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Alliance

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

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Abstract

This standard defines a linear string serialization that allows a simple specification of STC metadata for a subset of the STC model.

Status of This Document

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A list of current IVOA Recommendations and other technical documents can be found at http://www.ivoa.net/Documents/.

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Contents

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 and resource descriptions. A linear string representation provides a standard serialization that will achieve that purpose; we refer to it as STC-S.
The STC-S syntax is derived from the STC-X serialization. This derivation process is defined in the next section and illustrated in the one following.
By necessity, there will be restrictions compared to the XML serialization of the STC model (STC-X); these are enumerated in Section 4.
The last section of this standard provides a formal definition of the STC-S syntax. The first Appendix presents a EBNF representation of the syntax.

2 Definition of STC-S as Derived from STC-X

This standard specifies how a complete STCDescription (AstroCoordSystem, AstrCoords, and AstroCoordArea) element from STC-X can 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 in this document is based on a simple recipe that explains how to derive it from an STC-X instance:
1. Write out all elements and values of the STC element from an XML document, separated by whitespace, and ordered by coordinate frame
2. 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
3. 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.
STC-S will be case-insensitive except for strings expressing units.

3 How to Apply the Derivation: Query Example

The procedure of deriving the STC-S serialization from its STC-X counterpart is illustrated by using the Query example from Appendix B.5 of the STC Recommendation, version 1.33. The first two steps from the previous section yield the "verbose verson", the third step transforms it into the "economy version" which is the STC-S product:

Verbose version	Economy version	Comments
TimeInterval TimeFrame Name Time TimeScale TT BARYCENTER StartTime 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 coord_naxes=2 Circle unit=deg Center 148.9 69.1 Radius 2.0 Position2D unit=deg Name RA,Dec 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 Spectral 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 TT BARYCENTER 1900-01-01
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
SpectralInterval BARYCENTER Angstrom 4000 7000 Resolution 300 600
```

It may be of interest to note that, had there also been a stop time (say, 2000-01-01) and one did not care about resolutions, sizes, and pixel sizes, the phrase could simply have been composed as follows:

```
TimeInterval TT BARYCENTER 1900-01-01 2000-01-01
Circle ICRS BARYCENTER 148.9 69.1 2.0
SpectralInterval BARYCENTER Angstrom 4000 7000
```

4   A few Conventions and Restrictions

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".

The STC-S serialization is primarily intended to make simple cases easy to express; it will be restricted to those easy cases and will not support:
- Generic coordinate axes (i.e., only Time, Space, Spectral, and Redshift are supported)
- 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

5 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`, `Not`, or `Difference`) precedes the CoordinateFrame component which, in turn, is followed by two or more (if applicable) CoordinateArea components; any CoordinateArea identifier may be preceded by the negation operator `Not`. The arguments for the compound region 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.

5.1 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>]]
      [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.

5.2 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>]]
      [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.
- `<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>`.

5.3 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.

5.4 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; there is no default value.
- *<dopplerdef>* is OPTICAL, RADIO, or RELATIVISTIC; the default value is OPTICAL.
- *<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.

Appendix A: EBNF Representation

