CIP, FIP and GTG derived from HRRR
  - CIP, FIP Alaska derived from RAP
- **NEXRAD Tri-Agency inputs**
  - FAA Hydrometeor Classification Algorithm
  - FAA Icing Hazard Layers
  - NWS Upgrades to Hail & Mesocyclone & Tornado Algorithms
- **NextGen Weather CSS-Wx/NWP products**
  - CWAF & CWAP with Convective Turbulence
  - Growth Trends contours
  - Upgrade to ITWS Algorithms to meet users' needs
    - Gust Front, Microburst, Terminal Winds

Example of NWP Rapid Update Radar Mosaics

Mt. Kilauea eruption

NWP 25-sec update Echo Tops Mosaic of Ash Cloud



Summary

- **FAA NextGen Weather Systems implementation in progress**
  - Building and distributing digital weather products for users via SWIM
  - NextGen weather products improve significantly over legacy weather
- **Stakeholder coordination ongoing for further improvement in Work Package 2, e.g.,**
  - Utilize NextGen Weather WP1 technology for research
    - MIT LL runs live Test Reference System for PMO
  - Utilize FAA NEXRAD dual-pol processing improvements
    - Hail, Icing, Chaff Detection