



# **Encoding of FAA CIWS and ITWS Weather Products using WXXM**

**AIXM/WXXM Conference**

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MIT Lincoln Laboratory  
5 May, 2010**

**MIT Lincoln Laboratory**



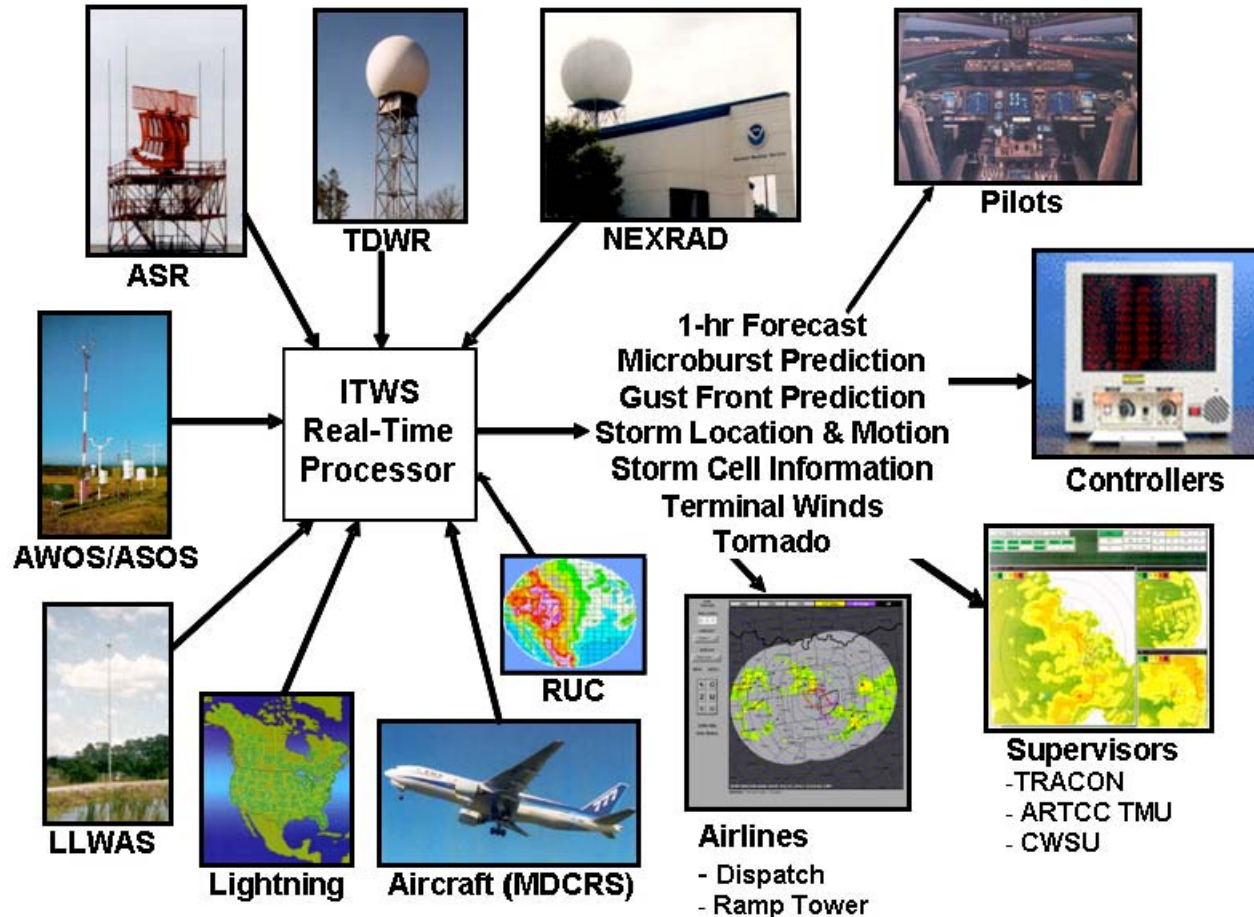
# Outline

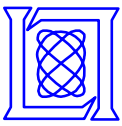
- **ITWS/CIWS System and Weather Product Background**
- **WXXM Data Model**
  - Core layers
  - ITWS/CIWS product extensions
- **Mapping the ITWS/CIWS legacy data models to WXXM**
- **Implications for Web Feature Service**
- **Summary**



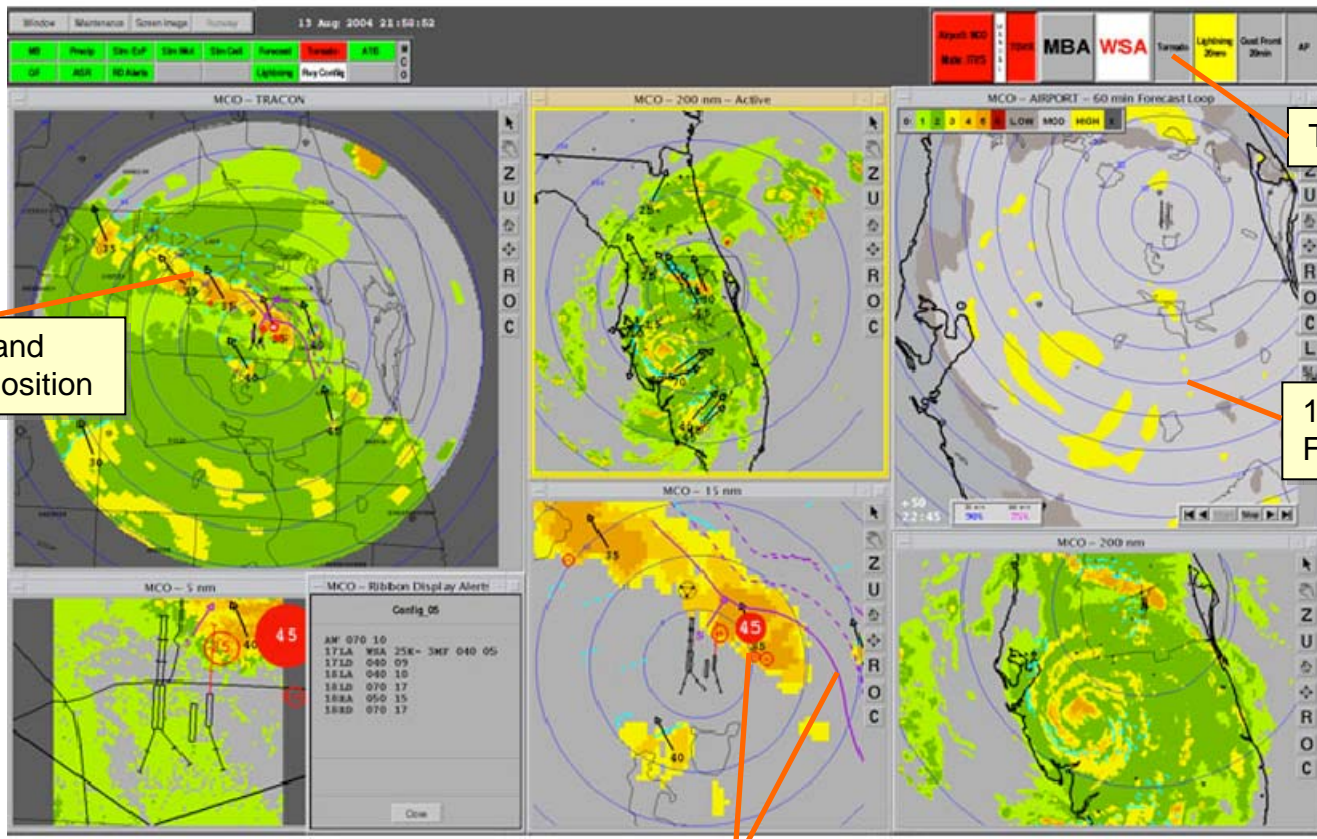
# Integrated Terminal Weather System

- FAA regional weather situational awareness system
- Operated at 40 Key FAA Sites (TDWR locations)





