

SBML Dynamic Structures (dyn) package and connection with other packages

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SBML L3V1 Core Limitations

Goal:

- Enabling SBML description of dynamic cellular behavior

Limitation:

- Indicating how elements change is not currently possible

Current approaches:

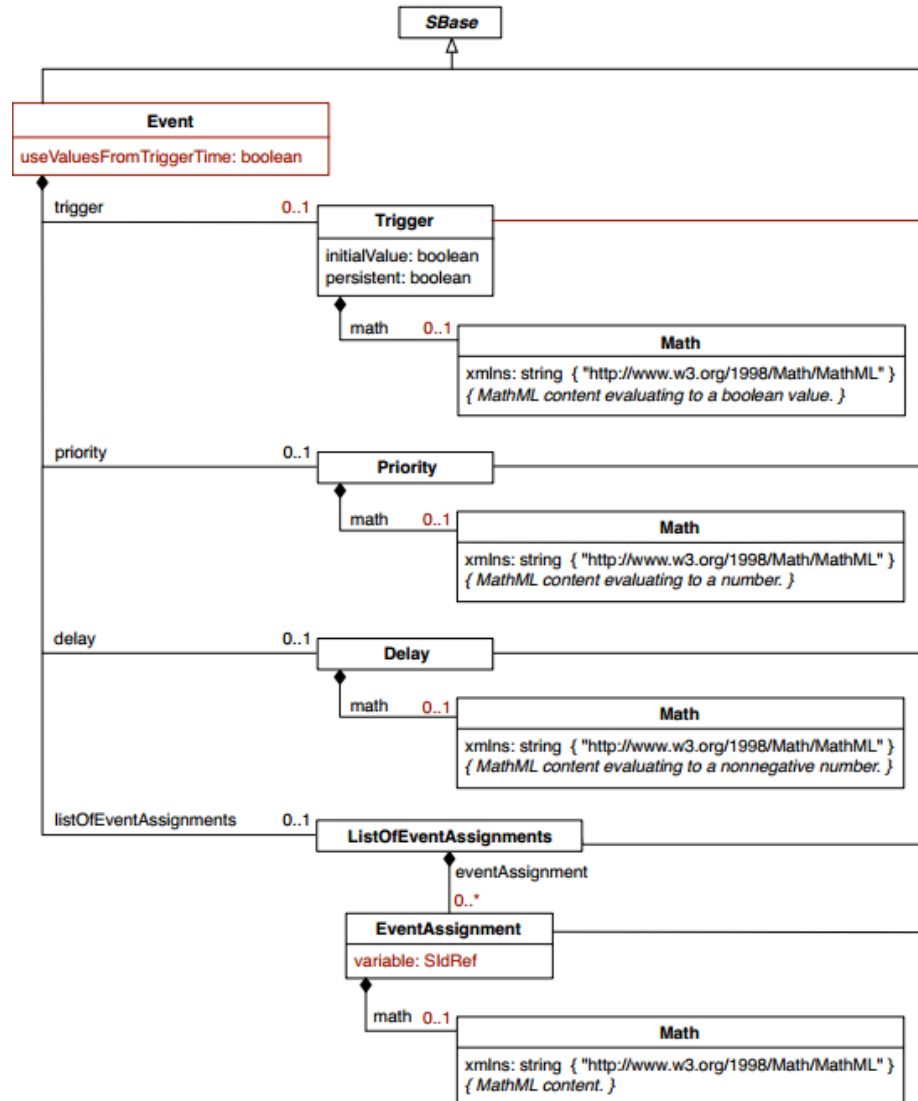
- Tool-specific annotations
- A-priori creation of all necessary compartments and usage of flags

Notes about dyn

- Modeling dynamics mirroring tool-specific semantics was problematic
- Leave the mathematic description of when this behavior happens in SBML
- How they are actually performed is up to each simulator
 - ✓ Using different integrators (ODE vs stochastic)
 - ✓ SBML and SED-ML

