Epoch Position Design Guidelines

-

Laurent MICHEL,

```xml
<ATTRIBUTE dmrole="mango:EpochPosition.pmLongitude" dmtype="ivoa:RealQuantity" unit="mas/yr" ref="pmRA" />
<ATTRIBUTE dmrole="mango:EpochPosition.pmLatitude" dmtype="ivoa:RealQuantity" unit="mas/yr" ref="pmDE" />
<ATTRIBUTE dmrole="mango:EpochPosition.epoch" dmtype="coords:Epoch" value="2016.5" />
<ATTRIBUTE dmrole="mango:EpochPosition.pmCosDeltApplied" dmtype="ivoa:boolean" value="true" />

<!-- Errors on individual quantities -->
<INSTANCE dmrole="mango:EpochPosition.errors" dmtype="mango:EpochPositionErrors">
  <!-- Error on parallax -->
  <INSTANCE dmrole="mango:EpochPositionErrors.parallax" dmtype="mango:ErrorTypes.PropertyError1D">
    <ATTRIBUTE dmrole="mango:ErrorTypes.PropertyError1D.sigma" dmtype="ivoa:real" unit="mas" ref="e_Plx" />
  </INSTANCE>
  <!-- Error on radial velocity -->
  <INSTANCE dmrole="mango:EpochPositionErrors.radialVelocity" dmtype="mango:ErrorTypes.PropertyError1D">
    <ATTRIBUTE dmrole="mango:ErrorTypes.PropertyError1D.sigma" dmtype="ivoa:real" unit="km/s" ref="e_RV" />
  </INSTANCE>
  <!-- Error on position (diagonal matrix) -->
  <INSTANCE dmrole="mango:EpochPositionErrors.position" dmtype="mango:ErrorTypes.ErrorMatrix">
    <!-- Error matrix for 2D quantities" -->
    <ATTRIBUTE dmrole="mango:ErrorTypes.ErrorMatrix.sigma1" dmtype=
    <ATTRIBUTE dmrole="mango:ErrorTypes.ErrorMatrix.sigma2" dmtype=
  </INSTANCE>
  <!-- Error on proper motion (diagonal matrix) -->
  <INSTANCE dmrole="mango:EpochPositionErrors.properMotion" dmtyp
    <!-- Error matrix for 2D quantities" -->
    <ATTRIBUTE dmrole="mango:ErrorTypes.ErrorMatrix.sigma1" dmtyp
    <ATTRIBUTE dmrole="mango:ErrorTypes.ErrorMatrix.sigma2" dmtyp
  </INSTANCE>
</INSTANCE>

<!-- Correlation between quantities -->
<INSTANCE dmrole="mango:EpochPosition.correlations" dmtype="mango:EpochPositionCorrelations">
  <!-- Position/proper-motion correlation -->
  <INSTANCE dmrole="mango:EpochPositionCorrelations.positionPm" dmtype="mango:Correlation22">
    <ATTRIBUTE dmrole="mango:QuantityCorrelation.isCovariance" dmtype="ivoa:boolean" value="false" />
    <ATTRIBUTE dmrole="mango:Correlation22.a2b1" dmtype="ivoa:real" ref="DEpmRAcor" />
    <ATTRIBUTE dmrole="mango:Correlation22.a2b2" dmtype="ivoa:real" ref="DEpmDEcor" />
    <ATTRIBUTE dmrole="mango:Correlation22.a1b1" dmtype="ivoa:real" ref="RApmRAcor" />
    <ATTRIBUTE dmrole="mango:Correlation22.a1b2" dmtype="ivoa:real" ref="RApmDEcor" />
```

The current proposal

- Every quantity is packed in objects (INSTANCE) which class is part of the MANGO model draft as it is today.

