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Referencing STC in VOTable
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http://www.ivoa.net/Documents/latest/VOTableSTC.pdf

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http://www.ivoa.net/Documents/Notes/VOTableSTC/VOTableSTC-20090612.pdf V1.1
http://www.ivoa.net/Documents/Notes/VOTableSTC/VOTableSTC-20081030.pdf V1.02
http://www.ivoa.net/Documents/Notes/VOTableSTC/VOTableSTC-20081018.pdf V1.01
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Abstract

This note specifies how to define the roles individual VOTable [2] fields have within the STC data model [3] and the coordinate systems they are expressed in using VOTable GROUP, PARAM, and FIELDref elements.

It is hoped that the basic mechanisms proposed here can be applied to data models other than STC as well.

Status of this document

This is an IVOA note expressing suggestions from and opinions of the authors. It is intended to share best practices, possible approaches, or other perspectives on interoperability with the Virtual Observatory.

While this note was made in agreement between the *VOTable* and the *Data Models* Working Groups, it should not be referenced or otherwise interpreted as a standard specification.

Comments to this note are welcome, either to Markus Demleitner or the VOTable mailing list.

Contents

1 Introduction

Astronomical tables like source catalogues, observation logs or even simulation data usually contain columns giving spatio-temporal data: Positions, velocities or proper motions, times, redshifts, frequencies. To be interpretable, such columns need a precise description of the system their values are expressed in (reference system, reference position, and the like). Also the "roles"within a set of space-time coordinates (e.g., x is the error of y, which in turn is a time derivative of z) need to be explicit within the transport format to allow automated analysis and later interpretation.

In the context of the Virtual Observatory (VO), tabular data is typically exchanged employing VOTables. In the early days of the VO, a dedicated `COOSYS` element was introduced in the original version (1.0) of the VOTable specification [1]. It allowed some minimal level of details about coordinate systems, merely supporting an enumeration of the most commonly used coordinate frames (ICRS, historical equatorial frames, galactic, ecliptic, etc) associated to a couple of parameters (equinox and epoch). Experience has shown that the `COOSYS` element is not expressive enough. It was therefore deprecated in VOTable version 1.2.

The description of coordinate systems should now proceed on the basis of the IVOA data model for space-time coordinates [3]. To link elements of a VOTable with those of a data model, version 1.1 of the VOTable specification introduced the `utype` attribute, which is allowed on most VOTable elements, among others on `GROUP`, `FIELD`, `PARAM`, and, since 1.2, `FIELDref` and

Table 1: Some systems defined in the STC library; to obtain valid values for the utype `stc:AstroCoordSystem.href`, prepend `ivo://STClib/CoordSys#`. Other coordinate systems defined in [3], Appendix C.1 include systems like TT-FK5-TOPO, UTC-ICRS-TOPO, UTC-ICRS-GEO, TDB-FK5-BARY, TDB-ECLIPTIC-BARY, or TT-ICRS-RADIO-LSR-TOPO.

`TT-ICRS-TOPO`	Terrestrial time reported at local place, ICRS orientation of axes with origin at local place
`UTC-FK5-TOPO`	As UTC-ICRS-TOPO but in FK5 system at Equinox J2000.0
`TT-ICRS-GEO`	Terrestrial time reported at center of Earth, ICRS orientation of axes with origin at center of Earth
`TDB-ICRS-BARY`	Barycentric Dynamical Time reported at Solar System Barycenter, ICRS orientation of axes with origin at Solar System Barycenter

`PARAMref`. The value of a `utype` attribute is a pointer into a data model in an application-specific sense.[1]

This note suggests a mechanism for combining utypes, the STC data model, and VOTables into a system to transfer and store STC information within VOTable without requiring all clients to support the entire (or even a significant part) of the STC data model.

2 Informal Guide to Embedding STC in VOTable

This section informally explains how to embed STC information and is hoped to cover simple use cases.

All STC-related information is contained in `GROUP`s with `utype="stc:CatalogEntryLocation"`. Any metadata – i.e., data not contained in table columns – is defined using `PARAM` elements with certain utypes, whereas the table `FIELD`s are furnished with utypes using `FIELDref` elements. The `GROUP` element(s) defining the system(s) are direct children of the `TABLE` containing the `FIELD`s.

