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DISSEMINATION OF UT1-UTC THROUGH THE USE OF VIRTUAL OBSERVATORY

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Information concerning UT1-UTC and the occurrence of the leap seconds are currently made available via IERS bulletins (Bulletin D and C) sent to users in ASCII format. However, this old-fashioned procedure does not satisfy automatic systems. We have investigated the way to develop a new service based on the concept of Virtual Observatory (VO). This concept, provided by the International Virtual Observatory Alliance (IVOA), allows scientists and the public to access and retrieve UT1-UTC information using on-line distributed computational resources. We describe here how we derived the concept, using the XML-based VOTable format to build this UT1-UTC dedicated new service.

INTRODUCTION

As mentioned on the *International Virtual Observatory Alliance* (IVOA) website, the IVOA was formed in June 2002 with a mission to "facilitate the international coordination and collaboration necessary for the development and deployment of the tools, systems and organizational structures necessary to enable the international utilization of astronomical archives as an integrated and interoperating virtual observatory."[**] The work of the IVOA focuses on the development of standards. Working Groups are constituted with cross-project membership in those areas where key interoperability standards and technologies have to be defined and agreed upon.[1] The Working Groups develop standards using a process modeled after the World Wide Web Consortium. Recommendations are ultimately endorsed by the Virtual Observatory (VO) Working Group of Commission 5 (Astronomical Data) of the International Astronomical Union (IAU).

Several independent Java-based tools have been developed in the VO framework that can be used in geodesy and more generally in Earth's Science.[2] These tools can either be downloaded and set up in PCs as Java applications, or used through a web browser as Java applets. In particular, some of the tools we started to use with IERS data are "VOPlot" and "TopCat", which are devoted to astronomical data and time series plotting.

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BASIC PRINCIPLES OF THE VIRTUAL OBSERVATORY

The VO-Table Data Exchange Format

VOTable is the XML-based format for representing astronomical data, recommended by IVOA (e.g. catalogues, as tables of the properties of celestial objects, celestial coordinates, brightness etc.). The VO-Table format has been defined in terms of XML in order to take advantage of computer-industry standards and to utilize standard software and tools. At the same time it is important not to lose the previous investment in astronomy-specific standards, such as the table variants of the *Flexible Image Transport System* (FITS) format. Also, astronomical tables are rich in *metadata*, which in this context means annotation, interpretable by either computers or humans, both of the tables and the individual columns that they contain. It is important to note that these metadata should be preserved with the table and the VO-Table has features to permit this.

Moreover, it is crucial to point out the fact adopting the VO-Table format does not mean giving up of its own data format: the VO-Table format can encapsulate existing files and simply supplies metadata to understand its content and facilitate data exchanges.

Why Choose the Virtual Observatory

There exists several software packages to treat metadata files, but the so-called "Virtual Observatory", as an ensemble of VO-Table-based software packages, is now widely used within the astronomical community, by several thousand users worldwide. The Virtual Observatory takes advantage on the notion of *Unified Content Descriptors* (UCD) to be inserted into metadata files to describe the data, following the self-descriptive format VO-Table based on these standards and XML. As a consequence, many tools already exist to manage, plot or analyze data supplied in VO-Table format. Converting ones own data in VO-Table format means benefiting of all existing tools, some of them providing a conversion from unformatted data files into the VO-Table format, as well. As a consequence, data will be described non-ambiguously, ensuring further exchange and better understanding between different scientific communities. By the way, the Virtual Observatory provides an easy access to all VO-Table data: they can be registered to a "registry", that means that any user can locate on the web, get details of, and make use of, any resource located anywhere in the IVOA space.

Using the Virtual Observatory in Geodesy?

VO standards have been developed for Earth-centered or body-centered reference frames in order to extend the VO to Earth and planetary sciences. Nevertheless, some improvements are to be made. Two years ago, our group proposed to the IVOA to adopt standards relevant to the Earth orientation data (polar motion, UT1-UTC, nutation, etc.) and to space geodesy. These were accepted for official use in all files relevant to VO.

