Solar System UCDs: Assessment Study of Unified Content Descriptors (UCDs) for the Solar System Resources (Planetary sciences and Heliophysics)

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1. Introduction

In the recent years, several FP7 projects have aimed at defining the building blocks of Solar System Virtual observatories, from the Sun to the planets: Europlanet (Grant 228319), HELIO (Grant 238969), IMPEx (Grant 262863). Europlanet (Planetary Sciences) and HELIO (Heliophysics) have been trying to use IVOA standards as much as possible in the data models and protocols they have selected and implemented.

Inside the Europlanet program, the IDIS (Integrated and Distributed Information System) group focused on setting up the basis of a Planetary Science Virtual Observatory. This group has developed a data model (EPN-DM) which is used to describe the services and resources that are made available. The EPN-DM is using IVOA standards. However, due to the large variety of science thematics (*Sun, planets, atmospheres, surfaces, interiors, small bodies, orbital parameters, in situ exploration, plasma (waves, particle and fields), radio astronomy...*), the IVOA standards have been sometimes extended in their allowed keyword values, and new keywords has also been forged when necessary. Solar System science also convey a large variety of data types (images, spectra, times series, movies, dynamic spectra, profiles, maps...), which also have to be described. An even larger variety of physical parameters is present (including remote data, in-situ data, laboratory experiments, field analogs).

From the beginning of the investigations, it was clear that we needed a keyword describing the "measurement type" (i.e., a generic information on the physical meaning of the parameter). The "measurement type" is already present in SPASE, which is another data model used in space plasma physics. More details are provided on the SPASE Measurement Type in Appendix 1. The SPASE group is providing a list of values, adapted to their scope, but too restrictive for the general planetary science. Furthermore, the SPASE data model has been built without interaction with IVOA, hence, there is no easy way to translate automatically between the two worlds. For EPN developments, we have chosen to keep the "measurement type" concept, but we are trying to use UCDs instead. This will be discussed in this document. We have also compare the UCDs with the Planetary Data Dictionary (from the NASA Planetary Data System [PDS]). We have set up an online tool where we store the correspondences between the SPASE, PDS and IVOA concept in terms of content descriptors: http://typhon.obspm.fr/idis/ucd.php, which includes a search interface.

As stated in the IVOA documentation, a UCD is defined as a Controlled Vocabulary for Astronomy. The concepts present in UCDs are strongly linked to astrophysics, but they can be used in a wider frame, such as planetary sciences or heliophysics. However, in many cases, when enlarging the scope of a UCD, it usually implies to modify its definition. Such modifications will be presented and discussed in this document. It is important to note that UCDs are not a data model. Indeed, there is a strong temptation from the unexperienced user to use UCDs to describe the parameters at a too refined level. We will present examples and discuss them.

NB: in all tables, ***bold face*** *UCDs are new UCDs proposed for evaluation.*

2. UCDs for Planetary Sciences

The main source for the inputs provided here were discussed within the Europlanet-RI/IDIS group. Several aspects were studied specifically: Comets and Samples, Space Physics, and Imaging and Spectroscopy. We will present this three cases separately, as they are addressing different conceptual aspects.

Case 1: Comets and Samples

The inputs for this science topic were provided by the "small body and dynamics node" (italian EPN/IDIS group). They are willing to describe cometary and samples data. They proposed a full list of new specific UCDs that cover their physical parameters. We have reviewed those propositions and proposed more generic UCDs instead. The resulting list is very restrictive, as this type of data is not present in astrophysics.

The list of descriptors can be divided into 2 series: the aspect description (usually defined by eye) and the physical description (measurements).

Table 1. List of aspect UCDs proposed for Comets and Samples.

Suggested UCDs	Proposed UCD	Note
phys.sample	src.sample;meta.code.class	related to samples collected within the solar system on Moon, Earth, Mars...
phys.sample.color	src.sample;meta.code.class	color of an object, generally assigned at eye, NOT USABLE for spectral type of stars NOR for the color index, e.g.: 'black', 'reddish'
phys.sample.luster	src.sample;meta.code.class	luster of an object, e.g.: 'pearly', 'metallic', 'vitreous'... mineralogical property, generally assigned at eye
phys.porosity	src.sample;meta.code.class	porosity percentage of the body
phys.sample.shape	src.sample;meta.code.class	shape of an object, e.g.: 'irregular', 'spherical'...
phys.sample.transparency	src.sample;meta.code.class	transparency of a solid, e.g.: 'opaque', 'translucent', 'transparent' mineralogical property, generally assigned at eye
phys.sample.dusttype	scr.sample;meta.code.class	'Cosmic dust', 'Artificial terrestrial contamination'...
phys.sample.magnetized	src.sample;phys.magField;meta.code.class	'yes', 'no', 'partially'
phys.sample.mass	src.sample;phys.mass	mass of the sample
phys.sample.parentbody	src.sample;meta.id.parent	Parent body of the sample, it can be generic or specific, very hard to recognize for dust, e.g.: 'Itokawa', 'asteroid', 'Moon'...
phys.sample.location	src.sample;pos	retrieval location of the sample, e.g.: 'Moon, Mare Serenitatis', 'Earth stratosphere, above Sahara desert', 'Interplanetary medium at 2 AU'...
phys.sample.lat	src.sample;pos.bodyrc.lat	latitude of the finding location
phys.sample.long	src.sample;pos.bodyrc.long	longitude of the finding location
phys.sample.alt	src.sample;pos.bodyrc.alt	altitude of the finding location
phys.sample.approxloc	src.sample;pos;meta.note	approximate location of the finding in the case that a precise coordinate is unavailable, e.g.: 'Mare Serenitatis', 'Sahara desert'...
phys.sample.cluster	src.sample;meta.id.parent	Eventually indicates the cluster to which the sample belongs
phys.sample.type	src.sample;meta.note	Cosmic dust', 'Artificial terrestrial contamination', 'Lunar basalt'...
phys.sample.composition	src.sample;phys.composition;meta.note	rough description of the sample's composition, e.g.: 'olivine, magnetite and glass', 'plagioclase feldspar and anorthite'...
src.id	src.sample;meta.id	Identifier of the object, e.g.: 'alpha CMa', 'Jupiter Sol-4', '2P/Encke', 'NGC 2683', it can coincide with src.name

Suggested UCDs	Proposed UCD	Note
src.name	src.sample;meta.id	Name of the object, e.g.: 'Sirius', 'Jupiter', 'Encke', 'NGC 2683', it can coincide with src.id
src.group	src.sample;meta.id.parent	group, family or dynamical class of the object, e.g.: 'Halley type comet', 'AGNII', 'Themis family asteroid'
src.asteroid	**src.asteroid**	related to asteroids
src.asteroid.family	**src.asteroid**;meta.id.parent (?)	family or group to which an asteroid belongs, e.g.: 'Hygiea', 'Themis'...
src.asteroid.specclass	**src.asteroid**;meta.code.class	spectral class of the asteroid, e.g.: 'B', 'C', 'S' ...
src.asteroid.dynclass	**src.asteroid**;meta.code.class	dynamical class of the asteroid, e.g.: 'NEO', Trojan', 'Main Belt'....
src.comet	**src.comet**	related to comets
src.comet.dynclassLev	**src.comet**;meta.code.class	dynamic class accorting to Levison, e.g.: 'External', 'Encke'...

The list presented in table 1 is rather specific to planetary or cometary samples. It is difficult to set the right level of description, as most of the physical parameters are describing the aspect of the sample, and are set "by eye". It would be possible to add a new UCD category for "samples", in which we would have a definition like "Relative to a physical sample of a body". That would cover the description of meteorites, of samples returned from space, and of in-situ geological measurements (such as the data acquired by rovers on Mars). However, the "src.sample" may be used instead. In that case, we just need to add the previous definition to that UCD. It is clear however, that many keywords will have the same UCD: "*src.sample;meta.code.class*". That may be a problem, but this should be discussed with the IVOA semantics group, in order to compare with the astrophysical concepts. A few additional UCDs are proposed here: *src.comet* and *src.asteroid*

A second list of descriptors consists in measurable physical parameters. They are listed in Table 2.

Table 2. List of measurement UCDs proposed for Comets and Samples.

Suggested UCDs	Proposed UCD	Note
phys.mol.elecband	phys.atmol.transition	electronic band of the transition
phys.mol.species	phys.atmol;meta.id	chemical species
phys.reflectance	phys.albedo	reflectance of the body
phys.size.smedAxis	**phys.size.smedAxis**	for 3d objects a third axis is necessary) linked to phys.size.smajAxis and phys.size.sminAxis
src.orbital.smajAxis	src;phys.size.smajAxis	«angSize» implies sky observation, not 3D measurement
src.orbital.TissJ	**src.orbital.TissJ**	Tisserand parameter respect to Jupiter
em.line.FeKalpha	em.line.**FeKalpha**	Fe K alpha line at 6.4 kev
em.molecline	em.line	Designation of molecular lines
em.molecline.C2	**em.line.C2**;meta.number	number of C2 lines in the observed range
em.molecline.C3	**em.line.C3**;meta.number	number of C3 lines in the observed range
em.molecline.CH	**em.line.CH**;meta.number	number of CH lines in the observed range
em.molecline.NH2	**em.line.NH2**;meta.number	number of NH2 lines in the observed range

Suggested UCDs	Proposed UCD	Note
em.molecline.CN	**em.line.CN**;meta.number	number of CN lines in the observed range

In conclusion, it is clear that we can use the UCDs for this type of science description, after a few additions. Some additions are straightforward and do not require too much discussion (e.g., adding "phys.size.smedAxis"). The list of molecular lines may be more problematic, because it opens the possibility to have a long (long!) list of possible molecules. The question should be seriously discussed, as some lines are already there, but they fit with the astrophysical needs, not the planetary science ones.

