ObsCore Metadata Extension for Time Properties

Version 1.0

IVOA Working Draft 2024-06-14

Working Group
DM

This version
https://www.ivoa.net/documents/ObscoreTimeExtension/20240614

Latest version
https://www.ivoa.net/documents/ObscoreTimeExtension

Previous versions
This is the first public release

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Abstract

This IVOA specification details a list of metadata dealing with time-related features needed for discovery of time series data sets, in the context of ObsTAP services. It is based on science cases explained in a previous IVOA note prepared in 2018 and recently revised (Nebot and Bonnarel et al., 2018). Here we discuss various use-cases. We highlight first which existing time related metadata in the ObsCore standard version 1.1 can be used, and second propose new features needed for an ObsCore time extension in order to allow more search criteria for time-resolved data sets.

Status of this document

This is an IVOA Working Draft for review by IVOA members and other interested parties. It is a draft document and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use IVOA Working Drafts as reference materials or to cite them as other than "work in progress".

A list of current IVOA Recommendations and other technical documents can be found in the IVOA document repository[1].

Contents

[1]https://www.ivoa.net/documents/

Acknowledgments

This work has been supported by various national projects related to the development of the virtual Observatory. We acknowledge support of the Astronomy ESFRI and Research Infrastructure Cluster ? ASTERICS project, funded by the European Commission under the Horizon 2020 Programme (GA 653477) and from ESCAPE (grant.) projects from the EU Horizon 2020 framework. Additional funding was provided by the INSU (Action Spécifique Observatoire Virtuel, ASOV), the Action édératrice CTA at the Observatoire de Paris and the Paris Astronomical Data Centre (PADC). Vespa, EPN tap, Inaf, via galactea, TBC

Conformance-related definitions

The words "MUST", "SHALL", "SHOULD", "MAY", "RECOMMENDED", and "OPTIONAL" (in upper or lower case) used in this document are to be interpreted as described in IETF standard RFC2119 (Bradner, 1997).

The *Virtual Observatory (VO)* is a general term for a collection of federated resources that can be used to conduct astronomical research, education, and outreach. The International Virtual Observatory Alliance (IVOA) is a global collaboration of separately funded projects to develop standards and infrastructure that enable VO applications.

1 Introduction

Time domain astronomy studies astrophysical phenomenae that vary in different time stamps and hence, in order to study the different physical underlying mechanisms a user might need to collect and analyse data from different missions and of different nature. Therefore she/he needs to search across various archives based on time related criteria. ObsCore and ObsTAP Louys and Tody et al. (2017) have proven their efficiency for the discovery of astronomical data sets in the IVOA. In this specification we consider how the

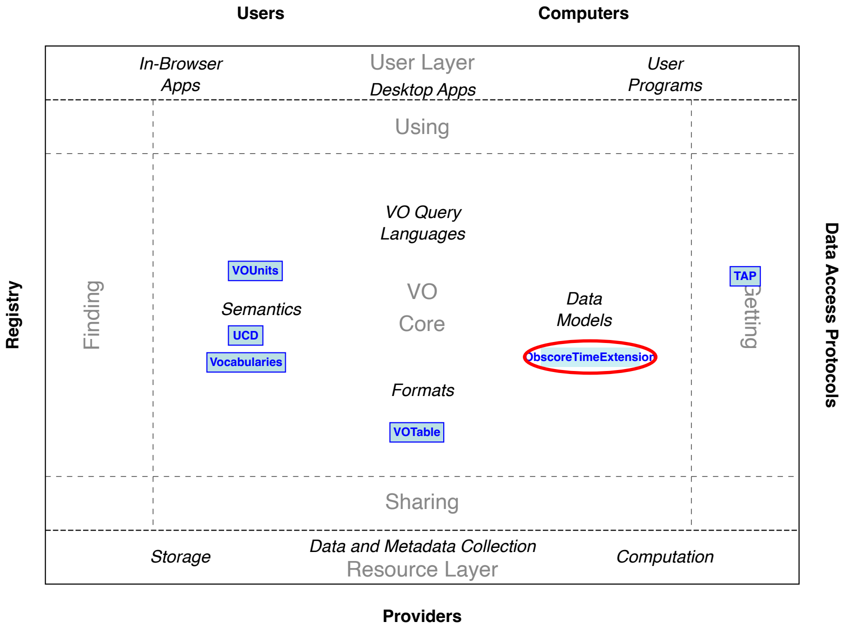

Figure 1: Architecture diagram for this document

ObsCore metadata profile can be extended to include time-related properties of the data, specific to time series and not yet covered.