Consider a simple example:

```
<TABLE name="withref">
  <GROUP utype="stc:CatalogEntryLocation">
    <PARAM name="href" datatype="char" arraysize="*"
      utype="stc:AstroCoordSystem.href"
      value="ivo://STClib/CoordSys#TT-ICRS-TOPO"/>
    <PARAM name="URI" datatype="char" arraysize="*"
      utype="stc:DataModel.URI"
      value="http://www.ivoa.net/xml/STC/stc-v1.30.xsd"/>
    <FIELDref ref="ra" utype="stc:AstroCoords.Position2D.Value2.C1"/>
    <FIELDref ref="de" utype="stc:AstroCoords.Position2D.Value2.C2"/>
    <FIELDref ref="dateObs" utype="stc:AstroCoords.Time.TimeInstant"/>
  </GROUP>
  <FIELD ID="dateObs" name="dateObs" datatype="char" arraysize="*"/>
  <FIELD ID="ra" name="ra" datatype="float"/>
  <FIELD ID="de" name="de" datatype="float"/>
</TABLE>
```

In this example, the coordinate system is defined via a reference to the STC library as specified

[1] The Data Models working group is preparing a document that will contain further guidelines on the relation between utypes and data models.

in Appendix C.1 of [3]. Table 1 lists some common values taken from there. The PARAM with utype="stc:DataModel.URI" is essentially constant. It is intended to tell clients where to learn more about the particular data model employed by the writing application.

We proceed to assign the roles the indiviual fields fill. For this purpose, FIELDrefs tie together a utype (designating the field's role) and the FIELD itself via a reference to the FIELD's ID.

Due to the complexity of the STC data model, the list of possible STC utypes is very long. In the formal definition of the utypes, we therefore give an algorithm that constructs utypes from the STC-X XML schema [4]. However, we give a list of common STC utypes in appendix A. It is intended to cover the common use cases. You are welcome to contact the authors to have more utypes included.

All PARAMs containing STC utype/value-pairs have the VOTable datatype="char" with arraysize="*". This is because the serialization of the values is defined in terms of the STC-X schema, which means all values going into PARAMs are XML character data. A welcome consequence of this is that clients in a "pipeline" need only store key/value pairs for the STC information, interpret as much as they need and can still correctly serialize the original information without having to understand all utypes involved.

PARAM elements must have name attributes. While you are free to choose them as convenient, it is recommended to use whatever is behind the last dot in the utype.

This mechanism of transmitting utype/value pairs using PARAMs extends to all parts of STC, allowing the definition of coordinate systems not available in the STC library as well as constant values.

