Units Markup Language (UnitsML)

Presentation for

SCC-20 TII/TAD Working Group

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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: $l = 7.24$ m $\quad v = 6.32$ m/s

$m = 1.53$ kg $\quad \dim v = \mathbf{L\ T^{-1}}$

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	°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, *et al.*	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 $\mathbf{m^2}$; and multiples and submultiples; e.g., km, cm.

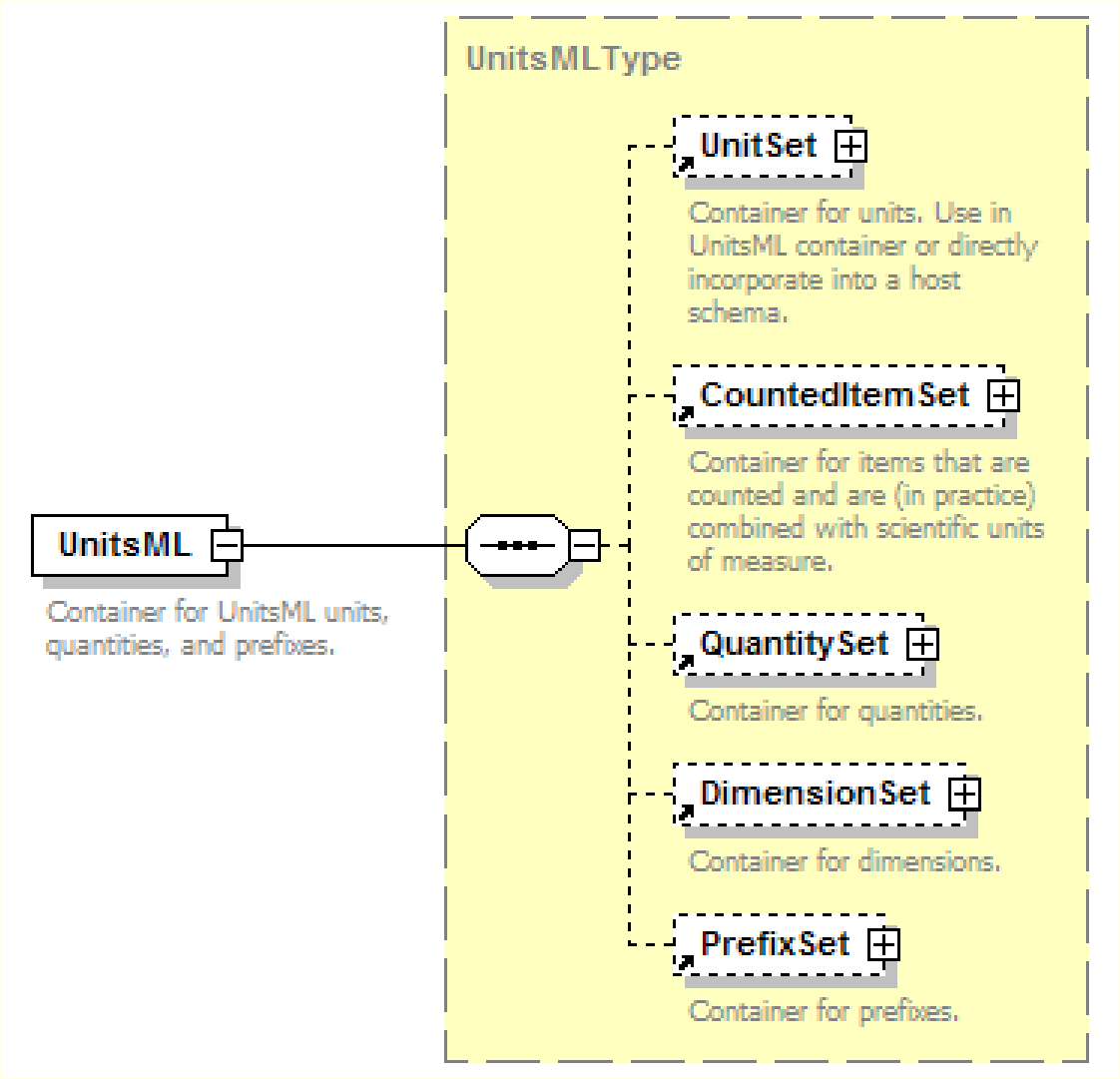
Non-SI Units

- 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

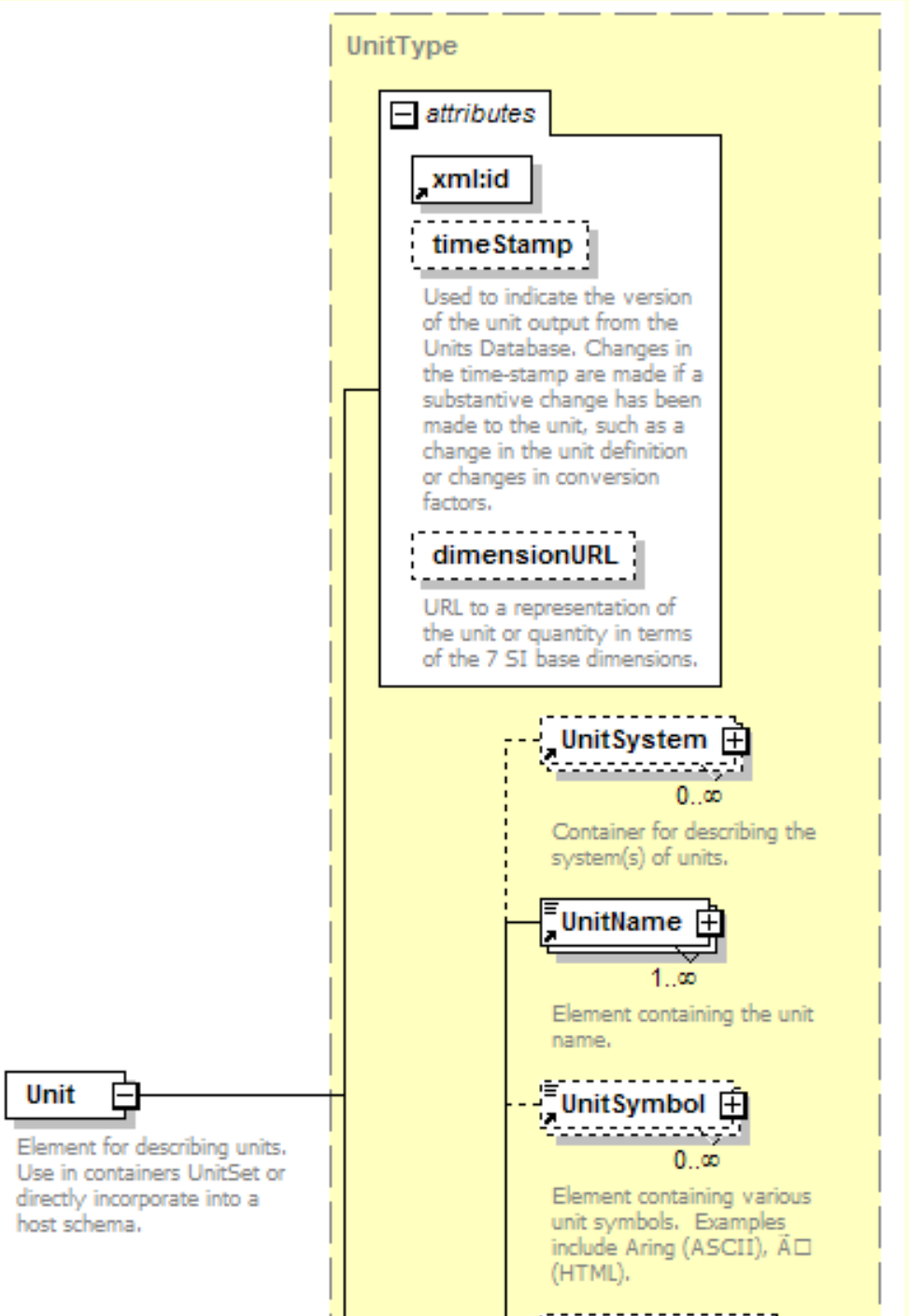
(UnitsML)

UnitsML Root Level



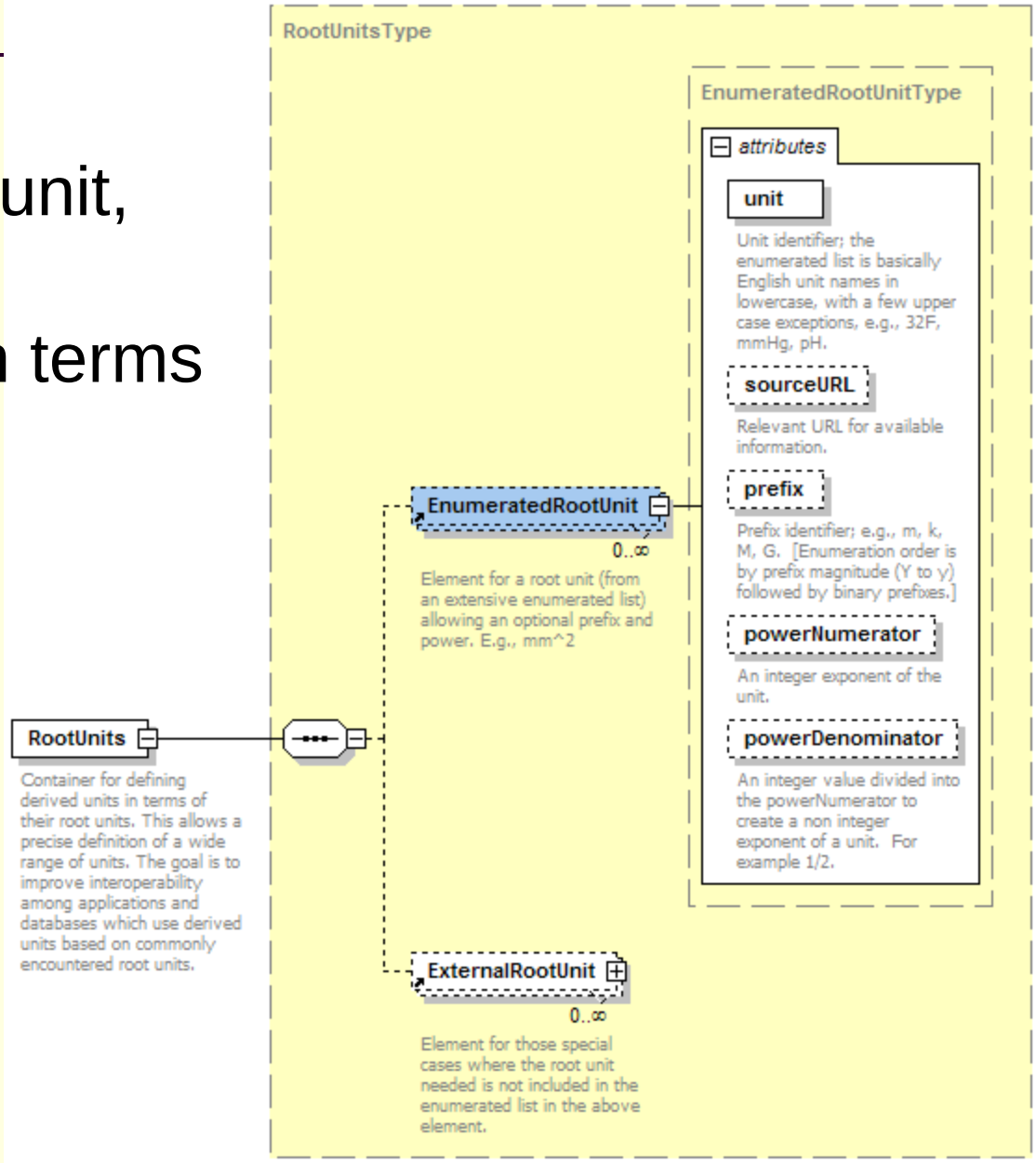
'Unit' Element

- Attributes
  - xml:id
  - dimensionURL
- Elements
  - RootUnits
  - Conversions
  - CodeListValue



