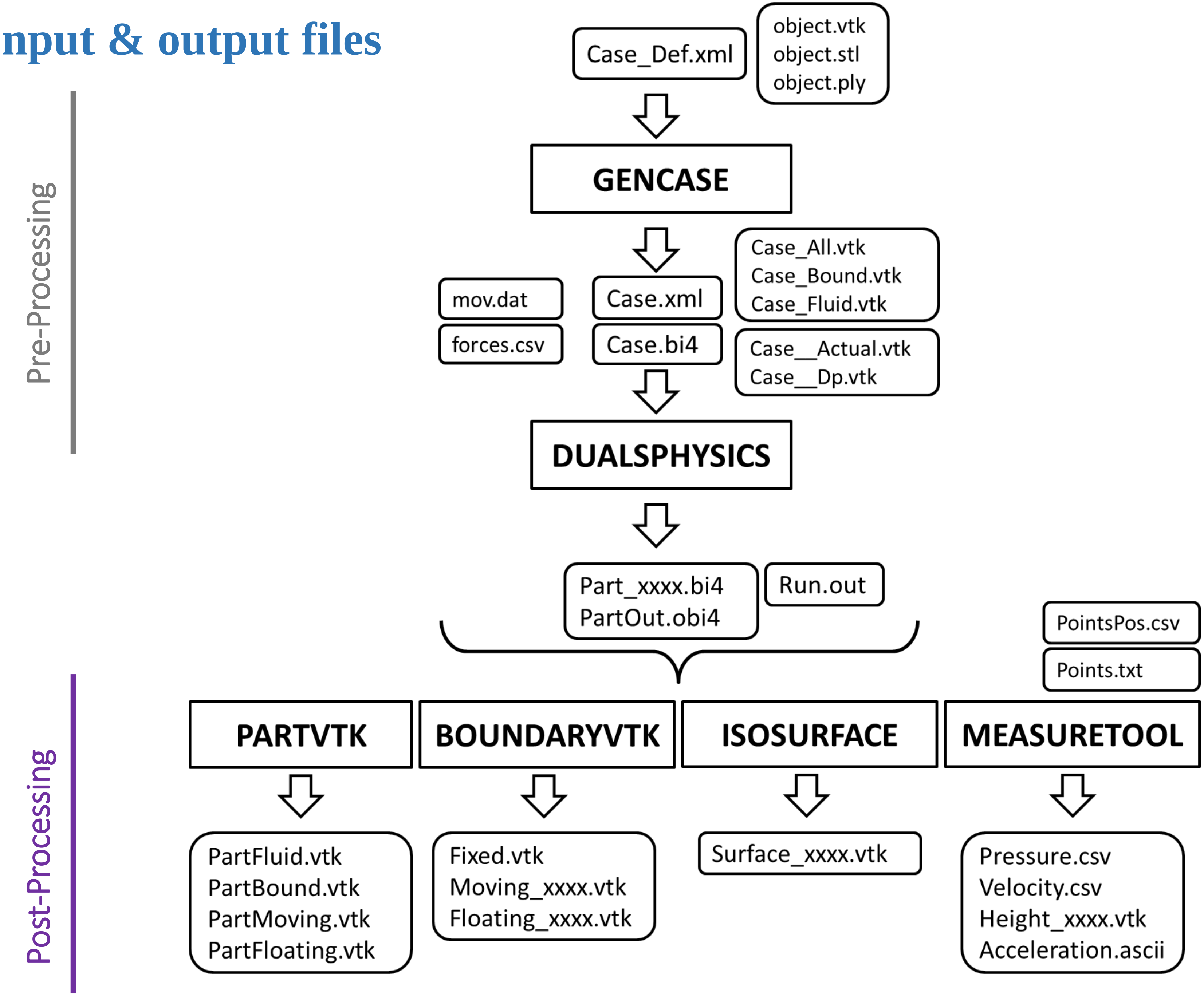
XML GUIDE FOR DUALSPHYSICS

Create your own case using the XML file

April 2016

DualSPHysics team

Input & output files



Pre-Processing

Case_Def.xml

object.vtk
object.stl
object.ply

GENCASE

mov.dat

forces.csv

Case.xml

Case.bi4

Case_All.vtk
Case_Bound.vtk
Case_Fluid.vtk

Case__Actual.vtk
Case__Dp.vtk

DUALSPHYSICS

Part_xxxx.bi4
PartOut.obi4

Run.out

PointsPos.csv

Points.txt

Post-Processing

PARTVTK

PartFluid.vtk
PartBound.vtk
PartMoving.vtk
PartFloating.vtk

BOUNDARYVTK

Fixed.vtk
Moving_xxxx.vtk
Floating_xxxx.vtk

ISOSURFACE

Surface_xxxx.vtk

MEASURETOOL

Pressure.csv
Velocity.csv
Height_xxxx.vtk
Acceleration.ascii

Input & output files: Format files

Case_Def.xml

Case.xml

XML File

- The eXtensible Markup Language is textual data format compatible with any hardware and software.
- Information is structured and organised by using labels.
- They can be easily edited using any text editor.

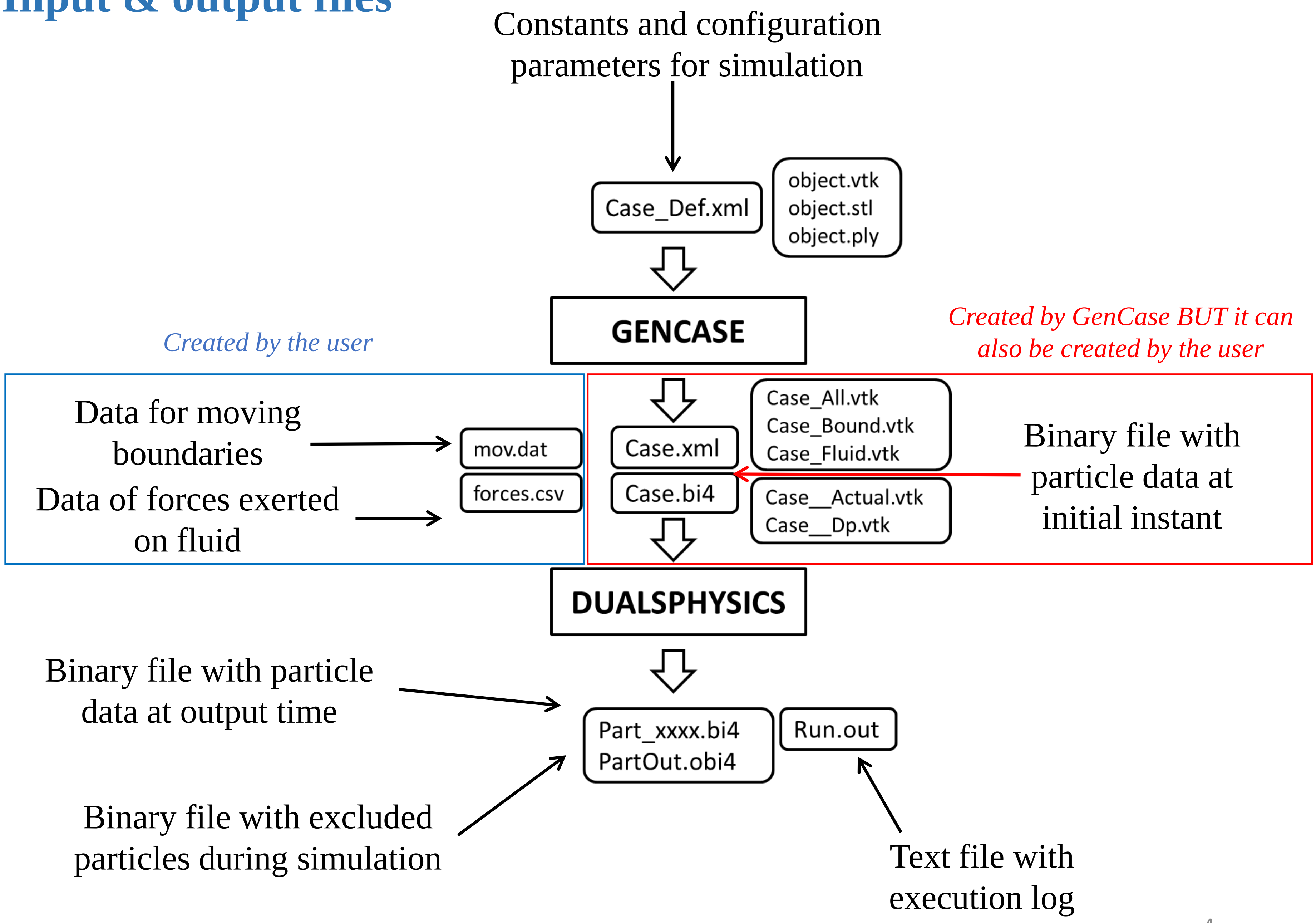
Case.bi4

Part_xxxx.bi4
PartOut.obi4

BINARY File

- Binary format consumes six times less memory than text format.
- Reading or writing is several times faster using a binary format.
- A special code is required to read the data (JPartDataBi4.cpp/.h).
- ".bi4" is the new binary format that also includes double precision.
- The user can also define new arrays that post-processing tools can automatic manage.

Input & output files



Constants and configuration parameters for simulation

Case_Def.xml

object.vtk
object.stl
object.ply

GENCASE

Created by the user

Data for moving boundaries

mov.dat

Data of forces exerted on fluid

forces.csv

Created by GenCase BUT it can also be created by the user

Case.xml

Case.bi4

Case_All.vtk
Case_Bound.vtk
Case_Fluid.vtk

Case__Actual.vtk
Case__Dp.vtk

Binary file with particle data at initial instant

DUALSPHYSICS

Binary file with particle data at output time

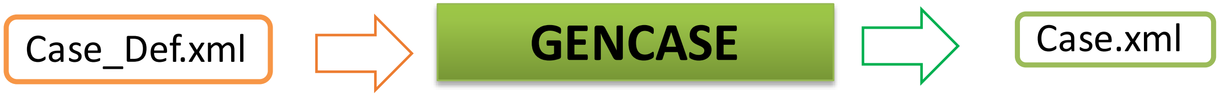
Part_xxxx.bi4
PartOut.obi4

Binary file with excluded particles during simulation

Run.out

Text file with execution log

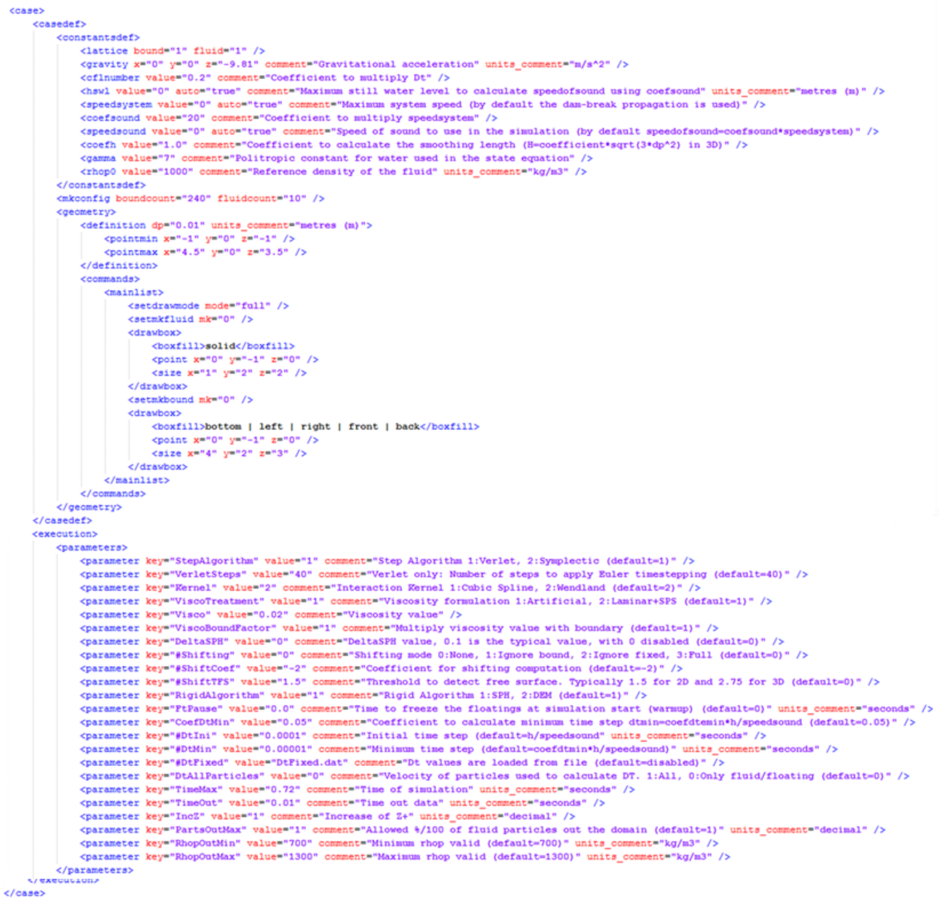
XML file



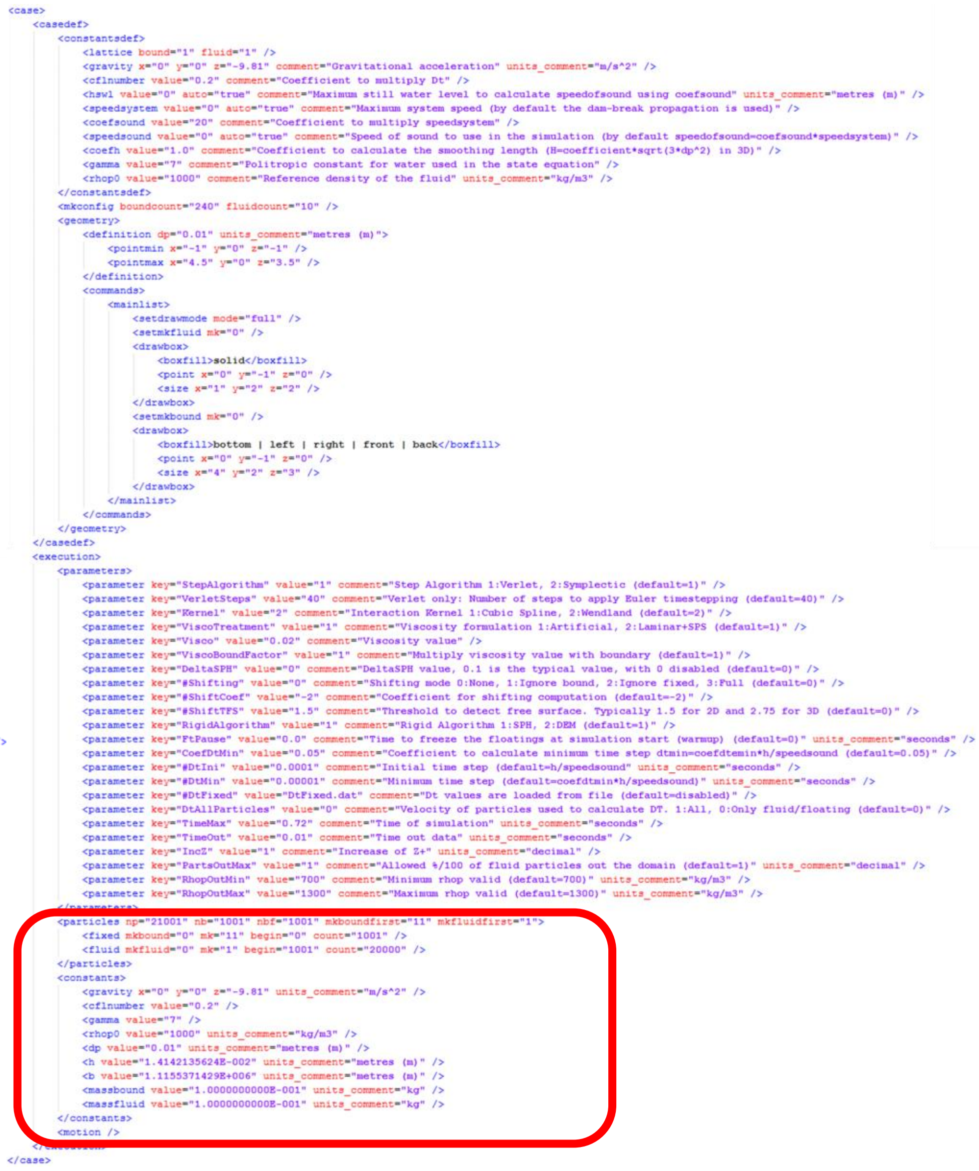
Case_Def.xml

GENCASE

Case.xml



```xml
<case>
    <casedef>
        <constantsdef>
            <lattice bound="1" fluid="1" />
            <gravity x="0" y="0" z="-9.81" comment="Gravitational acceleration" units_comment="m/s^2" />
            <cflnumber value="0.2" comment="Coefficient to multiply Dt" />
            <hswl value="0" auto="true" comment="Maximum still water level to calculate speedofsound using coefsound" units_comment="metres (m)" />
            <speedsystem value="0" auto="true" comment="Maximum system speed (by default the dam-break propagation is used)" />
            <coefsound value="20" comment="Coefficient to multiply speedsystem" />
            <speedsound value="0" auto="true" comment="Speed of sound to use in the simulation (by default speedofsound=coefsound*speedsystem)" />
            <coefh value="1.0" comment="Coefficient to calculate the smoothing length (H=coefficient*sqrt(3*dp^2) in 3D)" />
            <gamma value="7" comment="Politropic constant for water used in the state equation" />
            <rhop0 value="1000" comment="Reference density of the fluid" units_comment="kg/m3" />
        </constantsdef>
        <mkconfig boundcount="240" fluidcount="10" />
        <geometry>
            <definition dp="0.01" units_comment="metres (m)">
                <pointmin x="-1" y="0" z="-1" />
                <pointmax x="4.5" y="0" z="3.5" />
            </definition>
            <commands>
                <mainlist>
                    <setdrawmode mode="full" />
                    <setmkfluid mk="0" />
                    <drawbox>
                        <boxfill>solid</boxfill>
                        <point x="0" y="-1" z="0" />
                        <size x="1" y="2" z="2" />
                    </drawbox>
                    <setmkbound mk="0" />
                    <drawbox>
                        <boxfill>bottom | left | right | front | back</boxfill>
                        <point x="0" y="-1" z="0" />
                        <size x="4" y="2" z="3" />
                    </drawbox>
                </mainlist>
            </commands>
        </geometry>
    </casedef>
    <execution>
        <parameters>
            <parameter key="StepAlgorithm" value="1" comment="Step Algorithm 1:Verlet, 2:Symplectic (default=1)" />
            <parameter key="VerletSteps" value="40" comment="Verlet only: Number of steps to apply Euler timestepping (default=40)" />
            <parameter key="Kernel" value="2" comment="Interaction Kernel 1:Cubic Spline, 2:Wendland (default=2)" />
            <parameter key="ViscoTreatment" value="1" comment="Viscosity formulation 1:Artificial, 2:Laminar+SPS (default=1)" />
            <parameter key="Visco" value="0.02" comment="Viscosity value" />
            <parameter key="ViscoBoundFactor" value="1" comment="Multiply viscosity value with boundary (default=1)" />
            <parameter key="DeltaSPH" value="0" comment="DeltaSPH value, 0.1 is the typical value, with 0 disabled (default=0)" />
            <parameter key="#Shifting" value="0" comment="Shifting mode 0:None, 1:Ignore bound, 2:Ignore fixed, 3:Full (default=0)" />
            <parameter key="#ShiftCoef" value="-2" comment="Coefficient for shifting computation (default=-2)" />
            <parameter key="#ShiftTFS" value="1.5" comment="Threshold to detect free surface. Typically 1.5 for 2D and 2.75 for 3D (default=0)" />
            <parameter key="RigidAlgorithm" value="1" comment="Rigid Algorithm 1:SPH, 2:DEM (default=1)" />
            <parameter key="FtPause" value="0.0" comment="Time to freeze the floatings at simulation start (warmup) (default=0)" units_comment="seconds" />
            <parameter key="CoefDtMin" value="0.05" comment="Coefficient to calculate minimum time step dtmin=coefdtemin*h/speedsound (default=0.05)" />
            <parameter key="#DtIni" value="0.0001" comment="Initial time step (default=h/speedsound" units_comment="seconds" />
            <parameter key="#DtMin" value="0.00001" comment="Minimum time step (default=coefdtmin*h/speedsound)" units_comment="seconds" />
            <parameter key="#DtFixed" value="DtFixed.dat" comment="Dt values are loaded from file (default=disabled)" />
            <parameter key="DtAllParticles" value="0" comment="Velocity of particles used to calculate DT. 1:All, 0:Only fluid/floating (default=0)" />
            <parameter key="TimeMax" value="0.72" comment="Time of simulation" units_comment="seconds" />
            <parameter key="TimeOut" value="0.01" comment="Time out data" units_comment="seconds" />
            <parameter key="IncZ" value="1" comment="Increase of Z+" units_comment="decimal" />
            <parameter key="PartsOutMax" value="1" comment="Allowed %/100 of fluid particles out the domain (default=1)" units_comment="decimal" />
            <parameter key="RhopOutMin" value="700" comment="Minimum rhop valid (default=700)" units_comment="kg/m3" />
            <parameter key="RhopOutMax" value="1300" comment="Maximum rhop valid (default=1300)" units_comment="kg/m3" />
        </parameters>
    </execution>
</case>
```



```xml
<case>
    <casedef>
        <constantsdef>
            <lattice bound="1" fluid="1" />
            <gravity x="0" y="0" z="-9.81" comment="Gravitational acceleration" units_comment="m/s^2" />
            <cflnumber value="0.2" comment="Coefficient to multiply Dt" />
            <hswl value="0" auto="true" comment="Maximum still water level to calculate speedofsound using coefsound" units_comment="metres (m)" />
            <speedsystem value="0" auto="true" comment="Maximum system speed (by default the dam-break propagation is used)" />
            <coefsound value="20" comment="Coefficient to multiply speedsystem" />
            <speedsound value="0" auto="true" comment="Speed of sound to use in the simulation (by default speedofsound=coefsound*speedsystem)" />
            <coefh value="1.0" comment="Coefficient to calculate the smoothing length (H=coefficient*sqrt(3*dp^2) in 3D)" />
            <gamma value="7" comment="Politropic constant for water used in the state equation" />
            <rhop0 value="1000" comment="Reference density of the fluid" units_comment="kg/m3" />
        </constantsdef>
        <mkconfig boundcount="240" fluidcount="10" />
        <geometry>
            <definition dp="0.01" units_comment="metres (m)">
                <pointmin x="-1" y="0" z="-1" />
                <pointmax x="4.5" y="0" z="3.5" />
            </definition>
            <commands>
                <mainlist>
                    <setdrawmode mode="full" />
                    <setmkfluid mk="0" />
                    <drawbox>
                        <boxfill>solid</boxfill>
                        <point x="0" y="-1" z="0" />
                        <size x="1" y="2" z="2" />
                    </drawbox>
                    <setmkbound mk="0" />
                    <drawbox>
                        <boxfill>bottom | left | right | front | back</boxfill>
                        <point x="0" y="-1" z="0" />
                        <size x="4" y="2" z="3" />
                    </drawbox>
                </mainlist>
            </commands>
        </geometry>
    </casedef>
    <execution>
        <parameters>
            <parameter key="StepAlgorithm" value="1" comment="Step Algorithm 1:Verlet, 2:Symplectic (default=1)" />
            <parameter key="VerletSteps" value="40" comment="Verlet only: Number of steps to apply Euler timestepping (default=40)" />
            <parameter key="Kernel" value="2" comment="Interaction Kernel 1:Cubic Spline, 2:Wendland (default=2)" />
            <parameter key="ViscoTreatment" value="1" comment="Viscosity formulation 1:Artificial, 2:Laminar+SPS (default=1)" />
            <parameter key="Visco" value="0.02" comment="Viscosity value" />
            <parameter key="ViscoBoundFactor" value="1" comment="Multiply viscosity value with boundary (default=1)" />
            <parameter key="DeltaSPH" value="0" comment="DeltaSPH value, 0.1 is the typical value, with 0 disabled (default=0)" />
            <parameter key="#Shifting" value="0" comment="Shifting mode 0:None, 1:Ignore bound, 2:Ignore fixed, 3:Full (default=0)" />
            <parameter key="#ShiftCoef" value="-2" comment="Coefficient for shifting computation (default=-2)" />
            <parameter key="#ShiftTFS" value="1.5" comment="Threshold to detect free surface. Typically 1.5 for 2D and 2.75 for 3D (default=0)" />
            <parameter key="RigidAlgorithm" value="1" comment="Rigid Algorithm 1:SPH, 2:DEM (default=1)" />
            <parameter key="FtPause" value="0.0" comment="Time to freeze the floatings at simulation start (warmup) (default=0)" units_comment="seconds" />
            <parameter key="CoefDtMin" value="0.05" comment="Coefficient to calculate minimum time step dtmin=coefdtemin*h/speedsound (default=0.05)" />
            <parameter key="#DtIni" value="0.0001" comment="Initial time step (default=h/speedsound" units_comment="seconds" />
            <parameter key="#DtMin" value="0.00001" comment="Minimum time step (default=coefdtmin*h/speedsound)" units_comment="seconds" />
            <parameter key="#DtFixed" value="DtFixed.dat" comment="Dt values are loaded from file (default=disabled)" />
            <parameter key="DtAllParticles" value="0" comment="Velocity of particles used to calculate DT. 1:All, 0:Only fluid/floating (default=0)" />
            <parameter key="TimeMax" value="0.72" comment="Time of simulation" units_comment="seconds" />
            <parameter key="TimeOut" value="0.01" comment="Time out data" units_comment="seconds" />
            <parameter key="IncZ" value="1" comment="Increase of Z+" units_comment="decimal" />
            <parameter key="PartsOutMax" value="1" comment="Allowed %/100 of fluid particles out the domain (default=1)" units_comment="decimal" />
            <parameter key="RhopOutMin" value="700" comment="Minimum rhop valid (default=700)" units_comment="kg/m3" />
            <parameter key="RhopOutMax" value="1300" comment="Maximum rhop valid (default=1300)" units_comment="kg/m3" />
        </parameters>
        <particles np="21001" nb="1001" nbf="1001" mkboundfirst="11" mkfluidfirst="1">
            <fixed mkbound="0" mk="11" begin="0" count="1001" />
            <fluid mkfluid="0" mk="1" begin="1001" count="20000" />
        </particles>
        <constants>
            <gravity x="0" y="0" z="-9.81" units_comment="m/s^2" />
            <cflnumber value="0.2" />
            <gamma value="7" />
            <rhop0 value="1000" units_comment="kg/m3" />
            <dp value="0.01" units_comment="metres (m)" />
            <h value="1.4142135624E-002" units_comment="metres (m)" />
            <b value="1.1155371429E+006" units_comment="metres (m)" />
            <massbound value="1.0000000000E-001" units_comment="kg" />
            <massfluid value="1.0000000000E-001" units_comment="kg" />
        </constants>
        <motion />
    </execution>
</case>
```

STRUCTURE OF THE XML FILE

Divided in two sections:

“casedef”

Definition of the case with initial geometry and configuration.

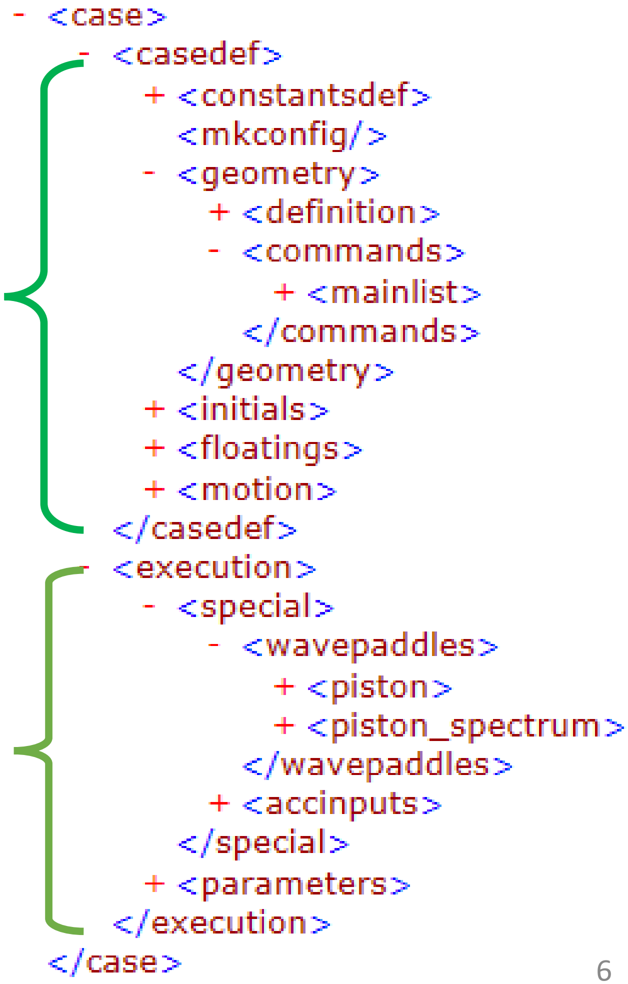
Created by the user and used by GenCase

“execution”

Information required to execute the case.