In this specification we examine how to enhance data discovery and data selection of time sampled data sets in the context of the ObsCore data model and its TAP implementations. The ObsCore Specification Louys and Tody et al. (2017) proposes a set of features to describe the data present in a data set as well as metadata about its acquisition, creation and publication (curation). The physical in terms of spatial, spectral, temporal, polarimetry, and observable measure are also described by a group of features dedicated to each axis, and considered independant from each other. The idea is to provide a physical feature profile for each axis with coverage, sampling, resolution, etc. Search criteria in ObsTAP are based on these features.

We examine in section 3.3 how the set of time parameters already present in ObsCore v1.1 can be used for time series discovery. In section 4 we consider specific time related uses cases and propose new parameters to be included for the tables extension in ObsCore. The extension mechanism in TAP is discussed in section 5 with user queries examples

1.1 Role within the VO Architecture

Fig. 1 shows the role this document plays within the IVOA architecture (Dowler and Evans et al., 2021). This specification builds up a metadata profile that must be used in a TAP service based on the ObsTAP TAP schema.

It relies on fundamental standards like TAP, VOTable, UCD, VOUnits and Vocabularies defined in the IVOA for data product type and TimeReference systems for instance.

2 Time Series

In this section we describe what Time Series data is in a wide context, describing the most relevant parameters that define it. We describe the common requirements of the different science use cases collected by the Science Priority Committee Solano, Enrique (2017). A common frame for time is defined with the minimum set of parameters taken from and compatible with the definition of SpaceTime coordinates and Coords DM. We then compare the defined fields describing time with the fields content of ObsCore and EPNcore.

2.1 Definition

Time Series can be defined in a very large sense as a collection of any kind of data over time for a particular source (e. g. star, binary, QSO) or part of a source (e. g. sun spots), independent on the type of data (images, light-curves, radial velocity, polarisation states or degrees, positions, number of sunspots, densities,...), the duration of the signal integration or the cadence. To clarify the vocabulary here we consider a time series as a sequence of signal integrations, or snap-shots observing an object or phenomenon over time, so diffrent observations over time. Considering how observations in general can be spanned along the time axis, we can sketch Time Series data as shown in Fig. 2. Time Series data is composed of a set of observations (n_observations = 3 in this example), each with a different exposure or integration time (t_exp). Although in some cases the cadence or time span between each signal intergration (delta_t) is fixed, in the general case it can be different and we can therefore define a minimum and a maximum value (delta_t_min, delta_t_max). Each observation has it's own time stamp (t_i) with a given precision or resolution (t_resolution). As can be seen from this figure the duration of the observation can be defined in different ways: a) as the total integration or exposure time, i. e. the sum of all the exposure times: $t\_exp\_total = \sum t\_exp$; or b) as the time span between the beginning and the end of the observations: $t\_exp\_total = t\_max$ - $time\_min$). Note that in the case that the exposure time is constant for all the observations then $t\_exp\_total = \mathrm{n\_observations} \times t\_exp$. The situation can be more complicated, for instance during the observation there could be clouds and we therefore pause the exposure for a while and resume once the cloud has passed or we might want to remove parts of the observation due to artefacts in the data. In any case these values can be taken as approximative of the minimum and the maximum value this specific field can have.

The most relevant fields of Time Series metadata are summarized in Table 1.