'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

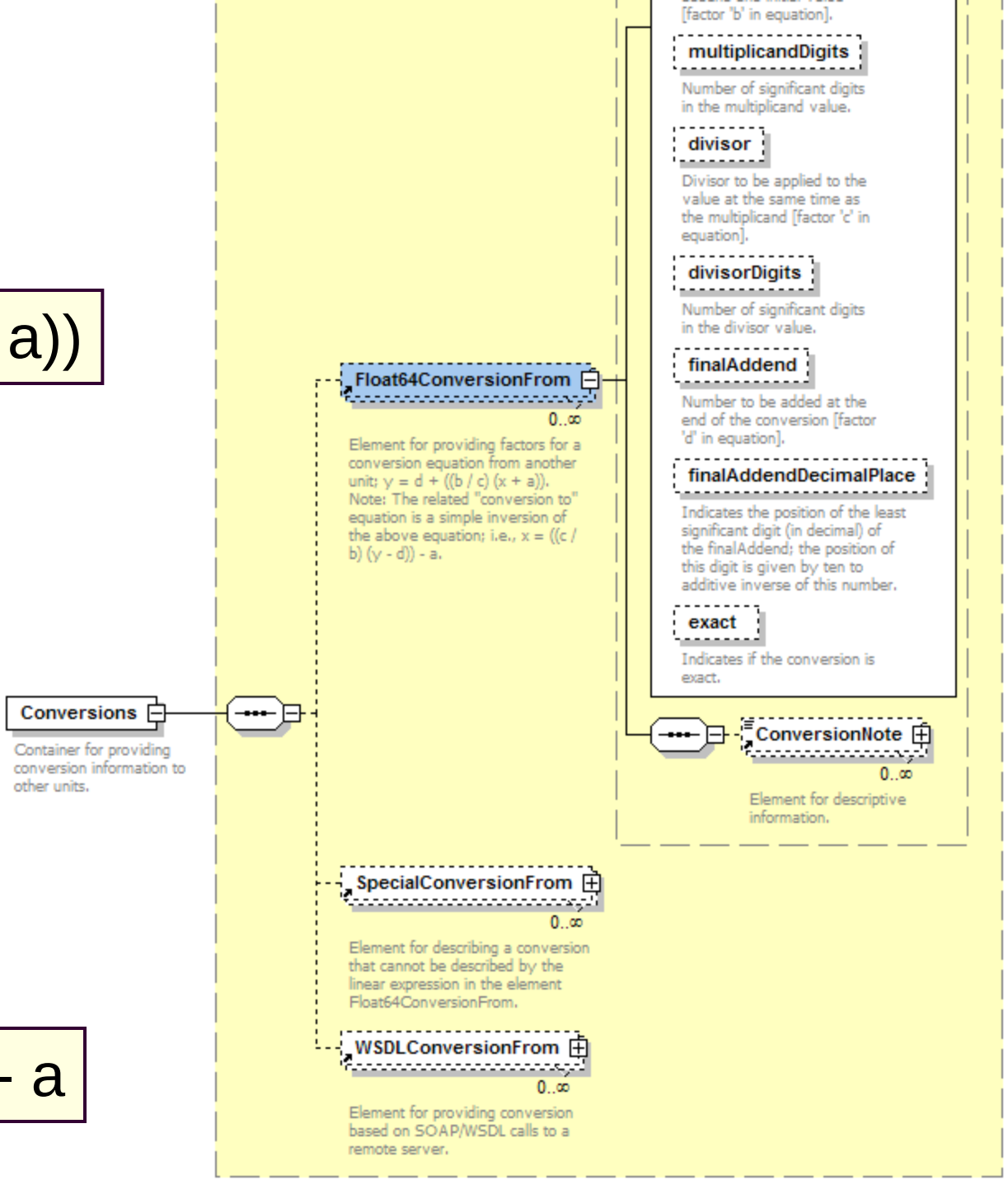
a, initialAddend

b, multiplicand

c, divisor

d, finalAddend

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

