3DXpert™

3DPRINTING EXERCISE

3DXpert- Extension of Lattice Development

Tutorial_V1- Updated: 14,0100,1592,863(SP1)

3D SYSTEMS

Table of Contents

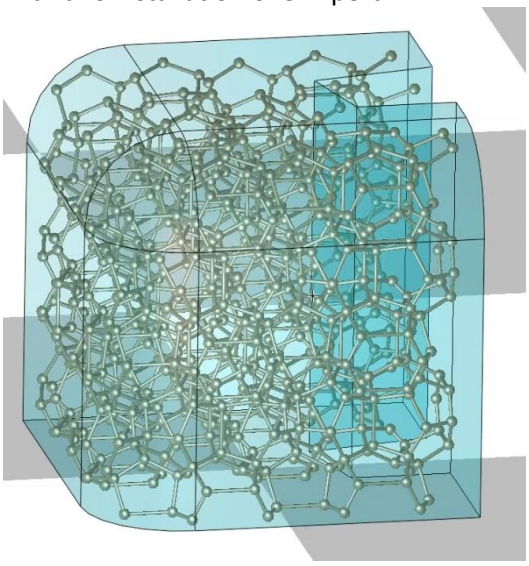
Introduction

An extension for the 3DXpert Lattice definition allows unlimited lattice structure design. This means that the user has also the following abilities:

1. The ability to use formulas to declare numerical values.
2. Full freedom over cell propagation.
3. Use assemblies of lattice cells as composite cell structures.

Cell structures, either standard structures or structures that include the new extension for cell structures are defined in an XML file.

Below is an image of a Weaire–Phelan lattice structure that was created using these capabilities and is now available with this installation of 3DXpert.



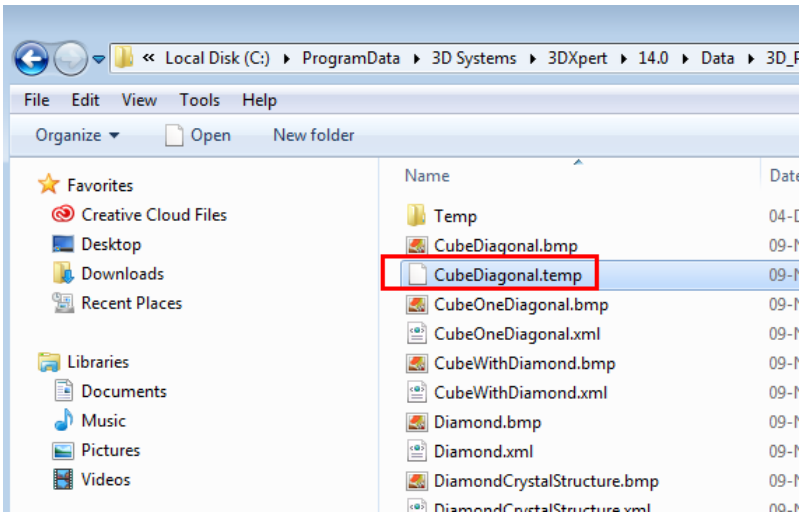
This extension is part of the lattice development license. Users that do not have this license can still use lattice structures based on the standard cell structures, which are provided with the installation.

Part 1 – Basic Structure

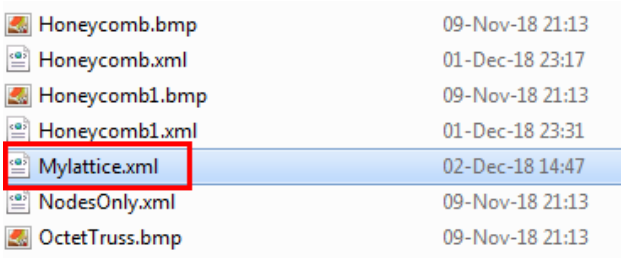
1. Let's have a look at the basic structure of a lattice cell xml file. By default the lattice cell xml files are located under: **\\ProgramData\3D Systems\3DXpert\14.0\Data\3D_Printing\LatticeCells**
2. 3DXpert loads the relevant latticecell file by its Cell ID number. Therefore, do not place latticecell files with the same CellID number under the LatticeCells folder. The ID should be created as a GUID or UUID (Trough these format generators)

```
<?xml version="1.0" encoding="UTF-8"?>
<Cell ID="{46430551-0E89-4FAD-A444-1FBFAF0C129C}" Name="Diagonals">
  <Nodes>
    <Node ID="0" X="0" Y="0" Z="0"/>
    <Node ID="1" X="1" Y="0" Z="0"/>
    <Node ID="2" X="1" Y="1" Z="0"/>
    <Node ID="3" X="0" Y="1" Z="0"/>

    <Node ID="4" X=".5" Y="0" Z=".5"/>
    <Node ID="5" X="1" Y=".5" Z=".5"/>
    <Node ID="6" X=".5" Y="1" Z=".5"/>
    <Node ID="7" X="0" Y=".5" Z=".5"/>

    <Node ID="8" X="0" Y="0" Z="1"/>
    <Node ID="9" X="1" Y="0" Z="1"/>
    <Node ID="10" X="1" Y="1" Z="1"/>
    <Node ID="11" X="0" Y="1" Z="1"/>
```

3. We will now load a user-defined xml into 3Dxpert. However it has the same Cell ID as in the existed file: cubediagonal.xml
4. Temporarily change the extension of cubediagonal.xml to cubediagonal.temp

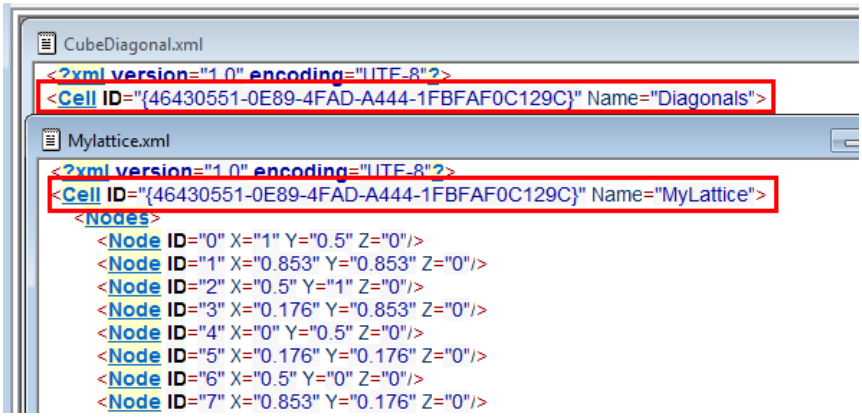


5. Place the user defined xml : **Mylattice.xml** under: \\ProgramData\3D Systems\3DXpert\14.0\Data\3D_Printing\LatticeCells

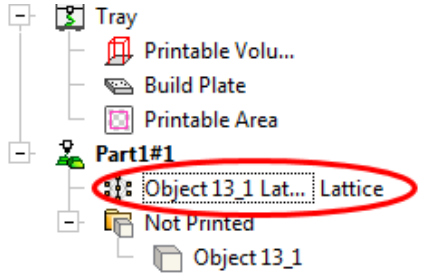


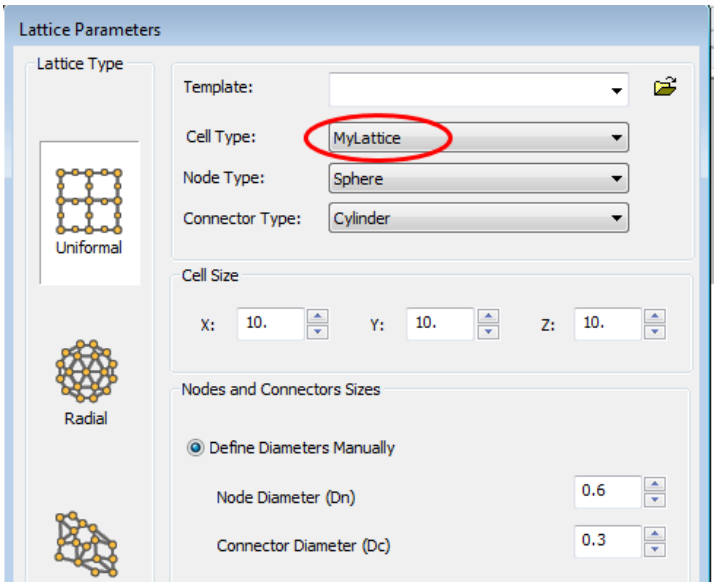
6. Open the **MyLattice xml** file.

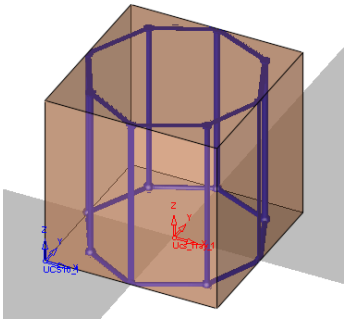
Notice that it has the same Cell ID as the old CubeDiagonal xml file as previously mentioned.



7. Load the file **3DP_Project_mylattice.elt**. Edit the lattice feature.
8. Ensure that MyLattice cell type is the chosen type.



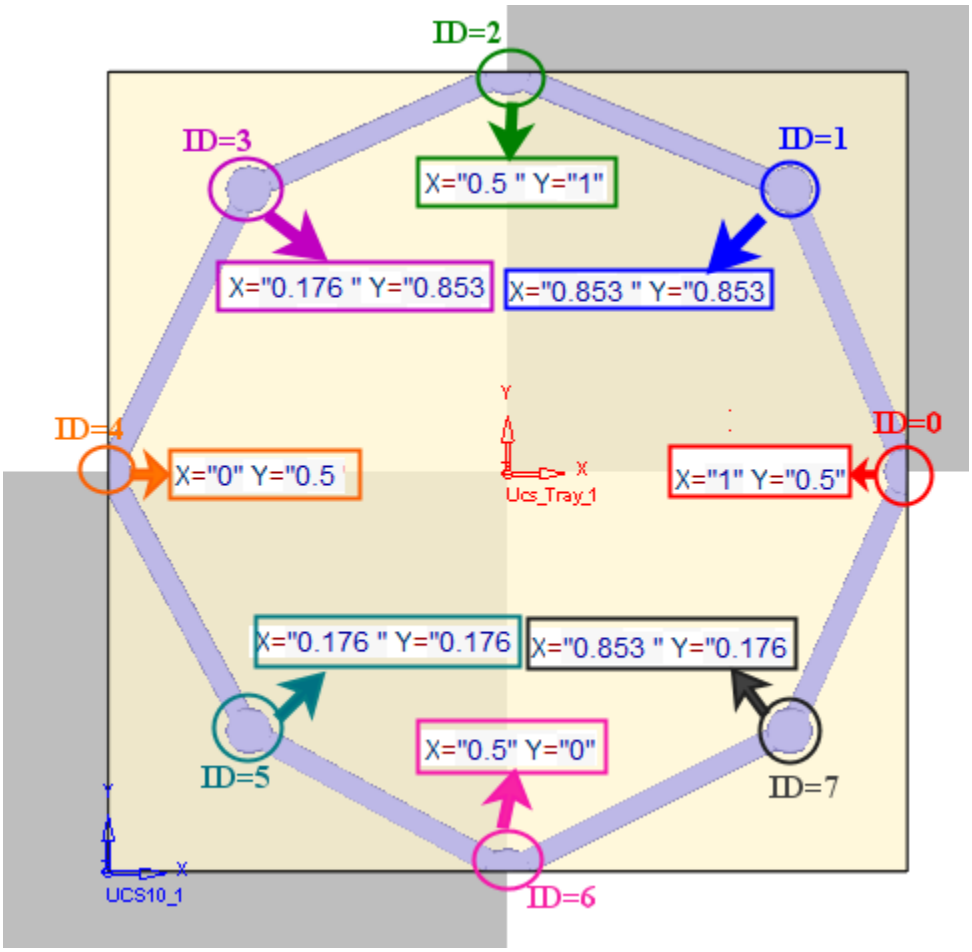




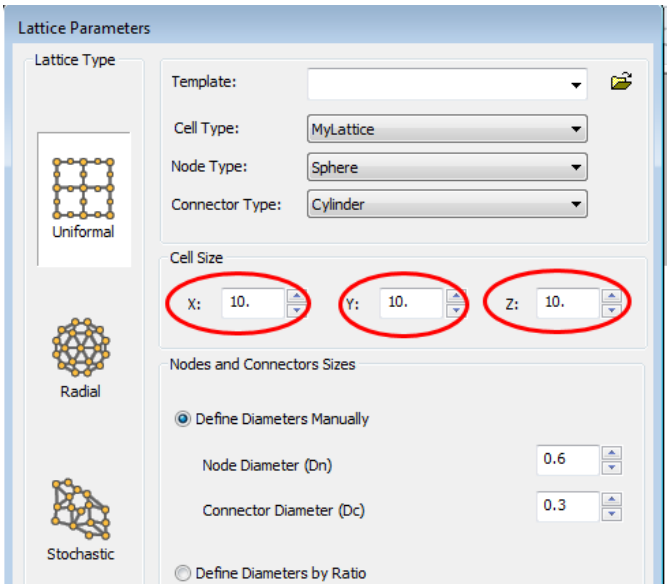
9. Examine the first **8 lines** in the **MyLattice xml** file. There are 16 nodes (0-15) 8 nodes for the bottom of the octagon shape (z height=0) and 8 nodes for the upper octagon (z height= 1).

