

Units Markup Language (UnitsML)

Presentation for
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Outline

- Vision
- Introduction
- Background information on units and quantities
- Units Markup Language
- Units Database
- Usage of UnitsML & UnitsDB

Vision

- UnitsML schema for encoding scientific units of measure – useful for unit dictionaries and incorporating within other markup languages
- Units Database (UnitsDB) containing extensive information on units, prefixes, quantities, & dimensions
- Guidelines and tools for use of UnitsML & UnitsDB
 - Web Services
 - Unit conversions

Introduction

- Units Markup Language (UnitsML) is a proposed method of representing scientific units of measure in XML.
- Original motivation for this project came from initial effort by Frank Olken and John McCarthy of the Lawrence Berkeley National Laboratory (LBNL).
- Initial Collaborators:
 - Barry Taylor (NIST-PL,emeritus)
 - Michael McLay (NIST-EEEL)
 - Frank Olken (LBNL)
 - Peter Murray-Rust (CML - Chemical Markup Language)

Introduction

■ NIST UnitsML Committee

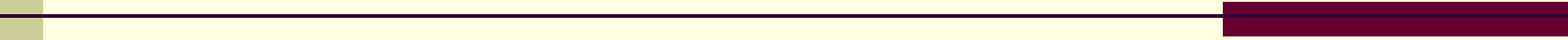
- Bob Dragoset (PL)
- Simon Frechette (MEL)
- Mark Carlisle (MEL)
- Peter Linstrom (CSTL)
- Gary Kramer (CSTL)
- Martin Weber (PL – NIST Associate)
- Kent Reed (BFRL)
- Evan Wallace (MEL)
- Karen Olsen (PL)
- Several NIST Associates (CSTL, PL, BFRL)

■ Funded in part by NIST's Systems Integration for Manufacturing Applications (SIMA) program.

- <http://www.nist.gov/sima>

Introduction

- UnitsML OASIS Technical Committee formed on July 12, 2006
- Deliverables due by July 2007:
 - UnitsML Working Draft identifying the requirements and data-model for units of measure
 - UnitsML Proposed Standard for the representation of units information in XML
 - Guidelines for implementation of UnitsML
- Participants from NIST, Granta Design, LSC Group Ltd, IBM, NPL, Univ. of North Florida, IEM
- Soliciting additional non-NIST participants



Background Information on Units and Quantities

7 SI Base Units & Quantities

Unit Name	Unit Symbol	Quantity	Quantity Symbol	Dimension Symbol
meter	m	length	l	L
kilogram	kg	mass	m	M
second	s	time	t	T
ampere	A	electric current	I	I
kelvin	K	thermodynamic temperature	T	Θ
mole	mol	amount of substance	n	N
candela	cd	luminous intensity	I_v	J

Examples: $l = 7.24 \text{ m}$ $v = 6.32 \text{ m/s}$
 $m = 1.53 \text{ kg}$ $\dim v = \mathbf{L T^{-1}}$

22 SI Special Derived Units

Derived quantity	Special name	Special symbol	Expression in terms of	
			other SI units	SI base units
plane angle	radian	rad	1	$m \cdot m^{-1}$
solid angle	steradian	sr	1	$m^2 \cdot m^{-2}$
frequency	hertz	Hz		s^{-1}
force	newton	N		$m \cdot kg \cdot s^{-2}$
pressure, stress	pascal	Pa	N/m^2	$m^{-1} \cdot kg \cdot s^{-2}$
energy, work, quantity of heat	joule	J	$N \cdot m$	$m^2 \cdot kg \cdot s^{-2}$
power, radiant flux	watt	W	J/s	$m^2 \cdot kg \cdot s^{-3}$
electric charge, quantity of electricity	coulomb	C		$s \cdot A$
electric potential, potential difference, electromotive force	volt	V	W/A	$m^2 \cdot kg \cdot s^{-3} \cdot A^{-1}$
capacitance	farad	F	C/V	$m^{-2} \cdot kg^{-1} \cdot s^4 \cdot A^2$
electric resistance	ohm	Ω	V/A	$m^2 \cdot kg \cdot s^{-3} \cdot A^{-2}$
electric conductance	siemens	S	A/V	$m^{-2} \cdot kg^{-1} \cdot s^3 \cdot A^2$