2

```
<TEMPLATES>
  <INSTANCE dmtype="mango:EpochPosition">
    <REFERENCE dmref="_spacesys_icrs" dmrole="mango:EpochPosition.coordSys" />
    <ATTRIBUTE dmrole="mango:EpochPosition.epoch" dmtype="coords:Epoch" value="2016.5" />
    <ATTRIBUTE dmrole="mango:EpochPosition.pmCosDeltApplied" dmtype="ivoa:boolean" value="true" />
    <ATTRIBUTE dmrole="mango:QuantityCorrelation.isCovariance" dmtype="ivoa:boolean" value="false" />

    <ATTRIBUTE dmrole="mango:EpochPosition.longitude" dmtype="ivoa:RealQuanti
    <ATTRIBUTE dmrole="mango:EpochPosition.latitude" dmtype="ivoa:RealQuantit
    <ATTRIBUTE dmrole="mango:EpochPosition.parallax" dmtype="ivoa:RealQuantit
    <ATTRIBUTE dmrole="mango:EpochPosition.pmLongitude" dmtype="ivoa:RealQuan
    <ATTRIBUTE dmrole="mango:EpochPosition.pmLatitude" dmtype="ivoa:RealQuant

    <ATTRIBUTE dmrole="mango:EpochPosition.lonErr" dmtype="ivoa:RealQuantity"
    <ATTRIBUTE dmrole="mango:EpochPosition.latErr" dmtype="ivoa:RealQuantity" ref="e_DEC_ICRS" />
    <ATTRIBUTE dmrole="mango:EpochPosition.parallaxErr" dmtype="ivoa:RealQuantity" ref="e_Plx" />
    <ATTRIBUTE dmrole="mango:EpochPosition.pmlonErr" dmtype="ivoa:RealQuantity" ref="e_pmRA" />
    <ATTRIBUTE dmrole="mango:EpochPosition.pmlatErr" dmtype="ivoa:RealQuantity" ref="e_pmDE" />

    <ATTRIBUTE dmrole="mango:EpochPosition.lonLatCor" dmtype="ivoa:RealQuantity" ref="RADEcor" />
    <ATTRIBUTE dmrole="mango:EpochPosition.lonParallaxCor" dmtype="ivoa:RealQuantity" ref="RAPlxcor" />
    <ATTRIBUTE dmrole="mango:EpochPosition.lonPmlonCor" dmtype="ivoa:RealQuantity" ref="RApmRAcor" />
    <ATTRIBUTE dmrole="mango:EpochPosition.lonPmlatCor" dmtype="ivoa:RealQuantity" ref="RApmDEcor" />
    <ATTRIBUTE dmrole="mango:EpochPosition.latParallaxCor" dmtype="ivoa:RealQuantity" ref="DEPlxcor" />
    <ATTRIBUTE dmrole="mango:EpochPosition.latPmlonCor" dmtype="ivoa:RealQuantity" ref="DEpmRAcor" />
    <ATTRIBUTE dmrole="mango:EpochPosition.latPmlatCor" dmtype="ivoa:RealQuantity" ref="DEpmDEcor" />
    <ATTRIBUTE dmrole="mango:EpochPosition.parallaxPmlonCor" dmtype="ivoa:RealQuantity" ref="PlxpmRAcor" />
    <ATTRIBUTE dmrole="mango:EpochPosition.parallaxPmlatCor" dmtype="ivoa:RealQuantity" ref="PlxpmDEcor" />
    <ATTRIBUTE dmrole="mango:EpochPosition.pmlonPmlatCor" dmtype="ivoa:RealQuantity" ref="pmRApmDEcor" />
  </INSTANCE>
</TEMPLATES>
```

M. Taylor suggestion (apps1)

- Only keep the object attributes
- Ignore the internal class hierarchy

3

2 Visions of the World

- **Users and developers want symplicity**
  - focused on the present case *(sometime at the expense of the general case)*
  - Like linear reading
    - Appreciate flat views

- **Modelers do modeling** *(sometime at the expense of the present case)*
  - Split things in elementary blocks
  - Connect elementary blocks to each others
  - Give each link a semantic
  - Generalize what can be generalised in abstract classes
  - Specialise abstract classes (polymorphism)

- **By construction, models are anything but flat**
- **What the path between these 2 worlds?**

2 Visions of the World (followed)

- **Are models meant to be exposed as such into datasets?**
  - Yes in an ORM context
  - No in the real VO life

- **Why is VO real life different from the ORM paradigm?**
  - Model views must co-exist with datasets that exist out of the model scope
  - DAL engine build dataset matching user queries, and user queries never ask for model instances

- **Model representation in datasets resulting from DAL queries must follow a narrow path**
  - Preserve the semantic defined in the models
  - Expose simplified and easy-to-access model views to stakeholders

The narrow path: **MIVOT Design Baselines**

- **Hide UML subtleties**
  - Inheritage replaced with class aggregations
  - No distinction between association/aggregation/reference
  - Only one REFERENCE pattern, similar to C pointers