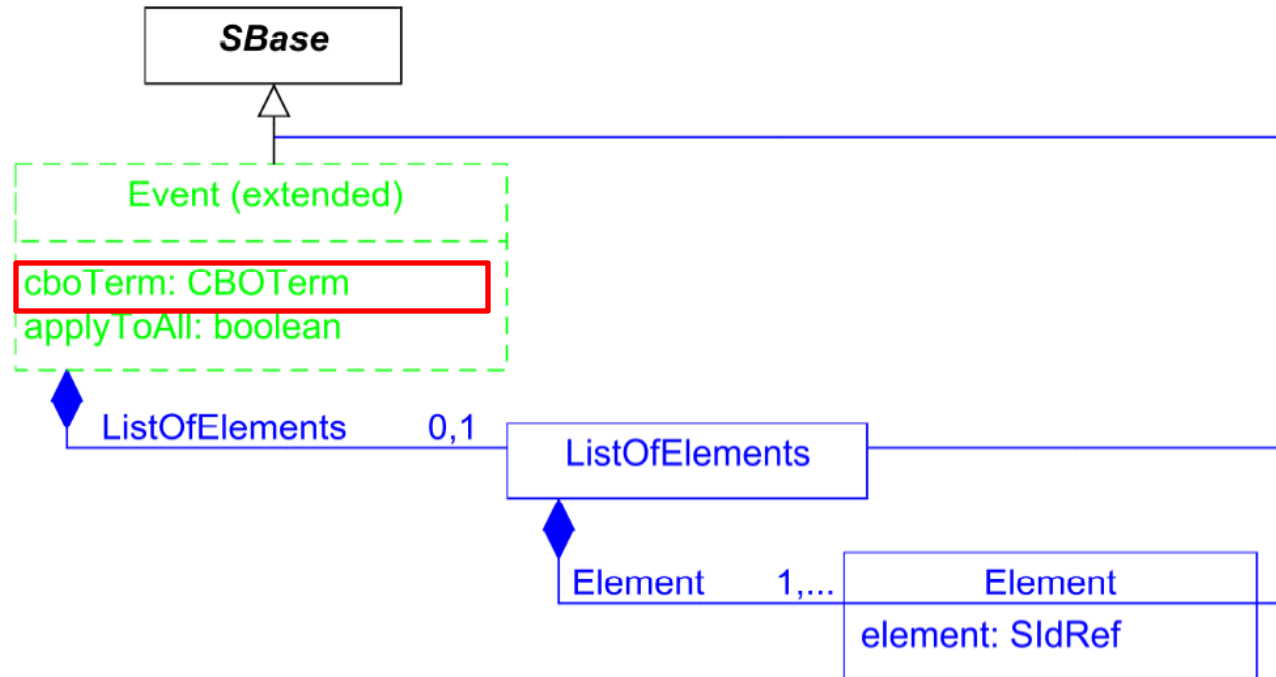
Data Model

The Event construct



Source: UML adapted from SBML L3V2 Core Specification

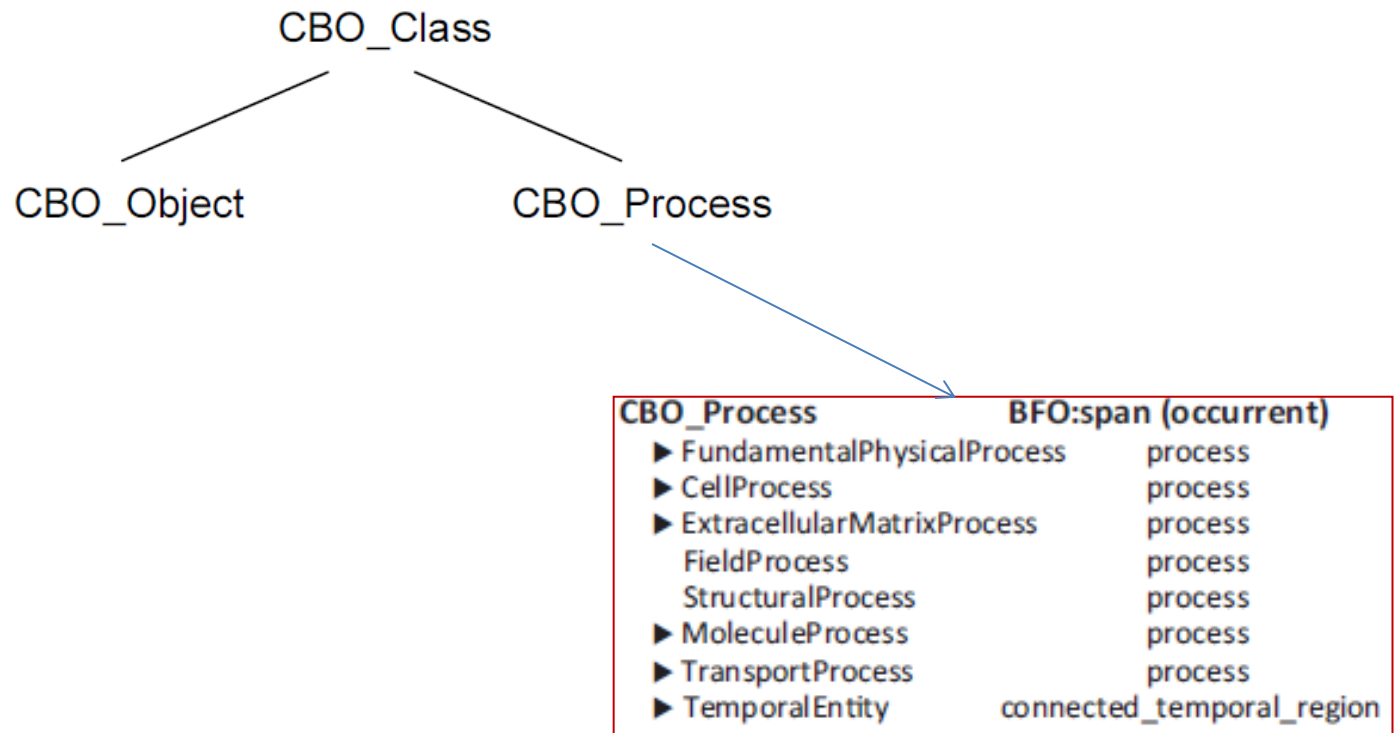
Extend Events to (1) associate a dynamic behavior



Source: UML adapted from Dynamic Structures (Version 1) Specification

What is the Cell Behavior Ontology (CBO)?

Taxonomy of CBO



Dynamic Processes and CBO

Cell Behaviors	CBO Terms
Cell Division	http://cbo.biocomplexity.indiana.edu/svn/cbo/trunk/CBO_1_0.owl#CellDivision
Cell Death	http://cbo.biocomplexity.indiana.edu/svn/cbo/trunk/CBO_1_0.owl#CellDeath
Cell Movement	http://cbo.biocomplexity.indiana.edu/svn/cbo/trunk/CBO_1_0.owl#Movement

Source: Adapted from Dynamic Structures (Version 1) Specification

- Relationship is of the form "the Event is-a X", where X is the CBO term.
- Chosen terms should be the most precise one that captures the intended process
- Each term suggests specific simulation semantics

Questions regarding proposed usage of CBO

Should we support any of these processes?

- http://cbo.biocomplexity.indiana.edu/svn/cbo/trunk/CBO_1_0.owl#CellDifferentiation
- http://cbo.biocomplexity.indiana.edu/svn/cbo/trunk/CBO_1_0.owl#CellMovement
- http://cbo.biocomplexity.indiana.edu/svn/cbo/trunk/CBO_1_0.owl#CellGrowth
- http://cbo.biocomplexity.indiana.edu/svn/cbo/trunk/CBO_1_0.owl#CellExport
- http://cbo.biocomplexity.indiana.edu/svn/cbo/trunk/CBO_1_0.owl#CellAdvection
- http://cbo.biocomplexity.indiana.edu/svn/cbo/trunk/CBO_1_0.owl#CellCellContact
- http://cbo.biocomplexity.indiana.edu/svn/cbo/trunk/CBO_1_0.owl#CellCellAdhesion

Questions regarding proposed usage of CBO

Are there any other processes we would like to support?

- Polarization
- Absorption
- Decay

CBO can be easily extended

Questions regarding proposed usage of CBO

Do we care to specify subtypes of a cellular process?

