WXXM 1.1 Development and Roadmap

Oliver Newell, Kajal Claypool

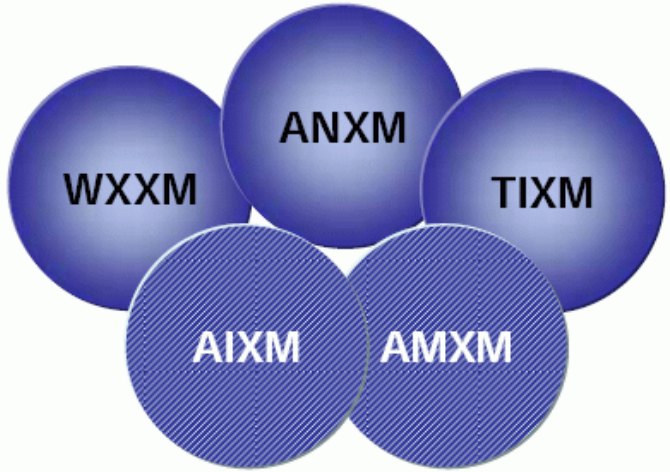
AIXM/WXXM Conference

14 May, 2009

Overview

- **WXXM Background**
- **Goals for WXXM 1.1**
- **WXXM 1.1 Development**
  - **Schema modularity**
  - **Alignment with relevant earth science/weather data models**
  - **Weather ontology linkage**
  - **Schema extensibility/versioning**
- **Current Status & Future Work**

WXXM and the AIM Data Model Family



- AIXM – Aeronautical Information Exchange Model
- AMXM – Airport Mapping Exchange Model
- WXXM – Weather Information Exchange Model
- ANXM – Airport Operations Information Exchange Model
- TIXM – Terrain Information Exchange Model

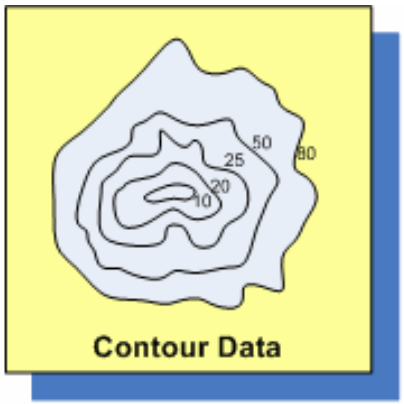
Established

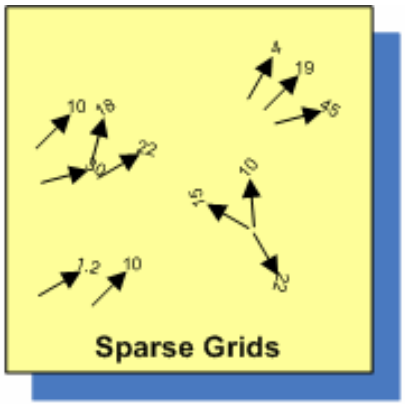
Under development*

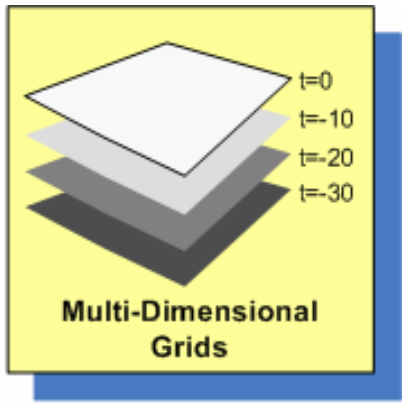
Source: Sam Van Der Stricht, "Digital AIM Evolution" Singapore Global AIM Congress, 2008

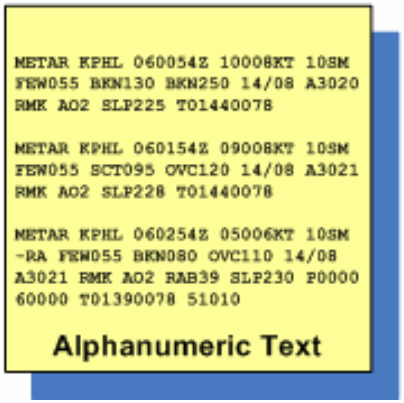
* Eurocontrol issued WXXM 1.0.1 release in mid-2008