Case 2: Space Physics (i.e., plasma measurements in space)

This science case was studied by the "plasma node" (Toulouse and Meudon in France, as well as Austria). Space sciences (i.e., electromagnetic waves, electric and magnetic fields, and particle measurements in space) has been long using the SPASE data model to describe their data. We propose here a set of UCDs that should cover the needs of that community. Appendix 1 presents a study of SPASE compared to UCDs, that was done to be comprehensive. We present the list of discussed UCDs in table 3.

Table 3. List of UCDs proposed for Planetary Plasmas.

Suggested UCDs	Proposed UCD	Note
phys.count	**phys.count**	Same as *phot.count*, but not restricted to photometric measurements.
phys.particle	**phys.particle**	relative to particle physics. This UCD does not exist, although *phys.particle.neutrino* does.
phys.particle.aerosol	**phys.particle.aerosol**	This keyword is inspired by the SPASE Particle.ParticleType.Aerosol defined as: A suspension of fine solid or liquid particles in a gas.
phys.particle.alpha	**phys.particle.alpha**	This keyword is inspired by the SPASE Particle.ParticleType.Alpha defined as: A positively charged nuclear particle that consists of two protons and two neutrons.
phys.particle.atom	phys.atmol	This keyword is inspired by the SPASE Particle.ParticleType.Atom defined as: Matter consisting of a nucleus surrounded by electrons which has no net charge.
phys.particle.dust	**phys.particle.dust**	This keyword is inspired by the SPASE Particle.ParticleType.Dust defined as: Free microscopic particles of solid material.
phys.particle.electron	phys.electron	This keyword is inspired by the SPASE Particle.ParticleType.Electron defined as: An elementary particle consisting of a charge of negative electricity equal to about 1.602 x 10^(-19) Coulomb and having a mass when at rest of about 9.109534 x 10^(-28) gram.
phys.particle.ion	phys.atmol.ionstage	This keyword is inspired by the SPASE Particle.ParticleType.Ion defined as: An atom that has acquired a net electric charge by gaining or losing one or more electrons.(Note: Z>2).
phys.particle.molecule	phys.atmol	This keyword is inspired by the SPASE Particle.ParticleType.Molecule defined as: A group of atoms so united and combined by chemical affinity that they form a complete, integrated whole, being the smallest portion of any particular compound that can exist in a free state.

Suggested UCDs	Proposed UCD	Note
phys.particle.neutron	**phys.particle.neutron**	This keyword is inspired by the SPASE Particle.ParticleType.Neutron defined as: An elementary particle that has no net charge and is a constituent of atomic nuclei, and that has a mass slightly large than a proton (1.673 x 10^(-24) gram.)
phys.particle.proton	**phys.particle.proton**	This keyword is inspired by the SPASE Particle.ParticleType.Proton defined as: An elementary particle that is a constituent of all atomic nuclei, that carries a positive charge numerically equal to the charge of an electron, and that has a mass of 1.673 x 10^(-24) gram.
em.pw	**em.pw**	plasma wave part of the electromagnetic spectrum. These waves are measured locally. They are trapped below their cutoff frequencies, and cannot escape toward free-space.
phys.energy.flux	**phys.energy.flux**	to be used instead of *phot.energy.flux*, when not referring to photometry (e.g., for particles).
phys.flow	**phys.flow**	relative to flow of particle or matter
phys.gyrofrequency	phys.magfield;em.freq	The number of gyrations around a magnetic guiding center (field line) a charged particle makes per unit time due to the Lorentz force.
phys.plasmafrequency	phys.density;phys.atmol;em.freq	A number-density-dependent characteristic frequency of a plasma.
phys.heatflux	**phys.heatflux** *or* phys.energy;**phys.flow**	Flow of thermal energy through a gas or plasma; typically computed as third moment of a distribution function.
phys.phasespacedensity	**phys.density.phasespace**	The number of particles per unit volume in the six-dimensional space of position and velocity.
em.radio.50-100MHz	**em.radio.50-100MHz**	Radio between 50 and 100 MHz
em.radio.10-50MHz	**em.radio.10-50MHz**	Radio between 10 and 50 MHz
em.radio.below10MHz	**em.radio.below10MHz**	Radio below 10 MHz

The question of having UCDs for describing the energy bands for particle (electrons, ions or neutral) measurements in terms of ranges in eV, keV or MeV, similarly to what is done with the em group. The same applies for mass spectroscopy, in atomic mass unit [amu]), as well as in mass per charge units. It seems that we don't want to put this type of information in UCDs (that would lead to a large increase of the allowed keywords) but there is a need to differentiate at least low energy (below 100 eV, TBC), middle energy (100 eV to 100 keV, TBC) and high energy (above 100 keV, TBC) particle in a magnetospheric context.

Case 3: Imaging and Spectroscopy

Inputs for this section were collected from the LESIA group (Meudon, France). A set of new UCDs was proposed, and studied in order to see how each of them could be described with existing UCDs. The studied list is presented in Table 4.

Table 4. List of UCDs proposed for Imaging and Spectroscopy.

Suggested UCDs	Proposed UCD	Note
em.UV.EUV	**em.UV.EUV**	next to *em.UV.FUV*
em.band	**em.line.band**	similarly to em.line, but for molecular bands
em.band.CH4	**em.line.band.CH4**	relative to CH4 molecular bands
em.band.H2O	**em.line.band.H2O**	relative to H2O molecular bands

Suggested UCDs	Proposed UCD	Note
em.band.CO2	**em.line.band.CO2**	relative to CO2 molecular bands
meta.id.coPI	**meta.id.coPI**	Name of Co-Principal-Investigator
meta.processed	**meta.processed**	obtained through a processing pipeline
meta.derived	**meta.derived**	obtained from a combination of observation and/or models
em.molecline.rotation	em.line;phys.mol.rotation	
em.molecline.vibration	em.line;phys.mol.vibration	
obs.calib.dark	**obs.calib.dark**	next to *obs.calib.flat*
phot.radiance	**phot.radiance**	
phot.reflectance	phys.albedo	
pos.occult	**pos.limb;obs.occult**	
src.orbital.smajAxis	src.orbital;phys.size.smajAxis	
src.orbital.sminAxis	src.orbital;phys.size.sminjAxis	
src.orbital.number	**src.orbital.number**	number of the current revolution
time.period.number	**time.period.number**	number of the current rotation, e.g., day number on Earth

The problem of molecular lines also arises from this study, as in case 1. Some propositions are rather generic and may be included easily (meta.id.coPi, meta.processed, meta.derived, obs.calib.dark...).

3. UCDs for Solar and Heliophysics

Inputs in this section were collected by the HELIO project (many groups in Europe). Very few UCDs were proposed for addition, and are listed in Table 5.

Table 5. List of UCDs proposed for Solar and Heliophysics.

Suggested UCDs	Proposed UCD	Note
time.period.number	**time.period.number**	number of the current rotation, e.g., day number on Earth, or the number of carrington rotation of the Sun
instr.obsty.experiment	**instr.obsty.experiment**	relative to the instrument suite (experiment) in which the instrument is place. This is a usual description in space borne instrumentation.
pos.heliographic	**pos.heliographic**	centered on the center of the sun as seen from observer

It is noticeable that one of the few UCDs proposed here is also proposed in case 3 (time.period.number).

4. Discussion

Although it is an ongoing work, and more use cases will help us to propose a complete set of UCDs, it is clear that the current UCDs list is more or less acceptable, to a few additions. There are two big questions that have to be addressed. The first is the way to describe atomic and molecular

bands. If we follow the path outlined in the current version of UCDs, it is clear that the number of UCDs will grow very fast, in order to include all observed species and molecules (a lot in planetary sciences). The same type problem arises with the low frequency electromagnetic spectrum (not included below 100 MHz), and for mass spectroscopy and particle physics experiments. The second issue is linked to empirical descriptions of data (e.g., qualifiers determined "by eye"), as described in Case 1. The natural trend (consistent with current use of UCDs) would be to describe them as "*meta.code.class*" (or similar), but then all are described the same way, without any possibility to differentiate them at the UCD level.

While building UCDs, we also realized that there is a temptation to use them as a data model. This is not intended, but is difficult to be restrained by newcomers to UCDs.

Finally, it is worth emphasizing that we did not identify the need for a new "main category".

Appendix 1. SPASE metadata for measurement description

In the SPASE data model, there are various keywords that can be mapped to UCDs: Field Type, Measurement Type, Particle Type, Quantity, Qualifier, Spectral Range, Wave Type.

