Development of Loop for ATLAS Simulation Packages

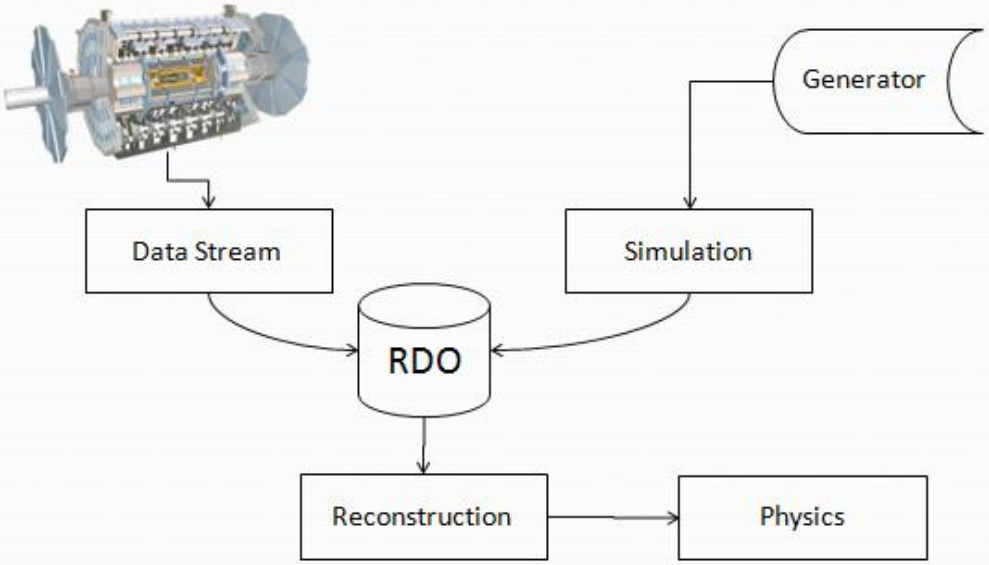
Niko TSUTSKIRIDZE

GEORGIAN TECHNICAL UNIVERSITY

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH, CERN

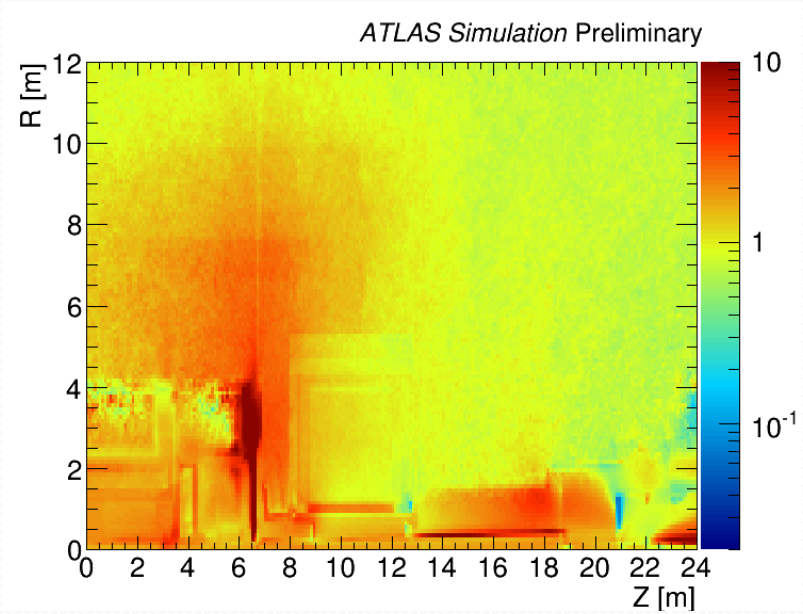
2th of July, 2014 CERN, Geneva, Switzerland

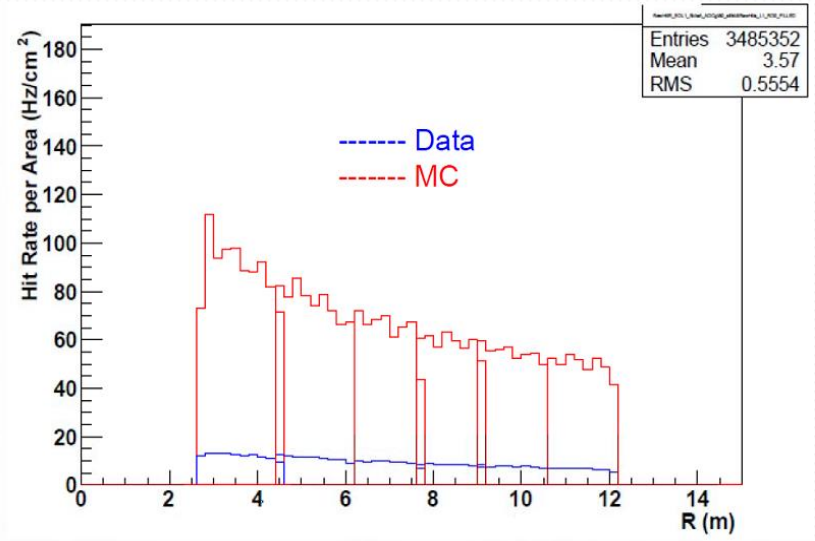
Tasks for Reconstruction / Simulation



- Reconstruction and Simulation providing data necessary for Physics analyses
- Simulation generates theoretical events
- Purpose of Reconstruction is collection data from the different subsystems and formation data which characterized particles

Data vs Monte Carlo Discrepancies





The difference may be caused by Geometric Discrepancies

Reasons of geometric discrepancies:

- Discrepancies between G4 and Real Geometry
- Tools which are used in simulation packages

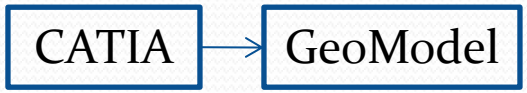
Development of Methods and Tools for Investigation of G4 Geometry in ATLAS Simulation Packages is Actual Task.

Development of Geometry HUB on the base of CATIA

Georgian Engineering Team has developed several interfaces with CATIA:

- CATIA -> XML/Persint

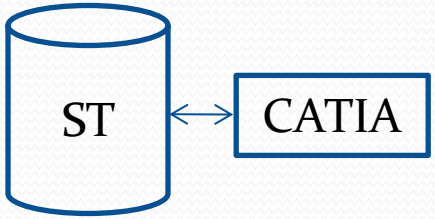
- CATIA -> GeoModel



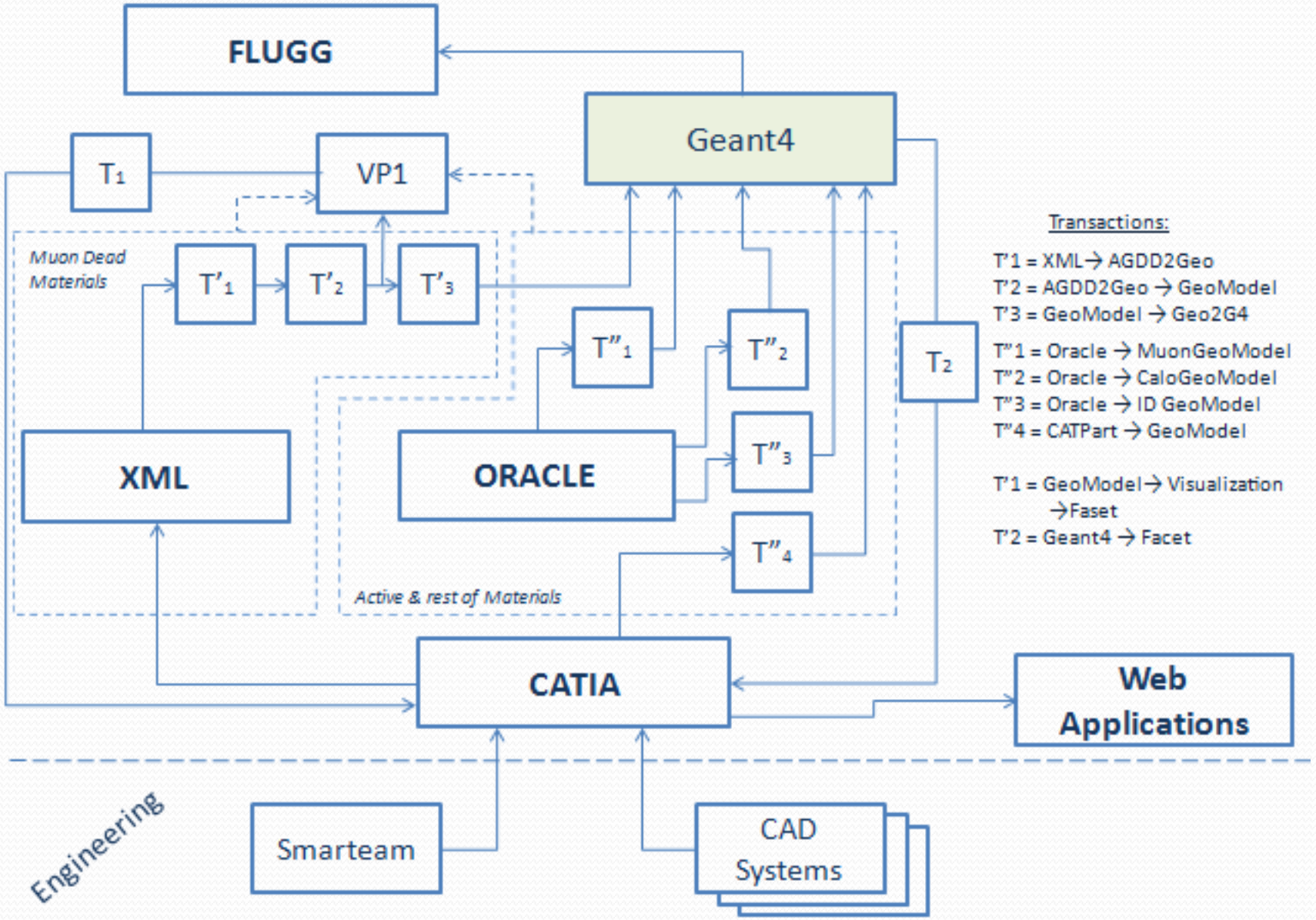
- VP1 -> CATIA

- Geant4 -> CATIA

- Smarteam -> CATIA (already existing)