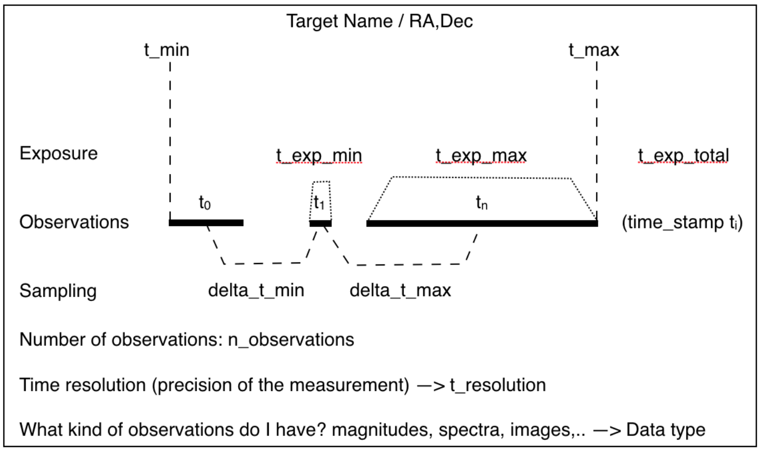

Figure 2: Simple representation of Time Series data.

Table 1: Time Series metadata fields.

Field	**Explanation**
(RA,Dec)	Coordinates[1]
target_name	Target name[1]
t_min	Date of the begining of the time series
t_max	Date of the end of the time series
t_exp_min	Minimum exposure time
t_exp_max	Maximum exposure time
t_exp_total	Total exposure time
delta_t_min	Minimum time sampling period / cadence
delta_t_max	Maximum time sampling period/ cadence
t_resolution	Time resolution/precision
n_observations	Number of time integrations in time series
type_of_data	Type of data (fluxes, radial velocities, images,...)

Note: [1]For SSO or moving objects coordinates might not be enough or relevant.

In many cases time series data is composed of only three columns: *Time, Magnitude, Magnitude Error*. This is the simplest kind of data set, which is identified in the data product type vocabulary as 'light-curve'. See the IVOA product-type vocabulary at https://www.ivoa.net/rdf/product-type/

2024-03-22/product-type.html.

For this data to be fully exploitable and reusable (interoperable) it has to be properly documented. In this specific case the minimum information that needs to be provided is: the object coordinates (or name), the filter in which the observations have been carried out, and the time frame and offset (if applicable). However, the dimensionality of what is observed at the time stamps' sequence may correspond to 1D or 2D observations, like spectra or images as well. That's why the dataproduct type defined in ObsCore 1.1 should be more precise and eventually rely on the IVOA product-type vocabulary.

In addition, a mechanism should be defined to clarify what part of the data is varying with time, as described further in section 3.2.

2.2 Science use cases

Different science use cases for Time Series have been collected and described in by E. Solano at http://wiki.ivoa.net/twiki/bin/view/IVOA/CSPTimeSeries. They highlight the case of optical light curves but can be generalized to all spectral regimes (xray, gamma ray, radio, multi-messengers) where time dependent measures have been taken. Science cases are grouped according to their common requirements summarized as:

- **Group A** Combine photometry and light curves of a given object/list of objects in the *same* photometric band
- **Group B** Combine photometry and light curves of a given object/list of objects in *different* photometric bands
- **Group C** Time series other than light curves

Looking at the different science cases we simplify the questions to two:

1. *Have these two missions observed this object within these two dates?*
2. *Is it possible to discover long/short term variability within the data?*

To answer the first question a user needs to be sure that dates are comparable, that is time has to be brought into a common time frame. To answer the second question we need to keep track of the minimum and maximum time span.

2.3 Using a common time frame

To compare datasets from different missions or archives a common representation of time is needed. In order to do so we propose to map time into a pivot format. Following Rots and Bunclark et al. (2015) and Rots (2007) we

Table 2: Metadata for time in Time Series data serialisation.

Parameter proposal	Explanation
t_scale	Time frame scale is the scale used to measure time. IAU definition: "A time scale is simply a well defined way of measuring time based on a specific periodic natural phenomenon." See http://aa.usno.navy.mil/publications/docs/Circular_179.pdf. Recognized time scale values and their meaning are listed in Table 7. If we don't know use UNKOWN.
t_ref_position	Time Frame Position is the place where the time is measured. Standard values are listed in Table 8. If we don't know use UNKOWN.
t_uncertainty	Resolution or uncertainty of the time stamps.
t_sys_error	Time Systematic Error to take into account our knowledge of the time frame (scale and position). If time_scale is not known then 100s as DEFAULT value::, if t_scale and t_ref_position are both not known then use 1000s as DEFAULT value. Approximately 100s is good for the time_scale since that is related to changes in the clock in space/earth; 1000s is good if we do not know if times are corrected for the position of the Earth/satellite on its orbit around the Sun since that is approximately twice the time it takes the light to travel the Sun-Earth/satellite distance.
t_format	Time representation as JD, MJD, ISO-8601.
t_offset	Offset that has been subtracted to the time. Time can be relative to a certain moment, e. g. time after the GRB that happened on date YYYYMMHHMMSS.SS or a random number the authors have subtracted from data to allow higher precision in the time stamps. Its default value is 0.0.
t_description	A text briefly describing what is varying with time. Photometric variability in filter V, Radial velocity curve in HJD. This field is aimed to help the reader.