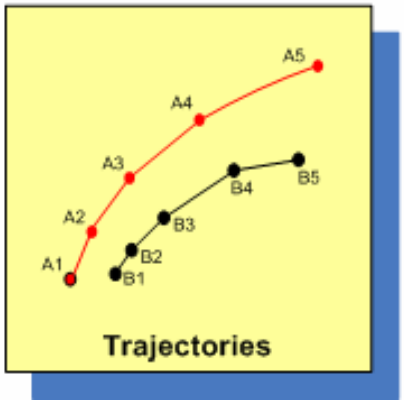
Common Weather Data Types

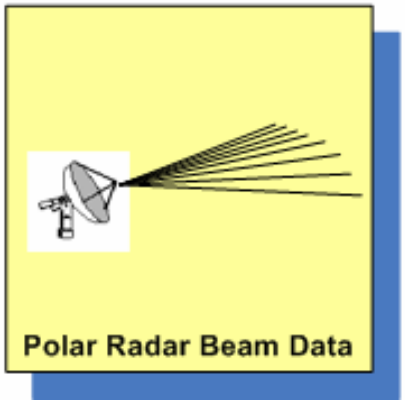


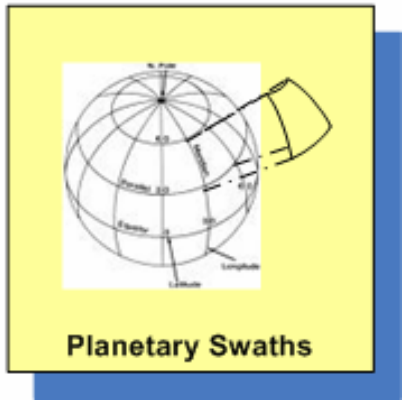












WXXM Workshop, November 10, 2008 Washington, D.C.

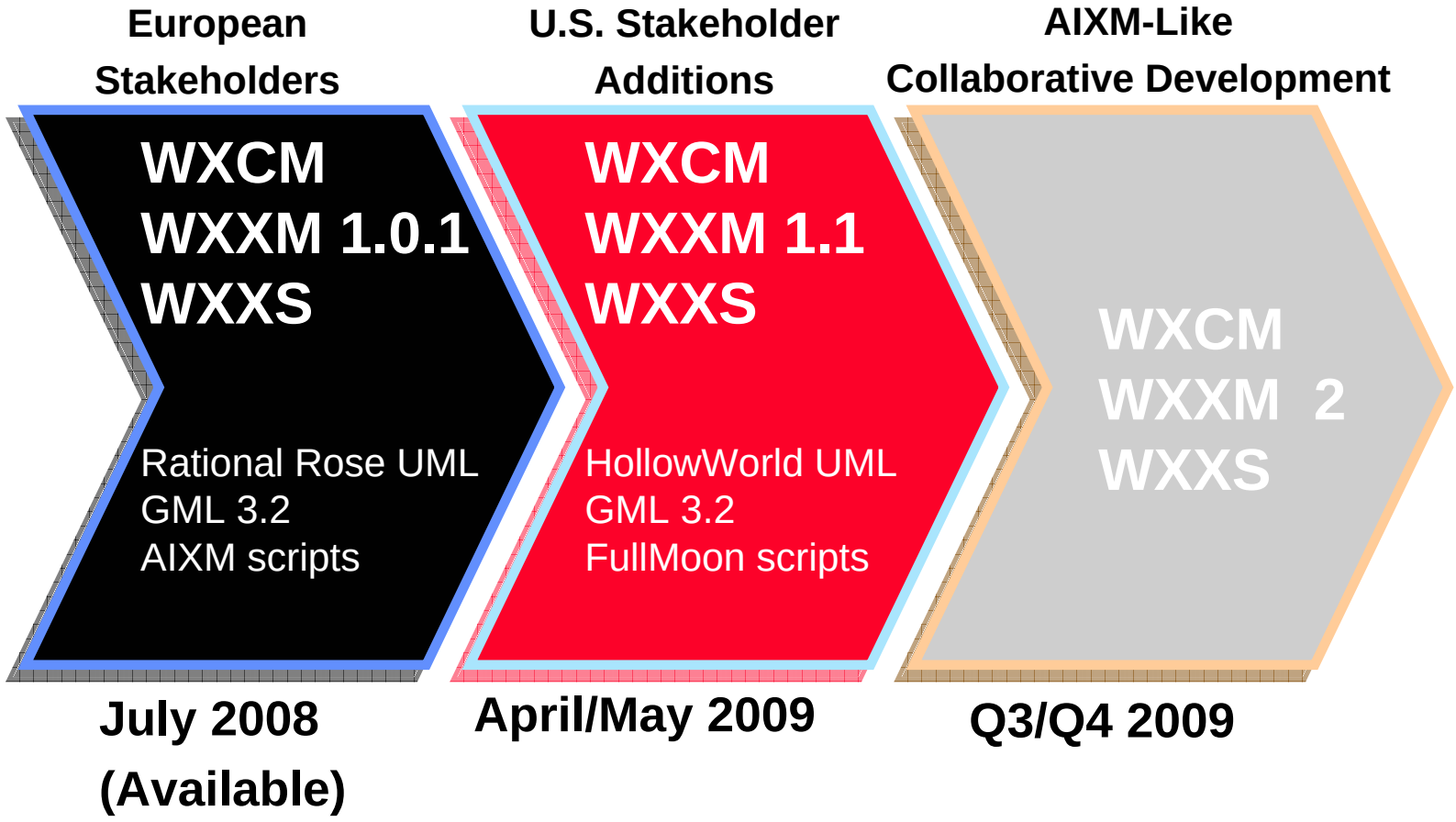
- **Goal – *Explore possible collaboration between U.S. and Eurocontrol on common weather model***
- **Attendees/Organizers**
  - **Dennis Hart (Eurocontrol)**
  - **David Hodgson (Mileridge – supporting Eurocontrol)**
  - **Silas Jones (Mileridge – supporting Eurocontrol)**
  - **Oliver Newell (MIT/LL)**
  - **Kajal Claypool (MIT/LL)**
  - **Aaron Braeckel (NCAR)**
  - **Chris MacDermaid (NOAA/ESRL)**
  - **Tim Hopkins (NWS)**
  - **John Chattel (NWS)**
  - **Stowe Davidson (NWS)**
  - **Eric Wise (DOD – AFWA)**
  - **Rich Deininger (Tectura/Boeing)**
  - **Andrew Wolfe (British Atmospheric Data Centre)**
  - **Jason Tuell (NWS)**
  - **Dave Pace (FAA)**
  - **Tom Ryan (FAA)**