SPECIFIC PROJECTS TO MAKE UT1-UTC AVAILABLE

Web application

An execute application is currently running. It makes available EOP and in particular UT1-UTC using the web service (Figure 1, Figure 2)

Figure 1. Webservice webpage at Paris Observatory: http://hpiers.obspm.fr/eop-pc/.

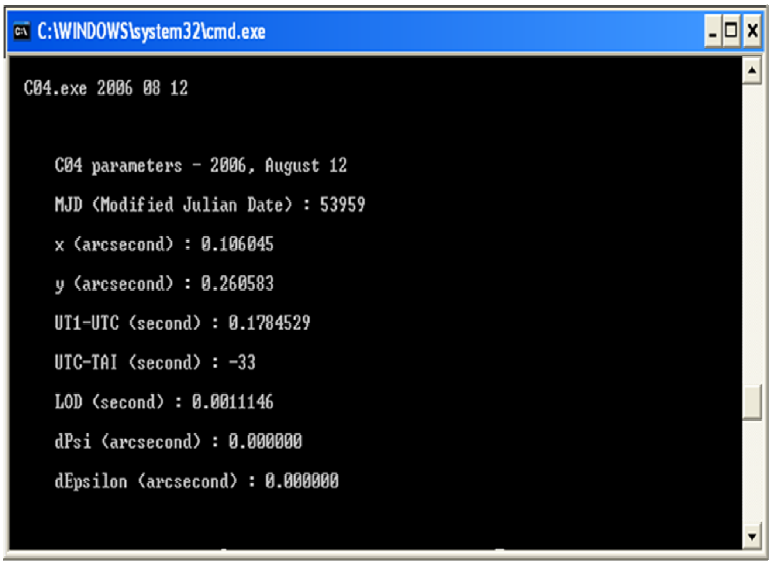


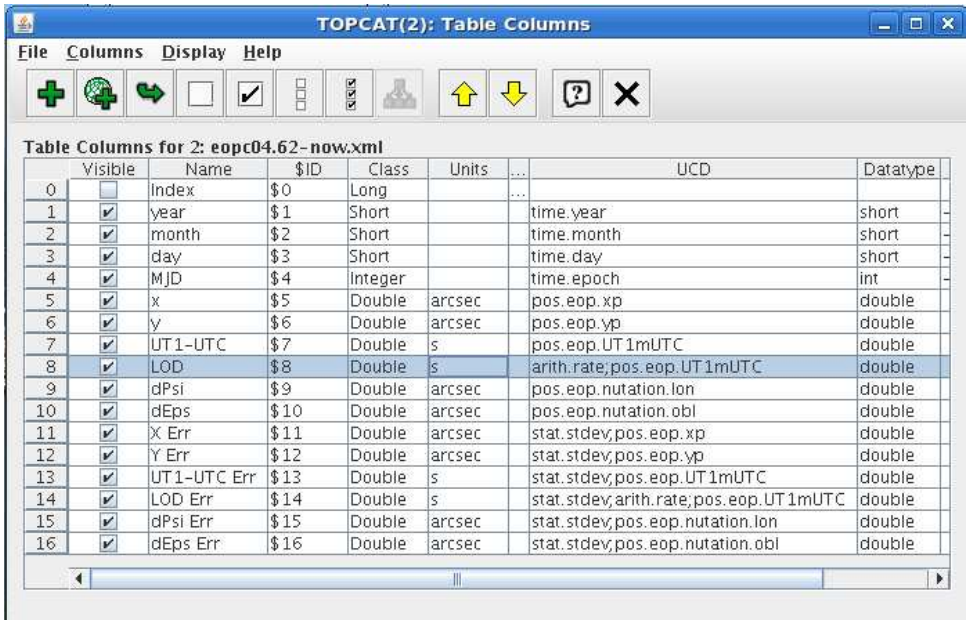
Figure 2. Example of a request

Application based on VO tools

The tool extracts and makes available EOP (Figure 4) and in particular UT1-UTC (Figure 5) over a period chosen by the user. The output is given through ASCII or VO-Table formats (XML file containing UCD). This tool is easy to be used, and is compatible with Internet Explorer, Firefox, in particular. It is made up of independent sub-programs, and made secure. Results are obtained very quickly and data do not need to be duplicated.