Let us give a second, more complex, example to illustrate the use of PARAMs and the definition of two sets of coordinates in one table:

```
<TABLE name="twosystems">
  <GROUP utype="stc:CatalogEntryLocation">
    <PARAM name="CoordFlavor" datatype="char" arraysize="*"
      utype="stc:AstroCoordSystem.SpaceFrame.CoordFlavor"
      value="SPHERICAL"/>
    <PARAM name="CoordRefFrame" datatype="char" arraysize="*"
      utype="stc:AstroCoordSystem.SpaceFrame.CoordRefFrame"
      value="ICRS"/>
    <PARAM name="ReferencePosition" datatype="char" arraysize="*"
      utype="stc:AstroCoordSystem.TimeFrame.ReferencePosition"
      value="BARYCENTER"/>
    <PARAM name="TimeScale" datatype="char" arraysize="*"
      utype="stc:AstroCoordSystem.TimeFrame.TimeScale" value="TT"/>
    <PARAM name="Epoch" datatype="char" arraysize="*"
      utype="stc:AstroCoords.Position2D.Epoch" value="2010.2"/>
    <PARAM name="yearDef" datatype="char" arraysize="*"
      utype="stc:AstroCoords.Position2D.Epoch.yearDef" value="J"/>
    <PARAM name="TimeInstant" datatype="char" arraysize="*"
      utype="stc:AstroCoords.Time.TimeInstant"
      value="2002-01-28T09:30:00"/>
    <PARAM name="URI" datatype="char" arraysize="*"
      utype="stc:DataModel.URI"
      value="http://www.ivoa.net/xml/STC/stc-v1.30.xsd"/>
    <FIELDref ref="raErr"
      utype="stc:AstroCoords.Position2D.Error2.C1"/>
    <FIELDref ref="deErr"
      utype="stc:AstroCoords.Position2D.Error2.C2"/>
```

```
    <FIELDref ref="ra" utype="stc:AstroCoords.Position2D.Value2.C1"/>
    <FIELDref ref="de" utype="stc:AstroCoords.Position2D.Value2.C2"/>
    <FIELDref ref="pmra"
      utype="stc:AstroCoords.Velocity2D.Value2.C1"/>
    <FIELDref ref="pmde"
      utype="stc:AstroCoords.Velocity2D.Value2.C2"/>
  </GROUP>
  <GROUP utype="stc:CatalogEntryLocation">
    <PARAM name="CoordFlavor" datatype="char" arraysize="*"
      utype="stc:AstroCoordSystem.SpaceFrame.CoordFlavor"
      value="SPHERICAL"/>
    <PARAM name="CoordRefFrame" datatype="char" arraysize="*"
      utype="stc:AstroCoordSystem.SpaceFrame.CoordRefFrame"
      value="GALACTIC_II"/>
    <PARAM name="ReferencePosition" datatype="char" arraysize="*"
      utype="stc:AstroCoordSystem.SpaceFrame.ReferencePosition"
      value="BARYCENTER"/>
    <PARAM name="URI" datatype="char" arraysize="*"
      utype="stc:DataModel.URI"
      value="http://www.ivoa.net/xml/STC/stc-v1.30.xsd"/>
    <FIELDref ref="glon"
      utype="stc:AstroCoords.Position2D.Value2.C1"/>
    <FIELDref ref="glat"
      utype="stc:AstroCoords.Position2D.Value2.C2"/>
  </GROUP>
  <FIELD ID="glon" name="glon" datatype="float"/>
  <FIELD ID="glat" name="glat" datatype="float"/>
  <FIELD ID="ra" name="ra" datatype="float"/>
  <FIELD ID="de" name="de" datatype="float"/>
  <FIELD ID="raErr" name="raErr" datatype="float"/>
  <FIELD ID="deErr" name="deErr" datatype="float"/>
  <FIELD ID="pmra" name="pmra" datatype="float"/>
  <FIELD ID="pmde" name="pmde" datatype="float"/>
</TABLE>
```

Note that the two coordinate sets present are translated into two groups with `utype="stc:CatalogEntryLocation"`.

The first group contains proper motions and errors, and specifies the time of the observation together with the time scale needed to make sense of the number. The positions have been brought to a specific epoch (that is not a property of the coordinate system but rather of the positions themselves) using the proper motions. The second group only contains a minimal definition of the galactic coordinates.

The remainder of this document gives a more formal specification of the embedding of STC in VOTable – which the reader may skip unless she needs to represent more advanced concepts – and some additional examples.

3 Specification

3.1 Location of Definitions

Each instance of STC, i.e., each coordinate system, is defined in exactly one GROUP element. All such groups have a utype with a data model identifier (i.e., the part in front of the colon)

of `stc`. The role identifier (i.e., the part behind the colon) of this utype could in principle be any name of an STC-X element of stcMetadataType or its descendants. However, for ease of implemenation we only allow two types:

1. `stc:CatalogEntryLocation` for groups describing coordinates of astronomical objects or observations. Whether what is contained in the VOTable actually are entries of a "catalog" in some sense is irrelevant. The idea is that user programs only need to locate `GROUP`s with this utype to obtain the STC information.
2. `stc:ObservatoryLocation` for groups describing the coordinates of the artefact that performed an observation. Except as part of Characterization, such groups should only be present if required to, e.g., define a the topocenter.

Each group *should* declare the URI of the data model used by including a utype/value pair of `stc:DataModel.URI` and `http://www.ivoa.net/xml/STC/stc-v1.30.xsd` (or possibly later versions).