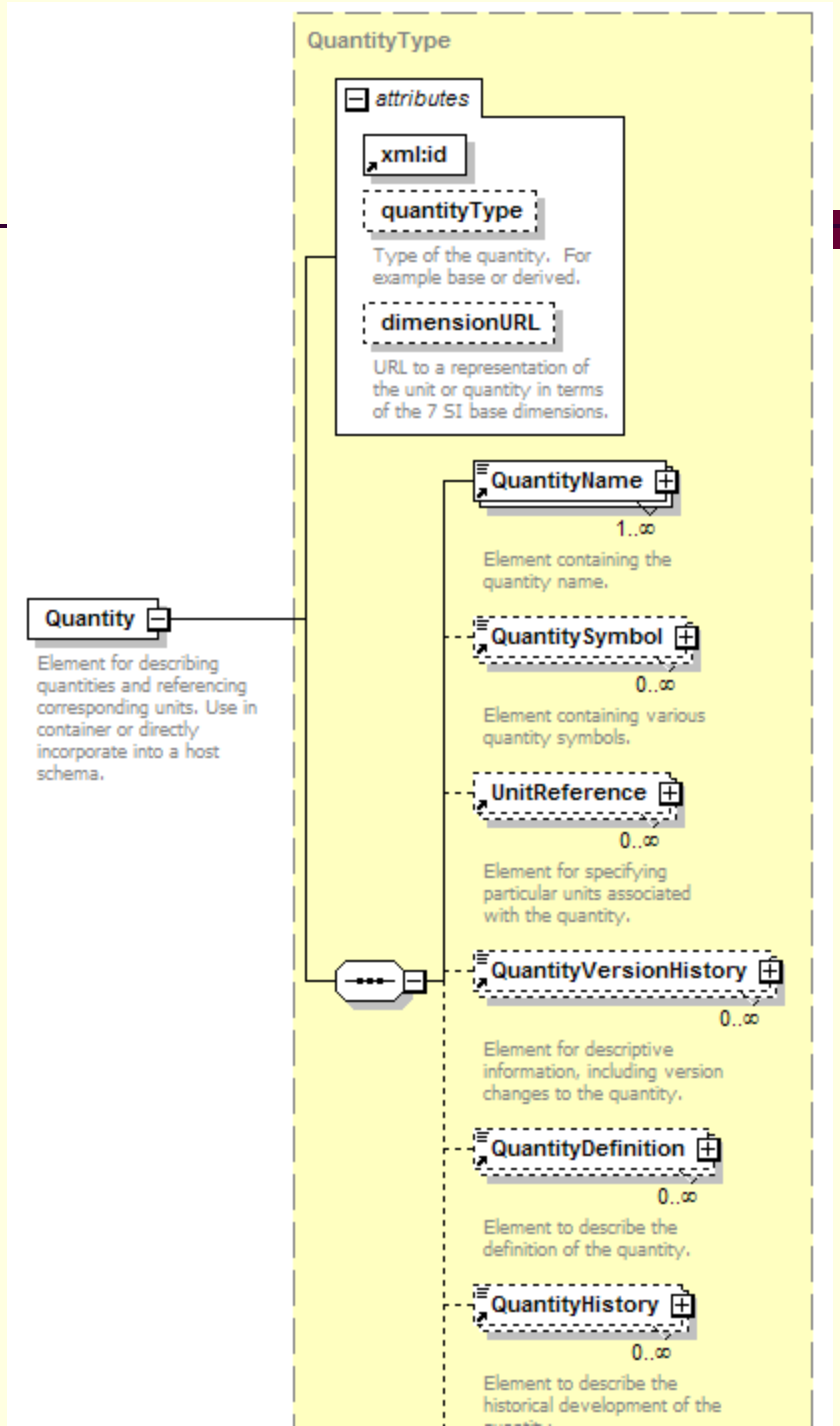


'CodeListValue' Element

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

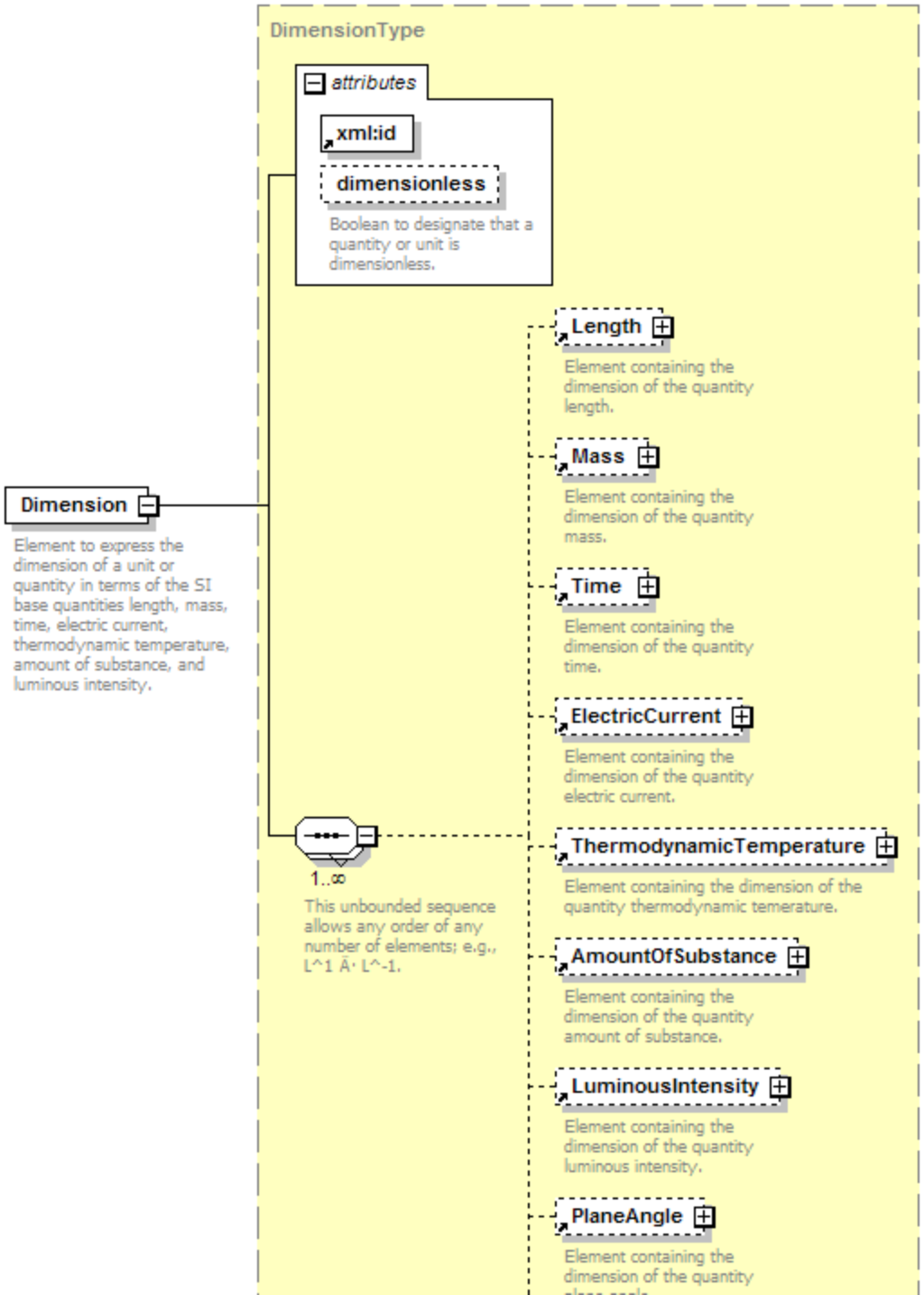
'Quantity' Element

- Attributes
  - xml:id