The definition of these concepts in SPASE are presented below:

SPASE-DM Concept	Definition of Concept	Allowed values if applicable (+ links to SPASE dict.)	Possible UCD equivalent
Field	The space around a radiating body within which its electromagnetic attributes can exert force on another similar body that is not in direct contact.	N/A	N/A
Field Type	The physical attribute of the field.	Current	phys.electron;phys.flow
		Electric	phys.elecField
		Electromagnetic	em
		Gyrofrequency	phys.magfield;em.freq
		Magnetic	phys.magField
		Plasma Frequency	phys.density;phys.electron;em.freq
		Potential	**phys.potential**
		Poynting Flux	phys.energy.flux
Measurement Type	A characterization of the quantitative assessment of a phenomenon.	Activity Index	meta.code;phys.magfield
		Dopplergram	phys.veloc
		Dust	**phys.particle.dust**
		Electric Field	phys.elecField
		Energetic Particles	**phys.particle**
		Ephemeris	pos.bodyrc
		Image Intensity	phot
		Instrument Status	instr.setup;meta.code.status
		Ion Composition	phys.atmol.ionStage

SPASE-DM Concept	Definition of Concept	Allowed values if applicable (+ links to SPASE dict.)	Possible UCD equivalent
		Irradiance	phot.flux
		Magnetic Field	phys.magField
		Magnetogram	phys.magField
		Neutral Atom Images	phys.atmol
		Neutral Gas	phys.atmol
		Profile	N/A
		Radiance	phot.flux.density
		Spectrum	N/A
		Thermal Plasma	phys.particle
		Waves	em.radio *or* **em.pw**
		Waves.Active	N/A
		Waves.Passive	N/A
Mixed	A parameter derived from more than one of the type of parameter. For example, plasma beta, the ratio of plasma particle energy density to the energy density of the magnetic field permeating the plasma, is "mixed."	N/A	N/A
Mixed Quantity	A characterization of the combined attributes of a quantity.	Akasofu Epsilon	phys.energy.flux;meta.code
		Alfven Mach Number	arith.ratio;phys.veloc
		Alfven Velocity	phys.magfield;phys.veloc
		Frequency-To-Gyrofrequency Ratio	arith.ratio;em.freq
		Magnetosonic Mach Number	arith.ratio;phys.veloc
		Other	N/A
		Plasma Beta	arith.ratio;phys.pressure;phys.magField
		Total Pressure	phys.pressure
		V Cross B	phys.elecField
Particle	A description of the types of particles observed in the measurement. This includes both direct observations and inferred observations.	N/A	**phys.particle**
Particle Quantity	A characterization of the physical properties of the particle.	Arrival Direction	pos.bodyrc
		Atomic Number Detected	phys.atmol.number
		Average Charge State	stat.mean;phys.atmol.ionstage; meta.number
		Charge State	phys.atmol.ionstage;meta.number
		Count Rate	arith.rate;phys.count
		Counts	phys.count
		Energy	phys.energy
		Energy Density	phys.energy.density

SPASE-DM Concept	Definition of Concept	Allowed values if applicable (+ links to SPASE dict.)	Possible UCD equivalent
		Energy Flux	phys.energy.flux
		Flow Speed	phys.flow;phys.veloc
		Flow Velocity	phys.flow;phys.veloc
		Gyrofrequency	phys.magfield;em.freq
		Heat Flux	**phys.heatflux**
		Mass	phys.mass
		Mass Density	phys.density;phys.mass
		Mass Number	phys.atmol.number
		Number Density	phys.density;meta.number
		Number Flux	**phys.flux**;meta.number
		Phase-Space Density	**phys.density.phasespace**
		Plasma Frequency	phys.density;phys.atmol;em.freq
		Pressure	phys.pressure
		Sonic Mach Number	arith.ratio;phys.veloc
		Sound Speed	phys.veloc
		Temperature	phys.temperature
		Thermal Speed	phys.veloc;phys.temperature
		Velocity	phys.veloc
Qualifier	Characterizes the refinement to apply to a type or attribute of a quantity.	Anisotropy	
		Array	
		Average	stat.mean
		Characteristic	
		CircularColumn	
		Component	
		Component.I	
		Component.J	
		Component.K	
		Cross Spectrum	
		Deviation	
		Differential	arith.diff
		Direction	
		Direction Angle	
		Direction Angle.Azimuth Angle	
		Direction Angle.Elevation Angle	
		Direction Angle.Polar Angle	
		Field-Aligned	

SPASE-DM Concept	Definition of Concept	Allowed values if applicable (+ links to SPASE dict.)	Possible UCD equivalent
		Fit	
		Group	
		Integral	
		Integral.Area	
		Integral.Bandwidth	
		Integral.Solid Angle	
		Line Of Sight	
		Linear	
		Magnitude	
		Moment	
		Parallel	
		Peak	
		Perpendicular	
		Phase	
		Phase Angle	
		Projection	
		Projection.IJ	
		Projection.IK	
		Projection.JK	
		Pseudo	
		Ratio	arith.ratio
		Scalar	
		Spectral	
		Standard Deviation	
		Stoke's Parameters	
		Symmetric	
		Tensor	
		Total	
		Trace	
		Uncertainty	
		Variance	
		Vector	
Spectral Range	The general term used to describe wavelengths or frequencies within a given span of values for those quantities.	Ca-K	**em.line.CaK**
		Extreme Ultraviolet	**em.UV.EUV**
		Far Ultraviolet	em.UV.FUV
		Gamma Rays	em.gamma

SPASE-DM Concept	Definition of Concept	Allowed values if applicable (+ links to SPASE dict.)	Possible UCD equivalent
		H-alpha	em.line.Halpha
		Hard X-rays	em.X-ray.hard
		He-10830	**em.line.He-10830**
		He-304	**em.line.He-304**
		Infrared	em.IR
		K-7699	**em.line.K-7699**
		LBH Band	**em.line.LBH**
		Microwave	em.mm
		Na-D	**em.line.NaD**
		Ni-6768	**em.line.Ni-6768**
		Optical	em.opt
		Radio Frequency	em.radio or **em.pw**
		Soft X-Rays	em.X-ray.soft
		Ultraviolet	em.UV
		White-Light	em.opt
		X-Rays	em.X-ray
Wave	Periodic or quasi-periodic (AC) variations of physical quantities in time and space, capable of propagating or being trapped within particular regimes.	N/A	em.radio or **em.pw**
Wave Type	A characterization of the carrier or phenomenon of wave information observed by the measurement.	Electromagnetic	phys.elecField;phys.magField
		Electrostatic	phys.elecField
		Hydrodynamic	
		MHD	
		Photon	phot
		Plasma Waves	**em.pw**
Wave Quantity	A characterization of the physical properties of a wave.	Absorption	phys.absorption
		AC-Electric Field	phys.elecField
		AC-Magnetic Field	phys.magField
		Doppler Frequency	em.freq;phys.veloc
		Emissivity	phys.emissivity
		Energy Flux	**phys.energy.flux**
		Equivalent Width	spect.line.eqWidth
		Frequency	em.freq
		Gyrofrequency	phys.magfield;em.freq
		Intensity	phys.energy.density (?)
		Line Depth	**spect.line.depth**

SPASE-DM Concept	Definition of Concept	Allowed values if applicable (+ links to SPASE dict.)	Possible UCD equivalent
		Magnetic Field	phys.magField
		Mode Amplitude	src.var.amplitude
		Plasma Frequency	phys.density;phys.electron;em.freq
		Polarization	phys.polarization
		Poynting Flux	phys.energy.flux
		Propagation Time	time.duration
		Stoke's Parameters	phys.polarization
		Velocity	phys.veloc
		Wavelength	em.wl

These metadata can't all be mapped to UCDs. Some of them are referring to the physical quantity. These keywords can be linked to UCDs. Some other are describing the organization of the data (mainly in the *Measurement Type* concept).

Appendix 2. UCDs used to describe AMDA (Automated Multi Data Analysis) tool datasets

In order to prepare the EPN-TAP interface to the AMDA database at CDPP (Toulouse), we have selected UCDs for all datasets of that database. The following table provides the list of these UCDs, with the name, definition and unit (when available) of the described parameters.