Such groups *must* be direct children of the `TABLE` element containing the `FIELD` elements being described. This specification does not propose any mechanism to describe coordinate sets with components in several tables. If such functionality should ever be desired, the `GROUP`s would probably be children of the enclosing `RESOURCE`, while coordinate systems spanning different resources would be forbidden.

procedure EMITUTYPESNODE(n, u)
→ n is a node within an STC-X Tree
→ u is a string containing the parent's `utype`
if n's type inherits from one of the types in table 2 **then**
$u \leftarrow u +$ `'.'` $+ n$'s substitution group's utype fragment
else if n's type inherits from AbsoluteTime **then**
emit a pair of $u +$ `'.xtype'`, name(n)
else
$u \leftarrow u +$ `'.'` $+$ name(n)
end if
if n has non-empty text content **then**
emit a pair of u and n's text content
end if
call EMITATTRUTYPES(n, u)
for all child nodes nodes n' of n **do**
call EMITUTYPESNODE(n', u)
end for
end procedure

Algorithm 1: Generation of utypes from STC-X trees

Table 2: Substitution group/utype mapping (for algorithm 1)

Substitution group head	utype fragment
spaceRefFrameType	`SpaceRefFrame`
referencePositionType	`ReferencePosition`
coordFlavorType	`CoordFlavor`

3.2 Values and Utypes

The point of using utypes to serialize data model instances is that a potentially complex structure is mapped to one or more sequence(s) of pairs of utype and value.

This process is defined here in terms of the STC-X serialization [4] since its schema currently provides the most rigorous representation of STC metadata. Any equivalent way of creating the key-value pairs is, of course, equally valid.

To generate the utype-value pairs for a given STC structure, first generate a DOM tree of STC-X, e.g., according to the rules of the W3C DOM [5]. Only STC-X documents rooted in either `CatalogEntryLocation` or `ObservatoryLocation` are admitted.

Values in the STC-X schema are restricted to floating point or similar value literals. For the current purposes, this is not enough, since roles in the STC data model might be filled by value references (i.e., references to `FIELD` elements) rather than (immediate) values. To avoid excessive formalism, we refrain from specifying a mechanism by which `FIELD` references could be injected into STC-X and just stipulate that any text content or attribute value in the STC-X DOM tree can be replaced by such a reference.

On the DOM tree obtained in this way, execute the procedure EMITUTYPESNODE (algorithm 1), passing the root node for n and a string containing `stc:` for u. For the determination of node names, namespaces are disregarded, i.e., a node with QName {http://www.ivoa.net/xml/STC/stc-v1.30.xsd}C1 just is C1 for the purposes of this algoritm.

Due to a typo in the STC-X schema in version 1.30, some elements there are called `Timescale`. For utype generation, assume these are called `TimeScale`.

procedure EMITATTRUTYPES(n, u_0)
  → n is a node within an STC-X-Tree
  → u_0 is a string containing the n's utype
  for all key-value pairs k, v formed from the n's attributes **do**
    → k is an attribute name without any namespace notation
    if k is not in the set of banned attributes **then**
      → The banned attributes are given in table 3.
      $u \leftarrow u_0 + \text{'.'} + k$
      Emit a pair u, v.
    end if
  end for
end procedure

Algorithm 2: Generation of utypes from STC-X attributes

If this procedure yields two values for a single utype, the result is undefined, but a utype generating program *should* raise an error. This means the STC-X instance documents containing, e.g., multiple generic coordinate systems or multiple area specifications cannot be serialized to utypes using this algorithm. Also, the STC-X root element must not have more than one child of each `AstroCoordSystem`, `AstroCoords`, and `AstroCoordArea`.

We believe this is acceptable for the purpose addressed in this note; generic coordinates are not supported by the mechanism defined here anyway and should be represented in VOTables by some other means. Multiple coordinate systems should be defined in multiple STC-X documents leading to multiple `GROUP`s as shown above.

At `http://vo.ari.uni-heidelberg.de/docs/utypes.xsl` we give an XSLT program that generates utype-value sequences from STC-X documents.

Table 3: Banned attributes for utype generation (for algorithm 2).

idref id frame_id coord_system_id	Not necessary in the scheme described here.
ucd unit pos_angle_unit pos_unit spectral_unit time_unit vel_time_unit gen_unit	Allowing these would create conflicts with VOTable's mechanisms of specifying them.
xlink:type	Fixed equal to simple here.