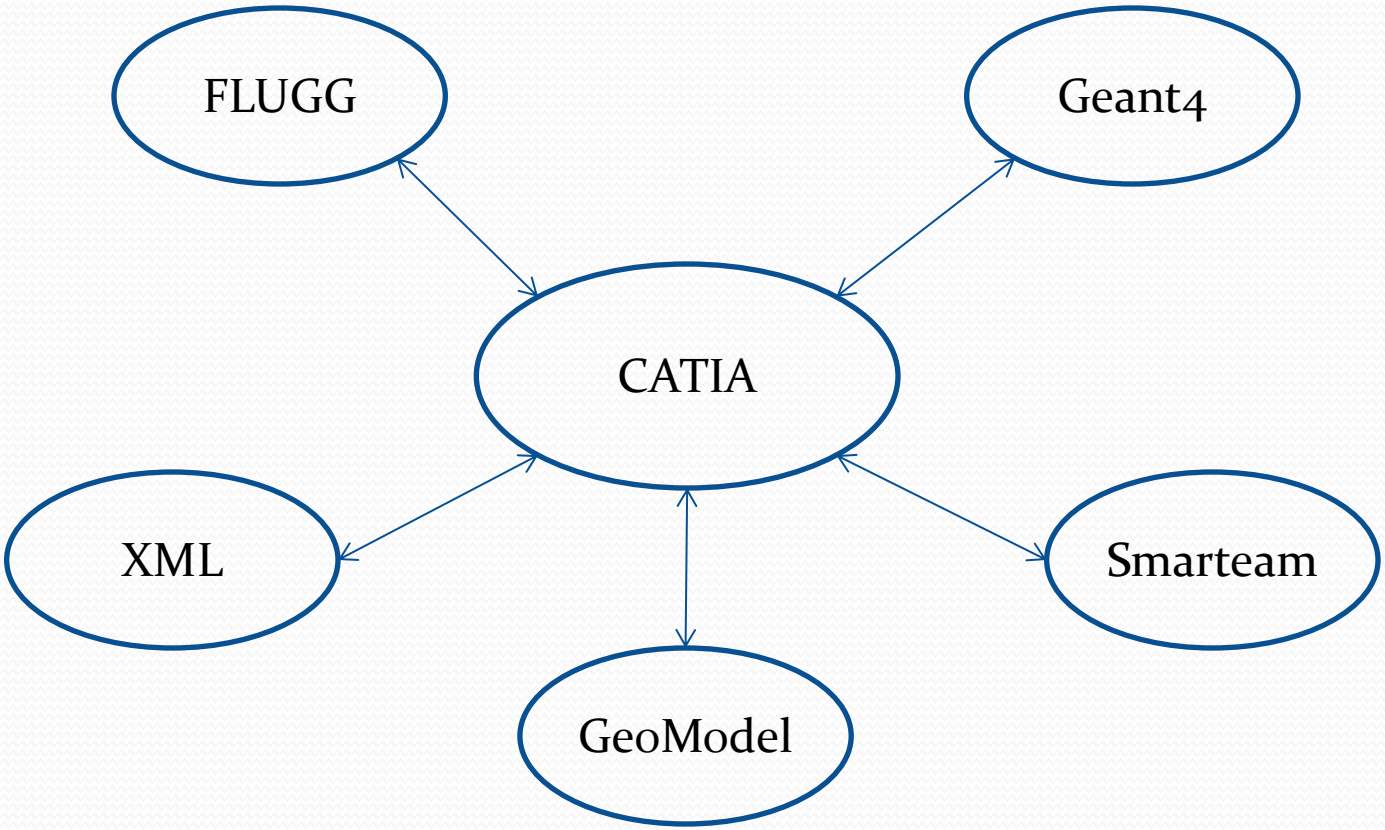


Development of Simulation Loop



Development of Simulation Loop

Simulation Loop permits to make several crosschecking of volume geometry descriptions, weights and materials presented in different sources.



Investigation of Quality of Simulation Loop

For ATLAS Detector components inaccuracies caused by transactions in the loop should be investigated:

- Checking of dimension inaccuracies
- Checking of Form inaccuracies
- Checking of Positioning inaccuracies

For this Purpose Test Examples for checking have to be selected

1st Step of Selection

Separation of unique cases of ATLAS detector geometry:

3 Classes of cases:

- Geometric Primitives
- Typical Joining
- Combined Objects

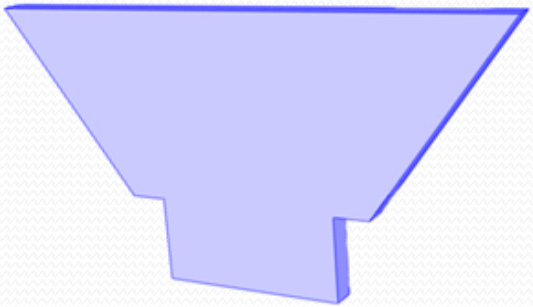
1st Step of Selection

Geometric Primitives. Selection criteria:

- ✓ Shapes with vertex
- ✓ Shapes without cuts
- ✓ Both regular/irregular shapes
- ✓ Both convex/concave shapes

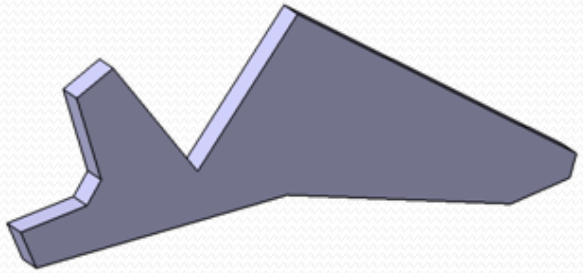
Thus: 22 geometric primitives have been separated:

Octagonal Prism



Pentagonal Prism

Dodecagonal Prism



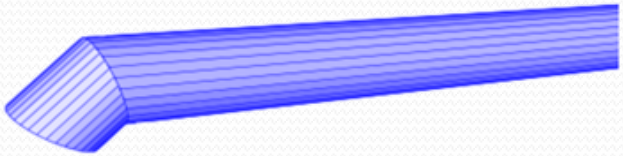
1st Step of Selection

Typical Joining. Selection criteria:

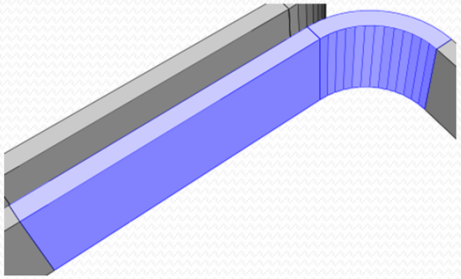
- ✓ Minimum 2 objects
- ✓ Tangent touches between objects
- ✓ Surfaces touches between objects

Thus: 33 geometric primitives have been separated:

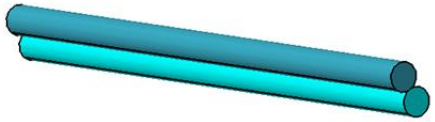
Tubes Joining



Cube and Tube Joining



Tubes Joining



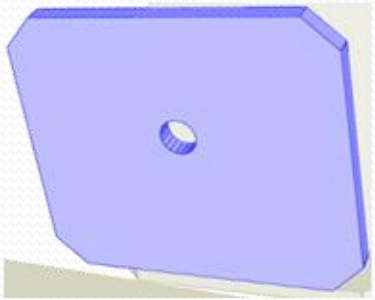
1st Step of Selection

Combined Geometry. Selection criteria:

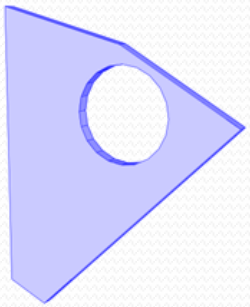
✓ Shapes with cuts

Thus: 19 geometric primitives have been separated:

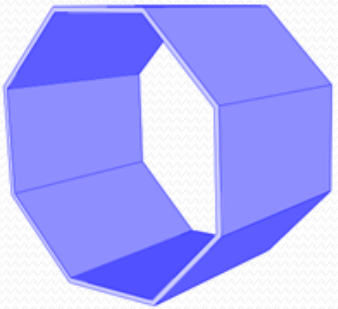
Octagonal Prism with cut



Pentagonal prism with cut



Octagonal prism with cut



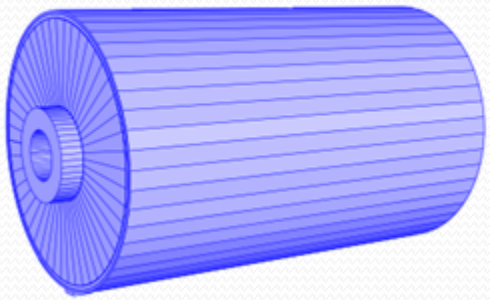
2nd Step of Selection

6 classes have been separated according to Simulation Loop:

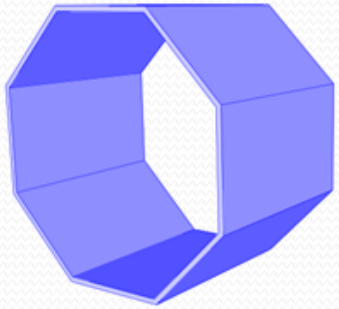
XML	Geometrics Primitives	19	Total: 58
	Typical Joining	13	
	Combined Objects	26	
GeoModel	Geometrics Primitives	3	Total: 26
	Typical Joining	16	
	Combined Objects	7	

Thus it increase total number of cases up to 84 while some of them are exiting in both classes (10 cases)

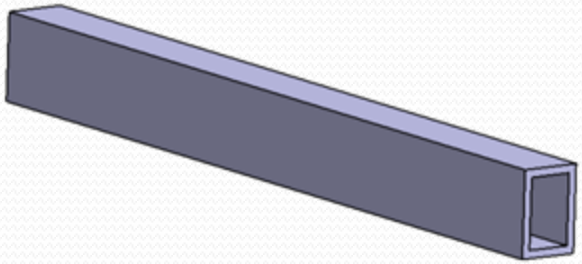
Tubes Joining



Octagonal prism with cut



Cube with Cut

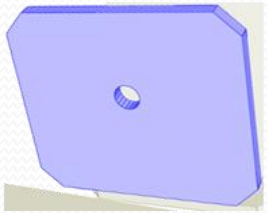


3rd Step of Selection

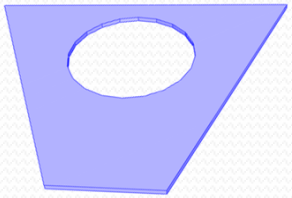
Cases was grouped according to sameness of topology:

✓ #26 = #36 = #39

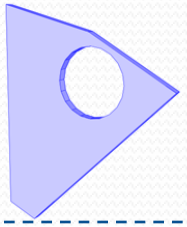
Octagonal Prism with cut



Quadrilateral Prism with Cut

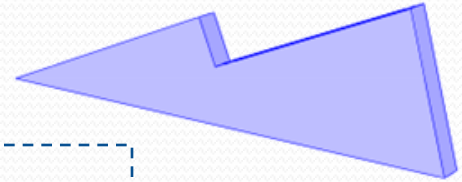


Pentagonal prism with cut



✓ #40 = #46

Pentagonal prism

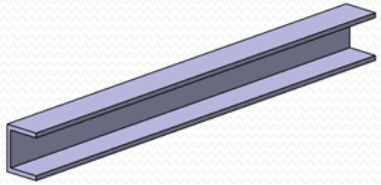


Pentagonal Prism

✓ #33 = #65

Octagonal Prism

Octagonal Prism

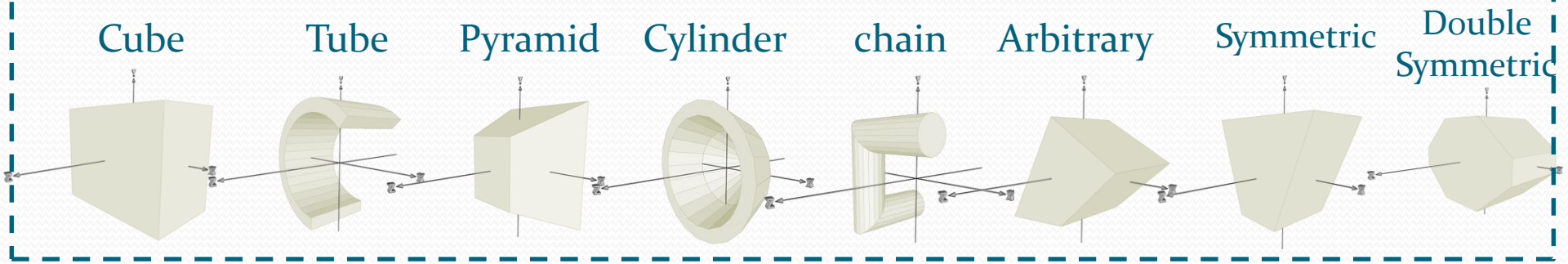


As a result 73 geometry cases have been selected

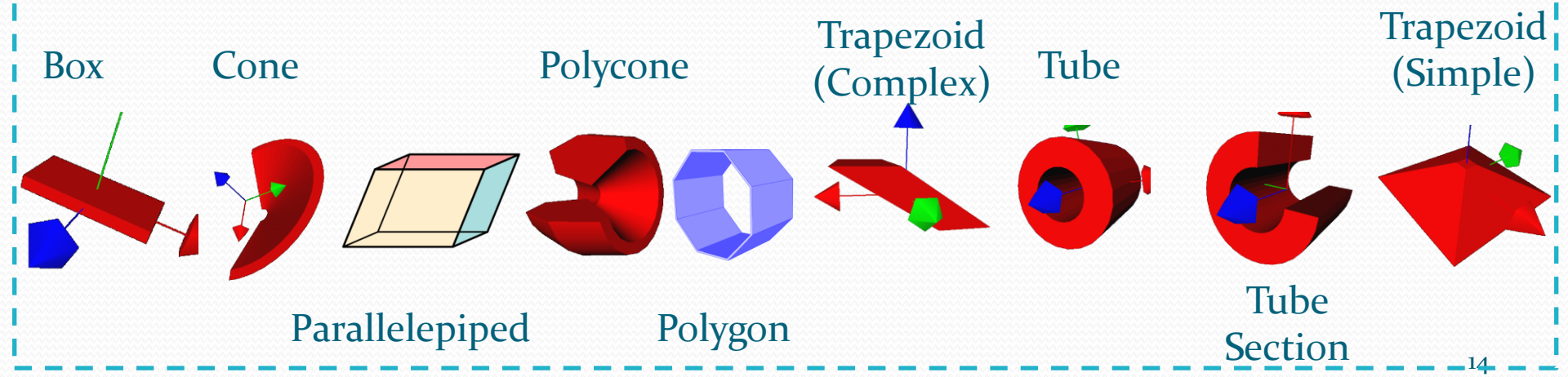
4th Step of Selection

Ways of programming of selected geometry cases have been considered according to exiting methods in AGDD/XML and GeoMode:

AGDD/XML



GeoModel



4th Step of Selection

As a result following number of programming cases have been separated:

		Geo Cases	Prog. Cases		
XML	Geometrics Primitives	17	3’ 871		
	Typical Joining	8	446		
	Combined Objects	23	5’ 215		
	Total:	**48**	**9’ 532**		**Total: 15’ 675**
GeoModel	Geometrics Primitives	3	589		
	Typical Joining	16	4’ 190		
	Combined Objects	7	1’ 364		
	Total:	**26**	**6’ 143**		

Selection Criteria

Criteria #1: Separate programming cases with Arbitrary polygon method from others because of:

1) Arbitrary Polygon method permits to create volume in final position by only Z displacement
2) Only rotation on Z axes is needed
3) Number of necessary boolean operation is minimal

Octadecagonal Prism

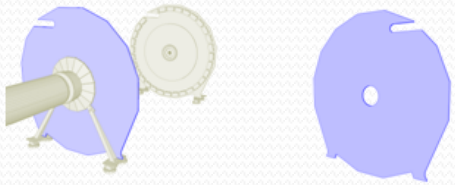
I class

Arbitrary
Move (Z)
Rotation

II class

Cube	Cube
Arbitrary	Pyramid
Subtraction	Move
Move	Subtraction
rotation	Cube
	Move
	Subtraction
	Cube
	Move
	Cube
	Move
	Cube
	Move
	Cube
	Pyramid
	Move
	Subtraction
	Union
	Move
	Rotation

Icositetrahedronal Prism with Cuts



I class

Arbitrary
Tube
Move
Subtraction
Tube
Move
Subtraction

II class

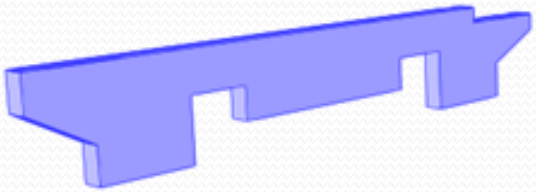
Cube	Pyramid
Symmetric	Symmetric
Move	Move
Subtraction	Subtraction
Move	Move
Subtraction	Subtraction
Arbitrary	Arbitrary
Subtraction	Subtraction
Tube	Tube
Move	Move
Subtraction	Subtraction
Cube	Cube
Move	Move
Subtraction	Subtraction
Tube	Tube
Move	Move
Subtraction	Subtraction

Selection Criteria

Criteria #2: Minimization of number of used methods ensure:

1) Compactness of code
2) Reduce number of received clashes, contacts and inaccuracies of positioning
3) Better performance by reducing number of regions for consideration during the simulation

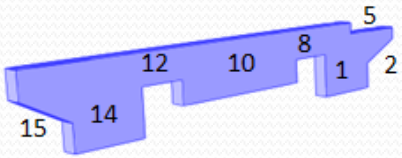
Octadecagonal Prism



```
Cube
Arbitrary
Subtraction
Move
rotation
```

Octadecagonal Prism

```
Cube
Pyramid
Move
Subtraction
Cube
Move
Subtraction
Cube
Move
Cube
Move
Cube
Move
Cube
Pyramid
Move
Subtraction
Union
Move
Rotation
```



Selection Criteria

Criteria #3: Sameness of used methods because of:

1) Brings same geometry
2) Difference in performance is negligible
    1) **Criteria #3.1:** Similarity of Method and Geometry