Meeting Outcome

"FAA and EUROCONTROL agree on the following to conjointly develop future versions of WXCM/WXXM/WXXS Weather Information Models and Schemas: ……."

- **"The basis for the Models and Schema will be ISO/OGC Standards and Best Practices**
  - **ISO 191## series**
  - **GML 3.2**
  - **OGC Observation and Measurement Model (O&M)"**
- **"Version 1.0.1 of the WXCM/WXXM/WXXS, developed by EUROCONTROL, will be used as the basis for future conjoint versions."**
- **"The WXXM/WXXS will, whenever possible, be aligned with the Climate Science Modeling Language (CSML) Best Practice when not conflicting with the current O&M."**
- **"FAA will officially lead the migration of version 1.0.1 of the models to version 1.1, which will include mature building blocks for the Agreed Design Changes and the foreseen alignment with CSML."**

WXXM Development Roadmap

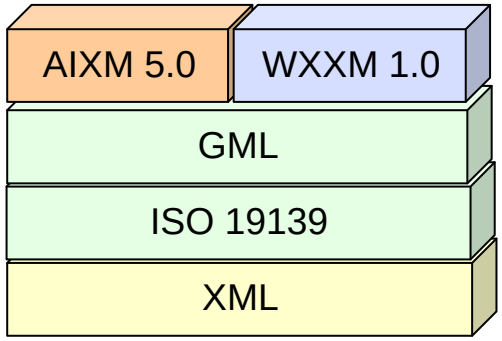


Overview

- WXXM Background
- Goals for WXXM 1.1
- WXXM 1.1 Development
  - Schema modularity
  - Alignment with relevant earth science/weather data models
  - Weather ontology linkage
  - Schema extensibility/versioning
- Current Status & Future Work

General High-Level WXXM Goals

- **Represent wide variety of weather data types**
- **Standards-based, ISO/OGC foundation**
  - **Increases interoperability with other AIM data models**