# ITWS Display Orlando, Hurricane Charley



Storm Motion and Extrapolated Position

Textual Alerts/Alarms

1-hour Precipitation Forecast Loop

Microbursts/Gustfronts



# ITWS Products with WXXM Representation

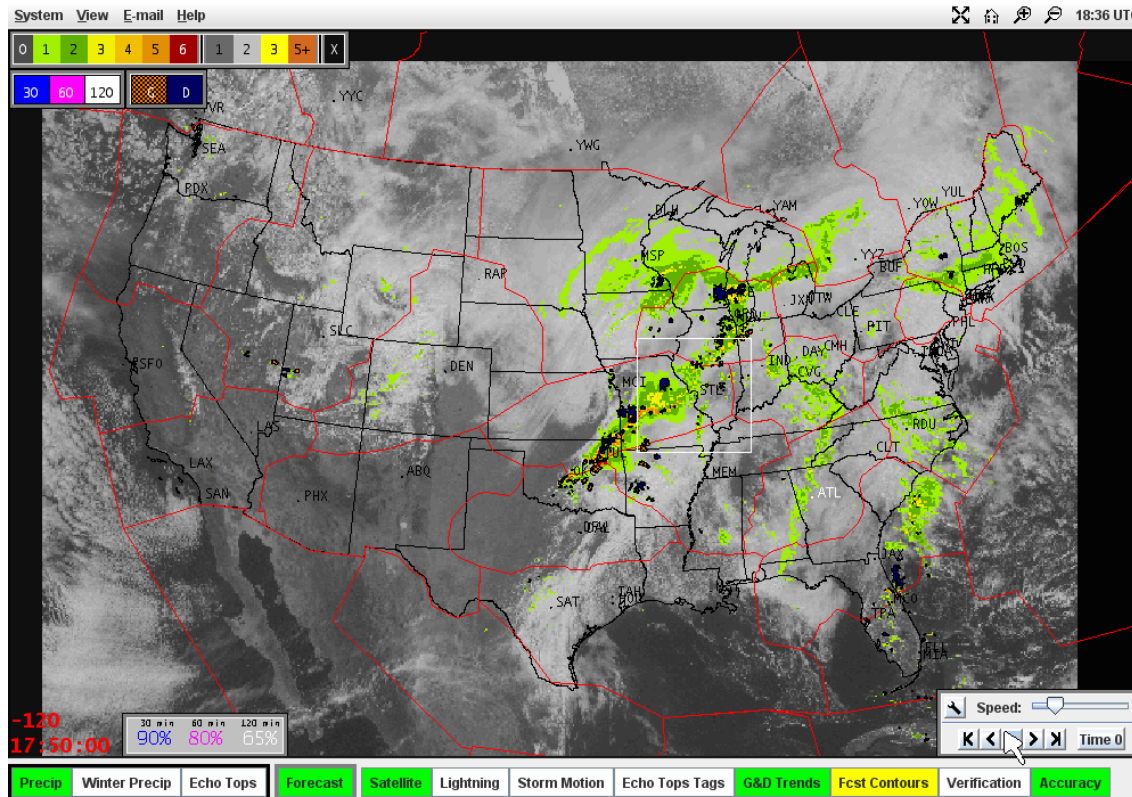
ITWS Non-Gridded Products					
Product Name	MSG ID	Format Defined	Product Name	MSG ID	Format Defined
Gust Front TRACON Map	9833	Y	AP Status	9847	Y
SM SEP 5 nm	9911	Y	Hazard Text 5nm	9857	Y
SM SEP TRACON	9912	Y	HazardText TRACON	9858	Y
SM SEP Long-Range	9906	Y	Hazard Text Long-Range	9904	Y
VIL Forecast Contour	9903	Y	Runway Configuration	9861	N *
Wind Profile	9837	Y	Gust Front ETI	9834	Y
Configured Alerts	9840	Y	Terminal Weather Text Normal	9844	Y
Forecast Accuracy	9902	Y	Microburst TRACON Map	9832	Y
Tornado Alert	9839	Y	Tornado Detections	9838	Y
Microburst Atis	9893	Y	Airport Lightning Warning	9845	Y
Wind Shear Atis	9894	Y			

\* Runway Configuration product not modeled. It contains ITWS ribbon display terminal configuration data that are not broadly useful outside of the ITWS system.



# Corridor Integrated Weather System

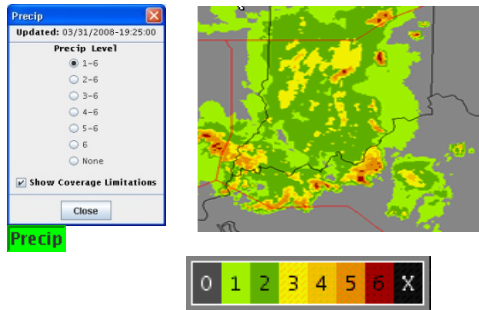
- Evolution of ITWS to CONUS scale
- Additional sensors
- Product suite tailored to needs of FAA en-route controller community





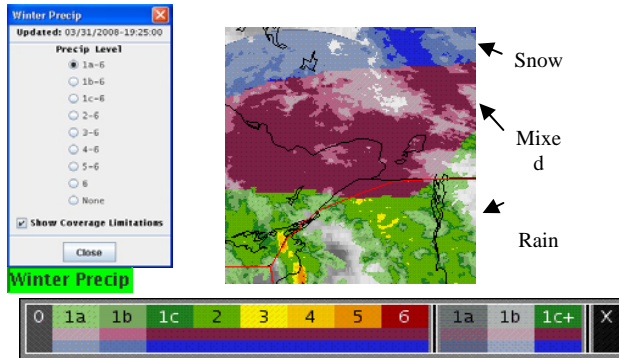
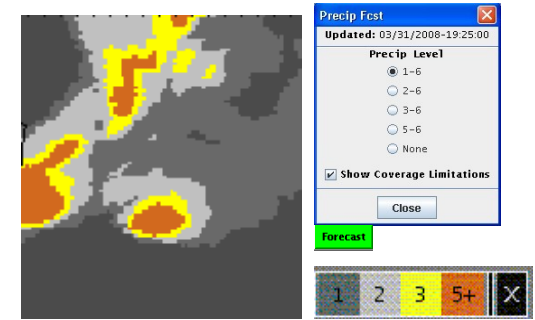
# CIWS Base Products and Their Forecasts

## Base Product

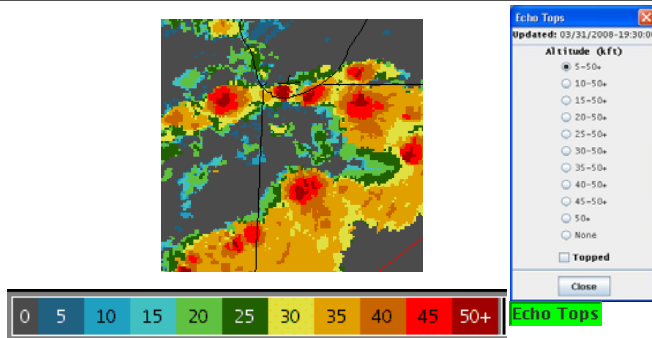
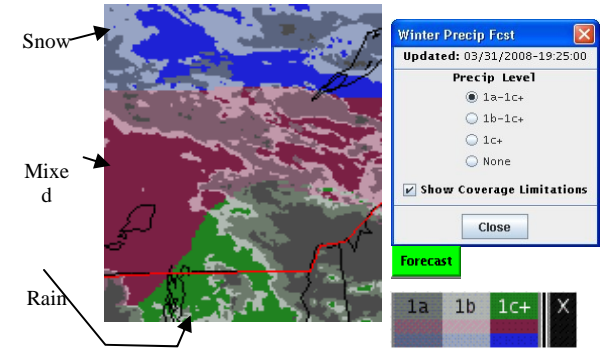