3.3 Pair serialization

The procedure outlined above yields a sequence of pairs of utypes and string-typed values. Generators will have to maintain some way of telling whether such a string represents a FIELD reference or an immediate value.

In VOTables, FIELD references are encoded as FIELDref elements with the utype and ref attributes representing the utype and the value of the pair, respectively.

Immediate values are serialized to PARAM elements. The utype and value attributes reflect utype and value of the pair, respectively. Since by construction all values are strings, datatype="char" and arraysize="*" must be given on all PARAMs. The application is free to set the (required) name attribute on PARAMs as it sees fit; absent other considerations, it is recommended to split the utype at the dots and use the last part of the resulting sequence as name.

In addition to the recipe given in section 3.2, an application *should* copy a ucd attribute from STC-X elements to VOTable PARAM elements if generating utypes from STC-X. Since clear rules on how to construct suitable unit strings from STC-X documents are beyond the scope of this document, we only note that applications *may* try to infer units for PARAMs; when serializing directly from some internal representation, the PARAM's unit attribute *should* be given.

Applications *may* drop any utype/value pair during serialization. On deserialization, the rules on handling unknown properties stated in [3] apply. In particular, utypes ending with xtype *should* be dropped in VOTables since VOTable FIELDs have a (possibly conflicting) xtype attribute. In case of conflicts, the attribute of FIELD *must* always take precedence.

The epoch is not part of the STC data model in version 1.30. It will be present in future versions. Until these versions are adopted by the IVOA, for epochs on positions use utype="AstroCoords.PositionX.Epoch", where X is one of 1D, 2D, or 3D. Literals for this utype in PARAMs are floating point literals understood to be Julian years. If you must give the epoch in Besselian years – which is discouraged –, add a utype="AstroCoords.PositionX.Epoch.yearDef" with the fixed value B.

4 Further Examples

Both as an illustration and to help understand the application of the STC data model's concepts to describing coordinates in VOTables, we give some further examples here; for two basic examples, see section 2. In all examples, we only show the relevant TABLE element.

4.1 Referring to Regions

In this example, we show how to describe a column that contains a region specification (as might be necessary in, e.g., TAP results).

```
<TABLE name="withreg">
  <GROUP utype="stc:CatalogEntryLocation">
    <PARAM name="href" datatype="char" arraysize="*"
      utype="stc:AstroCoordSystem.href"
      value="ivo://STClib/CoordSys#TT-ICRS-TOPO"/>
    <PARAM name="URI" datatype="char" arraysize="*"
      utype="stc:DataModel.URI"
      value="http://www.ivoa.net/xml/STC/stc-v1.30.xsd"/>
    <FIELDref ref="region" utype="stc:AstroCoordArea.Circle"/>
  </GROUP>
  <FIELD ID="region" name="region" datatype="char" xtype="adql:REGION"
    arraysize="*"/>
</TABLE>
```