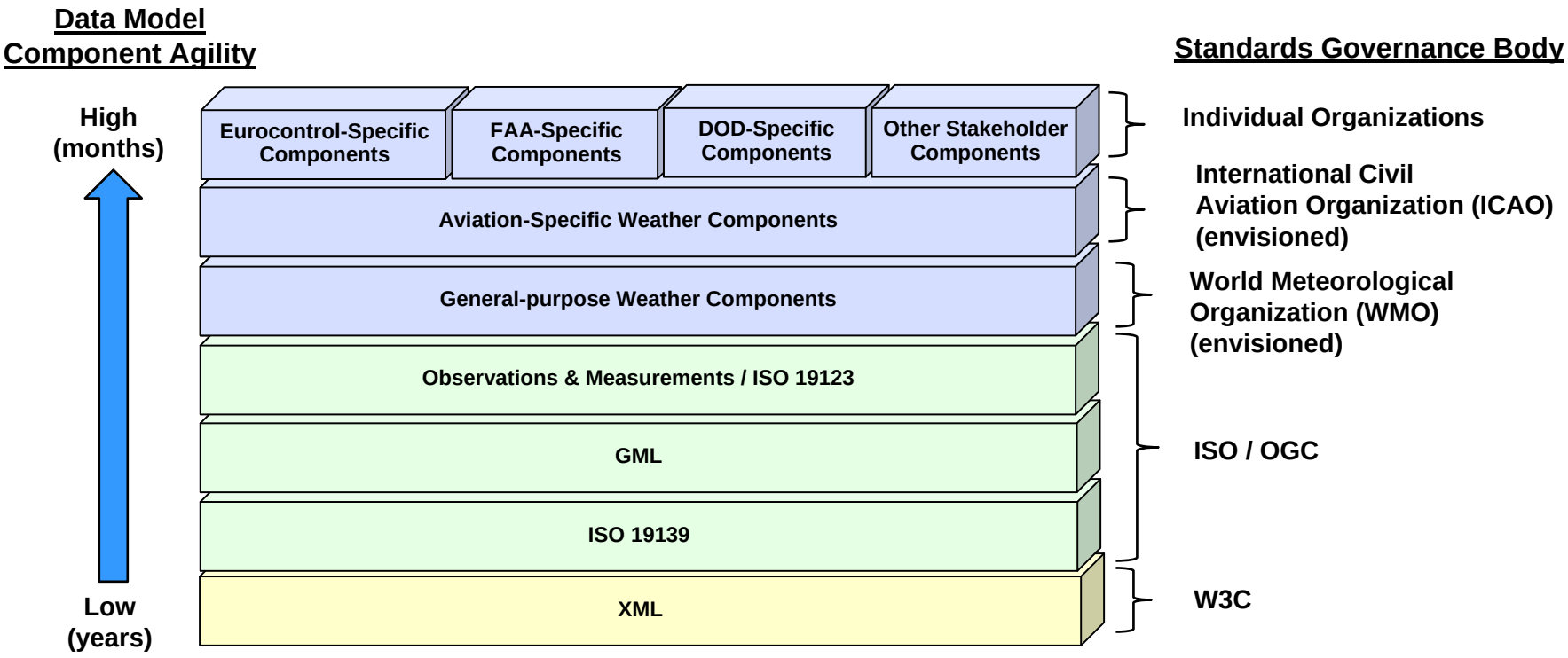
- **Modular**
- **Extensible**
- **Versionable**

Goals for WXXM 1.1

- Partition schema (WXXS) into general weather concepts and aviation-specific weather concepts
  - Motivation: Allow users to incorporate only the concepts they need (general schema best practice)
- Align with U.K. Climate Science Modeling Language (CSML) and NetCDF Common Data Model (CDM) general weather data types
- Support the ability to use NetCDF Climate and Forecast (CF) standard names and JMBL parameter names within WXXM.
- Refactor/simplify observation/forecast data type hierarchy
- Refine time semantics
  - Motivation: Forecast time semantics in WXXM 1.0 constrained by underlying O&M model
- Evaluate standards-based units of measure (applies to WXXM and AIXM)
- Enhance support for Ontologies

Composable Weather Data Model v1.1

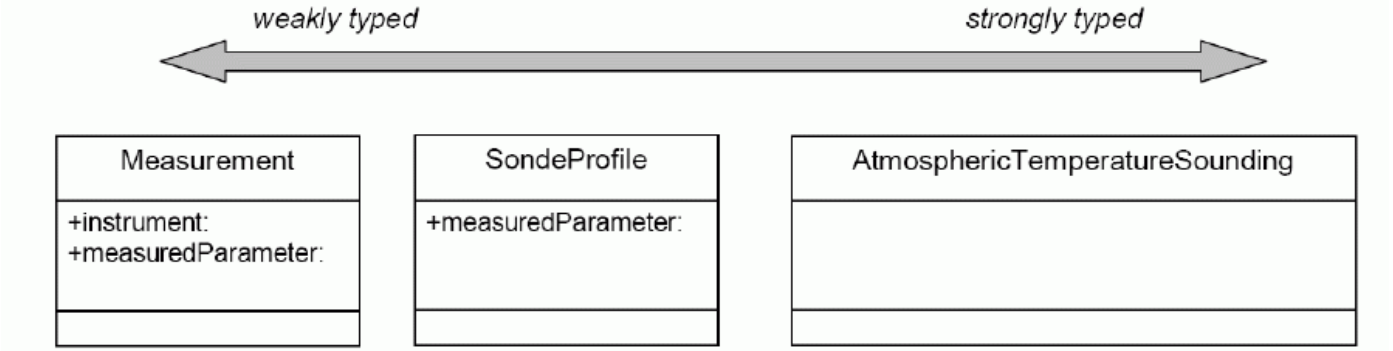
Composable, extensible data model balances standardization with the need for individual communities (FAA, Eurocontrol, DOD) to innovate



Data Type Alignment

- WXXM consists of a set of general types (grid) as well as more specialized types (METAR)
- The specialized types are often built on top of the more general types
- What are the most appropriate general types?
- Look to the weather community for existing relevant work…
  - Climate Science Modeling Language (CSML)
  - NetCDF Common Data Model (CDM)
- Key question: Prefer strong or weak typing for general types?

