

# ICAO Logical Data Model and WXXM 2.0

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# Introduction

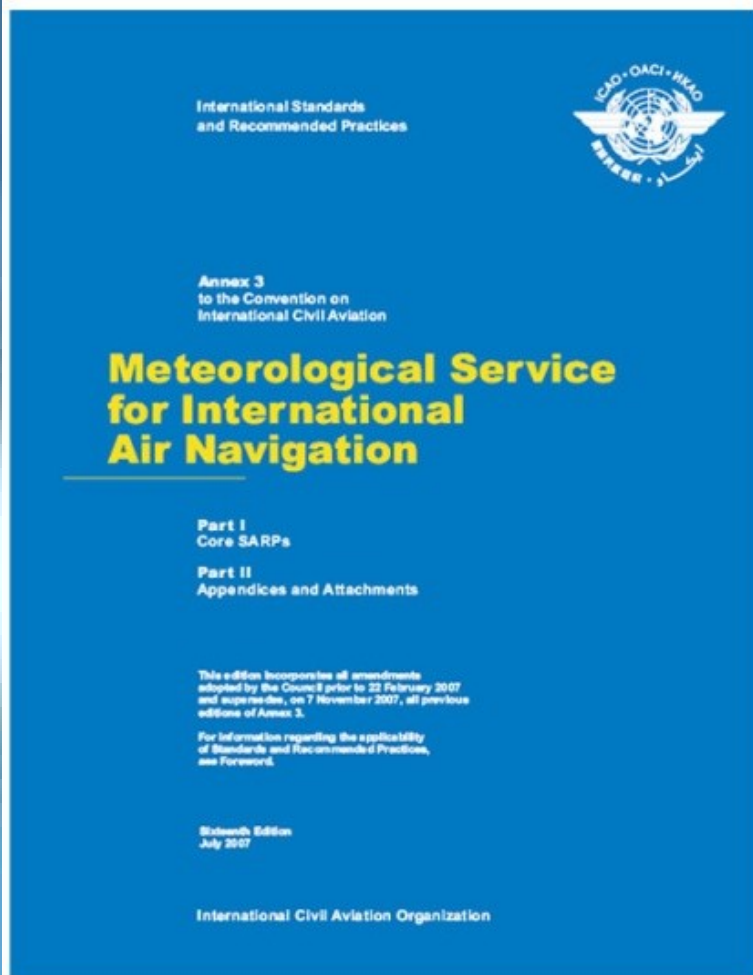


**Recent Developments**

**Data Model Evolution**

**Timeline**

# ICAO Annex 3



“... states in a position to do so ...”  
may exchange METAR, SPECI, TAF  
and SIGMET in XML starting in  
November 2013

# Introducing AMXM



Aviation Meteorological eXchange Model  
(proposed, unofficial name)

## ICAO Annex 3 Products

- METAR
- SPECI
- TAF
- SIGMET

Emphasis on **proposed...**  
As in **not yet decided...**

# METCE



## Relationship between WMO and ICAO

- ICAO is responsible for aviation
- WMO is responsible for meteorology
- *See METAR runway deposits* –  
ICAO Annex 3 METAR uses WMO 306 runway deposit
- ICAO relies upon WMO domain and technical expertise

# AMXM and METCE



## METCE

- Observations and Measurements (O&M) 2.0 General Constructs
- Generic Classes/Types not available from ISO
- Observable Property Model
- Meteorological Domain Features (volcano, tropical cyclone, etc.)
- Physical Phenomena (air temperature, altimeter setting)
- WMO Dictionaries/Web-Accessible Registers



## AMXM

- Reports (METAR, SPECI, TAF, SIGMET)
- Specialized Report O&M Constructs
- Aviation Domain Feature stubs (aerodrome, runway, FIR)
- ICAO Dictionaries/Web-Accessible Registers

# AMXM and WXXM



## AMXM

- Strict and complete representation of ICAO Annex 3 products (regulated products)
- Annex 3 business rules enforced

## WXXM

- General, reusable data types (aerial report, profile, trajectory, area forecast, point forecast, etc.)
  - Some may be adapted or used from METCE/GML
  - More inclusive than exclusive data policies
- Products/data types beyond Annex 3