22 SI Special Derived Units

Derived quantity	Special name	Special symbol	Expression in terms of	
			other SI units	SI base units
magnetic flux	weber	Wb	$V \cdot s$	$m^2 \cdot kg \cdot s^{-2} \cdot A^{-1}$
magnetic flux density	tesla	T	Wb/m^2	$kg \cdot s^{-2} \cdot A^{-1}$
inductance	henry	H	Wb/A	$m^2 \cdot kg \cdot s^{-2} \cdot A^{-2}$
Celsius temperature	degree Celsius	$^{\circ}C$		K
luminous flux	lumen	lm	$cd \cdot sr$	cd
illuminance	lux	lx	lm/m^2	$m^{-2} \cdot cd$
activity (of a radionuclide)	becquerel	Bq		s^{-1}
absorbed dose, specific energy (imparted), kerma	gray	Gy	J/kg	$m^2 \cdot s^{-2}$
dose equivalent, <i>et al.</i>	sievert	Sv	J/kg	$m^2 \cdot s^{-2}$
catalytic activity	katal	kat		$s^{-1} \cdot mol$

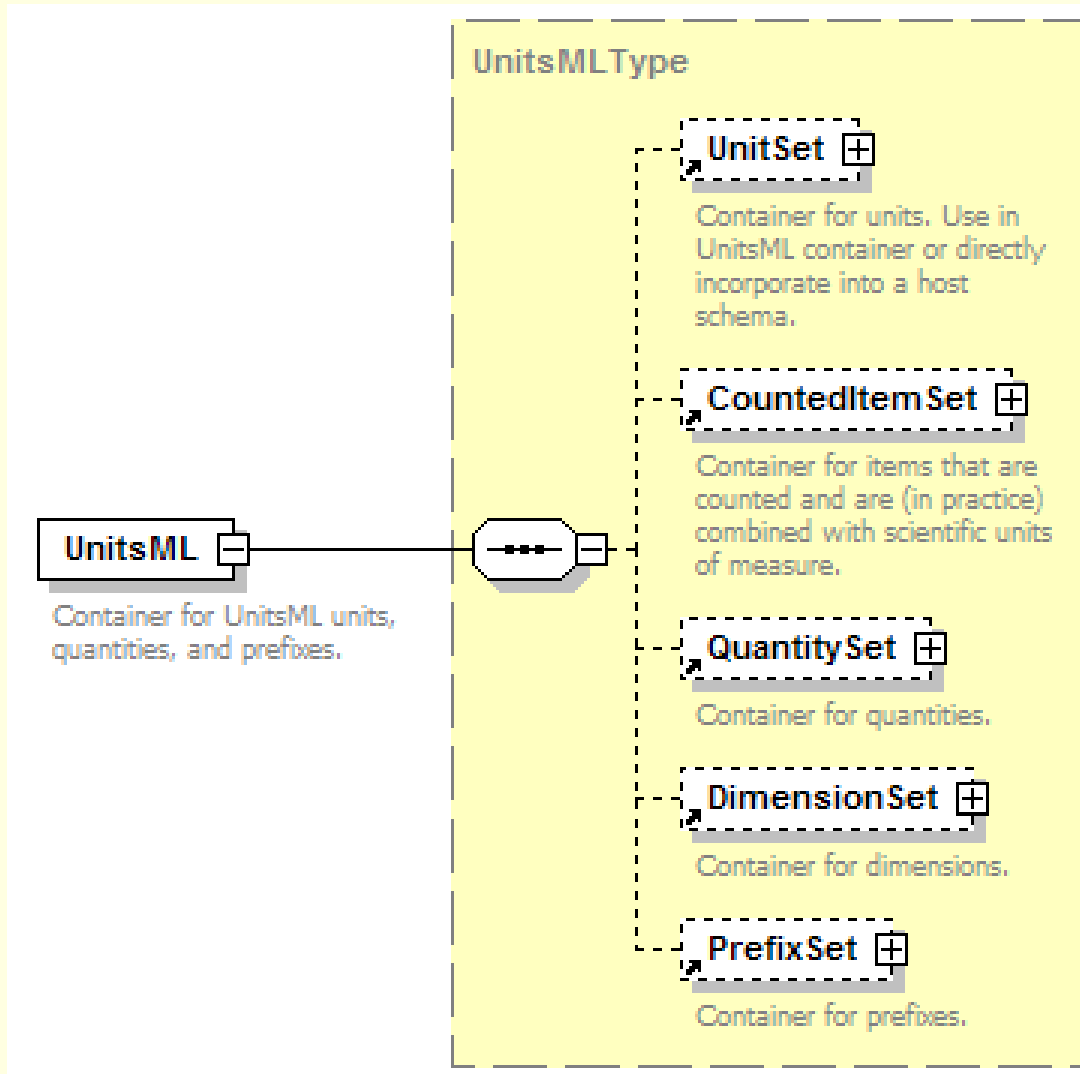
There are also many derived quantities with SI units without special names; e.g., the quantity **area** has units of m^2 ; and multiples and submultiples; e.g., km, cm.