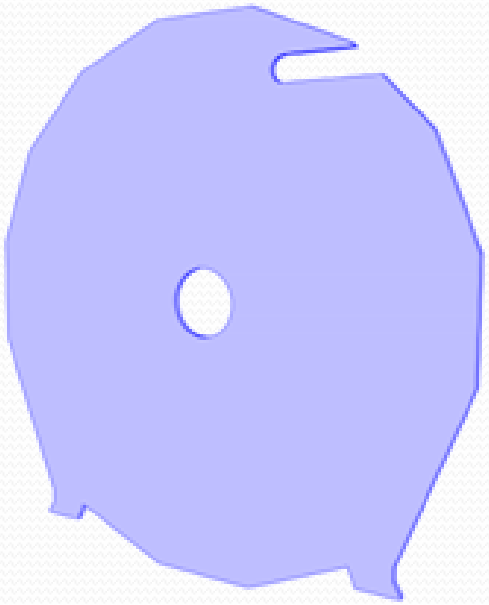
Icositetrahedronal Prism with Cuts

Cube	Pyramid
Symmetric	Symmetric
Move	Move
Subtraction	Subtraction
Move	Move
Subtraction	Subtraction
Arbitrary	Arbitrary
Subtraction	Subtraction
Tube	Tube
Move	Move
Subtraction	Subtraction
Cube	Cube
Move	Move
Subtraction	Subtraction
Tube	Tube
Move	Move
Subtraction	Subtraction

Selection Criteria

Criteria #4: Similarity of code Structures

Icositetrahedronal Prism with Cuts



Cube	Pyramid
Symmetric	Symmetric
Move	Move
Subtraction	Subtraction
Move	Move
Subtraction	Subtraction
Arbitrary	Arbitrary
Subtraction	Subtraction
Tube	Tube
Move	Move
Subtraction	Subtraction
Cube	Cube
Move	Move
Subtraction	Subtraction
Tube	Tube
Move	Move
Subtraction	Subtraction

5th Step of Selection

For each geometry case programming cases have been selected according to above mentioned criteria.

As a result:

		Number of Cases		
XML	Geometrics Primitives	37		
	Typical Joining	13		
	Combined Objects	39		
	Total:	**89**		
GeoModel	Geometrics Primitives	3		**Total: 113**
	Typical Joining	14		
	Combined Objects	7		
	Total:	**24**		

6th Step of Selection

For each geometry class programming cases have been selected according to **Criteria #3**

Result of selection:

		Number of Cases		
XML	Geometrics Primitives	9		
	Typical Joining	13		
	Combined Objects	33		
	Total:	**55**		**Total: 77**
GeoModel	Geometrics Primitives	3		
	Typical Joining	12		
	Combined Objects	7		
	Total:	**22**		

7th Step of Selection

Programming cases over the geometry classes have been considered and selected according to **Criteria #3**

Result of selection:

		Number of Cases		
XML	Geometrics Primitives	8		
	Typical Joining	12		
	Combined Objects	32		
	Total:	**52**		
GeoModel	Geometrics Primitives	3		**Total: 73**
	Typical Joining	12		
	Combined Objects	6		
	Total:	**21**		

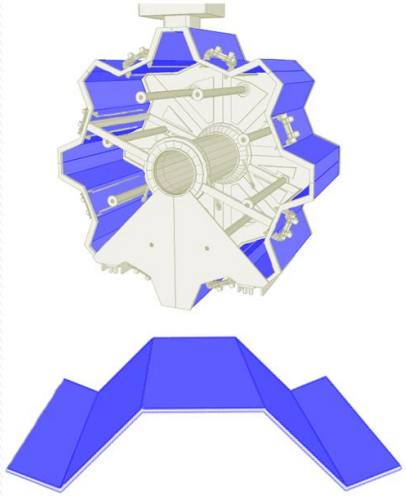
73 test examples have been separated:

AGDD / XML

1. Geometric Primitives

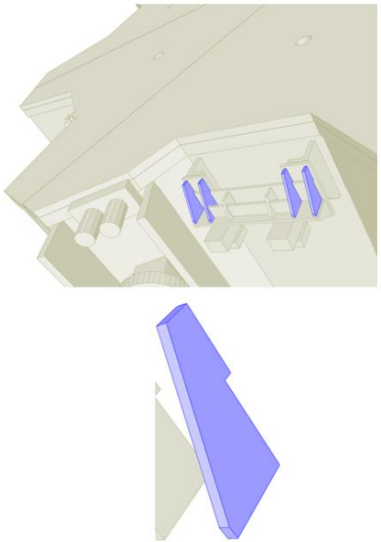
Test Examples for Simulation Loop

#01: Dodecagonal Prism



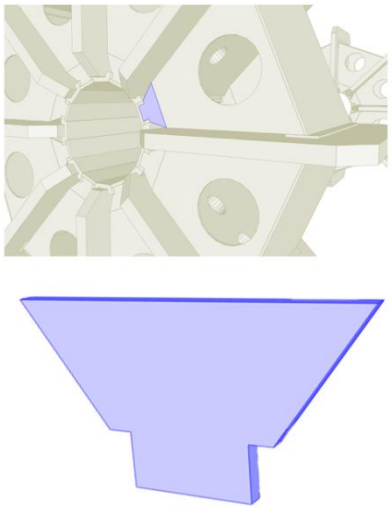
Pyramid
Pyramid
Move
Subtraction
Move
Rotation
Subtraction
Move
Rotation
Subtraction
Pyramid
Move
Rotation
Subtraction
Move
Rotation
Subtraction
Move
Rotation

#02: Heptagonal Prism



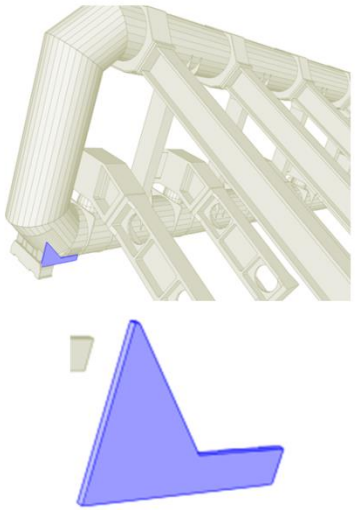
Cube
Cube
Move
Rotation
Subtraction
Move
Subtraction
Move
Rotation

#03: Octagonal Prism



Symmetric
Move
Rotation

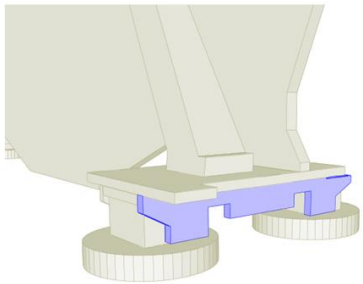
#04: Pentagonal Prism



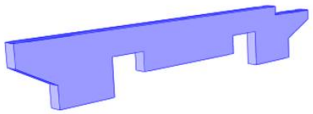
Cube
Arbitrary
Subtraction
Move
Rotation

Test Examples for Simulation Loop

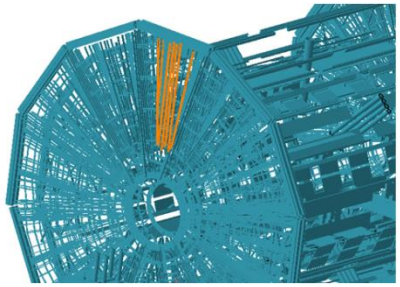
#05: Octadecagonal Prism



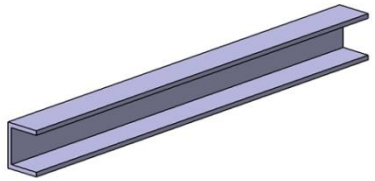
Arbitrary
Move (Z)
Rotation



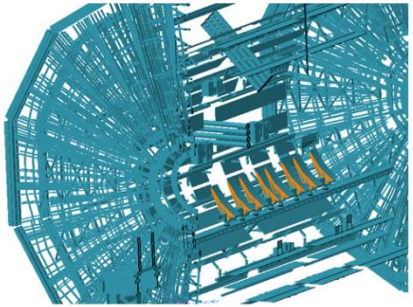
#06: Octagonal Prism



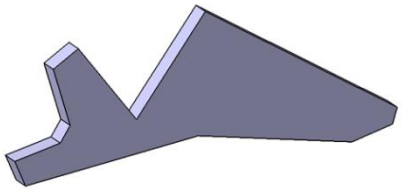
Cube
Cube
Move
Subtraction
Move
Rotation



#07: Dodecagonal Prism



Cube
Arbitrary
Subtraction
Arbitrary
Subtraction
Move
Rotation



#08: Pentagonal Prism

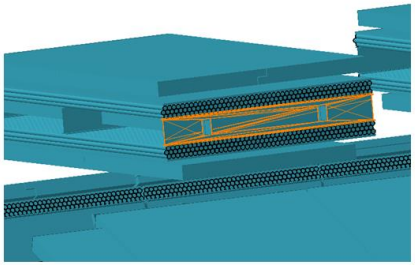
Cube
Cube
Move
Rotation
Subtraction
Move
Rotation

AGDD / XML

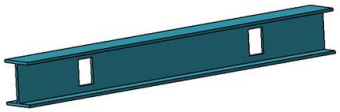
2. Combined Objects

Test Examples for Simulation Loop

#09; #10: Dodecagonal Prism with Cuts

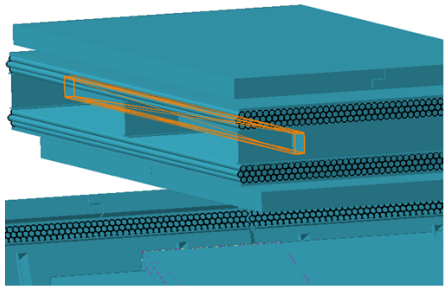


Arbitrary
Arbitrary
Move
Subtraction
Move
Subtraction
Move (Z)
Rotation

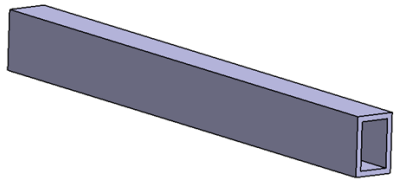


Cube
Cube
Move
Subtraction
Move
Subtraction
Cube
Move
Subtraction
Move
Subtraction
Move
Rotation