# Data Models (ATIEC 2011)



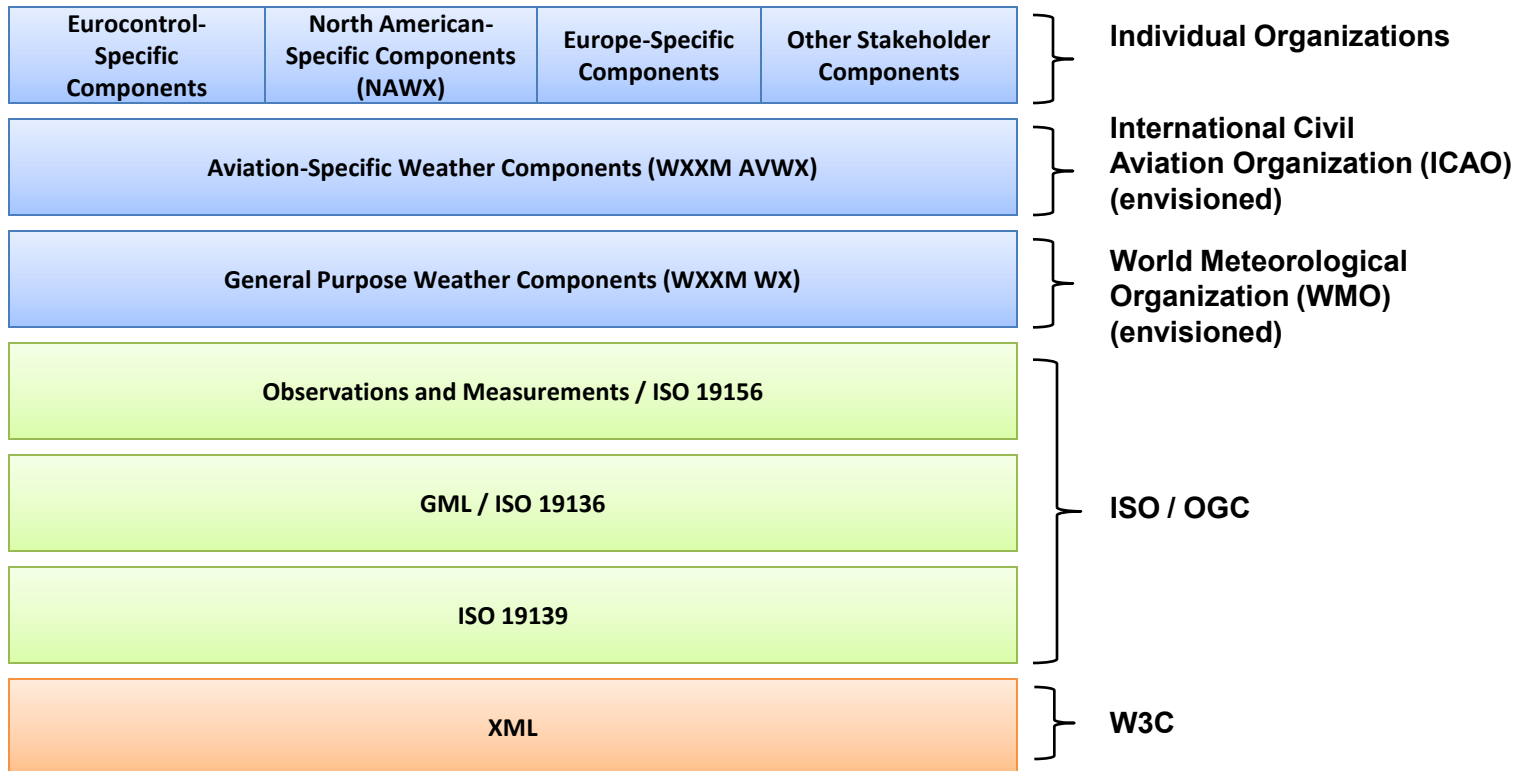
Data Model Component Agility

Standards Governance Body

High (months)



Low (years)