!	Node: The basic building block. Connector: The string or face connecting nodes. Cell: The building block of a lattice composed of nodes and connectors.

```
<Nodes>
 <Node ID="0" X="1" Y="0.5" Z="0"/>
 <Node ID="1" X="0.853 " Y="0.853 " Z="0"/>
 <Node ID="2" X="0.5 " Y="1" Z="0"/>
 <Node ID="3" X="0.176 " Y="0.853 " Z="0"/>
 <Node ID="4" X="0" Y="0.5 " Z="0"/>
 <Node ID="5" X="0.176 " Y="0.176 " Z="0"/>
 <Node ID="6" X="0.5" Y="0" Z="0"/>
 <Node ID="7" X="0.853 " Y="0.176 " Z="0"/>

 <Node ID="8" X="1" Y="0.5" Z="1"/>
 <Node ID="9" X="0.853 " Y="0.853 " Z="1"/>
 <Node ID="10" X="0.5 " Y="1" Z="1"/>
 <Node ID="11" X="0.176 " Y="0.853 " Z="1"/>

 <Node ID="12" X="0" Y="0.5 " Z="1"/>
 <Node ID="13" X="0.176 " Y="0.176 " Z="1"/>
 <Node ID="14" X="0.5" Y="0" Z="1"/>
 <Node ID="15" X="0.853 " Y="0.176 " Z="1"/>
```



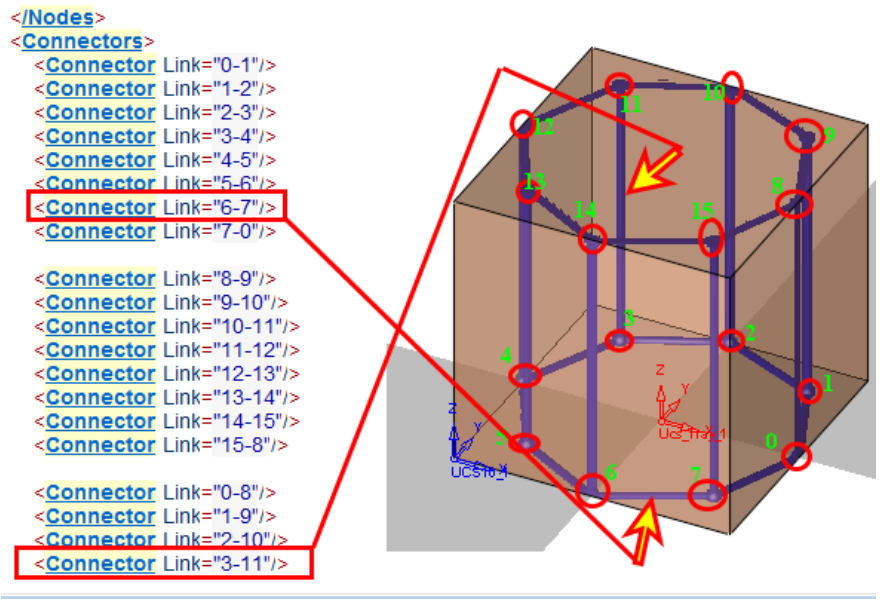
10. The basic unit's size of the hexagon cell (defined in the xml file) can be multiplied (resized) through the cell size values in the Lattice Parameters dialog.



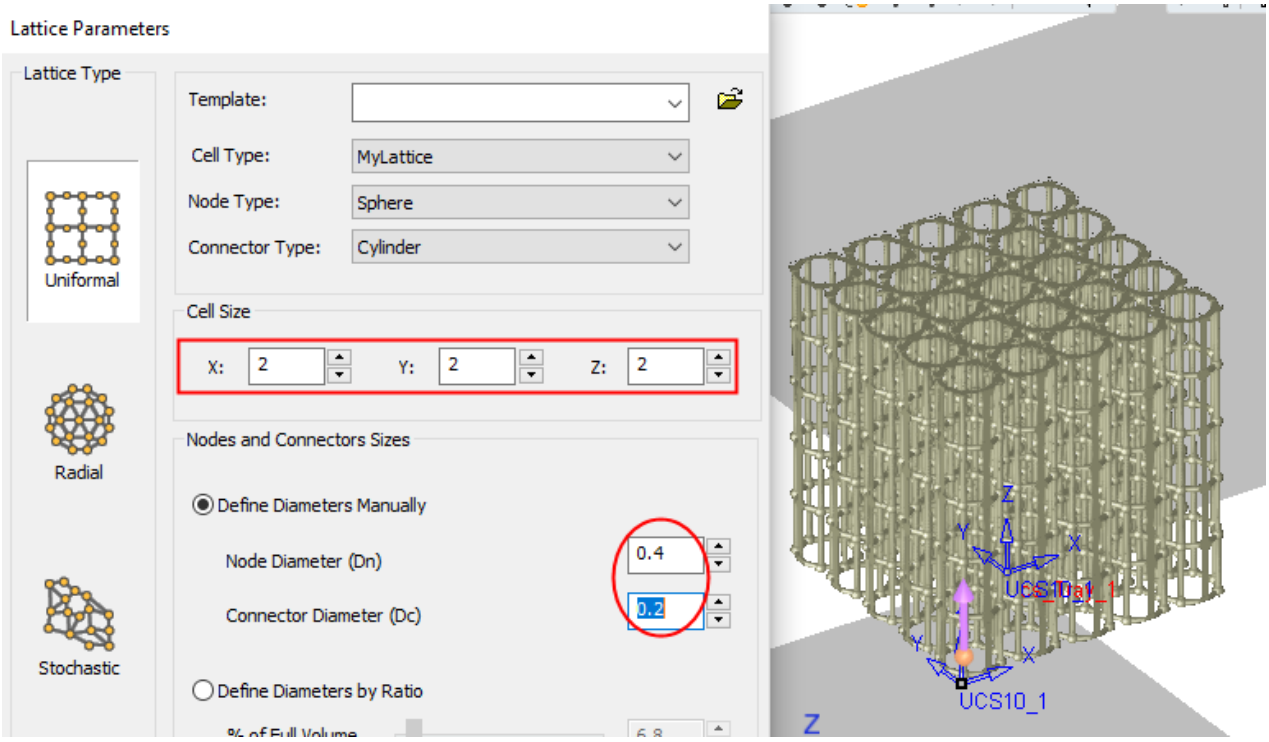
11. Let's have a look at the connectors. The connectors connect nodes to each other in an order, which create the cell structure.

```
<Node ID="10" X="0.5 " Y="1" Z="1"/>
<Node ID="11" X="0.176 " Y="0.853 " Z="1"/>

<Node ID="12" X="0" Y="0.5 " Z="1"/>
<Node ID="13" X="0.176 " Y="0.176 " Z="1"/>
<Node ID="14" X="0.5" Y="0" Z="1"/>
<Node ID="15" X="0.853 " Y="0.176 " Z="1"/>

</Nodes>
<Connectors>
  <Connector Link="0-1"/>
  <Connector Link="1-2"/>
  <Connector Link="2-3"/>
  <Connector Link="3-4"/>
  <Connector Link="4-5"/>
  <Connector Link="5-6"/>
  <Connector Link="6-7"/>
  <Connector Link="7-0"/>

  <Connector Link="8-9"/>
  <Connector Link="9-10"/>
  <Connector Link="10-11"/>
  <Connector Link="11-12"/>
  <Connector Link="12-13"/>
  <Connector Link="13-14"/>
  <Connector Link="14-15"/>
  <Connector Link="15-8"/>

  <Connector Link="0-8"/>
  <Connector Link="1-9"/>
  <Connector Link="2-10"/>
  <Connector Link="3-11"/>
    <Connector Link="4-12"/>
  <Connector Link="5-13"/>
  <Connector Link="6-14"/>
  <Connector Link="7-15"/>
</Connectors>
```

12. Each connector link in the xml file defines a connector between two node points in the lattice structure.



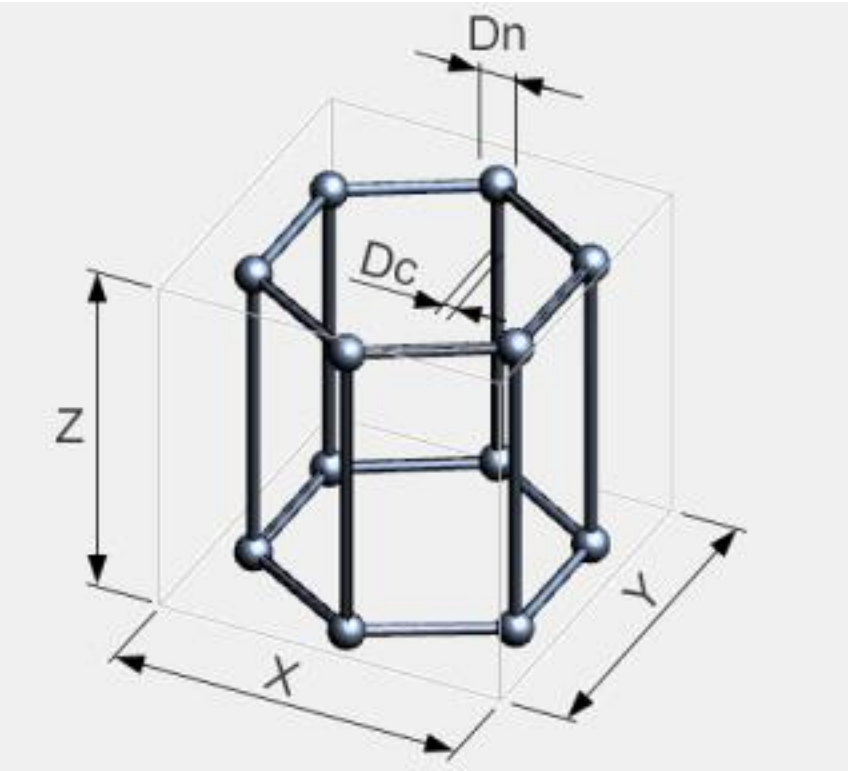
13. The progression of such a basic cell structure is done in the direction of X,Y,Z and one next to each other. Set the X, Y, Z to **2**. Set the Node Diameter to **0.4** and the connector diameter to **0.2**.