Non-SI Units

- According to SP 811, there are 3 categories of non-SI units relating to use within the SI
 - Acceptable
 - Examples: minute, hour, day, liter, metric ton, natural and atomic units
 - Temporarily acceptable
 - Examples: nautical mile, knot, ångström
 - Unacceptable
 - Examples: erg, dyne, fermi, torr, micron

Units Markup Language (UnitsML)

UnitsML Root Level



'Unit' Element

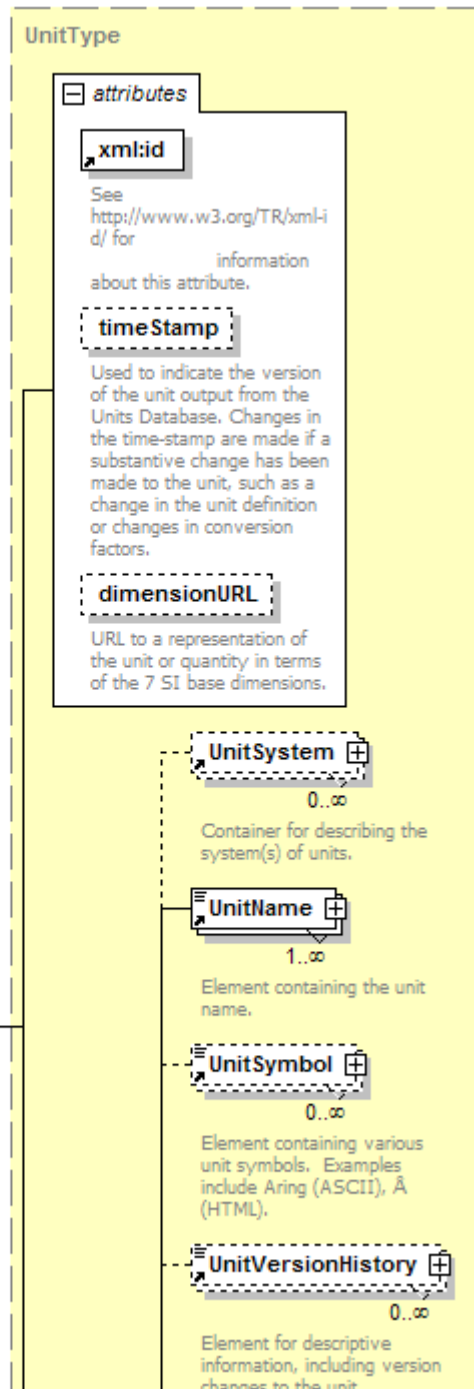
■ Attributes

- xml:id
- dimensionURL

■ Elements

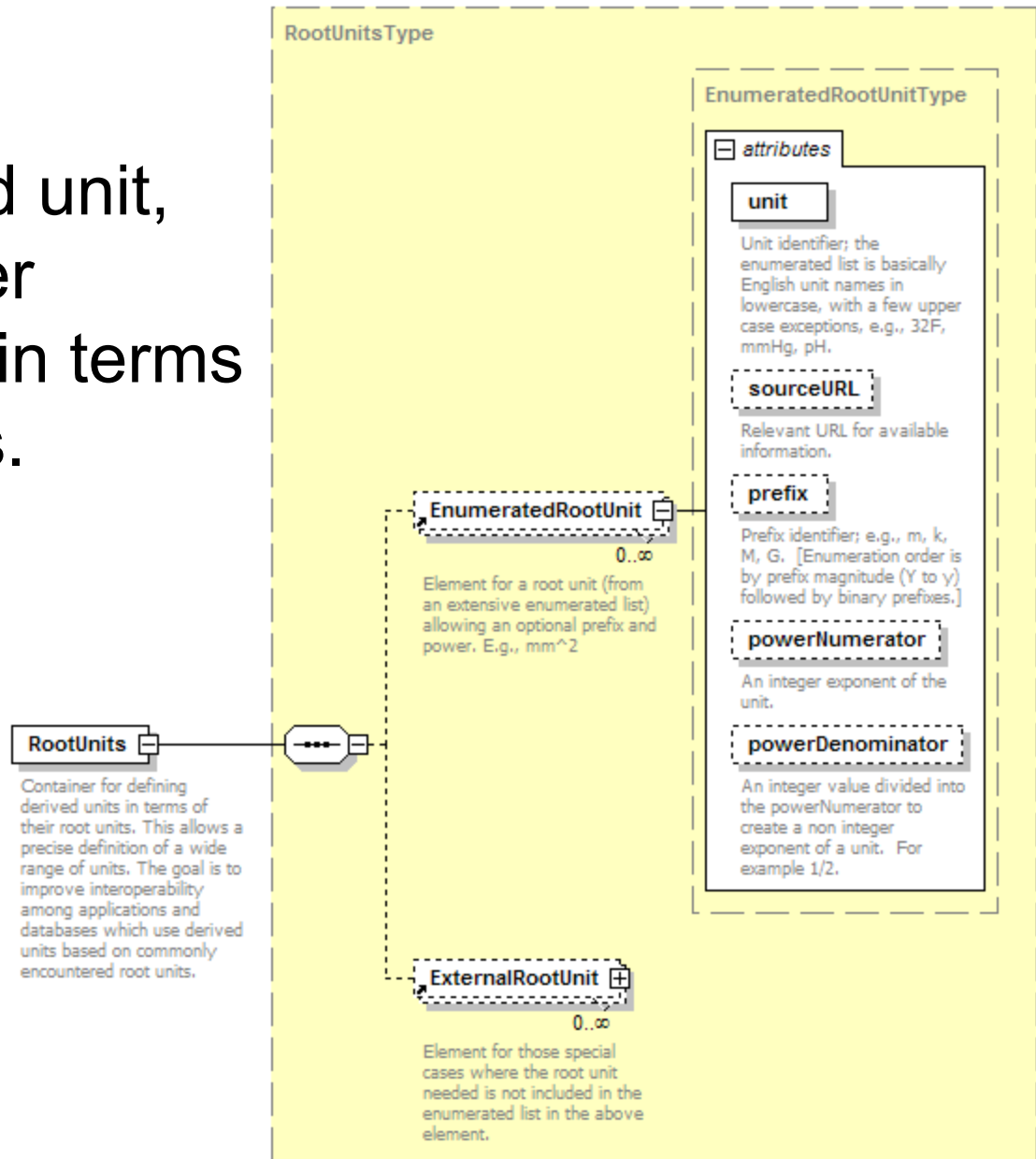
- RootUnits
- Conversions
- CodeListValue

Unit
Element for describing units. Use in containers UnitSet or directly incorporate into a host schema.