# Data Models (today)



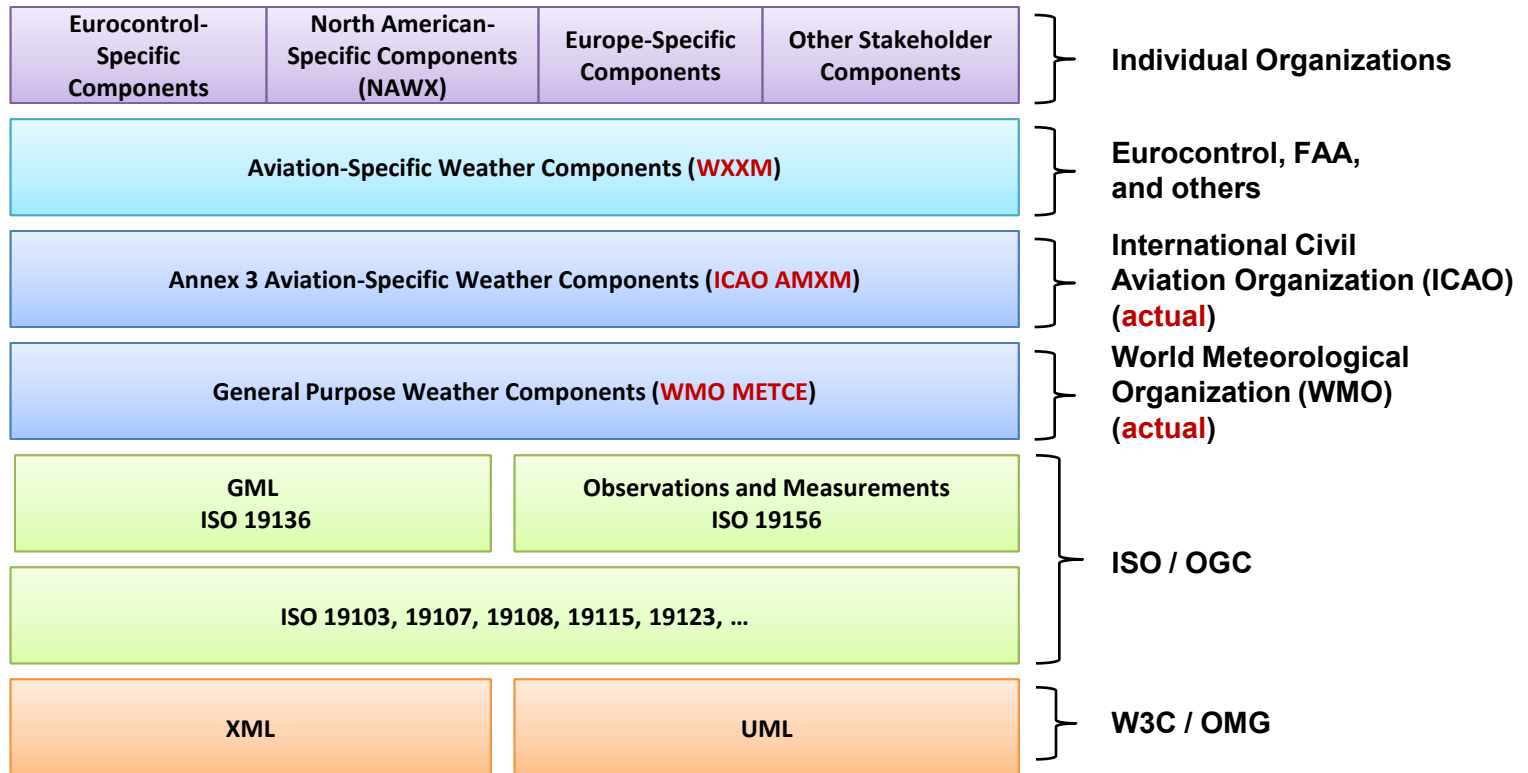
Data Model Component Agility

Standards Governance Body

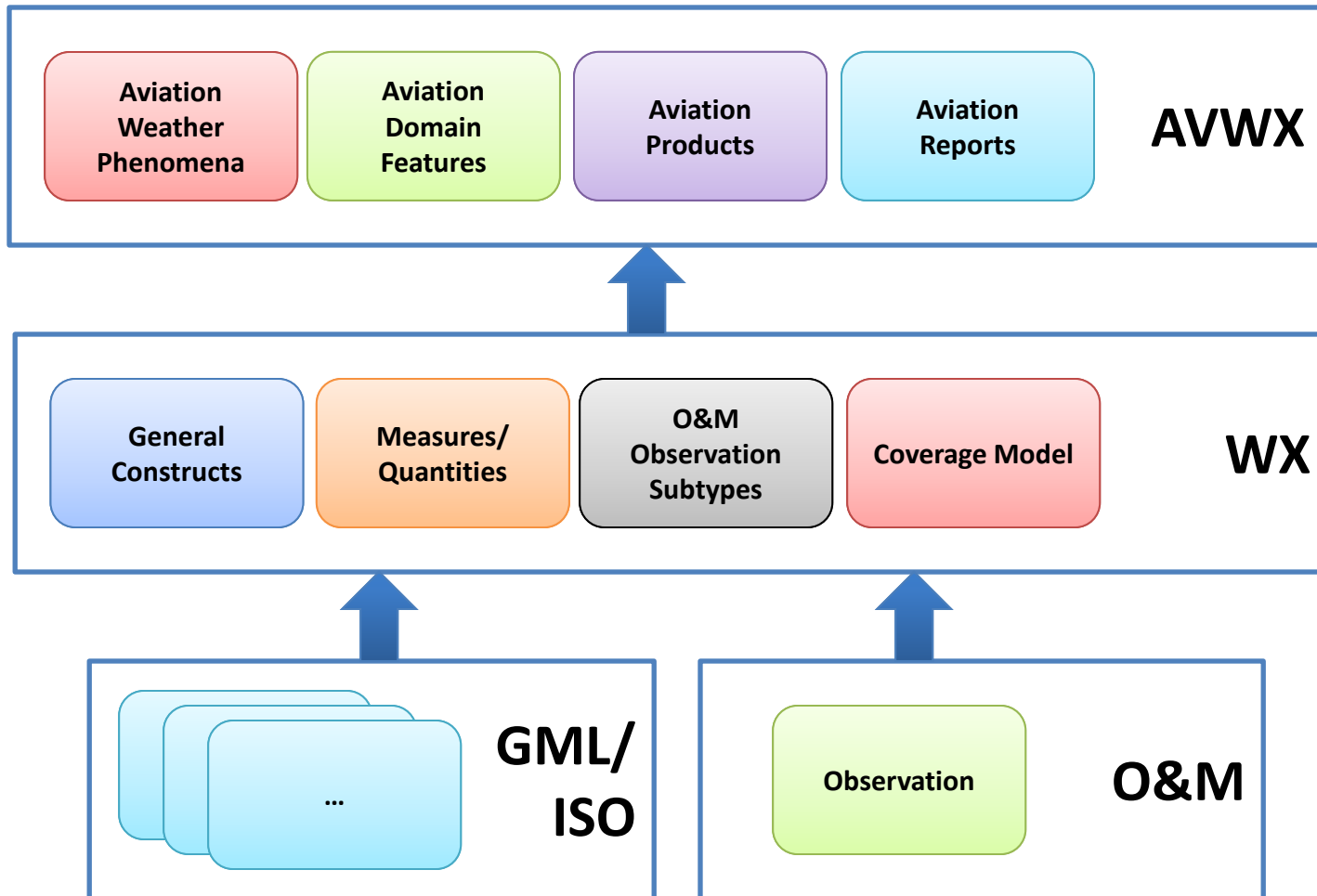
High  
(months)