#11; #12: Cube with Cut

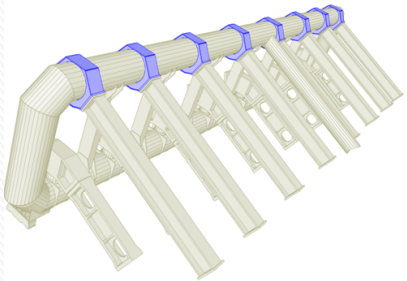


Cube
Cube
Subtraction
Move
Rotation

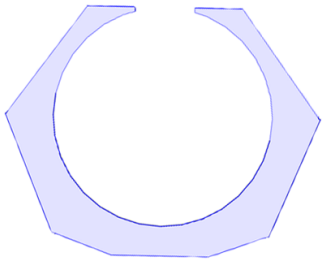


Arbitrary
Arbitrary
Subtraction
Move (Z)
Rotation

#13; #14: Octagonal Prism with Cuts

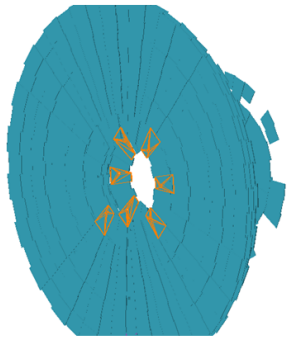


Symmetric
Tube
Subtraction
Cube
Move
Subtraction
Move
Rotation



Arbitrary
Tube
Move
Subtraction
Cube
Move
Subtraction
Move (Z)
Rotation

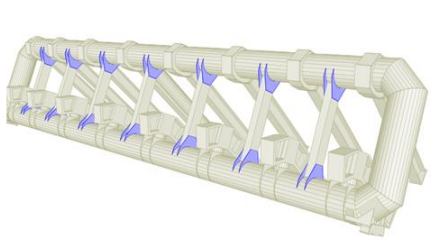
#15: Quadrilateral Prism with Cut

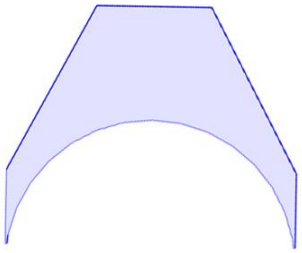


Pyramid
Cube
Move
Subtraction
Move
Rotation

Test Examples for Simulation Loop

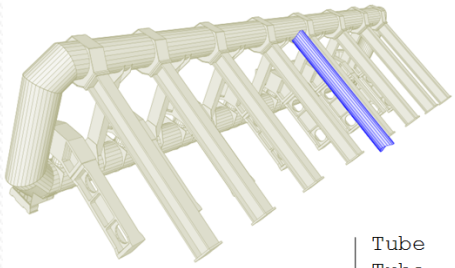
#16: Quadrilateral Prism with Cut

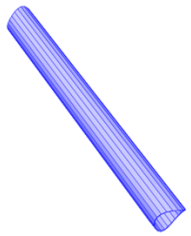




```
Arbitrary
Tube
Move
Subtraction
Move (Z)
Rotation
```

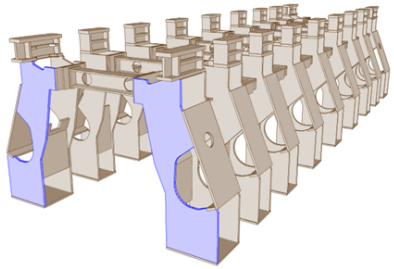
#17: Tube with Cut

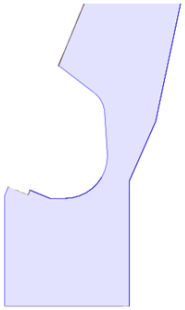




```
Tube
Tube
Move
Rotation
Subtraction
Move
Rotation
Subtraction
Move
Rotation
```

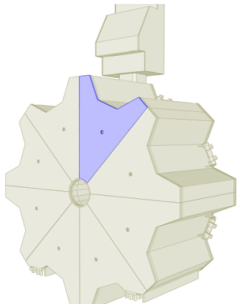
#18: Octagonal Prism with Cuts



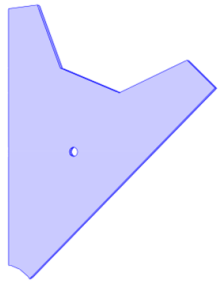


```
Symmetric
Arbitrary
Subtraction
Tube
Move
Subtraction
Tube
Move
Subtraction
Move
```

#19; #20: Hexagonal Prism with Cuts



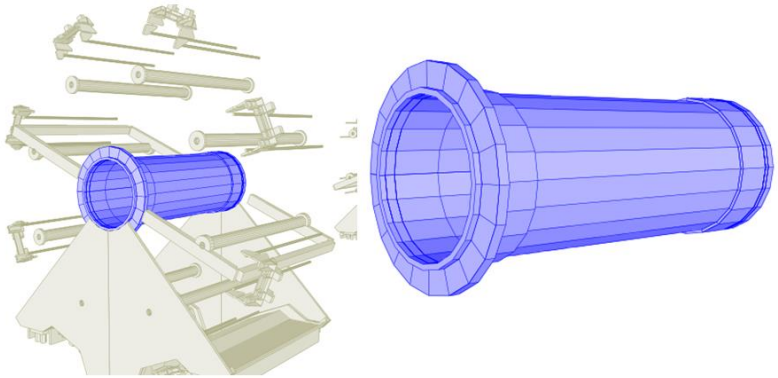
```
Arbitrary
Tube
Move
Subtraction
Tube
Move
Subtraction
Rotation
Move
```



```
Symmetric
Pyramid
Subtraction
Tube
Move
Subtraction
Tube
Move
Subtraction
Move
Rotation
```

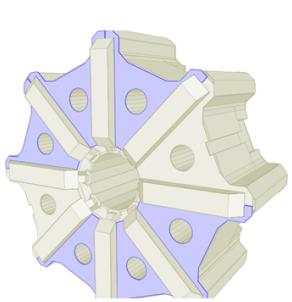
Test Examples for Simulation Loop

#21: Polycone

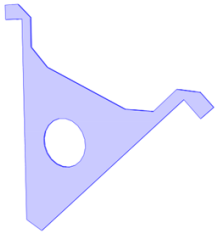


```
Cylinder
Move
```

#22; 23: Hexadecagonal Prism with cut

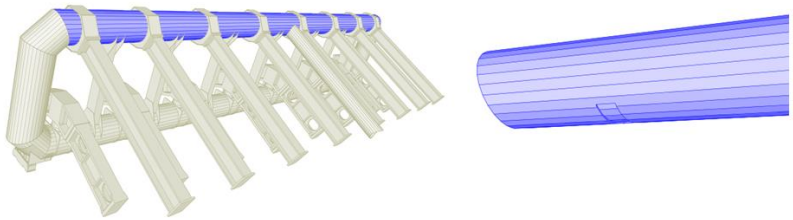


```
Arbitrary
Tube
Move
Subtraction
Move (Z)
Rotation
```



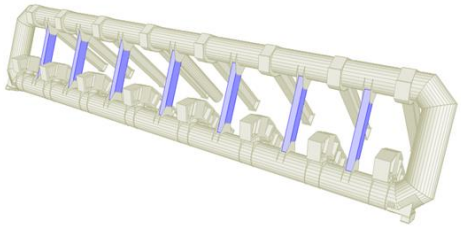
```
Pyramid
Arbitrary
Subtraction
Tube
Move
Subtraction
Arbitrary
Subtraction
Rotation
Subtraction
Move (Z)
Rotation
```

#24: Tube with Cut

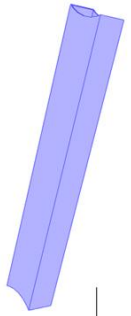


```
Tube
Cube
Move
Subtraction
Move
Rotation
```

#25; #26: Cube with Cuts



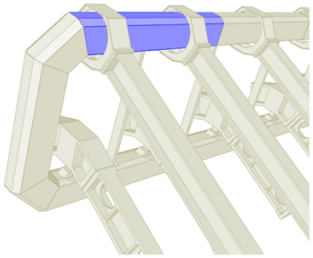
```
Arbitrary
Arbitrary
Subtraction
Tube
Move
Subtraction
Move
Subtraction
Move (Z)
Rotation
```

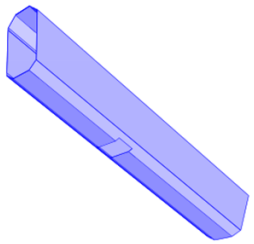


```
Cube
Cube
Subtraction
Tube
Move
Subtraction
Move
Subtraction
Move
Rotation
```

Test Examples for Simulation Loop

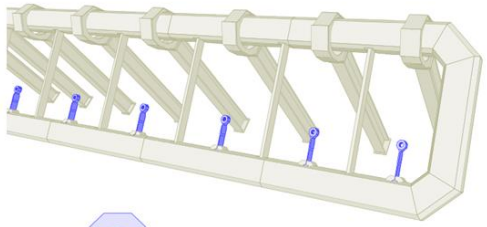
#27; #28: Octagonal Prism with Cuts





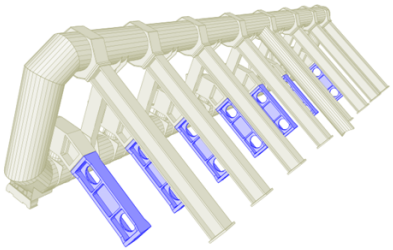
Arbitrary	Double Symmetric
Arbitrary	Double Symmetric
Subtraction	Subtraction
Arbitrary	Cube
Move	Move
Subtraction	Subtraction
Arbitrary	Cube
Move	Move
Rotation	Rotation
Subtraction	Subtraction
Move	Move
Rotation	Rotation
Subtraction	Subtraction
Move (Z)	Move
Rotation	Rotation