UCD	Name	Description	Unit
instr.setup;pos.posAng	angle	Angular position of the actuator	deg
meta.code	method	method code	none
	scan_mode	Scan mode	none
meta.code;instr.setup	telemetry_mode	Telemetry mode	
meta.code;phys.magField	Kp	Kp Geomagnetic index	no
meta.code.qual;phys.magField	quality_MAG	MAG quality flag	0:B_inside
	quality_PLA	PLA quality flag	0:corrected_by_PLA
meta.code.qual	el_density_contrast	Electron density contrast	no
	scan_flag	Scan quality flag	
meta.code.qual;phys.atmol.ionStage	moments_quality_heavy	Heavy ion moment quality flag	0-1
	moments_quality_protons	Proton moment quality flag	0-1
phot.flux;em.UV	flux_earth	EUV flux from Earth direction	sfu
	flux_mars	EUV flux from Mars direction	sfu
phys.abund	sw_alpha_ratio	Solar Wind alpha ratio	no
phys.count	sunspot_nb	Sunspot Number	no
phys.count;phys.atmol.ionStage	electrons_e4	energy-time spectrogram of ion counts for the E4 detector	count
	heavy_ions	energy-time spectrogram of heavy ion counts	counts
	ions_p2	energy-time spectrogram of ion counts for the P2 detector	count
	ions_p4	energy-time spectrogram of ion counts for the P4 detector	count
	ions_p6	energy-time spectrogram of ion counts for the P6 detector	count

UCD	Name	Description	Unit
	ions_spectra	Spin averaged energy-time spectrogram of ion counts	counts
	protons	energy-time spectrogram of proton counts	counts
phys.count;phys.atmol.ionStage;arith.rate	spectra_anode_1	Energy-time spectrogram of ion count rates observed by anode 1	count/s
	spectra_anode_2	Energy-time spectrogram of ion count rates observed by anode 2	count/s
	spectra_anode_3	Energy-time spectrogram of ion count rates observed by anode 3	count/s
	spectra_anode_4	Energy-time spectrogram of ion count rates observed by anode 4	count/s
	spectra_anode_5	Energy-time spectrogram of ion count rates observed by anode 5	count/s
	spectra_anode_6	Energy-time spectrogram of ion count rates observed by anode 6	count/s
	spectra_anode_7	Energy-time spectrogram of ion count rates observed by anode 7	count/s
	spectra_anode_8	Energy-time spectrogram of ion count rates observed by anode 8	count/s
phys.count;phys.electron	spectra	Averaged energy-time spectrogram of electron counts	counts
phys.count;phys.electron;arith.rate	spectra_anode_1	Energy-time spectrogram of electron count rates observed by anode 1	count/s
	spectra_anode_2	Energy-time spectrogram of electron count rates observed by anode 2	count/s
	spectra_anode_3	Energy-time spectrogram of electron count rates observed by anode 3	count/s
	spectra_anode_4	Energy-time spectrogram of electron count rates observed by anode 4	count/s
	spectra_anode_5	Energy-time spectrogram of electron count rates observed by anode 5	count/s
	spectra_anode_6	Energy-time spectrogram of electron count rates observed by anode 6	count/s
	spectra_anode_7	Energy-time spectrogram of electron count rates observed by anode 7	count/s
	spectra_anode_8	Energy-time spectrogram of electron count rates observed by anode 8	count/s
phys.density;arith.ratio;phys.atmol.ionStage	he2+_h_ratio	He2+ to H ratio	
phys.density;phys.atmol.ionStage	density	Electron density (preliminary data)	cm-3
	density	Electron density (final data)	cm-3
	density	Oxygen ion density	cm-3
	density	Solar wind density	cm-3
	density	Density	cm-3
	density_alpha	Density of Alpha Particle	cm-3
	density_heavy	Heavy ion density	cm-3
	density_proton	Density of Protons	cm-3
	density_protons	Proton density	cm-3
	h_density	proton density	cm-3
	ions_density	Ion density	1/cm^3
	Ni	Ion density	cm-3
	o_density	Density of Oxygens	cm-3
	sw_dens	Solar Wind density	cm-3
phys.density;phys.electron	density	Electron density calculated by integration technique	m-3
	density	Density	cm-3
	density_elec	electronic density	cm-3

UCD	Name	Description	Unit
	density:tot,core,halo	Total Electron density	cm-3
	el_density	electronic density	cm-3
	elec_density	Electron Density	cm-3
	electrons_flux_int	Integrated Electron Flux	cm-2.s-1.sr-1
	Ne	Electron density	cm-3
	tec	Total electron Content	cm-2
phys.density;phys.electron;stat.max	Ne_max	maximum electron density	cm-3
phys.density;phys.electron;stat.min	Ne_min	minimum electron density	cm-3
phys.density.phaseSpace	PAD_250eV	Phase Space Density at 250 eV	s3/km6
phys.elecField	e_dusk	Dusk electric field	mV/m
	e_gse	Electric field in GSE coordinates	mV/m
	e_sr2	Electric field	mV/m
	sw_electric_field	Solar Wind electric field	mV/m
phys.flux;phys.atmol.ionStage	alphas_flux_int	Integrated Alpha Flux	cm-2.sr-1.s-1
phys.flux;phys.count;phys.atmol.ionStage	protons_flux_int	Integrated Proton Flux	cm-2.s-1.sr-1
phys.flux.density;em.radio	skr_total_power_emitted	SKR total emitted power	W/sr
phys.flux.density;phys.count;phys.atmol.ionStage	alphas_flux_dif	Differential Alpha Flux	cm-2.sr-1.s-1.MeV-1
	diff_flux	particle Differential	1/cm^2_sr_s_keV
	proton_flux	Proton flux	counts/(s*(keV/e)*cm**2*sr)
	protons_flux_dif	Differential Proton Flux	cm-2.s-1.sr-1.MeV-1
phys.flux.density;phys.count;phys.electron	diff_flux	particle Differential flux	1/cm^2_sr_s_keV
	e_flux	Electron flux	cm-2 s-1 ster-1 eV-1
	electrons_flux_dif	Differential Electron Flux	cm-2.sr-1.s-1.MeV-1
phys.flux.density;phys.elecField	e_spectral_density_F1	electric spectral density in channel F1	(V/m)^2/Hz
	e_spectral_density_F2	electric spectral density in channel F2	(V/m)^2/Hz
	e_spectral_density_F3	electric spectral density in channel F3	(V/m)^2/Hz
	elec_density	Electric field spectral power density	V**2/m**2/Hz
phys.flux.density;phys.energy;phys.atmol.ionStage	ion_spectra	ion energy spectrum	eV/(cm^2-s-sr-eV)
phys.flux.density;phys.energy;phys.electron	elec_spectra	electron energy spectrum	eV/(cm^2-s-sr-eV)
phys.flux.density;phys.magField	b_spectral_density_F1	magnetic spectral density in channel F1	nT^2/Hz
	b_spectral_density_F2	magnetic spectral density in channel F2	nT^2/Hz
	b_spectral_density_F3	magnetic spectral density in channel F3	nT^2/Hz
	mag_density	magnetic field spectral power density	nT**2/Hz
phys.flux.density;phys.polarization.circular.LL;phys.elecField;em.radio	skr_flux_LH	SKR flux densities in Left-Hand Circular polarization	W/m2/Hz
phys.flux.density;phys.polarization.circular.RR;phys.elecField;em.radio	skr_flux_RH	SKR flux densities in Right-Hand Circular polarization	W/m2/Hz
phys.heatflux;phys.atmol.ionStage	heat_flux_gse	Heat flux of ions in GSE coordinates	microW/m^2
phys.heatflux;phys.electron	Qe_b	Heat flux of electrons in local magnetic coordinates	erg/sec/cm2
	Qe_rtn	Heat flux of electrons in RTN coordinates	erg/sec/cm2
phys.magField	|b|	magnitude of Magnetic Field	
	b_areographic	Magnetic field vector components in aerographic coordinates	nT
	b_calc	Local Magnetic Field magnitude	nT
	b_cphio	Magnetic field vector components in Callisto-centered Phi-Omega coordinates	nT

UCD	Name	Description	Unit
	b_csprh	Magnetic field vector components in Callisto-centered spherical coordinates	nT
	b_ephio	Magnetic field vector components in Europa-centered Phi-Omega coordinates	nT
	b_eq	Equatorial Magnetic Field magnitude	nT
	b_esprh	Magnetic field vector components in Europa-centered spherical coordinates	nT
	b_gphio	Magnetic field vector components in Ganymede-centered Phi-Omega coordinates	nT
	b_gse	Magnetic field vector components in GSE coordinates and magnitude	nT
	b_gsm	magnetic fiel in GSM coordinates	nT
	b_gsprh	Magnetic field vector components in Ganymede-centered spherical coordinates	nT
	b_iphio	Magnetic field vector components in Io-centered Phi-Omega coordinates	nT
	b_irc	Magnetic field vector components in IRC coordinates	nT
	b_isprh	Magnetic field vector components in Io-centered spherical coordinates	nT
	b_jg	magnetic field in jovigraphic coordinates	nT
	b_jse	Magnetic field vector components in JSE coordinates	nT
	b_jsm	Magnetic field vector components in JSM coordinates	nT
	b_krtp	Magnetic field vector components in KRTP coordinates	nT
	b_ksm	Magnetic field vector components in KSM coordinates	nT
	b_kso	Magnetic field vector components in KSO coordinates	nT
	b_mag	Magnetic field vector magnitude	nT
	b_mag	Magnetic field magnitude	nT
	b_mag	Magnetic field intensity	nT
	b_mbf	Magnetic field vector components in MBF coordinates	nT
	b_mso	Magnetic field vector components in MSO coordinates	nT
	b_nls	Magnetic field vector components in NLS coordinates	nT
	b_rtn	Magnetic field vector components in RTN coordinates	nT
	b_rtn	Magnetic Field in RTN coordinates	nT
	b_sc	Magnetic field vector components in SpaceCraft coordinates	nT
	b_sys3	Magnetic field vector components in SYS3 coordinates	nT
	b_sys3	Magnetic field vector components in System III coordinates	nT
	b_sys3	Magnetic Field in System III coordinates	nT
	b_u1	Magnetic field vector components in U1 coordinates	nT
	b_vso	Magnetic field vector components in VSO coordinates	nT
	bmag_strength	magnetic field strength	nT
	bmod	magnetic field vector modulus	nT
	bz_sc	Magnetic field Z-component in SpaceCraft coordinates	nT
	I	Integral Magnetic Invariant I	