Low  
(years)



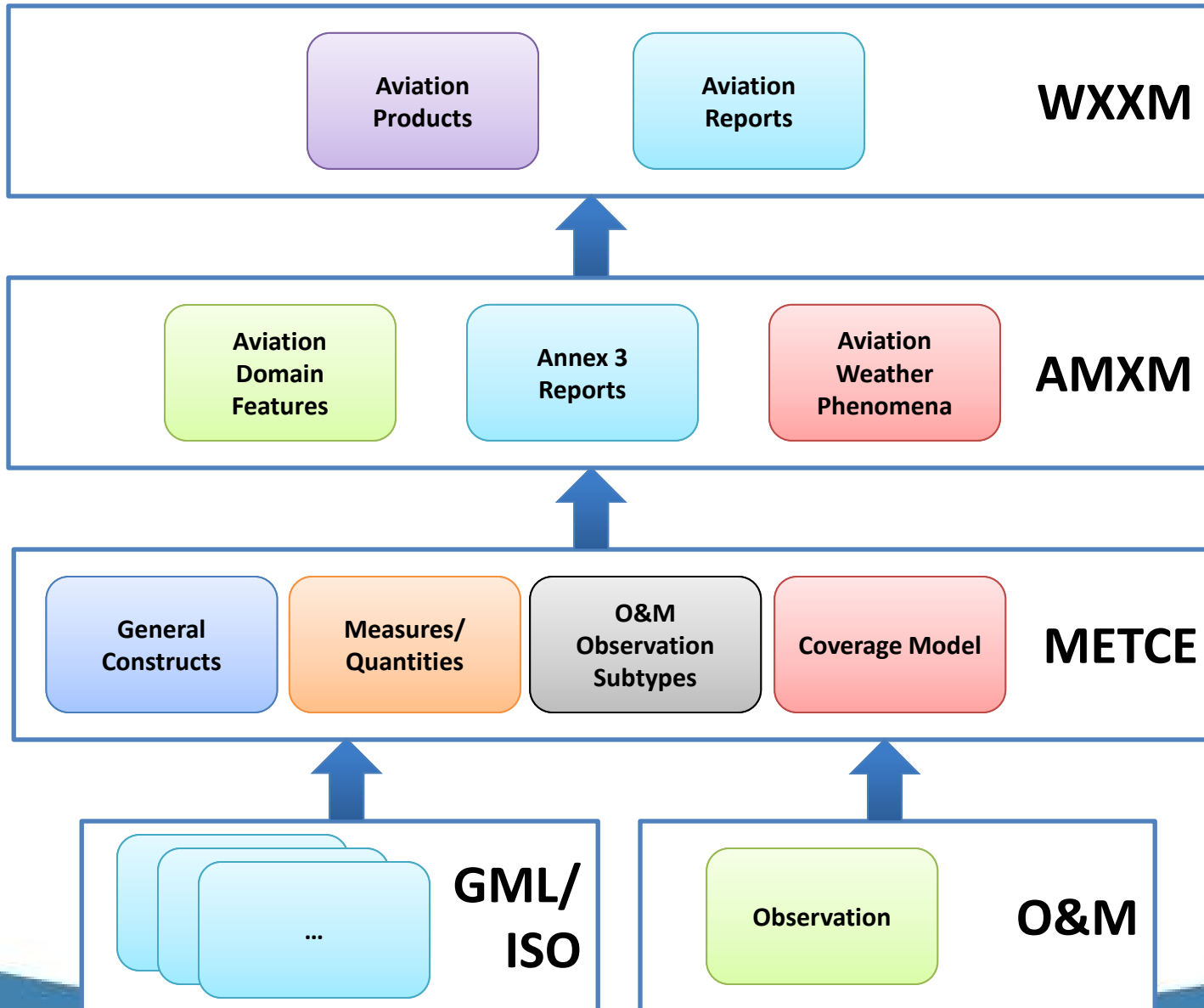
# WXXM 1.1



# WXXM 2



NCAR



# Timeline (proposed)



NCAR

## METCE 1.0 RC 1/AMXM 1.0 RC 1

- Initial version
- October 2012

## METCE 1.0 RC2/AMXM 1.0 RC2

- Changes based on feedback
- February 2013

## WXXM 2.0 RC1

- Initial version incorporating METCE and AMXM
- April 2013

## METCE 1.0/AMXM 1.0

- Official release
- July 2013

## WXXM 2.0

- Official release
- December 2013

# Testing and Evaluation



## TAC Code -> XML Instance Documents

- Required to ensure models are complete
- Both inclusive and exclusive cases

## Evaluation between releases

- WMO
- ICAO
- OGC Aviation Domain Working Group
- Other interested parties...

# Aviation Domain Features



<METAR>

<aerodrome xlink:href=<http://icao.int/def/aerodrome/KDEN/>>

<windShear>

<runway xlink:href=

</windShear>

...

</M

**Examples not to be confused with AMXM, METCE, AIXM,  
or WXXM**

<FIR xlink:href=<http://icao.int/def/fir/WIIF/>>

...

</SIGMET>

# AMXM METAR Example



```
<amxm:METAR xmlns:amxm="http://icao.int/amxm/1.0-RC1" xmlns:metce="http://schemas.wmo.int/metce/RC1"
  xmlns:om="http://www.opengis.net/om/2.0" xmlns:sam="http://www.opengis.net/sampling/2.0"
  xmlns:sams="http://www.opengis.net/samplingSpatial/2.0"
  xmlns:gml="http://www.opengis.net/gml/3.2" xmlns:gmd="http://www.isotc211.org/2005/gmd"
  xmlns:gco="http://www.isotc211.org/2005/gco" xmlns:xlink="http://www.w3.org/1999/xlink"
  xmlns:xsd="http://www.w3.org/2001/XMLSchema"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" gml:id="03839-20120824T12Z-metar">
  <amxm:status>
    <!-- NORMAL or CORRECTION -->
    <amxm:StatusCode>NORMAL</amxm:StatusCode>
  </amxm:status>
  <amxm:observation>
  <amxm:trendForecast>
</amxm:METAR>
```

# METAR Observation



```
<amxm:observation>
  <amxm:MeteorologicalAerodromeObservation gml:id="03839-20120824T12Z-observation">
    <!-- time at which the observation actually occurred -->
    <om:phenomenonTime>
      <gml:TimeInstant gml:id="time-instant-20120824T1150Z">
        <gml:timePosition>2012-08-24T11:50Z</gml:timePosition>
      </gml:TimeInstant>
    </om:phenomenonTime>