propose a set of minimum metadata to be added for serializations of Time Series (see Table 2).

We recommend to be specific on the time frame and we suggest to use:

JD(TT;BARYCENTER)

We also give some values that can be used as default in the case that some information is not known and impossible to recover. We minimize the impact of doing this by adding a systematic error to time when those values are unknown.

3 Extension of ObsCore

ObsCore has a normalized description of the data content along the various physical axes where the data are projected. The spatial properties are described in the *s_ ** group, the spectral ones in *em_ ** group, the temporal ones in *t_ **, etc. For each data set there is a minimal set of metadata to describe its sky position, spectral band, time interval, etc. which are independent from each other. This allows to enhance time sampling description by adding new parameters to the time group without putting the ObsCore existing model at risk.

3.1 Extension of ObsCore based on EPNCore

Astronomy and space science both consider time series data and have proposed metadata data description for it. Some metadata have already been defined and used in the context of data discovery using ObsCore Louys and Tody et al. (2017), and the remaining ones have been defined in the context of planetary data in the EPNcore specification Erard and Cecconi et al. (2022). In Table 3 we show the equivalence between the fields we require here and those existing in ObsCore and EPNcore specifications.

Note: *t_resolution* in ObsCore needs some clarification and the dataproduct_type labels defined in ObsCore and EPNCore are different currently. That is why *dataproduct_type* should be enriched in ObsCore, and harmonized with the product type IVOA vocabulary maintained at ivoa.net/rdf/.

3.2 Mentioning what part of the dataset varies with time

Obscore 1.1 uses the attribute *o_ucd* to describe what is the quantity observed depending on the various physical axes of the data product. The UCD string corresponding to the observable in a one dimensional dataset is easy to choose in the UCD list. We propose to extend this definition to generalize for time series of multiple dimensional data sets and add a *time_variant*

Table 3: Equivalence and complementarity between Time Series data fields and ObsCore and EPNCore fields

Field	**ObsCore field name**	**EPNCore field name**
coordinates	s_ra, s_dec	-
target_name	target_name	target_name
t_min	t_min	time_min
t_max	t_max	time_max
t_exp_min	-	time_exp_min
t_exp_max	-	time_exp_max
t_exp_total	t_exp	-
delta_min	-	time_sampling_step_min
delta_max	-	time_sampling_step_max
n_observations	t_xel	-
t_resolution type_of_data	t_resolution dataproduct_type	- dataproduct_type

attribute in ObsCore. In a time series, the principal axis considered is the Time axis. The time variant component can be either one dimensional, like for a light curve or velocity curve, or multi-dimensional. The time series is viewed as time dependent sequence of components, which can be characterized by a data product type, such as an image, a spectrum, a spectral cube, etc., also defined in the product-type vocabulary. Table 4 summarizes the use of *time_variant* in various cases. This parameter is worth to include in the Time ObsCore extension table.

Table 4: Time variant property of a temporally sampled dataset.

Main dataproduct_type	**o_ucd**	**time_variant component**
light curve	phot.flux	scalar value
velocity curve	doppler.veloc	scalar value
trajectory	pos.eq	sky position (vector)
dynamic spectrum	phot.flux	spectrum
movie	phot.flux	image
time cube	phot.flux	cube

3.3 Time parameters defined in ObsCore v1.1

We have seen the data product type helps to search for time sampled data sets. In order to describe properties of the data set along the time axis, we can reuse the axis properties defined in the Characterization data model Louys and Richards et al. (2008). The idea is to describe how the time stamps are spanned along the time axis, with time duration and cadence.