  - dimensionURL
- Elements
  - UnitReference

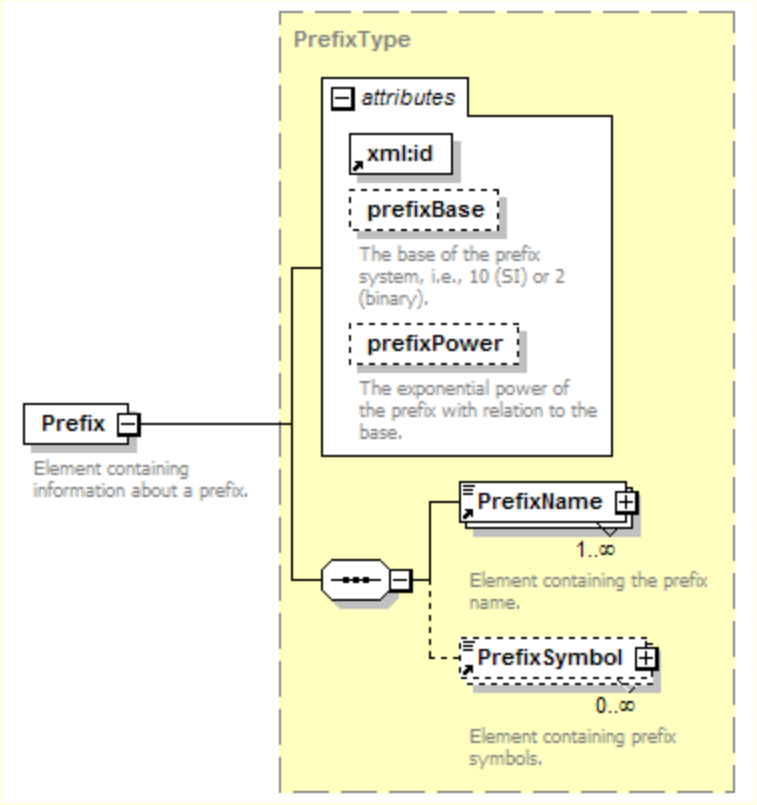


'Dimension' Element

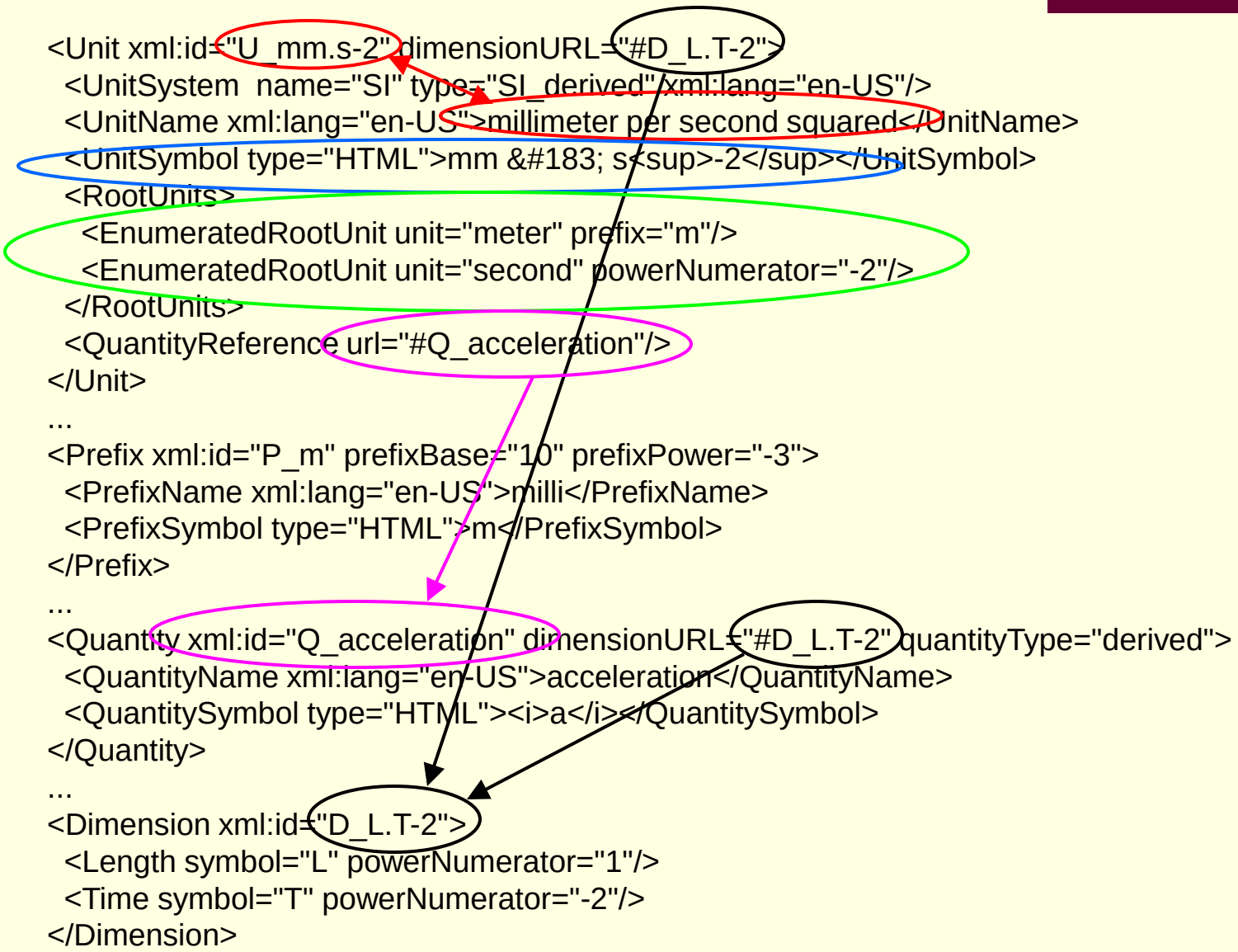
Express the dimensionality of a quantity or unit.