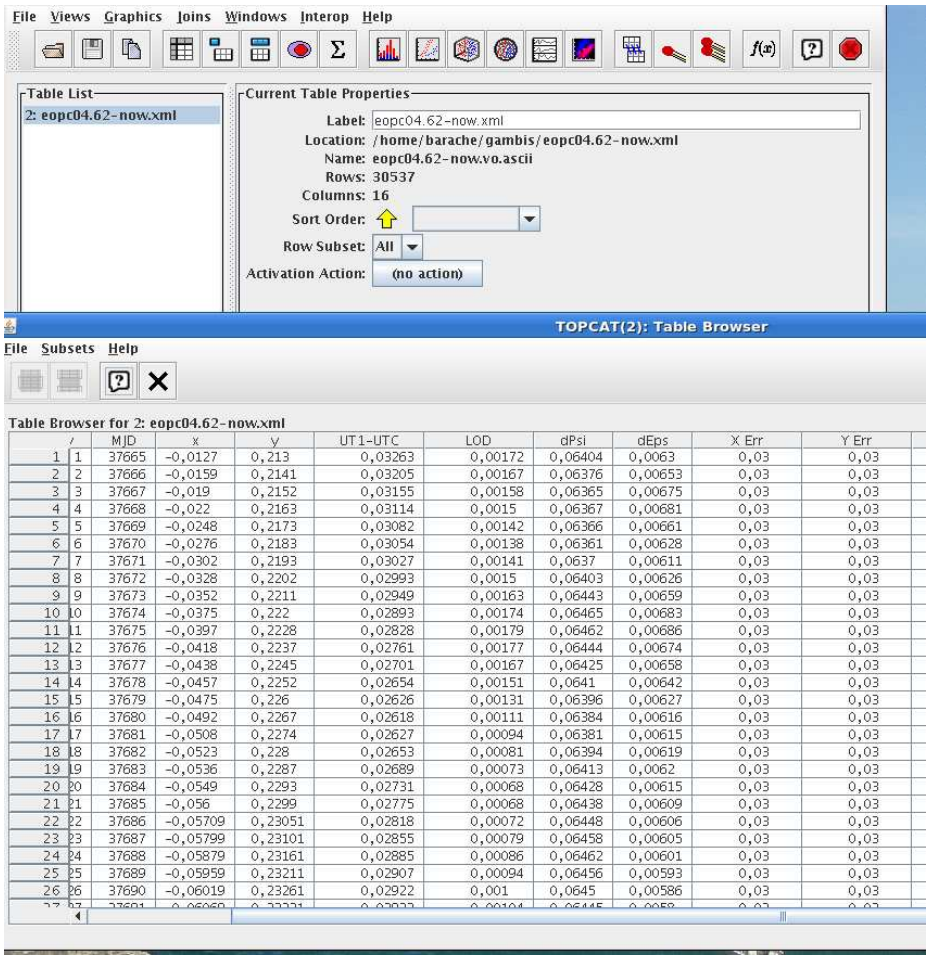
This process facilitates links between various user and scientific communities. The VO-Table format ensures the compatibility between external software.

The reference IERS EOP file, containing the official EOP C04 solution through the c04.62-now file is automatically retrieved of and converted into VO(XML) format compatible with VO software packages. Initially EOP parameters have to be declared accordingly to specific Unified Content Descriptors (Figure 3) for instance “time.epoch” standing for dates in MJD or “pos.eop.UT1mUTC” standing for UT1-UTC.