## Precipitation

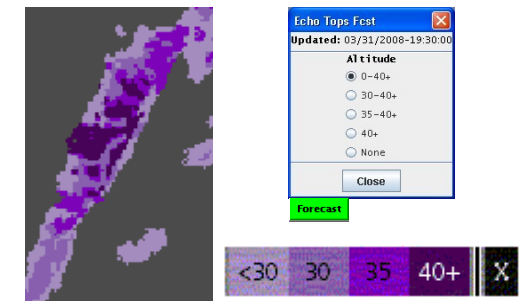
## Forecast



## Winter Precipitation

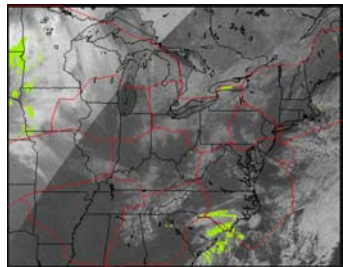


## Echo Tops





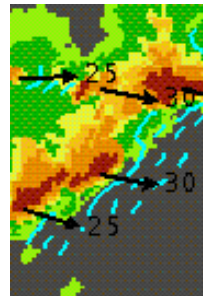
# Additional CIWS products



Satellite  
Updated: 03/31/2008-19:28:20  
Close

Satellite

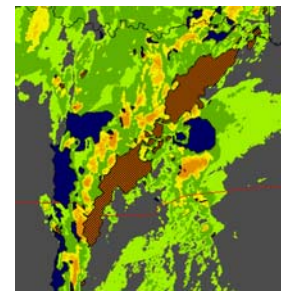
Satellite



Storm Motion  
Updated: 03/18/2008-20:00:00  
 Current Time Only  
Filter by:  
 Zoom Level  
Close

Storm Motion

Storm Motion



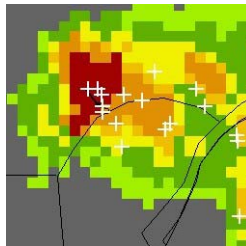
G&D Trends  
Updated: 03/18/2008-20:00:00  
 Current Time Only  
Legend  
■ Growth  
■ Decay  
Close

G&D Trends



Growth & Decay Trends

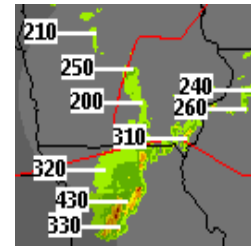
Lightning



Lightning  
Updated: 03/31/2008-19:34:49  
 Current Time Only  
Close

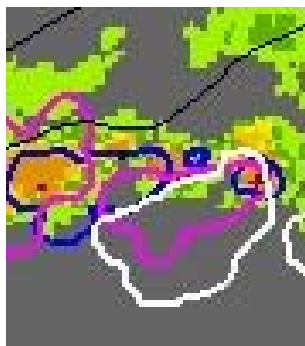
Lightning

Echo Tops Tags



Echo Tops Tags  
Updated: 03/31/2008-19:35:00  
 Current Time Only  
Label Position  
 Surround  
 Left only  
 Right only  
Filter by:  
 Zoom Level  
 Altitude: < 200 >  
Close

Echo Tops Tags

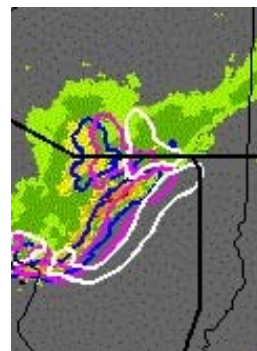


ET Verification  
Wntr Verification  
Precip Verification  
Updated: 03/31/2008-19:45:00  
 Current Time Only  
Contour Type  
 30 min  
 60 min  
 120 min  
Close

Verification

Verification on Precip

Verification Contours

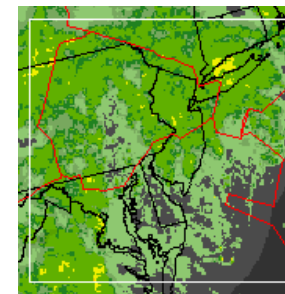


ET Fcst Contours  
Wntr Fcst Contours  
Precip Fcst Contours  
Updated: 03/31/2008-19:40:00  
 Current Time Only  
Contour Type  
 30 min  
 60 min  
 120 min  
Close

Fcst Contours

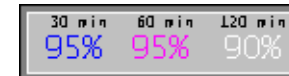
Forecast on Precip

Forecast Contours



Precip Accuracy  
Wntr Accuracy  
ET Accuracy  
Updated: 03/31/2008-19:50:00  
 Scoring Region  
Close

