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## **STC-S: Space-Time Coordinate (STC) Metadata Linear String Implementation**

**Version 1.33**

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**This version:**

<http://www.ivoa.net/Documents/Notes/STC-S/STC-S-20090724.html>

**Latest version:**

<http://www.ivoa.net/Documents/latest/STC-S.html>

**Previous version(s):**

<http://www.ivoa.net/Documents/Notes/STC-S/STC-S-20071205.html>

<http://www.ivoa.net/Documents/Notes/STC-S/STC-S-20050315.html>

<http://www.ivoa.net/Documents/Notes/LinearSTC/LinearSTC-20050301.html>

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### **Abstract**

An attempt at defining a linear string syntax that allows simple specification of STC metadata.

### **Status of This Document**

This is a Note. The first release of this document was 2005-03-01.

*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. It should not be referenced or otherwise interpreted as a standard specification.*

A list of [current IVOA Recommendations and other technical documents](http://www.ivoa.net/Documents/) can be found at <http://www.ivoa.net/Documents/>.

## Acknowledgements

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## 1 Scope and Basic Principles

The STC metadata design for the Virtual Observatory has been implemented in XML Schema. For documentation, see: <http://www.ivoa.net/Documents/latest/STC.html>. For further clarification, see: <http://www.ivoa.net/Documents/latest/STC-Model.html>. That design is complete and self-consistent, but may seem bewilderingly complex to the novice user; and, anyway, XML certainly does not lend itself to easy human readability.

There is an obvious need for a syntax that allows humans to specify and interpret STC metadata objects in a way that is as intuitive as possible without being sloppy – essentially a minimalist approach. This is especially true for queries

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and resource descriptions. A linear string representation is highly desirable to achieve that purpose.

We propose that a complete STCDescription (AstroCoordSystem, AstrCoords, and AstroCoordArea) be represented by a single phrase consisting of one or more sub-phrases, with each sub-phrase specifying the STC information for one coordinate frame. Each sub-phrase starts with the type of the CoordArea element assuming the additional role of Frame Identifier. If there is no CoordArea element, the Coord element type fulfills this role. It is followed by the associated coordinate frame specification (ReferenceFrame, ReferencePosition, etc.), the remaining CoordArea elements, and the Coords elements. Since the Frame Identifiers are unique, no additional punctuation or parenthesizing is required.

The syntax proposed in this document is based on a simple recipe:

- Write out all elements and values of the STC element from an XML document, separated by whitespace, and ordered by coordinate frame
- Within each coordinate frame, start with the identification of the CoordArea element, immediately followed by the CoordFrame, then the CoordArea elements, and finally the Coords elements; if there is no CoordArea element, start with the identification of the Coords element instead
- Allow omission of all words in the resulting sentence that does not change the information content (with the adoption of some common defaults)

As will become apparent, this second rule leads to very considerable economy (and thereby transparency) in what otherwise would be a very verbose construct. One should note that this definition allows transforming STC-X (XML) into STC-S and vice versa. A transformation and a subsequent inverse transformation are not guaranteed to produce a result that is identical to the original, but it should be equivalent.

## 2 Query Example

Let us take the query example from Appendix B.5 of the STC Working Draft version 1.20:

Verbose version	Economy version	Comments
TimeInterval TimeFrame Name Time TimeScale TT BARYCENTER StartTime TimeScale TT ISOTime 1900-01-01T00:00:00	StartTime TT BARYCENTER 1900-01-01	StartTime indicates that we are talking about time and a TimeInterval, TT is uniquely a TimeScale, and the format implies ISOTime
Region SpaceFrame Name Equatorial ICRS BARYCENTER SPHERICAL 2 Circle unit=deg Center 148.9 69.1 Radius 2.0 Position2D unit=deg Name RA,Dec unit=deg Resolution2 0.0001 0.0001 Resolution2 0.0003 0.0003 Size2 0.5 0.5 Size2 0.67 0.67 PixSize2 0.00005 0.00005 PixSize2 0.00015 0.00015	Circle ICRS BARYCENTER 148.9 69.1 2.0 Resolution 0.0001 0.0001 0.0003 0.0003 Size 0.5 0.5 0.67 0.67 PixSize 0.00005 0.00005 0.00015 0.00015	Circle uniquely implies a SpaceFrame and a Region, and the order of its parameters is fixed; ICRS implies spherical 2-D coordinates; and the two pairs of numbers for Resolution, Size, and PixSize implies upper and lower limits
SpectralInterval SpectralFrame Name Wavelength BARYCENTER unit=Angstrom LoLimit 4000 HiLimit 7000 Spectral unit=Angstrom Name Lambda Resolution 300 Resolution 600	SpectralInterval BARYCENTER 4000 7000 unit Angstrom Resolution 300 600	SpectralInterval implies a SpectralFrame; its unit implies Wavelength