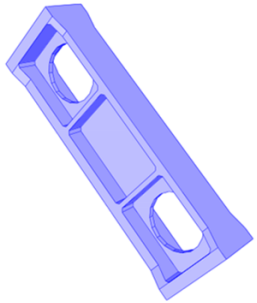
#29: Octadecagonal Prism with Cuts



Arbitrary
Tube
Move
Subtraction
Move (Z)
Subtraction

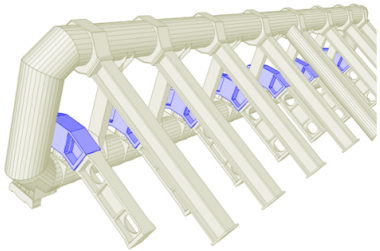
#30; #31: Dodecagonal Prism with Cuts

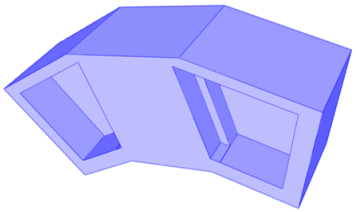




Arbitrary	Symmetric
Arbitrary	Double Symmetric
Rotation	Rotation
Move	Move
Subtraction	Subtraction
Rotation	Rotation
Move	Move
Subtraction	Subtraction
Rotation	Rotation
Move	Move
Subtraction	Subtraction
Rotation	Rotation
Move	Move
Subtraction	Subtraction
Rotation	Rotation
Move	Move
Subtraction	Subtraction
Tube	Tube
Rotation	Rotation
Move	Move
Subtraction	Subtraction
Rotation	Rotation
Move	Move
Subtraction	Subtraction
Move (Z)	Move
Rotation	Rotation

#32; #33: Octagonal Prism with Cuts

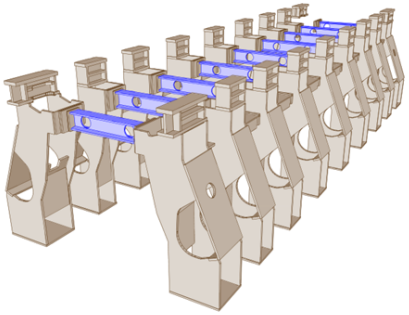




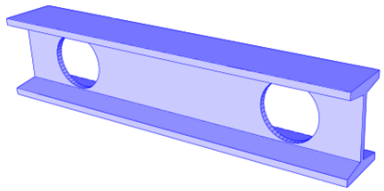
Arbitrary	Symmetric
Arbitrary	Arbitrary
Arbitrary	Arbitrary
Subtraction	Subtraction
Move	Move
Subtraction	Subtraction
Move	Move
Subtraction	Subtraction
Move	Move
Rotation	Rotation
Subtraction	Subtraction
Move	Move
Rotation	Rotation
Subtraction	Subtraction
Cone	Arbitrary
Move	Subtraction
Rotation	Cone
Subtraction	Move
Move (Z)	Rotation
Rotation	Subtraction
	Move
	Rotation

Test Examples for Simulation Loop

#34; #35: Dodecagonal Prism with Cuts

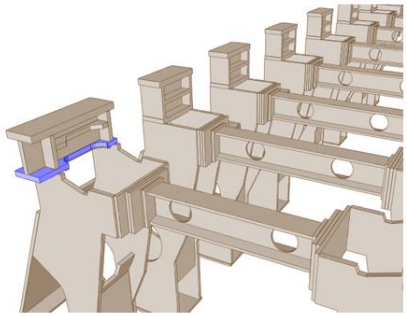


```
Arbitrary
Tube
Rotation
Move
Subtraction
Rotation
Move
Subtraction
Move (Z)
Rotation
```

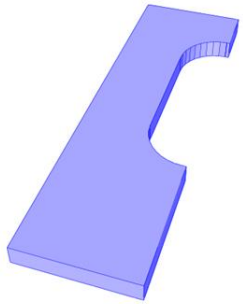


```
Symmetric
Tube
Rotation
Move
Subtraction
Rotation
Move
Subtraction
Move (Z)
Rotation
```

#36; #37: Octagonal Prism with Cuts

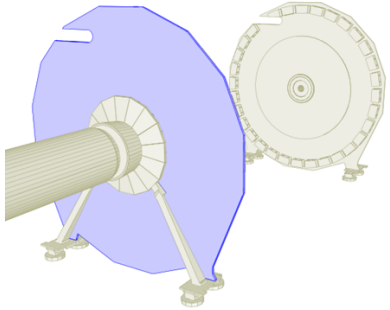


```
Arbitrary
Tube
Move
Subtraction
Move
Subtraction
Move (Z)
Rotation
```

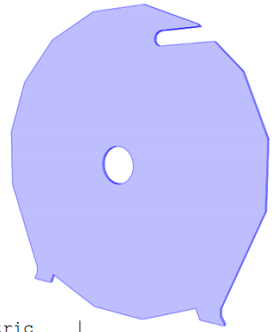


```
Cube
Cube
Move
Subtraction
Tube
Move
Subtraction
Move
Subtraction
Move
Rotation
```

#38; #39: Icositetragonal Prism with Cuts

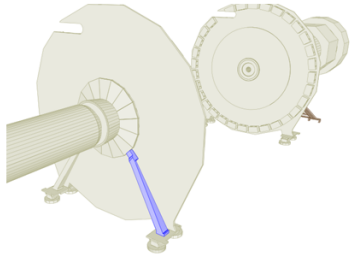


```
Arbitrary
Tube
Move
Subtraction
Tube
Move
Subtraction
Move (Z)
```

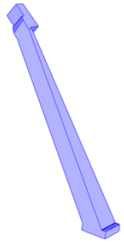


```
Symmetric
Arbitrary
Subtraction
Cube
Move
Subtraction
Tube
Move
Subtraction
Tube
Move
Subtraction
Move
```

#40; #41: Cube with Cuts



```
Arbitrary
Arbitrary
Subtraction
Arbitrary
Subtraction
Arbitrary
Rotation
Move
Subtraction
Arbitrary
Rotation
Move
Subtraction
Move
Rotation
```

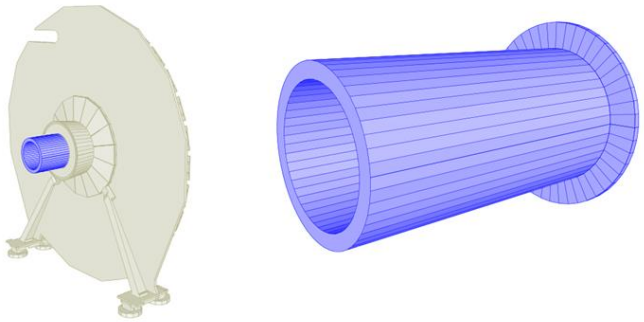


```
Cube
Arbitrary
Subtraction
Arbitrary
Subtraction
Arbitrary
Rotation
Move
Subtraction
Arbitrary
Rotation
Move
Subtraction
Move
Rotation
```

AGDD / XML
3. Typical Joining

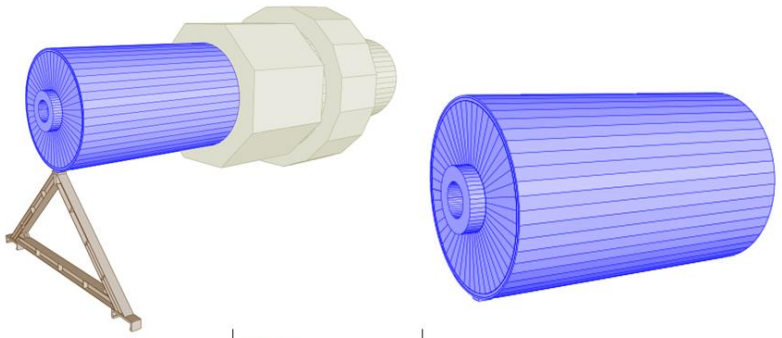
Test Examples for Simulation Loop

#42: Tubes Joining



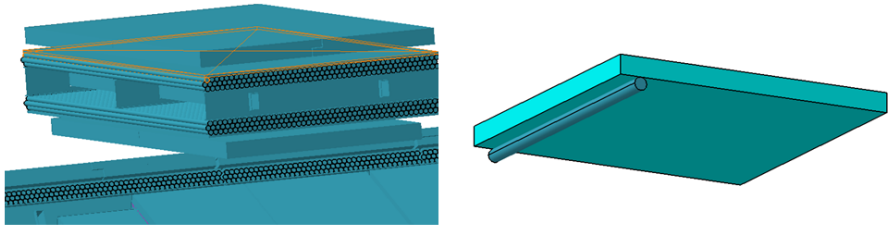
```
Tube
Tube
Move
Composition
Move
```

#43: Tubes Joining



```
Tube
Tube
Tube
Composition
Move
```

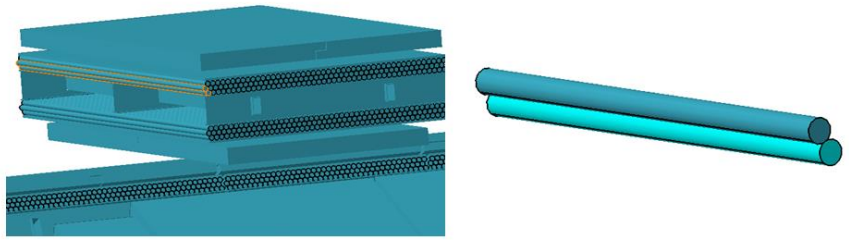
#44; #45: Cylinder and Cube Joining



```
Arbitrary
Tube
Move
Composition
Move (Z)
Rotation
```

```
Cube
Tube
Move
Composition
Move
Rotation
```