- **Representation of complex structures inspired by JSON**
  - Model hierarchies represented by 3 elements
    - ATTRIBUTE (key: value)
    - INSTANCE ({...})
    - COLLECTION ([...])
  - But each element comes with a @dmrole and a @dmtype(*) both defined by the model

# *The narrow path*: MIVOT Design Baselines

- **Easy to build**
  - The annotation **structure** only **depends** on the **model**
  - It does **not depends** on the way **data are arranged**

- **Easy to parse**
  - The model hierarchy being preserved, it it easy to retrieve any component by doing selection based on `@dmtype` or `@dmrole`
   - A simple XPath query returns a whole object

Quick Look on the EpochPosition

- **The `measurements` model comes with 6 front end classes**
  - All epoch position coordinates are covered
  - All built with the same pattern

measure → coordinate

measure → error

coordinate → Coordinate system
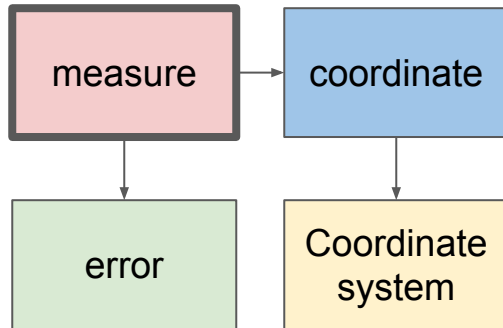
- **Available `measurements` classes**
  - Position
  - Proper motion
  - Velocity
  - *Time*
  - *Polarization*
  - Generic measure (valid for parallax)

Building epoch propagation with `measures` classes
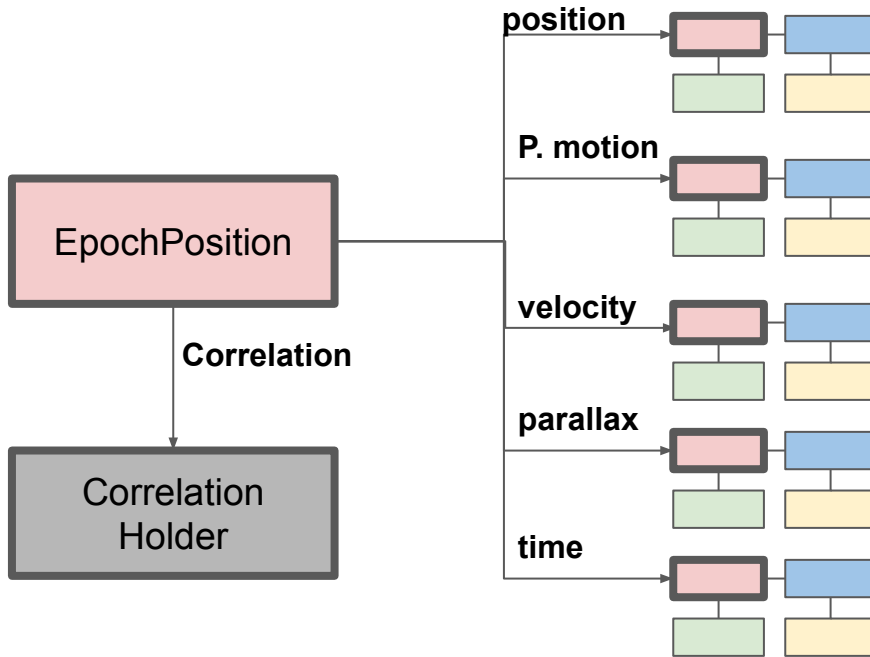
- **This is doable but**
  - Duplicate 4 times a complex pattern inside a new class
  - A user that wants to get the error has to browse all components to get error elements