Accuracy

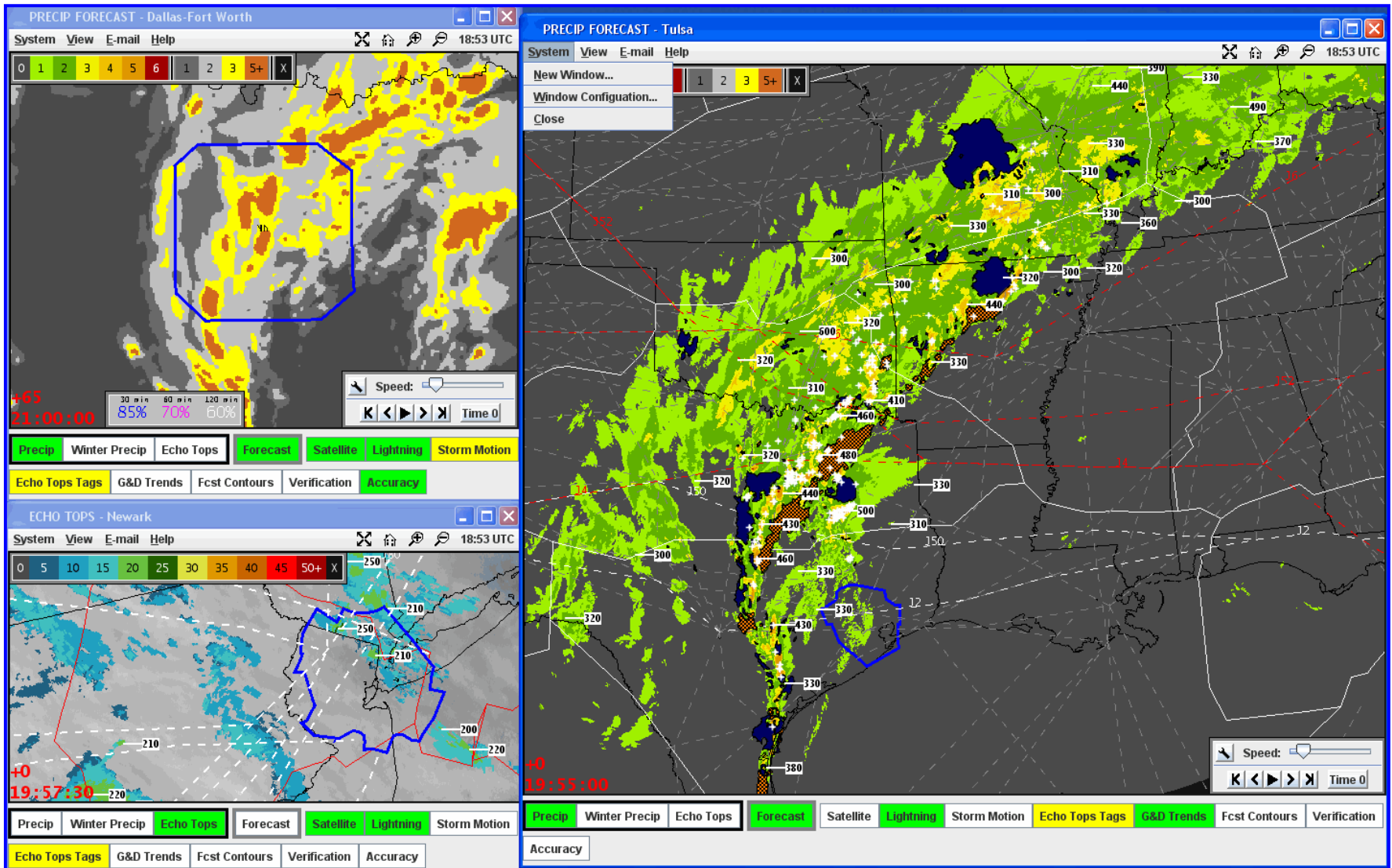


Forecast Accuracy





# CONUS CIWS Display





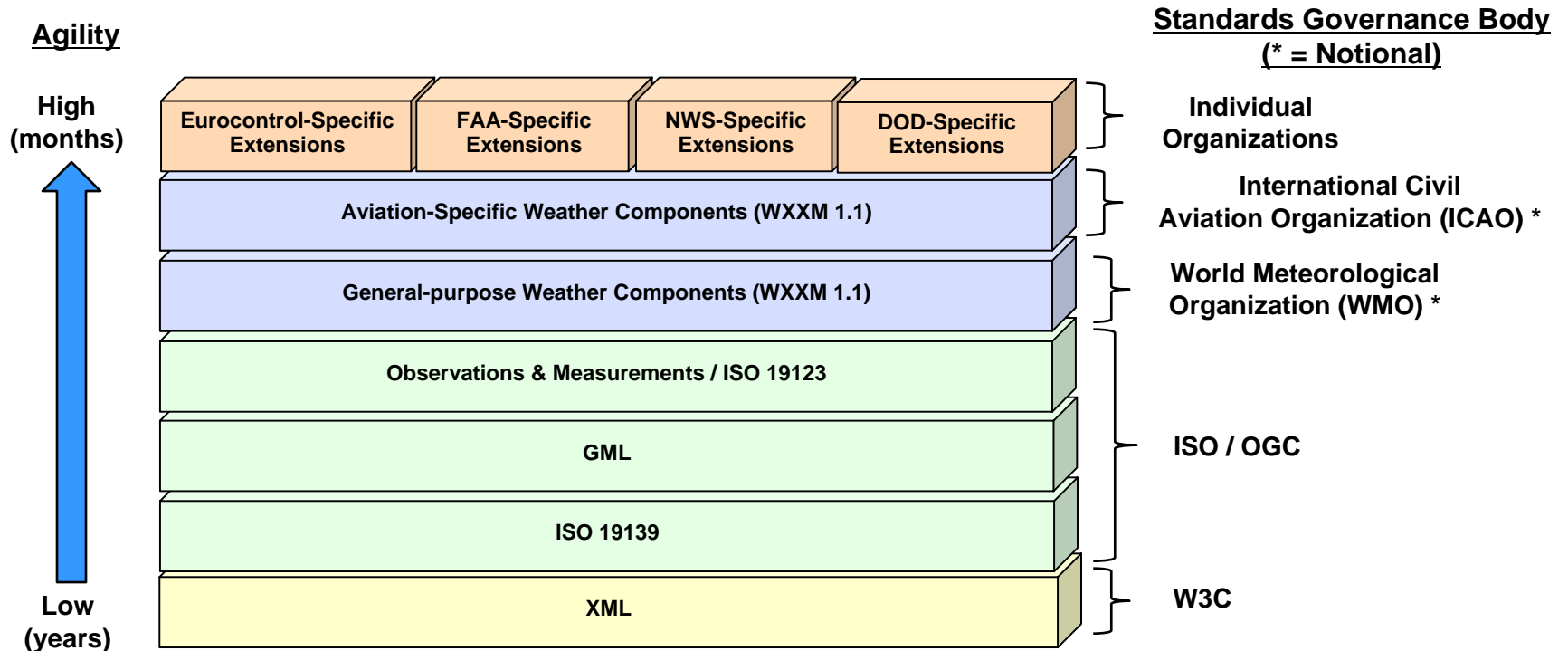
# Outline

- **ITWS/CIWS System and Weather Product Background**
- ➔ • **WXXM Data Model**
  - Core layers
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# WXXM 1.1 Data Model High-Level View

- Ad-Hoc Working Group Membership: *Eurocontrol, FAA, NWS, DOD( Air Force Weather Agency, Fleet Numerical Meteorology and Oceanography Center), NOAA, British Atmospheric Data Center*



*Composable, extensible data model balances standardization with the need for individual communities (FAA, Eurocontrol, NWS, DOD) to innovate over time*

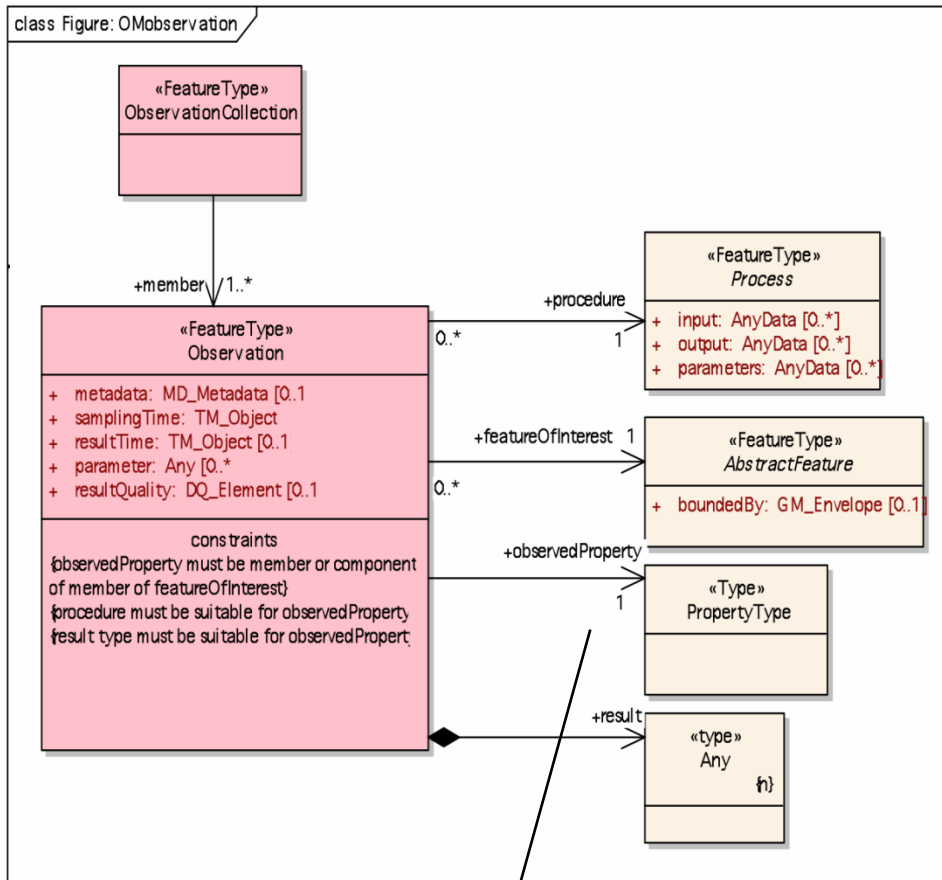


# Geography Markup Language (GML)

- **GML is OGC-standard XML extension to support geographic information**
  - Provides XML schemas for conceptual building blocks, e.g., for geometry and topology, spatial and temporal reference systems, “coverage” and gridded data.
- **GML is based on object-property model**
  - Objects are described by properties and property values
  - Objects are XML elements, e.g., `<app:Road>`
  - Element children are object properties, e.g., `<app:numLanes>`
- **Features and feature collections are GML objects used to represent concrete physical objects or abstract objects**
  - Features can be anything. They don’t need to have geospatial properties
  - Feature collections are features themselves
- **GML has full set of geometry primitives including Point, LineString, Curve, Polygon, Envelope**