'RootUnits' Element

Express a derived unit, e.g., millimeter per second squared, in terms of its components.



'Conversions' Element

$$y = d + ((b / c) (x + a))$$

Attributes

x, initialUnit

a, initialAddend

b, multiplicand

c, divisor

d, finalAddend

$$x = ((c / b) (y - d)) - a$$

ConversionsType

Float64ConversionFromType

attributes

xml:id

See <http://www.w3.org/TR/xml-id/> for information about this attribute.

initialUnit

URI indicating the unitID of the starting unit for the conversion. For units which are defined in the same document, the URI should consist of a pound sign (#) followed by the ID value.

initialAddend

Number to be added at the start of the conversion (prior to multiplication or division) [factor 'a' in equation].

initialAddendU95UncertaintyRadi...

U95 uncertainty radius for initial addend.

initialAddendDecimalPlace

Indicates the position of the least significant digit (in decimal) of the initialAddend; the position of this digit is given by ten to additive inverse of this number.

multiplicand

Number by which to multiply sum of initial addend and initial value [factor 'b' in equation].

multiplicandU95UncertaintyRadius

U95 uncertainty radius for multiplicand.

multiplicandDigits

Number of significant digits in the multiplicand value.

divisor

'CodeListValue' Element

Equate a unit with a code provided in a specific community's code list.

CodeListValue

Element for listing the unit code value from a specific code list.