'Prefix' Element



Instance Document Snippets



Units Database

(UnitsDB)

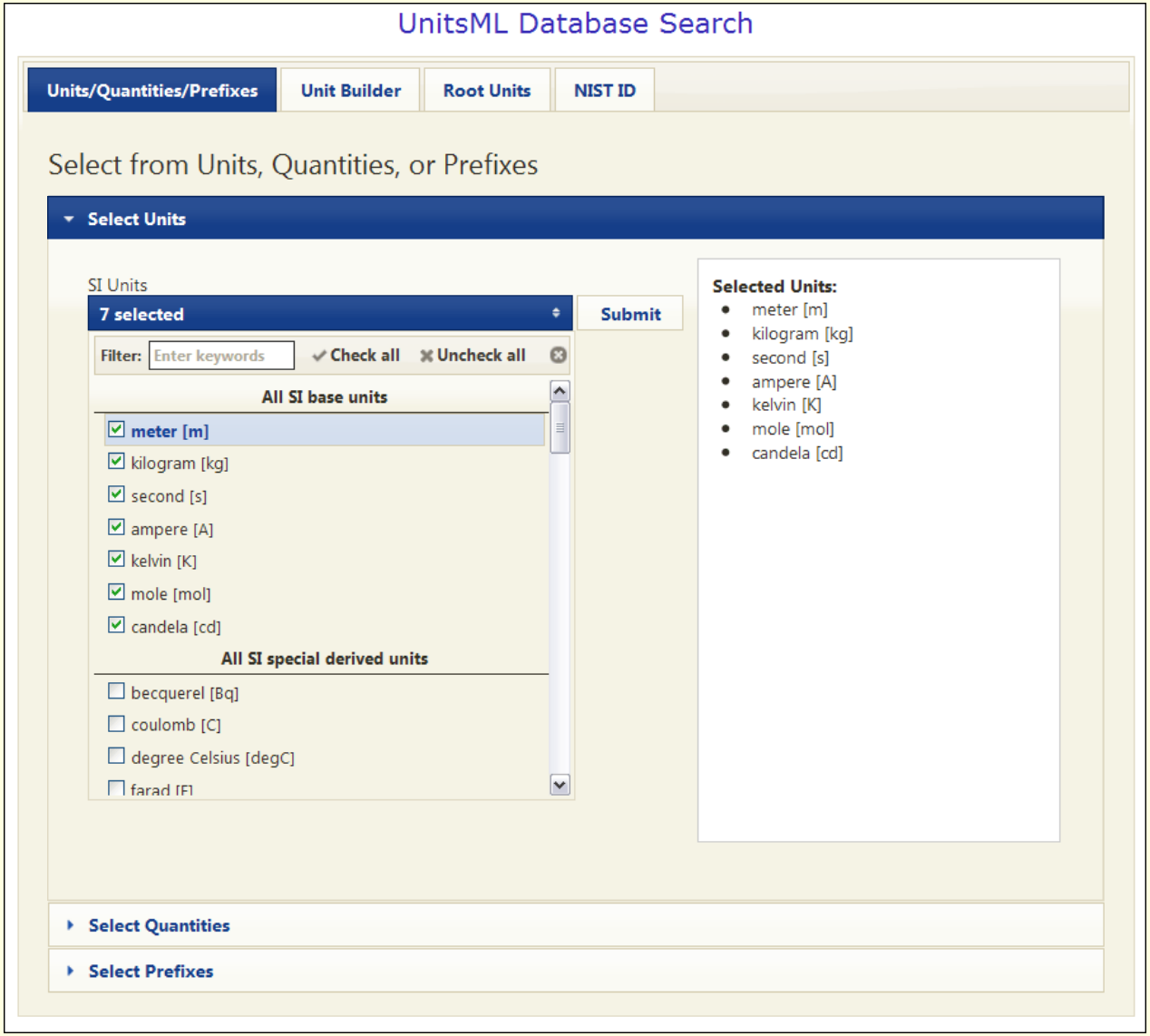
UnitsDB

- UnitsDB uses JAVA to query a MySQL database
- Human Web interface – possible search methods
  - Scrollable list
  - Specific categories; e.g., SI base, non-SI
  - Name search with partial matches
  - Unit symbol
  - Root units
  - Unique ID – e.g., NISTu1.u3e-1
  - Quantities
  - Prefixes
- Version 1.0 will provide XML & HTML
- Web Services interface planned