Created by the user, modified by GenCase

and only used by DualSPHysics



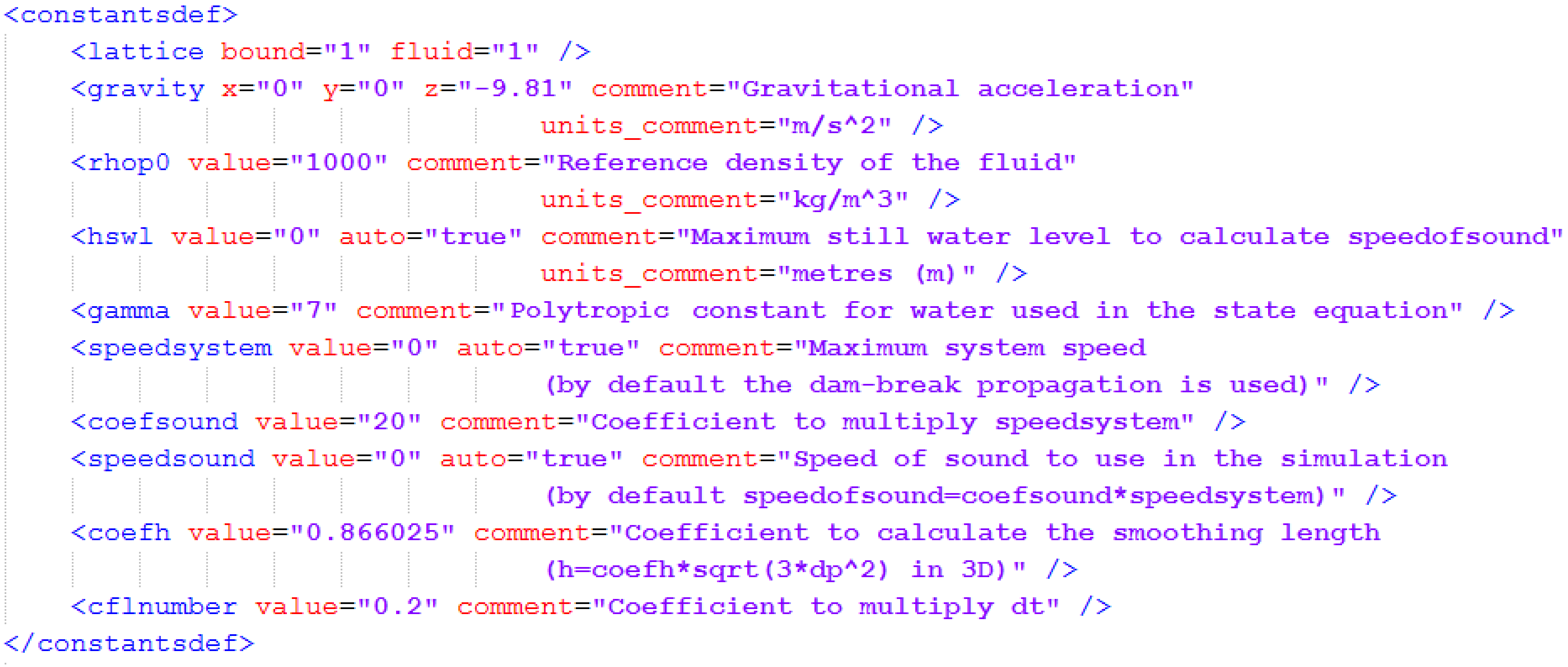
```
- <case>
  - <casedef>
    + <constantsdef>
      <mkconfig/>
    - <geometry>
      + <definition>
      - <commands>
        + <mainlist>
        </commands>
      </geometry>
    + <initials>
    + <floatings>
    + <motion>
    </casedef>
  - <execution>
    - <special>
      - <wavepaddles>
        + <piston>
        + <piston_spectrum>
        </wavepaddles>
      + <accinputs>
      </special>
    + <parameters>
    </execution>
  </case>
```

STRUCTURE OF THE XML FILE

- **“casedef” :**
  - **- constantsdef** constants needed in SPH
  - **- mkconfig** label configuration
  - **- geometry** system geometry (boundaries and fluid)
    - **- definition**
    - **- commands (list & mainlist)**
  - **- initials** special features for fluid particles
  - **- floatings** description of floating objects
  - **- motion** description of boundary movement
- **“execution”**
  - **- special** automatic wave generation and external forces
    - **- wavepaddles (piston & piston_spectrum)**
    - **- accinputs**
  - **- parameters** execution parameters in DualSPHysics

XML file

CASEDEF-CONSTANTSDEF

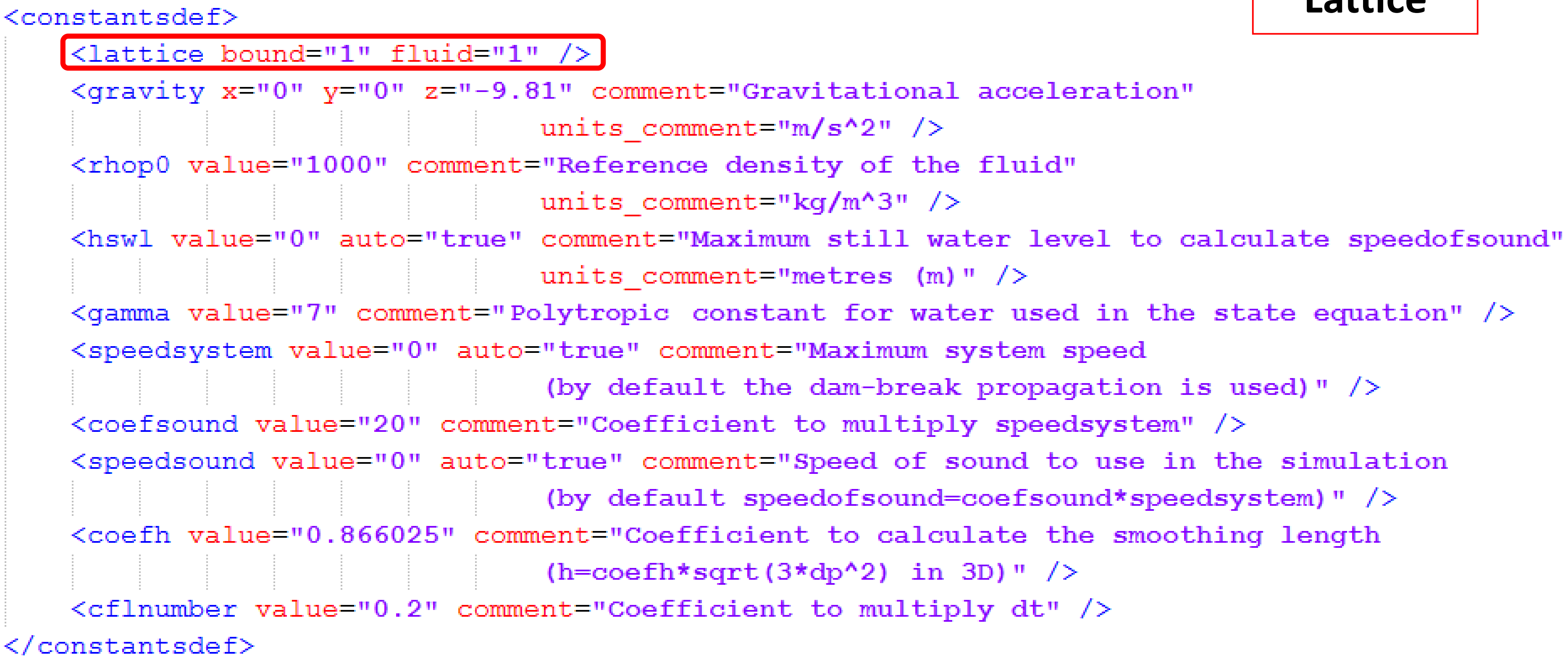


```
<constantsdef>
    <lattice bound="1" fluid="1" />
    <gravity x="0" y="0" z="-9.81" comment="Gravitational acceleration"
                                units_comment="m/s^2" />
    <rhop0 value="1000" comment="Reference density of the fluid"
                                units_comment="kg/m^3" />
    <hswl value="0" auto="true" comment="Maximum still water level to calculate speedofsound"
                                units_comment="metres (m)" />
    <gamma value="7" comment="Polytropic constant for water used in the state equation" />
    <speedsystem value="0" auto="true" comment="Maximum system speed
                                 (by default the dam-break propagation is used)" />
    <coefsound value="20" comment="Coefficient to multiply speedsystem" />
    <speedsound value="0" auto="true" comment="Speed of sound to use in the simulation
                                 (by default speedofsound=coefsound*speedsystem)" />
    <coefh value="0.866025" comment="Coefficient to calculate the smoothing length
                                 (h=coefh*sqrt(3*dp^2) in 3D)" />
    <cflnumber value="0.2" comment="Coefficient to multiply dt" />
</constantsdef>
```

XML file

CASEDEF-CONSTANTSDEF

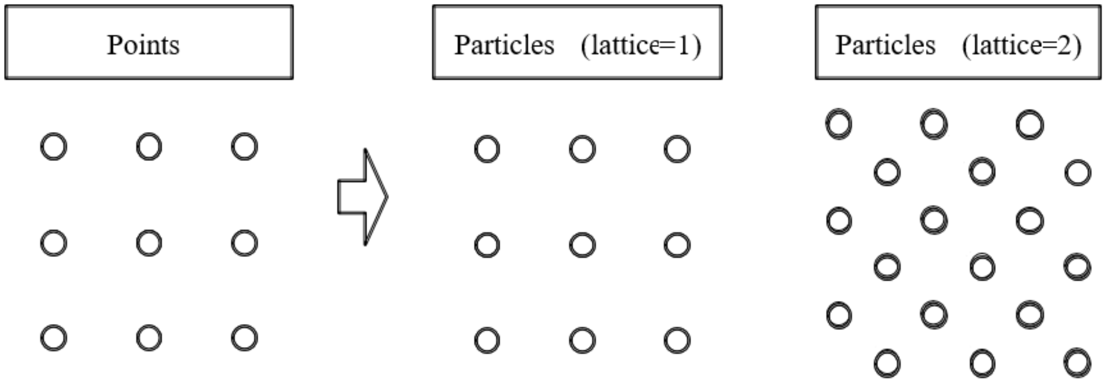
Lattice



```
<constantsdef>
    <lattice bound="1" fluid="1" />
    <gravity x="0" y="0" z="-9.81" comment="Gravitational acceleration"
                                units_comment="m/s^2" />
    <rhop0 value="1000" comment="Reference density of the fluid"
                                units_comment="kg/m^3" />
    <hswl value="0" auto="true" comment="Maximum still water level to calculate speedofsound"
                                units_comment="metres (m)" />
    <gamma value="7" comment="Polytropic constant for water used in the state equation" />
    <speedsystem value="0" auto="true" comment="Maximum system speed
                                (by default the dam-break propagation is used)" />
    <coefsound value="20" comment="Coefficient to multiply speedsystem" />
    <speedsound value="0" auto="true" comment="Speed of sound to use in the simulation
                                (by default speedofsound=coefsound*speedsystem)" />
    <coefh value="0.866025" comment="Coefficient to calculate the smoothing length
                                (h=coefh*sqrt(3*dp^2) in 3D)" />
    <cflnumber value="0.2" comment="Coefficient to multiply dt" />
</constantsdef>
```

lattice: indicates the type of mesh to create particles:

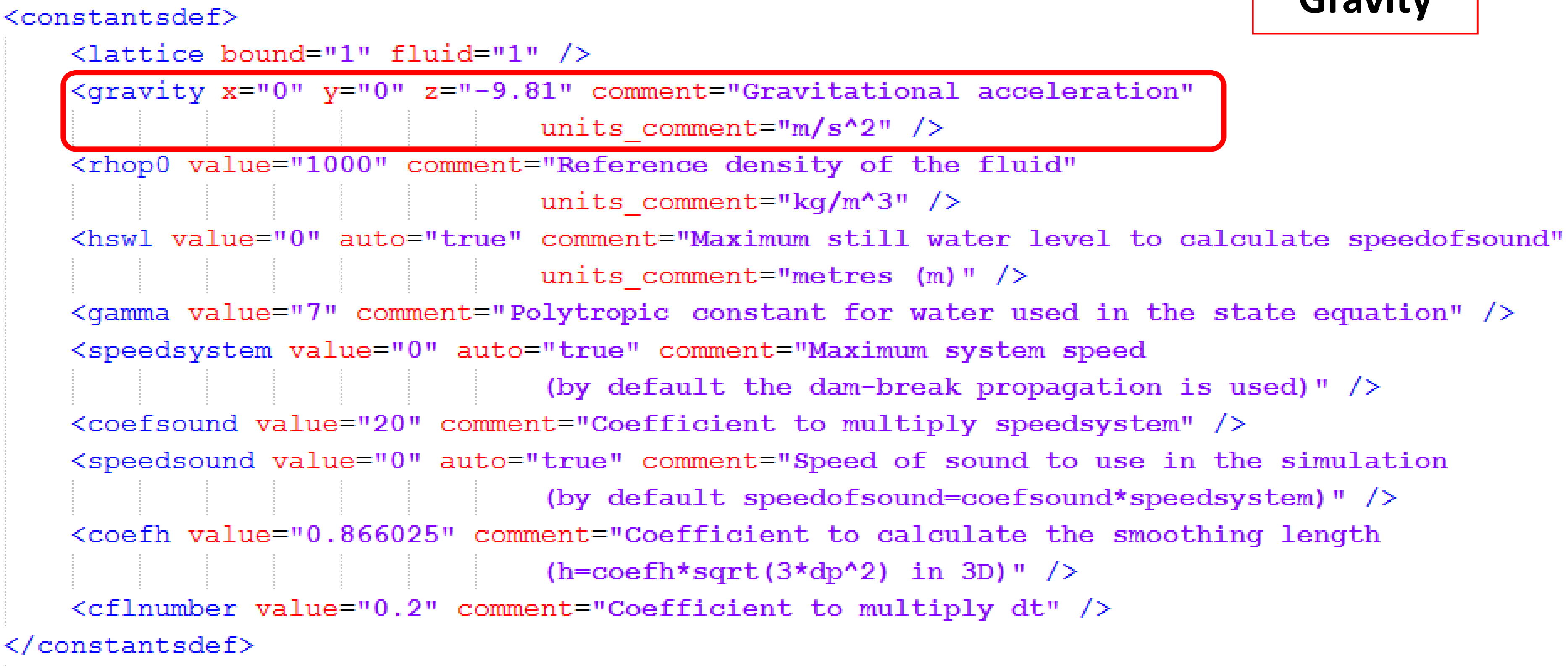
- 1: one particle per point
- 2: two particles per point



XML file

CASEDEF-CONSTANTSDEF

Gravity



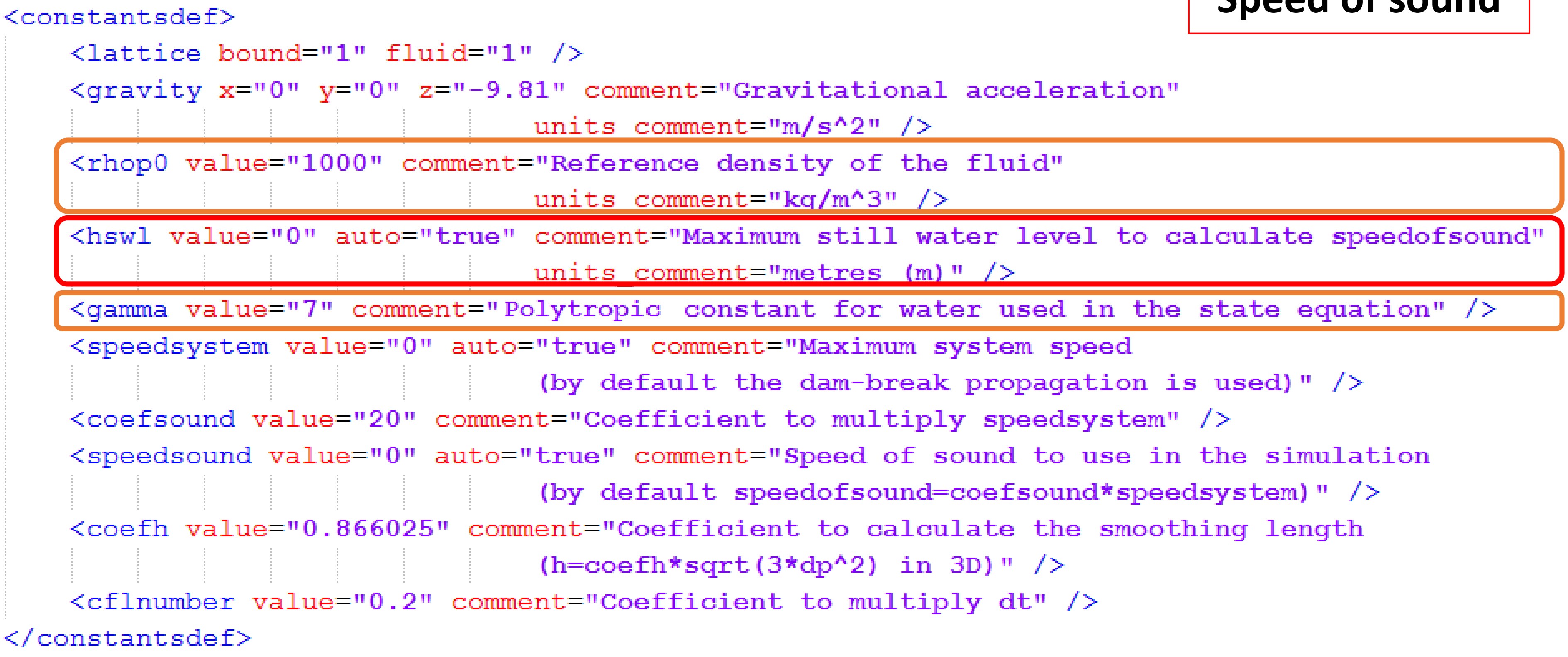
```
<constantsdef>
    <lattice bound="1" fluid="1" />
    <gravity x="0" y="0" z="-9.81" comment="Gravitational acceleration"
                                units_comment="m/s^2" />
    <rhop0 value="1000" comment="Reference density of the fluid"
                                units_comment="kg/m^3" />
    <hswl value="0" auto="true" comment="Maximum still water level to calculate speedofsound"
                                units_comment="metres (m)" />
    <gamma value="7" comment="Polytropic constant for water used in the state equation" />
    <speedsystem value="0" auto="true" comment="Maximum system speed
                                (by default the dam-break propagation is used)" />
    <coefsound value="20" comment="Coefficient to multiply speedsystem" />
    <speedsound value="0" auto="true" comment="Speed of sound to use in the simulation
                                (by default speedofsound=coefsound*speedsystem)" />
    <coefh value="0.866025" comment="Coefficient to calculate the smoothing length
                                (h=coefh*sqrt(3*dp^2) in 3D)" />
    <cflnumber value="0.2" comment="Coefficient to multiply dt" />
</constantsdef>
```

$$\frac{d\mathbf{v}_a}{dt} = -\sum_b m_b\left(\frac{P_b + P_a}{\rho_b \cdot \rho_a} + \Pi_{ab}\right)\nabla_a W_{ab} + \boxed{\mathbf{g}}$$

XML file

CASEDEF-CONSTANTSDEF

Speed of sound



```
<constantsdef>
    <lattice bound="1" fluid="1" />
    <gravity x="0" y="0" z="-9.81" comment="Gravitational acceleration"
                             units comment="m/s^2" />
    <rhop0 value="1000" comment="Reference density of the fluid"
                             units comment="kg/m^3" />
    <hswl value="0" auto="true" comment="Maximum still water level to calculate speedofsound"
                             units comment="metres (m)" />
    <gamma value="7" comment="Polytropic constant for water used in the state equation" />
    <speedsystem value="0" auto="true" comment="Maximum system speed
                              (by default the dam-break propagation is used)" />
    <coefsound value="20" comment="Coefficient to multiply speedsystem" />
    <speedsound value="0" auto="true" comment="Speed of sound to use in the simulation
                              (by default speedofsound=coefsound*speedsystem)" />
    <coefh value="0.866025" comment="Coefficient to calculate the smoothing length
                              (h=coefh*sqrt(3*dp^2) in 3D)" />
    <cflnumber value="0.2" comment="Coefficient to multiply dt" />
</constantsdef>
```

$$speedsystem = \sqrt{g \cdot \boxed{h_{swl}}}$$

$$P = \frac{c_s^2 \boxed{\rho_0}}{\boxed{\gamma}}\left(\left(\frac{\rho}{\boxed{\rho_0}}\right)^{\boxed{\gamma}} - 1\right)$$

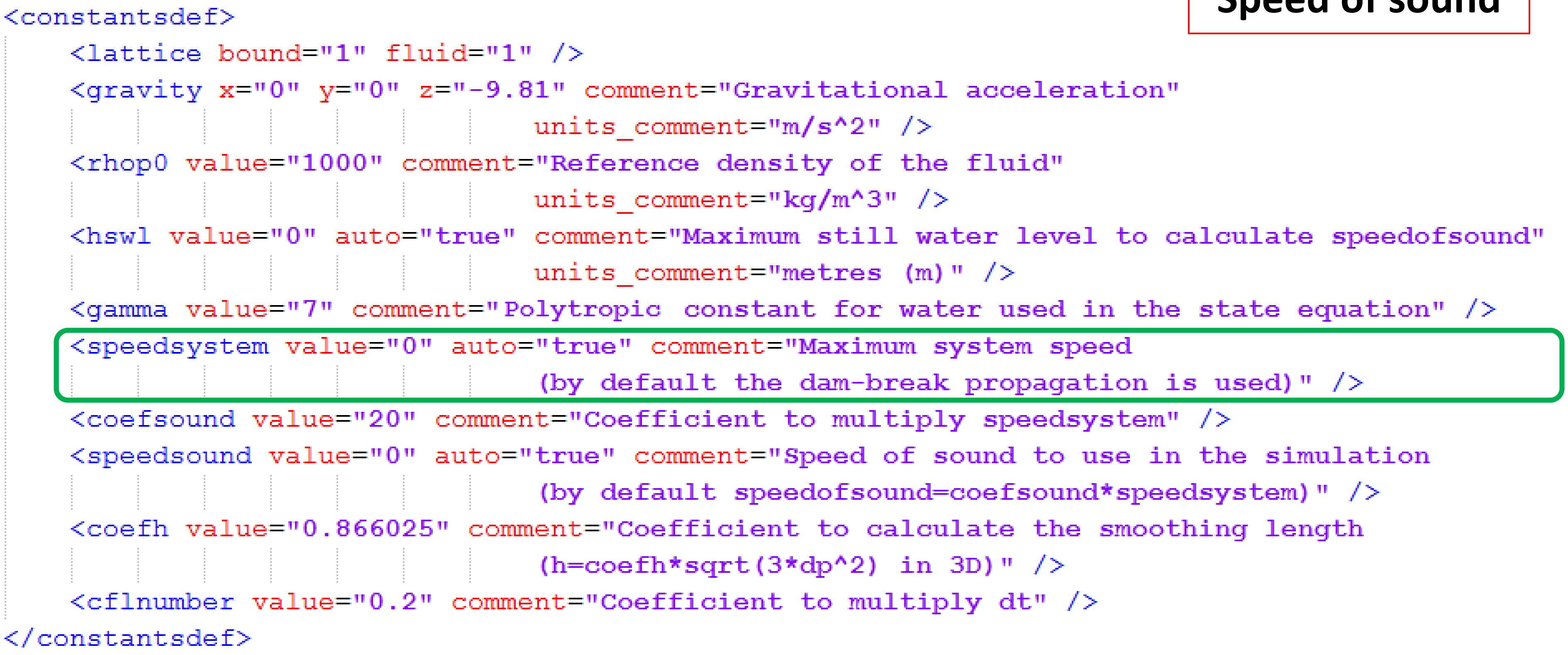
$$c_s = coef_{sound} \cdot \sqrt{g \cdot \boxed{h_{swl}}}$$

$$B = \frac{c_s^2 \cdot \boxed{\rho_0}}{\boxed{\gamma}} = \frac{coef_{sound}{}^2 \cdot g \cdot \boxed{h_{swl}} \cdot \boxed{\rho_0}}{\boxed{\gamma}}$$

XML file

CASEDEF-CONSTANTSDEF

Speed of sound



```
<constantsdef>
    <lattice bound="1" fluid="1" />
    <gravity x="0" y="0" z="-9.81" comment="Gravitational acceleration"
                                units_comment="m/s^2" />
    <rhop0 value="1000" comment="Reference density of the fluid"
                                units_comment="kg/m^3" />
    <hswl value="0" auto="true" comment="Maximum still water level to calculate speedofsound"
                                units_comment="metres (m)" />
    <gamma value="7" comment="Polytropic constant for water used in the state equation" />
    <speedsystem value="0" auto="true" comment="Maximum system speed
                                 (by default the dam-break propagation is used)" />
    <coefsound value="20" comment="Coefficient to multiply speedsystem" />
    <speedsound value="0" auto="true" comment="Speed of sound to use in the simulation
                                 (by default speedofsound=coefsound*speedsystem)" />
    <coefh value="0.866025" comment="Coefficient to calculate the smoothing length
                                 (h=coefh*sqrt(3*dp^2) in 3D)" />
    <cflnumber value="0.2" comment="Coefficient to multiply dt" />
</constantsdef>
```

$$\boxed{speedsystem = \sqrt{g \cdot h_{swl}}}$$

$$P = \frac{c_s^2 \rho_0}{\gamma}\left(\left(\frac{\rho}{\rho_0}\right)^{\gamma} - 1\right)$$

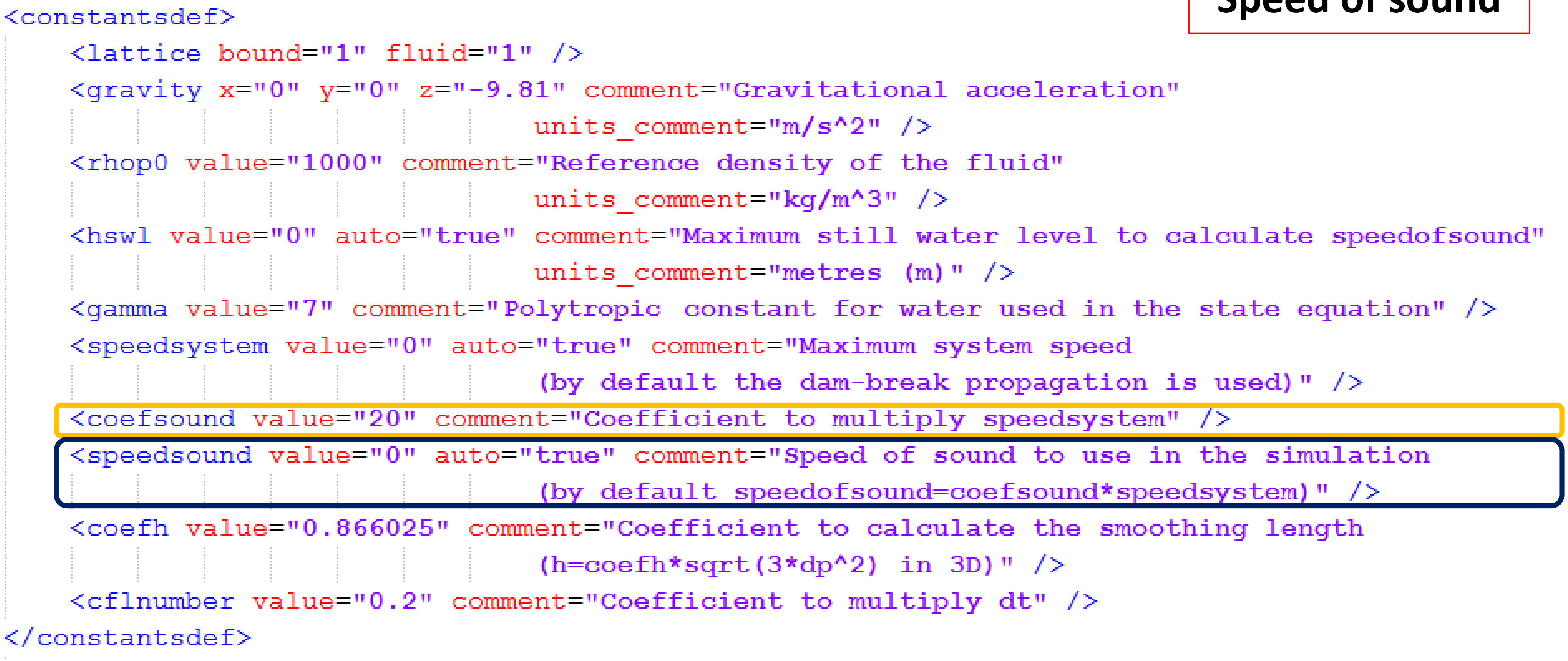
$$c_s = coef_{sound} \cdot \boxed{\sqrt{g \cdot h_{swl}}}$$

$$B = \frac{c_s^2 \cdot \rho_0}{\gamma} = \frac{coef_{sound}{}^2 \cdot g \cdot h_{swl} \cdot \rho_0}{\gamma}$$