```
_compoundGeoExprBinary ::= "Difference" "(" _compoundGeoOperand
    _compoundGeoOperand ")"
_compoundGeoExprNary ::= unionIntersect "(" _compoundGeoOperand
    _compoundGeoOperand { _compoundGeoOperand } ")"
_compoundGeoExprUnary ::= "Not" "(" _compoundGeoOperand ")"
_compoundGeoExpression ::= compoundGeo
_compoundGeoOperand ::= regionNumber | _compoundGeoExpression
_spaceUnitWord ::= RE<arcsec|arcmin|rad|Mpc|kpc|deg|mm|km|pc|AU|m>
_spectralUnitWord ::= RE<Angstrom|GHz|MeV|MHz|keV|Hz|nm|mm|um|eV|m>
_timeUnitWord ::= RE<cy|yr|a|s|d>
atomicGeometry ::= region [ fillfactor ] frame [ refpos ] [ flavor ]
    { number } [ positionSpec ] [ spaceUnit ] [ error ] [ resolution ]
    [ size ] [ pixelSize ] [ velocityInterval ]
compoundGeo ::= _compoundGeoExprUnary | _compoundGeoExprBinary |
    _compoundGeoExprNary
compoundString ::= unionIntersect [ fillfactor ] frame [ refpos ]
    [ flavor ] "(" _compoundGeoOperand _compoundGeoOperand
    { _compoundGeoOperand } ")" [ positionSpec ] [ spaceUnit ]
    [ error ] [ resolution ] [ size ] [ pixelSize ]
    [ velocityInterval ]
difference ::= "Difference" [ fillfactor ] frame [ refpos ] [ flavor ]
    "(" _compoundGeoOperand _compoundGeoOperand ")" [ positionSpec ]
    [ spaceUnit ] [ error ] [ resolution ] [ size ] [ pixelSize ]
    [ velocityInterval ]
dopplerdef ::= RE<OPTICAL|RADIO|RELATIVISTIC>
eqFrame ::= eqFrameName [ eqSpec ]
eqFrameName ::= "FK5" | "FK4" | "ECLIPTIC"
eqSpec ::= RE<[BJ][0-9]+([.][0-9]*)?>
error ::= "Error" number { number }
exactNumericLiteral ::= RE<[+-]?\d+(\.(\d+)?)?|[+-]?\.\d+>
fillfactor ::= "fillfactor" number
flavor ::= RE<UNITSPHER|SPHER2|SPHER3|CART3|CART2|CART1>
frame ::= eqFrame | "J2000" | "B1950" | "ICRS" | "GALACTIC" |
    "GALACTIC_I" | "GALACTIC_II" | "SUPER_GALACTIC" | "GEO_C" |
    "GEO_D" | "UNKNOWNFrame"
isoTimeLiteral ::=
    RE<\d\d\d\d-?\d\d-?\d\d(T\d\d:?\d\d:?\d\d(\.\d*)?Z?)?>
jdLiteral ::= "JD" exactNumericLiteral
mjdLiteral ::= "MJD" exactNumericLiteral
nakedTime ::= isoTimeLiteral | jdLiteral | mjdLiteral
not ::= "Not" [ fillfactor ] frame [ refpos ] [ flavor ]
    "(" _compoundGeoOperand ")" [ positionSpec ] [ spaceUnit ]
    [ error ] [ resolution ] [ size ] [ pixelSize ]
    [ velocityInterval ]
number ::= RE<(?i)([+-]?\d+(\.(\d+)?)?|[+-]?\.\d+)(E[+-]?\d+)?>
pixelSize ::= "PixSize" number { number }
position ::= "Position" frame [ refpos ] [ flavor ] [ { number } ]
    [ spaceUnit ] [ error ] [ resolution ] [ size ] [ pixelSize ]
    [ velocityInterval ]
positionInterval ::= "PositionInterval" [ fillfactor ] frame [ refpos ]
    [ flavor ] { number } [ positionSpec ] [ spaceUnit ] [ error ]
    [ resolution ] [ size ] [ pixelSize ] [ velocityInterval ]
positionSpec ::= "Position" [ { number } ]
redshift ::= "Redshift" [ refpos ] [ redshiftType ] [ dopplerdef ]
    [ { number } ] [ redshiftUnit ] [ error ] [ resolution ]
```