4.2 Ephemeris of a Comet

In solar system applications, it is usually necessary to specify the planetary ephemeris used. The following example illustrates how to do this, and in addition employs a coordinate system including distances.

```
<TABLE name="epcomet">
  <GROUP utype="stc:CatalogEntryLocation">
    <PARAM name="CoordFlavor" datatype="char" arraysize="*"
      utype="stc:AstroCoordSystem.SpaceFrame.CoordFlavor"
      value="SPHERICAL"/>
    <PARAM name="coord_naxes" datatype="char" arraysize="*"
      utype="stc:AstroCoordSystem.SpaceFrame.CoordFlavor.coord_naxes"
      value="3"/>
    <PARAM name="CoordRefFrame" datatype="char" arraysize="*"
      utype="stc:AstroCoordSystem.SpaceFrame.CoordRefFrame"
      value="ICRS"/>
    <PARAM name="ReferencePosition" datatype="char" arraysize="*"
      utype="stc:AstroCoordSystem.SpaceFrame.ReferencePosition"
      value="GEOCENTER"/>
    <PARAM name="PlanetaryEphem" datatype="char" arraysize="*" utype=
      "stc:AstroCoordSystem.SpaceFrame.ReferencePosition.PlanetaryEphem"
      value="JPL-DE405"/>
    <PARAM name="ReferencePosition" datatype="char" arraysize="*"
      utype="stc:AstroCoordSystem.TimeFrame.ReferencePosition"
      value="GEOCENTER"/>
    <PARAM name="TimeScale" datatype="char" arraysize="*"
      utype="stc:AstroCoordSystem.TimeFrame.TimeScale" value="UTC"/>
```

```
    <PARAM name="URI" datatype="char" arraysize="*"
      utype="stc:DataModel.URI"
      value="http://www.ivoa.net/xml/STC/stc-v1.30.xsd"/>
    <FIELDref ref="RA" utype="stc:AstroCoords.Position3D.Value3.C1"/>
    <FIELDref ref="DE" utype="stc:AstroCoords.Position3D.Value3.C2"/>
    <FIELDref ref="Dist"
      utype="stc:AstroCoords.Position3D.Value3.C3"/>
    <FIELDref ref="DateObs" utype="stc:AstroCoords.Time.TimeInstant"/>
  </GROUP>
  <FIELD ID="DateObs" name="DateObs" datatype="char"
    xtype="adql:TIMESTAMP" arraysize="*"/>
  <FIELD ID="RA" name="RA" datatype="float"/>
  <FIELD ID="DE" name="DE" datatype="float"/>
  <FIELD ID="Dist" name="Dist" datatype="float"/>
</TABLE>
```

4.3 Constant Values

If certain parts of your space-time coordinates are constant, you can use PARAMs to transmit them, as in the following example that might be produced by an experiment monitoring the variability of a single source:

```
<TABLE name="constpos">
  <GROUP utype="stc:CatalogEntryLocation">
    <PARAM name="CoordFlavor" datatype="char" arraysize="*"
      utype="stc:AstroCoordSystem.SpaceFrame.CoordFlavor"
      value="SPHERICAL"/>
    <PARAM name="CoordRefFrame" datatype="char" arraysize="*"
      utype="stc:AstroCoordSystem.SpaceFrame.CoordRefFrame"
      value="GALACTIC_II"/>
    <PARAM name="TimeScale" datatype="char" arraysize="*"
      utype="stc:AstroCoordSystem.TimeFrame.TimeScale" value="TT"/>
    <PARAM name="C1" datatype="char" arraysize="*"
      utype="stc:AstroCoords.Position2D.Value2.C1" value="289.9509"/>
    <PARAM name="C2" datatype="char" arraysize="*"
      utype="stc:AstroCoords.Position2D.Value2.C2" value="64.36"/>
    <PARAM name="URI" datatype="char" arraysize="*"
      utype="stc:DataModel.URI"
      value="http://www.ivoa.net/xml/STC/stc-v1.30.xsd"/>
    <FIELDref ref="dateObs" utype="stc:AstroCoords.Time.TimeInstant"/>
  </GROUP>
  <FIELD ID="dateObs" name="dateObs" datatype="float"/>
  <FIELD ID="flux" name="flux" datatype="float"/>
</TABLE>
```

4.4 Redshift and Spectral

For completeness, here is a table definition with frequency and redshift columns.

```
<TABLE name="specshift">
  <GROUP utype="stc:CatalogEntryLocation">
    <PARAM name="DopplerDefinition" datatype="char" arraysize="*"
      utype="stc:AstroCoordSystem.RedshiftFrame.DopplerDefinition"
```

```
      value="OPTICAL"/>
    <PARAM name="value_type" datatype="char" arraysize="*"
      utype="stc:AstroCoordSystem.RedshiftFrame.value_type"
      value="REDSHIFT"/>
    <PARAM name="value_type" datatype="char" arraysize="*"
      utype="stc:AstroCoordSystem.RedshiftFrame.value_type"
      value="REDSHIFT"/>
    <PARAM name="ReferencePosition" datatype="char" arraysize="*"
      utype="stc:AstroCoordSystem.SpectralFrame.ReferencePosition"
      value="TOPOCENTER"/>
    <PARAM name="URI" datatype="char" arraysize="*"
      utype="stc:DataModel.URI"
      value="http://www.ivoa.net/xml/STC/stc-v1.30.xsd"/>
    <FIELDref ref="z" utype="stc:AstroCoords.Redshift.Value"/>
    <FIELDref ref="freq" utype="stc:AstroCoords.Spectral.Value"/>
  </GROUP>
  <FIELD ID="freq" name="freq" datatype="float"/>
  <FIELD ID="z" name="z" datatype="float"/>
</TABLE>
```