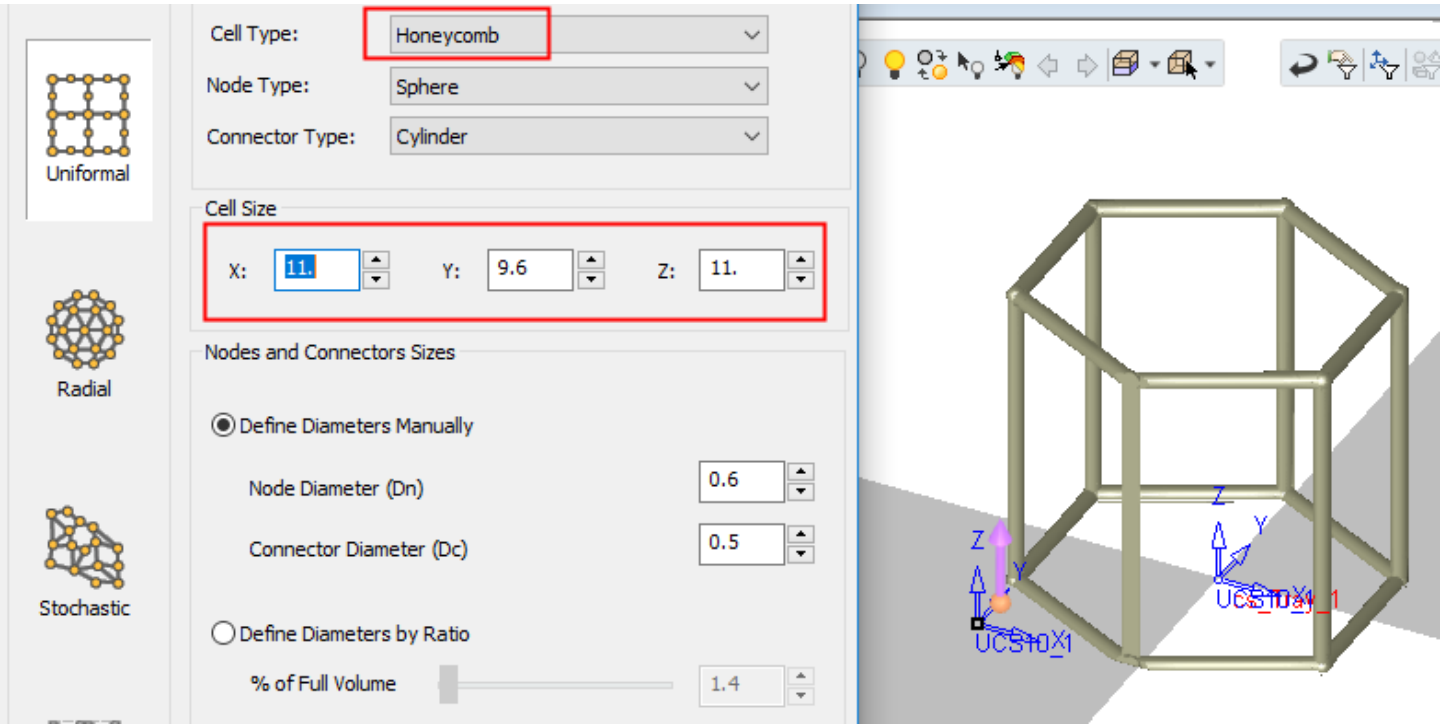
Part 2 – Progression and formulas

We will now examine a more complex structure of Lattice cell xml file.

14. Open the Honeycomb.xml file under **\\ProgramData\3D Systems\3DXpert\14.0\Data\3D_Printing\LatticeCells**
15. The Honeycomb structure is a hexagon cell structure.



16. Change the Cell type to Honeycomb and set the parameters as shown in the picture below: structure is a hexagon cell structure.



17. The **Honeycomb.xml** file is divided into three sections: Nodes, Connectors and Period:

```
<?xml version="1.0" encoding="UTF-8"?>
<Cell ID="{D744CE6B-A459-4819-8A07-8E69F55467A0}" Name="Honeycomb">
  <Nodes A=".25" B="sqrt(3)/4">
          <Node ID="0" X="0" Y="A" Z="0"/>
          <Node ID="1" X="0" Y="3A" Z="0"/>
          <Node ID="2" X="B" Y="4A" Z="0"/>
          <Node ID="3" X="2B" Y="3A" Z="0"/>
          <Node ID="4" X="2B" Y="A" Z="0"/>
          <Node ID="5" X="B" Y="0" Z="0"/>

          <Node ID="6" X="0" Y="A" Z="2B"/>
          <Node ID="7" X="0" Y="3A" Z="2B"/>
          <Node ID="8" X="B" Y="4A" Z="2B"/>
          <Node ID="9" X="2B" Y="3A" Z="2B"/>
          <Node ID="10" X="2B" Y="A" Z="2B"/>
          <Node ID="11" X="B" Y="0" Z="2B"/>
  </Nodes>
  <Connectors>
          <Connector Link="0-1"/>
          <Connector Link="1-2"/>
          <Connector Link="2-3"/>
          <Connector Link="3-4"/>
          <Connector Link="4-5"/>
          <Connector Link="5-0"/>

          <Connector Link="6-7"/>
          <Connector Link="7-8"/>
          <Connector Link="8-9"/>
          <Connector Link="9-10"/>
          <Connector Link="10-11"/>
          <Connector Link="11-6"/>

          <Connector Link="0-6"/>
          <Connector Link="1-7"/>
          <Connector Link="2-8"/>
          <Connector Link="3-9"/>
          <Connector Link="4-10"/>
          <Connector Link="5-11"/>
  </Connectors>
  <Period>
          <Nodes A=".25" B="sqrt(3)/4">
                  <Node ID="0" X="0" Y="0" Z="0"/>

                  <Node ID="1" X="2B" Y="0" Z="0"/>
                  <Node ID="2" X="B" Y="3A" Z="0"/>
                  <Node ID="3" X="-B" Y="3A" Z="0"/>
                  <Node ID="4" X="0" Y="0" Z="2B"/>
          </Nodes>
          <Connectors>
                  <Connector Link="0-1" Continue="Yes"/>
```

1

2

3

Notice the algebraic definition (or formulas) at the top of the file structure. You may add a list of expressions/formulas to define constancies.

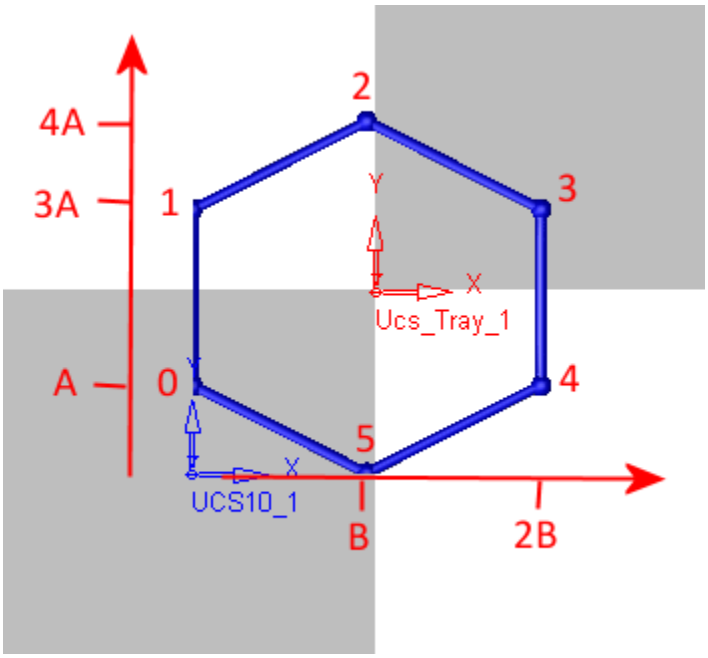
It is easier to define the node's coordinates in terms of these constancies as shown in the example below:

A=0.25 : B =sqrt(3)q4 which is 0.43301270189

!	Note: You cannot use variable names 'X' 'Y' 'Z'. You may add comments in the text , a standard XML comment, Using the following phrase prior to your comment: <!--*your comment* -->

```
File  Edit  Format  View  Help
<?xml version="1.0" encoding="UTF-8"?>
<Cell ID="{D744CF6B-A459-4819-8A07-8F69F55467A0}" Name="Honeycomb">
        <Nodes A=".25" B="sqrt(3)/4">
                <Node ID="0" X="0" Y="A" Z="0"/>
                <Node ID="1" X="0" Y="3A" Z="0"/>
                <Node ID="2" X="B" Y="4A" Z="0"/>
                <Node ID="3" X="2B" Y="3A" Z="0"/>
                <Node ID="4" X="2B" Y="A" Z="0"/>
                <Node ID="5" X="B" Y="0" Z="0"/>

                <Node ID="6" X="0" Y="A" Z="2B"/>
                <Node ID="7" X="0" Y="3A" Z="2B"/>
                <Node ID="8" X="B" Y="4A" Z="2B"/>
                <Node ID="9" X="2B" Y="3A" Z="2B"/>
                <Node ID="10" X="2B" Y="A" Z="2B"/>
                <Node ID="11" X="B" Y="0" Z="2B"/>
```

18. Nodes 0-5 of the hexagon defined by A and B expressions. (Nodes 6-11 are the same as 0-5 beside the Z value which is 2B)



The connectors connects nodes by their ID's

```
- <Connectors>
    <Connector Link="0-1"/>
    <Connector Link="1-2"/>
    <Connector Link="2-3"/>
    <Connector Link="3-4"/>
    <Connector Link="4-5"/>
    <Connector Link="5-0"/>
    <Connector Link="6-7"/>
    <Connector Link="7-8"/>
    <Connector Link="8-9"/>
    <Connector Link="9-10"/>
    <Connector Link="10-11"/>
    <Connector Link="11-6"/>
    <Connector Link="0-6"/>
    <Connector Link="1-7"/>
    <Connector Link="2-8"/>
    <Connector Link="3-9"/>
    <Connector Link="4-10"/>
    <Connector Link="5-11"/>
```

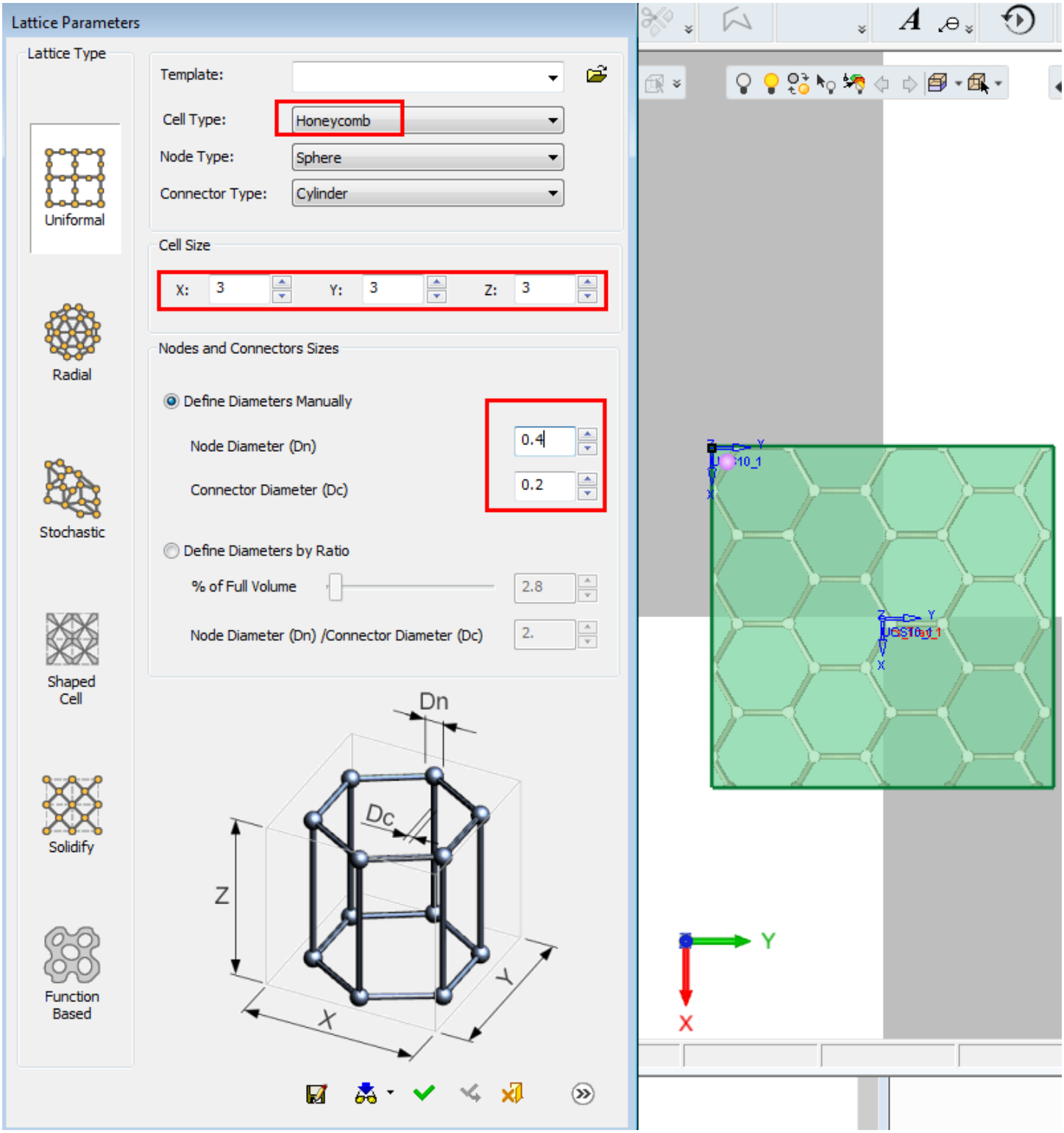
Periods:

The Period defines how the structure is being propagated in space. It defines the relationship between one hexagon and another hexagon

!	Once a period section was defined, the propagation is no longer done automatically (like in a basic cell structure in the direction of X,Y,Z and one next to each other). You must define each propagation's direction as required

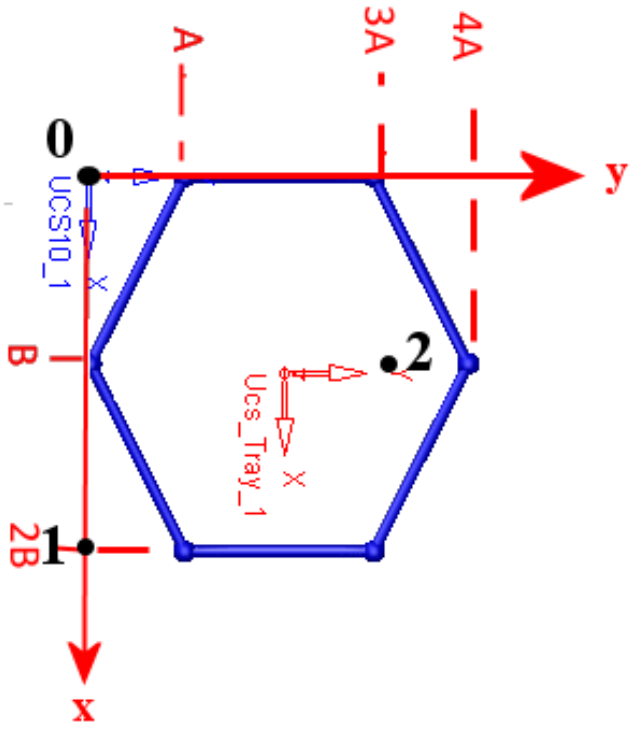
```
- <Period>
  - <Nodes B="sqrt(3)/4" A=".25">
      <Node ID="0" Z="0" Y="0" X="0"/>
      <Node ID="1" Z="0" Y="0" X="2B"/>
      <Node ID="2" Z="0" Y="3A" X="B"/>
      <Node ID="3" Z="0" Y="3A" X="-B"/>
      <Node ID="4" Z="2B" Y="0" X="0"/>
    </Nodes>
  - <Connectors>
      <Connector Link="0-1" Continue="Yes"/>
      <Connector Link="0-2" Continue="Yes"/>
      <Connector Link="0-3" Continue="Yes"/>
      <Connector Link="0-4" Continue="Yes"/>
    </Connectors>
  </Period>
</Cell>
```

19. Within 3DXpert, edit the lattice and select the Honycomb cell type. Set the **x,y,z values to 3**. **Node diameter = 0.4 Connector diameter=0.2**



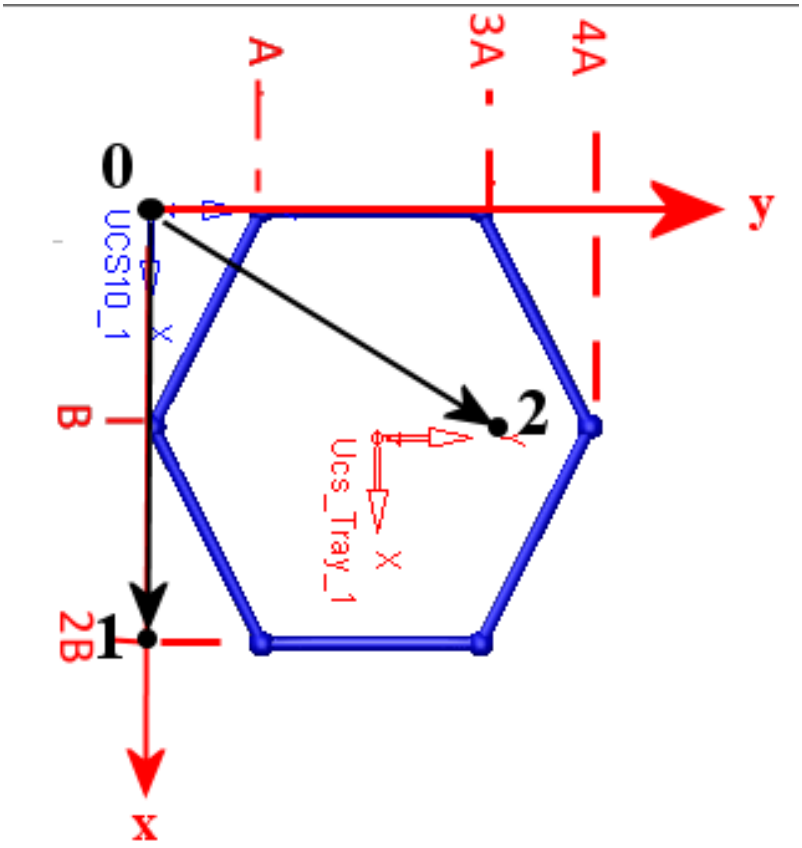
20. We will now examine the propagation of the hexagon as defined in the xml file. Under the Period section, we have defined the A & B constancies.
21. In this section, the nodes define vectors. Notice nodes 0, 1 and 2

```
- <Period>
  - <Nodes B="sqrt(3)/4" A=".25">
      <Node ID="0" Z="0" Y="0" X="0"/>
      <Node ID="1" Z="0" Y="0" X="2B"/>
      <Node ID="2" Z="0" Y="3A" X="B"/>
      <Node ID="3" Z="0" Y="3A" X="-B"/>
      <Node ID="4" Z="2B" Y="0" X="0"/>
    </Nodes>
  - <Connectors>
      <Connector Link="0-1" Continue="Yes"/>
      <Connector Link="0-2" Continue="Yes"/>
      <Connector Link="0-3" Continue="Yes"/>
      <Connector Link="0-4" Continue="Yes"/>
    </Connectors>
</Period>
```



22. The connectors defines as ‘translation’ vectors.

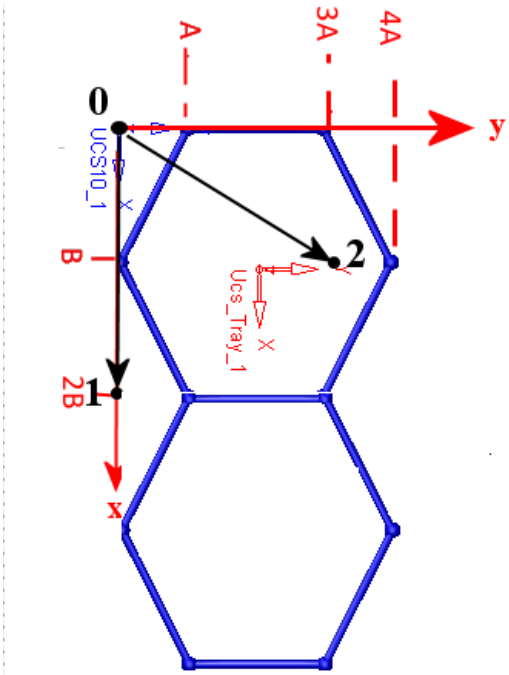
```
    </Nodes>
  - <Connectors>
      <Connector Link="0-1" Continue="Yes"/>
      <Connector Link="0-2" Continue="Yes"/>
      <Connector Link="0-3" Continue="Yes"/>
      <Connector Link="0-4" Continue="Yes"/>
    </Connectors>
</Period>
```



Vector 0-1 is in the x direction (Length = 2b). “Continue=Yes” means that the hexagon is being “translated” and placed in the new location. The vector’s direction and the calculated length define this new ‘zero’ location. The system start a new propagation, refer to this new ‘zero’ location, by jumping to the first row of the xml file.

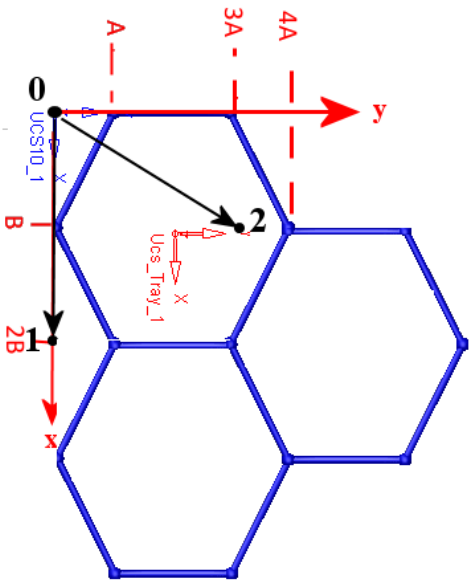
The systems also Jumps to the next row and follows further instructions.

In any case, the system does not create duplicated cells. It recognizes if a certain location is already occupied.



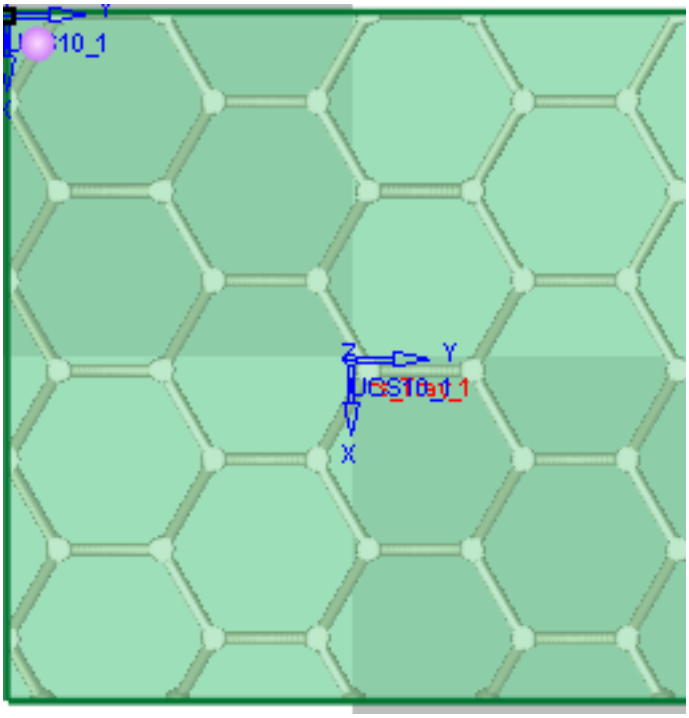
23. Vector 0-2 is in the direction of x=b; y=3a. “Continue=Yes” means that the hexagon is copied in the direction of the vector by its length from 0 point to 2 point, and start a new propagation (from the beginning of the xml file).

The system also move to the next row in the xml file.