If the reference positions and time scale do not matter, and one does not care about the Resolutions, Sizes, and PixSizes, the sum-total becomes simply:

```
StartTime 1900-01-01 Circle ICRS 148.9 69.1 2.0
SpectralInterval A 4000 7000
```

It may be of interest to note that, had there also been a stop time (say, 2000-01-01), the phrase could have been composed as follows:

```
TimeInterval 1900-01-01 2000-01-01 Circle ICRS 148.9 69.1
2.0 SpectralInterval A 4000 7000
```

### 3 A few Conventions

A missing required element, if its value or name is not implied by anything else in the phrase, should be interpreted as UNKNOWN or *nil*; i.e., “don’t care” in the context of a query. *nil* means “unspecified”, i.e., a missing element in STC-X.

Default units (“deg”, “m”, “s”, “m/s”, “Hz”) may be omitted.

To conform with common abuse, “J2000” and “FK5” will both be interpreted as “FK5 J2000”; “B1950” and “FK4” will be interpreted as “FK4 B1950”.

I have added a Box shape to the region definition – because it is so convenient and such a pain to figure out in terms of vertices on a sphere. The linear string syntax will be:

```
Box <Xcenter> <Ycenter> <Xsize> <Ysize>
```

In spherical coordinates the sides of the box will be **great circles**. It is defined in terms of the size of a cross through the center, parallel to the axes, with great circle sides perpendicular to the cross at its end points.

This mechanism is primarily intended to make simple cases easy to express; initially it will be restricted to those easy cases and will not support:

- Custom coordinate reference frames and custom reference positions
- Spatial frames with offset positions
- Error, resolution, sizes in 2 or 3 dimensions other than the 2 or 3 element vectors
- Relocatable frames
- Planetary reference frames
- Sectors and Convex Hulls
- For ellipses: position angle references other than ‘X’ and units other than “deg”
- Geodetic reference spheroids other than IAU 1976

Note that Region operations (Union, Intersection, Negation, Difference) are not supported. If it turns out that there is a demand for that support, we will add that capability by adding the keywords AND, OR, NOT, and MINUS, but this will require the introduction of parentheses – which we hesitate to do at this time. However, if and when this extension will be added, it shall be fully downward compatible.

Note: As of version 1.33, this extension is added as an optional element, but with different syntax.

## 4 Formal Definition

We shall refer to an STC-S expression as a **phrase**. A **phrase** is a linear concatenation of one or more **sub-phrases**. Each sub-phrase pertains to a particular coordinate frame and they shall be concatenated in the following order:

Time Space Spectrum Redshift

A **sub-phrase** is a linear concatenation of one, two, or three **sub-phrase components** in the order:

CoordinateFrame CoordinateArea Coordinates

A **sub-phrase component** is a linear concatenation of one or more **words**, the first of which is the **sub-phrase component identifier**. However, the CoordinateArea identifier (or, if CoordinateArea is absent, the Coordinates identifier) is moved in front of the CoordinateFrame sub-phrase component and serves as the **sub-phrase identifier**.

**Words** are the names of elements or attributes, or their values

**Sub-phrase component identifiers** are unique within each **sub-phrase** and **sub-phrase identifiers** are unique within each **phrase**. Words, components, and sub-phrases are separated by whitespace.

Optionally, **compound sub-phrases** may be recognized for compound Regions. Under those rules the CoordinateArea operational identifier (`Union`, `Intersection`, or `Difference`) precedes the CoordinateFrame component which, in turn, is followed by two or more (if applicable) CoordinateArea components; these CoordinateArea identifiers may be preceded by the negation operator `Not`. The arguments for these operators must be enclosed in parentheses. For `Union` and `Intersection` the argument may contain two or more elements; for `Difference` it must contain exactly two; and for `Not` it must contain only one. The enclosure in parentheses is merely intended to allow nesting and avoid ambiguities.