XML file

CASEDEF-CONSTANTSDEF

Speed of sound



```xml
<constantsdef>
    <lattice bound="1" fluid="1" />
    <gravity x="0" y="0" z="-9.81" comment="Gravitational acceleration"
                                units_comment="m/s^2" />
    <rhop0 value="1000" comment="Reference density of the fluid"
                                units_comment="kg/m^3" />
    <hswl value="0" auto="true" comment="Maximum still water level to calculate speedofsound"
                                units_comment="metres (m)" />
    <gamma value="7" comment="Polytropic constant for water used in the state equation" />
    <speedsystem value="0" auto="true" comment="Maximum system speed
                                (by default the dam-break propagation is used)" />
    <coefsound value="20" comment="Coefficient to multiply speedsystem" />
    <speedsound value="0" auto="true" comment="Speed of sound to use in the simulation
                                (by default speedofsound=coefsound*speedsystem)" />
    <coefh value="0.866025" comment="Coefficient to calculate the smoothing length
                                (h=coefh*sqrt(3*dp^2) in 3D)" />
    <cflnumber value="0.2" comment="Coefficient to multiply dt" />
</constantsdef>
```

$$speedsystem = \sqrt{g \cdot h_{swl}}$$

$$P = \frac{\boxed{c_s^2}\rho_0}{\gamma}\left(\left(\frac{\rho}{\rho_0}\right)^{\gamma} - 1\right)$$

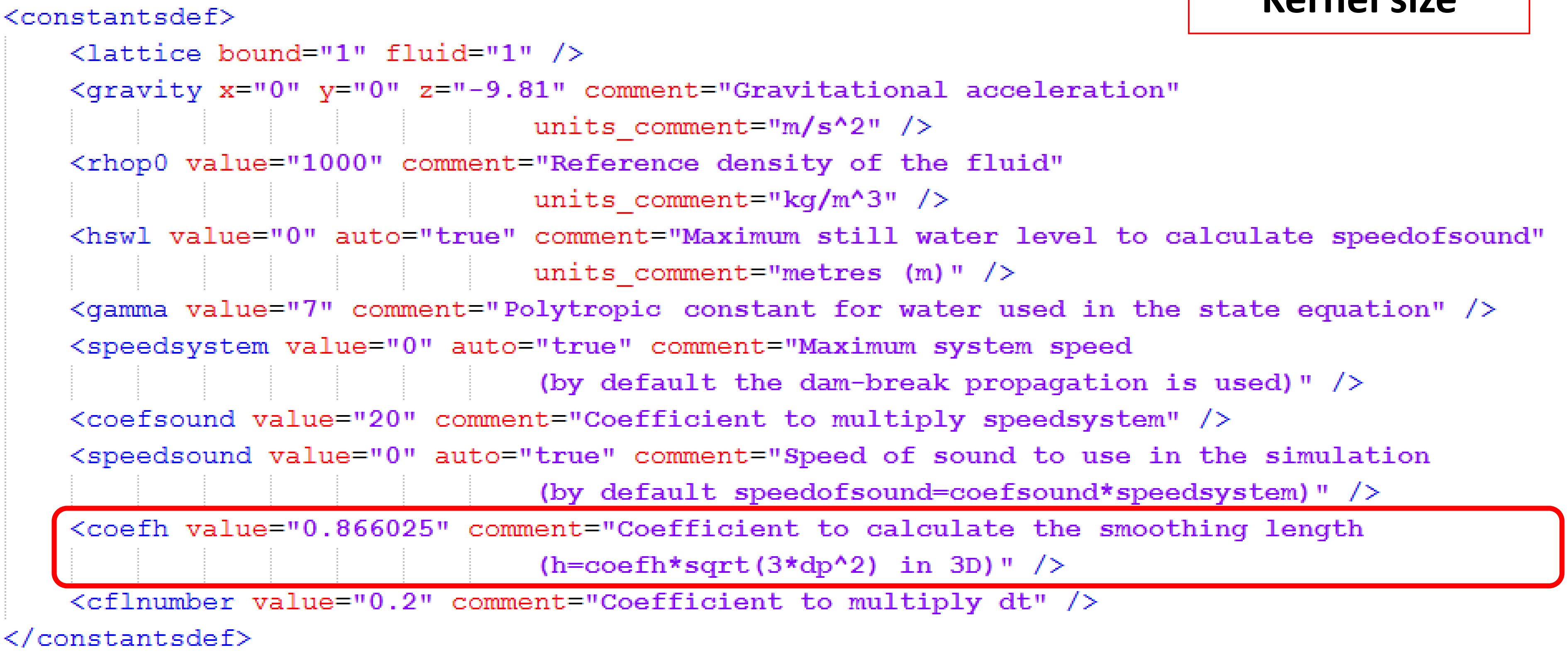
$$\boxed{c_s = \boxed{coef_{sound}} \cdot \sqrt{g \cdot h_{swl}}}$$

$$B = \frac{\boxed{c_s^2} \cdot \rho_0}{\gamma} = \frac{\boxed{coef_{sound}{}^2} \cdot g \cdot h_{swl} \cdot \rho_0}{\gamma}$$

XML file

CASEDEF-CONSTANTSDEF

Kernel size



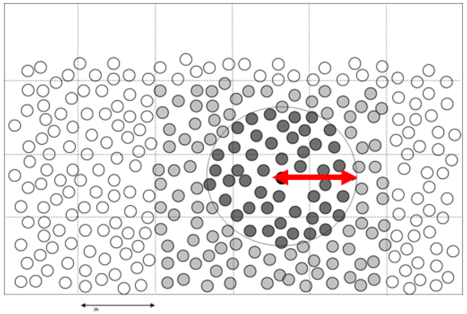
```
<constantsdef>
    <lattice bound="1" fluid="1" />
    <gravity x="0" y="0" z="-9.81" comment="Gravitational acceleration"
                                units_comment="m/s^2" />
    <rhop0 value="1000" comment="Reference density of the fluid"
                                units_comment="kg/m^3" />
    <hswl value="0" auto="true" comment="Maximum still water level to calculate speedofsound"
                                units_comment="metres (m)" />
    <gamma value="7" comment="Polytropic constant for water used in the state equation" />
    <speedsystem value="0" auto="true" comment="Maximum system speed
                                (by default the dam-break propagation is used)" />
    <coefsound value="20" comment="Coefficient to multiply speedsystem" />
    <speedsound value="0" auto="true" comment="Speed of sound to use in the simulation
                                (by default speedofsound=coefsound*speedsystem)" />
    <coefh value="0.866025" comment="Coefficient to calculate the smoothing length
                                (h=coefh*sqrt(3*dp^2) in 3D)" />
    <cflnumber value="0.2" comment="Coefficient to multiply dt" />
</constantsdef>
```

coefh=1	**typical value**
coefh=1.2, 1.5	**better for wave propagation**

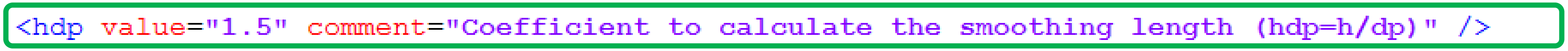
$$h = \boxed{coefh} \cdot \sqrt{dx^2 + dy^2 + dz^2}$$

$$h = \boxed{coefh} \cdot \sqrt{3 \cdot dp^2}$$

$$h = \boxed{coefh} \cdot \sqrt{3} \cdot dp$$



Other option is to define:



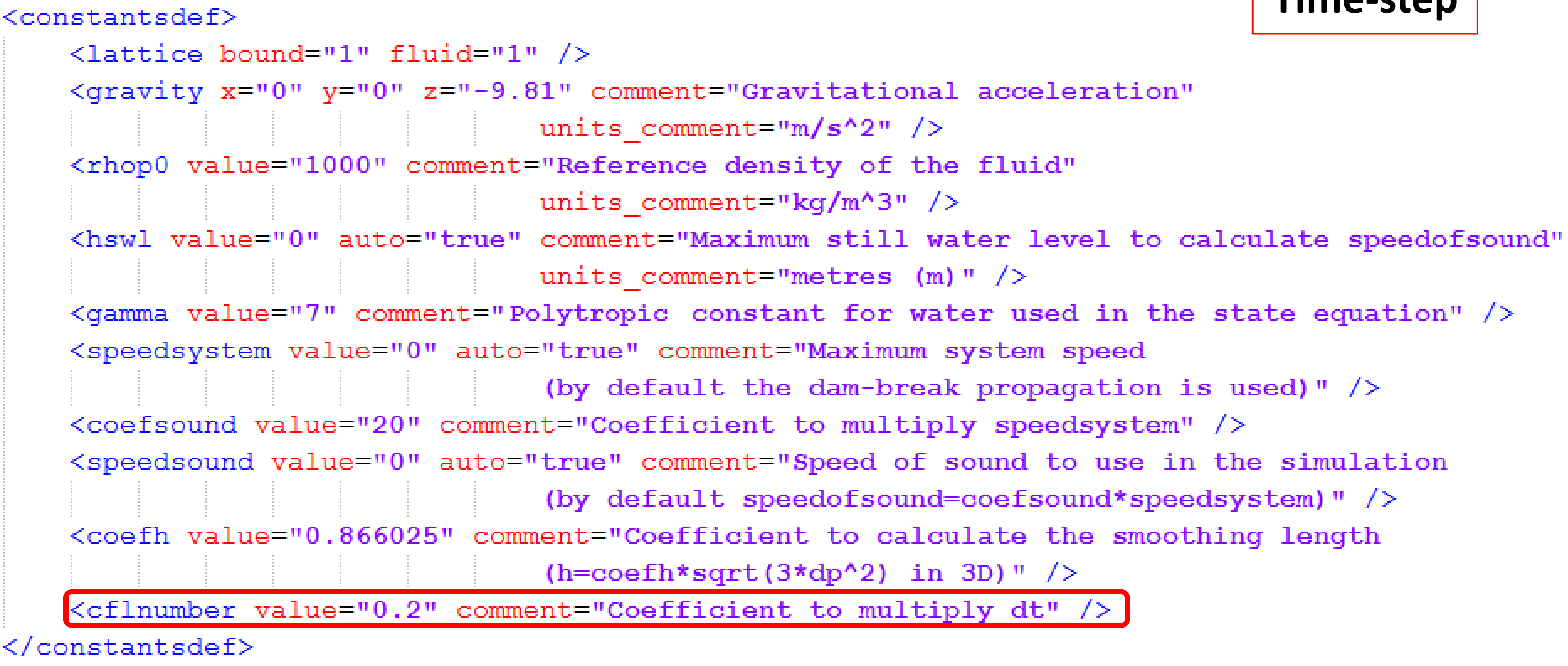
```
<hdp value="1.5" comment="Coefficient to calculate the smoothing length (hdp=h/dp)" />
```

$$\boxed{hdp} = h/dp$$

XML file

CASEDEF-CONSTANTSDEF

Time-step



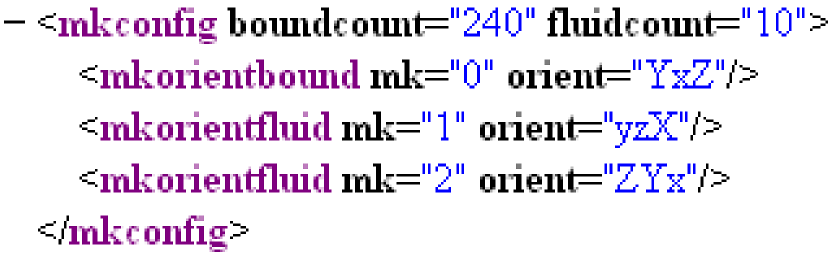
```
<constantsdef>
    <lattice bound="1" fluid="1" />
    <gravity x="0" y="0" z="-9.81" comment="Gravitational acceleration"
                              units_comment="m/s^2" />
    <rhop0 value="1000" comment="Reference density of the fluid"
                              units_comment="kg/m^3" />
    <hswl value="0" auto="true" comment="Maximum still water level to calculate speedofsound"
                              units_comment="metres (m)" />
    <gamma value="7" comment="Polytropic constant for water used in the state equation" />
    <speedsystem value="0" auto="true" comment="Maximum system speed
                              (by default the dam-break propagation is used)" />
    <coefsound value="20" comment="Coefficient to multiply speedsystem" />
    <speedsound value="0" auto="true" comment="Speed of sound to use in the simulation
                              (by default speedofsound=coefsound*speedsystem)" />
    <coefh value="0.866025" comment="Coefficient to calculate the smoothing length
                              (h=coefh*sqrt(3*dp^2) in 3D)" />
    <cflnumber value="0.2" comment="Coefficient to multiply dt" />
</constantsdef>
```

$$\Delta t = \boxed{\mathrm{CFL}} \cdot \min\left(\Delta t_f, \Delta t_{cv}\right)$$

$$\Delta t_f = \min_a\left(\sqrt{h / \left|f_a\right|}\right)$$

$$\Delta t_{cv} = \min_a \frac{h}{c_s + \max_b \left|\dfrac{h\mathbf{v}_{ab} \cdot \mathbf{r}_{ab}}{\mathbf{r}_{ab}^2}\right|}$$

CASEDEF-MKCONFIG



```
- <mkconfig boundcount="240" fluidcount="10">
    <mkorientbound mk="0" orient="YxZ"/>
    <mkorientfluid mk="1" orient="yzX"/>
    <mkorientfluid mk="2" orient="ZYx"/>
  </mkconfig>
```

mk: label used to

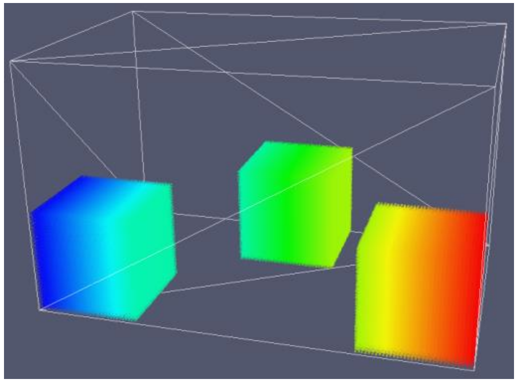
- defines the order objects are created

- applies specific features to the different set of points such as movement, rigid motion…

240 labels for boundary particles and

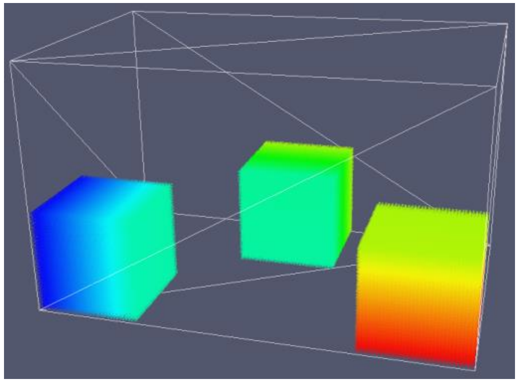
10 labels for fluid particles

mkorientfluid = “xyz”



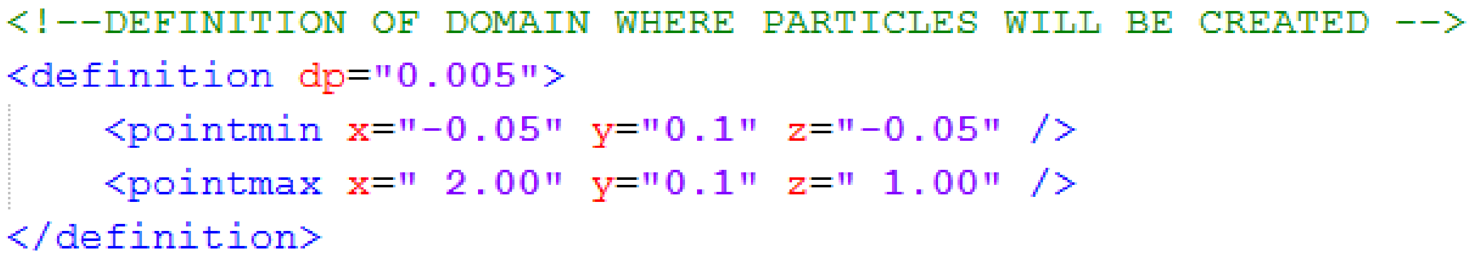
mkorientation: determines the order of particles when creating one object (useful for visualization with the variable *idp*)

mkorientfluid = “xyz”
mkorientfluid = “yzX”
mkorientfluid = “ZYx”



XML file

CASEDEF-GEOMETRY-DEFINITION

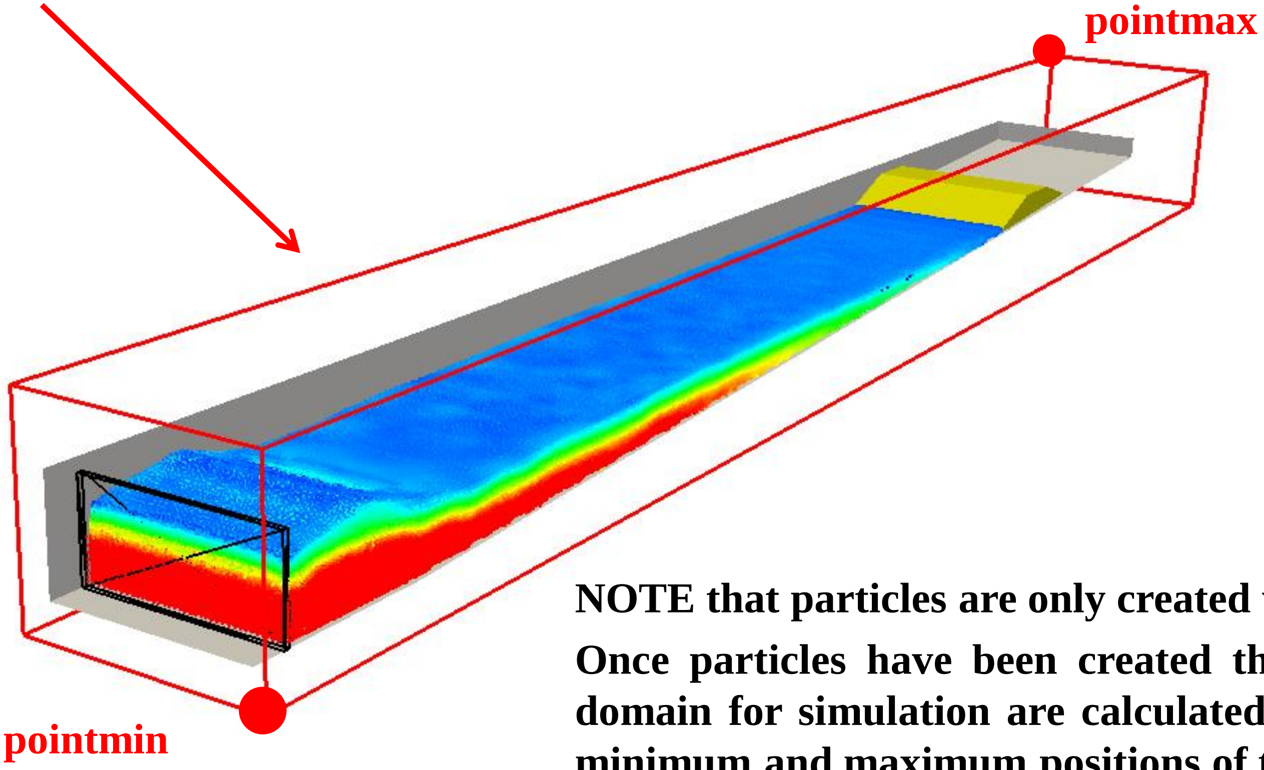


```
<!--DEFINITION OF DOMAIN WHERE PARTICLES WILL BE CREATED -->
<definition dp="0.005">
    <pointmin x="-0.05" y="0.1" z="-0.05" />
    <pointmax x=" 2.00" y="0.1" z=" 1.00" />
</definition>
```

dp defines the distance between particles

WHEN CHANGING THIS PARAMETER, THE TOTAL NUMBER OF PARTICLES IS MODIFIED

pointmin & pointmax defines the dimensions of the domain where particles can be created

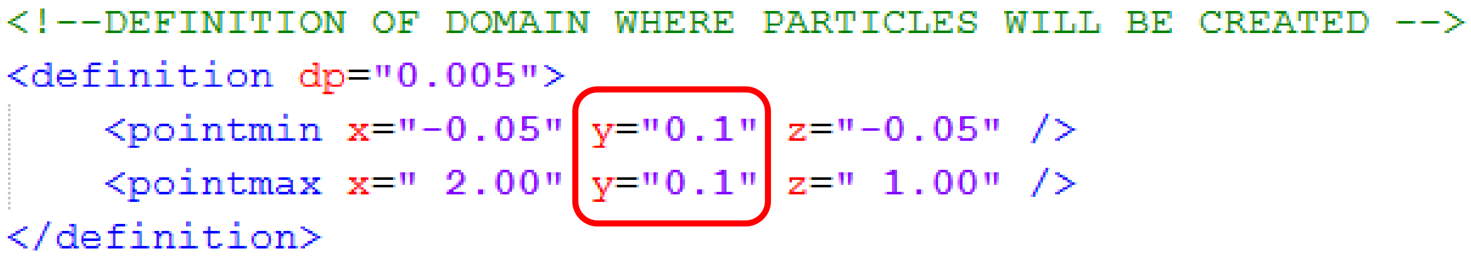


NOTE that particles are only created within this domain.

Once particles have been created the dimensions of the domain for simulation are calculated again starting from minimum and maximum positions of the created particles.

XML file

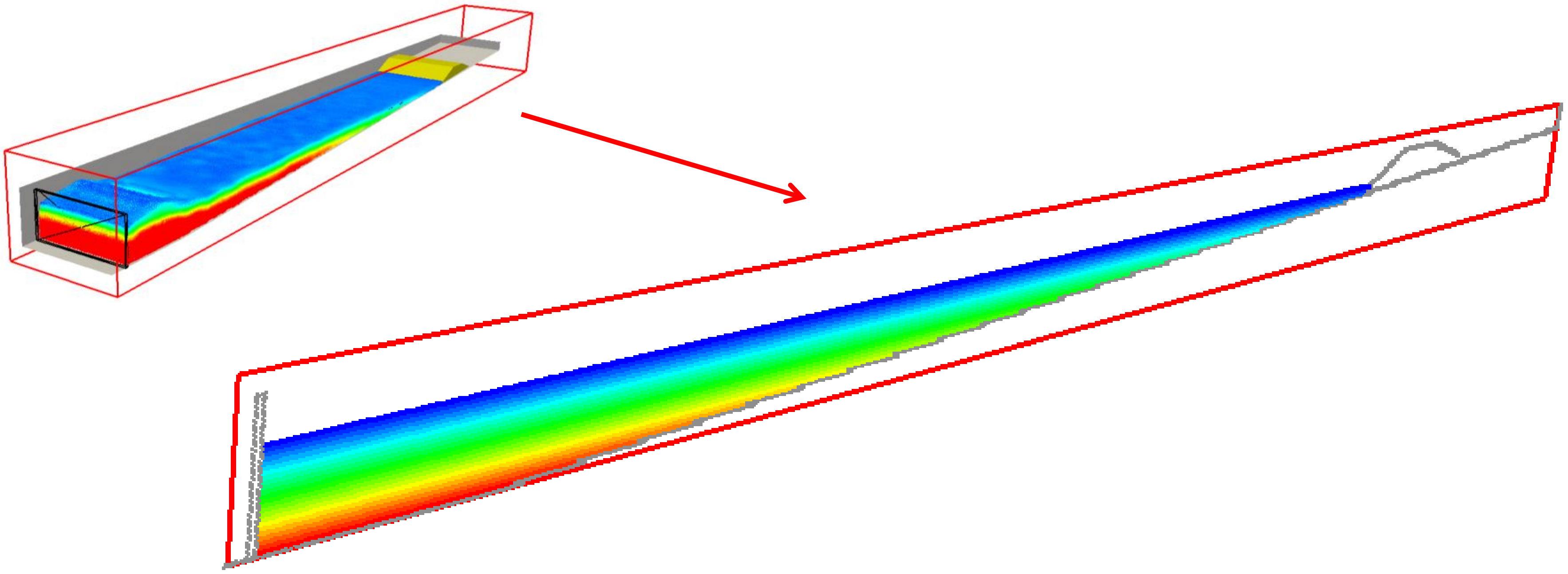
CASEDEF-GEOMETRY-DEFINITION



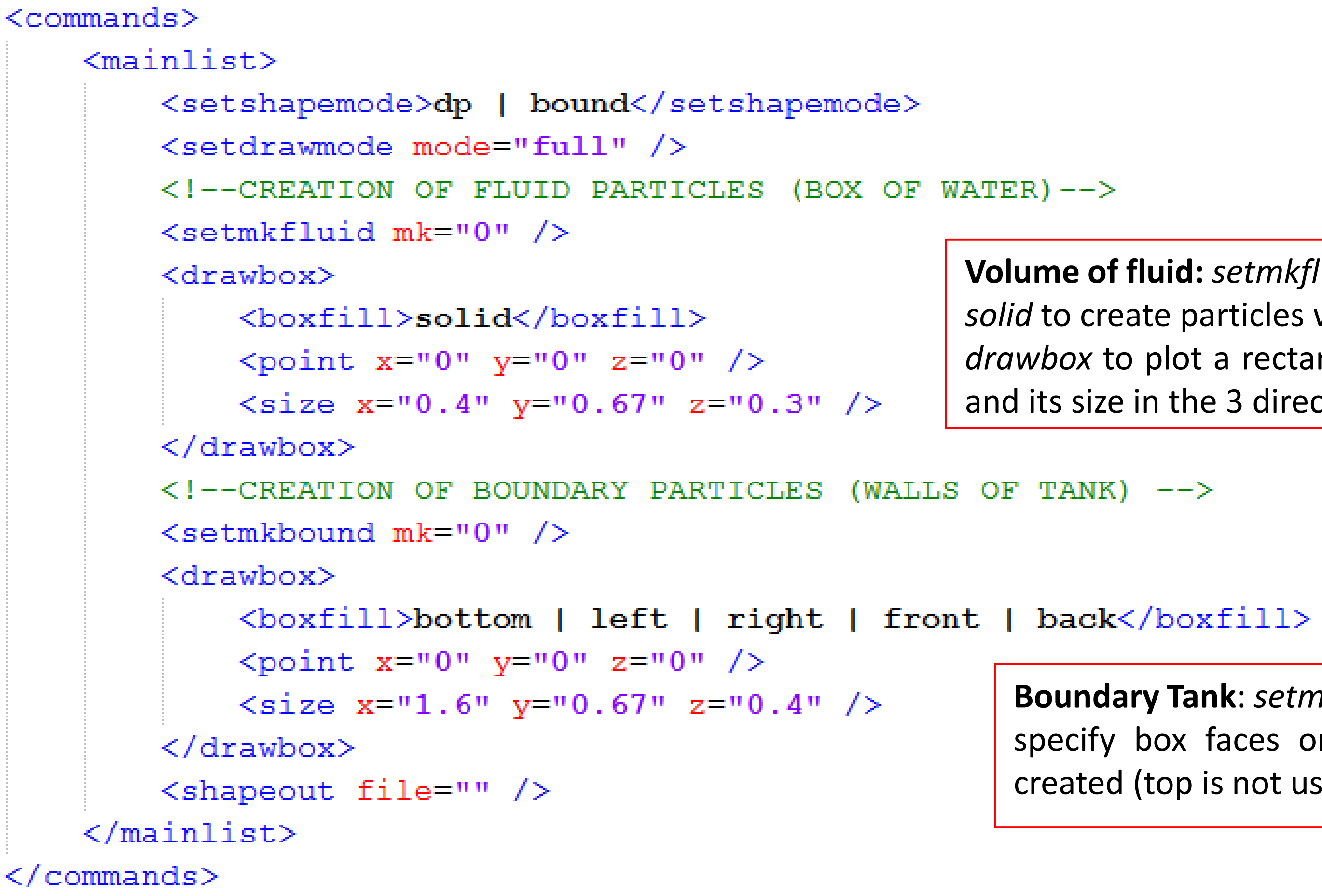
```
<!--DEFINITION OF DOMAIN WHERE PARTICLES WILL BE CREATED -->
<definition dp="0.005">
    <pointmin x="-0.05" y="0.1" z="-0.05" />
    <pointmax x=" 2.00" y="0.1" z=" 1.00" />
</definition>
```

A 2-D configuration can be generated by imposing the same values along Y-direction