24. Node ID 3 is the same as ID 2 but with x = -b instead of positive b. Therefore the (vector) connector 0-3 is in the opposite direction to (vector) connector 0-2
25. ID 4 defines the propagation in Z direction, connector 0-4 defines the translation vector in the Z direction
26. The propagation is done until its cover all space.

```
- <Period>
  - <Nodes B="sqrt(3)/4" A=".25">
      <Node ID="0" Z="0" Y="0" X="0"/>
      <Node ID="1" Z="0" Y="0" X="2B"/>
      <Node ID="2" Z="0" Y="3A" X="B"/>
      <Node ID="3" Z="0" Y="3A" X="-B"/>
      <Node ID="4" Z="2B" Y="0" X="0"/>
    </Nodes>
  - <Connectors>
      <Connector Link="0-1" Continue="Yes"/>
      <Connector Link="0-2" Continue="Yes"/>
      <Connector Link="0-3" Continue="Yes"/>
      <Connector Link="0-4" Continue="Yes"/>
    </Connectors>
  </Period>
'Cell>
```



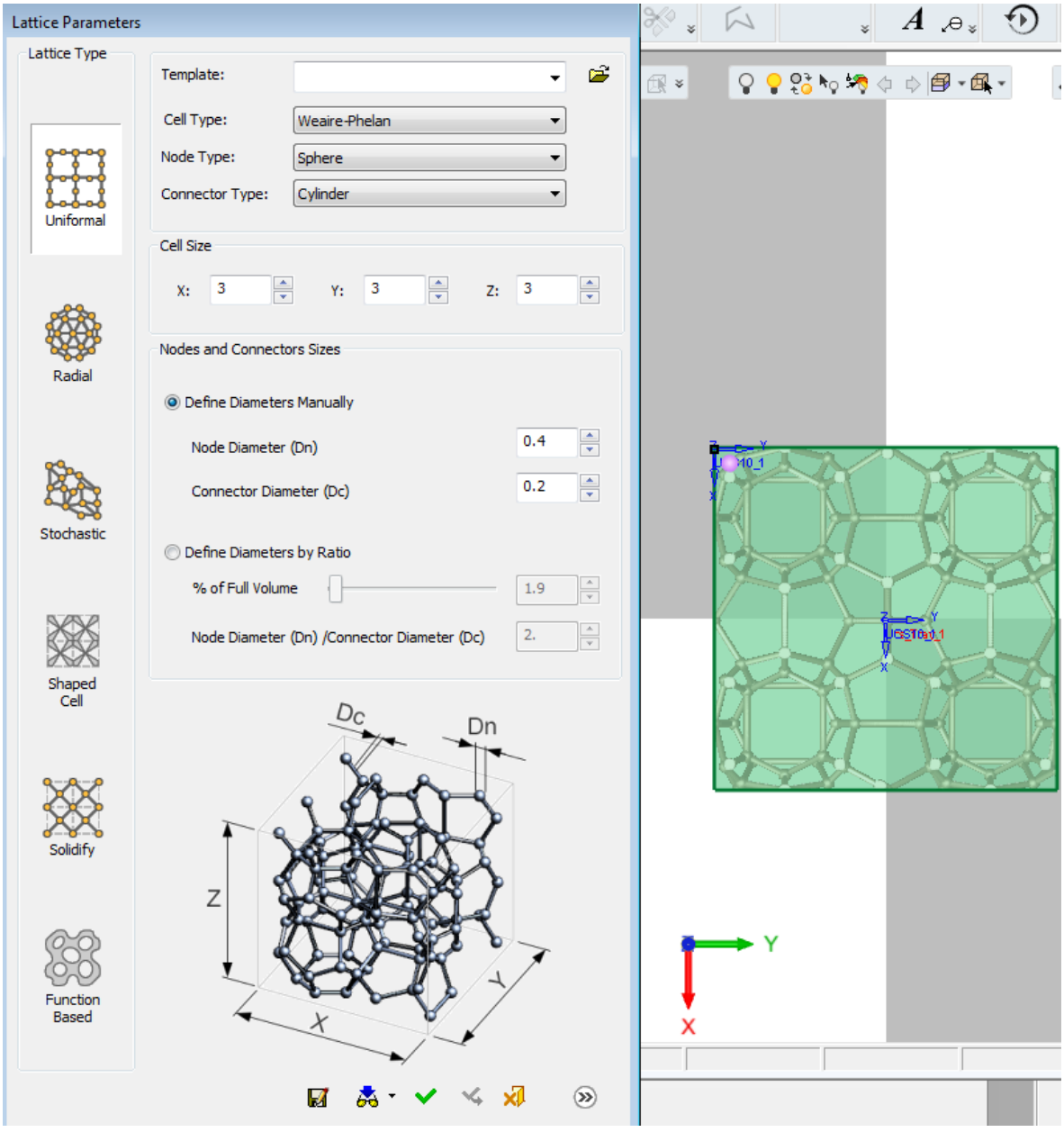
Part 3 – Advanced Assembly structure (within the xml file)

Weaire – Phelan cell type

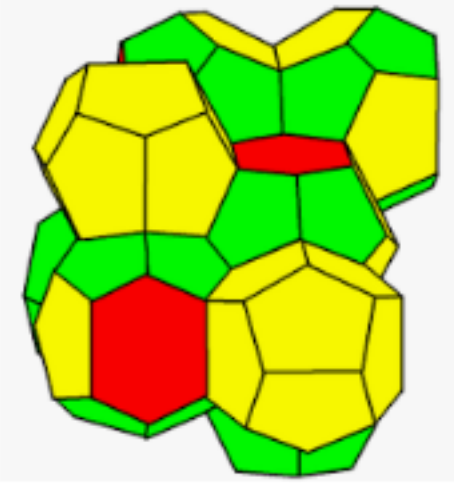
27. Open the **Weaire-Phelan.xml** file

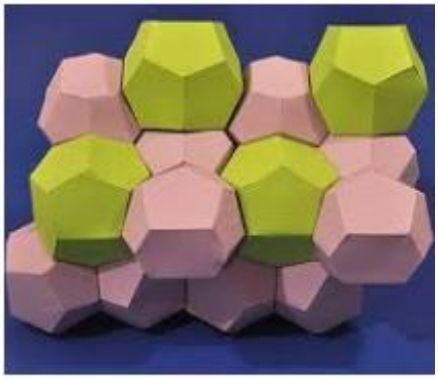
```
<?xml version="1.0" encoding="UTF-8"?>
- <Cell Type="Composite" Name="Weaire-Phelan" ID="{3F3B0FF7-91A7-4D71-8D2F-E59D310C0088}">
    <SubCell Name="Irregular Dodecahedra" ID="{10241C2B-8C5D-41E4-A41E-99473627D5C8}"/>
    <SubCell Name="Tetrakaidecahedra" ID="{35C527FC-B61D-4F60-92FD-F58E0EBF9F94}"/>
  </Cell>
```

28. Within 3Dxpert edit the lattice and select the **Weaire-Phelan** cell type.

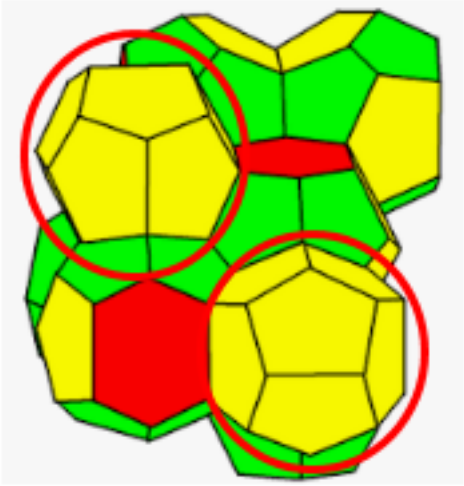


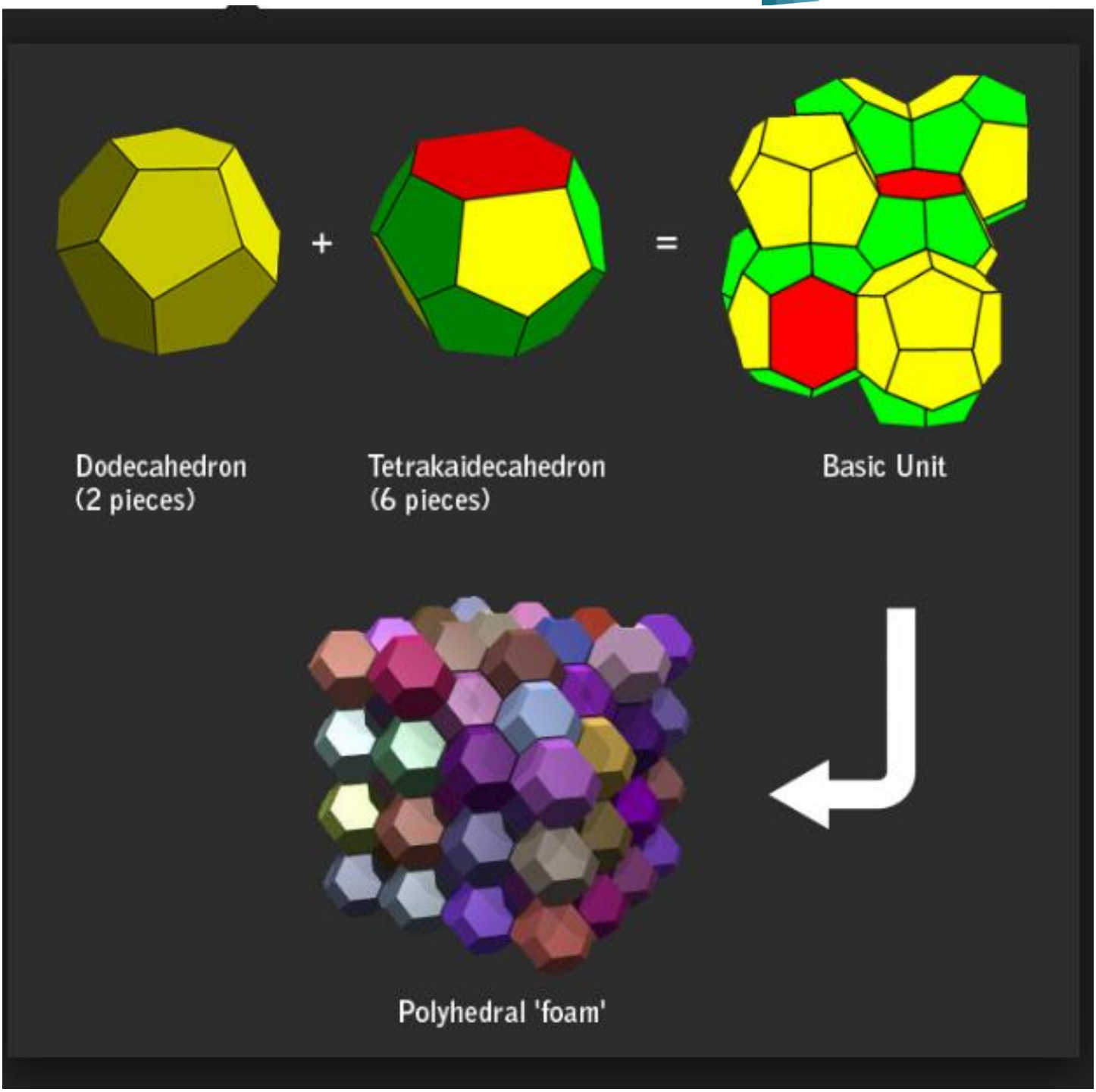
29. The structure of the Weaire-Phelan is composed of two different cell types.
30. A unit cell of **Weaire-Phelan** looks like this:



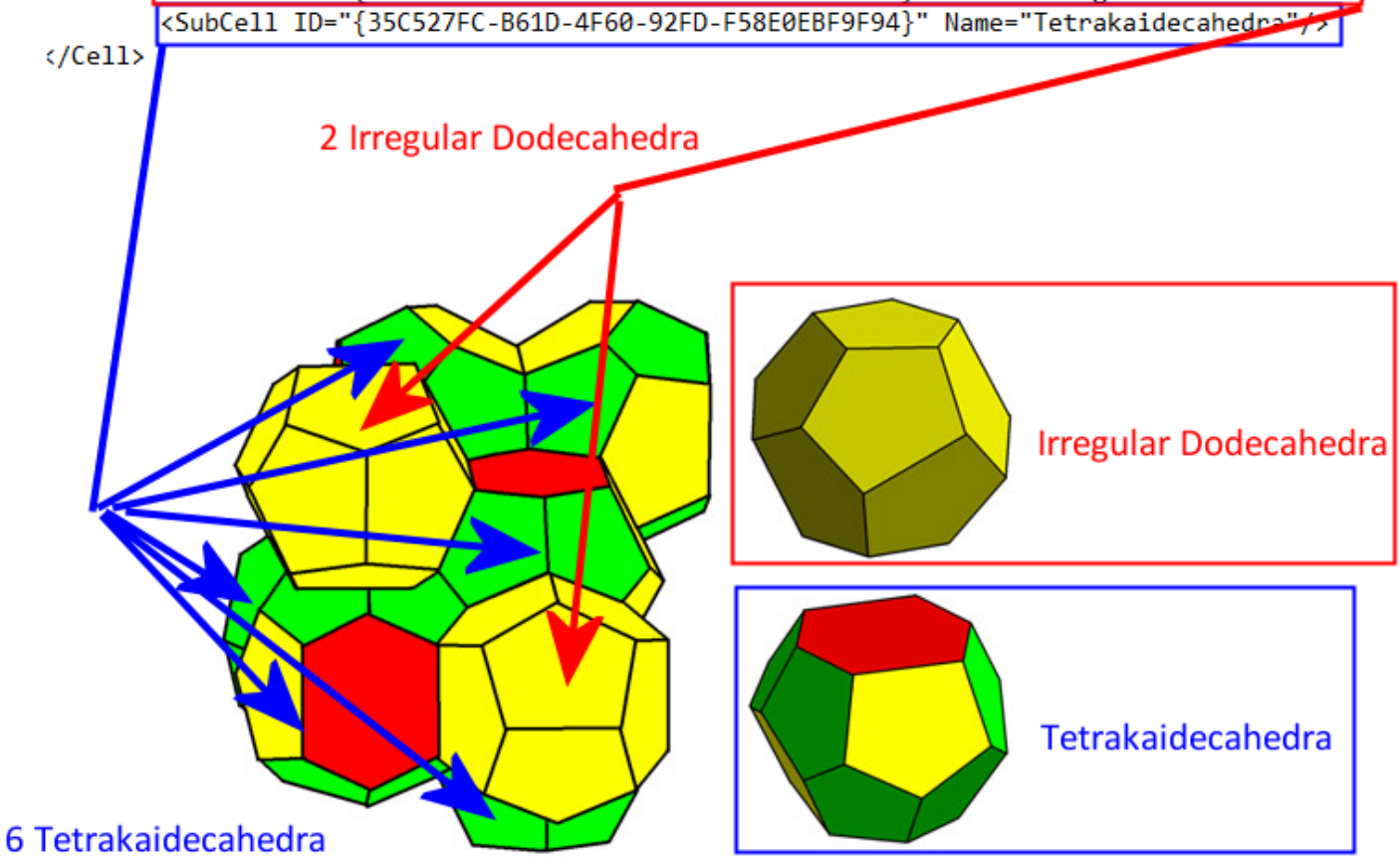


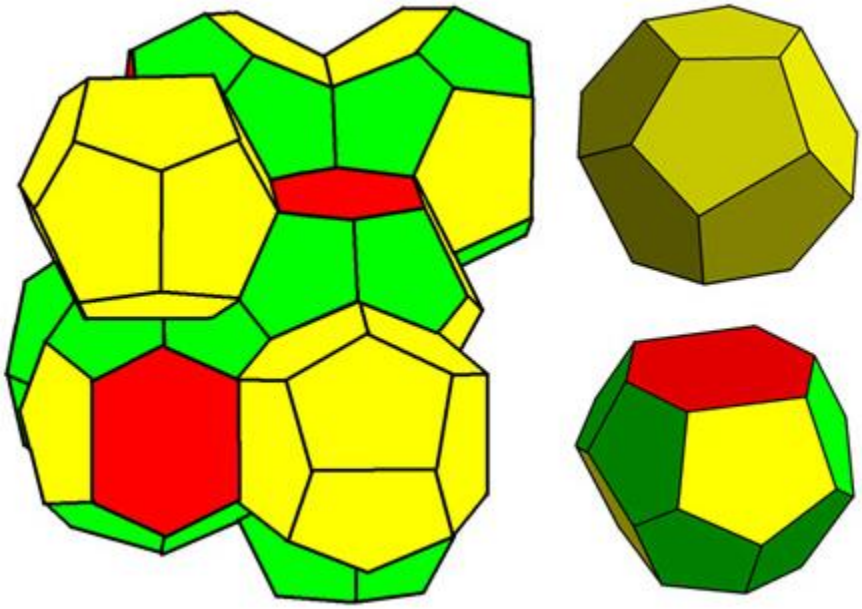
31. It composed of two (rotated) Dodecahedron (marked in red circles) and 6 tetrakaidecahedron (mirrored or rotated). Examine the structure in the following pictures.




+
=
Dodecahedron
(2 pieces)
Tetrakaidecahedron
(6 pieces)
Basic Unit
Polyhedral 'foam'

```
<?xml version="1.0" encoding="UTF-8"?>
<Cell ID="{3F3B0FF7-91A7-4D71-8D2F-E59D310C0088}" Name="Weaire-Phelan" Type="Composite">
        <SubCell ID="{10241C2B-8C5D-41E4-A41E-99473627D5C8}" Name="Irregular Dodecahedra"/>
        <SubCell ID="{35C527FC-B61D-4F60-92FD-F58E0EBF9F94}" Name="Tetrakaidecahedra"/>
</Cell>
```



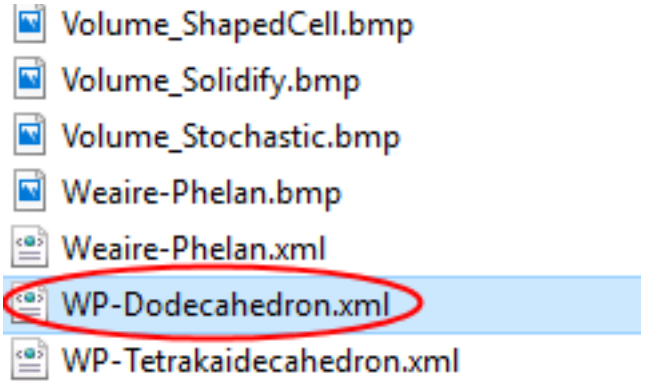


32. Note that the Dodecahedra shapes relatively rotated to each other. Therefor in addition to the 'translation', there is a need of rotation expression while propagating. The Tetrakaidecahedra shapes are mirrored or rotated while propagating.

33. The main xml file refers to two sub cells files: Each file is defined by its **Subcell Name** and **ID** number
34. We will now open the first Subcell. (**WP-Dodecahedra.xml**)

```
<?xml version="1.0" encoding="UTF-8"?>
<Cell ID="{3F3B0FF7-91A7-4D71-8D2F-E59D310C0088}" Name="Weaire-Phelan" Type="Composite">
        <SubCell ID="{10241C2B-8C5D-41E4-A41E-99473627D5C8}" Name="Irregular Dodecahedra"/>
        <SubCell ID="{35C527FC-B61D-4F60-92FD-F58E0EBF9F94}" Name="Tetrakaidecahedra"/>
</Cell>
```

35. Open the file **WP-Dodecahedra.xml** under **\\ProgramData\3D Systems\3DXpert\14.0\Data\3D_Printing\LatticeCells**



36. Notice that the ID number in the **WP-Dodecahedra**.xml is similar to the ID number of the first SubCell in the **Wearie-Phelan**.xml file

WP-Dodecahedron.xml - Notepad

File Edit Format View Help

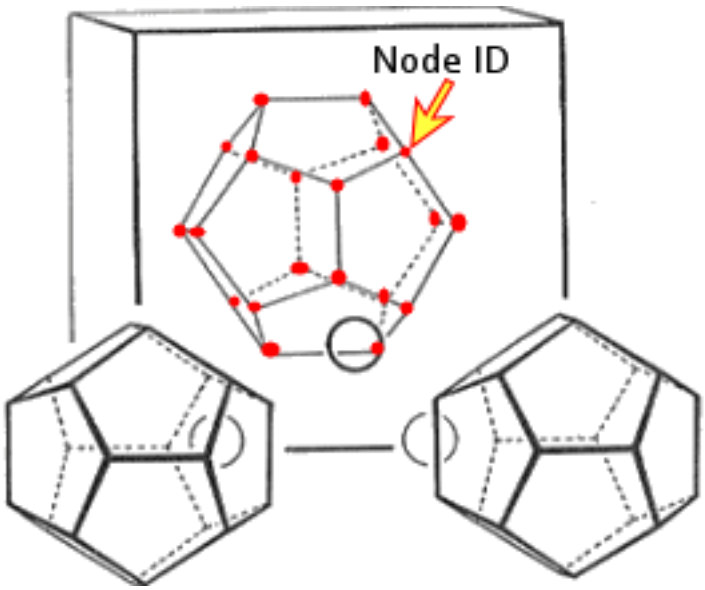
```
<?xml version="1.0" encoding="UTF-8"?>
<Cell ID="{10241C2B-8C5D-41E4-A41E-99473627D5C8}" Name="Wearie-Phelan Dodecahedron" Type="System">
        <Nodes A="3.1498 / U" B="2A" C="4/3 * A" U="10">
                <Node ID="0" X="A" Y="0" Z="B"/>
                <Node ID="1" X="-A" Y="0" Z="B"/>
                <Node ID="2" X="C" Y="C" Z="C"/>
                <Node ID="3" X="0" Y="B" Z="A"/>
                <Node ID="4" X="-C" Y="C" Z="C"/>

                <Node ID="5" X="-C" Y="-C" Z="C"/>
                <Node ID="6" X="0" Y="-B" Z="A"/>
                <Node ID="7" X="C" Y="-C" Z="C"/>
                <Node ID="8" X="B" Y="A" Z="0"/>
                <Node ID="9" X="-B" Y="A" Z="0"/>

                <Node ID="10" X="-B" Y="-A" Z="0"/>
                <Node ID="11" X="B" Y="-A" Z="0"/>
                <Node ID="12" X="C" Y="C" Z="-C"/>
                <Node ID="13" X="0" Y="B" Z="-A"/>
                <Node ID="14" X="-C" Y="C" Z="-C"/>

                <Node ID="15" X="-C" Y="-C" Z="-C"/>
                <Node ID="16" X="0" Y="-B" Z="-A"/>
                <Node ID="17" X="C" Y="-C" Z="-C"/>
```

Weaire-Phelan.xml - Notepad

File Edit Format View Help

```
<?xml version="1.0" encoding="UTF-8"?>
<Cell ID="{3F3B0FF7-91A7-4D71-8D2F-E59D310C0088}" Name="Weaire-Phelan" Type="Comp
        <SubCell ID="{10241C2B-8C5D-41E4-A41E-99473627D5C8}" Name="Irregular Dode
        <SubCell ID="{35C527FC-B61D-4F60-92FD-F58E0EBF9F94}" Name="Tetrakaidecahe
</Cell>
```

37. Each node 0-19 represent one of the 20 nodes of the Irregular Dodecahedra



38. As described in the previous example, the first line after the name, contain a list of constancies defined by formulas or values.

```
<?xml version="1.0" encoding="UTF-8"?>
<Cell ID="{10241C2B-8C5D-41E4-A41E-99473627D5C8}" Name="Weari
        <Nodes A="3.1498 / U" B="2A" C="4/3 * A" U="10">
                <Node ID="0" X="A" Y="0" Z="B"/>
                <Node ID="1" X="-A" Y="0" Z="B"/>
                <Node ID="2" X="C" Y="C" Z="C"/>
                <Node ID="3" X="0" Y="B" Z="A"/>
                <Node ID="4" X="-C" Y="C" Z="C"/>

                <Node ID="5" X="-C" Y="-C" Z="C"/>
                <Node ID="6" X="0" Y="-B" Z="A"/>
                <Node ID="7" X="C" Y="-C" Z="C"/>
                <Node ID="8" X="B" Y="A" Z="0"/>
                <Node ID="9" X="-B" Y="A" Z="0"/>

                <Node ID="10" X="-B" Y="-A" Z="0"/>
                <Node ID="11" X="B" Y="-A" Z="0"/>
```