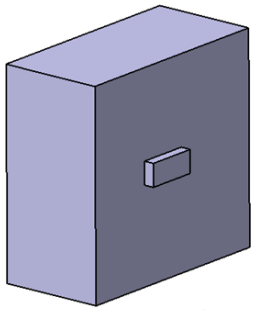
#46: Tubes Joining



```
Tube
Tube
Move
Composition
Move
Rotation
```

Test Examples for Simulation Loop

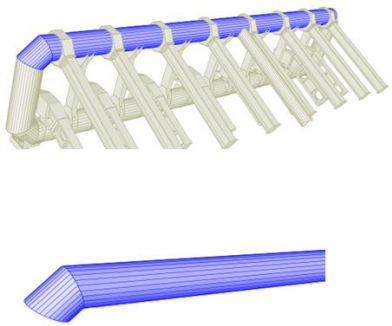
#47; #48: Cubes Joining



Arbitrary
Arbitrary

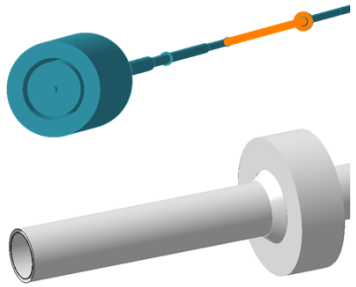
Cube
Cube
Move

#49: Tubes Joining



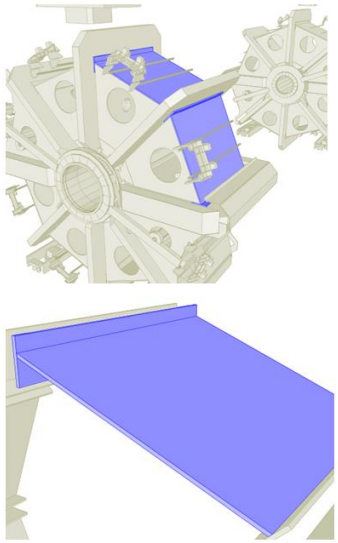
Tube
Cube
Move
Rotation
Subtraction
Tube
Move
Rotation
Subtraction
Rotation
Move
Composition
Move
Rotation

#50: Tubes and Cone Joining



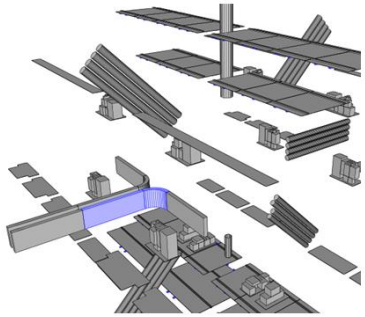
Tube
Cone
Tube
Move
Composition
Move

#51: Cubes Joining

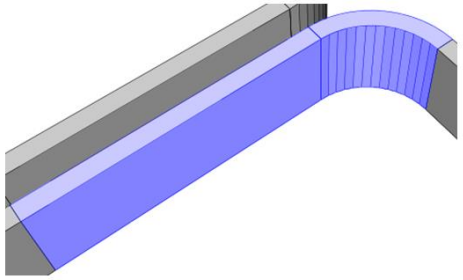


Symmetric
Cube
Rotation
Move
Composition
Move
Rotation

#52: Cube and Tube Joining



Arbitrary
Tube
Move
Composition
Move (Z)
Rotation



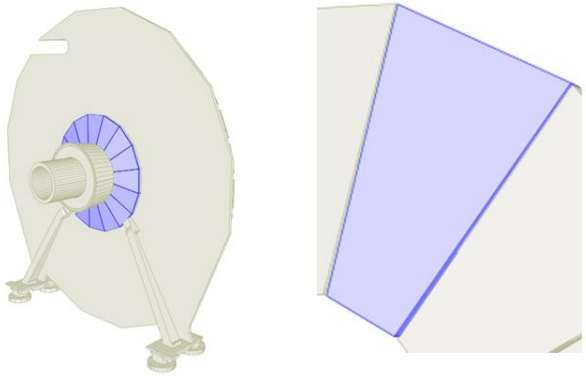
Cube
Tube
Move
Composition
Move

GeoModel

1. Geometric Primitives

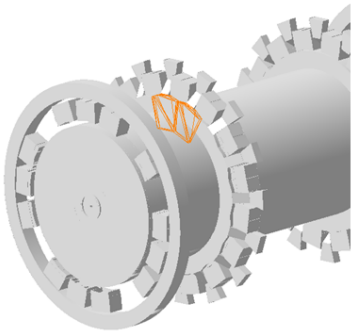
Test Examples for Simulation Loop

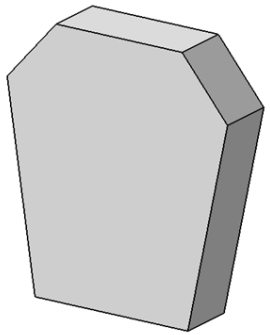
#53: Trapezoid




```
Trapezoid (Simple)
Rotation
Move
```

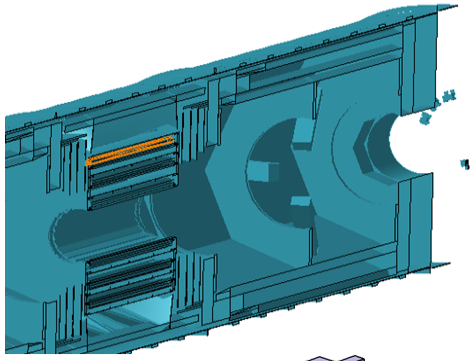
#54: Hexagonal Prism



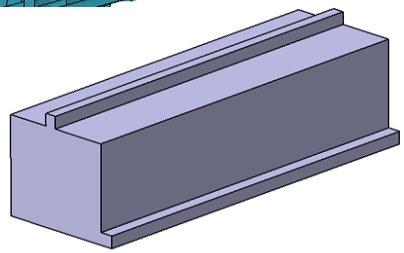


```
Trapezoid (Simple)
Box
Move
Rotation
Subtraction
Move
Rotation
Subtraction
Move
Rotation
```

#55: Decagonal Prism



```
Box
Box
Move
Subtraction
Move
Subtraction
Move
Subtraction
Move
Rotation
```

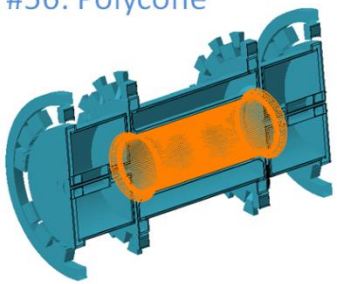


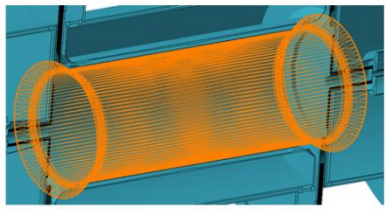
GeoModel

2. Combined Objects

Test Examples for Simulation Loop

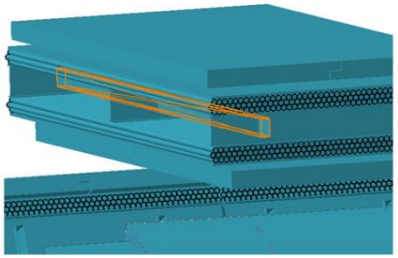
#56: Polycone

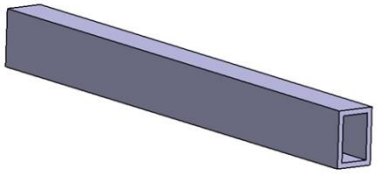




```
Polycone
Move
```

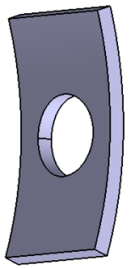
#57: Cube with Cut





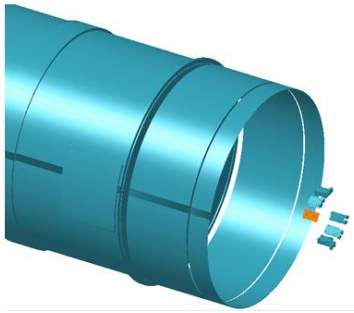
```
Box
Box
Subtraction
Move
Rotation
```

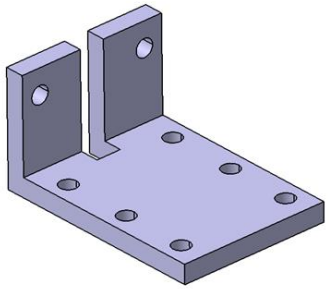
#58: Tube with Cut



```
Tubs
Tube
Move
Rotation
Subtraction
Move
Rotation
```

#59: Box with cuts

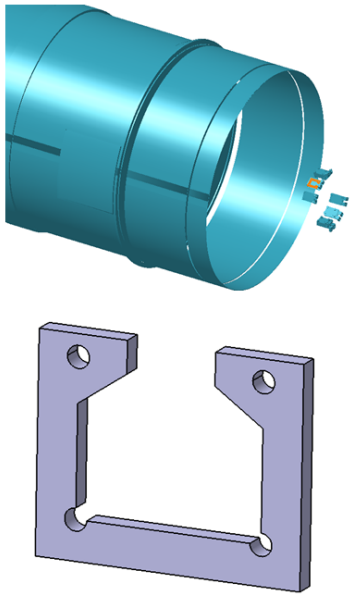




```
Box
Box
Move
Subtraction
Box
Move
Subtraction
Tube
Move
Subtraction
Move
Subtraction
Move
Subtraction
Move
Subtraction
Move
Subtraction
Move
Subtraction
Move
Subtraction
Move
Rotation
Subtraction
Move
Rotation
Subtraction
Move
Rotatio
```