3.3.1 t_min, t_max

These parameters provide the bounds of the time coverage for this data set. For a light-curve it is the beginning of the first time sample and the end of the last sample.

3.3.2 t_exptime

This parameter represents the duration or live time of the observation. For a light-curve it is the sum of all valid time samples. For instance for a time-cube it is the total exposure time summing up all the poses.

3.3.3 t_resolution

t_resolution can be defined as the time limit under which two observable quantities cannot be distinguished from each other. This works for event-list, light-curve, time-cube data sets, etc.

3.3.4 t_xel, number of time stamps

This parameter entails the number of observations in the time series. It is important to query for guessing how rich is the dataset, especially for observing variability.

Table 5: Definitions of ObsCore time related attributes in the current specification.

Name	Definition &Utype	UCD	Units	Status
t_min	Time start of the sequence (MJD) Char.TimeAxis.Coverage.Bounds.Limits.LoLim	time.start;obs.sequence	d	man
t_max	Time end of the sequence Char.TimeAxis.Coverage.Bounds.Limits.HiLim	time.end;obs.sequence	d	man
t_exptime	Exposure time (sum of multiple exposures) Char.TimeAxis.Support.Extent	time.duration;obs.exposure	s	man
t_resolution	Minimal interpretable time difference Char.TimeAxis.Resolution.Refval I	time.resolution	s	man
t_xel	Number of time stamps in the series Char.TimeAxis.numBins	meta.number	null	man

3.4 Time series uses cases already covered by ObsCore1.1

Several uses-cases for time series discoveries were considered in the ObsCore 1.1 specification, built on its short list of time related features. They are available in appendix A in section A.4. Discovering time series. Here the *dataproduct_type* value is "timeseries", very general, but the same uses cases can be applied for more specific time sampled datasets like "time-cube" or or "light-curve" available now in the **product-type** vocabulary . ObsCore uses cases are also provided in a web page available at : http://saada.unistra.fr/voexamples/show/ObsCore/.

4 Time parameters proposed for Obscore Extension

4.1 Time Frame description

As mentioned in section 2.3 the Time Frame description is essential for comparing various time series data sets. This metadata was described first in the STC data model (Rots, 2007), then in the Coords DM (Rots and Cresitello-Dittmar et al., 2022), and serialized in the VOTABLE format in the TimeSYS element. Up to now, this metadata was not defined in ObsCore1.1. It is coded into the VOTable metadata of the dataset. Having it as part of the query response coming back for a search for time series would help the user application to interpret time stamps precisely. MJD is the time format used for an ObsTAP query related to time. We propose to add the time frame parameters in the Time Obscore extension. These various definitions are harmonized in the proposal given in table 6a. We list the corresponding terms used in the Coords Data model and in the UCD vocabulary, as well as the attribute of the TIMESYS param defined for VOTable serialization. All terms are proposed as mandatory, but can be set to UNKNOWN if not available. With the expansion of massive time series datasets, where efficient data discovery will serve the selection of big training sets for analysis workflows, such parameters are highly recommended especially for new data collections.

Values to fill these terms should rely on the terms defined in IVOA vocabularies, namely for time scales and time reference position. As an example Appendix A summarize the definitions listed in previous models like STC.

4.2 Time axis sampling description

t_delta_min , *t_delta_max* represent the minimal (resp. maximal) time interval between two time samples.

This concept is covered in the Characterization data model (Louys and Richards et al., 2008) and designated as sampling period along the Time axis. The cadence of the observations in the time series can be assumed from theses parameters.

The Time Axis Sampling Extent defined in Characterization DM is the duration of each sample and may vary along the time sequence. During the observation process, it corresponds to an exposure time. If the sampling is not regular the minimal and maximal value described in *t_exp_min,* *t_exp_max* give the bounds values of the sampling extent. When the sampling is even, all samples have the same duration and t_exp_min, t_exp_max have the same value. When the sampling period, or cadence is even, *t_delta_min* , *t_delta_max* have the same value.

In general the *t_resolution*, the minimal distinguishable time interval between two time stamps is much finer than the chosen cadence in the instrument.