<pointmin> = <pointmax>



XML file CASEDEF-GEOMETRY-COMMANDS-MAINLIST



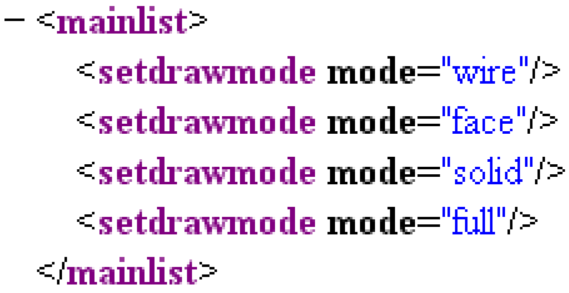
```
<commands>
    <mainlist>
        <setshapemode>dp | bound</setshapemode>
        <setdrawmode mode="full" />
        <!--CREATION OF FLUID PARTICLES (BOX OF WATER)-->
        <setmkfluid mk="0" />
        <drawbox>
            <boxfill>solid</boxfill>
            <point x="0" y="0" z="0" />
            <size x="0.4" y="0.67" z="0.3" />
        </drawbox>
        <!--CREATION OF BOUNDARY PARTICLES (WALLS OF TANK) -->
        <setmkbound mk="0" />
        <drawbox>
            <boxfill>bottom | left | right | front | back</boxfill>
            <point x="0" y="0" z="0" />
            <size x="1.6" y="0.67" z="0.4" />
        </drawbox>
        <shapeout file="" />
    </mainlist>
</commands>
```

Volume of fluid: *setmkfluid* mk=0,
solid to create particles within the specified volume
drawbox to plot a rectangular box defining a corner and its size in the 3 directions

Boundary Tank: *setmkbound* mk=0,
specify box faces on which particles are created (top is not used in this example)

CASEDEF-GEOMETRY-COMMANDS-MAINLIST

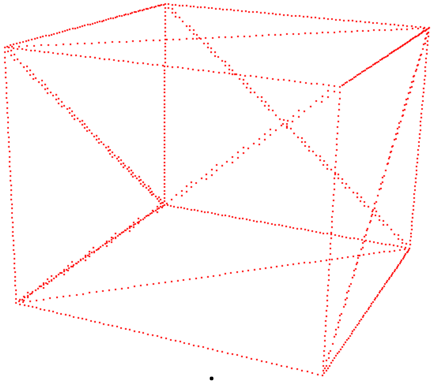
This command indicates the mode to create points where particles will be generated



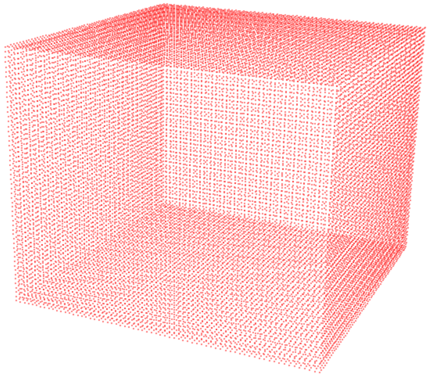
```
− <mainlist>
    <setdrawmode mode="wire"/>
    <setdrawmode mode="face"/>
    <setdrawmode mode="solid"/>
    <setdrawmode mode="full"/>
  </mainlist>
```

<setdrawmode>:

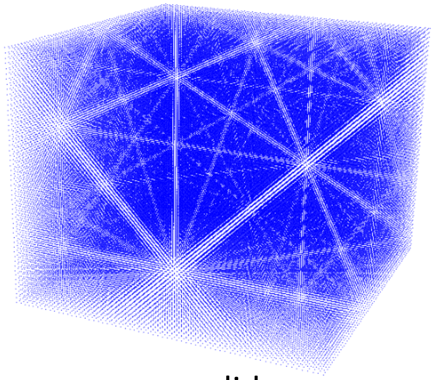
- **"wire"**: wire mode
- **"face"**: draw faces
- **"solid"**: draw inside
- **"full"**: combines *face* and *solid*



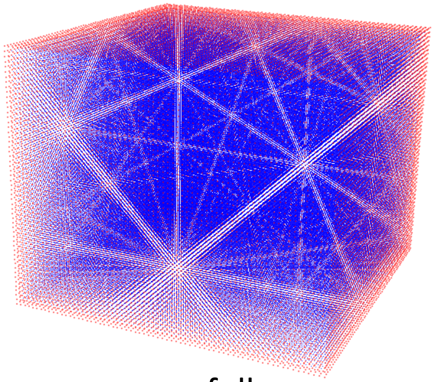
wire



face

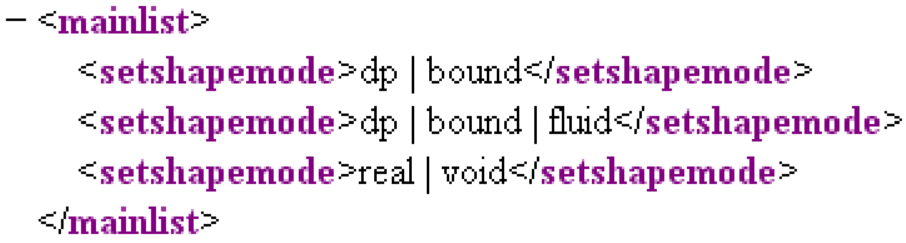


solid



full

CASEDEF-GEOMETRY-COMMANDS-MAINLIST



```
– <mainlist>
      <setshapemode>dp | bound</setshapemode>
      <setshapemode>dp | bound | fluid</setshapemode>
      <setshapemode>real | void</setshapemode>
  </mainlist>
```

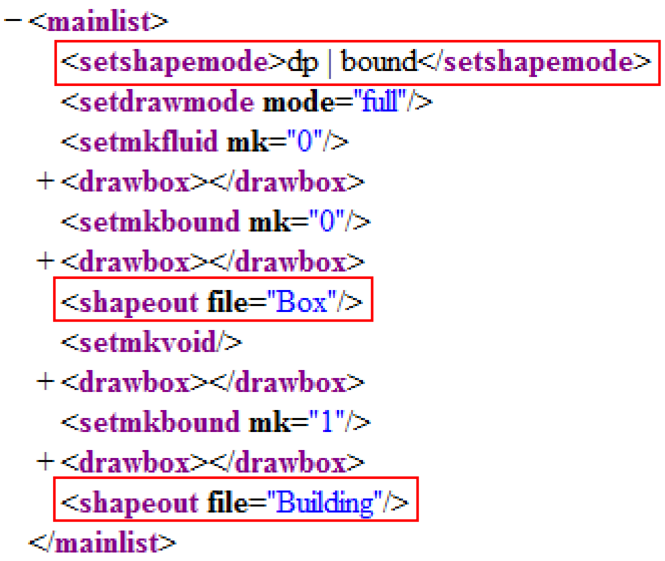
<setshapemode>: defines the draw operations to create VTK files (polygons)

- “**real**”: using the real coordinates
- “**dp**”: adjusting coordinates to *dp*

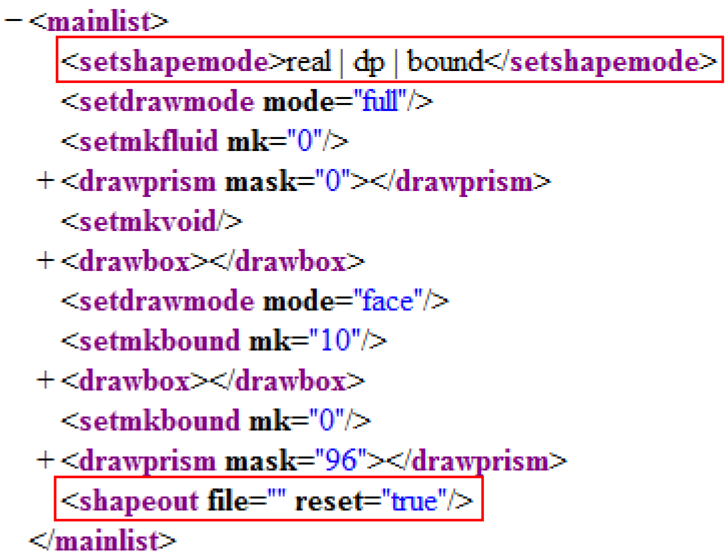
- “**fluid**”: operations with *mk-fluid*
- “**bound**”: operations with *mk-bound*
- “**void**”: operations with *mk-void*

CASEDEF-GEOMETRY-COMMANDS-MAINLIST

<setshapemode>: defines the draw operations to create a VTK files (polygons)



```
- <mainlist>
    <setshapemode>dp | bound</setshapemode>
    <setdrawmode mode="full"/>
    <setmkfluid mk="0"/>
  + <drawbox></drawbox>
    <setmkbound mk="0"/>
  + <drawbox></drawbox>
    <shapeout file="Box"/>
    <setmkvoid/>
  + <drawbox></drawbox>
    <setmkbound mk="1"/>
  + <drawbox></drawbox>
    <shapeout file="Building"/>
  </mainlist>
```



```
- <mainlist>
    <setshapemode>real | dp | bound</setshapemode>
    <setdrawmode mode="full"/>
    <setmkfluid mk="0"/>
  + <drawprism mask="0"></drawprism>
    <setmkvoid/>
  + <drawbox></drawbox>
    <setdrawmode mode="face"/>
    <setmkbound mk="10"/>
  + <drawbox></drawbox>
    <setmkbound mk="0"/>
  + <drawprism mask="96"></drawprism>
    <shapeout file="" reset="true"/>
  </mainlist>
```

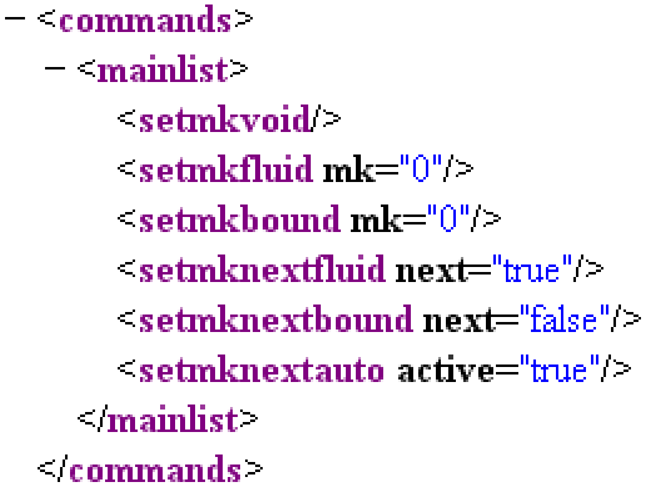
shapeout: creates VTK files (polygons)
of only some *bound* objects
Case_Box_Dp.vtk
Case_Building_Dp.vtk

shapeout: creates VTK files (polygons)
of all the *bound* objects
Case__Real.vtk
Case__Dp.vtk

reset="true" objects created after this command will be saved on a different VTK file

CASEDEF-GEOMETRY-COMMANDS-MAINLIST

These commands indicate the type of particles to be generated



```
- <commands>
  - <mainlist>
      <setmkvoid/>
      <setmkfluid mk="0"/>
      <setmkbound mk="0"/>
      <setmknextfluid next="true"/>
      <setmknextbound next="false"/>
      <setmknextauto active="true"/>
    </mainlist>
  </commands>
```

<setmkvoid>, **<setmkfluid>**, **<setmkbound>**: defines the label *mk* to draw points of type:

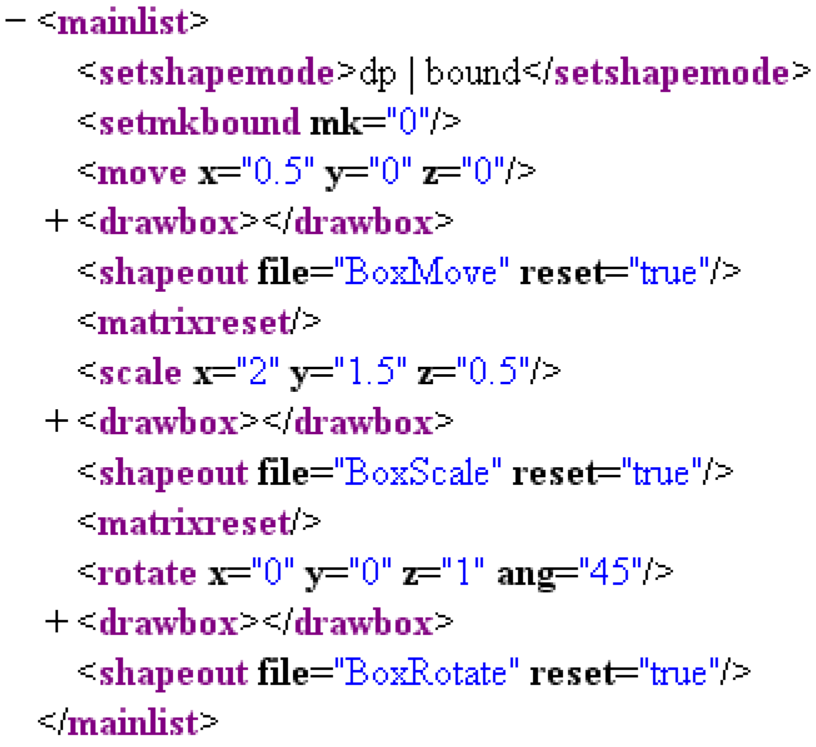
void (empty), fluid, bound

<setmknextfluid>, **<setmknextbound>**: increases (decreases) the value of *mk* with next=*true* (=*false*)

<setmknextauto>: after each draw command *mk* is increased automatically

CASEDEF-GEOMETRY-COMMANDS-MAINLIST

Transformation utilities



```
- <mainlist>
    <setshapemode>dp | bound</setshapemode>
    <setmkbound mk="0"/>
    <move x="0.5" y="0" z="0"/>
  + <drawbox></drawbox>
    <shapeout file="BoxMove" reset="true"/>
    <matrixreset/>
    <scale x="2" y="1.5" z="0.5"/>
  + <drawbox></drawbox>
    <shapeout file="BoxScale" reset="true"/>
    <matrixreset/>
    <rotate x="0" y="0" z="1" ang="45"/>
  + <drawbox></drawbox>
    <shapeout file="BoxRotate" reset="true"/>
  </mainlist>
```

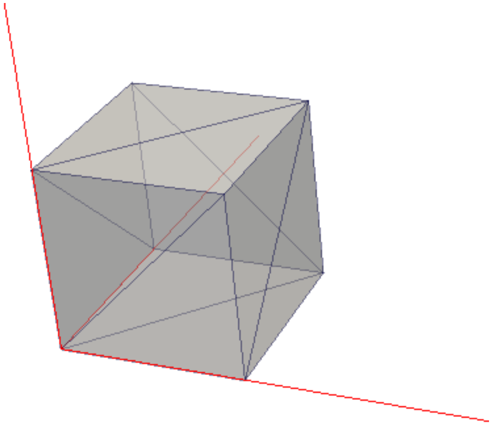
<move>: a displacement is applied to the transformation matrix

<scale>: scaling is applied to matrix

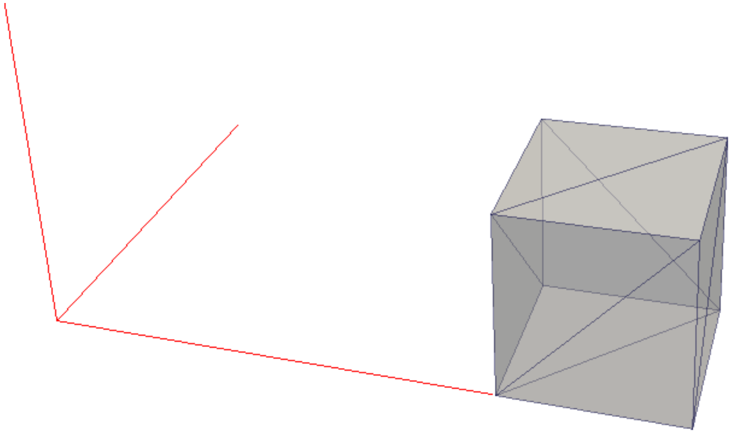
<rotate>:a starting vector and angle are given for object rotation

<matrixreset>: the modified matrix is replaced by the original one (identity matrix)

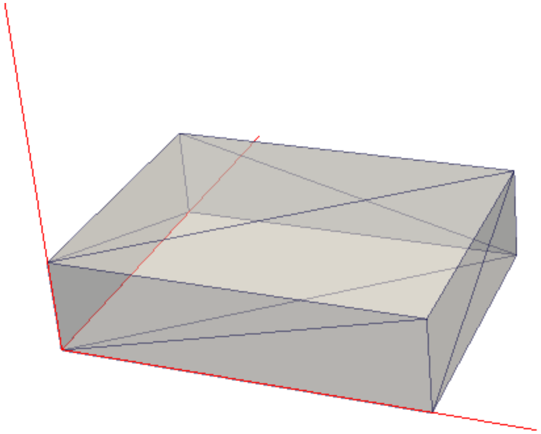
CASEDEF-GEOMETRY-COMMANDS-MAINLIST



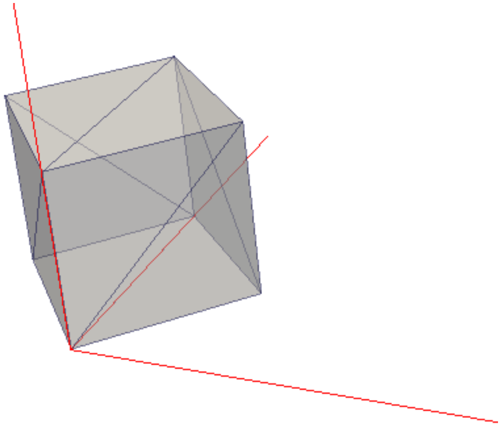
```
<drawbox …>
```



```
<move x="0.5" y="0" z="0"/>
 <drawbox …>
```

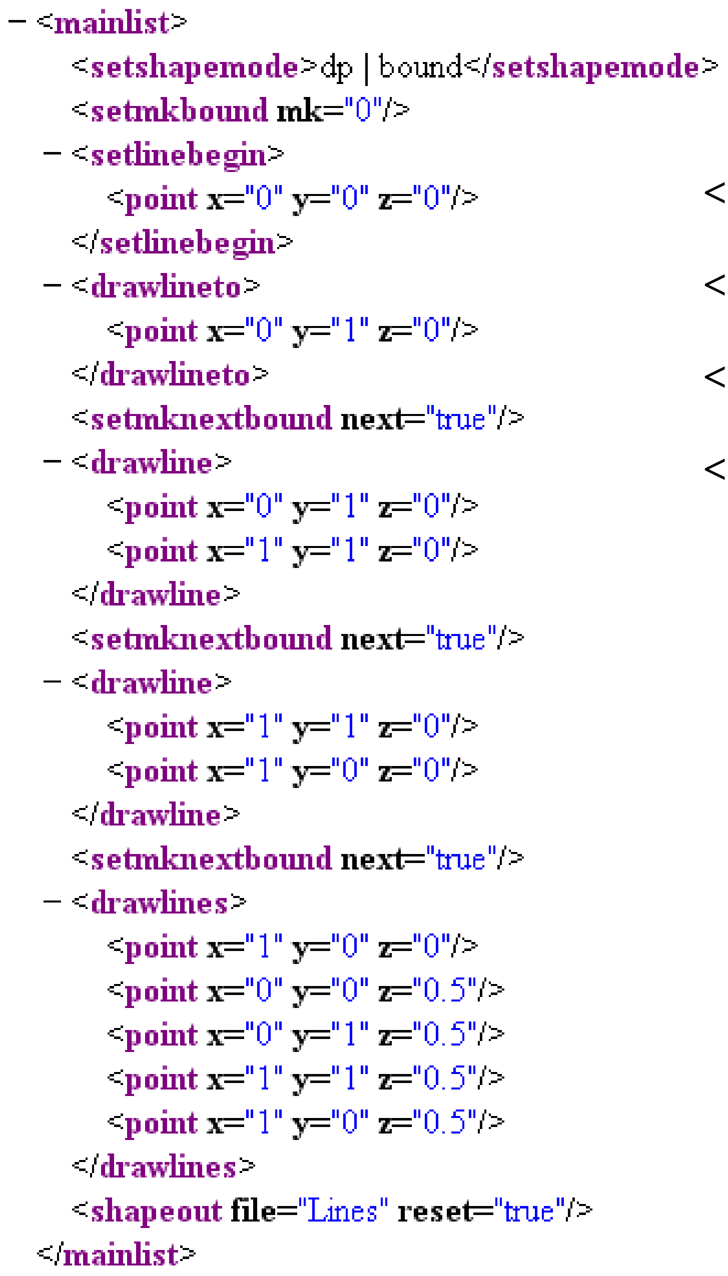


```
<scale x="2" y="1.5" z="0.5"/>
<drawbox …>
```



```
<rotate x="0" y="0" z="1" ang="45"/>
<drawbox …>
```

CASEDEF-GEOMETRY-COMMANDS-MAINLIST



```
- <mainlist>
    <setshapemode>dp | bound</setshapemode>
    <setmkbound mk="0"/>
  - <setlinebegin>
      <point x="0" y="0" z="0"/>
    </setlinebegin>
  - <drawlineto>
      <point x="0" y="1" z="0"/>
    </drawlineto>
    <setmknextbound next="true"/>
  - <drawline>
      <point x="0" y="1" z="0"/>
      <point x="1" y="1" z="0"/>
    </drawline>
    <setmknextbound next="true"/>
  - <drawline>
      <point x="1" y="1" z="0"/>
      <point x="1" y="0" z="0"/>
    </drawline>
    <setmknextbound next="true"/>
  - <drawlines>
      <point x="1" y="0" z="0"/>
      <point x="0" y="0" z="0.5"/>
      <point x="0" y="1" z="0.5"/>
      <point x="1" y="1" z="0.5"/>
      <point x="1" y="0" z="0.5"/>
    </drawlines>
    <shapeout file="Lines" reset="true"/>
  </mainlist>
```

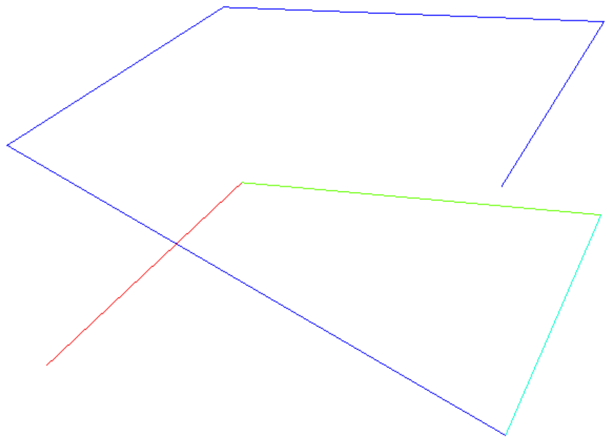
LINES

<setlinebegin>: sets the begining of the line with <drawlineto>

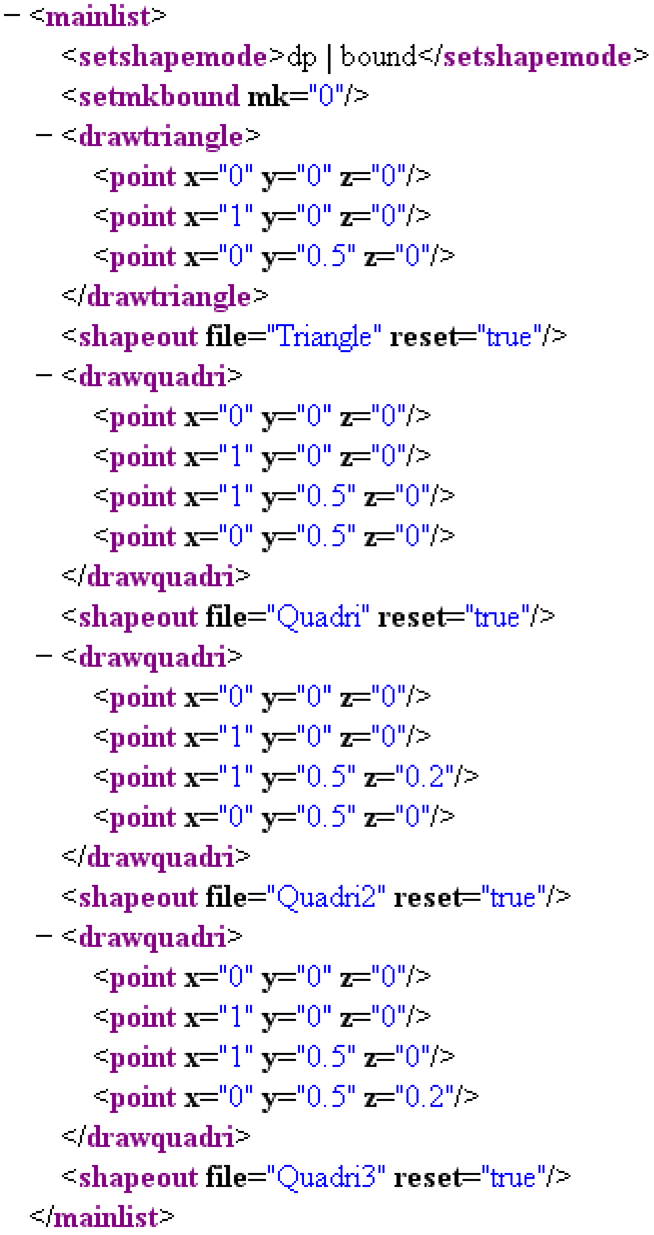
<drawlineto>: draws a line to a given point

<drawline>: draws a line between two points

<drawlines>: draws lines between several points



CASEDEF-GEOMETRY-COMMANDS-MAINLIST

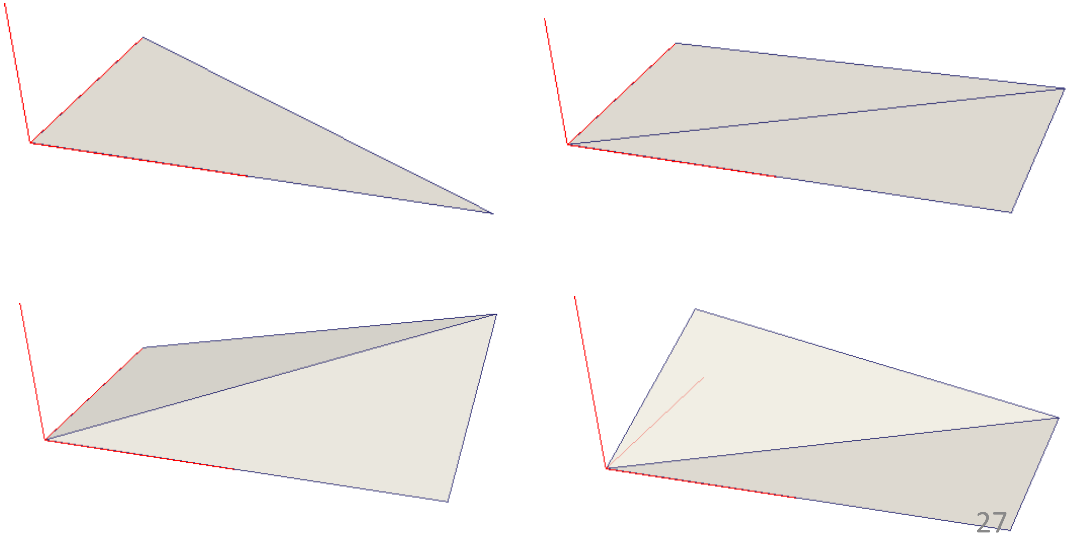


```
- <mainlist>
    <setshapemode>dp | bound</setshapemode>
    <setmkbound mk="0"/>
  - <drawtriangle>
      <point x="0" y="0" z="0"/>
      <point x="1" y="0" z="0"/>
      <point x="0" y="0.5" z="0"/>
    </drawtriangle>
    <shapeout file="Triangle" reset="true"/>
  - <drawquadri>
      <point x="0" y="0" z="0"/>
      <point x="1" y="0" z="0"/>
      <point x="1" y="0.5" z="0"/>
      <point x="0" y="0.5" z="0"/>
    </drawquadri>
    <shapeout file="Quadri" reset="true"/>
  - <drawquadri>
      <point x="0" y="0" z="0"/>
      <point x="1" y="0" z="0"/>
      <point x="1" y="0.5" z="0.2"/>
      <point x="0" y="0.5" z="0"/>
    </drawquadri>
    <shapeout file="Quadri2" reset="true"/>
  - <drawquadri>
      <point x="0" y="0" z="0"/>
      <point x="1" y="0" z="0"/>
      <point x="1" y="0.5" z="0"/>
      <point x="0" y="0.5" z="0.2"/>
    </drawquadri>
    <shapeout file="Quadri3" reset="true"/>
  </mainlist>
```