39. Notice the connectors link.

```
    </Nodes>
    <Connectors>
            <Connector Link="0-1"/>
            <Connector Link="1-5"/>
            <Connector Link="5-6"/>
            <Connector Link="6-7"/>
            <Connector Link="0-7"/>

            <Connector Link="1-4"/>
            <Connector Link="4-3"/>
            <Connector Link="3-2"/>
            <Connector Link="2-0"/>

            <Connector Link="18-19"/>
            <Connector Link="17-18"/>
            <Connector Link="16-17"/>

            <Connector Link="15-16"/>
            <Connector Link="15-19"/>
            <Connector Link="19-14"/>

            <Connector Link="14-13"/>
            <Connector Link="12-13"/>
            <Connector Link="12-18"/>

            <Connector Link="16-6"/>
            <Connector Link="13-3"/>

            <Connector Link="4-9"/>
            <Connector Link="9-10"/>
            <Connector Link="5-10"/>

            <Connector Link="2-8"/>
            <Connector Link="8-11"/>
            <Connector Link="7-11"/>

            <Connector Link="14-9"/>
            <Connector Link="15-10"/>

            <Connector Link="12-8"/>
            <Connector Link="17-11"/>
```

40. The periods contains value and formula constancies.

```
<Period>
        <Nodes A="3.1498 / U" B="5 / U" G="2B-A" U="10">
                <Node ID="0" X="2B + G" Y="G" Z="0"/>

                <Node ID="1" X="6B + G" Y="G" Z="0"/>
                <Node ID="2" X="2B + G" Y="4B + G" Z="0"/>
                <Node ID="3" X="2B + G" Y="G" Z="4B"/>

                <Node ID="4" X="G" Y="2B + G" Z="2B"/>
```

expressions

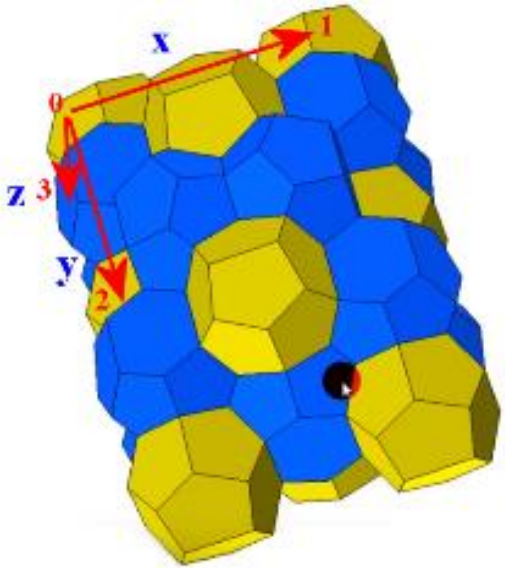
Zero point

Translation vectors points

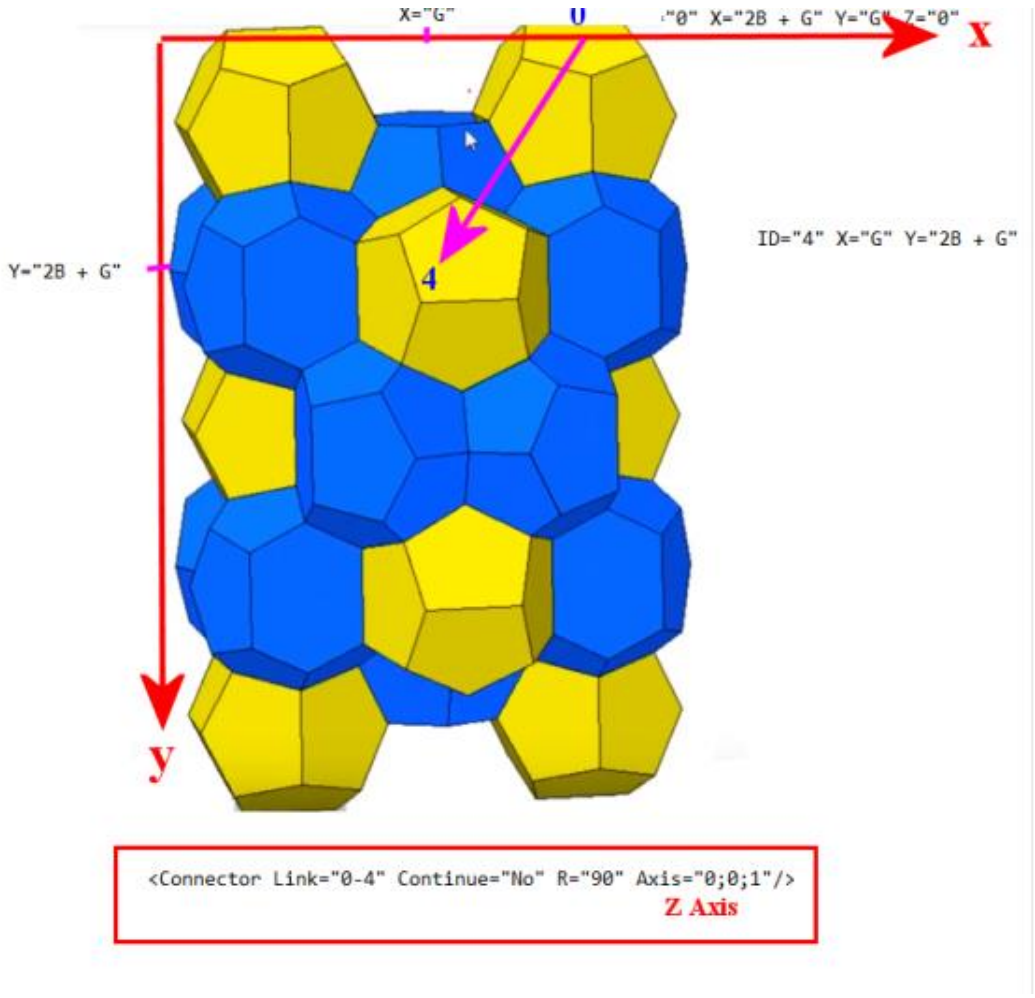
41. Note that vectors 0-1, 0-2, 0-3 are in the direction of x, y, z with a translation of a constant value

```
<Period>
  - <Nodes U="10" B="5 / U" A="3.1498 / U" G="2B-A">
      <Node ID="0" Z="0" Y="G" X="2B + G"/>
      <Node ID="1" Z="0" Y="G" X="6B + G"/>
      <Node ID="2" Z="0" Y="4B + G" X="2B + G"/>
      <Node ID="3" Z="4B" Y="G" X="2B + G"/>
      <Node ID="4" Z="2B" Y="2B + G" X="G"/>
    </Nodes>
  - <Connectors>
      <Connector Link="0-1" Continue="Yes"/>
      <Connector Link="0-2" Continue="Yes"/>
      <Connector Link="0-3" Continue="Yes"/>
      <Connector Link="0-4" Continue="No" Axis="0;0;1" R="90"/>
```

42. The translation **vector 0-1** is between **ID 0** ; coordinates **(2B+G, G, 0)** to **ID 1** ; coordinates (**6B+G, G, 0).** Therefore, the propagation is done by intervals of **4B** in **X direction** and place a new cell and the **0** point in this new location. Continue means that it start building a new propagation, at the new 0 location, by jumping to the beginning of the xml file. In the other hand, it also continue to the next line in the xml file.
43. The next line in the xml file describes the translation **vector 0-2** . The vector is between **ID 0** ; coordinates **(2B+G, G, 0)** to **ID 2** ; coordinates (**2B+G, 4B+G, 0**). Therefore the propagations is done by intervals of **4B** in **Y direction** and continue
44. The translation **vector 0-3** is between ID **0** with the coordinates (**2B+G, G, 0**) to **ID 3** with the coordinates (**2B+G, G, 4B**). Therefore, the propagation is done by intervals of **4B** in **Z direction** and continue.



45. There are no duplicated cells in the structure. The system does not create a new cell, new cell in a location that already captured by an existed cell.
46. The next line in the xml file describes the translation **vector 0-4** . The vector is between **ID 0** ; coordinates **(2B+G, G, 0)** to **ID 4** ; coordinates (**G, 2B+G, 2B**). Therefore, the "translation" is done by the vector (shown in the picture below) and by the calculated interval. The cell is placed in the new location, then rotated by 90 deg around the Z axis. The system **does not continu**e to the beginning of the xml file, but proceeds to the next line in the xml file, if there is any.



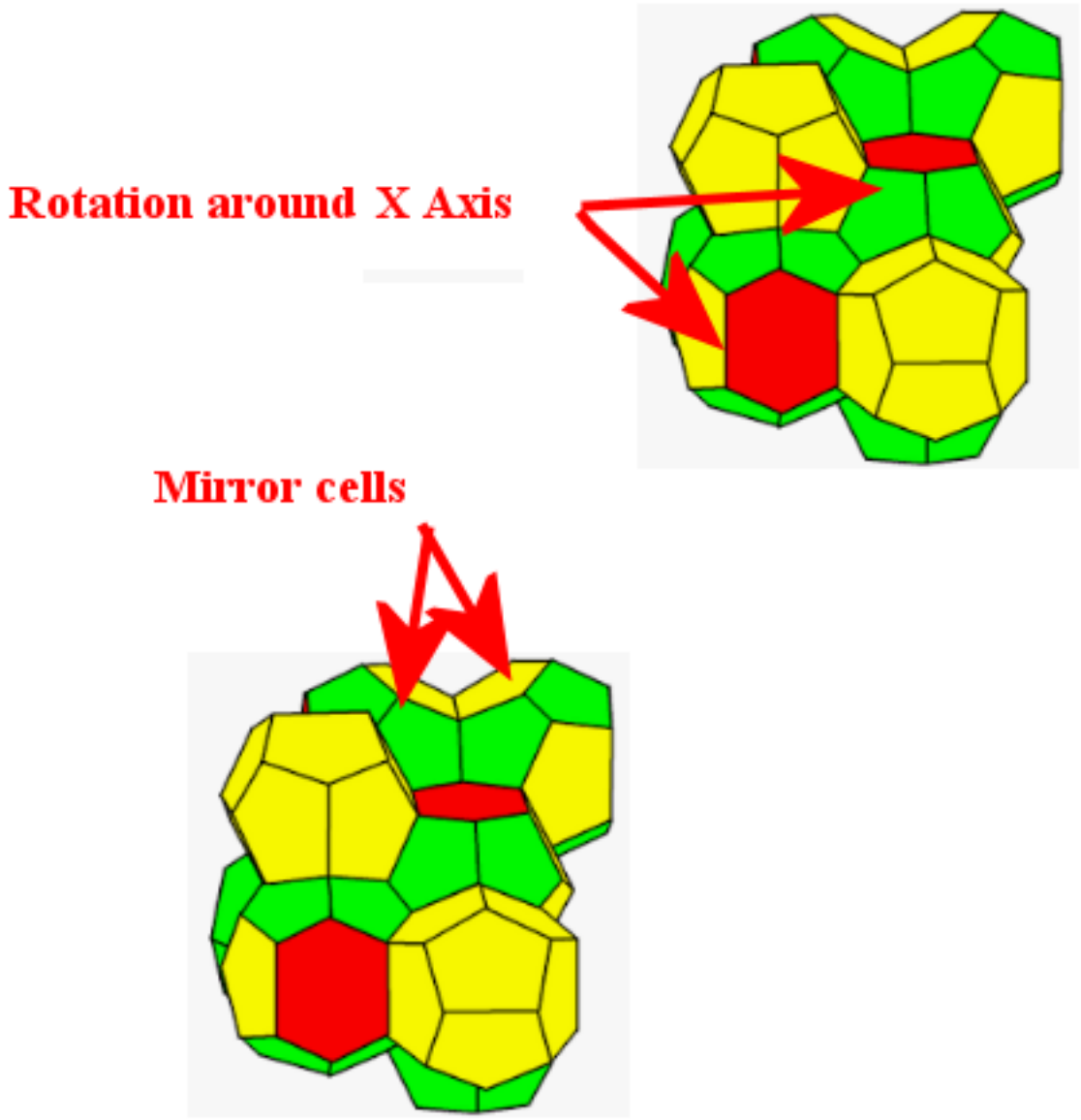
47. Open the file WP-Tetrakaidecahedron.xml Notice the constancies list.

```
<?xml version="1.0" encoding="UTF-8"?>
- <Cell Type="System" Name="Wearie-Phelan Tetrakaidecahedron" ID="{35C527FC-B61D-4F60-92FD-F58E0EBF9F94}">
  - <Nodes U="10" I="B-H" H="A-D" G="2B-A" F="B+E" E="B-C" D="B-A" C="4/3 * A" B="5 / U" A="3.1498 / U">
      <Node ID="0" Z="B" Y="I" X="A"/>
      <Node ID="1" Z="B" Y="I" X="-A"/>
      <Node ID="2" Z="B" Y="0" X="-B"/>
      <Node ID="3" Z="B" Y="-I" X="-A"/>
      <Node ID="4" Z="B" Y="-I" X="A"/>
      <Node ID="5" Z="B" Y="0" X="B"/>
      <Node ID="6" Z="E" Y="F" X="C"/>
      <Node ID="7" Z="E" Y="F" X="-C"/>
      <Node ID="8" Z="H" Y="0" X="-G"/>
      <Node ID="9" Z="E" Y="-F" X="-C"/>
      <Node ID="10" Z="E" Y="-F" X="C"/>
      <Node ID="11" Z="H" Y="0" X="G"/>
      <Node ID="12" Z="-E" Y="C" X="F"/>
      <Node ID="13" Z="-H" Y="G" X="0"/>
      <Node ID="14" Z="-E" Y="C" X="-F"/>
      <Node ID="15" Z="-E" Y="-C" X="-F"/>
      <Node ID="16" Z="-H" Y="-G" X="0"/>
      <Node ID="17" Z="-E" Y="-C" X="F"/>
```