# Observation & Measurements Model

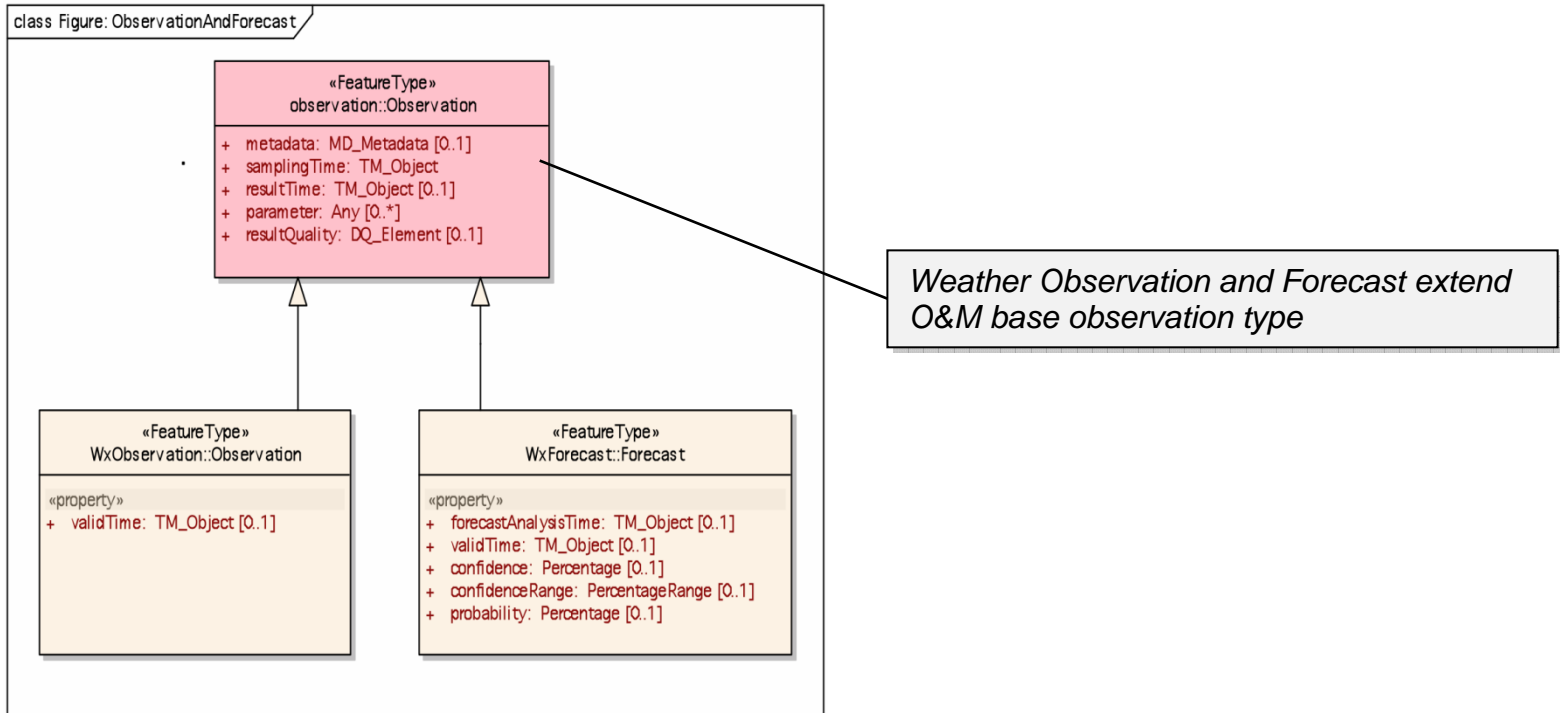


“An **Observation** is an action with a **result** which has a value describing some **phenomenon**. [...] An observation feature binds a result to a **feature of interest**, upon which the observation was made. The observed property is a property of the feature of interest. An observation uses a **procedure** to determine the value of the result, which may involve a sensor or observer, analytical procedure, simulation, or other numerical process.”

How to map legacy ITWS, CIWS data models to the concepts in the O&M and derived WXXM Model?



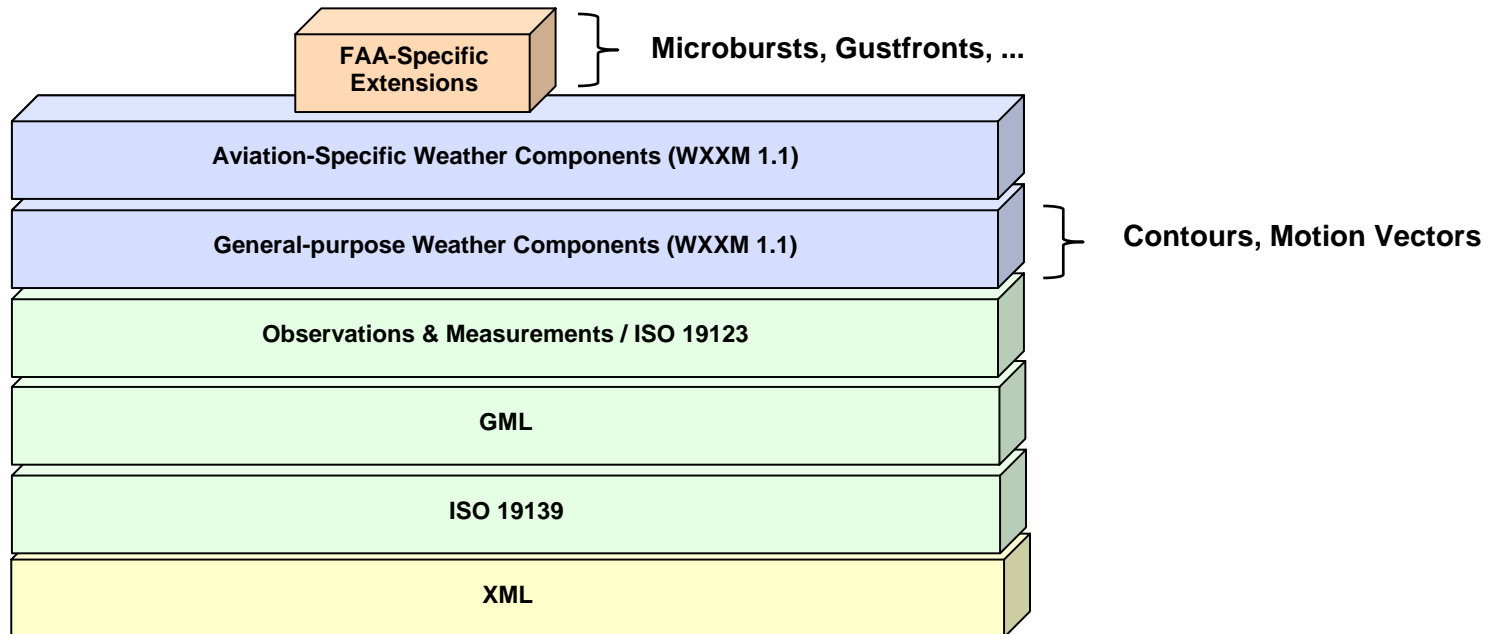
# Weather Observation & Forecast Model





# FAA WXXM Extensions for ITWS/CIWS Products

- Some of the ITWS/CIWS products are quite general (e.g., Contours, Motion Vectors)
- Others, though potentially general, are more system-specific (e.g., Microbursts, Gustfronts)