TRIANGLES

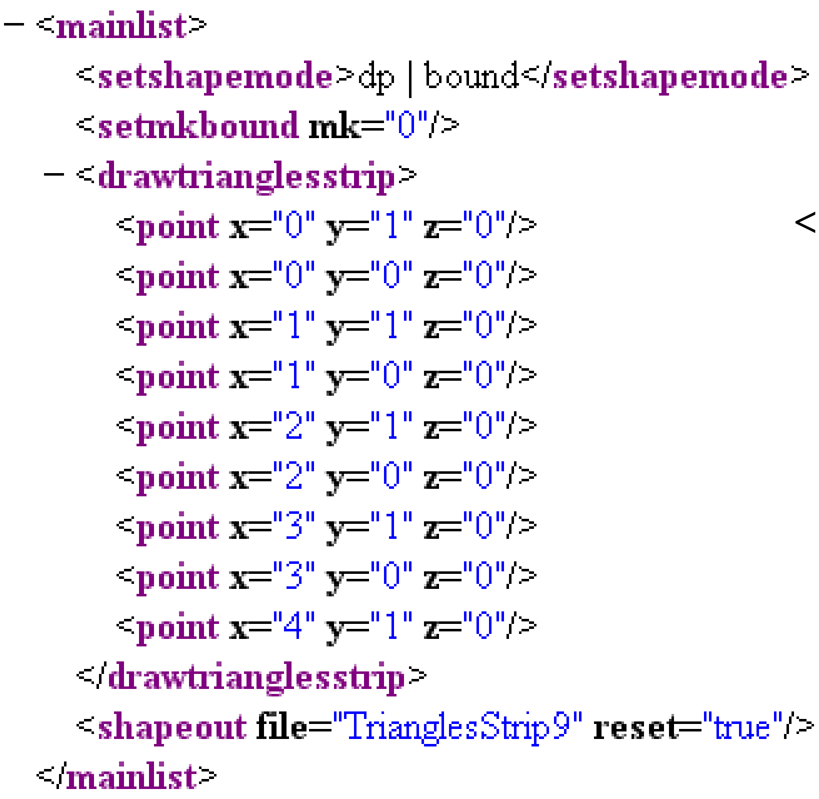
<drawtriangle>: draws a triangle with tree points (points must always go counterclockwise)

<drawquadri>: draws the quadrilateral described by four points (points may not be in the same plane)



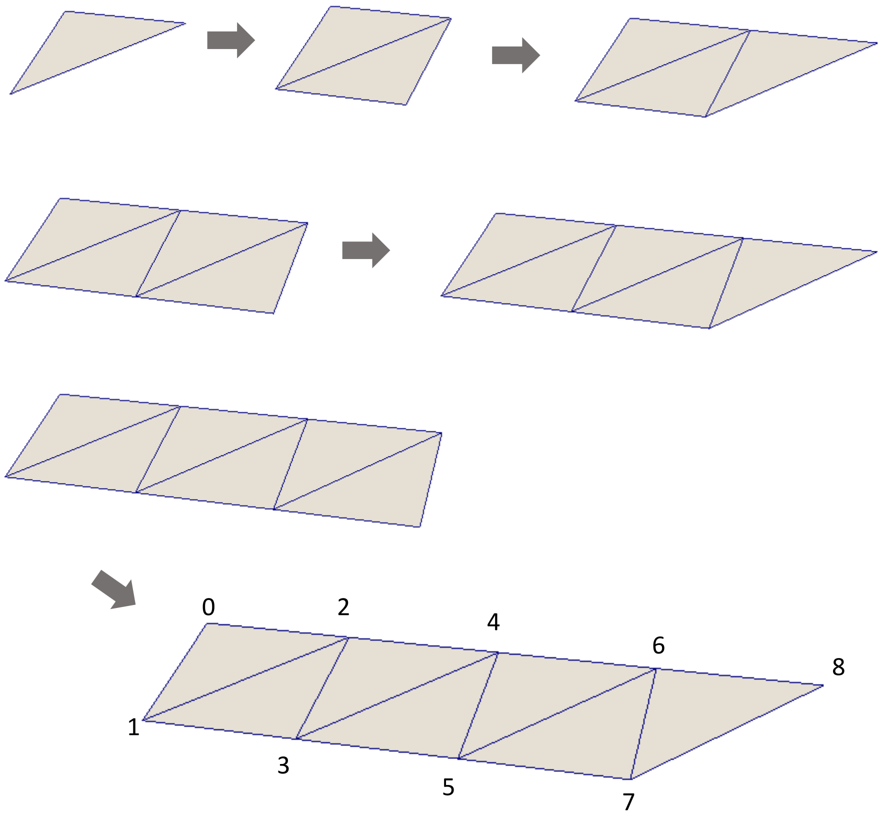
CASEDEF-GEOMETRY-COMMANDS-MAINLIST

TRIANGLES

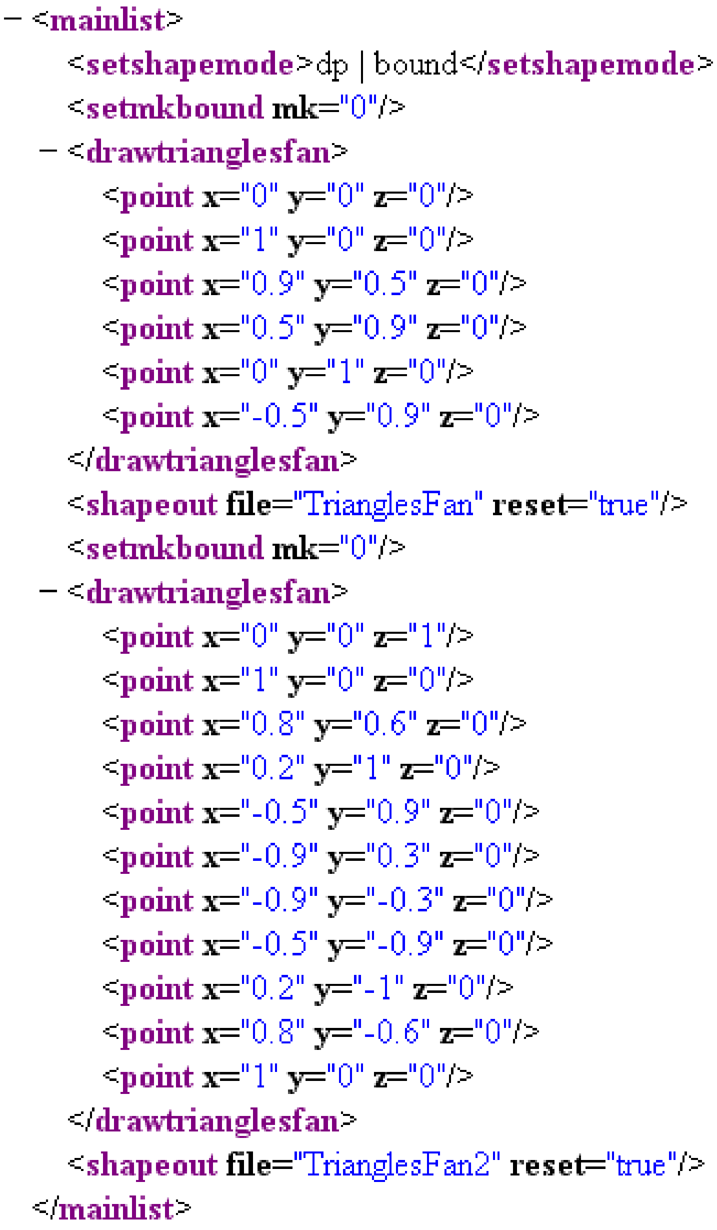


```
− <mainlist>
    <setshapemode>dp | bound</setshapemode>
    <setmkbound mk="0"/>
  − <drawtrianglesstrip>
      <point x="0" y="1" z="0"/>
      <point x="0" y="0" z="0"/>
      <point x="1" y="1" z="0"/>
      <point x="1" y="0" z="0"/>
      <point x="2" y="1" z="0"/>
      <point x="2" y="0" z="0"/>
      <point x="3" y="1" z="0"/>
      <point x="3" y="0" z="0"/>
      <point x="4" y="1" z="0"/>
    </drawtrianglesstrip>
    <shapeout file="TrianglesStrip9" reset="true"/>
  </mainlist>
```

<drawtrianglesstrip>: draws a series of chained triangles



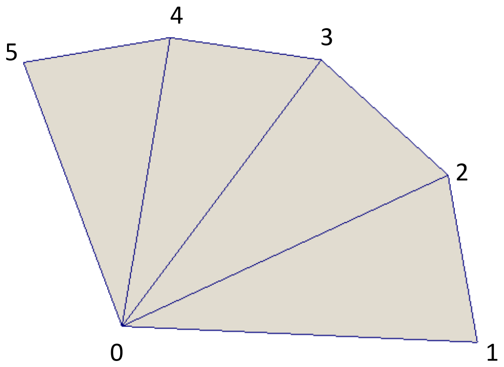
CASEDEF-GEOMETRY-COMMANDS-MAINLIST

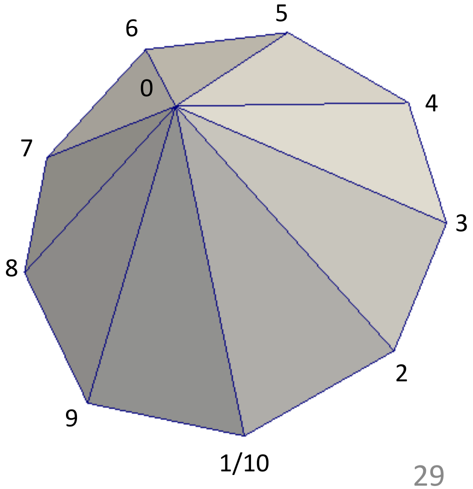


```
− <mainlist>
    <setshapemode>dp | bound</setshapemode>
    <setmkbound mk="0"/>
  − <drawtrianglesfan>
      <point x="0" y="0" z="0"/>
      <point x="1" y="0" z="0"/>
      <point x="0.9" y="0.5" z="0"/>
      <point x="0.5" y="0.9" z="0"/>
      <point x="0" y="1" z="0"/>
      <point x="-0.5" y="0.9" z="0"/>
    </drawtrianglesfan>
    <shapeout file="TrianglesFan" reset="true"/>
    <setmkbound mk="0"/>
  − <drawtrianglesfan>
      <point x="0" y="0" z="1"/>
      <point x="1" y="0" z="0"/>
      <point x="0.8" y="0.6" z="0"/>
      <point x="0.2" y="1" z="0"/>
      <point x="-0.5" y="0.9" z="0"/>
      <point x="-0.9" y="0.3" z="0"/>
      <point x="-0.9" y="-0.3" z="0"/>
      <point x="-0.5" y="-0.9" z="0"/>
      <point x="0.2" y="-1" z="0"/>
      <point x="0.8" y="-0.6" z="0"/>
      <point x="1" y="0" z="0"/>
    </drawtrianglesfan>
    <shapeout file="TrianglesFan2" reset="true"/>
  </mainlist>
```

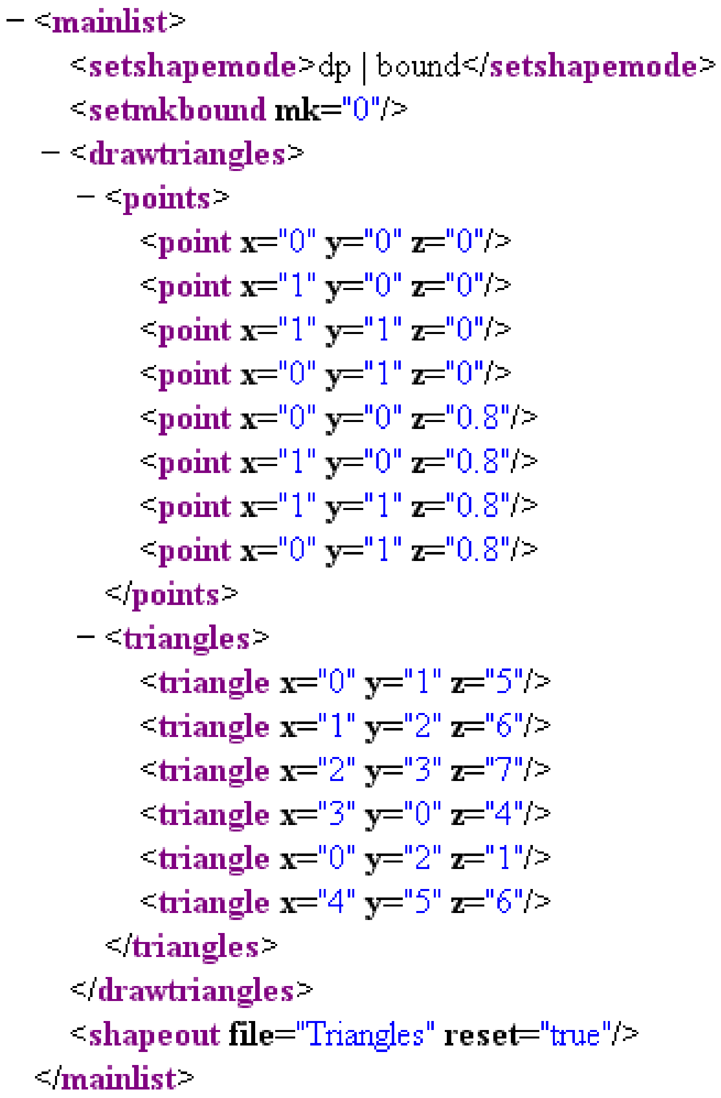
TRIANGLES

<drawtrianglesfan>: draws a range of triangles





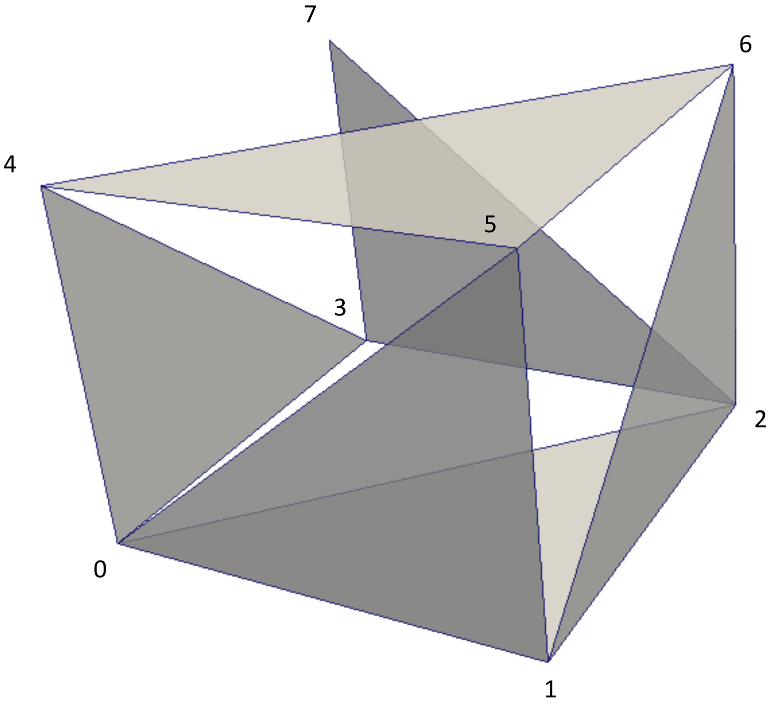
CASEDEF-GEOMETRY-COMMANDS-MAINLIST



```
− <mainlist>
    <setshapemode>dp | bound</setshapemode>
    <setmkbound mk="0"/>
  − <drawtriangles>
    − <points>
        <point x="0" y="0" z="0"/>
        <point x="1" y="0" z="0"/>
        <point x="1" y="1" z="0"/>
        <point x="0" y="1" z="0"/>
        <point x="0" y="0" z="0.8"/>
        <point x="1" y="0" z="0.8"/>
        <point x="1" y="1" z="0.8"/>
        <point x="0" y="1" z="0.8"/>
      </points>
    − <triangles>
        <triangle x="0" y="1" z="5"/>
        <triangle x="1" y="2" z="6"/>
        <triangle x="2" y="3" z="7"/>
        <triangle x="3" y="0" z="4"/>
        <triangle x="0" y="2" z="1"/>
        <triangle x="4" y="5" z="6"/>
      </triangles>
    </drawtriangles>
    <shapeout file="Triangles" reset="true"/>
 </mainlist>
```

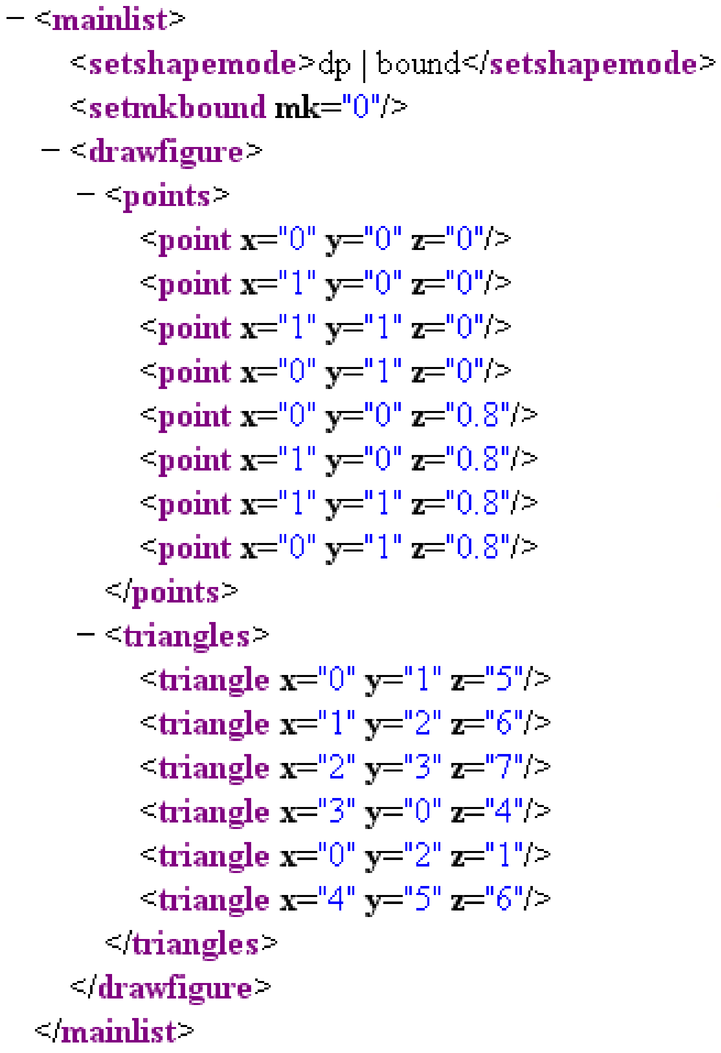
TRIANGLES

<drawtriangles>: draws a series of triangles defined by a set of points or a set of triangles



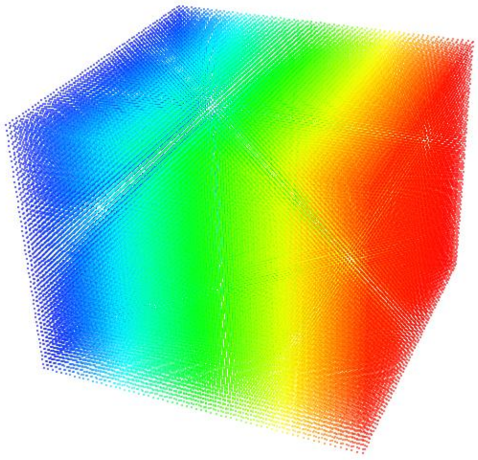
CASEDEF-GEOMETRY-COMMANDS-MAINLIST

FIGURE

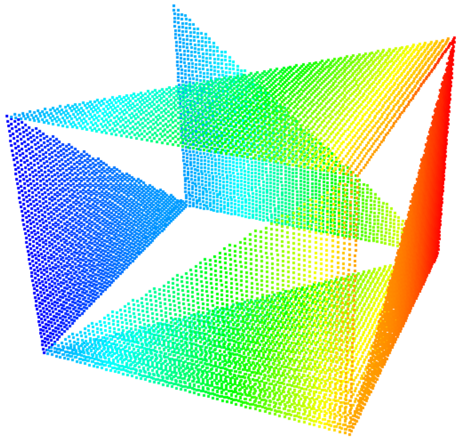


```
- <mainlist>
    <setshapemode>dp | bound</setshapemode>
    <setmkbound mk="0"/>
  - <drawfigure>
    - <points>
        <point x="0" y="0" z="0"/>
        <point x="1" y="0" z="0"/>
        <point x="1" y="1" z="0"/>
        <point x="0" y="1" z="0"/>
        <point x="0" y="0" z="0.8"/>
        <point x="1" y="0" z="0.8"/>
        <point x="1" y="1" z="0.8"/>
        <point x="0" y="1" z="0.8"/>
      </points>
    - <triangles>
        <triangle x="0" y="1" z="5"/>
        <triangle x="1" y="2" z="6"/>
        <triangle x="2" y="3" z="7"/>
        <triangle x="3" y="0" z="4"/>
        <triangle x="0" y="2" z="1"/>
        <triangle x="4" y="5" z="6"/>
      </triangles>
    </drawfigure>
  </mainlist>
```

<drawfigure>: draws a solid figure consisting of all the interior points to the planes formed by the given triangles

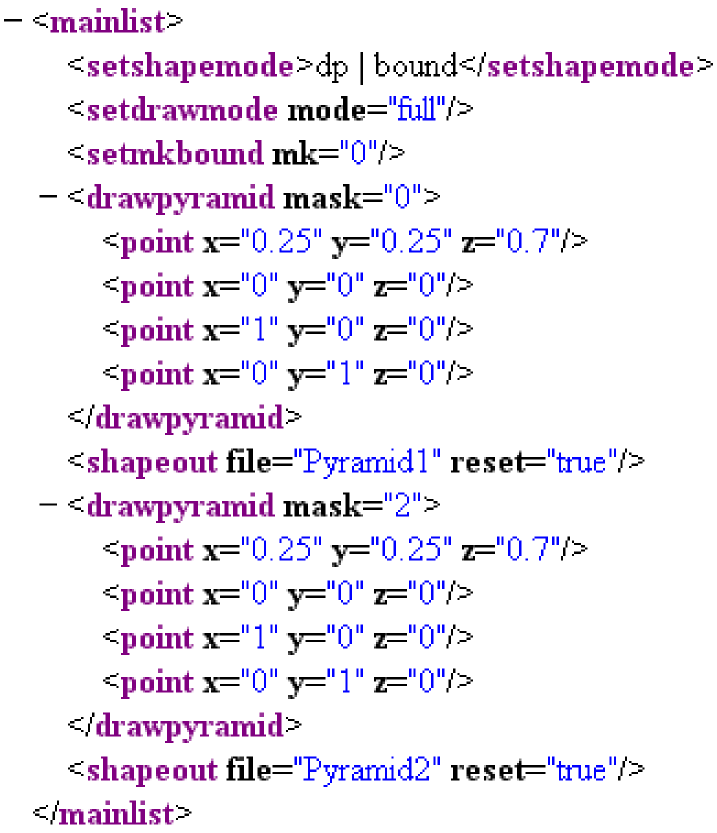


DrawFigure
(*drawmode=solid*)



DrawTriangles or
DrawFigure (*drawmode=face*)

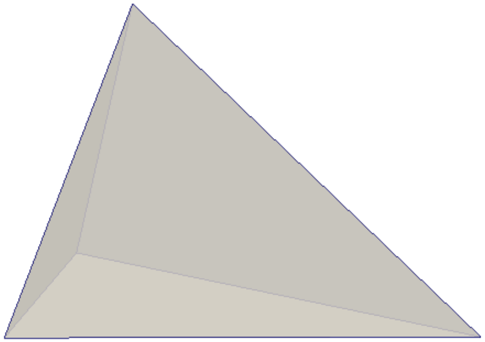
CASEDEF-GEOMETRY-COMMANDS-MAINLIST



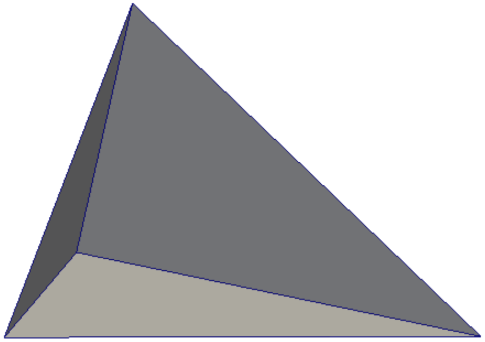
```
- <mainlist>
    <setshapemode>dp | bound</setshapemode>
    <setdrawmode mode="full"/>
    <setmkbound mk="0"/>
  - <drawpyramid mask="0">
      <point x="0.25" y="0.25" z="0.7"/>
      <point x="0" y="0" z="0"/>
      <point x="1" y="0" z="0"/>
      <point x="0" y="1" z="0"/>
    </drawpyramid>
    <shapeout file="Pyramid1" reset="true"/>
  - <drawpyramid mask="2">
      <point x="0.25" y="0.25" z="0.7"/>
      <point x="0" y="0" z="0"/>
      <point x="1" y="0" z="0"/>
      <point x="0" y="1" z="0"/>
    </drawpyramid>
    <shapeout file="Pyramid2" reset="true"/>
  </mainlist>
```

<drawpyramid>: draws a pyramid with the top point and other points of the base (minimum 3)

mask indicates the faces to be hidden with bits
the first bit always corresponds to the base and the rest to the faces following the order



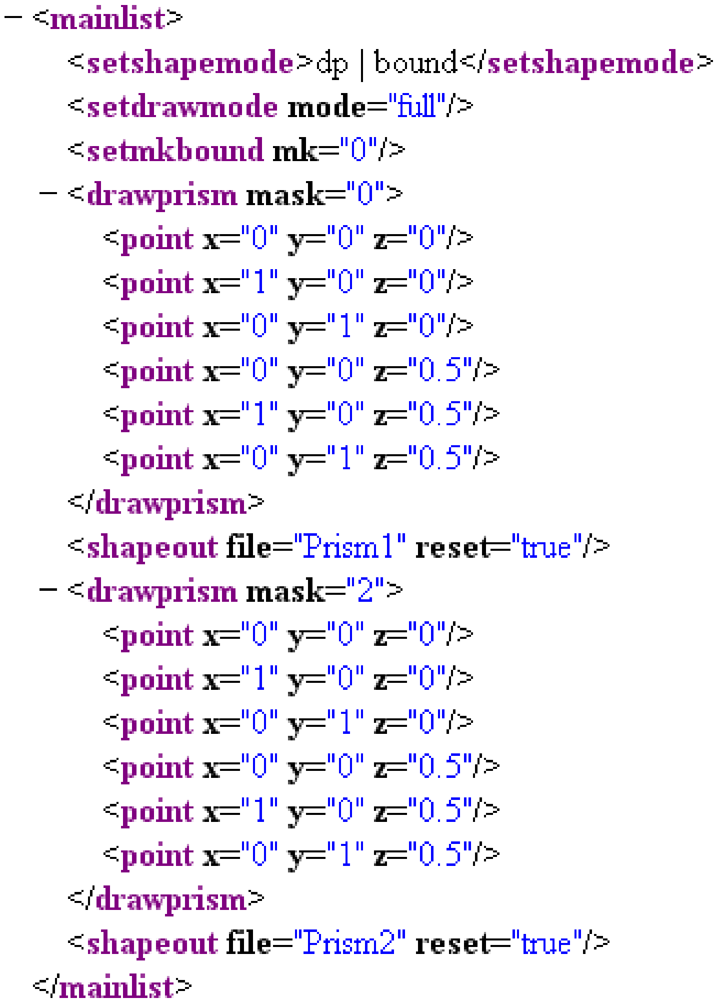
Pyramid1
(*mask=0*)



Pyramid2
(*mask=2=0010*)

CASEDEF-GEOMETRY-COMMANDS-MAINLIST

PRISM

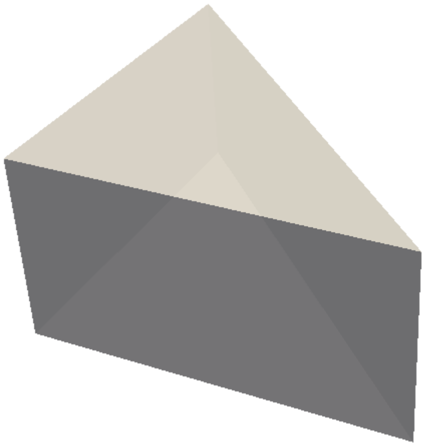


```
- <mainlist>
    <setshapemode>dp | bound</setshapemode>
    <setdrawmode mode="full"/>
    <setmkbound mk="0"/>
  - <drawprism mask="0">
      <point x="0" y="0" z="0"/>
      <point x="1" y="0" z="0"/>
      <point x="0" y="1" z="0"/>
      <point x="0" y="0" z="0.5"/>
      <point x="1" y="0" z="0.5"/>
      <point x="0" y="1" z="0.5"/>
    </drawprism>
    <shapeout file="Prism1" reset="true"/>
  - <drawprism mask="2">
      <point x="0" y="0" z="0"/>
      <point x="1" y="0" z="0"/>
      <point x="0" y="1" z="0"/>
      <point x="0" y="0" z="0.5"/>
      <point x="1" y="0" z="0.5"/>
      <point x="0" y="1" z="0.5"/>
    </drawprism>
    <shapeout file="Prism2" reset="true"/>
  </mainlist>
```