    <!-- time at which the results of the observation were made available (10-minutes later) -->
    <om:resultTime>
      <gml:TimeInstant gml:id="time-instant-20120824T1200Z">
        <gml:timePosition>2012-08-24T12:00Z</gml:timePosition>
      </gml:TimeInstant>
    </om:resultTime>
    <om:procedure xlink:href="http://data.wmo.int/process/AutomatedMETARObservation"/>
    <!-- a SKOS Concept (fictionally) published by ICAO to represent observed weather conditions at a given site -->
    <om:observedProperty xlink:href="http://icao.int/property/AerodromeWeather-obs"
      xlink:title="METAR observation properties"/>
    <om:featureOfInterest>
      <!-- featureOfInterest_MUST_ be an instance of SF_SamplingPoint as specified in the Application Schema -->
      <sam:SamplingPoint gml:id="sampling-point-03839">
        <!-- sampledFeature in this case is Exeter International Airport -->
        <sam:sampledFeature xlink:href="http://icao.int/def/aerodrome/EGTE" xlink:title="Exeter Airport"/>
        <sam:position>
          <!-- This is where the observation took place, this is assumed to be representative of the sampledFeature -->
          <gml:Point gml:id="point-03839" gml:axisLabels="Lat Lon" gml:srsDimension="2"
            gml:srsName="http://www.opengis.net/def/crs/EPSG/0/4326">
            <gml:pos>50.74 -3.40</gml:pos>
          </gml:Point>
        </sam:position>
      </sam:SamplingPoint>
    </om:featureOfInterest>
    <om:result>
      <amxm:MeteorologicalAerodromeObservationRecord gml:id="03839-20120824T12Z-record">
        <amxm:airTemperature gml:uom="http://opengis.net/def/uom/UCUM/0/C">15.1</amxm:airTemperature>
        <amxm:windSpeed gml:uom="http://opengis.net/def/uom/UCUM/0/m/s">3.6</amxm:windSpeed>
        <amxm:gustSpeed gml:uom="http://opengis.net/def/uom/UCUM/0/m/s">7.6</amxm:gustSpeed>
        <amxm:windDirection gml:uom="http://opengis.net/def/uom/UCUM/0/deg">180</amxm:windDirection>
        <amxm:visibility gml:uom="http://opengis.net/def/uom/UCUM/0/m">4000</amxm:visibility>
        <!-- ... -->
      </amxm:MeteorologicalAerodromeObservationRecord>
    </om:result>
  </amxm:MeteorologicalAerodromeObservation>
</amxm:observation>
```