	Visible	Name	$ID	Class	Units	...	UCD	Datatype	
0	☐	Index	$0	Long		...			
1	☑	year	$1	Short			time.year	short	-
2	☑	month	$2	Short			time.month	short	-
3	☑	day	$3	Short			time.day	short	-
4	☑	MJD	$4	Integer			time.epoch	int	-
5	☑	x	$5	Double	arcsec		pos.eop.xp	double	
6	☑	y	$6	Double	arcsec		pos.eop.yp	double	
7	☑	UT1-UTC	$7	Double	s		pos.eop.UT1mUTC	double	
8	☑	LOD	$8	Double	s		arith.rate;pos.eop.UT1mUTC	double	
9	☑	dPsi	$9	Double	arcsec		pos.eop.nutation.lon	double	
10	☑	dEps	$10	Double	arcsec		pos.eop.nutation.obl	double	
11	☑	X Err	$11	Double	arcsec		stat.stdev;pos.eop.xp	double	
12	☑	Y Err	$12	Double	arcsec		stat.stdev;pos.eop.yp	double	
13	☑	UT1-UTC Err	$13	Double	s		stat.stdev;pos.eop.UT1mUTC	double	
14	☑	LOD Err	$14	Double	s		stat.stdev;arith.rate;pos.eop.UT1mUTC	double	
15	☑	dPsi Err	$15	Double	arcsec		stat.stdev;pos.eop.nutation.lon	double	
16	☑	dEps Err	$16	Double	arcsec		stat.stdev;pos.eop.nutation.obl	double	

Figure 3. Unified Content Descriptors relevant to Earth rotation.



/	MJD	x	y	UT1-UTC	LOD	dPsi	dEps	X Err	Y Err
1	37665	-0,0127	0,213	0,03263	0,00172	0,06404	0,0063	0,03	0,03
2	37666	-0,0159	0,2141	0,03205	0,00167	0,06376	0,00653	0,03	0,03
3	37667	-0,019	0,2152	0,03155	0,00158	0,06365	0,00675	0,03	0,03
4	37668	-0,022	0,2163	0,03114	0,0015	0,06367	0,00681	0,03	0,03
5	37669	-0,0248	0,2173	0,03082	0,00142	0,06366	0,00661	0,03	0,03
6	37670	-0,0276	0,2183	0,03054	0,00138	0,06361	0,00628	0,03	0,03
7	37671	-0,0302	0,2193	0,03027	0,00141	0,0637	0,00611	0,03	0,03
8	37672	-0,0328	0,2202	0,02993	0,0015	0,06403	0,00626	0,03	0,03
9	37673	-0,0352	0,2211	0,02949	0,00163	0,06443	0,00659	0,03	0,03
10	37674	-0,0375	0,222	0,02893	0,00174	0,06465	0,00683	0,03	0,03
11	37675	-0,0397	0,2228	0,02828	0,00179	0,06462	0,00686	0,03	0,03
12	37676	-0,0418	0,2237	0,02761	0,00177	0,06444	0,00674	0,03	0,03
13	37677	-0,0438	0,2245	0,02701	0,00167	0,06425	0,00658	0,03	0,03
14	37678	-0,0457	0,2252	0,02654	0,00151	0,0641	0,00642	0,03	0,03
15	37679	-0,0475	0,226	0,02626	0,00131	0,06396	0,00627	0,03	0,03
16	37680	-0,0492	0,2267	0,02618	0,00111	0,06384	0,00616	0,03	0,03
17	37681	-0,0508	0,2274	0,02627	0,00094	0,06381	0,00615	0,03	0,03
18	37682	-0,0523	0,228	0,02653	0,00081	0,06394	0,00619	0,03	0,03
19	37683	-0,0536	0,2287	0,02689	0,00073	0,06413	0,0062	0,03	0,03
20	37684	-0,0549	0,2293	0,02731	0,00068	0,06428	0,00615	0,03	0,03
21	37685	-0,056	0,2299	0,02775	0,00068	0,06438	0,00609	0,03	0,03
22	37686	-0,05709	0,23051	0,02818	0,00072	0,06448	0,00606	0,03	0,03
23	37687	-0,05799	0,23101	0,02855	0,00079	0,06458	0,00605	0,03	0,03
24	37688	-0,05879	0,23161	0,02885	0,00086	0,06462	0,00601	0,03	0,03
25	37689	-0,05959	0,23211	0,02907	0,00094	0,06456	0,00593	0,03	0,03
26	37690	-0,06019	0,23261	0,02922	0,001	0,0645	0,00586	0,03	0,03

Figure 4. Example of an Earth rotation time series.