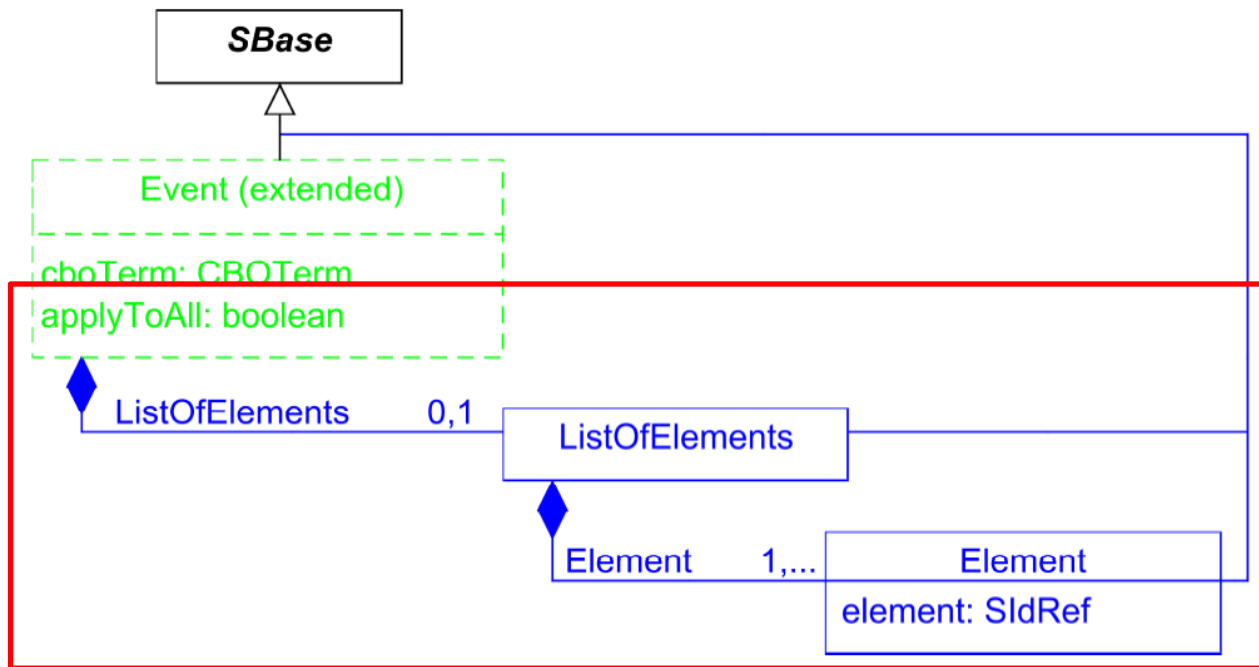
http://cbo.biocomplexity.indiana.edu/svn/cbo/trunk/CBO_1_0.owl#CellDeath



http://cbo.biocomplexity.indiana.edu/svn/cbo/trunk/CBO_1_0.owl#Necrosis

http://cbo.biocomplexity.indiana.edu/svn/cbo/trunk/CBO_1_0.owl#Apoptosis

Extend Events to (2) specify involved model components



Source: Adapted from Dynamic Structures (Version 1) Specification

Example applyToAll usage in Extended Events

1 cell case

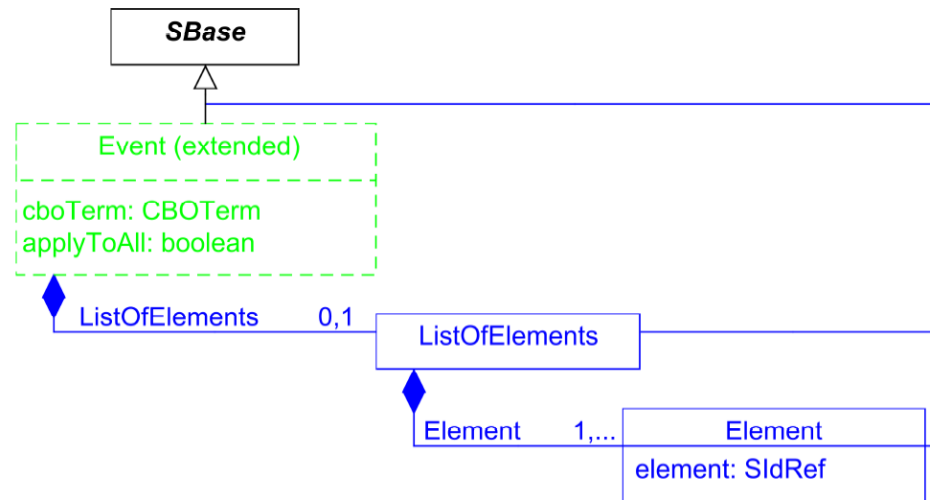
```
<comp:listOfSubmodels>  
  <comp:submodel comp:id="bCell" comp:modelRef="BCell"/>  
</comp:listOfSubmodels>
```

```
<comp:modelDefinition id="BCell">  
  <listOfEvents>  
    <event id="event0" useValuesFromTriggerTime="false" dyn:applyToAll="true"  
      dyn:cboTerm="http://cbo.biocomplexity.indiana.edu/svn/cbo/trunk/CBO_1_0.owl#CellDivision">  
      <trigger initialValue="false" persistent="false">  
        <math xmlns="http://www.w3.org/1998/Math/MathML">  
          <true/>  
        </math>  
      </trigger>  
    </event>  
  </listOfEvents>  
</comp:modelDefinition>
```