# METAR Observation Time



```
<amxm:observation>
  <amxm:MeteorologicalAerodromeObservationRecord gml:id="03839-20120824T112Z-record">
    <!-- time at which the observation actually occurred -->
    <om:phenomenonTime>
      <gml:TimeInstant gml:id="time-instant-20120824T1150Z">
        <gml:timePosition>2012-08-24T11:50Z</gml:timePosition>
      </gml:TimeInstant>
    </om:phenomenonTime>
    <!-- time at which the results of the observation were made available (10-minutes later) -->
    <om:resultTime>
      <gml:TimeInstant gml:id="time-instant-20120824T1200Z">
        <gml:timePosition>2012-08-24T12:00Z</gml:timePosition>
      </gml:TimeInstant>
    </om:resultTime>
    <om:procedure xlink:href="http://icao.int/property/AerodromeWeather-obs"
      <!-- a SKOS Concept (fictionally published by ICAO to represent observed weather conditions at a given site) -->
      xlink:title="METAR observation properties"/>
    <om:featureOfInterest>
      <!-- featureOfInterest_MUST_ be an instance of SF_SamplingPoint as specified in the Application Schema -->
      <sam:SamplingPoint gml:id="sampling-point-03839">
        <!-- sampledFeature in this case is Exeter International Airport -->
        <sam:sampledFeature xlink:href="http://icao.int/def/aerodrome/EGTE" xlink:title="Exeter Airport"/>
        <sam:position>
          <!-- This is where the observation took place, this is assumed to be representative of the sampledFeature -->
          <gml:Point gml:id="point-03839" gml:axisLabels="Lat Lon" gml:srsDimension="2"
            gml:srsName="http://www.opengis.net/def/crs/EPSG/0/4326">
            <gml:pos>50.74 -3.40</gml:pos>
          </gml:Point>
        </sam:position>
      </sam:SamplingPoint>
    </om:featureOfInterest>
    <om:result>
      <amxm:MeteorologicalAerodromeObservationRecord gml:id="03839-20120824T12Z-record">
        <amxm:airTemperature gml:uom="http://opengis.net/def/uom/UCUM/0/C">15.1</amxm:airTemperature>
        <amxm:windSpeed gml:uom="http://opengis.net/def/uom/UCUM/0/m/s">3.6</amxm:windSpeed>
        <amxm:gustSpeed gml:uom="http://opengis.net/def/uom/UCUM/0/m/s">7.6</amxm:gustSpeed>
        <amxm:windDirection gml:uom="http://opengis.net/def/uom/UCUM/0/deg">180</amxm:windDirection>
        <amxm:visibility gml:uom="http://opengis.net/def/uom/UCUM/0/m">4000</amxm:visibility>
        <!-- ... -->
      </amxm:MeteorologicalAerodromeObservationRecord>
    </om:result>
  </amxm:MeteorologicalAerodromeObservationRecord>
</amxm:observation>
```

# METAR Observation Metadata



```
<amxm:observation>
  <amxm:MeteorologicalAerodromeObservation gml:id="03839-20120824T12Z-observation">
    <!-- time at which the observation actually occurred -->
    <om:phenomenonTime>
      <gml:TimeInstant gml:id="time-instant-20120824T1150Z">
        <gml:timePosition>2012-08-24T11:50Z</gml:timePosition>
      </gml:TimeInstant>
    </om:phenomenonTime>
    <!-- time at which the results of the observation were made available (10-minutes later) -->
    <om:resultTime>
      <gml:TimeInstant gml:id="time-instant-20120824T1200Z">
        <gml:timePosition>2012-08-24T12:00Z</gml:timePosition>
      </gml:TimeInstant>
    </om:resultTime>
    <om:procedure xlink:href="http://data.wmo.int/process/AutomatedMETARObservation"/>
    <!-- a SKOS Concept (fictionally) published by ICAO to represent observed weather conditions at a given site -->
    <om:observedProperty xlink:href="http://icao.int/property/AerodromeWeather-obs"
      xlink:title="METAR observation properties"/>
    <om:featureOfInterest_ MUST_ Be an instance of SF_SamplingPoint as specified in the Application Schema -->
    <sam:SamplingPoint gml:id="sampling-point-03839">
      <!-- sampledFeature in this case is Exeter International Airport -->
      <sam:sampledFeature xlink:href="http://icao.int/def/aerodrome/EGTE" xlink:title="Exeter Airport"/>
      <sam:position>
        <!-- This is where the observation took place, this is assumed to be representative of the sampledFeature -->
        <gml:Point gml:id="point-03839" gml:axisLabels="Lat Lon" gml:srsDimension="2"
          gml:srsName="http://www.opengis.net/def/crs/EPSSG/0/4326">
          <gml:pos>50.74 -3.40</gml:pos>
        </gml:Point>
      </sam:position>
    </sam:SamplingPoint>
    </om:featureOfInterest>
    <om:result>
      <amxm:MeteorologicalAerodromeObservationRecord gml:id="03839-20120824T12Z-record">
        <amxm:airTemperature gml:uom="http://opengis.net/def/uom/UCUM/0/C">15.1</amxm:airTemperature>
        <amxm:windSpeed gml:uom="http://opengis.net/def/uom/UCUM/0/m/s">3.6</amxm:windSpeed>
        <amxm:gustSpeed gml:uom="http://opengis.net/def/uom/UCUM/0/m/s">7.6</amxm:gustSpeed>
        <amxm:windDirection gml:uom="http://opengis.net/def/uom/UCUM/0/deg">180</amxm:windDirection>
        <amxm:visibility gml:uom="http://opengis.net/def/uom/UCUM/0/m">4000</amxm:visibility>
        <!-- ... -->
      </amxm:MeteorologicalAerodromeObservationRecord>
    </om:result>
  </amxm:MeteorologicalAerodromeObservation>
</amxm:observation>
```