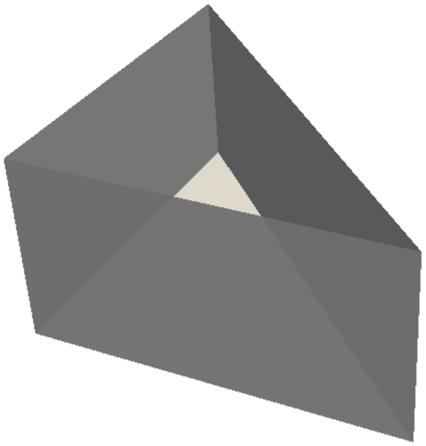
<drawprism>: draws a prism with a minimum of 6 points

The first half of points are the base and the second half the top (the number of points must be even)

mask indicates the faces to be hidden with bits
The first bit corresponds to the base, the second to the top and the rest to the faces following the order



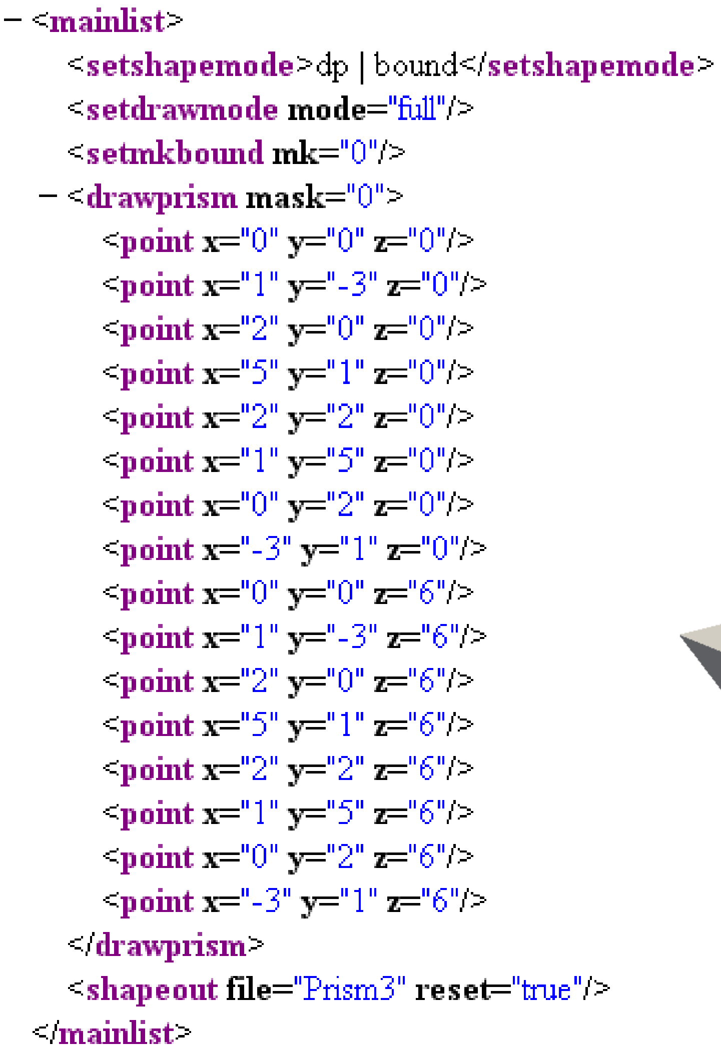
Prism1 (*mask=0*)



Prism2 (*mask=2=00010*)

CASEDEF-GEOMETRY-COMMANDS-MAINLIST

PRISM

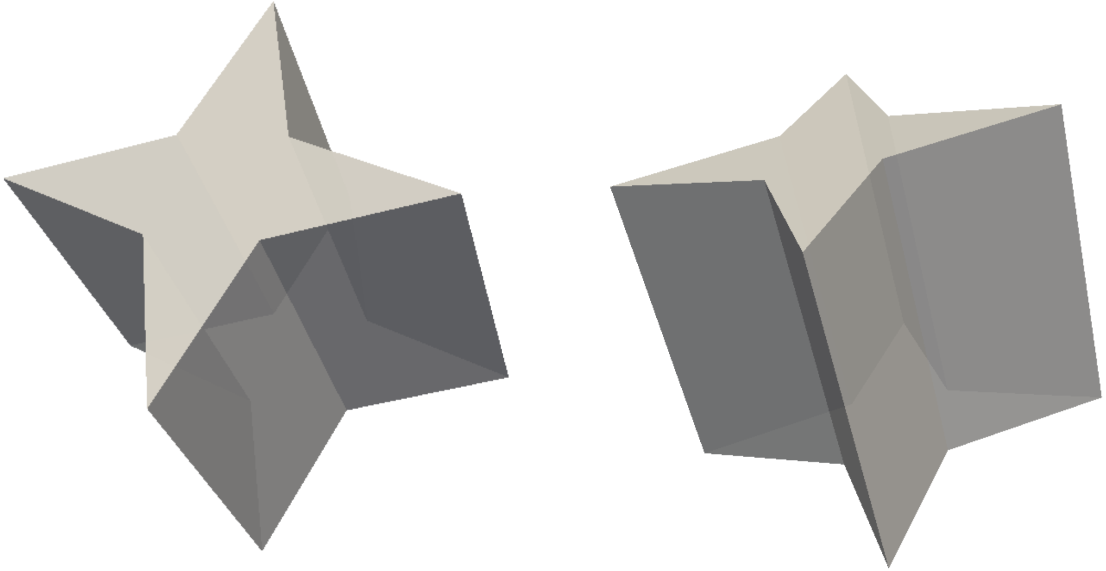


```
- <mainlist>
    <setshapemode>dp | bound</setshapemode>
    <setdrawmode mode="full"/>
    <setmkbound mk="0"/>
  - <drawprism mask="0">
      <point x="0" y="0" z="0"/>
      <point x="1" y="-3" z="0"/>
      <point x="2" y="0" z="0"/>
      <point x="5" y="1" z="0"/>
      <point x="2" y="2" z="0"/>
      <point x="1" y="5" z="0"/>
      <point x="0" y="2" z="0"/>
      <point x="-3" y="1" z="0"/>
      <point x="0" y="0" z="6"/>
      <point x="1" y="-3" z="6"/>
      <point x="2" y="0" z="6"/>
      <point x="5" y="1" z="6"/>
      <point x="2" y="2" z="6"/>
      <point x="1" y="5" z="6"/>
      <point x="0" y="2" z="6"/>
      <point x="-3" y="1" z="6"/>
    </drawprism>
    <shapeout file="Prism3" reset="true"/>
  </mainlist>
```

<drawprism>: draws a prism with a minimum of 6 points

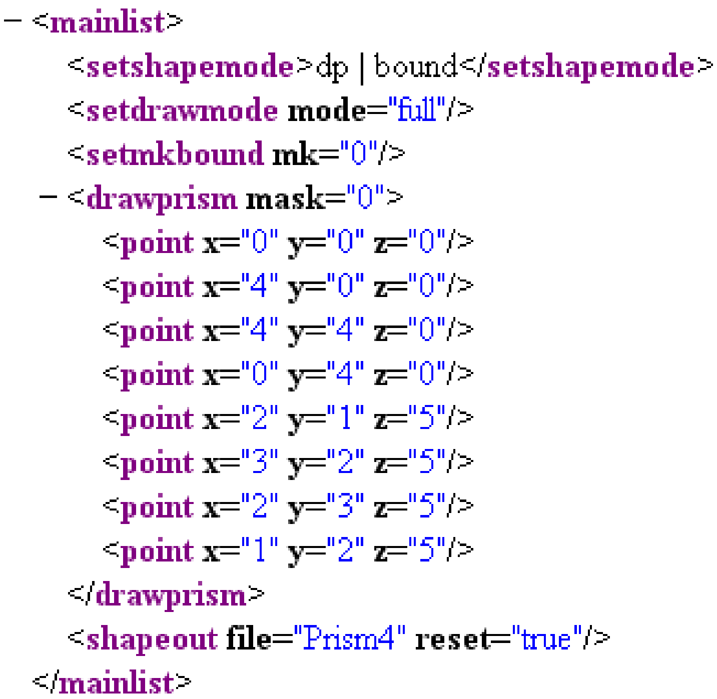
The first half of points are the base and the second half the top (the number of points must be even)

mask indicates the faces to be hidden with bits
The first bit corresponds to the base, the second to the top and the rest to the faces following the order

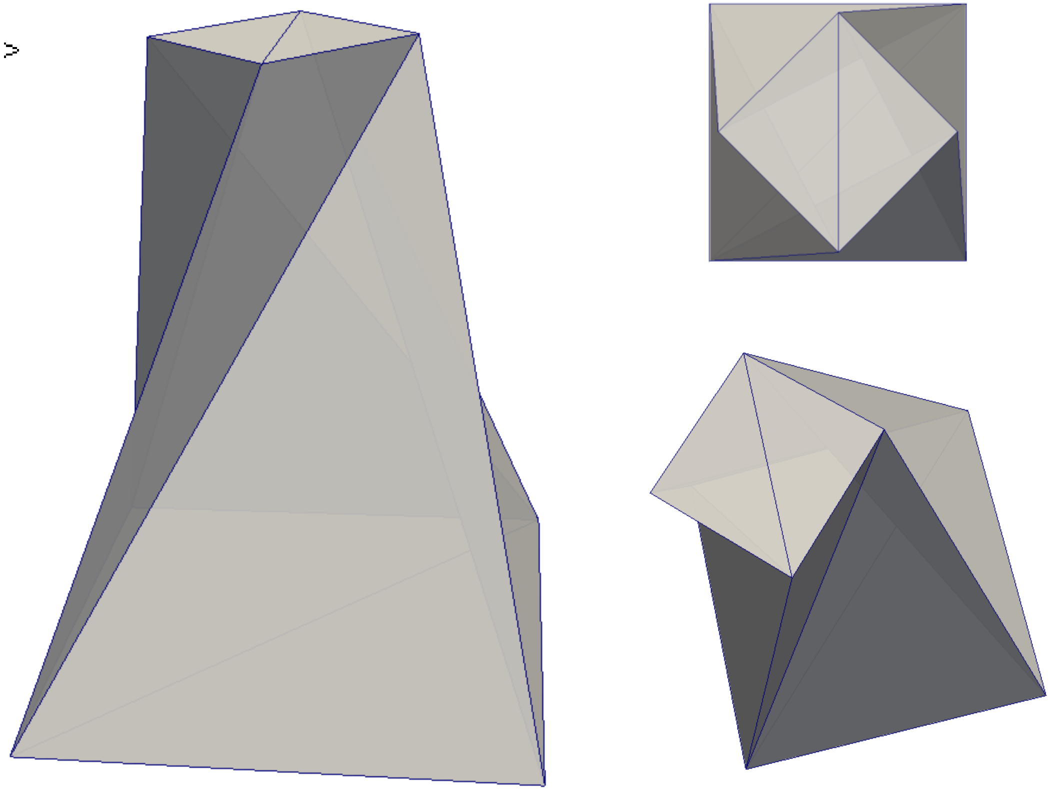


CASEDEF-GEOMETRY-COMMANDS-MAINLIST

PRISM



```
− <mainlist>
    <setshapemode>dp | bound</setshapemode>
    <setdrawmode mode="full"/>
    <setmkbound mk="0"/>
  − <drawprism mask="0">
      <point x="0" y="0" z="0"/>
      <point x="4" y="0" z="0"/>
      <point x="4" y="4" z="0"/>
      <point x="0" y="4" z="0"/>
      <point x="2" y="1" z="5"/>
      <point x="3" y="2" z="5"/>
      <point x="2" y="3" z="5"/>
      <point x="1" y="2" z="5"/>
    </drawprism>
    <shapeout file="Prism4" reset="true"/>
  </mainlist>
```



CASEDEF-GEOMETRY-COMMANDS-MAINLIST

MASK

mask indicates the faces to be hidden

Initially this is defined using BITS

FOR EXAMPLE: OBJECT WITH 4 FACES:

mask="0"	decimal **0** is **0000** in binary	no faces are hidden
mask="1"	decimal **1** is **0001** in binary	first face is hidden
mask="2"	decimal **2** is **0010** in binary	second face is hidden
mask="4"	decimal **4** is **0100** in binary	third face is hidden
mask="8"	decimal **8** is **1000** in binary	fourth face is hidden
mask="12"	decimal **12** is **1100** in binary	third and fourth face are hidden

CASEDEF-GEOMETRY-COMMANDS-MAINLIST

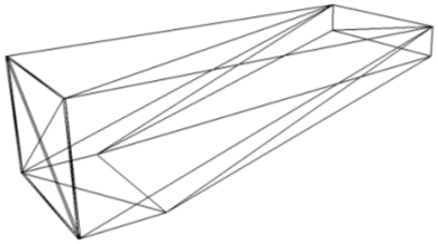
PRISM

There is a second and easiest system to use mask

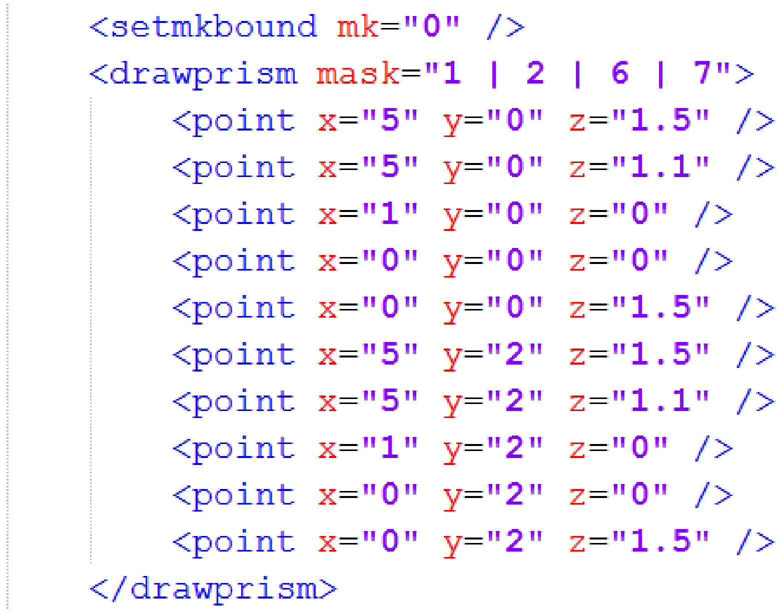
mask can be also defined using the index of the faces instead of bits

In this example, faces 1, 2, 6 and 7 are not created, only 3,4 and 5

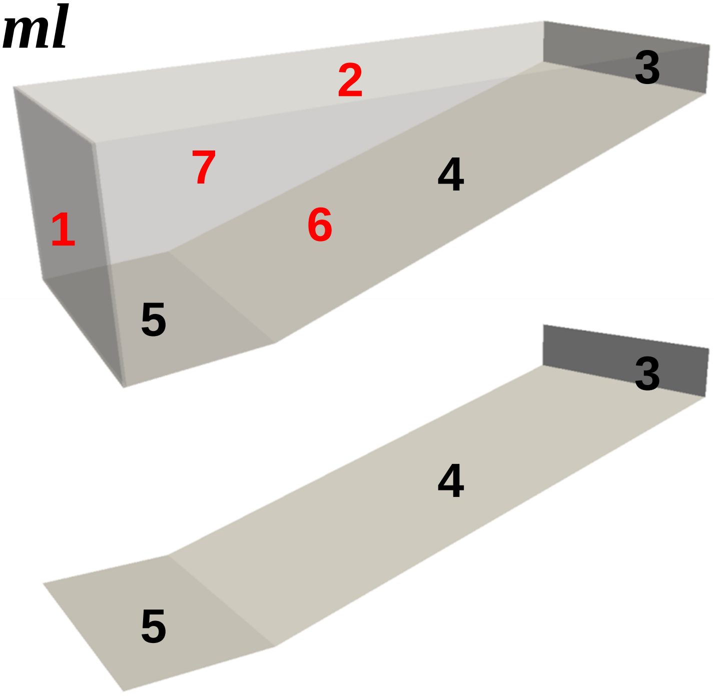
It is important to use symbol “|” to detect this system!!!



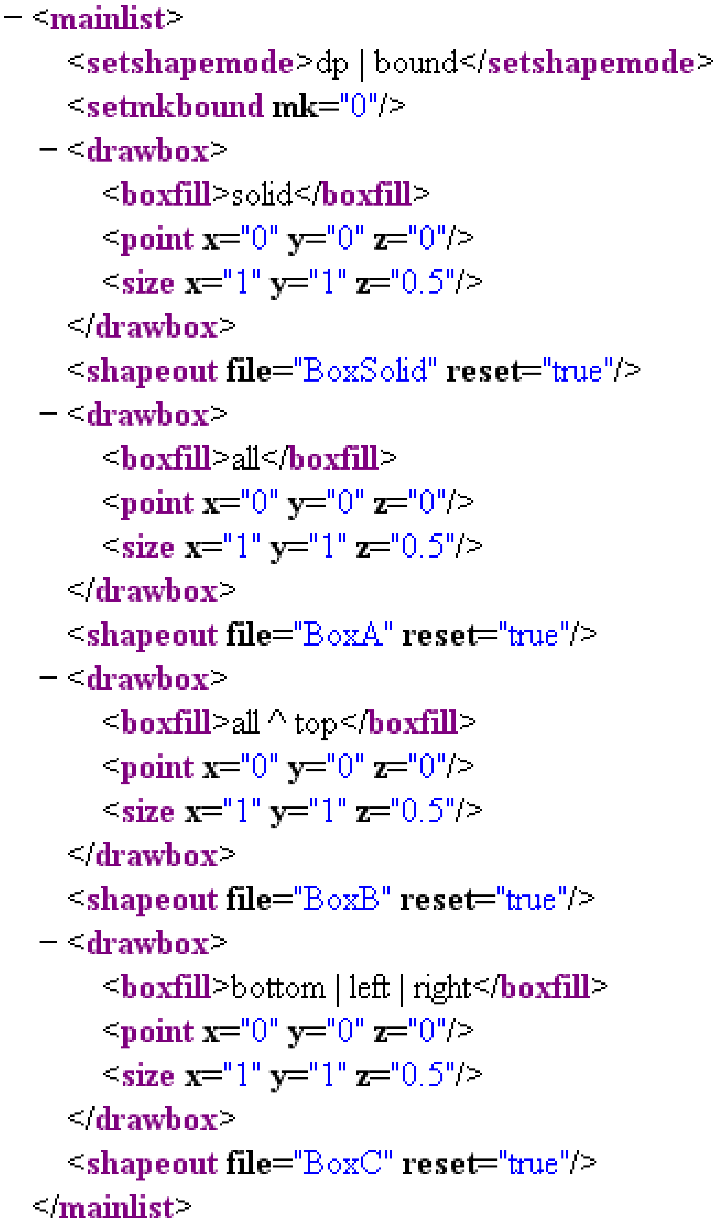
EXAMPLE: *CaseWavemaker_Def.xml*



```
    <setmkbound mk="0" />
    <drawprism mask="1 | 2 | 6 | 7">
        <point x="5" y="0" z="1.5" />
        <point x="5" y="0" z="1.1" />
        <point x="1" y="0" z="0" />
        <point x="0" y="0" z="0" />
        <point x="0" y="0" z="1.5" />
        <point x="5" y="2" z="1.5" />
        <point x="5" y="2" z="1.1" />
        <point x="1" y="2" z="0" />
        <point x="0" y="2" z="0" />
        <point x="0" y="2" z="1.5" />
    </drawprism>
```



CASEDEF-GEOMETRY-COMMANDS-MAINLIST

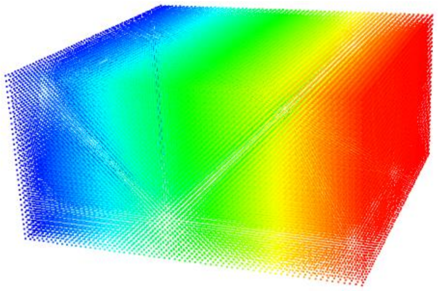


```
- <mainlist>
    <setshapemode>dp | bound</setshapemode>
    <setmkbound mk="0"/>
  - <drawbox>
      <boxfill>solid</boxfill>
      <point x="0" y="0" z="0"/>
      <size x="1" y="1" z="0.5"/>
    </drawbox>
    <shapeout file="BoxSolid" reset="true"/>
  - <drawbox>
      <boxfill>all</boxfill>
      <point x="0" y="0" z="0"/>
      <size x="1" y="1" z="0.5"/>
    </drawbox>
    <shapeout file="BoxA" reset="true"/>
  - <drawbox>
      <boxfill>all ^ top</boxfill>
      <point x="0" y="0" z="0"/>
      <size x="1" y="1" z="0.5"/>
    </drawbox>
    <shapeout file="BoxB" reset="true"/>
  - <drawbox>
      <boxfill>bottom | left | right</boxfill>
      <point x="0" y="0" z="0"/>
      <size x="1" y="1" z="0.5"/>
    </drawbox>
    <shapeout file="BoxC" reset="true"/>
  </mainlist>
```

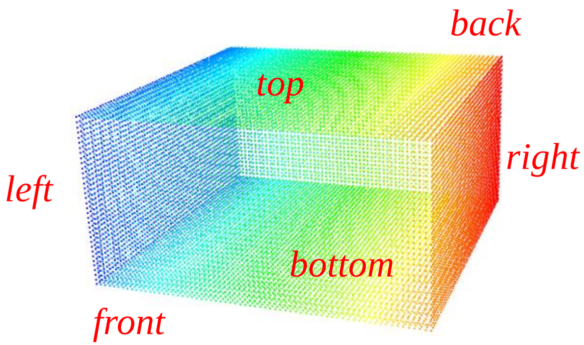
BOX

<drawbox>: draws a box with an initial point and the size

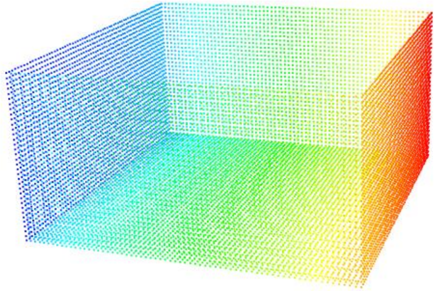
<boxfill> indicates if *solid* or *face* and the faces to be hidden



BoxSolid (solid)

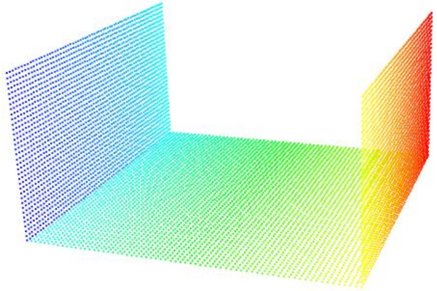


BoxA (all)



BoxB (all^top)

means
all faces excluding top

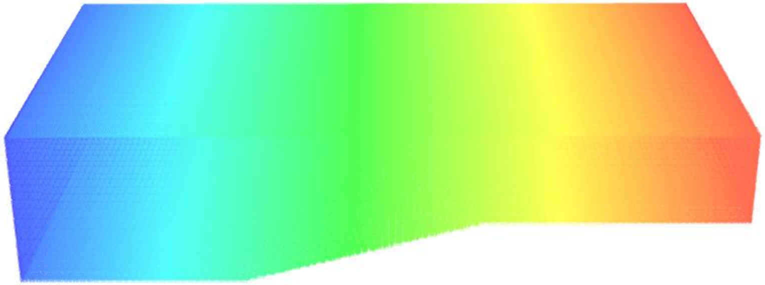


BoxC (bottom|left|right)

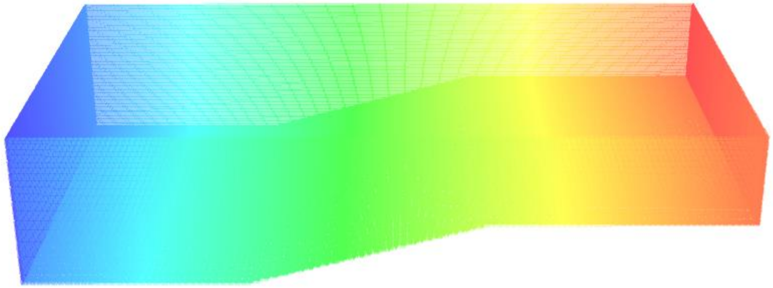
means only
bottom+left+right

CASEDEF-GEOMETRY-COMMANDS-MAINLIST

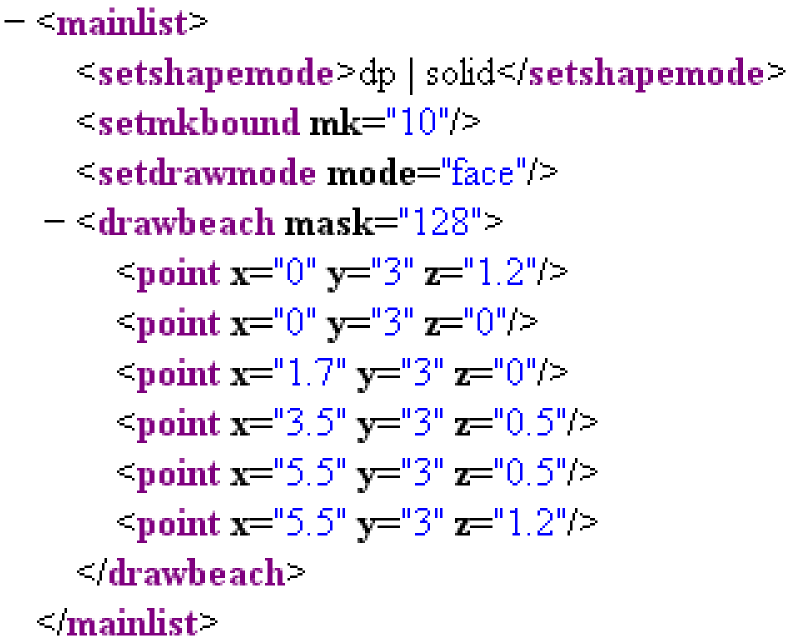
BEACH



BeachFace



BeachFace
(mask="128")



```
– <mainlist>
      <setshapemode>dp | solid</setshapemode>
      <setmkbound mk="10"/>
      <setdrawmode mode="face"/>
    – <drawbeach mask="128">
          <point x="0" y="3" z="1.2"/>
          <point x="0" y="3" z="0"/>
          <point x="1.7" y="3" z="0"/>
          <point x="3.5" y="3" z="0.5"/>
          <point x="5.5" y="3" z="0.5"/>
          <point x="5.5" y="3" z="1.2"/>
      </drawbeach>
  </mainlist>
```

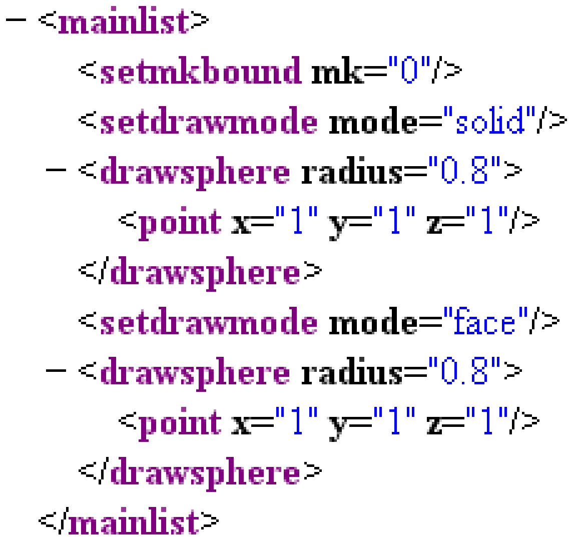
<drawbeach>: draws a beach with the lateral points that formed the profile of the beach

mask indicates the faces to be hidden .

mask="128" decimal **128** is **10000000** in binary eighth face is hidden

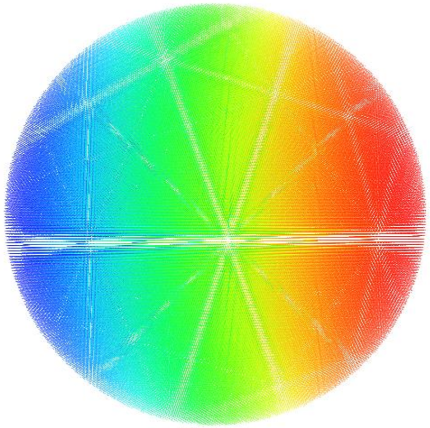
CASEDEF-GEOMETRY-COMMANDS-MAINLIST

SPHERE

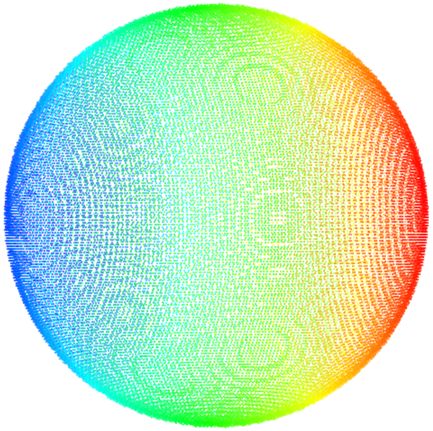


```
– <mainlist>
      <setmkbound mk="0"/>
      <setdrawmode mode="solid"/>
    – <drawsphere radius="0.8">
         <point x="1" y="1" z="1"/>
      </drawsphere>
      <setdrawmode mode="face"/>
    – <drawsphere radius="0.8">
         <point x="1" y="1" z="1"/>
      </drawsphere>
  </mainlist>
```