UnitsDB Search: Screen Captures

Select:
- Units
  - SI / non-SI
- Quantities
- Prefixes

Output Format:
XML / HTML

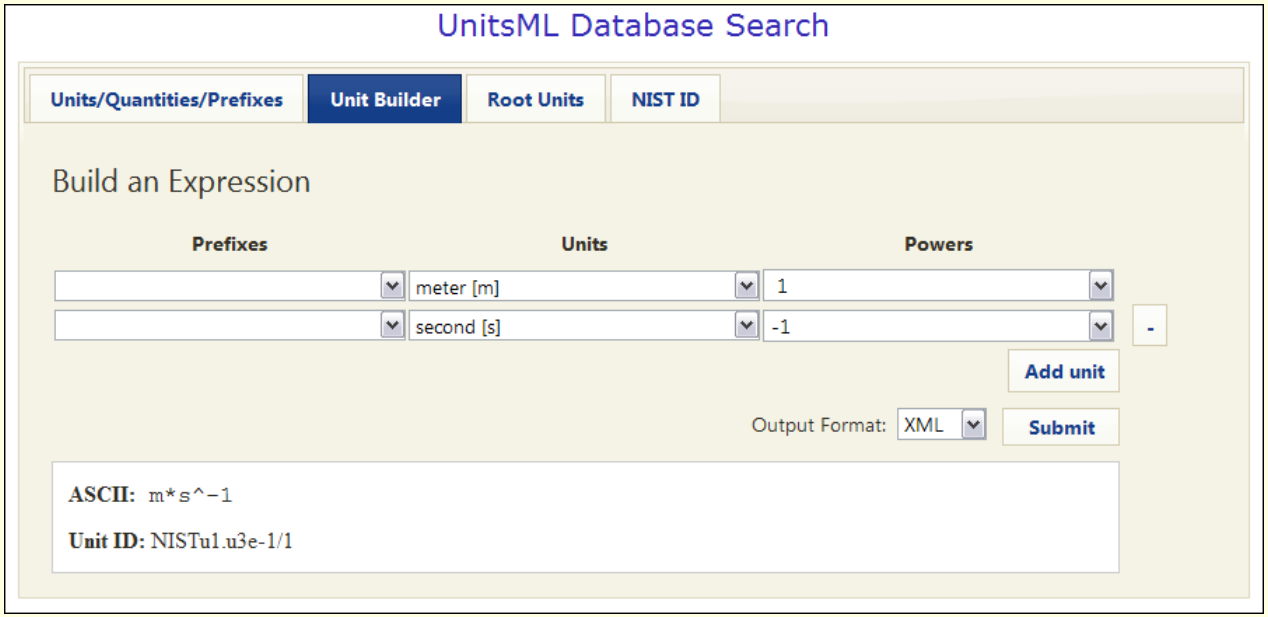


UnitsDB Search: Screen Captures

Unit Builder
Unit
w/ prefix, power

Add Unit

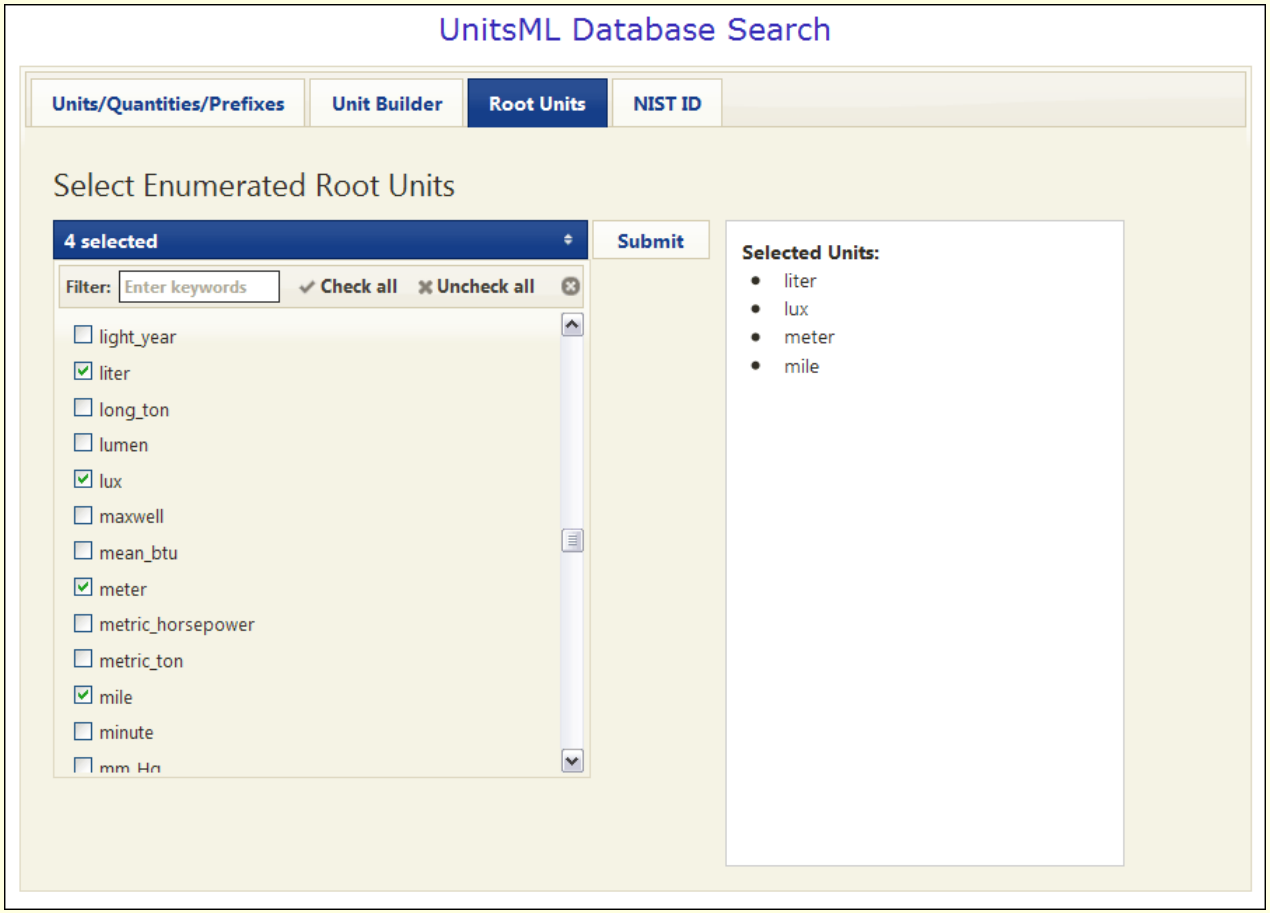
Output Format:
XML / HTML



UnitsDB Search: Screen Captures

Root Units
Select from enumerated list

Output Format:
XML / HTML



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:
    - Reference a unique unit ID
    - Refer to the UnitsML schema
    - <include> the UnitsML schema
    - <import> the UnitsML schema
    - <redefine> the UnitsML schema

Reference a Unique Unit ID

‘Simple’ language instance document

```
<?xml version="1.0" encoding="UTF-8"?>
<SimpleSchemaRoot xsi:noNamespaceSchemaLocation="SimpleSchema0.xsd"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  <Text>The width of the room is: </Text>
  <Measurement>
    <NumericValue>3.14159</NumericValue>
  </Measurement>
  <Text>meters. The width has been obtained by ...</Text>
</SimpleSchemaRoot>
```