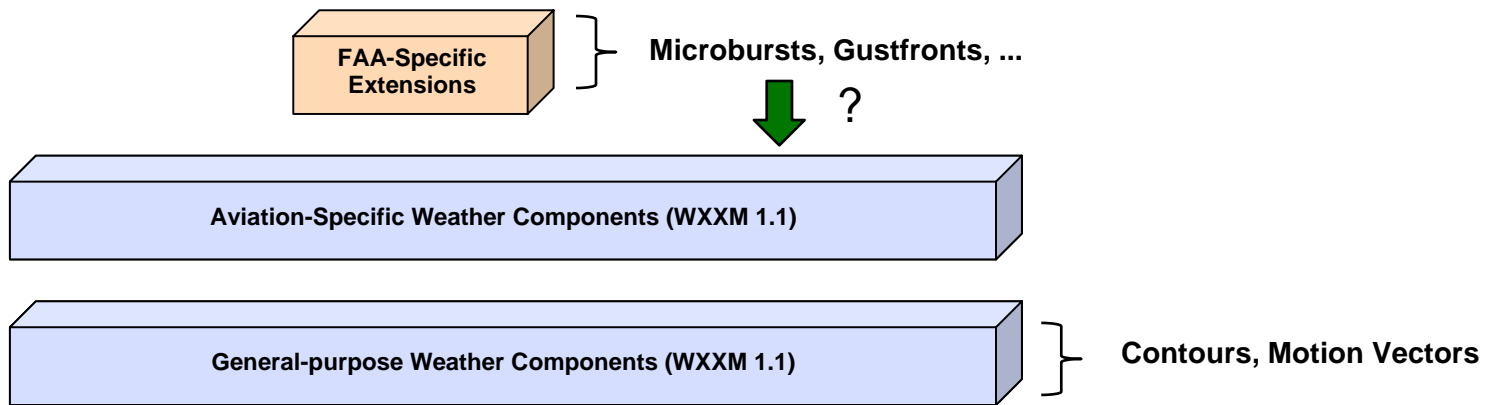


- FAA extensions defined in their own schema, using their own namespace prefix – ('nawx:', for 'North American Weather')
- Easily used in conjunction with other WXXM components



# Aside: Managing WXXM Change over Time Minor vs. Major Releases

- Over time, some extensions will be identified as being useful in the broader community
  - Will want to be 'trickled down' into the lower WXXM layers
- Others, though potentially general, are more system-specific (e.g., Microbursts, Gustfronts)



- By convention, minor release is defined as backwards-compatible
- Movement of types between layers is not a backwards-compatible change
  - *Refactorings of this type limited to major releases*





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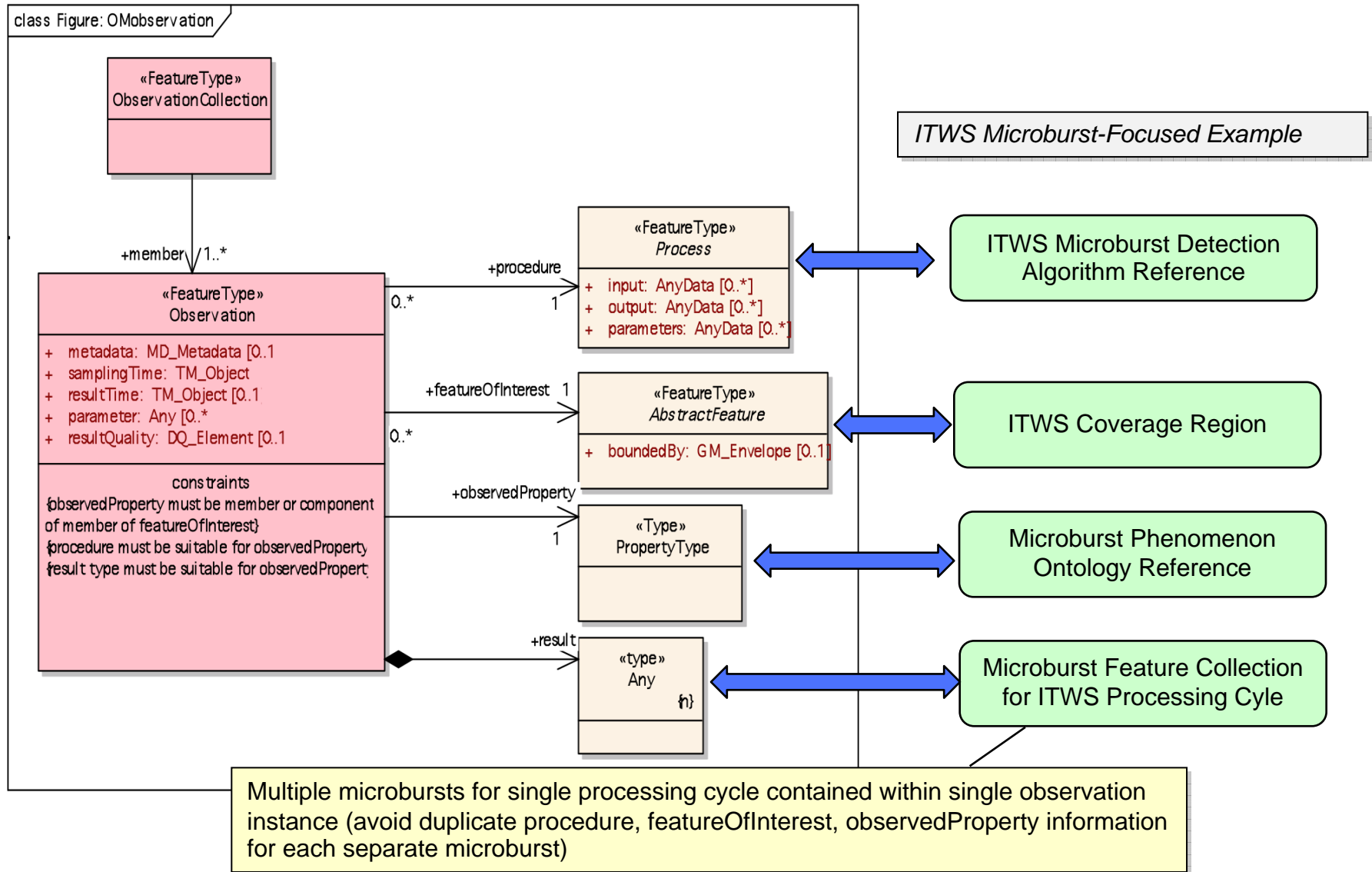


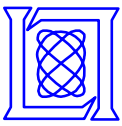
# Legacy ITWS/CIWS Data Model Patterns

- **For each product type, systems output a logical set of 'features' at regular intervals**
  - **Example: CIWS storm motion vectors output as a set for the entire CONUS every 2.5 minutes**
  - **Potentially thousands of objects per update in some cases**
- **Information common to each feature in set is shared at the logical set level (not replicated in each vector object)**
- **Products generally classified as real-time (now) products or forecast products**
  - **Aligns with WXXM (Features generally classified as Observations or Forecasts)**