Strong vs. Weak Typing




```
<Measurement>
  <instrument>RADIOSONDE</instrument>
  <measuredParameter>TEMPERATURE</measuredParameter>
</Measurement>
```

Weak-typing example. Schema has relatively few elements and can represent multiple types of measurements. External vocabularies required.

```
<SondeProfile>
  <measuredParameter>TEMPERATURE</measuredParameter>
</SondeProfile>
```

```
<AtmosphericTemperatureSounding/>
```

Strong-typing example. Schema fully defines a particular data type. One type required for each measurement type. External vocabularies not required.

WXXM/CSML/NetCDF Data Type Alignment:Strong vs. Weak Typing

- **CSML User's Guide:**
  - ***"A-priori, it is not always obvious to a designer of feature types how strongly typed they should be. In general, the more specialised the feature types, the greater will be the number required to capture the spectrum of information types used by the community."***
- ***Strong types = Build-time implementation***
  - ***Schema -> Schema Compiler -> Java Objects -> Application***
- ***Build-time behavior inherently more heavyweight w/respect to change***
- ***If additional strong types add primarily type information, and not addtional attributes/behaviour, consider substituting weak types in name of agility.***

- **CSML Key Concept:** ***Support typical weather sampling geometries, and allow flexibility with what type of weather product is sampled within that geometry (soft-typing)***
- **Well-aligned with NetCDF Common Data Model approach**
- **Supports large number of data types**

