



Fig. 1



Fig. 2

## 1. Make COOSYS Ready for 2025

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We're getting further and further away from J2000.0: If you're working with stars, proper motions will matter more and more.

This talk is about enabling robust epoch propagation in native VOTable.

(cf. Fig. 1)

## 2. Direction

(cf. Fig. 2)

Goal: Something like Aladin's epoch slider, robustly and without guesswork, covering 90% of the cases with 10% of the effort of the full Meas/Coord.

This would give VOTable consumers a means to easily do epoch propagation without having to understand the complex annotation and models. We would probably say: "If you understand the models, use them in preference to COOSYS and TIMESYS."

The extra annotation effort for data providers should be negligible, because simple Meas/Coord directly maps to the extended COOSYS, and more complex things (cartesian coordinates, ...) cannot be represented anyway.

So, we ought to have this ready by the time data providers start adding Meas/Coords annotation.

## 3. State of Affairs

```

<COOSYS id="sys1" epoch="1991.5" system="IRCS"/>
<TABLE>
  <FIELD name="ra" ucd="pos.eq.ra" ref="sys1"/>
  <FIELD name="dec" ucd="pos.eq.dec" ref="sys1"/>
  <FIELD name="pmra" ucd="pos.pm;pos.eq.ra" ref="sys1"/>
  <FIELD name="pmdec" ucd="pos.pm;pos.eq.dec" ref="sys1"/>
</TABLE>
<TABLE>
  <FIELD name="otherra" ucd="pos.eq.ra" ref="sys1"/>
  <FIELD name="otherdec" ucd="pos.eq.dec" ref="sys1"/>
</TABLE>

```

Problems:

- Group positions into instances – a client needs (at least) RA, Dec and the proper motions to do epoch propagation, all belonging to one "instance". In the example, a client cannot confidently do that because completely unrelated coordinates (ra and otherra) both reference sys1.
- Figure out field roles – in the example, a client might guess, based on UCDs, that pmra is the proper motion belonging to ra, but that's guesswork. It would be a lot better if COOSYS could say "this field contains the error in proper motion for my set of coordinates" (say).
- Perhaps: the epoch cannot be annotated with TIMESYS – when the tiny effects of time systems play a role for epoch propagation, it probably shouldn't be done by a dumb machine anyway, but still: it's not ideal to have a time specification in VOTable that cannot be annotated with VOTable's own TIMESYS.

## 4. Proposal

```

<COOSYS epoch="1991.5" system="IRCS">
  <FIELDref utype="coosys.lon" ref="ra"/>
  <FIELDref utype="coosys.lat" ref="dec"/>
  <FIELDref utype="coosys.ProperMotion.x" ref="pmra"/>
  <FIELDref utype="coosys.ProperMotion.y" ref="pmdec"/>
</COOSYS>
<COOSYS epoch="1991.5" system="IRCS">
  <FIELDref utype="coosys.lon" ref="otherra"/>
  <FIELDref utype="coosys.lat" ref="otherdec"/>
</COOSYS>

<TABLE>
  <FIELD ID="ra" name="ra" ucd="pos.eq.ra"/>
  <FIELD ID="dec" name="dec" ucd="pos.eq.dec"/>
  <FIELD ID="pmra" name="pmra" ucd="pos.pm;pos.eq.ra"/>
  <FIELD ID="pmdec" name="pmdec" ucd="pos.pm;pos.eq.dec"/>
</TABLE>
<TABLE>
  <FIELD ID="otherra" name="otherra" ucd="pos.eq.ra"/>
  <FIELD ID="otherdec" name="otherdec" ucd="pos.eq.dec"/>
</TABLE>

```

So, the referencing would now go the other way, from the COOSYS to the individual FIELD-s. This lets a field participate in multiple coordinate systems (e.g., when there are several proper motions for one object, all sharing a single position, or when a time is both part of a TIMESYS and a COOSYS), and it allows one to clearly label the role a field has in a coordinate instance.

The roles are designated by utypes loosely derived from current drafts of the Measurement and Coordinate DMs (I'll not quarrel if people prefer other utypes; just try to keep them shorter than 40 characters if you can).

## 5. Perhaps even

```
<COOSYS epoch="@my_epoch" system="IRCS">
  ...
</COOSYS>

<TIMESYS reposition="BARYCENTER" timescale="TCB">
  <PARAMref utype="timesys.instant" ref="my_epoch"/>
</TIMESYS>

<PARAM ID="my_epoch" value="1991.25"/>
```

This would let us annotate the epoch and perhaps even the equinox, but I give you the referencing is a wart. And so is the alternative of adding a utype for epoch and equinox and perhaps deprecating the epoch and equinox attributes.

So... my take would be that TIMESYS annotation of current COOSYS attributes doesn't pass the 90/10 test.

## 6. What to annotate

- Position: `lon`, `lat`, `dist` – distance is a bit of a problem here, as we'll have to tell apart parallaxes and linear distances; let's see how `Coords` does that.
- The derivatives: `ProperMotion.x`, `ProperMotion.y`, `ProperMotion.rv` – I'd say we only allow tangential plane motion, i.e., what `Coords` calls `cosLat_applied`; the radial velocity should probably become the z-coordinate of a `Velocity`, but I'll leave that to the `Coords` experts.
- Position errors: `lon.statError`, `lat.statError`, `dist.statError`
- PM errors: `ProperMotion.x.statError`, `ProperMotion.y.statError`, `ProperMotion.rv.statError` – I'd totally not oppose to shorten these utypes if you'd like to.
- *Perhaps* substitutes for the current attributes so they can live in `FIELDS` or `PARAMs` (see above)
- *Not* full covariances (fails the 90/10 test at this point)

## 7. What do you think?

We did `TIMESYS` in about a year. I *think* we could have (somethink like) this in place in about a year, too.

So: Who's in?