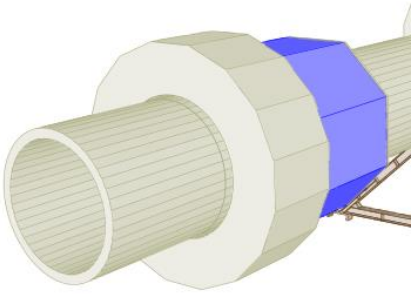
Test Examples for Simulation Loop

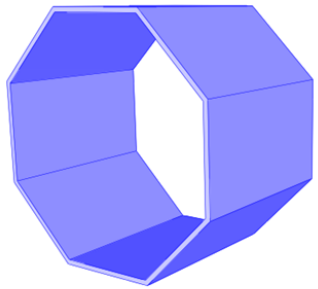
#60: Box with cuts



```
Box
Box
Move
Subtraction
Trapezoid (Simple)
Move
Subtraction
Rotation
Move
Subtraction
Tube
Move
Subtraction
Move
Subtraction
Move
Subtraction
Move
Subtraction
Move
Rotation
```

#61: Octagonal prism with cut



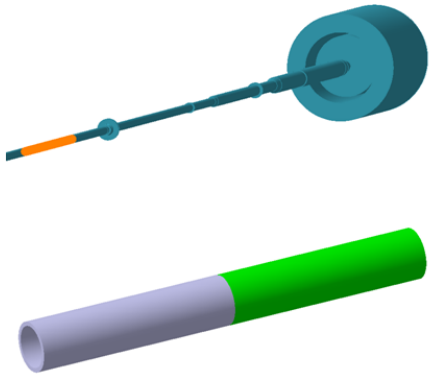


```
Polygon
Move
```

GeoModel
3. Typical Joining

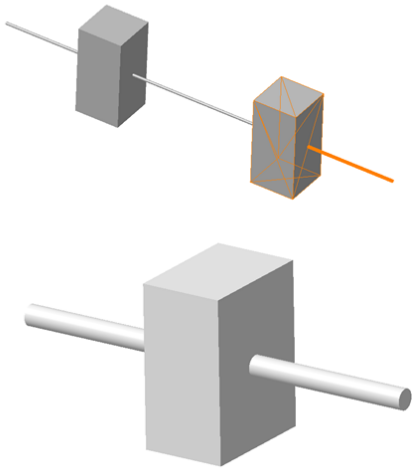
Test Examples for Simulation Loop

#62: Tubes joining



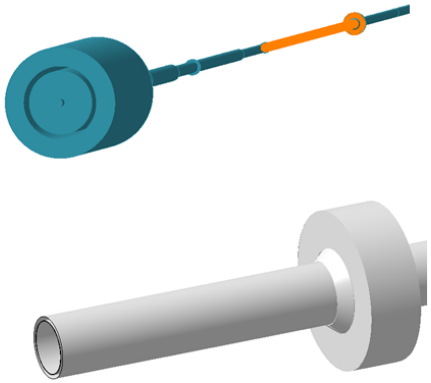
Tube
Tube
Move
Move

#63: Tube and Box joining



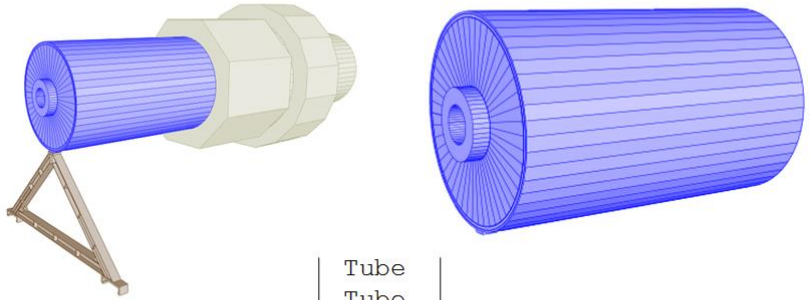
Box
Tube
Move
Subtraction
Move
Move

#64: Tubes and Cone Joining



Tube
Cone
Tube
Move
Move
Move

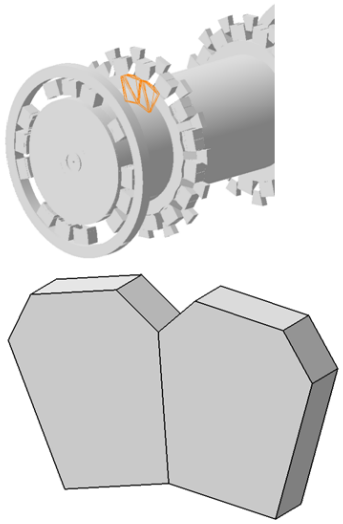
#65: Tubes Joining



Tube
Tube
Tube
Move
Move
Move

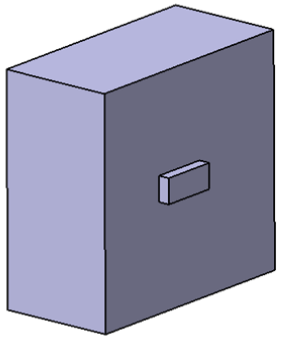
Test Examples for Simulation Loop

#66: Hexagonal Prism Joining



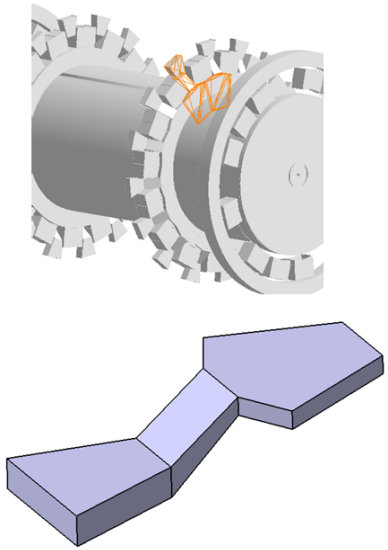
```
Trapezoid (Simple)
Box
Move
Rotation
Subtraction
Move
Rotation
Subtraction
Move
Rotation
Move
Rotation
```

#68: Boxes Joining



```
Box
Box
Move
Move
```

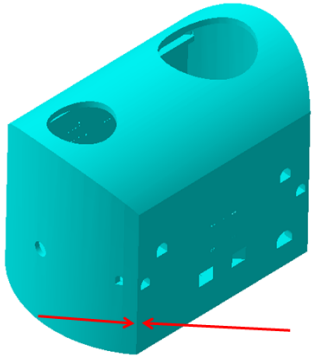
#67: Trapezoid, tetragonal and Hexagonal Prism Joining



```
Trapezoid (Simple)
Box
Move
Rotation
Subtraction
Move
Rotation
Subtraction
Move
Rotating
Parallelepiped
Move
Rotation
Trapezoid (Simple)
Move
Rotatio
```

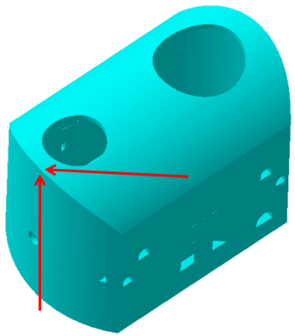
Test Examples for Simulation Loop

#69: Tubs and Box Joining



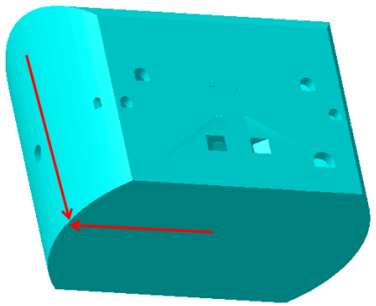
Tubs
Box
Move
Subtraction
Rotation
Box
Move

#70: Tubes Joining



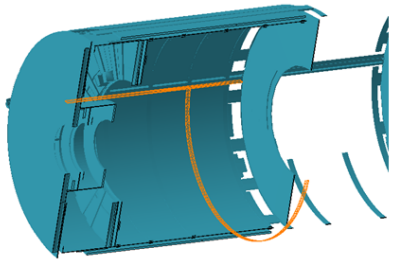
Tubs
Box
Move
Rotation
Subtraction
Tube
Move
Rotation
Subtraction
Move
Rotation
Move

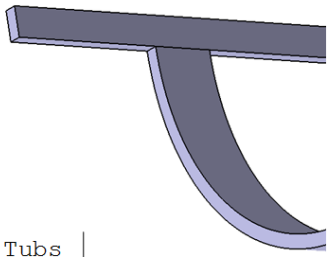
#71: Tubs and Box Joining



Box
Tubs
Move
Subtraction
Rotation
Tubs
Move
Rotation

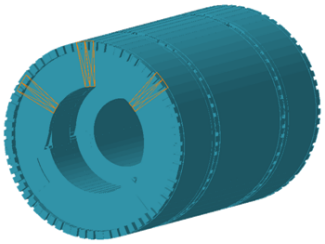
#72: Tubs and Box Joining

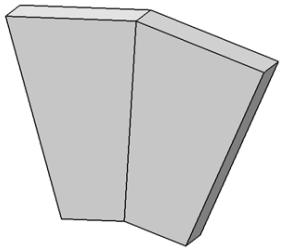




Tubs
Move
Box
Move

#73: Trapezoids Joining





Trapezoid (Simple)
Move
Rotation
Trapezoid (Simple)
Move
Rotation

Thank you for attention