2 cell case?

Questions regarding proposed usage of Events

- Can we reference everything that we want to reference in this way?

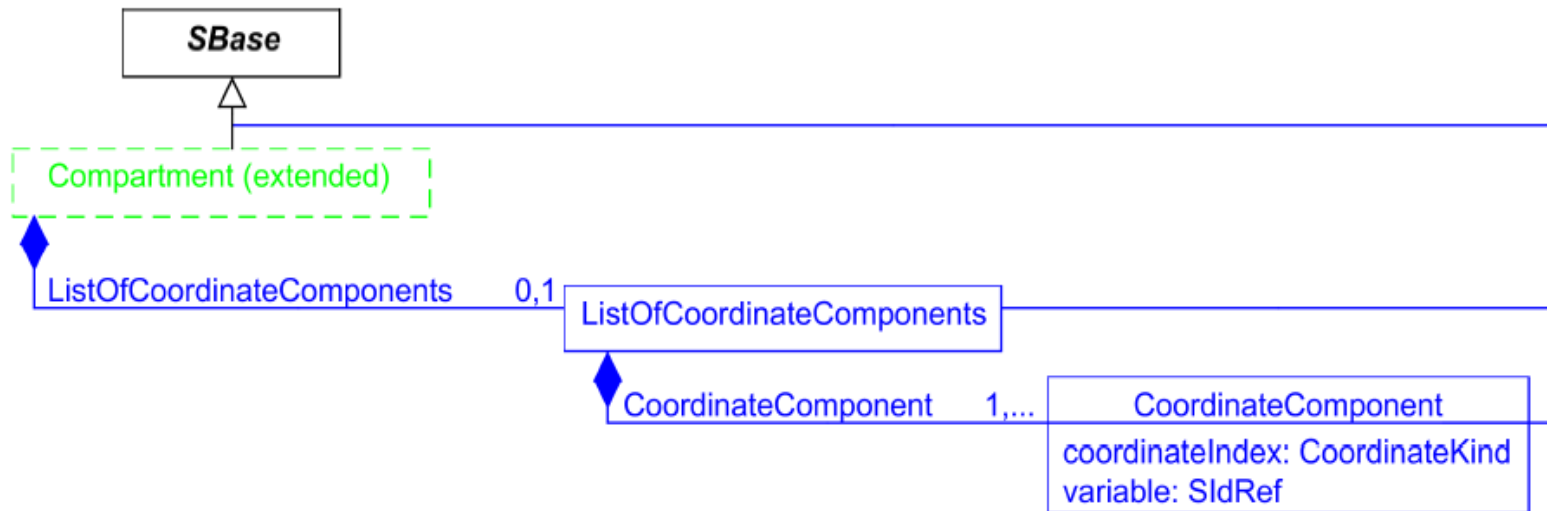


Source: Adapted from Dynamic Structures (Version 1) Specification

How can we specify spatial location of modeling components?

Software tool	Features			
	Modeling framework	Lattice	Off-lattice	Native Space
iBioSim	Stochastic cellular automata	X		2D
STOCHSIM	Stochastic cellular automata	X		2D
CompuCell3D	Cellular Potts Model	X		2D
Daphne	Center-based		X	3D
CellModeler	Center-based (orientation)		X	3D
Chaste	Cellular Potts Model - Cellular Automata - Vertex and center-based	X	X	2D-3D

Extend Compartments to specify spatial location



Source: Adapted from Dynamic Structures (Version 1) Specification

Orthogonality vs. using SBML in a straight forward way!