A Common utypes

Due to the sheer size of the STC data model, it is impractical to enumerate all utypes that can be generated from it by the recipe given here. Thus, we simply give commonly useful utypes here. The explanations given here are only intended to suggest possible uses. Since utypes really are pointers into data models, the STC data model is authoritative for the interpretation of the utypes.

For concepts expressible in STC-S, you can generate utypes using a GAVO web service [6].

`stc:AstroCoordArea.Position2VecInterval.HiLimit2Vec.C1`
: largest value of the first component in a 2D spatial interval (a "box")

`stc:AstroCoordArea.Position2VecInterval.HiLimit2Vec.C2`
: largest value of the second component in a 2D spatial interval (a "box")

`stc:AstroCoordArea.Position2VecInterval.LoLimit2Vec.C1`
: smallest value of the first component in a 2D spatial interval (a "box")

`stc:AstroCoordArea.Position2VecInterval.LoLimit2Vec.C2`
: smallest value of the second component in a 2D spatial interval (a "box")

`stc:AstroCoordArea.SpectralInterval.HiLimit`
: the upper limit of a range of frequencies

`stc:AstroCoordArea.SpectralInterval.LoLimit`
: the lower limit of a range of frequencies

`stc:AstroCoordArea.TimeInterval.StartTime`
: date and time of the beginning of an observation or event

`stc:AstroCoordArea.TimeInterval.StartTime.Error`
: associated Error

`stc:AstroCoordArea.TimeInterval.StopTime`
: date and time of the end of an observation or event

`stc:AstroCoordArea.TimeInterval.StopTime.Error`
: associated Error

`stc:AstroCoords.Position2D.Epoch`
: point in time the positions are reduced to using given proper motions[2]

`stc:AstroCoords.Position2D.Epoch.yearDef`
: (see Epoch utype)

`stc:AstroCoords.Position2D.Error2.C1`
: error in the first component of a 2D position

`stc:AstroCoords.Position2D.Error2.C2`
: error in the second component of a 2D position

`stc:AstroCoords.Position2D.Error2Radius`
: error radius of a 2D position

`stc:AstroCoords.Position2D.Resolution2.C1`
: the resolution of the first component of a 2D spatial position

`stc:AstroCoords.Position2D.Resolution2.C2`
: the resolution of the second component of a 2D spatial position

`stc:AstroCoords.Position2D.Resolution2Radius`
: resolution of a 2D spatial position specification

`stc:AstroCoords.Position2D.Value2.C1`
: first component (e.g., right ascension or longitude on a sphere) of a 2D position

`stc:AstroCoords.Position2D.Value2.C2`
: second component (e.g., declination or latitude on a sphere) of a 2D position

`stc:AstroCoords.Redshift.Value`
: a redshift (or radial velocity when position is 2D)

`stc:AstroCoords.Spectral.Value`
: a frequency or wavelength

`stc:AstroCoords.Time.Resolution`
: The resolution of a time axis

`stc:AstroCoords.Time.TimeInstant`
: date and time of an observation or event

`stc:AstroCoords.Time.TimeInstant.Error`
: associated error

`stc:AstroCoords.Velocity2D.Error2.C1`
: error in the first component of 2D proper motion

`stc:AstroCoords.Velocity2D.Error2.C2`
: error in the second component of 2D proper motion

`stc:AstroCoords.Velocity2D.Error2Radius`
: error radius for a 2D proper motion

`stc:AstroCoords.Velocity2D.Value2.C1`
: first component of 2D proper motion

`stc:AstroCoords.Velocity2D.Value2.C2`
: second component of 2D proper motion

`stc:AstroCoordSystem.RedshiftFrame.DopplerDefinition`
: OPTICAL, RADIO, or RELATIVISTIC

`stc:AstroCoordSystem.RedshiftFrame.ReferencePosition`
: see stc:AstroCoordSystem.SpectralFrame.ReferencePosition