### 4.1 Time Sub-phrase

```
TimeInterval [fillfactor <fill>] [<timescale>] [<refpos>]
  [<start> <stop> ...]
  [Time <time>] [unit <unit>] [Error <error> [<error>]]
  [Resolution <resln> [<resln>]] [Size <size> [<size>]]
  [PixSize <pixsiz> [<pixsiz>]]
```

```
StartTime [fillfactor <fill>] [<timescale>] [<refpos>] <start>
  [Time <time>] [unit <unit>] [Error <error> [<error>]]
  [Resolution <resln> [<resln>]] [Size <size> [<size>]]
  [PixSize <pixsiz> [<pixsiz>]]
```

```
StopTime [fillfactor <fill>] [<timescale>] [<refpos>] <stop>
  [Time <time>] [unit <unit>] [Error <error> [<error>]]
  [Resolution <resln> [<resln>]] [Size <size> [<size>]]
  [PixSize <pixsiz> [<pixsiz>]]
```

```
Time [<timescale>] [<refpos>] [<time>]
  [unit <unit>] [Error <error> [<error>]]
```

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```
[Resolution <resln> [<resln>]] [Size <size> [<size>]]  
[PixSize <pixsiz> [<pixsiz>]]
```

### Notes:

- *<timescale>* is one of the following: TT, TDT, ET, TAI, IAT, UTC, TEB, TDB, TCG, TCB, LST, nil; the default value is nil.
- *<refpos>* is one of the following: GEOCENTER, BARYCENTER, HELIOCENTER, TOPOCENTER, GALACTIC\_CENTER, EMBARYCENTER, MOON, MERCURY, VENUS, MARS, JUPITER, SATURN, URANUS, NEPTUNE, PLUTO, UNKNOWNRefPos; the default value is UNKNOWNRefPos.
- *<time>*, *<start>*, and *<stop>* are one of the following: *<ISOstring>*, JD *<JDvalue>*, MJD *<MJDvalue>*; there is no default.
- *<unit>* only applies to the arguments that follow it and is one of the following: s, d, a, yr, cy; the default value is s.
- *<error>*, *<resln>*, *<size>*, and *<pixsiz>* are doubles; two doubles indicate a range.
- [...] indicates that the preceding parameter set may occur more than once, to specify a “support” area that consists of multiple intervals.
- *<fill>* (single interval only) is a number between 0 and 1; the default value is 1.0.

## 4.2 Space Sub-phrase

```
PositionInterval [fillfactor <fill>] <frame> [<refpos>] [<flavor>]  
  [<lolimit> <hilimit> ...]  
  [Position <pos>] [unit <unit>] [Error <error> [<error>]]  
  [Resolution <resln> [<resln>]] [Size <size> [<size>]]  
  [PixSize <pixsiz> [<pixsiz>]]  
  [<Velocity sub-phrase>]
```

```
AllSky [fillfactor <fill>] <frame> [<refpos>] [<flavor>]  
  [Position <pos>] [unit <unit>] [Error <error> [<error>]]  
  [Resolution <resln> [<resln>]] [Size <size> [<size>]]  
  [PixSize <pixsiz> [<pixsiz>]]  
  [<Velocity sub-phrase>]
```

```
Circle [fillfactor <fill>] <frame> [<refpos>] [<flavor>] <pos> <radius>  
  [Position <pos>] [unit <unit>] [Error <error> [<error>]]  
  [Resolution <resln> [<resln>]] [Size <size> [<size>]]  
  [PixSize <pixsiz> [<pixsiz>]]  
  [<Velocity sub-phrase>]
```

```
Ellipse [fillfactor <fill>] <frame> [<refpos>] [<flavor>] <pos> <radius>  
  <radius> <posangle>  
  [Position <pos>] [unit <unit>] [Error <error> [<error>]]  
  [Resolution <resln> [<resln>]] [Size <size> [<size>]]  
  [PixSize <pixsiz> [<pixsiz>]]  
  [<Velocity sub-phrase>]
```