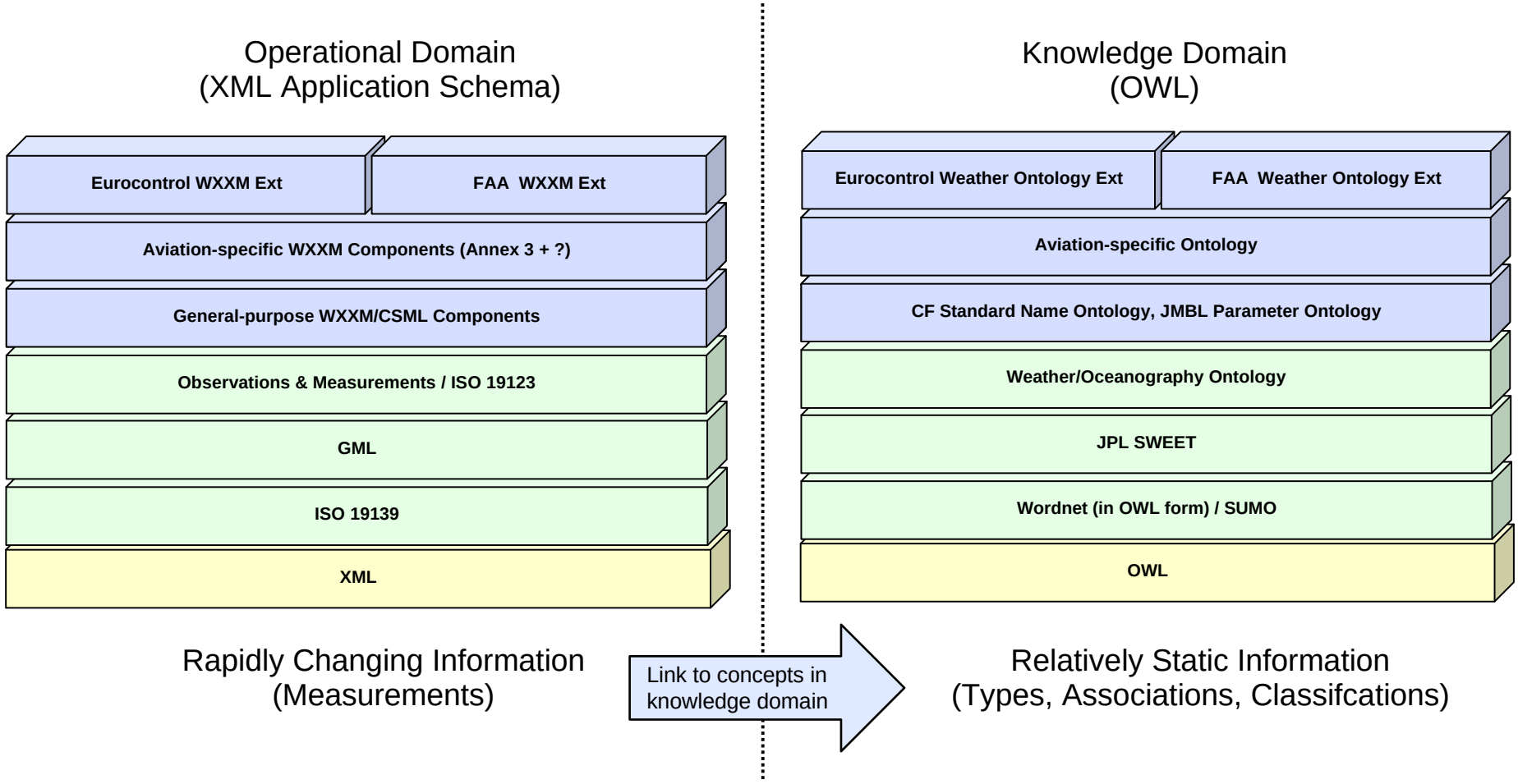
CSML Version 2 Feature Types

Feature type	Description	Example
PointFeature	Single point measurement.	raingauge measurement
PointSeriesFeature	Time-series of single datum measurements at a fixed location in space.	tidegauge, rainfall timeseries
TrajectoryFeature	Measurement along a discrete path in time and space.	surface salinity along a ship's cruise track; atmospheric aerosols along an aircraft's flight path
PointCollectionFeature	Collection of distributed single datum measurements at a particular time	2m temperatures measured at weather stations across the UK at 0600z.
ProfileFeature	Single 'profile' of some parameter along a vertical line in space.	wind sounding, XBT, CTD, radiosonde
ProfileSeriesFeature	Time-series of profiles on fixed vertical levels at a fixed location	vertical radar timeseries, thermistor chain timeseries
RaggedProfileSeriesFeature	Time-series of unequal-length profiles, but on fixed vertical levels, at a fixed location	repeat daily balloon soundings of atmospheric temperature from the same
SectionFeature	Series of profiles from positions along a trajectory in time and space.	shipborne ADCP
RaggedSectionFeature	Series of profiles of unequal length along a trajectory in time and space	marine CTD measurements along a ship's cruise track
ScanningRadarFeature	Backscatter profiles along a look direction at fixed elevation but rotating in azimuth	weather radar
GridFeature	Single time-snapshot of a gridded field.	gridded analysis field
GridSeriesFeature	Time-series of gridded parameter fields	numerical weather prediction model, ocean general circulation model
SwathFeature	Two-dimensional grid of data along a satellite ground-path	AVHRR satellite imagery

Overview

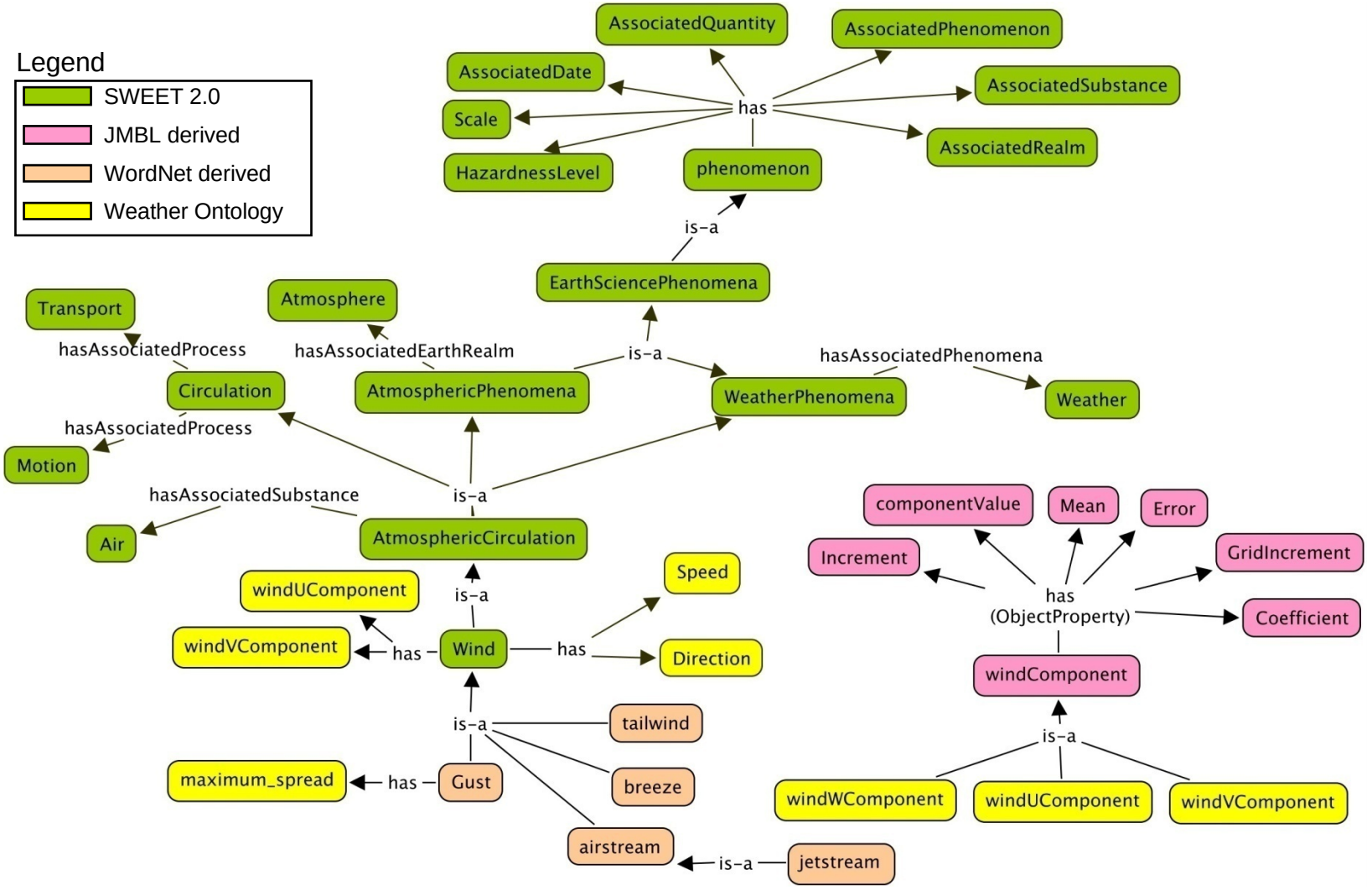
- WXXM Background
- Goals for WXXM 1.1
- WXXM 1.1 Development
  - Schema modularity
  - Alignment with relevant earth science/weather data models
  - Weather ontology linkage
  - Schema extensibility/versioning
- Current Status & Future Work