[2]Not part of the STC data model yet. See section 3.3

`stc:AstroCoordSystem.RedshiftFrame.value_type`
: REDSHIFT or VELOCITY

`stc:AstroCoordSystem.SpaceFrame.CoordFlavor.naxis`
: number of axes in the coordinate system

`stc:AstroCoordSystem.SpaceFrame.CoordFlavor`
: takes values like SPHERICAL, CARTESIAN, POLAR; 2D-spherical implied for common reference frames if omitted

`stc:AstroCoordSystem.SpaceFrame.CoordRefFrame`
: takes values like ICRS, FK5, FK4, ECLIPTIC, GALACTIC, SUPER_GALACTIC, J2000, B1950

`stc:AstroCoordSystem.SpaceFrame.ReferencePosition`
: see stc:AstroCoordSystem.TimeFrame.ReferencePosition

`stc:AstroCoordSystem.SpectralFrame.ReferencePosition`
: see stc:AstroCoordSystem.TimeFrame.ReferencePosition; additionally, values like LSR, LSRK, LSRD are admitted.

`stc:AstroCoordSystem.TimeFrame.ReferencePosition`
: takes values like TOPOCENTER, BARYCENTER, HELIOCENTER, GEOCENTER, GALACTIC_CENTER, RELOCATABLE, UNKNOWNRefPos, or planet names

`stc:AstroCoordSystem.TimeFrame.TimeScale`
: takes values like TT, TAI, UTC, TDB, LST, or LOCAL

For positional utypes, only the two-dimensional variants are given. The one- and three-dimensional utypes can be obtained by applying fairly obvious changes.

B History and Modifications

- Version 1.0 (2008-09-10) to 1.01 (2008-10-18):
  - the reference to STC-Lib definitions in the form `ref="ivo://STClib/CoordSys#UTC-ICRS-TOPO"` was removed (not conforming to the *ID/IDref* XML definitions). The `PARAM` with the `utype="AstroCoordSystem.coord_system_id"` is used instead.
  - the `PARAM` element with `utype="AstroCoordSystem.coord_system_id"` is reserved for STC-Lib standard values; these parameters were removed from examples.
  - specification of coordinate components was partly rewritten.
- Version 1.01 (2008-10-18) to 1.02 (2008-10-30): cosmetics
- Version 1.02 (2008-10-30) to 1.1 (2009-06-12):
  - explicitation of how to specify the epoch of coordinates.
  - recommendation to write the coordinate definitions *before* referencing them.
  - usage of `xtype="iso8601"`.
- Version 2.0 (2010-06-18)
  - Basically a re-write; new document structure with an introductory section for the benefit of the 80/20 rule.
  - Define utypes and values in terms of the STC-X serialization.
  - Scrap two-group principle; one system is now contained in one group.
  - Remove second-level groups within AstroCoordSystem (there can be only one of each anyway).
  - Move stclib references into AstroCoordSystem.href.
  - Change examples (to machine-generated ones).

References

[1] Ochsenbein, F., et, al, 2003: *VOTable: A Proposed XML Format for Astronomical Tables*, Version 1.0, http://www.ivoa.net/Documents/VOTable/20031017/PR-VOTable-1.0-20031017.html

[2] Ochsenbein, F., et al., 2009: *VOTable Format Definition*, Version 1.2, http://www.ivoa.net/Documents/VOTable/20091130/REC-VOTable-1.2.html

[3] Rots, A., 2007: *Space-Time Coordinate Metadata for the Virtual Observatory*, Version 1.33, http://www.ivoa.net/Documents/REC/DM/STC-20071030.html

[4] Rots, A, 2005: *STC-X: Space-Time Coordinate (STC) Metadata XML Implementation*, Version 1.0, http://www.ivoa.net/Documents/Notes/STC-X/STC-X-20050315.html

[5] Le Hors, A., et al, 2000: *Document Object Model (DOM) Level 2 Core Specification*, http://www.w3.org/TR/2000/REC-DOM-Level-2-Core-20001113/

[6] The GAVO Data Center Team, 2010: *STC utype generator*, http://vo.uni-hd.de/stctrans/q/utypes/form