```
Box [fillfactor <fill>] <frame> [<refpos>] [<flavor>] <pos> <bsize>  
  [Position <pos>] [unit <unit>] [Error <error> [<error>]]  
  [Resolution <resln> [<resln>]] [Size <size> [<size>]]
```

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```
[PixSize <pixsiz> [<pixsiz>]]
[<Velocity sub-phrase>]

Polygon [fillfactor <fill>] <frame> [<refpos>] [<flavor>] [<pos> ...]
[Position <pos>] [unit <unit>] [Error <error> [<error>]]
[Resolution <resln> [<resln>]] [Size <size> [<size>]]
[PixSize <pixsiz> [<pixsiz>]]
[<Velocity sub-phrase>]

Convex [fillfactor <fill>] <frame> [<refpos>] [<flavor>] [<hspace> ...]
[Position <pos>] [unit <unit>] [Error <error> [<error>]]
[Resolution <resln> [<resln>]] [Size <size> [<size>]]
[PixSize <pixsiz> [<pixsiz>]]
[<Velocity sub-phrase>]

Position <frame> [<refpos>] [<flavor>] [<pos>]
[unit <unit>] [Error <error> [<error>]]
[Resolution <resln> [<resln>]] [Size <size> [<size>]]
[PixSize <pixsiz> [<pixsiz>]]
[<Velocity sub-phrase>]
```

### Notes:

- **<frame>** is one of the following: ICRS, FK5, FK4, J2000, B1950, ECLIPTIC, GALACTIC[\_II], SUPER\_GALACTIC, GEO\_C, GEO\_D, UNKNOWNFrame. ECLIPTIC shall be assumed to have an equinox of J2000 with respect to ICRS.
- **<refpos>** is one of the following: GEOCENTER, BARYCENTER, HELIOCENTER, TOPOCENTER, GALACTIC\_CENTER, EMBARYCENTER, MOON, MERCURY, VENUS, MARS, JUPITER, SATURN, URANUS, NEPTUNE, PLUTO, UNKNOWNRefPos; the default value is UNKNOWNRefPos.
- **<flavor>** is one of the following: SPHER2, UNITSPHER, CART1, CART2, CART3, SPHER3; the default value is SPHER2, except for Convex, where the default is UNITSPHER.
- **<unit>** applies to all numerical arguments except <fill> and is one of the following: deg, arcmin, arcsec, m, mm, km, AU, pc, kpc, Mpc; the default value for spherical coordinates, except GEO, is deg; for GEO: deg deg m; for Cartesian coordinates: m. For multi-dimensional frames one may specify a unit for each axis, such as “deg deg m”.
- **<pos>**, **<lolimit>**, **<hilimit>**, **<center>**, **<bsize>**, **<error>**, **<resln>**, **<size>**, and **<pixsiz>** are lists of 1, 2, or 3 doubles, depending on the dimensionality of the space frame; the last four may be pairs of vectors, indicating ranges; if the vector components are identical, their value will be interpreted as a radius.
- **<hspace>** is a list of 4 doubles: a 3-dimensional unit sphere vector, followed by an offset.
- **<radius>** and **<posangle>** are doubles; position angle reference is ‘Y’ for spherical coordinates, ‘X’ for Cartesian, unit=deg.
- [...] indicates that the preceding parameter set may occur more than once, to specify a “support” area that consists of multiple intervals.



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- *<fill>* (single interval only) is a number between 0 and 1; the default value is 1.0.
- The Velocity sub-phrase:  
[VelocityInterval [fillfactor *<fill>*] *<lolimit>* *<hilimit>* ...]  
[Velocity *<vel>*] [unit *<unit>*] [Error *<error>* [*<error>*]]  
[Resolution *<resln>* [*<resln>*]] [PixSize *<pixsiz>* [*<pixsiz>*]]  
with m/s as default unit; allowed values are *<spatial unit>/<time unit>*.

Example of a compound Region phrase:

```
Union ICRS TOPOCENTER
  (Circle 180 10 20
   Circle 190 20 20
   Intersection
     (Circle 120 -10 20
      Difference
        (Circle 130 -10 20
         Circle 125 -10 2
        )
      Not
        (Circle 118 -8 3)
      )
   )
 )
```

### 4.3 Spectral Sub-phrase

```
SpectralInterval [fillfactor <fill>] [<refpos>]
  [<lolimit> <hilimit> ...]
  [Spectral <spec>] [unit <unit>] [Error <error> [<error>]]
  [Resolution <resln> [<resln>]] [Size <size> [<size>]]
  [PixSize <pixsiz> [<pixsiz>]]
```

```
Spectral [<refpos>] [<spec>] [unit <unit>] [Error <error> [<error>]]
  [Resolution <resln> [<resln>]] [Size <size> [<size>]]
  [PixSize <pixsiz> [<pixsiz>]]
```