4.3 Time axis mode, folding period and phase reference

Time series may be distributed in two modes, "search mode" or "folded". The folding allows to improve the SNR and to analyse further the periodicity of the observed phenomenon. For data discovery purpose one parameter may be introduced : *t_fold_period*, the time duration of the folding. A *t_fold_period* parameter set to zero means that the time axis is not folded and then indicates it belongs to search mode .

4.3.1 t_fold_period, t_fold_phaseReference

This metadata gives the length of the folding interval. It is given in the same time units as the time stamps along the sequence. The time origin at which the folding starts is another important metadata and stored in *t_fold_phaseReference*. It is given as a time stamp within the *t_min, t_max* interval of the time series before folding. This value is usually chosen according to the transient phenomenon under study, on peak or gap, etc. and cannot be standardized, that is why the time reference in the original curve is more convenient. Both attributes enable to study the periodicity of the signal and compare between various light curves.

5 Extension mechanism in ObsTAP

ObsCore is mostly implemented in the TAP protocol (Dowler and Rixon et al., 2019). An ObsTAP service is considered compliant to the standard if it serves all the attributes tagged as mandatory in the specification. These are gathered in the TAP_SCHEMA in the table usually named *ivoa.obscore*. Following the practice introduced for EPNTap, the utype column in *ivoa.obscore* should be the standard identifier of the specification supported by the table content, so here `ivo://ivoa.net/std/obscore#table-1.1`

This table can also hold more columns corresponding to optional attributes, as summarized in the Table 7 - Optional Parameters of the ObsCore specification. There is no guarantee that an optional parameter will be filled in an ObsTAP service; this must be checked first by the user.

Therefore the Time extension for Obscore should rely on mandatory parameters. They may be set UNKNOWN if unknown. In order to warn users that extra time parameters have been included in ObsTAP, we propose to gather them in another table named *ivoa.t-obs* for services that distribute time sampled data sets. The utype column in *ivoa.t_ obs* should be the standard identifier of this specification, so here `ivo://ivoa.net/std/obscore#t-obs-1.0`.

If this table contains an identifier for the corresponding dataset described in main *ivoa.obscore* table, then it is easy to join general Obscore properties to the time specific ones in an ADQL query. Here is a query example : (to be checked)

```

SELECT obs_id, t_min, t_max, obs_publisher_did, obs_collection
   , access.reference FROM ivoa.obscore
WHERE dataproduct_type=='light-curve'
AND t_min > 55197
AND t_max < 55204
JOIN ivoa.t-obs as tt
ON obs_publisher_did==tt.obs_publisher_did
 WHERE tt.delta_min < 10s AND  tt.t_xel > 10

```

Listing 1: Query example for Join between the main ObsCore table and the Time extension table

Other examples of queries using these extra parameters are proposed in Appendix B.

More generally, other extensions can be considered in ObsTAP, like the radio extension or high energy extension specific to these spectral domains and instrumentations. In an extended ObsTAP service the main ObsCore table and the other extension tables must be gathered in a TAP_SCHEMA with utype
`ivo://ivoa.net/std/obscore1.1`, for version 1.1 and containing the different tables : ivoa.obscore, ivoa.t-obs, ivoa.radio, ivoa.heig etc.... when needed. This would guarantee that all the tables for data discovery are grouped together and discovered, and that the service can allow the table joins.

6 References

References

Bradner, S. (1997), 'Key words for use in RFCs to indicate requirement levels', RFC 2119. http://www.ietf.org/rfc/rfc2119.txt.

Dowler, P., Evans, J., Arviset, C., Gaudet, S. and Technical Coordination Group (2021), 'IVOA Architecture Version 2.0', IVOA Endorsed Note 01

November 2021. doi:10.5479/ADS/bib/2021ivoa.spec.1101D, https://ui.adsabs.harvard.edu/abs/2021ivoa.spec.1101D.

Dowler, P., Rixon, G., Tody, D. and Demleitner, M. (2019), 'Table Access Protocol Version 1.1', IVOA Recommendation 27 September 2019. doi:10.5479/ADS/bib/2019ivoa.spec.0927D, https://ui.adsabs.harvard.edu/abs/2019ivoa.spec.0927D.