'Quantity' Element

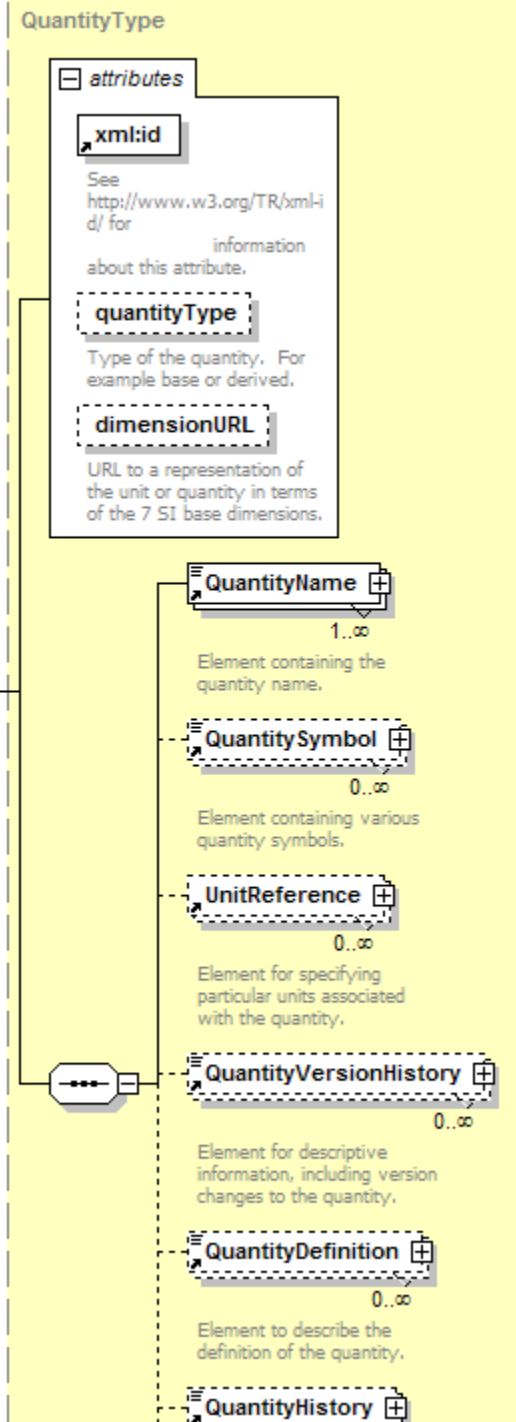
■ Attributes

- xml:id
- dimensionURL

■ Elements

- UnitReference

Quantity
Element for describing quantities and referencing corresponding units. Use in container or directly incorporate into a host schema.



'Dimension' Element

Express the dimensionality of a quantity or unit.

Dimension

Element to express the dimension of a unit or quantity in terms of the SI base quantities length, mass, time, electric current, thermodynamic temperature, amount of substance, and luminous intensity.

DimensionType

attributes

xml:id

See <http://www.w3.org/TR/xml-id/> for information about this attribute.

dimensionless

Boolean to designate that a quantity or unit is dimensionless.

Length

Element containing the dimension of the quantity length.

Mass

Element containing the dimension of the quantity mass.

Time

Element containing the dimension of the quantity time.

ElectricCurrent

Element containing the dimension of the quantity electric current.

ThermodynamicTemperature

Element containing the dimension of the quantity thermodynamic temperature.

AmountOfSubstance

Element containing the dimension of the quantity amount of substance.

LuminousIntensity

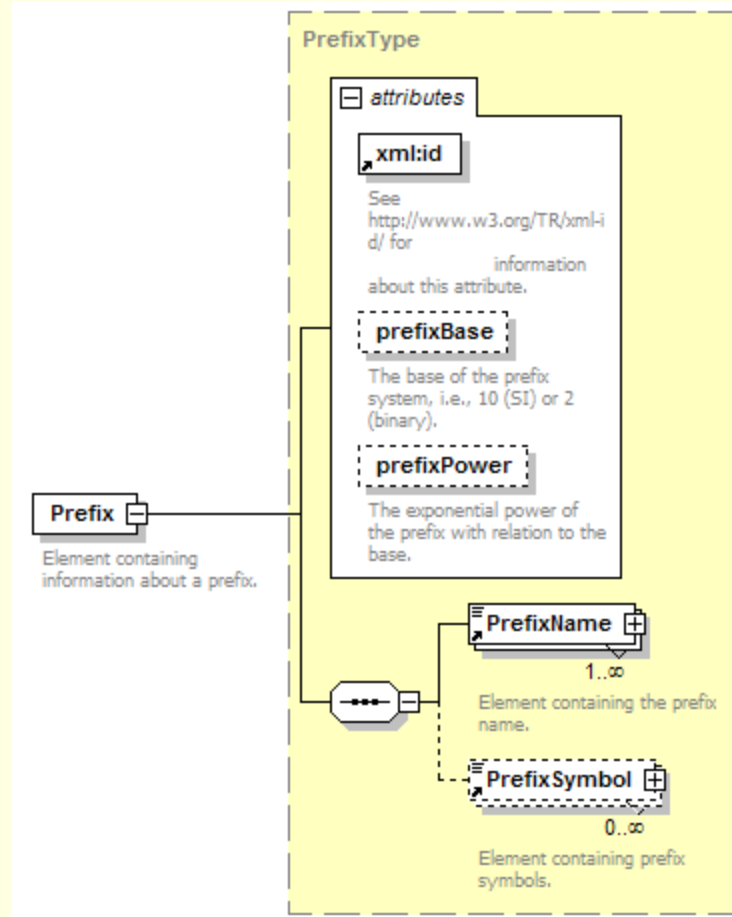
Element containing the dimension of the quantity luminous intensity.



1..∞

This unbounded sequence allows any order of any number of elements; e.g., $L^1 \cdot L^{-1}$.