UCD	Name	Description	Unit
	imf_average_magn	average interplanetary magnetic field magnitude	nT
	imf_average_vec_magn	average interplanetary magnetic field vector magnitude	nT
	imf_gse	interplanetary magnetic field in GSE coordinates	nT
	sym_d	??	nT
	sym_h	??	nT
phys.mass;phys.atmol.ionStage	Mi	Ion mass	amu
phys.polarization.circular;phys.elecField;em.radio	skr_polarisation	SKR Circular polarization degree	
phys.potential;phys.elecField;instr.obsty	potential	electric potential	V
	s/c potential	Spacecraft electric potential	V
	SC_Pot	Spacecraft potential	V
	sc_pot	Spacecraft potential	V
	Usc	Spacecraft Potential	V
phys.pressure	pdyn	Dynamic pressure	Pa
phys.pressure;arith.ratio	sw_beta	Solar Wind plasma beta ratio	no
phys.pressure;phys.atmol.ionStage	pres_xx_gse	XX component of the ion pressure tensor in GSE coordinates	nPa
	pres_yy_gse	YY component of the ion pressure tensor in GSE coordinates	nPa
	pres_zz_gse	ZZ component of the ion pressure tensor in GSE coordinates	nPa
	pressure	pressure	nPa
	sw_ram_pressure	solar wind ram pressure	nPa
phys.pressure;phys.electron	pres_xx_gse	XX component of the electron pressure tensor in GSE coordinates	nPa
	pres_yy_gse	YY component of the electron pressure tensor in GSE coordinates	nPa
	pres_zz_gse	ZZ component of the electron pressure tensor in GSE coordinates	nPa
phys.temperature	t_sc_yy_zz	Temperature	eV
phys.temperature;phys.atmol.ionStage	h_temperature	proton temperature	eV
	ions_temperature	Ion temperature	eV
	sw_temp	solar wind temperature	K
	t_heavy	Heavy ion temperature	eV
	T_para	Parallel to the magnetic field oxygen ion temperature	eV
	T_perp	Perpendicular to the magnetic field oxygen ion temperature	eV
	t_protons	Proton temperature	eV
	t_radial	radial temperature	eV
	temp_par	parallel to the magnetic field temperature	eV
	temp_perp	perpendicular to the magnetic field temperature	eV
	temp_proton	proton temperature	eV
	temperature	Temperature	eV
	temperature	Solar wind temperature	K
phys.temperature;phys.atmol.ionStage;arith.ratio	T_ratio	Oxygen ion temperature anisotropy	
phys.temperature;phys.electron	T	Electron temperature calculated by integration technique	eV
	Tc	Electron core temperature	K
	Te	Electron Temperature	eV
	Te_b	Electron Temperature	eV

UCD	Name	Description	Unit
	temp_elec	Electron Temperature	K
	temperature	Temperature	eV
	temperature_par	parallel electronic temperature	eV
	temperature_perp	perpendicular electronic temperature	eV
	temperature_tot	total electron temperature	eV
	temperature_core	electron temperature of the core	eV
	temperature_halo	electron temperature of the halo	eV
phys.temperature;phys.electron;stat.max	Tc_max	Electron core temperature max	K
phys.temperature;phys.electron;stat.min	Tc_min	Electron core temperature min	K
phys.veloc;arith.ratio	sw_mach_alfven	solar Wind alfvenic Mach number	no
phys.veloc;phys.atmol.ionStage	|v|	velocity magnitude	km/s
	h_v_gse	proton volecity in GSE coordinates	km/s
	plasma_velocity	Ion bulk velocity components in SpaceCraft coordinates	km.s-1
	plasma_velocity_mag	Ion bulk velocity magnitude	km.s-1
	sw_v_bulk	solar Wind bulk velocity	km/s
	sw_v_gse	solar Wind velocity in GSE coordinates	km/s
	v_bulk	Bulk Velocity	km/s
	v_gse	solar wind Velocity in GSE coordinates	km/s
	v_krtp	Oxygen ion bulk velocity components in KRTP coordinates	km/s
	v_mag	Solar wind bulk velocity	km/s
	v_mag	Solar wind bulk velocity magnitude	km/s
	v_mso_heavy	Heavy ion bulk velocity components in MSO coordinates	km/s
	v_mso_protons	Proton bulk velocity components in MSO coordinates	km/s
	v_rtn	proton velocity in RTN coordinates	km/s
	v_rtn	Solar wind velocity components in RTN coordinates	km/s
	v_sc	Oxygen ion bulk velocity magnitude	km/s
	v_thermal	thermal velocity	km/s
	v_vso_heavy	Heavy ion bulk velocity components in VSO coordinates	km/s
	v_vso_protons	Proton bulk velocity components in VSO coordinates	km/s
	v_xyz	velocity in cartesian coordinates	km/s
	Vdi	Ion drift velocity	km.s-1
	vmod	velocity magnitude	km/s
phys.veloc;phys.electron	v_gse	electron bulk velocity in GSE coordinates	km/s
	v_par_gse	electron parallel velocity	km/s
	v_perp_gse	electron perpendicular velocity	km/s
pos.angDistance;instr.setup	rotor_declination	Rotor Declination	rad
pos.angDistance;phys.magField	Alpha	Local pitch angle	deg
	Alpha_Eq	Equatorial pitch angle	deg
pos.angDistance;phys.veloc;phys.atmol.ionStage	vel_N/S_angle	N/S Orientation angle of the velocity vector	degrees
pos.angDistance;pos.bodyrc.long	IoPhase	Callisto Phase relative to Io	deg
	IoPhase	Europa Phase relative to Io	deg
	IoPhase	Ganymede Phase relative to Io	deg
	IoPhase	Galileo Phase relative to Io	deg

UCD	Name	Description	Unit
	IoPhase	Io Phase relative to Io	deg
	IoPhase	Io Phase	deg
	IoPhase	Io Phase	deg
pos.angDistance;pos.heliocentric.long	dPhi	Longitudinal separation between Jupiter and Earth	degrees
	dPhi	Longitudinal separation between Saturn and Earth	degrees
pos.az.zd	solar_zenith_angle	Solar Zenith Angle	deg
pos.bodyrc	phobos_xyz_mso	Phobos orbital data in MSO coordinates	Rm
	polar_areographic	Mars Global Surveyor trajectory in polar aerographic coordinates	Rm
pos.bodyrc;instr.obsty	xyz_cphio	Galileo trajectory coordinates in CPIO coordinates	Rca
	xyz_ephio	Galileo trajectory coordinates in EPIO coordinates	Reu
	xyz_eqt	Cassini cartesian coordinates in the Jovian equatorial system (in Jovian radii)	Rj
	xyz_eqt	Galileo spacecraft trajectory in JSE coordinates	Rj
	xyz_gphio	Galileo trajectory coordinates in GPIO coordinates	Rga
	xyz_iphio	Galileo trajectory coordinates in IPIO coordinates	Rio
	xyz_ksm	Cassini cartesian coordinates in the Kronian equatorial system (in Saturn radii)	Rs
	xyz_mbf	MESSENGER trajectory in MBF coordinates	km
	xyz_mso	MESSENGER trajectory in MSO coordinates	km
	xyz_spin_axis_vso	Spin axis coordinates in VSO coordinates	
	xyz_vso	MESSENGER trajectory in VSO coordinates	km
pos.bodyrc;pos.cartesian	deimos_xyz_mso	Deimos orbital data in MSO coordinates	Rm
pos.bodyrc.alt	Alt	Altitude (in Titan radii)	Rt
	altitude	Distance from Venus surface (altitude)	km
	lat	Callisto Latitude (relative to Jovian equator)	deg
	lat	Cassini latitude (from Saturn equatorial plane)	deg
	lat	Dione latitude (from Saturn)	deg
	lat	Enceladus latitude (from Saturn equatorial plane)	deg
	lat	Europa Latitude (relative to Jovian equator)	deg
	lat	Ganymede Latitude (relative to Jovian equator)	deg
	lat	Galileo Latitude (relative to Jovian equator)	deg
	lat	Io Latitude (relative to Jovian equator)	deg
	lat	Mimas latitude (from Saturn equatorial plane)	deg
	lat	Planetographic latitude of the spacecraft	deg
	lat	Rhea latitude (from Saturn equatorial plane)	deg
	lat	Tethys latitude (from Saturn equatorial plane)	deg
	lat	Titan latitude (from Saturn equatorial plane)	deg
	lat	Latitude	deg
pos.bodyrc.lat;instr.obsty	lat	Latitude	deg
	lat_csprh	Galileo latitude in CSPRH coordinates	deg
	lat_esprh	Galileo latitude in ESPRH coordinates	deg
	lat_gsprh	Galileo latitude in GSPRH coordinates	deg
	lat_isprh	Galileo latitude in ISPRH coordinates	deg
	lat_sys3	Galileo latitude in System 3 coordinates system	deg
	lat_sys3	Galileo latitude in System III coordinates	deg
	latitude_rtn	MESSENGER solar latitude	deg
pos.bodyrc.lat;phys.magField	Mlat	Callisto invariant Magnetic Latitude	deg