Erard, S., Cecconi, B., Le Sidaner, P., Demleitner, M. and Taylor, M. (2022), 'EPN-TAP: Publishing Solar System Data to the Virtual Observatory Version 2.0', IVOA Recommendation 22 August 2022. https://ui.adsabs.harvard.edu/abs/2022ivoa.spec.0822E.

Louys, M., Richards, A., Bonnarel, F., Micol, A., Chilingarian, I., McDowell, J. and IVOA Data Model Working Group (2008), 'Data Model for Astronomical DataSet Characterisation Version 1.13', IVOA Recommendation 25 March 2008, arXiv:1111.2281. doi:10.5479/ADS/bib/2008ivoa.spec.0325L, https://ui.adsabs.harvard.edu/abs/2008ivoa.spec.0325L.

Louys, M., Tody, D., Dowler, P., Durand, D., Michel, L., Bonnarel, F., Micol, A. and IVOA DataModel Working Group (2017), 'Observation Data Model Core Components, its Implementation in the Table Access Protocol Version 1.1', IVOA Recommendation 09 May 2017. doi:10.5479/ADS/bib/2017ivoa.spec.0509L, https://ui.adsabs.harvard.edu/abs/2017ivoa.spec.0509L.

Nebot, A., Bonnarel, F., Michel, L., Louys, M. and Cresitello-Dittmar, M. (2018), 'Ivoa time series data modeling and representation', IVOA Note. http://ivoa.net/documents/Notes/.

Rots, A., Cresitello-Dittmar, M. and Laurino, O. (2022), 'Astronomical Coordinates, Coordinate Systems Version 1.0', IVOA Recommendation 04 October 2022. https://ui.adsabs.harvard.edu/abs/2022ivoa.specQ1004R.

Rots, A. H. (2007), 'Space-Time Coordinate Metadata for the Virtual Observatory Version 1.33', IVOA Recommendation 30 October 2007, arXiv:1110.0504. doi:10.5479/ADS/bib/2007ivoa.spec.1030R, https://ui.adsabs.harvard.edu/abs/2007ivoa.spec.1030R.

Rots, A. H., Bunclark, P. S., Calabretta, M. R., Allen, S. L., Manchester, R. N. and Thompson, W. T. (2015), 'Representations of time coordinates in FITS. Time and relative dimension in space', *Astronomy and Astrophysics* **574**, A36, arXiv:1409.7583. doi:10.1051/0004-6361/201424653, http://ads.ari.uni-heidelberg.de/abs/2015A%26A...574A..36R.

Solano, Enrique (2017), 'Science priorities for the ivoa', Ivoa Wiki . http://wiki.ivoa.net/twiki/bin/view/IVOA/CSPTimeSeries.

Table 6: Time extension Table Summary.

(a) Time reference frame for searching and comparing temporally sampled datasets.

t-obs attribute	Definition	VODML-ID in Coords DM	TIMESYS attribute	UCD	Units	Status
t_origin	Time frame origin	TimeOffset.time0	timeorigin	time.epoch		man
t_scale	Time frame scale	TimeFrame.timeScale	timescale	time.scale	?	man
t_refPosition	Time reference position	TimeFrame.refPosition	refposition			man
t_refDirection	Time reference direction	TimeFrame.refDirection	refdirection			man
t_format	Time representation			time;meta.code.class	null	man

(b) Sampling properties along Time axis.

Name	**Definition**	**Utype**	**UCD**	**Units**	**Status**
t_variant	sub product attached to a time stamp		meta.code.class		opt
t_exp_min	minimal length of time sample (min integration time)	Char.TimeAxis.Sampling.Extent.loLim	time.duration; obs.sequence;stat.min	s	man
t_exp_max	maximal length of time sample (max integration time)	Char.TimeAxis.Sampling.Extent.hiLim	time.duration; bs.sequence;stat.max	s	man
t_delta_min	minimal length of time interval cadence (min)	Char.TimeAxis.Sampling.Period.loLim	time.interval; obs.sequence;stat.min	s	man
t_delta_max	maximal length of time interval cadence (max)	Char.TimeAxis.Sampling.Period.hiLim	time.interval; obs.sequence;stat.max	s	man
t_fold_period	folding period length		time.period	d	man
t_fold_phaseReference	time stamp of folding start in time series		meta.ref; time.phase	d	opt