Sample instance document: referencing a unique ID

```
<?xml version="1.0" encoding="UTF-8"?>
<SimpleSchemaRoot xsi:noNamespaceSchemaLocation="SimpleSchema1.xsd"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  <Text>The width of the room is: </Text>
  <Measurement unit="http://authorative.source/Units#u1">
    <NumericValue>3.14159</NumericValue>
  </Measurement>
  <Text>. The width has been obtained by ...</Text>
</SimpleSchemaRoot>
```

Refer to the UnitsML Schema

Sample instance document: referring to UnitsML

```
<?xml version="1.0" encoding="UTF-8"?>
<simple:SimpleSchemaRoot
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xmlns:simple="http://unitsml.nist.gov/simple"
    xmlns:unitsml="urn:oasis:names:tc:unitsml:schema:xsd:UnitsMLSchema
    xsi:schemaLocation="http://unitsml.nist.gov/simple SimpleSchema2.x
    urn:oasis:names:tc:unitsml:schema:xsd:UnitsMLSchema-1.0 UnitsML-1.
  <simple:Text>The width of the room is: </simple:Text>
  <simple:Measurement>
    <simple:NumericValue>3.14159</simple:NumericValue>
    <unitsml:Unit xml:id="u42">
      <unitsml:UnitName xml:lang="en-US">meter</unitsml:UnitName>
      <unitsml:UnitSymbol type="ASCII">m</unitsml:UnitSymbol>
    </unitsml:Unit>
  </simple:Measurement>
  <simple:Text>. The width has been obtained by ...</simple:Text>
</simple:SimpleSchemaRoot>
```

Uses **<xsd: any>** in the simple schema.
The value of **@xml:id** must be unique within a document.

Combination of Reference & Refer

Sample instance document: referencing a local units database

```
<?xml version="1.0" encoding="UTF-8"?>
<SimpleSchemaRoot
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xmlns:unitsml="urn:oasis:names:tc:unitsml:schema:xsd:UnitsMLSchema
    xsi:schemaLocation="urn:oasis:names:tc:unitsml:schema:xsd:UnitsMLS
        unitsmlSchema-1.0.xsd"
    xsi:noNamespaceSchemaLocation="SimpleSchema6.xsd">
  <Text>The width of the room is: </Text>
  <Measurement unit="#u42">
    <NumericValue>3.14159</NumericValue>
  </Measurement>
  <Text>. The width has been obtained by ...</Text>
  <unitsml:Unit xml:id="u42">
    <unitsml:UnitName xml:lang="en-US">meter</unitsml:UnitName>
    <unitsml:UnitSymbol type="ASCII">m</unitsml:UnitSymbol>
  </unitsml:Unit>
</SimpleSchemaRoot>
```

Uses **<xsd: any>** in the simple schema.

<import> the UnitsML Schema

Sample instance document: importing UnitsML

```
<?xml version="1.0" encoding="UTF-8"?>
<simple:SimpleSchemaRoot
    xsi:schemaLocation="http://unitsml.nist.gov/simple SimpleSchema7.x
    xmlns:simple="http://unitsml.nist.gov/simple"
    xmlns:unitsml="urn:oasis:names:tc:unitsml:schema:xsd:UnitsMLSchema
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  <simple:Text>The width of the room is: </simple:Text>
  <simple:Measurement unit="#u42">
    <simple:NumericValue>3.14159</simple:NumericValue>
  </simple:Measurement>
  <simple:Text>. The width has been obtained by ...</simple:Text>
  <unitsml:UnitSet>
    <unitsml:Unit xml:id="u42">
      <unitsml:UnitName xml:lang="en-US">meter</unitsml:UnitName>
      <unitsml:UnitSymbol type="ASCII">m</unitsml:UnitSymbol>
    </unitsml:Unit>
  </unitsml:UnitSet>
</simple:SimpleSchemaRoot>
```

Uses **<xsd: import>** in the simple schema.

<include> the UnitsML Schema

Sample instance document: including UnitsML

```
<?xml version="1.0" encoding="UTF-8"?>
<SimpleSchemaRoot xsi:noNamespaceSchemaLocation="SimpleSchema3.xsd"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  <Text>The width of the room is: </Text>
  <Measurement>
    <NumericValue>3.14159</NumericValue>
    <Unit xml:id="u42">
      <UnitName xml:lang="en-US">meter</UnitName>
      <UnitSymbol type="ASCII">m</UnitSymbol>
    </Unit>
  </Measurement>
  <Text>. The width has been obtained by ...</Text>
</SimpleSchemaRoot>
```

Uses **`<xsd: include>`** in the simple schema.

The UnitsML schema must be modified to have either no namespace or that of the simple schema.

<redefine> the UnitsML Schema

Sample instance document: redefining UnitsML

```
<?xml version="1.0" encoding="UTF-8"?>
<SimpleSchemaRoot xsi:noNamespaceSchemaLocation="SimpleSchema5.xsd"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  <Text>The width of the room is: </Text>
  <Measurement>
    <NumericValue>3.14159</NumericValue>
    <Unit xml:id="u42">
      <UnitName xml:lang="en-US">meter</UnitName>
      <UnitSymbol type="ASCII">m</UnitSymbol>
      <MyText>This is sample text in an added element.</MyText>
    </Unit>
  </Measurement>
  <Text>. The width has been obtained by ...</Text>
</SimpleSchemaRoot>
```

Uses **<xsd: redefine>** in the simple schema.

The UnitsML schema must be modified to have either no namespace or that of the simple schema.

In addition, the UnitsML schema can be extended.

Usage of UnitsML & UnitsDB

- We are working with members from other Markup Languages 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, documentation with images, and *Guidelines for the Use of UnitsML*: http://unitsml.nist.gov

For information about SI units and non-SI units for the U.S: http://physics.nist.gov/sp811

Thank you for your attention.

Questions/Comments?