Units of Measure

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Definitions of Units of Measure used in MMS data product files:

Quantity	Units (original)	Notation in CDF		SI_CONVERSIONS
		markup in CDF	as rendered by plot routines	
Number densities	cm^-3	cm^{-3}	cm^{-3}	1e6>m^{-3}
Speeds, velocities	km/s	km/s	km/s	1.0e3>m/s
Angles, phase shifts	deg	deg	deg	0.0174532925>rad
Pressures (plasma - dynamic, thermal, magnetic)	nPa	nPA	nPa	1.0e-9>Pa
Temperatures	eV	eV	eV	11604.50520>K
Heat Flux	mW/m^2	mW/m^{2}	mW/m^2	1.0e-3>W/m^{2}
Entropy	J/K	J/K	J/K	1.0>J/K
Electric Field	mV/m	mV/m	mV/m	1.0e-3>V/m
Probe to Spacecraft Potential	V	V	V	1.0>V
Electric field power spectral density	(V/m)^2/Hz	(V/m)^{2}/Hz	$(V/m)^2/Hz$	1.0>(V/m)^{2}/Hz
ExB Velocity	km/s	km/s	km/s	1.0e3>m/s
Poynting Flux	mW/m^2	mW/m^{2}	mW/m^2	1.0e-3>W/m^{2}
Magnetic Field	nT	nT	nT	1.0e-9>T
Magnetic Field Power Spectral Density	nT^2/Hz	nT^{2}/Hz	nT^2/Hz	1.0e-18>T^{2}/Hz
Current Density	nA/m^2	nA/m^{2}	nA/m^2	1.0e-9>A/m^{2}
Differential Number Flux	1/(cm^2 s sr eV)	1/(cm^{2} s sr eV)	$1/(cm^2$ s sr eV)	
Differential Energy Flux	eV/(cm^2 s sr eV)	eV/(cm^{2} s sr eV)	$eV/(cm^2$ s sr eV)	
Distance	km	km	km	1.0e3>m

- Earth radius: 6371.2 km
- ASCII Date/Time: ISO8601 standard (e.g. YYYY-MM-DDTHH:MM:SS.SSS or YYYY-DDDTHH:MM:SS.SSS)

MMS Team members are welcome to ADD ADDITIONAL QUANTITIES as they are defined.

The CDF Format Guide requires that UNITS and SI_CONVERSION must be specified for each parameter.

- It is proposed that conventions should be defined, so that a standard nomenclature is used for these metadata.
- UNITS attribute
  - units in Level 2 CDF files shall be taken from the list above
  - The units shall be specified as a human-readable ASCII string, using the abbreviations listed above.
  - guidelines for unit nomenclature are proposed, below.
- SI_CONVERSION attribute
  - Gives the conversion from the MMS unit of measure to SI units
  - This attribute allows for plotting/analysis tools to combine MMS data with data from other missions which use different units.
  - Guidelines for SI unit nomenclature are proposed, below.
  - Requires guidelines for syntax, which are also included below.

Convention for unit nomenclature and SI conversion attribute (see table above):

- SI unit symbols to be used for SI conversion (rather than SI unit names) without SI prefixes: e.g. T, rather than nT or Tesla; sr, rather than steradians.
  The SI_CONVERSION from nT would then be "1.0e-9>T".
- SI prefixes are allowed in variable units, but not in the converted SI unit (units of [km] are required for distances, but the SI conversion must be to [m]).
- **Note that the SI unit for angles is radians [rad].**
  The SI_CONVERSION for angles (in degrees as defined above) would be "0.0174532925>rad"
- Dimensionless variables are required (by ISTP standard) to be a blank character. For consistency the conversion should also be a blank character.
  The SI_CONVERSION for a dimensionless variable would be " > ".
- Units that are already SI (e.g. Hz, V) will have a multiplicative factor of 1, so the SI_CONVERSION for spacecraft potential would be "1.0>V".

Convention for compound units (see table above):

- Only dimensional units should be used. For example, a number density would have units of [cm^{-3}] not [#/cm^{3}].
- LaTeX math notation is to be used exponents, so the units for acceleration would be [m/s^{2}]
  - This is usable through IDL with the graphics routines from "Coyote's guide" (David Fanning) or the TexToIDL package.
  - This is usable through MATLAB, which directly supports TeX markup in graphics by specifying an interpreter to the text object.
  - This is usable in Python through the graphics package matplotlib, which can use LaTeX to render the text in graphics output for several plotting backends.
  - LaTeX is directly supported by GNUplot, in case anyone still uses that!
  - Where this isn't currently supported is Autoplot, though it may not be difficult for Jeremy to support basic TeX-style markup for units.
  - If LaTeX markup is allowed here then there is no reason people can't use it to give equations in other attributes, which could be handy when defining calculated quantities.