Notes:

- *<refpos>* is one of the following: GEOCENTER, BARYCENTER, HELIOCENTER, TOPOCENTER, LSR[K], LSRD, GALACTIC\_CENTER, LOCAL\_GROUP\_CENTER, EMBARYCENTER, MOON, MERCURY, VENUS, MARS, JUPITER, SATURN, URANUS, NEPTUNE, PLUTO, UNKNOWNRefPos; the default value is UNKNOWNRefPos.
- *<unit>* applies to all numeric arguments except *<fill>* and is one of the following:  
Hz, MHz, GHz, m, mm, um, nm, Angstrom, eV, keV, MeV;  
the default value is Hz.
- *<spec>*, *<lolimit>*, *<hilimit>*, *<error>*, *<resln>*, *<size>*, and *<pixsiz>* are doubles; the last three may be pairs of doubles, indicating ranges.
- [...] indicates that the preceding parameter set may occur more than once, to specify a “support” area that consists of multiple intervals.

- *<fill>* (single interval only) is a number between 0 and 1; the default value is 1.0.

#### 4.4 Redshift Sub-phrase

```
RedshiftInterval [fillfactor <fill>] [<refpos>] <type> [<dopplerdef>]
  [<lolimit> <hilimit> ...]
  [Redshift <rs>] [unit <unit>] [Error <error> [<error>]]
  [Resolution <resln> [<resln>]] [Size <size> [<size>]]
  [PixSize <pixsiz> [<pixsiz>]]
```

```
Redshift [<refpos>] [<type>] [<dopplerdef>] [<rs>]
  [unit <unit>] [Error <error> [<error>]]
  [Resolution <resln> [<resln>]] [Size <size> [<size>]]
  [PixSize <pixsiz> [<pixsiz>]]
```

#### Notes:

- *<refpos>* is one of the following: GEOCENTER, BARYCENTER, HELIOCENTER, TOPOCENTER, LSR[K], LSRD, GALACTIC\_CENTER, LOCAL\_GROUP\_CENTER, EMBARYCENTER, MOON, MERCURY, VENUS, MARS, JUPITER, SATURN, URANUS, NEPTUNE, PLUTO, UNKNOWNRefPos; the default value is UNKNOWNRefPos.
- *<unit>* applies to all numeric arguments except *<fill>*; the only allowed value is km/s for velocities, and it should be omitted for redshifts.
- *<type>* is VELOCITY or REDSHIFT; the default value is REDSHIFT.
- *<dopplerdef>* is OPTICAL, RADIO, or RELATIVISTIC; there is no default value.
- *<rs>*, *<lolimit>*, *<hilimit>*, *<error>*, *<resln>*, *<size>*, and *<pixsiz>* are doubles; the last three may be pairs of doubles, indicating ranges..
- [...] indicates that the preceding parameter set may occur more than once, to specify a “support” area that consists of multiple intervals.
- *<fill>* (single interval only) is a number between 0 and 1; the default value is 1.0.

## Changes from Previous Versions

From V1.00 to V1.10:

- Changed the name from LinearSTC to STC-S

From V1.10 to V1.30:

- Changed UNKNOWN to UNKNOWNRefPos or UNKNOWNFrame
- Added Convex

From V1.30 to V1.32:

- Removed default frame for spatial, since the reference frame is required
- Allowed optionally compound sub-phrases (for compound Regions)
- Corrected typo in order of elements in Redshift
- Allow multiple unit specification for multi-dimensional frames
- If all elements of 2- or 3-D errors are identical, interpret as a radius

From V1.32 to V1.33

- Changed Redshift default to Redshift
- Allowed Size in all coordinates (for consistency, not functionality)
- Changed syntax for compound Regions

## References

A. H. Rots, *Space-Time Coordinate Metadata for the Virtual Observatory*, <http://www.ivoa.net/Documents/latest/STC.html>

A. H. Rots, *STC-X: Space-Time Coordinate (STC) Metadata XML Implementation* <http://www.ivoa.net/Documents/latest/STC-X.html>

A. H. Rots, *STC-Model: Space-Time Coordinate (STC) Metadata Model* <http://www.ivoa.net/Documents/latest/STC-Model.html>