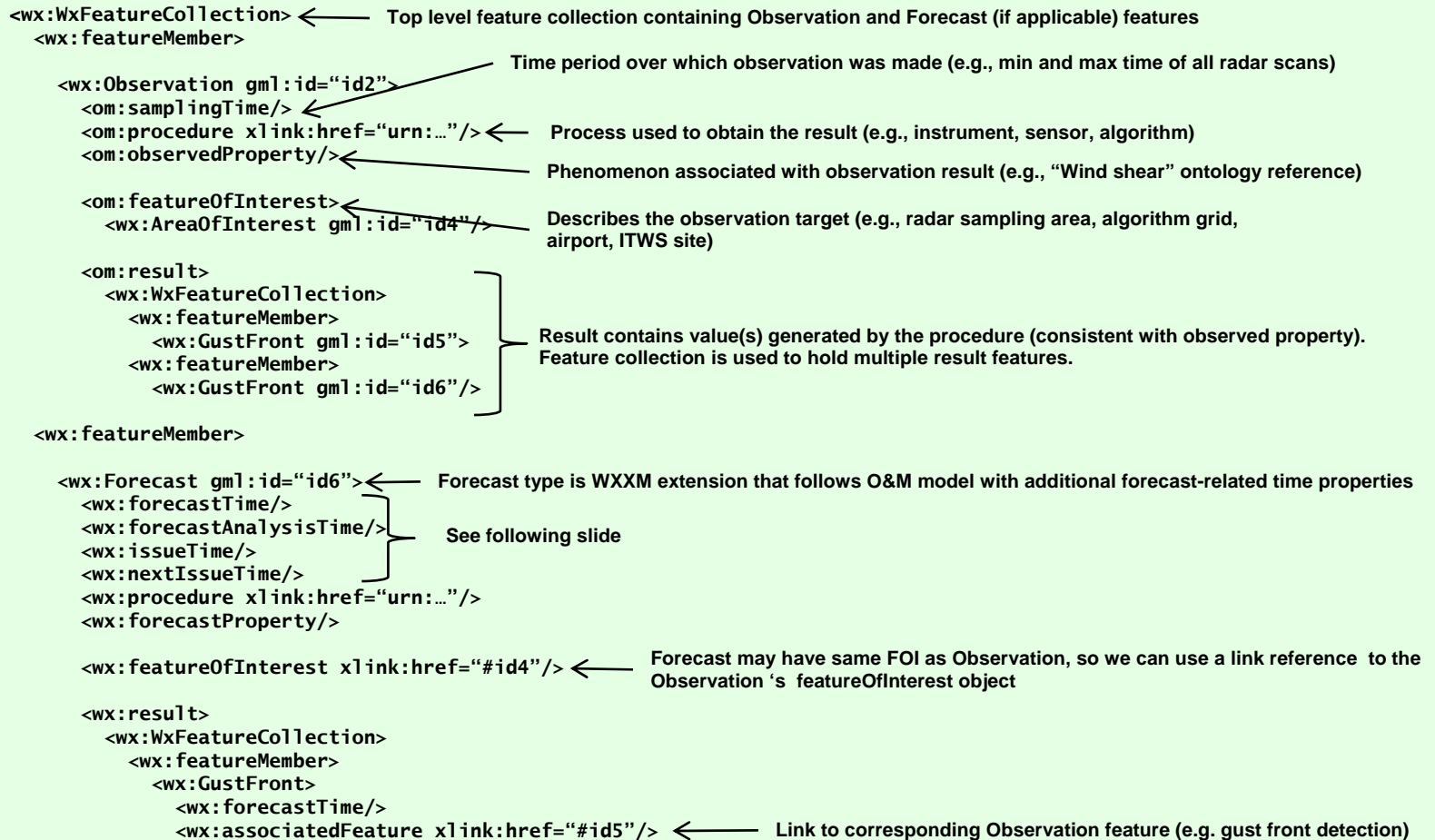


# ITWS/CIWS WXXM Product Mapping Pattern - UML View





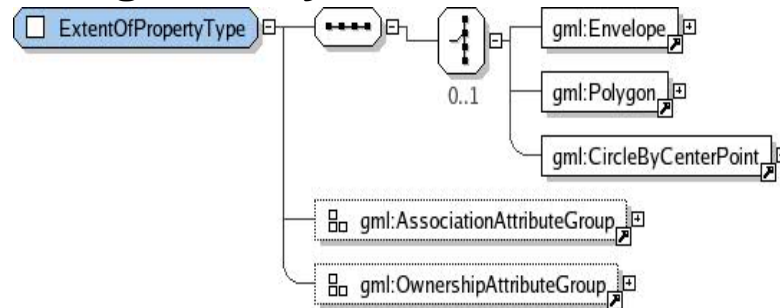
# ITWS/CIWS WXXM Product Mapping Pattern - XML View





# Observation Feature of Interest

- Can be a feature of any type representing the observation target (e.g. wx:AreaOfInterest)
- Optional wx:AreaOfInterest *extentOf* property allows for specification of geometry associated with feature of interest



```
<om:featureOfInterest>
  <wx:AreaOfInterest gml:id="id6">
    <gml:description>Boston ITWS radar coverage area</gml:description>
    <gml:identifier
      codeSpace="urn:fdc:faa.gov:AreaOfInterest:System:ITWS:">BOS</gml:identifier>
    <wx:extentOf>
      <gml:CircleByCenterPoint numArc="1">
        <gml:pos>45.20 -77.02</gml:pos>
        <gml:radius uom="m">50000</gml:radius>
      </gml:CircleByCenterPoint>
    </wx:extentOf>
  </wx:AreaOfInterest>
</om:featureOfInterest>
```

URN for registry-based lookup



# ITWS Microburst Example (Part 1 of 2)

```
<?xml version="1.0" encoding="UTF-8"?>
<wx:FeatureCollection gml:id="id0" xmlns:wx="http://www.eurocontrol.int/wx/1.1" xmlns:gml="http://www.opengis.net/gml/3.2"
xmlns:om="http://www.opengis.net/om/1.0/gml32" xmlns:xlin="http://www.w3.org/1999/xlink"
xmlns:nawx="http://www.faa.gov/nawx/1.1">
  <wx:featureMember>
    <wx:Observation gml:id="id1">
      <om:samplingTime>
        <gml:TimePeriod gml:id="id2">
          <gml:beginPosition>2007-10-11T20:48:15Z</gml:beginPosition>
          <gml:endPosition>2007-10-11T20:48:53Z</gml:endPosition>
        </gml:TimePeriod>
      </om:samplingTime>
      <om:procedure xlin:href="urn:fdc:faa.gov:System:ITWS:Algorithm:MBTMAP"/>
      <om:observedProperty xlin:href="http://www.ll.mit.edu/2009/wind.owl#WindShear"/>
      <om:featureOfInterest>
        <wx:AreaOfInterest gml:id="id3">
          <gml:description>N90 ITWS radar coverage area</gml:description>
          <gml:identifier codeSpace="urn:fdc:faa.gov:AreaOfInterest:System:ITWS:">N90</gml:identifier>
          <wx:extentOf>
            <gml:CircleByCenterPoint numArc="1">
              <gml:pos>45.20 -77.02</gml:pos>
              <gml:radius uom="m">50000</gml:radius>
            </gml:CircleByCenterPoint>
          </wx:extentOf>
        </wx:AreaOfInterest>
      </om:featureOfInterest>
      <om:result>
        <wx:FeatureCollection gml:id="id4">
          <wx:featureMember>
            <nawx:MicroburstShape gml:id="id8">
              <wx:obsOfFcstTime>
                <gml:TimeInstant gml:id="id9">
                  <gml:timePosition>2007-10-11T20:48:53Z</gml:timePosition>
                </gml:TimeInstant>
              </wx:observationTime>
              <nawx:geometry>
                <nawx:BandAidShape>
                  <gml:posList srsName="urn:ogc:def:crs:EPSG:4326" srsDimension="2" count="2">40.6468 -73.6171 40.6468 -
153.6171</gml:posList>
                  <nawx:radius uom="m">1317.0</nawx:radius>
                </nawx:BandAidShape>
              </nawx:geometry>
              <nawx:maxDeltaV uom="m/s">12.86</nawx:maxDeltaV>
            </nawx:MicroburstShape>
          </wx:featureMember>
        </wx:FeatureCollection>
      </om:result>
    </wx:Observation>
  </wx:featureMember>
</wx:FeatureCollection>
```



