**Introduction**

STILTS is a package of command-line tools for tables, based on STIL, the Starlink Tables Infrastructure Library. It offers various format conversion, data and metadata manipulation, and processing functions for astronomical catalogues or other tables, and can deal with data in many formats including VOTable, FITS, relational databases, CSV and ASCII.

The software is:

- pure Java (J2SE >= 1.4)
- open source (GPL)
- efficient
- robust
- scalable (most functions not limited by memory)
- fully documented

It provides a non-graphical counterpart to the GUI table analysis program TOPCAT, and can be used in shell scripts, interactively from the command-line, or as part of server-based services or workloads.

There is a tutorial and reference document in HTML and PDF format, and comprehensive help is available using the help flags of the commands themselves.

The package currently comprises these generic table commands:

- **tcat** - concatenator
- **tpipe** - multi-purpose pipeline processor
- **tmatch2** - pairwise crossmatcher

and these VOTable-specific commands:

- **tcopy** - encoding converter
- **tvotlint** - validator

**Acknowledgements & Status**

The bulk of the work for STILTS was performed under the now-terminated Starlink project. Development and support will continue, funded by the UK Particle Physics and Astronomy Research Council.

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**tpipe**

tpipe performs general-purpose table-processing pipeline operations; it's like a Unix pipeline, but for processing streams of table data and metadata rather than bytes. Operations, which can be combined freely, include:

- coordinate conversion
- row selection
- data sampling
- metadata display/editing
- column calculations
- column rearrangement
- row sorting
- statistical calculations
- blank value substitution

The algebraic expression language used for column calculation and row selection is powerful, extensible and straightforward to use.

Example: selections and column calculations on an ASCII table using the result to a VOTable:

```
tpipe
  in=some_data.cat ifmt=ascii \\
  cmd='Badval 999.9 'MAG' "' \\
  cmd='select OBJ_CLASS=3 "' \\
  cmd='select purity=pname+pmdec+pmdec<0.5' "' \\
  cmd='addcol l_v' IMAG-VMAG "' \\
  cmd='sort -down Z_2AB' "' \\
  ofmt=votable out=data1.vot
```

Quick look at the statistics for a sample of rows from some columns from a fits file:

```
tpipe
  in=survey.fits ifmt=votable \\
  cmd='keepcols flux vel vel_err qual"' "' \\
  cmd='every 1000' "' \\
  cmd=stats
```

**tmatch2**

tmatch2 performs crossmatching between two tables. The matching options are flexible:

- select best or all matched pairs
- error radius constant or per-row
- choose join type: both, either, unmatched, ...
- various error geometries: celestial sphere, isotropic/anisotropic Cartesian in 1, 2 or many dimensions, exact match of ID value, or any combination of these
- performance scales as O(N log N)
- fast - match two 10^5-row tables in ~30 sec

Example: locate all matches within 3 arcsec and 0.5 blue magnitudes, returning only matched pairs:

```
tmatch2 in1=ence.fits in2=sdofs.xml \\
  matcher=sky1d params='3 0.5' "' \\
  values1='ra dec mag' "' \\
  values2='RA2000 DEC2000 B_MAG' "' \\
  join=land2 findwall 1 out-pairs.fits
```

**tcopy**

tcopy converts between different table formats (in fact it's just a cut-down form of tpipe).

Supported input/output formats include:

- FITS (binary and ASCII tables)
- VOTable (all encodings)
- relational databases (via SQL queries)
- plain ASCII
- Comma-Separated Values

You can convert from any of these to any other (and a number of additional ones for output).

Compressed data (.gz, .bz2) and streams from URLs are handled automatically.

You can use tcopy to convert from legacy formats to VOTable/FITS or vice versa, turn SQL queries into tabular data files, populate relational databases from FITS files, provide a choice of output formats for tables returned from a web service, ...

Example:

```
tcopy
  in=fits.fits ofmt=votable out=conv.flt
  http://data.okean.ru?ra=123.4&dec=21'
```

**tvotlint**

tvotlint checks VOTable documents for illegal constructs and probable errors, providing much better checks than schema/DTD validation can offer. It's very easy to make mistakes when writing VOTables and often hard to spot them except by seeing that software doesn't do what you expect. tvotlint is designed for writers and users of programs which generate or consume VOTables to ensure that documents published to the VO are legal and mean what the author intended.

**Related Software**

- **STIL**
  - http://www.starlink.ac.uk/stil/
  - Starlink Tables Infrastructure Library
  - Public table/VOTable API underlying STILTS.
- **TOPCAT**
  - http://www.starlink.ac.uk/topcat/
  - Tool for OPerations on Catalogues And Tables
  - GUI view/edit/analysis tool based on STIL.