'Prefix' Element



Instance Document Snippets

```
<Unit xml:id="U_mm.s-2" dimensionURL="#D_L.T-2">
  <UnitSystem name="SI" type="SI_derived" xml:lang="en-US"/>
  <UnitName xml:lang="en-US">millimeter per second squared</UnitName>
  <UnitSymbol type="HTML">mm &#183; s<sup>-2</sup></UnitSymbol>
  <RootUnits>
    <EnumeratedRootUnit unit="meter" prefix="m"/>
    <EnumeratedRootUnit unit="second" powerNumerator="-2"/>
  </RootUnits>
  <QuantityReference url="#Q_acceleration"/>
</Unit>
...
<Prefix xml:id="P_m" prefixBase="10" prefixPower="-3">
  <PrefixName xml:lang="en-US">milli</PrefixName>
  <PrefixSymbol type="HTML">m</PrefixSymbol>
</Prefix>
...
<Quantity xml:id="Q_acceleration" dimensionURL="#D_L.T-2" quantityType="derived">
  <QuantityName xml:lang="en-US">acceleration</QuantityName>
  <QuantitySymbol type="HTML"><i>a</i></QuantitySymbol>
</Quantity>
...
<Dimension xml:id="D_L.T-2">
  <Length symbol="L" powerNumerator="1"/>
  <Time symbol="T" powerNumerator="-2"/>
</Dimension>
```

UnitsML Schema 0.9.18

```
<?xml version="1.0" encoding="UTF-8"?>
<!--
  Units Markup language (UnitsML) Schema
  Website: http://unitsml.nist.gov
  Version History: http://unitsml.nist.gov/Schema/schema\_changes.txt
-->
<xsd:schema xmlns="urn:oasis:names:tc:unitsml:schema:xsd:UnitsMLSchema-0.9.18" xml
  <xsd:import namespace="http://www.w3.org/XML/1998/namespace" schemaLocatio
  <!--=== Root-Node of an UnitsML document ===-->
  <xsd:element name="UnitsML" type="UnitsMLType">
    <xsd:annotation>
      <xsd:documentation>Container for UnitsML units, quantities, and prefix
    </xsd:annotation>
  </xsd:element>
  <xsd:complexType name="UnitsMLType">
    <xsd:annotation>
      <xsd:documentation>ComplexType for the root element of an UnitsML (
    </xsd:annotation>
    <xsd:sequence>
      <xsd:element ref="UnitSet" minOccurs="0"/>
      <xsd:element ref="CountedItemSet" minOccurs="0"/>
      <xsd:element ref="QuantitySet" minOccurs="0"/>
      <xsd:element ref="DimensionSet" minOccurs="0"/>
      <xsd:element ref="PrefixSet" minOccurs="0"/>
    </xsd:sequence>
```

Units Database (UnitsDB)

UnitsDB

- UnitsDB is based on MySQL
- JAVA & PHP is used to query the MySQL database
- Human Web interface – possible search methods
 - Unique ID – e.g., U_m.s-1
 - Name search with close and partial matches
 - Scrollable list
 - A-Z alphabetic list
- Version 1.0 will provide XML & HTML
- Web Services interface planned

Usage of UnitsML & UnitsDB

Usage of UnitsML & UnitsDB

- Methods of using UnitsML & UnitsDB with other markup languages
 - Incorporating part or all of the UnitsML schema:
 - Refer to the schema
 - Include the schema
 - Import the schema
 - Provide a choice of unit markup
 - Reference the unique IDs in UnitsDB
- We are working with members from other MLs to implement using UnitsML
 - AnIML – Analytical Information Markup Language
 - MatML – Materials Property Data Markup Language
 - AMDML – Atomic and Molecular Data Markup Language

Resources

For the most recent UnitsML schema and documentation with images, go to:

<http://unitsml.nist.gov>

For information about SI units and non-SI units for the U.S., go to:

<http://physics.nist.gov/sp811>

Thank you for your attention.

Questions/Comments?