# ITWS Microburst Example (continued)

```
</wx:featureMember>
</wx:FeatureCollection>
</om:result>
</wx:Observation>

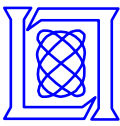
</wx:featureMember>
<wx:featureMember>
  <wx:Forecast gml:id="id5">
    <wx:samplingTime>
      <gml:TimePeriod gml:id="id6">
        <gml:beginPosition>2007-10-11T20:48:15Z</gml:beginPosition>
        <gml:endPosition>2007-10-11T20:48:53Z</gml:endPosition>
      </gml:TimePeriod>
    </wx:samplingTime>
    <wx:forecastAnalysisTime>2007-10-11T20:48:52Z</wx:forecastAnalysisTime>
    <om:procedure xlin:href="urn:fdc:faa.gov:System:ITWS:Algorithm:MBTMAP"/>
    <om:observedProperty xlin:href="http://www.ll.mit.edu/2009/wind.owl#WindShear"/>
    <om:featureOfInterest xlin:href="#id3"/>
    <om:result>
      <wx:FeatureCollection gml:id="id7">
        <wx:featureMember>
          <nawx:MicroburstShape gml:id="id14">
            <wx:obsOrFcstTime>
              <gml:TimeInstant gml:id="id15">
                <gml:timePosition>2007-10-11T20:48:53Z</gml:timePosition>
              </gml:TimeInstant>
            </wx:obsOrFcstTime>
            <nawx:geometry>
              <gml:CircleByCenterPoint numArc="1">
                <gml:pos srsName="urn:ogc:def:crs:EPSG:4326" srsDimension="2">40.6392 -73.608</gml:pos>
                <gml:radius uom="m">1128.0</gml:radius>
              </gml:CircleByCenterPoint>
            </nawx:geometry>
            <nawx:maxDeltaV uom="m/s">15.43</nawx:maxDeltaV>
          </nawx:MicroburstShape>
        </wx:featureMember>
      </wx:FeatureCollection>
    </om:result>
  </wx:Forecast>
</wx:featureMember>
</wx:FeatureCollection>
```



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# Impact of Nested Feature Collection on WFS

```
<?xml version="1.0" encoding="UTF-8"?>
<wx:FeatureCollection gml:id="id0" xmlns:wx="http://www.eurocontrol.int/wx/1.1" xmlns:gml="http://www.opengis.net/gml/3.2"
xmlns:om="http://www.opengis.net/om/1.0/gml32" xmlns:xlin="http://www.w3.org/1999/xlink"
xmlns:nawx="http://www.faa.gov/nawx/1.1">
  <wx:featureMember>
    <wx:Observation gml:id="id1" ←
      <om:samplingTime>
        <gml:TimePeriod gml:id="id2">
          <gml:beginPosition>2007-10-11T20:48:15Z</gml:beginPosition>
          <gml:endPosition>2007-10-11T20:48:53Z</gml:endPosition>
        </gml:TimePeriod>
      </om:samplingTime>
      <om:procedure xlin:href="urn:fdc:faa.gov:System:ITWS:Algorithm:MBTMAP"/>
      <om:observedProperty xlin:href="http://www.ll.mit.edu/2009/wind.owl#WindShear"/>
      <om:featureOfInterest>
        <wx:AreaOfInterest gml:id="id3">
          <gml:description>N90 ITWS radar coverage area</gml:description>
          <gml:identifier codeSpace="urn:fdc:faa.gov:AreaOfInterest:System:ITWS:">N90</gml:identifier>
          <wx:extentOf>
            <gml:CircleByCenterPoint numArc="1">
              <gml:pos>45.20 -77.02</gml:pos>
              <gml:radius uom="m">50000</gml:radius>
            </gml:CircleByCenterPoint>
          </wx:extentOf>
        </wx:AreaOfInterest>
      </om:featureOfInterest>
      <om:result> ←
        <wx:FeatureCollection gml:id="id4">
          <wx:featureMember>
            <nawx:MicroburstShape gml:id="id8">
              <wx:obsOfFcstTime>
                <gml:TimeInstant gml:id="id9">
                  <gml:timePosition>2007-10-11T20:48:53Z</gml:timePosition>
                </gml:TimeInstant>
              </wx:observationTime>
              <nawx:geometry>
                <nawx:BandAidShape>
                  <gml:posList srsName="urn:ogc:def:crs:EPSG:4326" srsDimension="2" cou
173.6171</gml:posList>
                  <nawx:radius uom="m">1317.0</nawx:radius>
                </nawx:BandAidShape>
              </nawx:geometry>
              <nawx:maxDeltaV uom="m/s">12.86</nawx:maxDeltaV>
            </nawx:MicroburstShape>
          </wx:featureMember>
        </wx:FeatureCollection>
      </om:result>
    </wx:Observation>
  </wx:featureMember>
</wx:FeatureCollection>
```

- Top-level feature inserted into WFS is Observation or Forecast

- Observation *result* contains nested collection of features. For large areas of interest (e.g., CIWS), the ability to spatially filter the nested collection is desirable.
- Similar problem to nested feature collections in plain GML
- Discussion topic for ad-hoc sessions



# Summary

- **FAA WXXM extension schema created with initial definitions for ITWS/CIWS non-gridded weather products**
- **Schemas created during WXXM 1.1 development – served as test case for WXXM encoding**
- **Some types are likely candidates for inclusion in WXXM 'core' (e.g., Microburst/Gustfront windshears) in future major version**
- **Encoding patterns developed to minimize XML bloat**
  - **Nested feature collections within a single observation result**
- **Sample FAA WXXM extension schemas available on NNEW Wiki**
  - **<https://wiki.ucar.edu/display/NNEW/Downloads>**



# Backups

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# Time Stamps

- **wx:Observation features have the following optional time properties:**
  - **samplingTime**: Time period over which observation was made
  - **resultTime**: Time when observation procedure was applied (may be omitted if same as **samplingTime**)
  - **issueTime**: Issue time of observation
  - **nextIssueTime**: Next (expected) issue time of observation
- **wx:Forecast features have the following optional time properties:**
  - **forecastTime**: Time period (analogous to Observation **samplingTime**)
  - **validTime**: Valid time of forecast. May be time period surrounding the **forecastTime**
  - **forecastAnalysisTime**: aka “forecast reference time”
  - **resultTime**: Time when procedure was applied
- **All features derived from wx:AbstractWxFeature (e.g., GustFront, MicroburstShape) have the following optional time properties:**
  - **obsOrFcstTime**: Time instant for feature observation (use in Observation result)
  - **validTime**: Time period over which feature is valid (this could be used to incorporate the ITWS product expiration time)