Mark proposal: flat view

```
<TEMPLATES>
  <INSTANCE dmtype="mango:EpochPosition">
    <REFERENCE dmref="_spacesys_icrs" dmrole="mango:EpochPosition.coordSys" />
    <ATTRIBUTE dmrole="mango:EpochPosition.epoch" dmtype="coords:Epoch" value="2016.5" />
    <ATTRIBUTE dmrole="mango:EpochPosition.pmCosDeltApplied" dmtype="ivoa:boolean" value="true" />
    <ATTRIBUTE dmrole="mango:QuantityCorrelation.isCovariance" dmtype="ivoa:boolean" value="false" />

    <ATTRIBUTE dmrole="mango:EpochPosition.longitude" dmt
    <ATTRIBUTE dmrole="mango:EpochPosition.latitude" dmty
    <ATTRIBUTE dmrole="mango:EpochPosition.parallax" dmty
    <ATTRIBUTE dmrole="mango:EpochPosition.pmLongitude" d
    <ATTRIBUTE dmrole="mango:EpochPosition.pmLatitude" dm

    <ATTRIBUTE dmrole="mango:EpochPosition.lonErr" dmtype
    <ATTRIBUTE dmrole="mango:EpochPosition.latErr" dmtype
    <ATTRIBUTE dmrole="mango:EpochPosition.parallaxErr" dm
    <ATTRIBUTE dmrole="mango:EpochPosition.pmlonErr" dmtyp
    <ATTRIBUTE dmrole="mango:EpochPosition.pmlatErr" dmtyp

    <ATTRIBUTE dmrole="mango:EpochPosition.lonLatCor" dmt
    <ATTRIBUTE dmrole="mango:EpochPosition.lonParallaxCor
    <ATTRIBUTE dmrole="mango:EpochPosition.lonPmlonCor" d
    <ATTRIBUTE dmrole="mango:EpochPosition.lonPmlatCor" d
    <ATTRIBUTE dmrole="mango:EpochPosition.latParallaxCor
    <ATTRIBUTE dmrole="mango:EpochPosition.latPmlonCor" d
    <ATTRIBUTE dmrole="mango:EpochPosition.latPmlatCor" d
    <ATTRIBUTE dmrole="mango:EpochPosition.parallaxPmlonC
    <ATTRIBUTE dmrole="mango:EpochPosition.parallaxPmlatC
    <ATTRIBUTE dmrole="mango:EpochPosition.pmlonPmlatCor" dmtype="ivoa:RealQuantity" ref="pmRApmDEcor" />
  </INSTANCE>
</TEMPLATES>
```

This is doable but:

- No way to retrieve any component other than by looking at them all
- The different roles are mixed up
  - Coordinates
  - Error
  - Correlation
- What happens if one component change from a dataset to another
  - Ellipse -> error matrix
  - No indication of the error types

A Quick Look at the Error

Dataset #1: error box

```
<ATTRIBUTE dmrole="mango:EpochPosition.longError" dmtype="ivoa:realQuantity" ref="ra_err" />
<ATTRIBUTE dmrole="mango:EpochPosition.latError" dmtype="ivoa:realQuantity" ref="dec_err" />


<ATTRIBUTE dmrole="mango:EpochPosition.lonlatError" dmtype="ivoa:realQuantity" ref="radec_err" />
```

Dataset #2: circle error

- This flat view is valid for GAIA but not necessarily or another dataset
- No clear indication of the nature of the error
- The client has to do inferences on @dmrole to guess the error. type
- This is exactly what the use of models aims to prevent

11

A Quick Look at the Error

Dataset #1: error box

```
<INSTANCE dmrole="mango:EpochPosition.positionError" dmtype="mango:BoxError">
    <ATTRIBUTE dmrole="mango:EpochPosition.longError" dmtype="ivoa:realQuantity" ref="ra_err" />
    <ATTRIBUTE dmrole="mango:EpochPosition.latError" dmtype="ivoa:realQuantity" ref="dec_err" />
</INSTANCE>


<INSTANCE dmrole="mango:EpochPosition.positionError" dmtype="mango:ConeError">
    <ATTRIBUTE dmrole="mango:EpochPosition.radiusError" dmtype="ivoa:realQuantity" ref="radec_err" />
</INSTANCE>
```

Dataset #2: circle error

- The type of the error is given by INSTANCE@dmtype
- INSTANCE@dmtype tells the client how to process the object
- The role (position error) is the same whatever the error type is
- No implicit information
- The cost is to encapsulate ATTRIBUTE in and INSTANCE block

12

Global Thumb Rule

- ## When flattening classes

  - When components **relate to the same group** of functions
    - Vector coordinates

  - When component models does **not support polymorphism**
    - Error elliptical or error box

  - When components models are **not meant to be reused**
    - Flattening is a sort of compression with lost.