UCD	Name	Description	Unit
	Mlat	Europa invariant Magnetic Latitude	deg
	Mlat	Ganymede invariant Magnetic Latitude	deg
	Mlat	Galileo invariant Magnetic Latitude	deg
	Mlat	Io invariant Magnetic Latitude	deg
pos.bodyrc.lat;phys.magField;instr.obsty	MLat	invariant magnetic latitude	deg
	Mlat	Magnetic Latitude	deg
pos.bodyrc.long	lon	Callisto Longitude (in System III jovian longitude)	deg
	lon	Europa Longitude (in System III jovian longitude)	deg
	lon	Ganymede Longitude (in System III jovian longitude)	deg
	lon	Galileo Longitude (in System III jovian longitude)	deg
	lon	Io Longitude (in System III jovian longitude)	deg
	lon_IAU	Cassini Longitude around Saturn (relative to the IAU period)	deg
	lon_IAU	Dione Longitude around Saturn (relative to the IAU period)	deg
	lon_IAU	Enceladus Longitude around Saturn (relative to the IAU period)	deg
	lon_IAU	Mimas Longitude around Saturn (relative to the IAU period)	deg
	lon_IAU	Rhea Longitude around Saturn (relative to the IAU period)	deg
	lon_IAU	Tethys Longitude around Saturn (relative to the IAU period)	deg
	lon_IAU	Titan Longitude around Saturn (relative to the IAU period)	deg
	lon_SLS3	Dione Longitude around Saturn (relative to the SLS3 period)	deg
	lon_SLS3	Enceladus Longitude around Saturn (relative to the SLS3 period)	deg
	lon_SLS3	Mimas Longitude around Saturn (relative to the SLS3 period)	deg
	lon_SLS3	Rhea Longitude around Saturn (relative to the SLS3 period)	deg
	lon_SLS3	Tethys Longitude around Saturn (relative to the SLS3 period)	deg
	lon_SLS3	Titan Longitude around Saturn (relative to the SLS3 period)	deg
	lon_SLS4_North_SC	Northern SLS4 sub-spacecraft Longitude	deg
	lon_SLS4_North_Solar	Northern SLS4 sub-solar Longitude	deg
	lon_SLS4_South_SC	Southern SLS4 sub-spacecraft Longitude	deg
	lon_SLS4_South_Solar	Southern SLS4 sub-solar Longitude	deg
	LT	Callisto Local Time	h
	LT	Dione Local Time	h
	LT	Enceladus Local Time	h
	LT	Europa Local Time	h
	LT	Ganymede Local Time	h
	LT	Galileo Local Time	h
	LT	Io Local Time	h
	LT	Mimas Local Time	h
	LT	Rhea Local Time	h
	LT	Tethys Local Time	h
	LT	Titan Local Time	h
pos.bodyrc.long;instr.obsty	lon	Longitude	deg

UCD	Name	Description	Unit
	lon_csprh	Galileo longitude in CSPRH coordinates	deg
	lon_east	Planetographic east longitude of the spacecraft	deg
	lon_east_sys3	Galileo east-longitude to Jupiter in System 3 coordinates system	deg
	lon_east_sys3	Galileo east-longitude in System III coordinates	deg
	lon_esprh	Galileo longitude in ESPRH coordinates	deg
	lon_gsprh	Galileo longitude in GSPRH coordinates	deg
	lon_IAU	Longitude IAU	deg
	lon_isprh	Galileo longitude in ISPRH coordinates	deg
	lon_SLS3	Cassini Longitude around Saturn (relative to the SLS3 period)	deg
	lon_west_sys3	Galileo west-longitude to Jupiter in System 3 coordinates system	deg
	lon_west_sys3	Galileo west-longitude in System III coordinates	deg
	LT	Cassini Local Time	h
	LT	Local Time of the spacecraft	hours
	LT	Local Time	hours
pos.bodyrc.long;phys.magField;instr.obsty	MLT	Magnetic Local Time	h
pos.distance	r	Callisto distance to Jupiter (in Jovian Radii)	Rj
	r	Cassini distance to Saturn (in Kronian radii)	Rs
	r	Dione distance to Saturn (in Kronian radii)	Rs
	r	Enceladus distance to Saturn (in Kronian radii)	Rs
	r	Europa distance to Jupiter (in Jovian Radii)	Rj
	r	Ganymede distance to Jupiter (in Jovian Radii)	Rj
	r	Galileo distance to Jupiter (in Jovian radii)	Rj
	r	Galileo distance to Jupiter (in Jovian Radii)	Rj
	r	Io distance to Jupiter (in Jovian Radii)	Rj
	r	Mimas distance to Saturn (in Kronian radii)	Rs
	r	Rhea distance to Saturn (in Kronian radii)	Rs
	R	Distance Jupiter-Sun	km
	R	Distance Saturn-Sun	km
	r	Tethys distance to Saturn (in Kronian radii)	Rs
	r	Titan distance to Saturn (in Kronian radii)	Rs
pos.distance;instr.obsty	r	Cassini distance to Jupiter (in Jovian radii)	Rj
	r	Cassini distance to Saturn (in Saturn radii)	Rs
	r	Range of the spacecraft from the Jupiter center of mass	Rj
	r	Range of the spacecraft from the Jupiter center of mass	Rj
	r	Radial distance to Venus	Rv
	r	Distance	Rs
	r_csprh	Galileo distance to Callisto (in Callisto Radii)	Rca
	r_esprh	Galileo distance to Europa (in Europa Radii)	Reu
	r_gsprh	Galileo distance to Ganymede (in Ganymede Radii)	Rga
	r_isprh	Galileo distance to Io (in Io Radii)	Rio
	r_rtn	MESSENGER radial distance to the Sun	km
	r_sun	Distance to Sun	AU
	r_sys3	Galileo distance to Jupiter in System 3 coordinates system	Rj

UCD	Name	Description	Unit
	r_sys3	Galileo distance to Jupiter in Jovian Radii	Rj
pos.distance;phys.magField	L	McIlwain parameter	Rj
	L*	Modified McIlwain parameter	Rj
	Ldip	Cassini L-shell (assuming dipolar magnetic field)	
	Ldip	Dione L-shell (assuming dipolar magnetic field)	
	Ldip	Enceladus L-shell (assuming dipolar magnetic field)	
	Ldip	Mimas L-shell (assuming dipolar magnetic field)	
	Ldip	Rhea L-shell (assuming dipolar magnetic field)	
	Ldip	Tethys L-shell (assuming dipolar magnetic field)	
	Ldip	Titan L-shell (assuming dipolar magnetic field)	
	Ldip	L-Shell (Dipolar field)	no
pos.earth;instr.obsty	xyz_gse	Spacecraft positions in GSE coordinates and radial distance to the Earth	Re
pos.heliocentric	pol_heliographic	AU, deg, deg	
pos.heliocentric;pos.distance;instr.obsty	xyz_hae	heliocentric location in HAE coordinates	AU
	xyz_hee	heliocentric location in HEE coordinates	AU
pos.heliocentric.lat;instr.obsty	celestial_lat	Celestial latitude	deg
pos.heliocentric.long	azimuth_rtn	MESSENGER solar longitude	deg
	celestial_lon_earth	Celestial Earth longitude	deg
pos.heliocentric.long;instr.obsty	celestial_lon	Celestial longitude	deg
pos.posAng;instr.setup	rotor_right_ascension	Rotor Right Ascension	rad
	rotor_spin	Rotor Spin	rad
	rotor_twist	Rotor Twist	rad
pos.posAng;phys.magField	draping_azymuth_ang	Draping azimuth angle of the magnetic field	deg
pos.posAng;phys.veloc;phys.atmol.ionStage	vel_E/W_angle	E/W Orientation angle of the solar wind velocity	degrees
src.var.index;phys.magField	aa	aa geomagnetic index	nT
	AE	AE geomagnetic index	nT
	AL	AL geomagnetic	nT
	am	am Geomagnetic Index	nT
	asy_d	Geomagnetic Index	nT
	asy_h	Geomagnetic Index	nT
	AU	Geomagnetic Index	nT
	dst	dst geomagnetic index	nT
	Dst	Dst geomagnetic index	nT
	pcn	pcn index	nT
	pcs	pcs index	nT
time.period	period_North	Northern SKR dominant period	h
	period_South	Southern SKR dominant period	h
time.phase	drift_North	Northern SKR phase drift from fixed 10.6h period	deg
	drift_South	Southern SKR phase drift from fixed 10.7928h period	deg
	phi_North	Northern SKR phase	deg
	phi_South	Southern SKR phase	deg

Appendix 3. PDS data dictionary

The PDS (NASA Planetary Data System) Data Dictionary (PSDD) has several entities that can be matched to UCDs. The main relevant keyword is INSTRUMENT_PARAMETER_NAME. The INSTRUMENT_PARAMETER_NAME element provides the name of the data parameter which was measured by an instrument. As an example, the INSTRUMENT_PARAMETER_NAME value could be "ELECTRIC FIELD COMPONENT". It is intended that the INSTRUMENT_PARAMETER_NAME element provide the name of the rawest measured value which has some physical significance. Thus, for example, while the detector of an instrument may actually record voltage differences, the electric field component which is proportional to those differences is considered to be the instrument parameter.