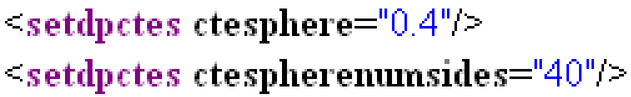
<drawsphere>: draws a sphere with the center point and the radius



Sphere
(*drawmode=solid*)



Sphere
(*drawmode=face*)



```
<setdpctes ctesphere="0.4"/>
<setdpctes ctespherenumsides="40"/>
```

when *face:*

ctesphere indicates the width of the sphere

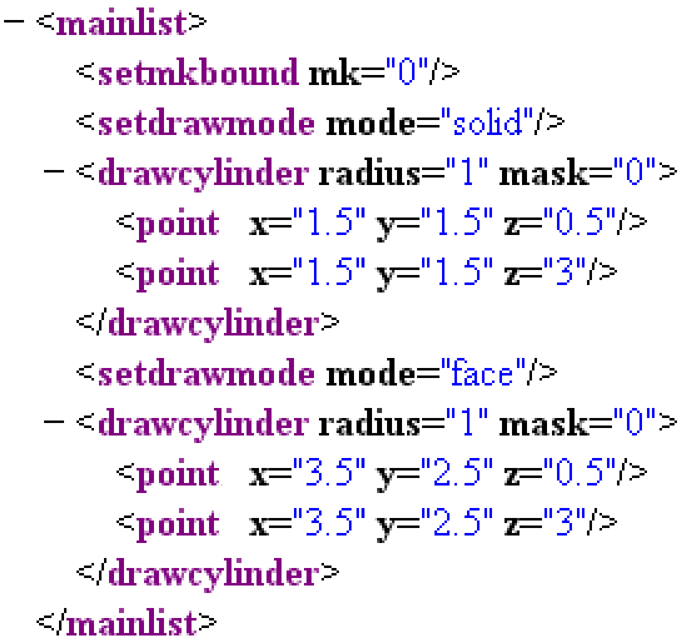
ctespherenumsides indicates the number of triangles used to create the VTK of polygons

CASEDEF-GEOMETRY-COMMANDS-MAINLIST

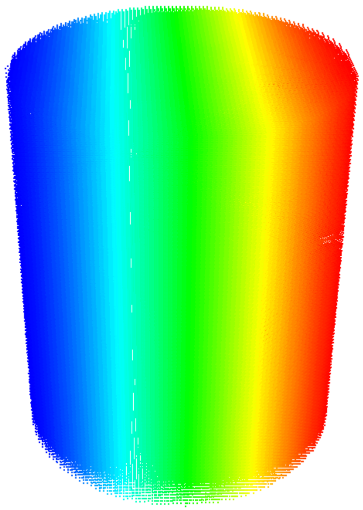
CYLINDER

<drawcylinder>: draws a cylinder with two points and radius

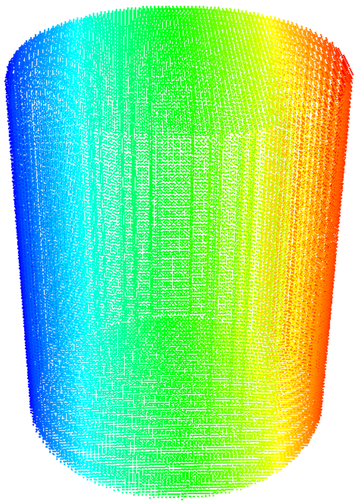
mask indicates the faces to be hide



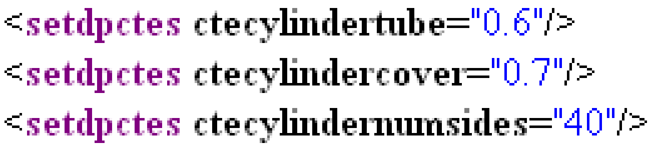
```
- <mainlist>
    <setmkbound mk="0"/>
    <setdrawmode mode="solid"/>
  - <drawcylinder radius="1" mask="0">
      <point  x="1.5" y="1.5" z="0.5"/>
      <point  x="1.5" y="1.5" z="3"/>
    </drawcylinder>
    <setdrawmode mode="face"/>
  - <drawcylinder radius="1" mask="0">
      <point  x="3.5" y="2.5" z="0.5"/>
      <point  x="3.5" y="2.5" z="3"/>
    </drawcylinder>
  </mainlist>
```



Cylinder
(*drawmode=solid*)



Cylinder
(*drawmode=face*)



```
<setdpctes ctecylindertube="0.6"/>
<setdpctes ctecylindercover="0.7"/>
<setdpctes ctecylindernumsides="40"/>
```

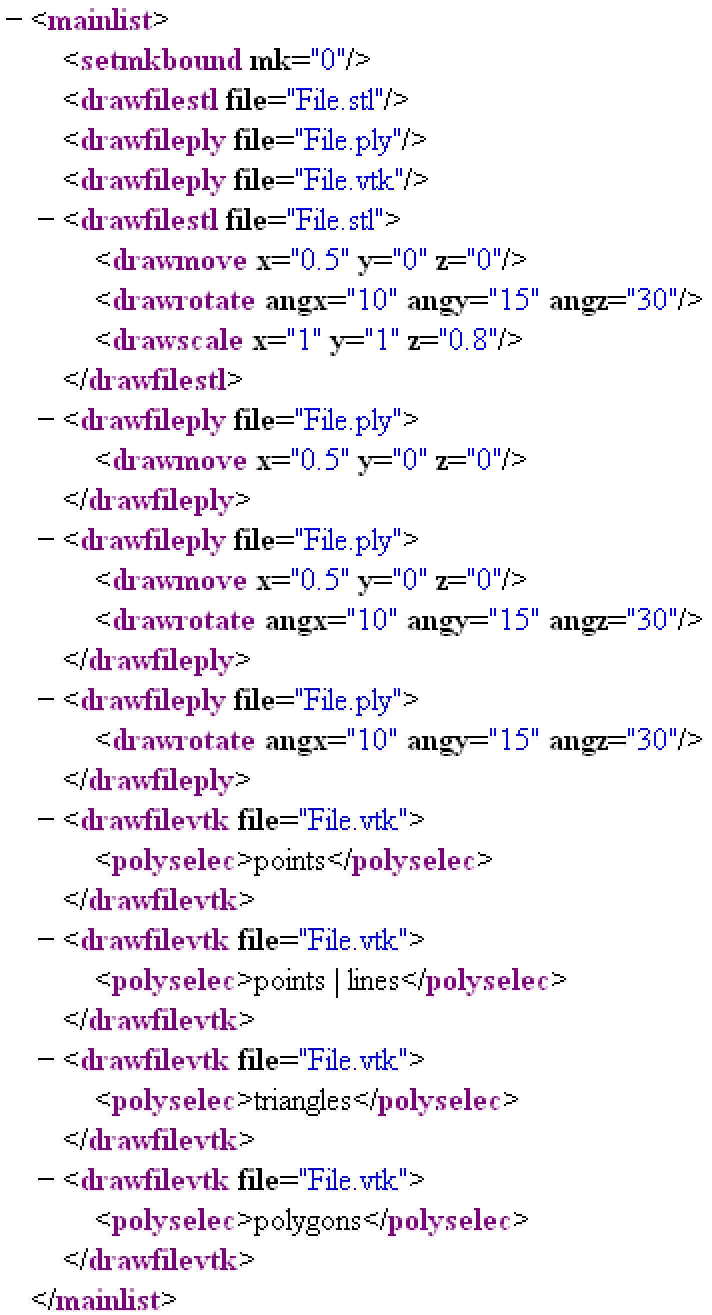
when *face:*

ctecylindertube indicates the width of the tube

ctecylindercover indicates the width of the covers

ctespherenumsides indicates the number of triangles used to create the VTK of polygons

CASEDEF-GEOMETRY-COMMANDS-MAINLIST



```
- <mainlist>
    <setmkbound mk="0"/>
    <drawfilestl file="File.stl"/>
    <drawfileply file="File.ply"/>
    <drawfileply file="File.vtk"/>
  - <drawfilestl file="File.stl">
      <drawmove x="0.5" y="0" z="0"/>
      <drawrotate angx="10" angy="15" angz="30"/>
      <drawscale x="1" y="1" z="0.8"/>
    </drawfilestl>
  - <drawfileply file="File.ply">
      <drawmove x="0.5" y="0" z="0"/>
    </drawfileply>
  - <drawfileply file="File.ply">
      <drawmove x="0.5" y="0" z="0"/>
      <drawrotate angx="10" angy="15" angz="30"/>
    </drawfileply>
  - <drawfileply file="File.ply">
      <drawrotate angx="10" angy="15" angz="30"/>
    </drawfileply>
  - <drawfilevtk file="File.vtk">
      <polyselec>points</polyselec>
    </drawfilevtk>
  - <drawfilevtk file="File.vtk">
      <polyselec>points | lines</polyselec>
    </drawfilevtk>
  - <drawfilevtk file="File.vtk">
      <polyselec>triangles</polyselec>
    </drawfilevtk>
  - <drawfilevtk file="File.vtk">
      <polyselec>polygons</polyselec>
    </drawfilevtk>
  </mainlist>
```

IMPORTING EXTERNAL GEOMETRIES

<drawfilevtk>: load a VTK file to be converted into points

<drawfileply>: load a PLY file to be converted into points

<drawfilestl>: load a STL file to be converted into points

Some modifications can be applied to the VTK, PLY or STL

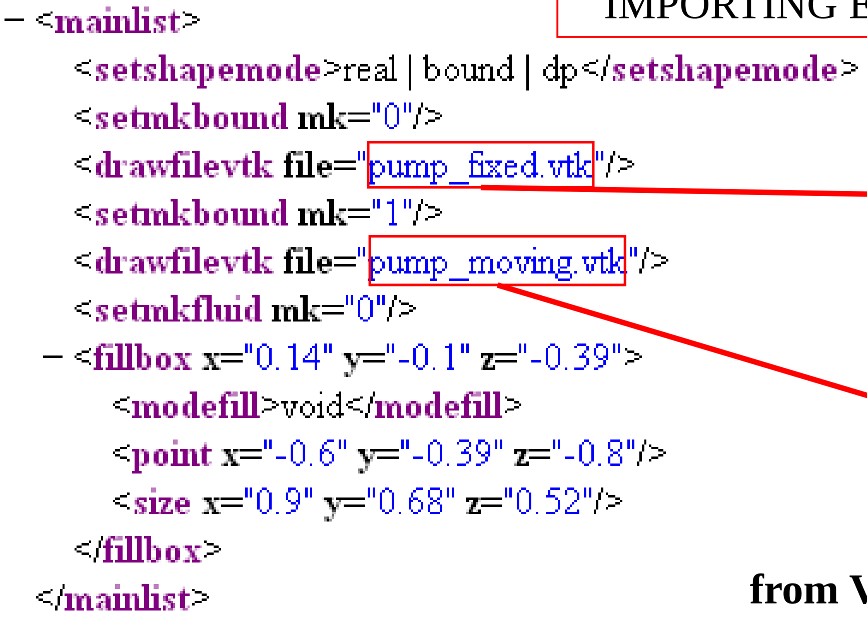
drawmove a displacement is applied to the external object

drawrotate a rotation is applied to the external object

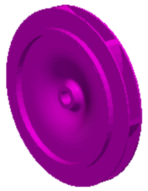
drawscale scaling is applied to the external object

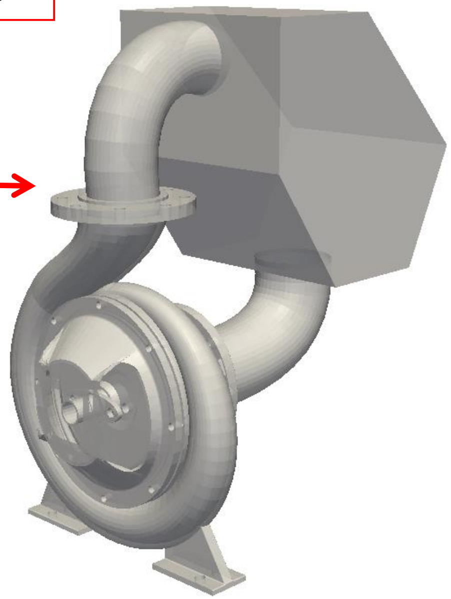
CASEDEF-GEOMETRY-COMMANDS-MAINLIST

IMPORTING EXTERNAL GEOMETRIES

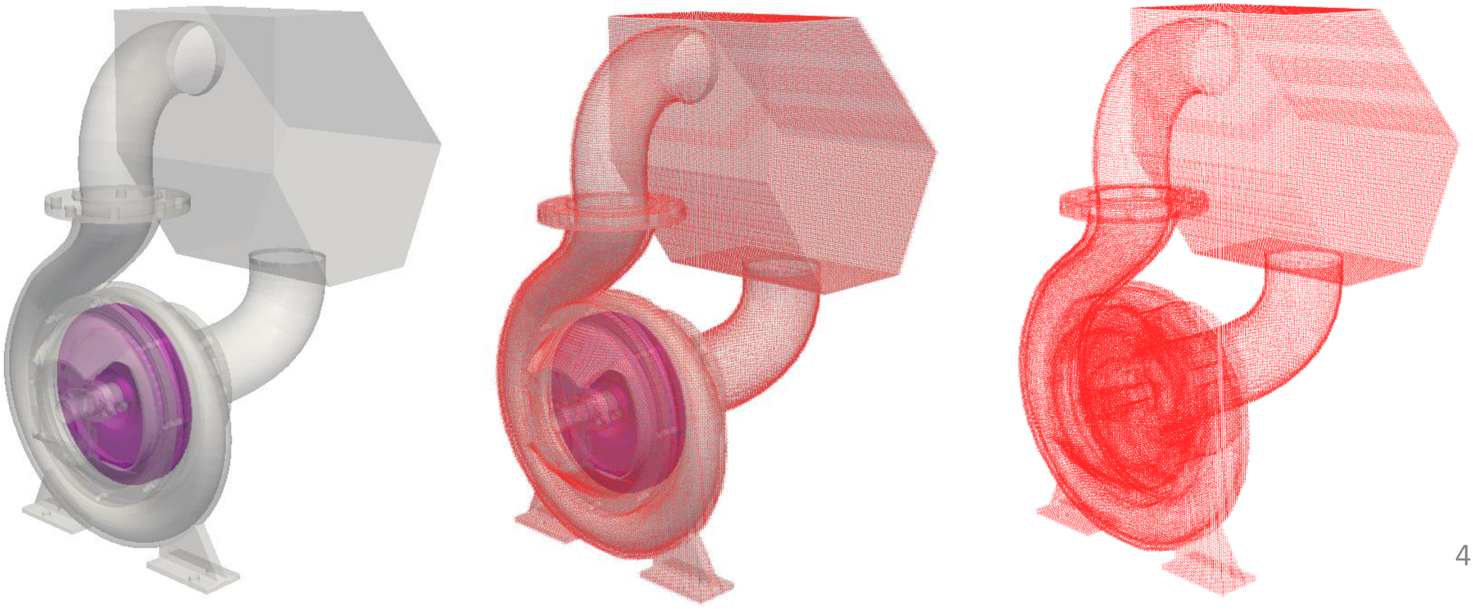


```
- <mainlist>
    <setshapemode>real | bound | dp</setshapemode>
    <setmkbound mk="0"/>
    <drawfilevtk file="pump_fixed.vtk"/>
    <setmkbound mk="1"/>
    <drawfilevtk file="pump_moving.vtk"/>
    <setmkfluid mk="0"/>
  - <fillbox x="0.14" y="-0.1" z="-0.39">
      <modefill>void</modefill>
      <point x="-0.6" y="-0.39" z="-0.8"/>
      <size x="0.9" y="0.68" z="0.52"/>
    </fillbox>
  </mainlist>
```

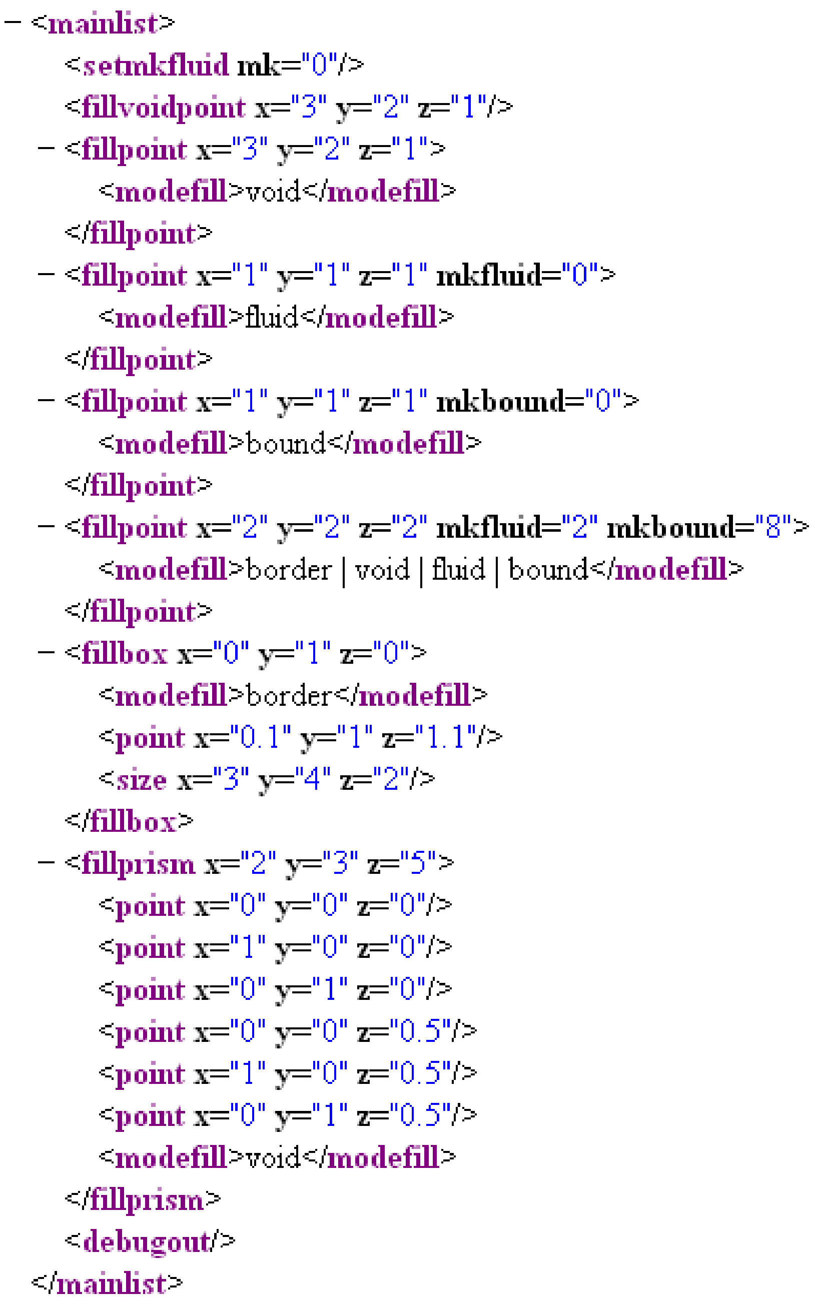




from VTK to points



CASEDEF-GEOMETRY-COMMANDS-MAINLIST



```
- <mainlist>
    <setmkfluid mk="0"/>
    <fillvoidpoint x="3" y="2" z="1"/>
  - <fillpoint x="3" y="2" z="1">
      <modefill>void</modefill>
    </fillpoint>
  - <fillpoint x="1" y="1" z="1" mkfluid="0">
      <modefill>fluid</modefill>
    </fillpoint>
  - <fillpoint x="1" y="1" z="1" mkbound="0">
      <modefill>bound</modefill>
    </fillpoint>
  - <fillpoint x="2" y="2" z="2" mkfluid="2" mkbound="8">
      <modefill>border | void | fluid | bound</modefill>
    </fillpoint>
  - <fillbox x="0" y="1" z="0">
      <modefill>border</modefill>
      <point x="0.1" y="1" z="1.1"/>
      <size x="3" y="4" z="2"/>
    </fillbox>
  - <fillprism x="2" y="3" z="5">
      <point x="0" y="0" z="0"/>
      <point x="1" y="0" z="0"/>
      <point x="0" y="1" z="0"/>
      <point x="0" y="0" z="0.5"/>
      <point x="1" y="0" z="0.5"/>
      <point x="0" y="1" z="0.5"/>
      <modefill>void</modefill>
    </fillprism>
    <debugout/>
  </mainlist>
```

FILLING DOMAINS

<fillpoint>: fills with points starting from the seed

<fillbox>: fills with points starting from the seed within the limits defined by a box

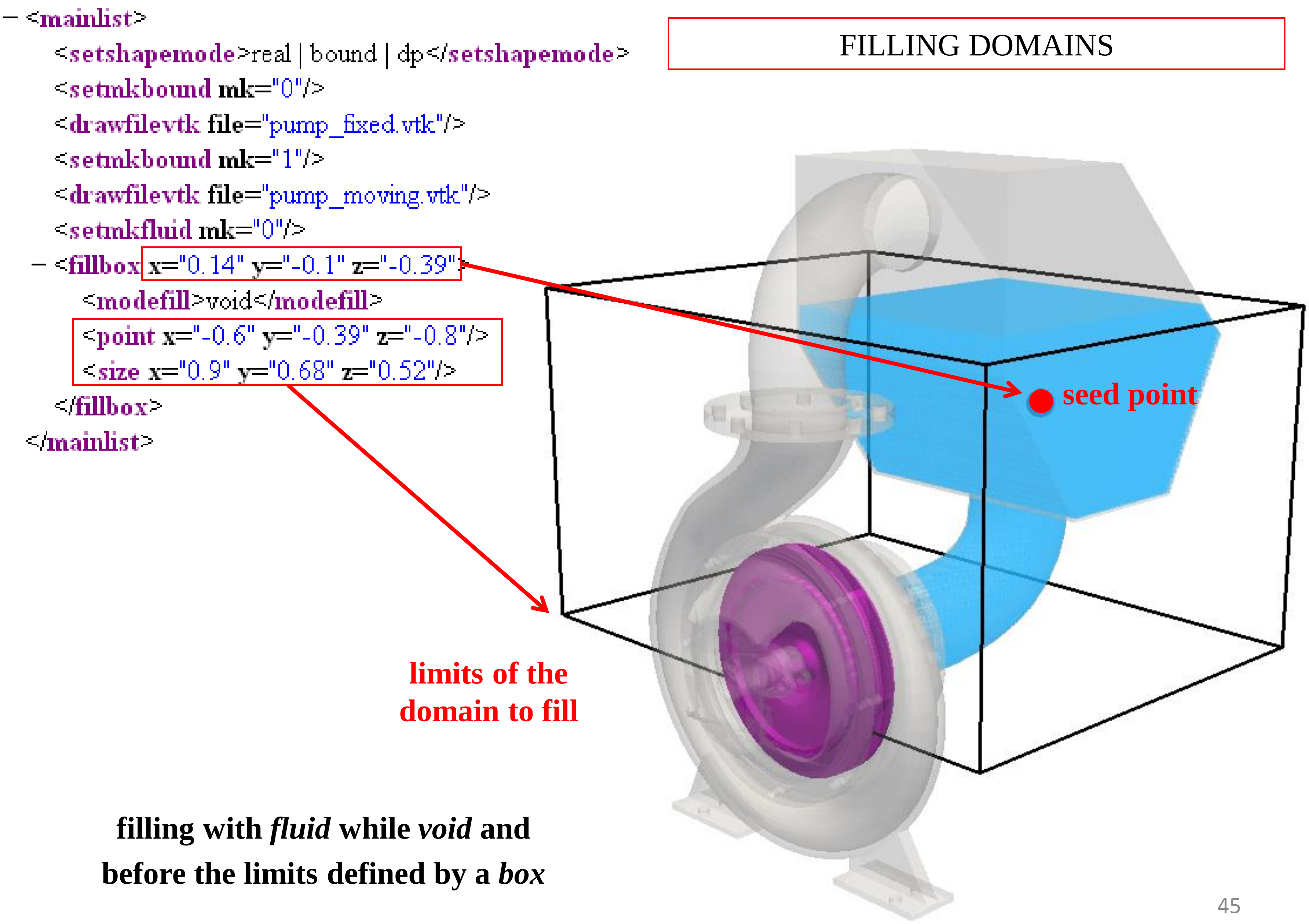
<fillfigure>: fills with points starting from the seed within the limits defined by a figure

<fillprism>: fills with points starting from the seed within the limits defined by a prism

<modefill> indicates what type of points can be filled with *void*, *fluid*, *bound*, it fills with that type of points inside the specified limits or the presence of a given type of point using *border*

CASEDEF-GEOMETRY-COMMANDS-MAINLIST

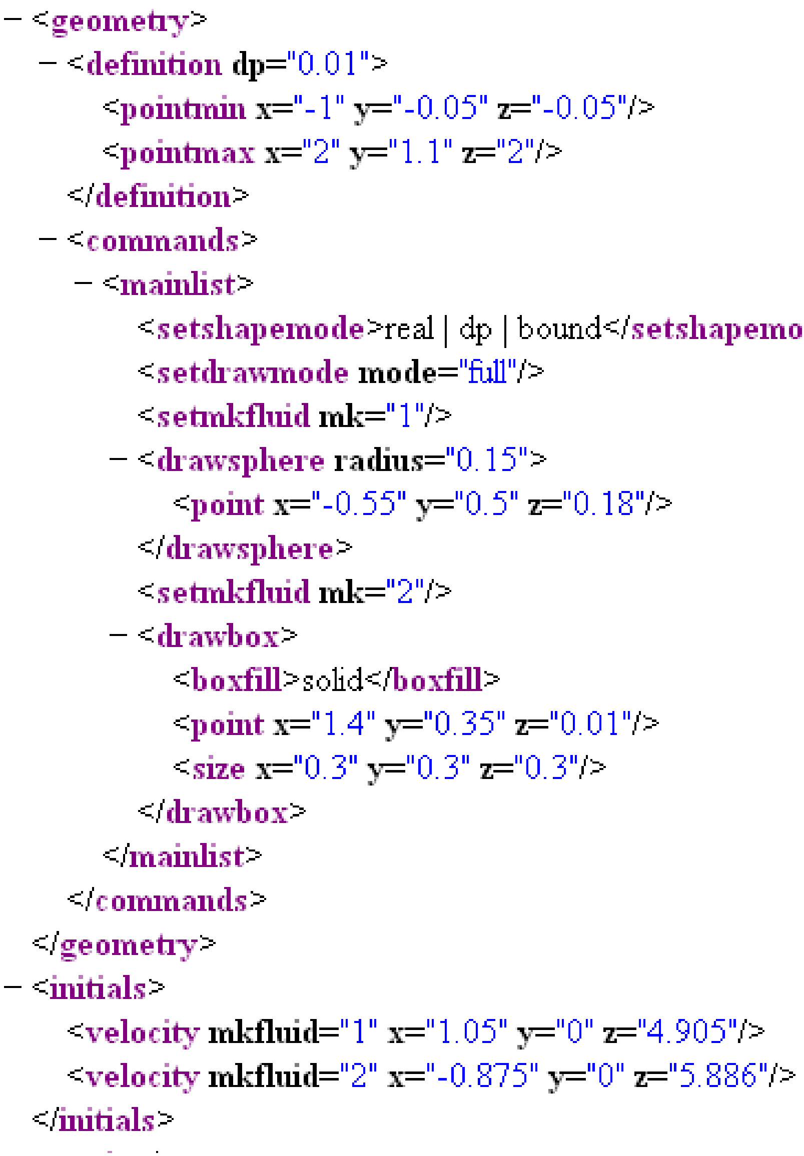
FILLING DOMAINS



```
– <mainlist>
    <setshapemode>real | bound | dp</setshapemode>
    <setmkbound mk="0"/>
    <drawfilevtk file="pump_fixed.vtk"/>
    <setmkbound mk="1"/>
    <drawfilevtk file="pump_moving.vtk"/>
    <setmkfluid mk="0"/>
  – <fillbox x="0.14" y="-0.1" z="-0.39">
      <modefill>void</modefill>
      <point x="-0.6" y="-0.39" z="-0.8"/>
      <size x="0.9" y="0.68" z="0.52"/>
    </fillbox>
  </mainlist>
```

filling with *fluid* while *void* and before the limits defined by a *box*

CASEDEF-INITIALS



```
- <geometry>
  - <definition dp="0.01">
      <pointmin x="-1" y="-0.05" z="-0.05"/>
      <pointmax x="2" y="1.1" z="2"/>
    </definition>
  - <commands>
    - <mainlist>
        <setshapemode>real | dp | bound</setshapemode>
        <setdrawmode mode="full"/>
        <setmkfluid mk="1"/>
      - <drawsphere radius="0.15">
          <point x="-0.55" y="0.5" z="0.18"/>
        </drawsphere>
        <setmkfluid mk="2"/>
      - <drawbox>
          <boxfill>solid</boxfill>
          <point x="1.4" y="0.35" z="0.01"/>
          <size x="0.3" y="0.3" z="0.3"/>
        </drawbox>
      </mainlist>
    </commands>
  </geometry>
- <initials>
    <velocity mkfluid="1" x="1.05" y="0" z="4.905"/>
    <velocity mkfluid="2" x="-0.875" y="0" z="5.886"/>
  </initials>
```