Data Model
Operational and Knowledge Domains



Notional Only - Intent is to delineate the two domains and illustrate the layered structure of each. Layers at same relative level in each domain do not necessary map to each other

NextGen Weather Ontology – Wind



Ontologies wind.owl & precipitation.owl with more complete set of concepts available

Overview

- WXXM Background
- Goals for WXXM 1.1
- WXXM 1.1 Development
  - Schema modularity
  - Alignment with relevant earth science/weather data models
  - Weather ontology linkage
  - Schema extensibility/versioning
- Current Status & Future Work

Schema Extension and Versioning

- ***Extensible*** **in eXtensible Markup Language refers to define new XML tags rather than creating extensible data models**
- **Versioning support is XML Schema 1.0 is limited**
- **No uniformly agreed-upon best practices**
  - ***Very easy to build a brittle system using XML***
- **W3C has gathered comprehensive set of versioning use cases**
  - **http://www.w3.org/XML/2005/xsd-versioning-use-cases**
  - **Use cases for backwards-compatibility**
  - **Use cases for forwards-compatibility**

- **XML Schema 1.1 designed to handle numerous versioning use cases**
  - **http://www.w3.org/TR/xmlschema-guide2versioning**

- **XML Schema 1.1 not yet released**
  - **May be a while yet before it is adopted…**
  - **Still possible to utilize lessons learned in draft 1.1 specification today**

Extending XML Schemas - Options

- Use XmlSchema #any element definitions in strategic spots within Domain-specific types
  - Prevents type derivation from those types in some situations
- Incorporate <ext> </ext> block(s) into domain-specific types, and let them contain any element type
  - Labor intensive, additions are 2nd-class citizens in some respects
- Open content model
  - Extensions typically added in their own namespace
  - No limitation on where elements are added
  - Use rules-based validation in place of XmlSchema 1.0 validation if consumer-side validation is required. (Schematron)
  - XmlSchema 1.1 adding explicit support for open content models

XML Schema 1.1
Open Content Model Support

```
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
  targetNamespace="http://www.example.org/ns/personName/1.0"
  elementFormDefault="qualified">

  <xs:openContent mode="interleave">
    <xs:any namespace="##any" processContents="lax"
            minOccurs="0" maxOccurs="unbounded"/>
  </xs:openContent>

  <xs:complexType name="nameType">
    <xs:sequence>
      <xs:element name="given" type="xs:string"/>
      <xs:element name="family" type="xs:string"/>
    </xs:sequence>
    <xs:anyAttribute/>
  </xs:complexType>

  <xs:element name="personName" type="namens:nameType"/>
</xs:schema
```

Global declaration of open content model will allow insertion of additional elements

(e.g., 'middleName')

over time, while still supporting XmlSchema-based validation

- **While emerging support for versioning using XmlSchema 1.1 validation is a good thing, it is not yet released, and software infrastructure support will not be immediate when it is released (2009?)**
- **As with general extension case, use alternate means of validation where necessary (e.g., Schematron or other rules-based validation)**