INSTRUMENT PARAMETER NAME	UCD
ATMOSPHERIC PRESSURE	phys.pressure
ATMOSPHERIC TEMPERATURE	phys.pressure
ATOMIC NUMBER (Z)	phys.atmol.number
DYNAMIC	
BRIGHTNESS	phot.flux.sb
D1 RATE	arith.rate
D2 RATE	arith.rate
ELECTRIC FIELD COMPONENT	phys.elecField
ELECTRIC FIELD WAVEFORM	phys.elecField
ELECTRON CURRENT	**phys.flow**;phys.electron
ELECTRON RATE	arith.rate;phys.electron
ENERGY/NUCLEON	phys.energy
ION CURRENT	phys.flow;phys.atmol.ionStage
ION RATE	arith.rate;phys.atmol.ionStage
MAGNETIC FIELD COMPONENT	phys.magField
N/A	
PARTICLE MULTIPLE PARAMETERS	**phys.particle**
PARTICLE RATE	arith.rate;**phys.particle**
PHOTON FLUX	phot.flux
PLANETARY RADIUS	phys.size.radius
POSITION VECTOR	pos
PRESSURE	phys.pressure
RADAR ECHO POWER	**phys.power**
RADIANCE	**phys.radiance**
RADIANT POWER	**phys.power**
RSSDETEB POWER	??
SPECTRAL INTENSITY	spect.line.intensity ?
SPECTRAL RADIANCE	??
TEMPERATURE	phys.temperature
UNK	meta.cryptic
WAVE ELECTRIC FIELD AMPLITUDE	phys.elecField
WAVE ELECTRIC FIELD INTENSITY	phys.elecField

INSTRUMENT PARAMETER NAME	UCD
WAVE FLUX DENSITY	**phys.flux.density**
WAVE MAGNETIC FIELD INTENSITY	phys.magField
WIND DIRECTION	phys.posAng
WIND SPEED	phys.veloc
WIND VELOCITY	phys.veloc

As there is no definition for the values (which are simply extracted from the existing database, so there is only little control on that parameter value).

Other entities can be mapped to UCDs, such as the CLASSES and DESCRIPTORS concepts defined in the PSDD (section 2.2.2, in Aug. 2002 version). Those entities are bricks to build PDS keywords. This mapping can thus be used to help building corresponding UCDs.

CLASS WORD	CLASS WORD DEFINITION	Suggested UCDs
count	A numeric value indicating a current total or tally. The class word count is implied by the use of plural descriptor words such as lines, bytes or bits. For example, LINES = 800 is interpreted as LINE_COUNT = 800.	**phys.count**
date	A representation of time in which the smallest unit of measure is a day. The value is expressed in one of the standard forms. Example: PUBLICATION_DATE = 1959-05-30	time.epoch
description	A free-form, unlimited-length character string that provides a description of the item identified. Example: MISSION_DESC provides the description of a mission, as in The Magellan spacecraft was launched from the Kennedy Space Center on May 5, 1989. The spacecraft was deployed from the Shuttle cargo bay.... See also: the class word TEXT. Note: In the PDS, this term is abbreviated to DESC in every instance except when the word is unqualified. Hence, the data element name DESCRIPTION is spelled out, but INSTRUMENT_DESC contains the abbreviation.	meta.note
direction	A literal value indicating the line or course on which something is moving, pointing or facing. For example, NORTH, SOUTH, INGRESS, EGRESS, RETROGRADE, PROGRADE	pos;meta.code
flag	A boolean condition indicator, limited to two states. Example: PLANETARY_OCCULTATION_FLAG = Y	meta.flag
format	A specified or predetermined arrangement of data within a file or on a storage medium.	meta.code
group	Names a collection or aggregation of elements. Example: ALT_FLAG_GROUP	meta.id
id	A shorthand alphanumeric identifier. In some cases, a notation representing a shortened name of an NAME. See abbreviation standard. See also: 'name'. Example: SPACECRAFT_ID = VG1	meta.id
mask	An unsigned numeric value representing the bit positions within a value. Example: SAMPLE_BIT_MASK = 2#00011111#	meta.code
name	A literal value representing the common term used to identify an element. See also: 'id'. Example: SPACECRAFT_NAME = MAGELLAN.	meta.id
note	A textual expression of opinion, an observation, or a criticism; a remark.	meta.note
number	A quantity associated with an NAME. Example: START_SAMPLE_NUMBER = 5	meta.number
range	Numeric values which identify the starting and stopping points of an interval. Note: the use of the descriptor word 'distance' supersedes the use of the word 'range' as a measure of linear separation See: 'distance'. Example: IRAS_CLOCK_ANGLE_RANGE	**stat.range**
ratio	The relation between two quantities with respect to the number of times the first contains the second. Example: DETECTOR_ASPECT_RATIO	arith.ratio
sequence	1) an arrangement of items in accordance with some criterion that defines their spacewise or timewise succession; 2) an orderly progression of items or operations in accordance with some rule, such as alphabetical or numerical order.	obs.sequence ?
set	A collection of items having some feature in common or which bear a certain relation to one another, e.g. all even numbers.	

CLASS WORD	CLASS WORD DEFINITION	Suggested UCDs
summary	An abridged description. Example: SCIENTIFIC_OBJECTIVES_SUMMARY	meta.note
text	A free-form, unlimited length character string that represents the value of a data element. Example: ADDRESS_TEXT provides the value of an address, such as 4800 Oak Grove Dr. Pasadena, CA 91109. In contrast, ADDRESS_DESC would describe an address such as An address consists of a street, city, state, and zip code. See also: the class word DESCRIPTION.	meta.note
time	A value that measures the point of occurrence of an event expressed as date and time in a standard form. Example: START_TIME = 1987-06-21T17:30:30.00	time.epoch
type	A literal that indicates membership in a predefined class. See: standard values for data elements. Example: TARGET_TYPE = PLANET	
unit	A determinate quantity adopted as a standard of measurement.	meta.unit
value	The default class word for data element names not terminated with a class word. It represents the amount or quantity of a data element. For example, SURFACE_TEMPERATURE = 98.6 would be interpreted as SURFACE_TEMPERATURE_VALUE = 98.6.	
vector	A quantity that has both length and direction which are independent of both the units and of the coordinate system in which each are measured. The vector direction is uniquely defined in terms of an ordered set of components with respect to the particular coordinate system for which those components have been defined.	

DESCRIPTOR WORD	CLASS WORD DEFINITION	Suggested UCDs
albedo	Reflectivity of a surface or particle. Example: BOND_ALBEDO	phys.albedo
altitude	The distance above a reference surface measured normal to that surface. Altitudes are not normally measured along extended body radii, but along the direction normal to the geoid; these are the same only if the body is spherical. See also: 'elevation', 'height.' Example: SPACECRAFT_ALTITUDE	pos.bodyrc.alt
angle	A measure of the geometric figure formed by the intersection of two lines or planes. Definitions for data element names containing the word 'angle' should include origin and relevant sign conventions where applicable. Example: MAXIMUM_EMISSION_ANGLE	pos.posAng
axis	A straight line with respect to which a body or figure is symmetrical. Example: ORBITAL_SEMIMAJOR_AXIS	
azimuth	One of two angular measures in a spherical coordinates system. Azimuth is measured in a plane which is normal to the principal axis, with increasing azimuth following the right hand rule convention relative to the positive direction of the principal axis. PDS adopts the convention that an azimuth angle is never signed negative. The point of zero azimuth must be defined in each case.	pos.az
bandwidth	The range within a band of wavelengths, frequencies or energies.	meta.code
bits	A quantity to be added to a value.	meta.id
base	A count of the number of bits within an elementary data item. Examples: SAMPLE_BITS	
bytes	A count of the number of bytes within a record, or within a sub-component of a record. Example: RECORD_BYTES	
channel	A band of frequencies or wavelengths.	meta.id
circumference	The length of any great circle on a sphere.	
coefficient	A numeric measure of some property or characteristic.	
columns	A count of the number of distinct data elements within a row in a table.	
component	1) The part of a vector associated with one coordinate. 2) A constituent part. Example: VECTOR_COMPONENT_1	