A Recognized time scales

Table 7: Recognized time scale values.
Table reference for time scales : Table 2, p17 in Space-Time Coordinate Metadata for the Virtual Observatory Version 1.33

Parameter	**Explanation**
TAI	(International Atomic Time) atomic time standard maintained on the rotating geoid
TT	(Terrestrial Time; IAU standard) defined on the rotating geoid, usually derived as TAI + 32.184 s
TDT	(Terrestrial Dynamical Time) synonym for TT (deprecated)
ET	(Ephemeris Time) continuous with TT; should not be used for data taken after 1984-01-01
IAT	synonym for TAI (deprecated)
UT1	(Universal Time) Earth rotation time
UTC	(Universal Time, Coordinated; default) runs synchronously with TAI, except for the occasional insertion of leap seconds intended to keep UTC within 0.9 s of UT1; as of 2012-07-01 UTC = TAI - 35 s
GMT	(Greenwich Mean Time) continuous with UTC; its use is deprecated for dates after 1972-01-01
UT()	(Universal Time, with qualifier) for high-precision use of radio signal distributions between 1955 and 1972; see Sect. A.9
GPS	(Global Positioning System) runs (approximately) synchronously with TAI; GPS $\approx$ TAI - 19 s
TCG	(Geocentric Coordinate Time) TT reduced to the geocenter, corrected for the relativistic effects of the Earth's rotation and gravitational potential; TCG runs faster than TT at a constant rate.
TCB	(Barycentric Coordinate Time) derived from TCG by a 4-dimensional transformation, taking into account the relativistic effects of the gravitational potential at the barycenter (relative to that on the rotating geoid) as well as velocity time dilation variations due to the eccentricity of the Earth's orbit, thus ensuring consistency with fundamental physical constants; Irwin & Fukushima (1999) provide a time ephemeris.
TDB	(Barycentric Dynamical Time) runs slower than TCB at a constant rate so as to remain approximately in step with TT; runs therefore quasi-synchronously with TT, except for the relativistic effects introduced by variations in the Earth's velocity relative to the barycenter; when referring to celestial observations, a pathlength correction to the barycenter may be needed which requires the Time Reference Direction used in calculating the pathlength correction.
LOCAL	for simulation data and for free-running clocks.

Table 8: Recognized time reference positions. Table reference for time position : Table 1, p15 in Space-Time Coordinate Metadata for the Virtual Observatory Version 1.33, https://www.ivoa.net/documents/REC/DM/STC-20071030.pdf

Parameter	**Explanation**
TOPOCENTER	Topocenter: the location from where the observation was made (default)
GEOCENTER	Geocenter
BARYCENTER	Barycenter of the Solar System
RELOCATABLE	Relocatable: to be used for simulation data only
CUSTOM	A position specified by coordinates that is not the observatory location
HELIOCENTER	Heliocenter
GALACTIC	Galactic center
EMBARYCENTER	Earth-Moon barycenter
MERCURY	Center of Mercury
VENUS	Center of Venus
MARS	Center of Mars
JUPITER	Barycenter of the Jupiter system
SATURN	Barycenter of the Saturn system
URANUS	Barycenter of the Uranus system
NEPTUNE	Barycenter of the Neptune system

B Query examples for join tables

C Previous work on the Time series characterization and description

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- Very initial draft initiated by D. Tody. https://wiki.ivoa.net/internal/IVOA/LightCurves/STSP.pdf
- Table reference for time position : Table 1, p15 in Space-Time Coordinate Metadata for the Virtual Observatory Version 1.33, https://www.ivoa.net/documents/REC/DM/STC-20071030.pdf
- Table reference for time scales : Table 2, p17 in Space-Time Coordinate Metadata for the Virtual Observatory Version 1.33
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D Vocabulary enhancement

https://www.ivoa.net/rdf/product-type/2024-03-22/product-type.html has evolved to clarify the various temporally-sampled datasets and their class. light-curve, velocity-curve, dynamic-spectrum, time-cube clarifies categories of time dependent data sets.

E Changes from Previous Versions

First version of this WD. No previous versions yet.