Core METAR Observation

Namespaces for individual schema components

```
<an3:METAR
  xmlns:an3="http://www.icao.int/annex3/1.0"
  xmlns:wx="http://www.eurocontrol.int/wxxs/1.0"
  xmlns:om="http://www.opengis.net/om/1.0/gml32"
  xmlns:swe="http://www.opengis.net/swe/1.0/gml32"
  xmlns:gml="http://www.opengis.net/gml/3.2"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">

  <rawText>METAR KTTN 051853Z 04011KT 1/2SM VCTS SN ...</rawText>
  <type>METAR</type>
  <observationTime>2008-11-04T14:46:21.735-05:00</observationTime>
  <automatedOrMissing>false</automatedOrMissing>
  <cavok>true</cavok>

  <observation>
    <wx:AerodromeAreaWeatherObservation>

      <om:observedProperty>
        <swe:Phenomenon>
          <gml:identifier>http://noaa.gov/ontology/wx.owl#airTemperature</gml:identifier>
        </swe:Phenomenon>
      </om:observedProperty>

      <om:featureOfInterest>
        <wx:AerodromeArea>
          <qfe>20.0</qfe>
        </wx:AerodromeArea>
      </om:featureOfInterest>

      <om:result uom="C" xsi:type="gml:MeasureType"">10.0</om:result>
    </wx:AerodromeAreaWeatherObservation>
  </observation>

</an3:METAR>
```

Notional FAA-Extended METAR Observation

```
<an3:METAR xsi:type="faa-an3:ExtendedMETARType"
 xmlns:faa-an3="http://faa.gov/annex3-ext/1.0"
 xmlns:an3="http://www.icao.int/annex3/1.0"
 xmlns:wx="http://www.eurocontrol.int/wxxs/1.0"
 xmlns:om="http://www.opengis.net/om/1.0/gml32"
 xmlns:swe="http://www.opengis.net/swe/1.0/gml32"
 xmlns:gml="http://www.opengis.net/gml/3.2"
 xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">

 <rawText>METAR KTTN 051853Z 04011KT 1/2SM VCTS SN ...</rawText>
 <type>METAR</type>
 <observationTime>2008-11-04T14:46:21.735-05:00</observationTime>
 <automatedOrMissing>false</automatedOrMissing>
 <cavok>true</cavok>

 <faa-an3:starbucksAtAerodrome>true</faa-an3:starbucksAtAerodrome>

 <observation>
  <wx:AerodromeAreaWeatherObservation>

   <om:observedProperty>
    <swe:Phenomenon>
     <gml:identifier>http://noaa.gov/ontology/wx.owl#airTemperature</gml:identifier>
    </swe:Phenomenon>
   </om:observedProperty>

   <om:featureOfInterest>
    <wx:AerodromeArea>
     <qfe>20.0</qfe>
    </wx:AerodromeArea>
   </om:featureOfInterest>

   <om:result uom="C" xsi:type="gml:MeasureType"">10.0</om:result>
  </wx:AerodromeAreaWeatherObservation>
 </observation>

</an3:METAR>
```

- **Extensions added in separate namespace**
- **Can be ignored by consumers that do not support the extended namespace**
- **Base <an3:METAR> element name used for extended type. This preserves the ability of consumers that support the base class to process the base class data elements**
- **Assumes use of open content model on consumer side**
- ***No extension points required in core schema***

Namespace-based versioning

- Use major/minor numbering schema
  - *Minor* number change implies a backwards/forwards compatible change
  - Major number change implies a change that breaks backwards and/or forwards compatibility
- Use open-content model and *ignore-unknowns* parsing policy
  - New XML elements in minor releases are ignored by older consumers
- Any new elements must be optional to preserve forwards compatibility
  - Allows new consumers to parse data from older producers
  - Balance between too many optional elements and interoperability. When threshold reached, move to next major version. (a bit of an art to determine when that is)
- Today's tooling can support this versioning approach
  - Parsers support ignore-unknowns policy when XmlSchema 1.0 validation is turned off

Current Status

- Established collaboration environment
  - Wiki page
  - WXXM data model repository, issue tracker
- Initial modifications to support WXXM 1.1 goals completed
  - Standardization of Units of Measure delayed to version 2
- UML model of version 1.1 produced using Enterprise Architect, handed off to Eurocontrol for final evaluation and comment
- Full Moon tool used to automatically generate Xml Schema from UML
  - Several issues resolved, one issue remains and is being worked with the authors of the FullMoon tool (CSIRO)
- Initial version of 1.1 schema being incorporated in several SWIM segment 1 programs (CIWS, ITWS, WMSCR)
  - Lessons learned will feed into WXXM version 2.

Next Steps

- **Near Term**
  - **Work with Eurocontrol to complete formal WXXM 1.1 release**
  - **Establish governance model for future collaboration**
- **Longer Term**
  - **Begin work on WXXM version 2**
  - **Work within ISO and OGC working groups to improve support for weather data types (forecasts, parametric grid axes, etc…)**
  - **Increased collaboration with AIXM community to enable future cross-domain applications**

Questions?