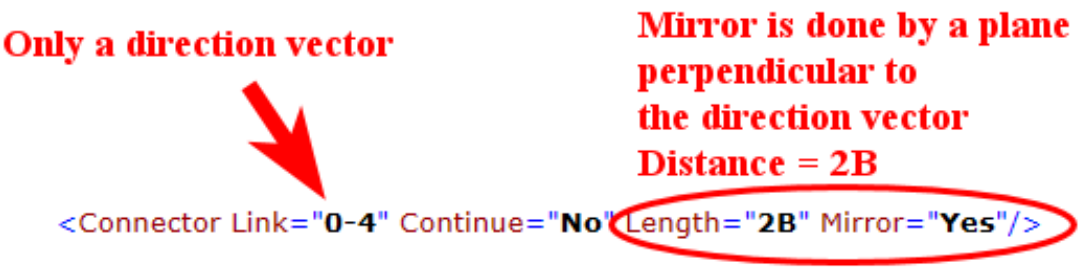
48. Examine the period section in the file:

```
    </Connectors>
  - <Period>
    - <Nodes U="10" G="2B-A" B="5 / U" A="3.1498 / U">
        <Node ID="0" Z="B" Y="G" X="G"/>
        <Node ID="1" Z="B" Y="G" X="4B + G"/>
        <Node ID="2" Z="B" Y="4B + G" X="G"/>
        <Node ID="3" Z="5B" Y="G" X="G"/>
        <Node ID="4" Z="3B" Y="G" X="G"/>
        <Node ID="5" Z="2B" Y="G-B" X="2B + G"/>
        <Node ID="6" Z="2B" Y="5B" X="2B + G"/>
        <Node ID="7" Z="0" Y="2B + G" X="G-B"/>
        <Node ID="8" Z="0" Y="2B + G" X="5B"/>
      </Nodes>
    - <Connectors U="10" B="5 / U">
        <Connector Link="0-1" Continue="Yes"/>
        <Connector Link="0-2" Continue="Yes"/>
        <Connector Link="0-3" Continue="Yes"/>
        <Connector Link="0-4" Continue="No" Length="2B" Mirror="Yes"/>
        <Connector Link="0-5" Continue="No" Axis="1;0;0" R="270"/>
        <Connector Link="5-6" Continue="No" Length="2B" Mirror="Yes"/>
        <Connector Link="0-7" Continue="No" Axis="0;1;0" R="270"/>
        <Connector Link="7-8" Continue="No" Length="2B" Mirror="Yes"/>
      </Connectors>
    </Period>
</Cell>
```

49. Some of the cell are rotated and some of them are mirrored.

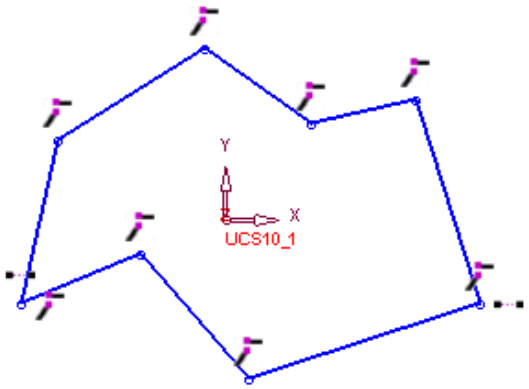


50. The mechanism takes care of the topology. There are no duplicated edges or faces.

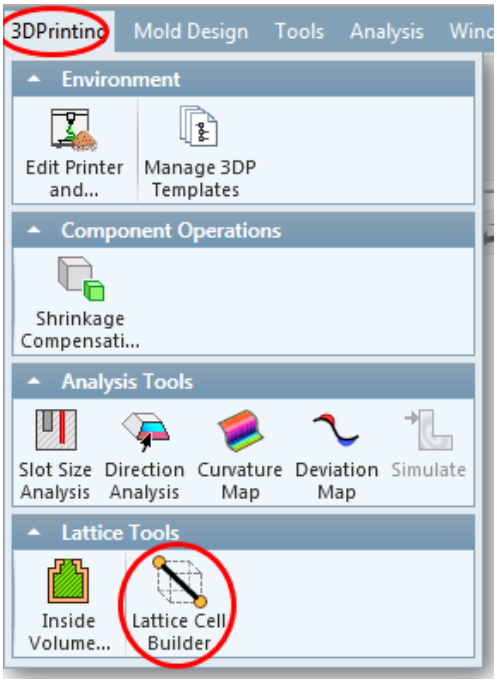


Part 4 – Lattice cell builder

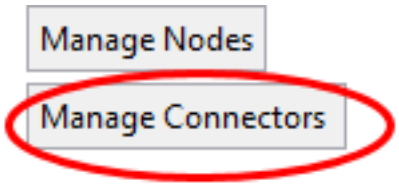
51. Open a new part file. Create the following sketch on XY plane



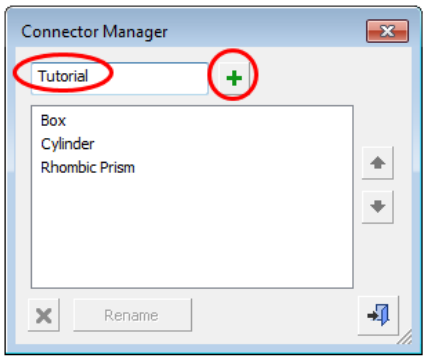
52. Enter the Lattice Cell Builder under the 3DPrinting dialog

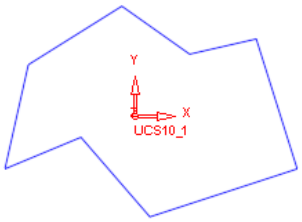


53. Press the Manage Connectors tab

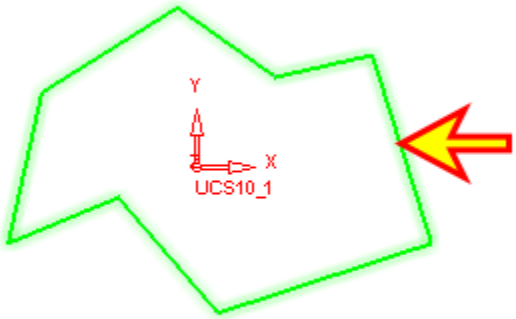


54. Create a new connector name it ‘Tutorial’. Press the + button

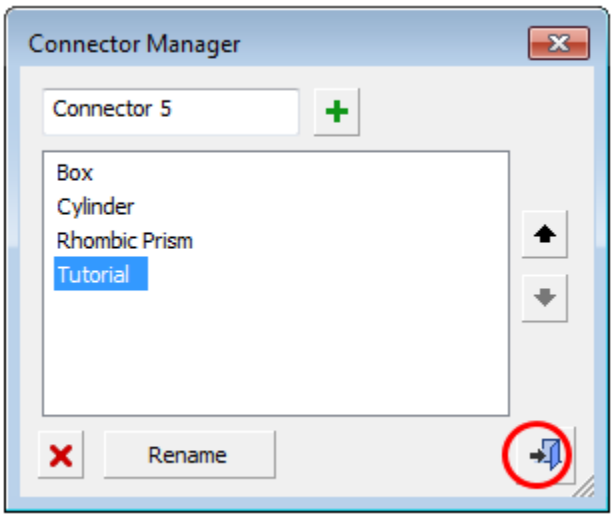




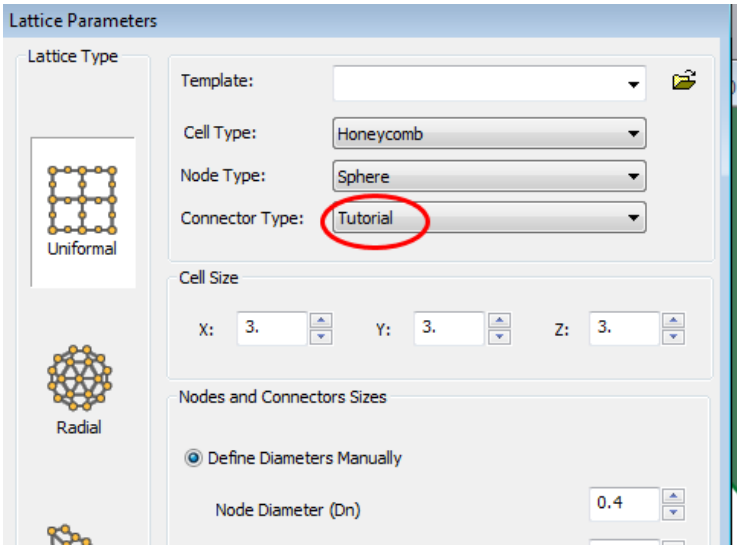
55. Select the previously created sketch

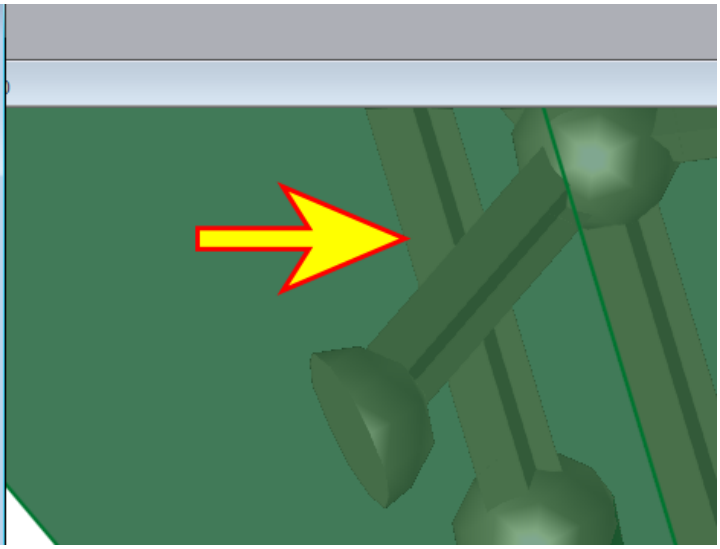


56. Exit the dialog



57. Switch back to the project file and set the Connector Type to 'Tutorial'. View the new shape of the connectors





End of Exercise.