```
    [ pixelSize ]
redshiftInterval ::= "RedshiftInterval" [ fillfactor ] [ refpos ]
    [ redshiftType ] [ dopplerdef ] { number } [ redshiftSpec ]
    [ redshiftUnit ] [ error ] [ resolution ] [ pixelSize ]
redshiftSpec ::= "Redshift" number
redshiftSubPhrase ::= redshiftInterval | redshift
redshiftType ::= RE<VELOCITY|REDSHIFT>
redshiftUnit ::= "unit" velocityUnitNil
refpos ::= RE<LOCAL_GROUP_CENTER|GALACTIC_CENTER|UNKNOWNRefPos|
    EMBARYCENTER|    HELIOCENTER|CoordRefPos|RELOCATABLE|BARYCENTER|
    TOPOCENTER|GEOCENTER|JUPITER|MERCURY|NEPTUNE|URANUS|SATURN|PLUTO|
    VENUS|LSRD|LSRK|MOON|MARS|LSR>
region ::= "AllSky" | "Circle" | "Ellipse" | "Box" | "Polygon" |
    "Convex"
regionNumber ::= region { number }
resolution ::= "Resolution" number { number }
size ::= "Size" number { number }
spaceSubPhrase ::= positionInterval | position | atomicGeometry | not |
    difference | compoundString
spaceUnit ::= "unit" _spaceUnitWord { _spaceUnitWord }
spectral ::= "Spectral" [ refpos ] [ { number } ] [ spectralUnit ]
    [ error ] [ resolution ] [ pixelSize ]
spectralInterval ::= "SpectralInterval" [ fillfactor ] [ refpos ]
    { number } [ spectralSpec ] [ spectralUnit ] [ error ]
    [ resolution ] [ pixelSize ]
spectralSpec ::= "Spectral" number
spectralSubPhrase ::= spectralInterval | spectral
spectralUnit ::= "unit" _spectralUnitWord
startTime ::= "StartTime" [ fillfactor ] [ timescale ] [ refpos ]
    nakedTime [ timestamp ] [ timeUnit ] [ error ] [ resolution ]
    [ pixelSize ]
stcsPhrase ::= [ timeSubPhrase ] [ spaceSubPhrase ]
    [ spectralSubPhrase ] [ redshiftSubPhrase ]
stopTime ::= "StopTime" [ fillfactor ] [ timescale ] [ refpos ]
    nakedTime [ timestamp ] [ timeUnit ] [ error ] [ resolution ]
    [ pixelSize ]
time ::= "Time" [ timescale ] [ refpos ] [ nakedTime ] [ timeUnit ]
    [ error ] [ resolution ] [ pixelSize ]
timeInterval ::= "TimeInterval" [ fillfactor ] [ timescale ] [ refpos ]
    { nakedTime } [ timestamp ] [ timeUnit ] [ error ] [ resolution ]
    [ pixelSize ]
timescale ::= RE<UTC|nil|TDB|TT|TEB|LST|TCG|IAT|ET|TCB|TAI|TDT>
timestamp ::= "Time" nakedTime
timeSubPhrase ::= timeInterval | startTime | stopTime | time
timeUnit ::= "unit" _timeUnitWord
unionIntersect ::= "Union" | "Intersection"
velocityInterval ::= "VelocityInterval" [ fillfactor ] { number }
    [ velocitySpec ] [ velocityUnit ] [ error ] [ resolution ]
    [ pixelSize ]
velocitySpec ::= "Velocity" number { number }
velocityUnit ::= "unit" _spaceUnitWord "/" _timeUnitWord
    { velocityUnitWord }
velocityUnitNil ::= velocityUnitWord | "nil"
velocityUnitWord ::= _spaceUnitWord "/" _timeUnitWord
```

Appendix B: Examples

STC-S allows, within the restrictions listed in Section 4, a simple character string to represent any type of STC metadata information, such as:
- Positions
- Times and time ranges
- Spectral metadata
- Redshift and Doppler velocity information
- Spatial regions – simple or compound

Or any combination of these – and many more.

B.1   Simple Examples

For instance, this string defines a volume in observing coordinate space:

```
TimeInterval TT GEOCENTER 2011-01-01 2012-03-30 Resolution 0.2
 PositionInterval ICRS GEOCENTER 170 -20 190 10 Resolution 0.0001
 SpectralInterval GEOCENTER 4.95 5.0 unit GHz Size 0.05
```

A single point in Time and Space:

```
Time TDB BARYCENTER MJD 50814.0
 Position ICRS BARYCENTER 147.3 69.3
```

B.2   Simple and Compound Regions

A simple region:

```
Circle ICRS TOPOCENTER 147.6 69.9 0.4
```

Two compound regions:

```
Union ICRS TOPOCENTER
 (Polygon 147.8 69.2 147.4 69.2 147.3 69.4 147.9 69.4
  Polygon 147.9 69.7 147.6 69.7 147.5 69.9 148.0 69.9)
```

and:

```
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)
       )
     )
```

B.3   STC-S and STC-X Serializations

The following comprehensive example:

```
TimeInterval TT GEOCENTER 1996-01-01T00:00:00 1996-01-01T00:30:00
  Time MJD 50814.0 Error 1.2 Resolution 0.8 PixSize 1024.0
Circle ICRS GEOCENTER 179.0 -11.5 0.5 Position 179.0 -11.5
  Error 0.000889 Resolution 0.001778 Size 0.000333 0.000278
  PixSize 0.000083 0.000083
Spectral BARYCENTER 1420.4 unit MHz Resolution 10.0
RedshiftInterval BARYCENTER VELOCITY OPTICAL 200.0 2300.0
  Redshift 300.0 Resolution 0.7 PixSize 0.3
```

is the equivalent of this STC-X expression:

```xml
<?xml version="1.0" encoding="UTF-8"?>
<CatalogEntryLocation xsi:schemaLocation="http://www.ivoa.net/xml/STC/stc-v1.30.xsd
    stc-v1.30.xsd" xmlns="http://www.ivoa.net/xml/STC/stc-v1.30.xsd"
    xmlns:xlink="http://www.w3.org/1999/xlink"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
    <AstroCoordSystem id="ID_2">
        <TimeFrame id="ID_23">
            <TimeScale>TT</TimeScale>
            <GEOCENTER/>
        </TimeFrame>
        <SpaceFrame id="ID_93">
            <ICRS/>
            <GEOCENTER/>
            <SPHERICAL coord_naxes="2"/>
        </SpaceFrame>
        <SpectralFrame id="ID_101">
            <BARYCENTER>
                <PlanetaryEphem>JPL-DE405</PlanetaryEphem>
            </BARYCENTER>
        </SpectralFrame>
        <RedshiftFrame value_type="VELOCITY" id="ID_102">
            <DopplerDefinition>OPTICAL</DopplerDefinition>
            <BARYCENTER>
                <PlanetaryEphem>JPL-DE405</PlanetaryEphem>
            </BARYCENTER>
        </RedshiftFrame>
    </AstroCoordSystem>
    <AstroCoords id="ID_103" coord_system_id="ID_2">
        <Time unit="s">
            <Name>Time</Name>
            <TimeInstant>
                <MJDTime>50814.0</MJDTime>
            </TimeInstant>
            <Error>1.2</Error>
            <Resolution>0.8</Resolution>
            <Size>1024.0</Size>
            <PixSize>1024.0</PixSize>
        </Time>
        <Position2D unit="deg">
```

```xml
                    <Name>Position</Name>
                    <Name1>RA</Name1>
                    <Name2>Dec</Name2>
                    <Value2>
                        <C1>179.0</C1>
                        <C2>-11.5</C2>
                    </Value2>
                    <Error2Radius pos_unit="arcsec">3.2</Error2Radius>
                    <Resolution2Radius pos_unit="arcsec">6.4</Resolution2Radius>
                    <Size2>
                        <C1>1.2</C1>
                        <C2>1.0</C2>
                    </Size2>
                    <PixSize2 unit="arcsec">
                        <C1>0.3</C1>
                        <C2>0.3</C2>
                    </PixSize2>
                </Position2D>
                <Spectral unit="MHz">
                    <Name>Frequency</Name>
                    <Value>1420.4</Value>
                    <Resolution spectral_unit="MHz">10.0</Resolution>
                </Spectral>
                <Redshift vel_time_unit="s" unit="km">
                    <Name>Doppler velocity</Name>
                    <Value>300</Value>
                    <Resolution>0.7</Resolution>
                    <Size>1000</Size>
                    <PixSize>0.3</PixSize>
                </Redshift>
            </AstroCoords>
            <AstroCoordArea id="ID_172" coord_system_id="ID_2">
                <TimeInterval>
                    <StartTime>
                        <ISOTime>1996-01-01T00:00:00</ISOTime>
                    </StartTime>
                    <StopTime>
                        <ISOTime>1996-01-01T00:30:00</ISOTime>
                    </StopTime>
                </TimeInterval>
                <Circle>
                    <Center>
                        <C1>179</C1>
                        <C2>-11.5</C2>
                    </Center>
                    <Radius>0.5</Radius>
                </Circle>
                <RedshiftInterval vel_time_unit="s" unit="km">
                    <LoLimit>200</LoLimit>
                    <HiLimit>2300</HiLimit>
                </RedshiftInterval>
            </AstroCoordArea>
        </CatalogEntryLocation>
```

STC-S

The example in Section 3:

```
StartTime TT BARYCENTER 1900-01-01
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
SpectralInterval BARYCENTER Angstrom 4000 7000 Resolution 300 600
```

was derived from the following STC-X element:

```xml
<?xml version="1.0" encoding="UTF-8"?>
    <!--
        This STC metadata description specifies a query:
            Find all images, within 2 degrees from a certain position, that have these
            properties:
                spatial resolution: between 0.0001 and 0.003 degrees
                size: between 30 and 40 arcmins on the side
                pixelsize: between 0.00005 and 0.00015 degrees
                covering a band of 300 to 600 Angstrom
                    in the spectral range 4000 to 7000 A
                taken since 1900.0
        AstroCoordSystem specifies the coordinate system used in this query.
        AstroCoordArea specifies where to look in coordinate space
        AstroCoords specifies the (ranges of) properties along the coordinates
    -->
<SearchLocation xmlns="http://www.ivoa.net/xml/STC/stc-v1.30.xsd"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="http://www.ivoa.net/xml/STC/stc-v1.30.xsd http://hea-
    www.harvard.edu/~arots/nvometa/v1.30/stc-v1.30.xsd">
    <AstroCoordSystem id="TT-ICRS-BARY">
        <TimeFrame>
            <Name>Time</Name>
            <TimeScale>TT</TimeScale>
            <BARYCENTER/>
        </TimeFrame>
        <SpaceFrame>
            <Name>Equatorial</Name>
            <ICRS/>
            <BARYCENTER/>
            <SPHERICAL coord_naxes="2"/>
        </SpaceFrame>
        <SpectralFrame>
            <Name>Wavelength</Name>
            <BARYCENTER/>
        </SpectralFrame>
    </AstroCoordSystem>
    <AstroCoords coord_system_id="TT-ICRS-BARY">
        <Position2D unit="deg">
            <Name>RA,Dec</Name>
            <Resolution2>
                <C1>0.0001</C1>
                <C2>0.0001</C2>
            </Resolution2>
            <Resolution2>
                <C1>0.0003</C1>
                <C2>0.0003</C2>
            </Resolution2>
```

```xml
                <Size2>
                    <C1>0.5</C1>
                    <C2>0.5</C2>
                </Size2>
                <Size2>
                    <C1>0.67</C1>
                    <C2>0.67</C2>
                </Size2>
                <PixSize2>
                    <C1>0.00005</C1>
                    <C2>0.00005</C2>
                </PixSize2>
                <PixSize2>
                    <C1>0.00015</C1>
                    <C2>0.00015</C2>
                </PixSize2>
            </Position2D>
            <Spectral unit="Angstrom">
                <Name>Lambda</Name>
                <Resolution>300</Resolution>
                <Resolution>600</Resolution>
            </Spectral>
        </AstroCoords>
        <AstroCoordArea id="M81" coord_system_id="TT-ICRS-BARY">
            <TimeInterval>
                <StartTime>
                    <ISOTime>1900-01-01T00:00:00</ISOTime>
                </StartTime>
            </TimeInterval>
            <Circle unit="deg">
                <Center>
                    <C1>148.9</C1>
                    <C2>69.1</C2>
                </Center>
                <Radius>2</Radius>
            </Circle>
            <SpectralInterval unit="Angstrom">
                <LoLimit>4000</LoLimit>
                <HiLimit>7000</HiLimit>
            </SpectralInterval>
        </AstroCoordArea>
    </SearchLocation>
```

Changes from Previous Versions

Note
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

Working Draft V0.10
- Modified sectioning; split Section 2 into 2 and 3
- Cleaned up out-of-date text in early sections
- Added Appendix with examples

Working Draft V0.11
- Added EBNF representation

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