# METAR Observation Feature of Interest



```
<amxm:observation>
  <amxm:MeteorologicalAerodromeObservation gml:id="03839-20120824T12Z-observation">
    <!-- time at which the observation actually occurred -->
    <om:phenomenonTime>
      <gml:TimeInstant gml:id="time-instant-20120824T1150Z">
        <gml:timePosition>2012-08-24T11:50Z</gml:timePosition>
      </gml:TimeInstant>
    </om:phenomenonTime>
    <!-- time at which the results of the observation were made available (10-minutes later) -->
    <om:resultTime>
      <gml:TimeInstant gml:id="time-instant-20120824T1200Z">
        <gml:timePosition>2012-08-24T12:00Z</gml:timePosition>
      </gml:TimeInstant>
    </om:resultTime>
    <om:procedure xlink:href="http://data.wmo.int/process/AutomatedMETARObservation"/>
    <!--
    <om:featureOfInterest>
      <!-- featureOfInterest _MUST_ be an instance of SF_SamplingPoint as specified in the Application Schema -->
      <om:featureOfInterest>
        <sam:SamplingPoint gml:id="sampling-point-03839">
          <!-- sampledFeature in this case is Exeter International Airport -->
          <sam:sampledFeature xlink:href="http://icao.int/def/aerodrome/EGTE" xlink:title="Exeter Airport"/>
          <sam:position>
            <!-- This is where the observation took place, this is assumed to be representative of the sampledFeature -->
            <gml:Point gml:id="point-03839" gml:axisLabels="Lat Lon" gml:srsDimension="2"
              gml:srsName="http://www.opengis.net/def/crs/EPSG/0/4326">
              <gml:pos>50.74 -3.40</gml:pos>
            </gml:Point>
          </sam:position>
        </sam:SamplingPoint>
      </om:featureOfInterest>
    </om:featureOfInterest>
    <amxm:windSpeed gml:uom="http://opengis.net/def/uom/UCUM/0/m/s">3.6</amxm:windSpeed>
    <amxm:gustSpeed gml:uom="http://opengis.net/def/uom/UCUM/0/m/s">7.6</amxm:gustSpeed>
    <amxm:windDirection gml:uom="http://opengis.net/def/uom/UCUM/0/deg">180</amxm:windDirection>
    <amxm:visibility gml:uom="http://opengis.net/def/uom/UCUM/0/m">4000</amxm:visibility>
    <!-- ... -->
  </amxm:MeteorologicalAerodromeObservationRecord>
</om:result>
</amxm:MeteorologicalAerodromeObservation>
</amxm:observation>
```