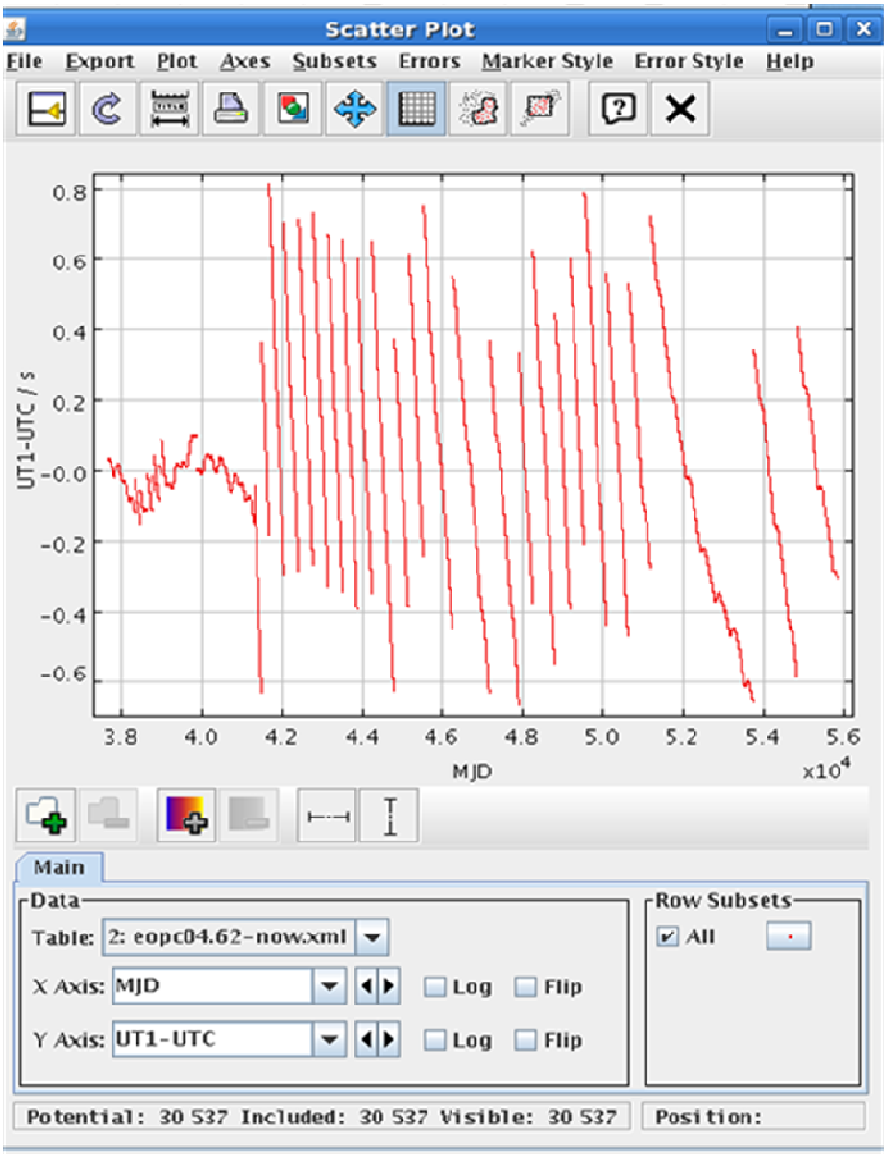


Figure 5. Time series of UT1-UTC.

CONCLUSIONS

The scientific community working in different field and requiring in particular UT1-UTC on a regular and reliable basis can benefit from the VO concept mainly through two points. On the one hand, the concept of metadata allows to gather up a single file with a description supposed to be exhaustive.

In our opinion, such tools can give an extraordinary visibility of all data and in particular earth orientation parameters and UT1-UTC derived by the IERS.

REFERENCES

[1] Souchay, J.; Andrei, A. H.; Barache, C.; Bouquillon, S.; Gontier, A.-M.; Lambert, S. B.; Le Poncin-Lafitte, C.; Taris, F.; Arias, E. F.; Suchet, D.; Baudin, M., "The construction of the large quasar astrometric catalogue (LQAC).", *Astronomy and Astrophysic*s, Volume 494, Issue 2, pp.799-815, 2009.

[2] Lambert, S., F., Deleflie; A.-M., Gontier; P., Berio; C. Barache, "The Astronomical Virtual Observatory and Application to Earth's Sciences." IVS 2008 General Meeting Proc., 2008.