  MANGO design: flatten as much as possible as long this does not break sematic

The way MANGO builds the EPOCH Position

- **3 functional groups (classes)**
  - **Epoch Position (core class)** is a vector giving the position in the sky.
    - No need to split coordinates in sub-components
    - Can be (is) flattened
  - **Errors**
    - Placeholder for errors related to coordinates
    - Must support polymorphism
      - error type might change from a dataset to another
      - Error data type can be reuse in other contexts
    - Can not be flattened
  - **Correlation is a vector** giving the correlations between the sky coordinates
    - Placeholder for correlations
    - Each attribute relates to one pairs of EpochPosition coordinates
    - Can be flattened as EpochPosition is

Correlation: Before - After

```xml
<INSTANCE dmrole="mango:EpochPosition.correlations" dmtype="mango:EpochPositionCorrelations">
  <!-- Position/proper-motion correlation -->
  <INSTANCE dmrole="mango:Ep...
    <ATTRIBUTE dmrole="mango...
    <ATTRIBUTE dmrole="mango...
    <ATTRIBUTE dmrole="mango...
    <ATTRIBUTE dmrole="mango...
    <ATTRIBUTE dmrole="mango...
  </INSTANCE>

  <!-- parallax/proper-motion correlation -->
  <INSTANCE dmrole="mango:Ep...
    <ATTRIBUTE dmrole="mango...
    <ATTRIBUTE dmrole="mango...
    <ATTRIBUTE dmrole="mango...
  </INSTANCE>

  <!-- position/parallax correlation -->
  <INSTANCE dmrole="mango:Ep...
    <ATTRIBUTE dmrole="mango...
    <ATTRIBUTE dmrole="mango...
    <ATTRIBUTE dmrole="mango...
  </INSTANCE>

  <!-- position/position correlation -->
  <INSTANCE dmrole="mango:EpochPositionCorrelations.positionPosition" dmtype="mango:Correlation22">
    <ATTRIBUTE dmrole="mango:QuantityCorrelation.isCovariance" dmtype="ivoa:boolean" value="false" />
    <ATTRIBUTE dmrole="mango:Correlation22.a2b1" dmtype="ivoa:real" ref="RADEcor" />
    <ATTRIBUTE dmrole="mango:Correlation22.a1b2" dmtype="ivoa:real" ref="RADEcor" />
  </INSTANCE>

  <!-- proper-motion/proper-motion correlation -->
  <INSTANCE dmrole="mango:EpochPositionCorrelations.properMotionPm" dmtype="mango:Correlation22">
    <ATTRIBUTE dmrole="mango:QuantityCorrelation.isCovariance" dmtype="ivoa:boolean" value="false" />
    <ATTRIBUTE dmrole="mango:Correlation22.a2b1" dmtype="ivoa:real" ref="pmRApmDEcor" />
    <ATTRIBUTE dmrole="mango:Correlation22.a1b2" dmtype="ivoa:real" ref="pmRApmDEcor" />
  </INSTANCE>
</INSTANCE>
```

```xml
<!-- Correlation between quant...
<INSTANCE dmrole="mango:EpochP...
  <!-- Position/proper-motion ...
  <ATTRIBUTE dmrole="mango:Qua...
  <ATTRIBUTE dmrole="mango:Epo...
  <ATTRIBUTE dmrole="mango:Epo...
  <ATTRIBUTE dmrole="mango:Epo...
  <ATTRIBUTE dmrole="mango:EpochPositionCorrelations.lonPmLat" dmtype="ivoa:real" ref="RApmDEcor" />
  <!-- parallax/proper-motion correlation -->
  <ATTRIBUTE dmrole="mango:EpochPositionCorrelations.plxLon" dmtype="ivoa:real" ref="PlxpmRAcor" />
  <ATTRIBUTE dmrole="mango:EpochPositionCorrelations.plxLat" dmtype="ivoa:real" ref="PlxpmDEcor" />
  <!-- position/parallax correlation -->
  <ATTRIBUTE dmrole="mango:EpochPositionCorrelations.latPlx" dmtype="ivoa:real" ref="DEPlxcor" />
  <ATTRIBUTE dmrole="mango:EpochPositionCorrelations.lonPlx" dmtype="ivoa:real" ref="RAPlxcor" />
  <!-- position/position correlation -->
  <ATTRIBUTE dmrole="mango:EpochPositionCorrelations.lonLat" dmtype="ivoa:real" ref="RADEcor" />
  <!-- proper-motion/proper-motion correlation -->
  <ATTRIBUTE dmrole="mango:EpochPositionCorrelations.pmLonPmLat" dmtype="ivoa:real" ref="pmRApmDEcor" />
</INSTANCE>
```

- Keep 3 top level classes
- Keep **EpochPosition** vector unchanged (flat)
- Keep **EpochPosition.errors** unchanged (hierarchy)
- Flatten **EpochPosition.correlation** (flattened)