# METAR Observation Result



```
<amxm:observation>
  <amxm:MeteorologicalAerodromeObservation gml:id="03839-20120824T12Z-observation">
    <!-- time at which the observation actually occurred -->
    <om:phenomenonTime>
      <gml:TimeInstant gml:id="time-instant-20120824T1150Z">
        <gml:timePosition>2012-08-24T11:50Z</gml:timePosition>
      </gml:TimeInstant>
    </om:phenomenonTime>
    <!-- time at which the results of the observation were made available (10-minutes later) -->
    <om:resultTime>
      <gml:TimeInstant gml:id="time-instant-20120824T1200Z">
        <gml:timePosition>2012-08-24T12:00Z</gml:timePosition>
      </gml:TimeInstant>
    </om:resultTime>
    <om:procedure xlink:href="http://data.wmo.int/process/AutomatedMETARObservation"/>
    <!-- a SKOS Concept (fictionally) published by ICAO to represent observed weather conditions at a given site -->
    <om:observedProperty xlink:href="http://icao.int/property/AerodromeWeather-obs"
      xlink:title="METAR observation properties"/>
    <om:featureOfInterest>
      <!-- featureOfInterest_MUST_ be an instance of SF_SamplingPoint as specified in the Application Schema -->
      <sam:SamplingPoint gml:id="sampling-point-03839">
        <!-- sampledFeature in this case is Exeter International Airport -->
        <sam:sampledFeature xlink:href="http://icao.int/def/aerodrome/EGTE" xlink:title="Exeter Airport"/>
        <sam:position>
          <!-- This is where the observation took place, this is assumed to be representative of the sampledFeature -->
          <gml:Point gml:id="point-03839" gml:axisLabels="Lat Lon" gml:srsDimension="2"
            gml:srsName="http://www.opengis.net/def/crs/EPSG/0/4326">
            <gml:pos>50.74 -3.40</gml:pos>
          </gml:Point>
        </sam:position>
      </sam:SamplingPoint>
    </om:featureOfInterest>
    <om:result>
      <amxm:MeteorologicalAerodromeObservationRecord gml:id="03839-20120824T12Z-record">
        <amxm:airTemperature gml:uom="http://opengis.net/def/uom/UCUM/0/C">15.1</amxm:airTemperature>
        <amxm:windSpeed gml:uom="http://opengis.net/def/uom/UCUM/0/m/s">3.6</amxm:windSpeed>
        <amxm:gustSpeed gml:uom="http://opengis.net/def/uom/UCUM/0/m/s">7.6</amxm:gustSpeed>
        <amxm:windDirection gml:uom="http://opengis.net/def/uom/UCUM/0/deg">180</amxm:windDirection>
        <amxm:visibility gml:uom="http://opengis.net/def/uom/UCUM/0/m">4000</amxm:visibility>
        <!-- ... -->
      </amxm:MeteorologicalAerodromeObservationRecord>
    </om:result>
  </amxm:MeteorologicalAerodromeObservation>
</amxm:observation>
```

# METAR Trend Forecast



```
<amxm:trendForecast>
  <MeteorologicalAerodromeTrendForecast gml:id="03839-20120824T12Z-trend-fcst-1">
    <!-- time at which the forecast conditions actually occur -->
    <om:phenomenonTime>
      [REDACTED]
    </om:phenomenonTime>
    <!-- time at which the results of the observation were made available -->
    <om:resultTime>
      <gml:TimeInstant gml:id="fcst-time-instant-20120824T1200Z">
        <gml:timePosition>2012-08-24T12:00Z</gml:timePosition>
      </gml:TimeInstant>
    </om:resultTime>
    [REDACTED] />
    <!-- a SKOS Concept (fictionally) published by Met Office to represent observed weather conditions at a given site -->
    <om:observedProperty xlink:href="http://icao.int/property/AerodromeWeather-trend-fcst"
      xlink:title="METAR trend forecast properties"/>
    [REDACTED]
    <om:result>
      <amxm:MeteorologicalAerodromeTrendForecastRecord
        gml:id="03839-20120824T12Z-trend-fcst-record">
        [REDACTED]
      </amxm:MeteorologicalAerodromeTrendForecastRecord>
    </om:result>
  </MeteorologicalAerodromeTrendForecast>
</amxm:trendForecast>
```

**Time period**

**Not automated**

**Link to sampled point**

**Trend forecast record**

# WXXM 2 Changes



- Import METCE and AMXM
  - Observations and Measurements 2/ISO 19156
    - Observation/Forecast split
  - Common (non-ISO) constructs – ex: Compass8
  - Measures and Quantities
  - WXXM constructs extend AMXM and/or METCE
  - CSML
  - Coverage model
  - The “wx” namespace
- Product-centrism to Data-centrism
  - Ex: CCFP -> AreaForecastReport
- XML Schema 1.1
  - Open content model
  - Rules-based validation

- Will NOT include:
- GML 3.3

# Open Content Model (XML Schema 1.1)



Allow for extension:

- Pending additions
- Domain-specific extensions
- Regional extensions

```
<avwx:AerodromeWx>  
  <avwx:airTemperature uom="Cel" wxxmExt:qcScore="0.8">12.2</avwx:airTemperature>  
  <atc:authority name="ZTC" />  
  <avwx:airTemperature uom="degF">53.96</avwx:airTemperature>  
  <org:project>Weather Factory</org:project>  
  <org:qc evaluator="QCwatch" />  
</avwx:AerodromeWx>
```

# Open Content Challenge



```
myMisspelledAttribute="aValue"  
<myElement />  
<myElement/>
```

**Valid!**



# Open Content Tradeoffs



Open  
Content

Unenforceable maximum  
cardinality  
Uncaught spelling/coding  
mistakes

**Work in progress**  
**Not a binary problem, multiple solutions**

Closed  
Content

(changes break older software)  
Strictly validatable content

# Documentation



## UML Model Documentation

- In place today

## XML Schema Documentation

- Derived from UML documentation

## Primer/Educational Material

- Alongside major releases

# More Information



<http://www.wxxm.aero>

<https://wiki.ucar.edu/display/NNEWD/WXXM>