Example Extended Compartment

```
compartment id="Loc1" spatialDimensions="2" size="1" constant="false">  
  <dyn:listOfCoordinateComponents>  
    <dyn:coordinateComponent coordinateIndex="cartesianX" variable="q1_X" />  
    <dyn:coordinateComponent coordinateIndex="cartesianY" variable="q1_Y" />  
  </dyn:listOfCoordinateComponents>
```

Source: Adapted from Dynamic Structures (Version 1) Specification

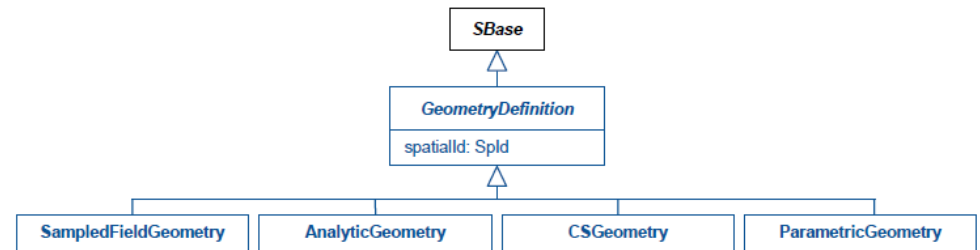
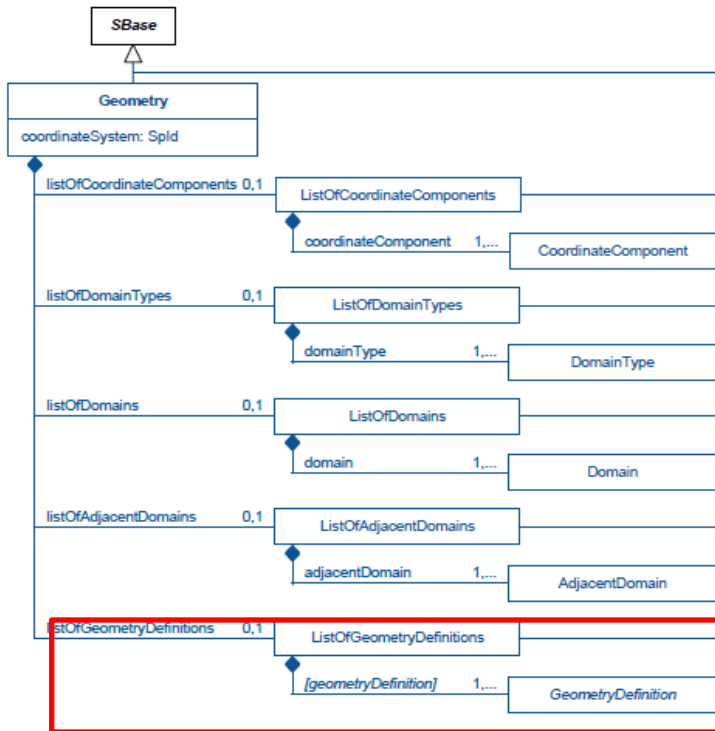
Allow us to indicate position in off-lattice and lattice-based frameworks and reference it

Decouple location from shape in cases where not necessary

Questions regarding proposed extended Compartment

- Do we need any coordinate systems other than Cartesian?
- Do we need to represent the dimensions of the modeling space?
- Should we represent the size of objects (minX/maxX)?
- How do we represent rotation as well, not just location of center of mass?
- How do we represent position in vertex-based model representation?

Spatial Package and object position



Can we use it to simply represent spatial location?

Source: Adapted from Spatial Processes (Version 1) Specification

Using **Spatial** in **dyn**

- Do we need any coordinate systems other than Cartesian?
- Do we need to represent the dimensions of the modeling space?
- Should we represent the size of objects (minX/maxX)?
- How do we represent rotation as well, not just location of center of mass?
- How do we represent position in vertex-based model representation?

Using Spatial in dyn

1. Software tools would need to describe how objects look, not just where they are
2. Inability to access element positions by id

```
<spatial:csgTranslation spatial:translateX="5" spatial:translateY="5" spatial:translateZ="5">  
  <csgScale scaleX="10" scaleY="10" scaleZ="10">  
    <csgPrimitive primitiveType="SOLID_CUBE"/>  
  </csgScale>  
</spatial:csgTranslation
```

Would users need to use only a specific geometry?

Where is the line where what we want is different enough that grants a representation of its own?

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