DESCRIPTOR WORD	CLASS WORD DEFINITION	Suggested UCDs
constant	A value that does not change significantly with time.	meta.code
consumption	The usage of a consumable. Example: INSTRUMENT_POWER_CONSUMPTION	instr.param
contrast	The degree of difference between things having a comparable nature. Example: MAXIMUM_SPECTRAL_CONTRAST	arith.ratio
declination	An angular measure in a spherical coordinate system, declination is the arc between the Earth's equatorial plane and a point on a great circle perpendicular to the equator. Positive declination is measured towards the Earth's north pole, which i is the positive spin axis per the right hand rule; declinations south of the equator are negative. The Earth mean equator and equinox shall be as defined by the International Astronomical Union (IAU) as The 'J2000' reference system unless noted as The 'B1950' reference system. See also: 'right_ascension'.	pos.eq.dec
density	1) The mass of a given body per unit volume. 2) The amount of a quantity per unit of space. Example: MASS_DENSITY	phys.density
detectors	A count of the number of detectors contained, for example, in a given instrument.	meta.number
Deviation	Degree of deviance.	stat.stdev
diameter	The length of a line passing through the center of a circle or a circular NAME. Example: TELESCOPE_DIAMETER	phys.size.diameter
distance	A measure of the linear separation of two points, lines, surfaces, or NAMEs. See also 'altitude', which refers to a specific type of distance. The use of the descriptor word 'distance' supersedes the use of the word 'range' as a measure of linear separation. See also: 'range'. Example: SLANT_DISTANCE	pos.distance
duration	A measure of the time during which a condition exists. Example: INSTRUMENT_EXPOSURE_DURATION	time.duration
eccentricity	A measure of the extent to which the shape of an orbit deviates from circular. Example: ORBITAL_ECCENTRICITY	src.orbital.eccentricity
elevation	1) The distance above a reference surface measured normal to that surface. Elevation is the altitude of a point on the physical surface of a body measured above the reference surface; height is the distance between the top and bottom of an NAME. 2) An angular measure in a spherical coordinate system, measured positively and negatively on a great circle normal to the azimuthal reference plane. The zero elevation point lies in the azimuthal reference plane, and positive elevation is measured towards the direction of the positive principal axis. See also: 'azimuth'.	pos.posAng
epoch	A specific instance of time selected as a point of reference. Example: COORDINATE_SYSTEM_REFERENCE_EPOCH	time.epoch
error	The difference between an observed or calculated value and a true value. Example: TELESCOPE_T_NUMBER_ERROR	stat.error
factor	A quantity by which another quantity is multiplied or divided. Example: SAMPLING_FACTOR	arith.factor
first	An indication of the initial element in a set or sequence. As with minimum and maximum, the values in the set may be out of order or discontinuous. For examples of the use of range-related terms, please see the following section.	stat.min;meta.number
flattening	A measure of the geometric oblateness of a solar system body, defined as the ratio of the difference between the body's equatorial and polar diameters to the equatorial diameter, or '(a-c)/a'.	phys.size.radius;arith.ratio
fov (field_of_view)	The angular size of the field viewed by an instrument or detector. Note that a field may require multiple field_of_view measurements, depending upon its shape (e.g., height and width for a rectangular field). Example: HORIZONTAL_FOV	instr.fov
fovs	A count of the number of different fields of view characteristic of an instrument or detector.	instr.fov;meta.number
Fraction	The non-integral part of a real number. See also: 'base'.	
frequency	The number of cycles completed by a periodic function in unit time.	em.freq

DESCRIPTOR WORD	CLASS WORD DEFINITION	Suggested UCDs
gravity	The gravitational force of a body, nominally at its surface. Example: SURFACE_GRAVITY	phys.gravity
height	The distance between the top and bottom of an NAME. Example: SCALED_IMAGE_HEIGHT	
images	A count of the number of images contained, for example, in a given mosaic. Example: MOSAIC_IMAGES	obs.image;meta.number
inclination	The angle between two intersecting planes, one of which is deemed the reference plane and is normally a planet's equatorial plane as oriented at a	pos.posAng
index	An indicator of position within an arrangement of items.	meta.number
interval	1) The intervening time between events. 2) The distance between points along a coordinate axis. See also: 'duration'. Example: SAMPLING_INTERVAL	time.interval ?
last	An indication of the final element in a set or sequence. As with minimum and maximum, the values in the set may be out of order or discontinuous. For examples of the use of range-related terms, please see the following section.	stat.max;meta.number
latitude	In a cylindrical coordinate system the angular distance from the plane orthogonal to the axis of symmetry. See also: 'longitude'. Example: MINIMUM_LATITUDE	pos.bodyrc.lat
length	A measured distance or dimension. See also: 'height', 'width'. Example: TELESCOPE_FOCAL_LENGTH	phys.size
level	The magnitude of a continuously varying quantity. Example: NOISE_LEVEL	
line	1) A row of data within a two-dimensional data set; 2) A narrow feature within a spectrum.	spect.line
lines	1) A count of the number of data occurrences in an image array; 2) Any plural of 'line'.	
location	The position or site of a NAME	pos.bodyrc
longitude	n a cylindrical coordinate system, the angular distance from a standard origin line, measured in the plane orthogonal to the axis of symmetry. (See also: 'latitude'.) Example: MAXIMUM_LONGITUDE	pos.bodyrc.long
mass	A quantitative measure of a body's resistance to acceleration. Example: INSTRUMENT_MASS	phys.mass
maximum	An indicator of the element in a range that has the greatest value, regardless of the order in which the values are listed or stored. For example, in the set {4, 5, 2, 7, 9, 3}, the minimum is 2, the maximum is 9. The use of minimum and maximum, as with first and last implies that the set may be out of order or discontinuous. For examples of the use of range-related terms, please see the following section.	stat.max
minimum	An indicator of the element in a range that has the least value, regardless of the order in which the values are listed or stored. For example, in the set {4, 5, 2, 7, 9, 3}, the minimum is 2, the maximum is 9. The use of minimum and maximum, as with first and last implies that the set may be out of order or discontinuous. For examples of the use of range-related terms, please see the following section.	stat.min
moment	The product of a quantity (such as a force) and the distance to a particular point or axis. Example: MAGNETIC_MOMENT	
obliquity	Angle between a body's equatorial plane and its orbital plane.	pos.posAng
parameter	A variable. Example: MAXIMUM_SAMPLING_PARAMETER	
parameters	A count of the number of parameters in a given application. Example: IMPORTANT_INSTRUMENT_PARAMETERS	meta.number
password	An alphanumeric string which must be entered by a would-be user of a computer system in order to gain access to that system.	meta.code;meta.cryptic :-)

DESCRIPTOR WORD	CLASS WORD DEFINITION	Suggested UCDs
percentage	A part of a whole, expressed in hundredths. Example: DATA_COVERAGE_PERCENTAGE	arith.ratio
period	The duration of a single repetition of a cyclic phenomenon or motion. Example: REVOLUTION_PERIOD	time.period
points	A count of the number of points (i.e., data samples) occurring, for example, within a given bin. Example: BIN_POINTS	meta.number
pressure	Force per unit area. Example: MEAN_SURFACE_ATMOSPHERIC_PRESSURE	phys.pressure
radiance	A measure of the energy radiated by an NAME. Example: SPECTRUM_INTEGRATED_RADIANCE	
radius	The distance between the center of and a point on a circle, sphere, ellipse or ellipsoid. Example: MEAN_INNER_RADIUS	phys.size.radius
rate	The amount of change of a quantity per unit time. Example: NOMINAL_SPIN_RA TE	arith.rate
records	A count of the number of physical or logical records within a file or a subcomponent of a file. Example: FILE_RECORDS	meta.number
resolution	A quantitative measure of the ability to distinguish separate values. Example: SAMPLING_PARAMETER_RESOLUTION	
right ascension	The arc of the celestial equator between the vernal equinox and the point where the hour circle through the given body intersects the Earth's mean equator reckoned eastward, in degrees. The Earth mean equator and equinox shall be as defined by the International Astronomical Union (IAU) as the 'J2000' reference system unless noted as the 'B1950' reference system. Note: In the PDS, this term is abbreviated to RA in most instances, except when the term is unqualified. Hence, the data element name RIGHT_ASCENSION is spelled out, but other terms referring to specific right ascensions contain the abbreviation.	pos.eq.ra
rows	A count of the number of data occurrences in a table.	meta.number
samples	A count of the number of data elements in a line of an image array or a set of data. Example: SEQUENCE_SAMPLES	meta.number
scale	A proportion between two sets of dimensions. Example: MAP_SCALE	instr.scale
start	An indication of the beginning of an activity or observation. For examples of the use of range-related terms, please see the following section.	time.start
stop	An indication of the end of an activity or observation. For examples of the use of range-related terms, please see the following section.	time.end
temperature	The degree or intensity of heat or cold as measured on a thermometric scale. Example: MEAN_SURFACE_TEMPERATURE	phys.temperature
title	A descriptive heading or caption. Example: SEQUENCE_TITLE	meta.title
transmittance	The ratio of transmitted to incident energy. Example: TELESCOPE_TRANSMITTANCE	
wavelength	The distance that a wave travels in one cycle. Example: MINIMUM_W A VELENGTH	em.wl
width	The distance between two sides of an NAME. See also: 'height', 'length'. Example: SCALED_IMAGE_WIDTH	phys.size