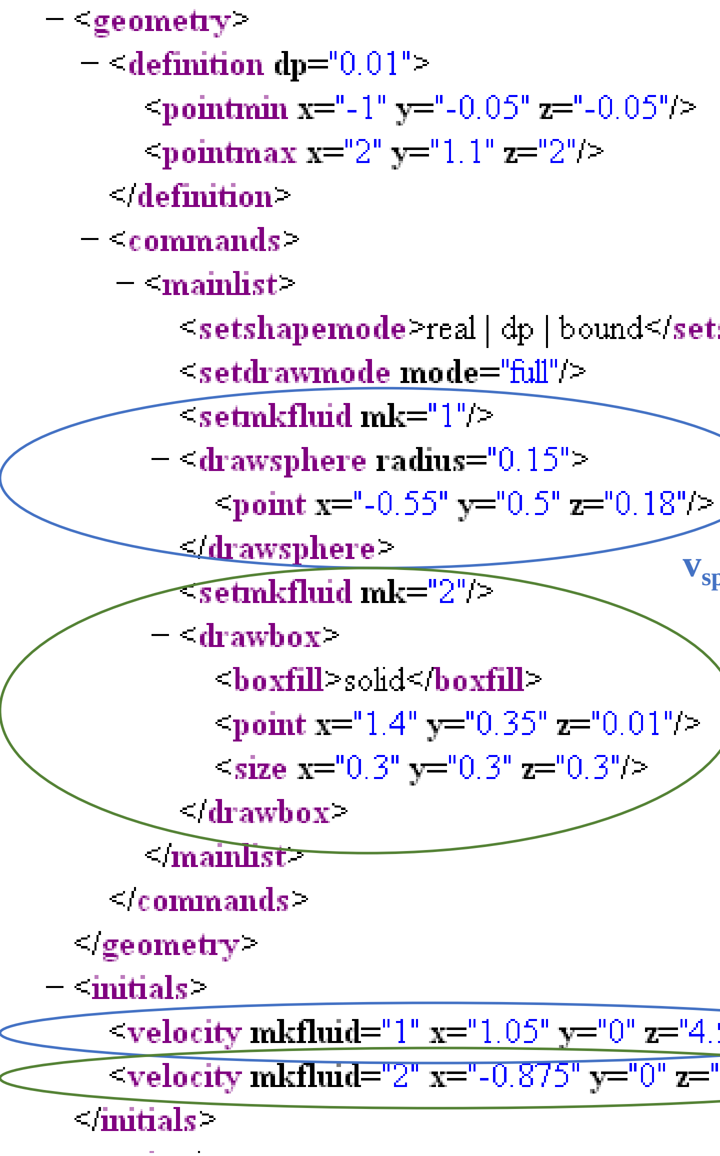
INITIAL VELOCITIES

<initials>: special behaviours can be imposed to a set of fluid particles labeled with a *mk*, such as:

<velocity> initial velocity defined by a vector

<velwave> a solitary wave defined by *depth* and *amplitude*

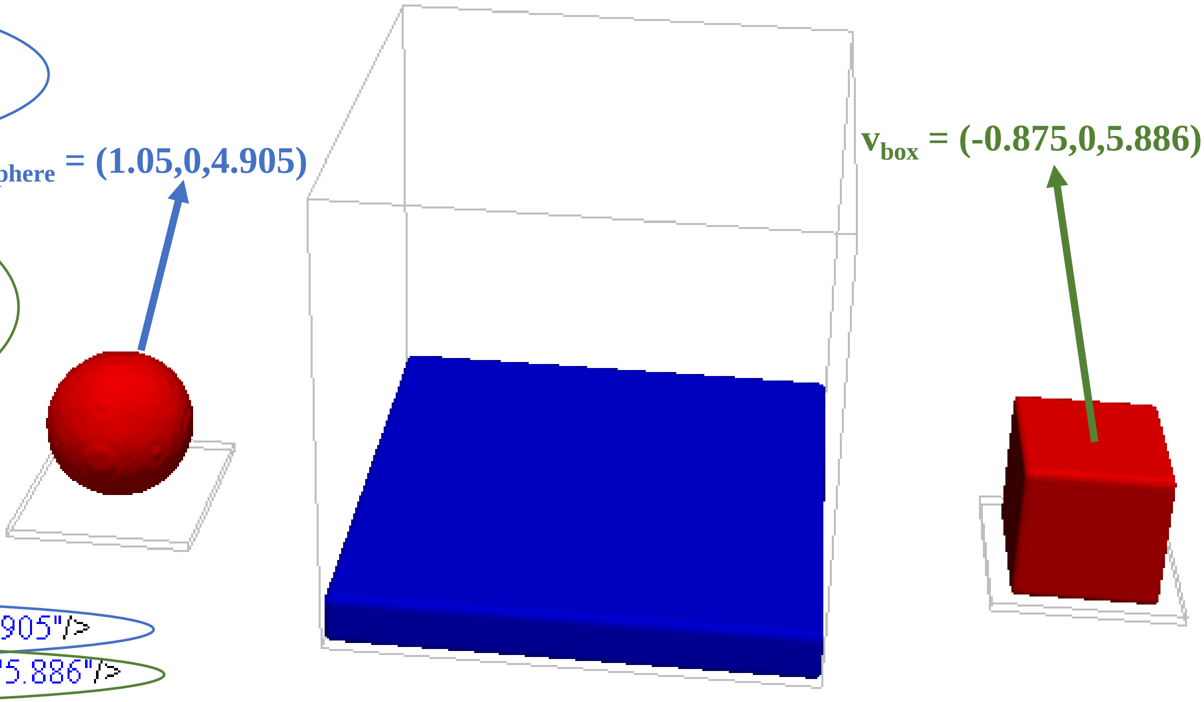
CASEDEF-INITIALS



```
- <geometry>
  - <definition dp="0.01">
      <pointmin x="-1" y="-0.05" z="-0.05"/>
      <pointmax x="2" y="1.1" z="2"/>
    </definition>
  - <commands>
    - <mainlist>
        <setshapemode>real | dp | bound</setshapemode>
        <setdrawmode mode="full"/>
        <setmkfluid mk="1"/>
      - <drawsphere radius="0.15">
          <point x="-0.55" y="0.5" z="0.18"/>
        </drawsphere>
        <setmkfluid mk="2"/>
      - <drawbox>
          <boxfill>solid</boxfill>
          <point x="1.4" y="0.35" z="0.01"/>
          <size x="0.3" y="0.3" z="0.3"/>
        </drawbox>
      </mainlist>
    </commands>
  </geometry>
- <initials>
    <velocity mkfluid="1" x="1.05" y="0" z="4.905"/>
    <velocity mkfluid="2" x="-0.875" y="0" z="5.886"/>
  </initials>
```

INITIAL VELOCITIES

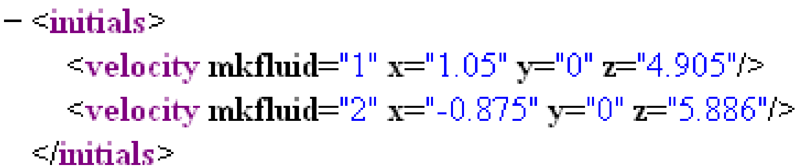
different initial velocities are imposed to two volumes of fluid *mk=1* (sphere) and *mk=2* (box)



v_{sphere} = (1.05,0,4.905)

v_{box} = (-0.875,0,5.886)

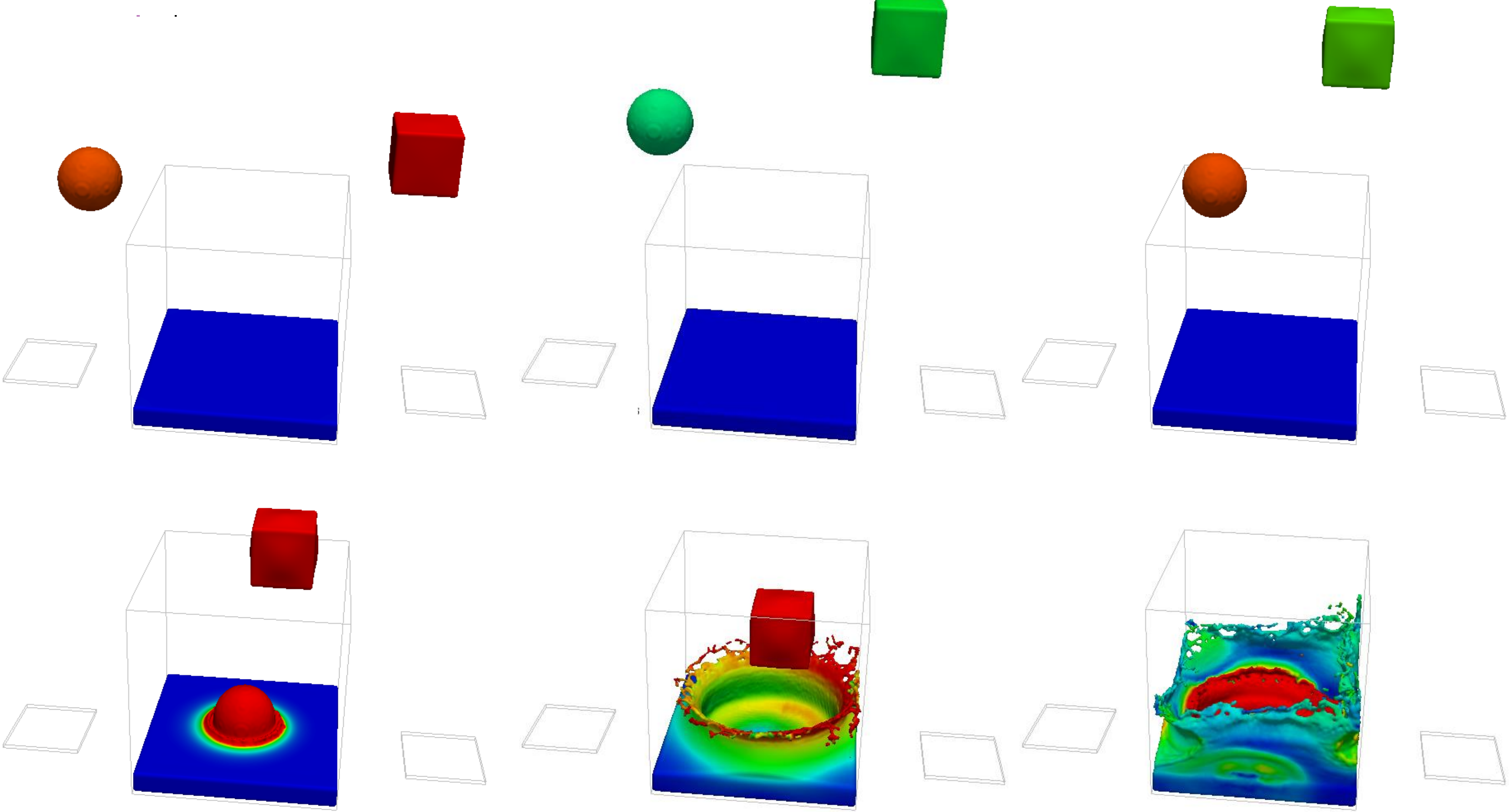
CASEDEF-INITIALS



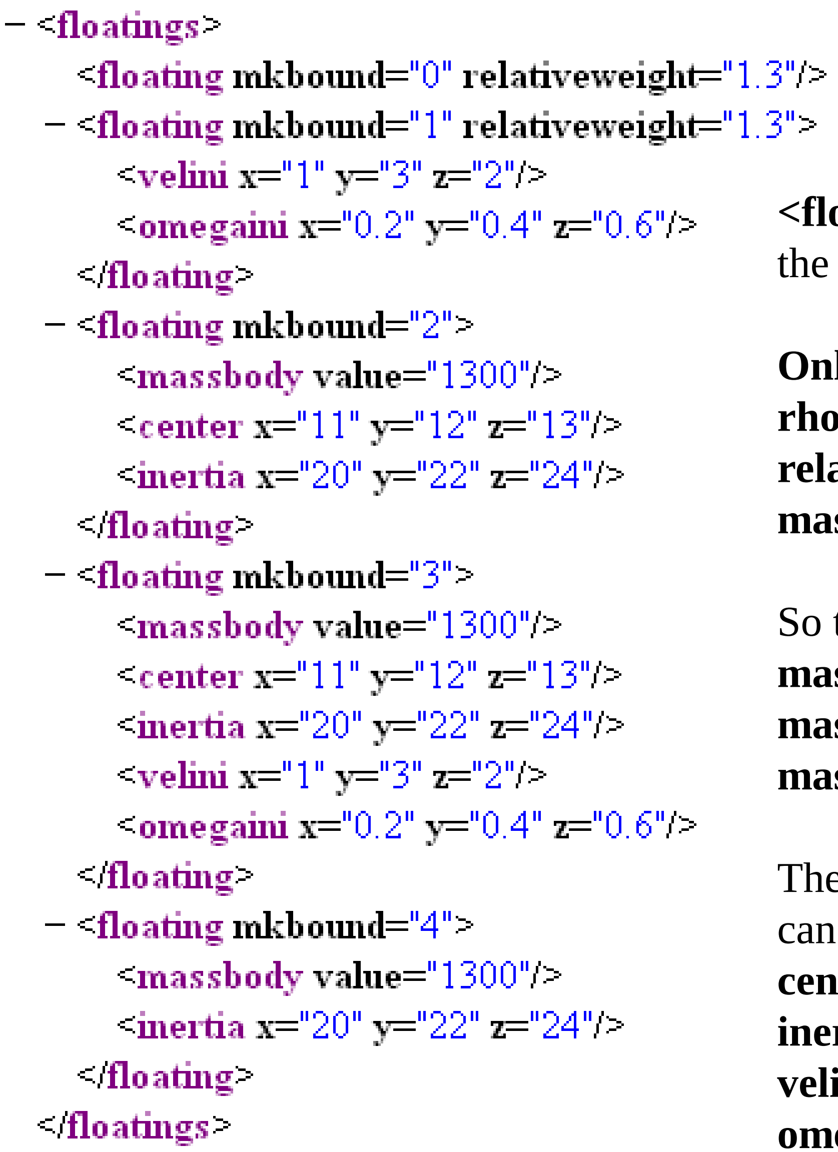
```
− <initials>
      <velocity mkfluid="1" x="1.05" y="0" z="4.905"/>
      <velocity mkfluid="2" x="-0.875" y="0" z="5.886"/>
  </initials>
```

INITIAL VELOCITIES

colour represents velocity



CASEDEF-FLOATINGS



```
- <floatings>
    <floating mkbound="0" relativeweight="1.3"/>
  - <floating mkbound="1" relativeweight="1.3">
      <velini x="1" y="3" z="2"/>
      <omegaini x="0.2" y="0.4" z="0.6"/>
    </floating>
  - <floating mkbound="2">
      <massbody value="1300"/>
      <center x="11" y="12" z="13"/>
      <inertia x="20" y="22" z="24"/>
    </floating>
  - <floating mkbound="3">
      <massbody value="1300"/>
      <center x="11" y="12" z="13"/>
      <inertia x="20" y="22" z="24"/>
      <velini x="1" y="3" z="2"/>
      <omegaini x="0.2" y="0.4" z="0.6"/>
    </floating>
  - <floating mkbound="4">
      <massbody value="1300"/>
      <inertia x="20" y="22" z="24"/>
    </floating>
  </floatings>
```

DEFINING FLOATINGS

<floatings>: indicates that a set of particles labelled with the same *mk* constitutes a floating object

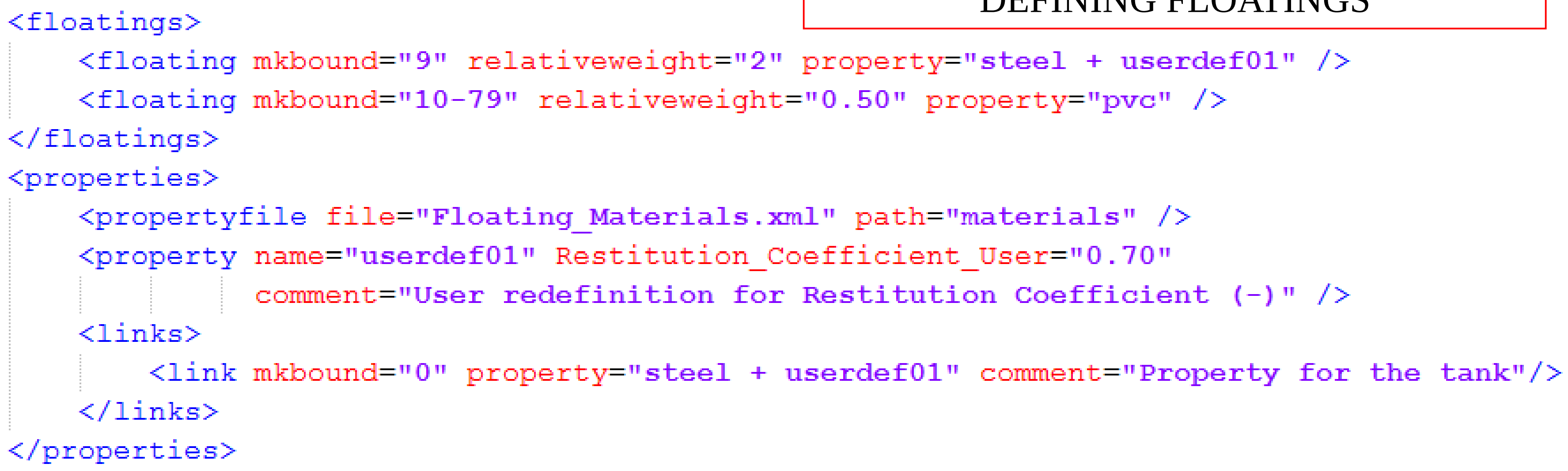
Only one of these values can be defined:
rhopbody density of the object
relativeweight in relation to the reference density
massbody total mass of the object

So that, the mass of a floating particles is:
masspart = massbody / nfloat **or**
masspart = relativeweight * rhop0 * dp^3 **or**
masspart = rhopbody * dp^3

These variables are computed by GenCase or can be also specified in advance:
center gravity center of the rigid object
inertia momentum of inertia of the rigid object
velini initial linear velocity of the object
omegaini initial angular velocity of the object

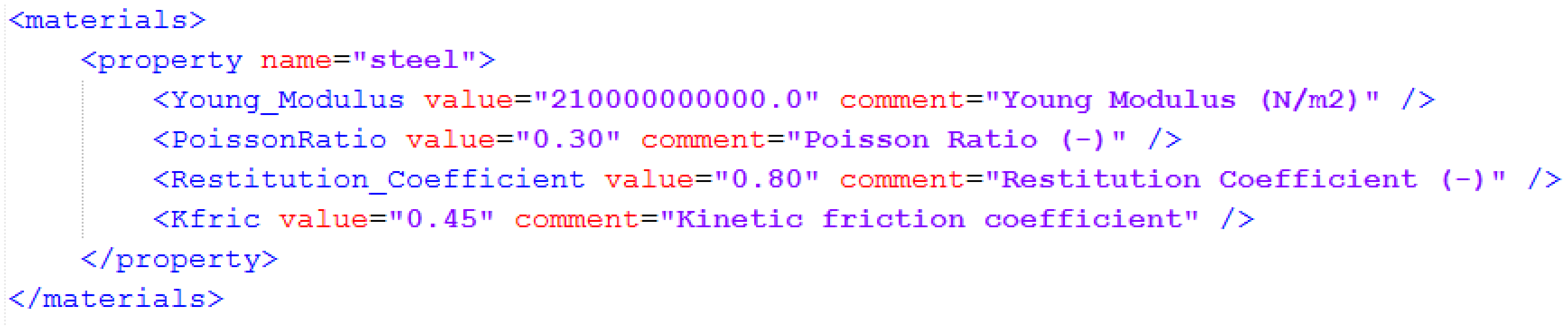
CASEDEF-FLOATINGS

DEFINING FLOATINGS



```
<floatings>
    <floating mkbound="9" relativeweight="2" property="steel + userdef01" />
    <floating mkbound="10-79" relativeweight="0.50" property="pvc" />
</floatings>
<properties>
    <propertyfile file="Floating_Materials.xml" path="materials" />
    <property name="userdef01" Restitution_Coefficient_User="0.70"
              comment="User redefinition for Restitution Coefficient (-)" />
    <links>
        <link mkbound="0" property="steel + userdef01" comment="Property for the tank"/>
    </links>
</properties>
```

When the interaction of solids (boundaries or floatings) is computed using **Discrete Element Method (DEM)** some extra properties with parameters used in DEM are loaded from **“Floating_Materials.xml”:**

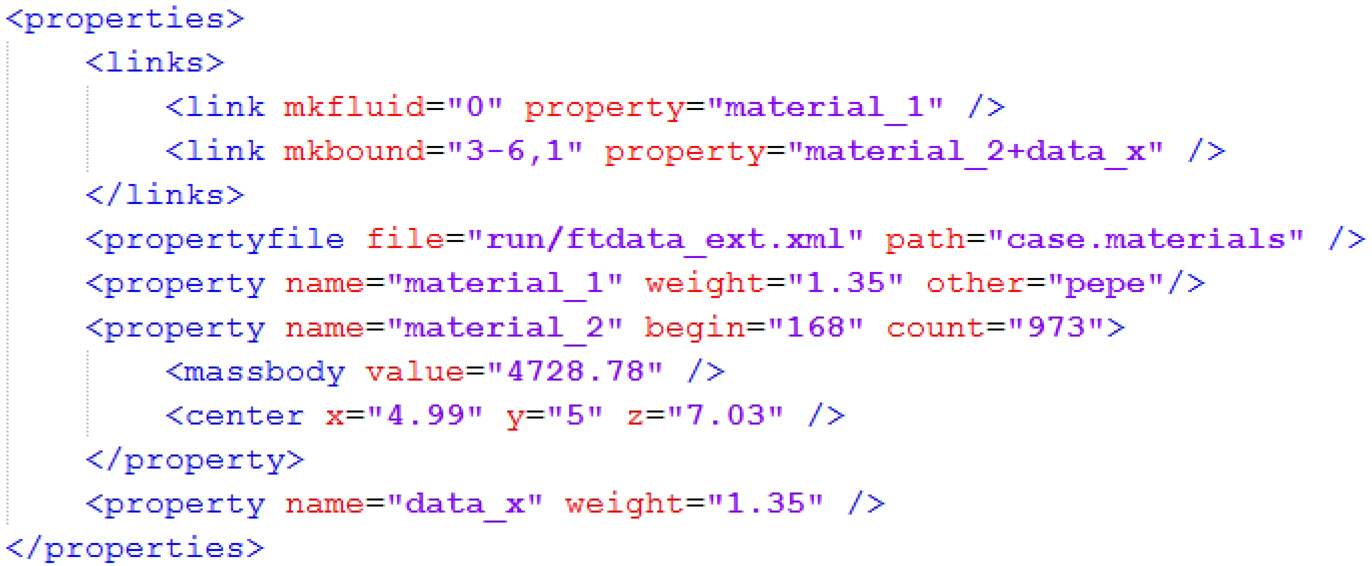


```
<materials>
    <property name="steel">
        <Young_Modulus value="210000000000.0" comment="Young Modulus (N/m2)" />
        <PoissonRatio value="0.30" comment="Poisson Ratio (-)" />
        <Restitution_Coefficient value="0.80" comment="Restitution Coefficient (-)" />
        <Kfric value="0.45" comment="Kinetic friction coefficient" />
    </property>
</materials>
```

CASEDEF-PROPERTIES

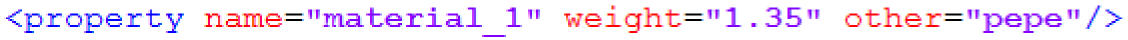
DEFINING OTHER VARIABLES

Using section ***properties***, users can define variables to be assigned to one or more ***mk***.



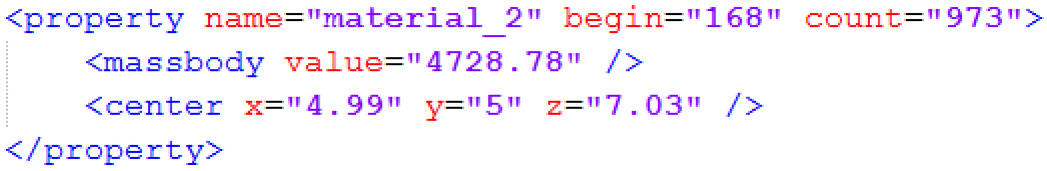
```
<properties>
    <links>
        <link mkfluid="0" property="material_1" />
        <link mkbound="3-6,1" property="material_2+data_x" />
    </links>
    <propertyfile file="run/ftdata_ext.xml" path="case.materials" />
    <property name="material_1" weight="1.35" other="pepe"/>
    <property name="material_2" begin="168" count="973">
        <massbody value="4728.78" />
        <center x="4.99" y="5" z="7.03" />
    </property>
    <property name="data_x" weight="1.35" />
</properties>
```

Each label of ***property*** has a name and can group several values that can be text (***other***) or a number (***weight***)



```
<property name="material_1" weight="1.35" other="pepe"/>
```

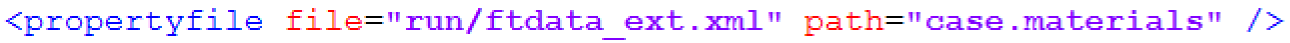
or other subvalues (***massbody*** and ***center***)



```
<property name="material_2" begin="168" count="973">
    <massbody value="4728.78" />
    <center x="4.99" y="5" z="7.03" />
</property>
```

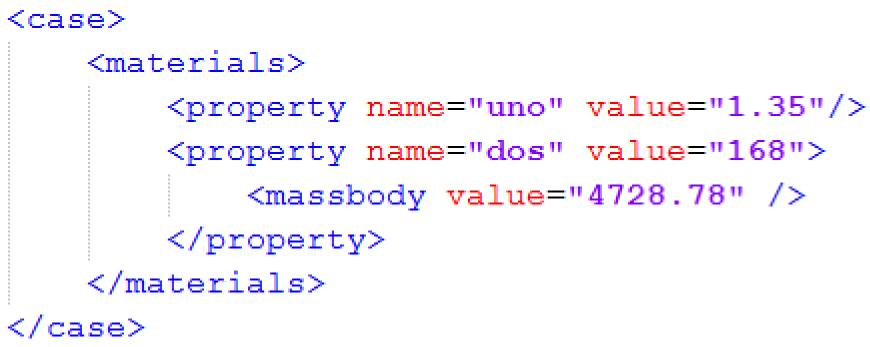
CASEDEF-PROPERTIES

These properties can be loaded from an external file using ***propertyfile.***
In this case, users have to indicate file name and path to access section with properties.



```
<propertyfile file="run/ftdata_ext.xml" path="case.materials" />
```

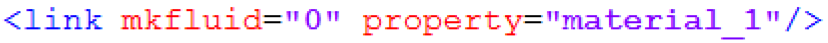
Example of file “ftdata_ext.xml”:



```
<case>
    <materials>
        <property name="uno" value="1.35"/>
        <property name="dos" value="168">
            <massbody value="4728.78" />
        </property>
    </materials>
</case>
```

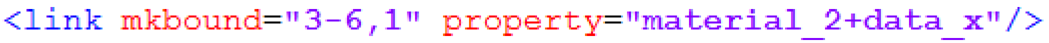
Section ***links*** assigns one or more ***property*** to one or several values of ***mk***:

- Values of ***material_1*** are assigned to fluid particles with ***mk***=0



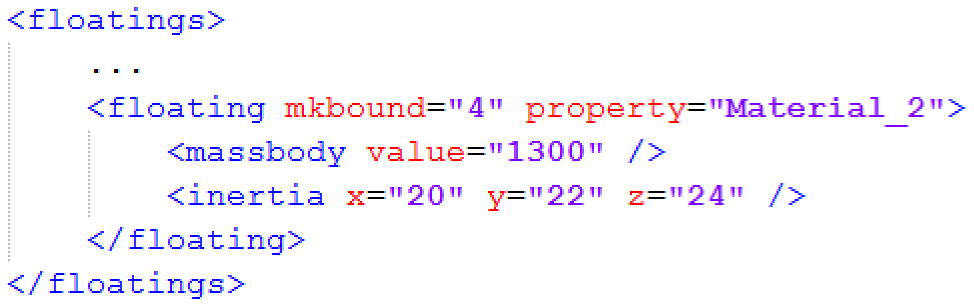
```
<link mkfluid="0" property="material_1"/>
```

- Values of ***material_2*** and ***data_x*** are assigned to boundary particles with ***mk***=1,3,4,5,6



```
<link mkbound="3-6,1" property="material_2+data_x"/>
```

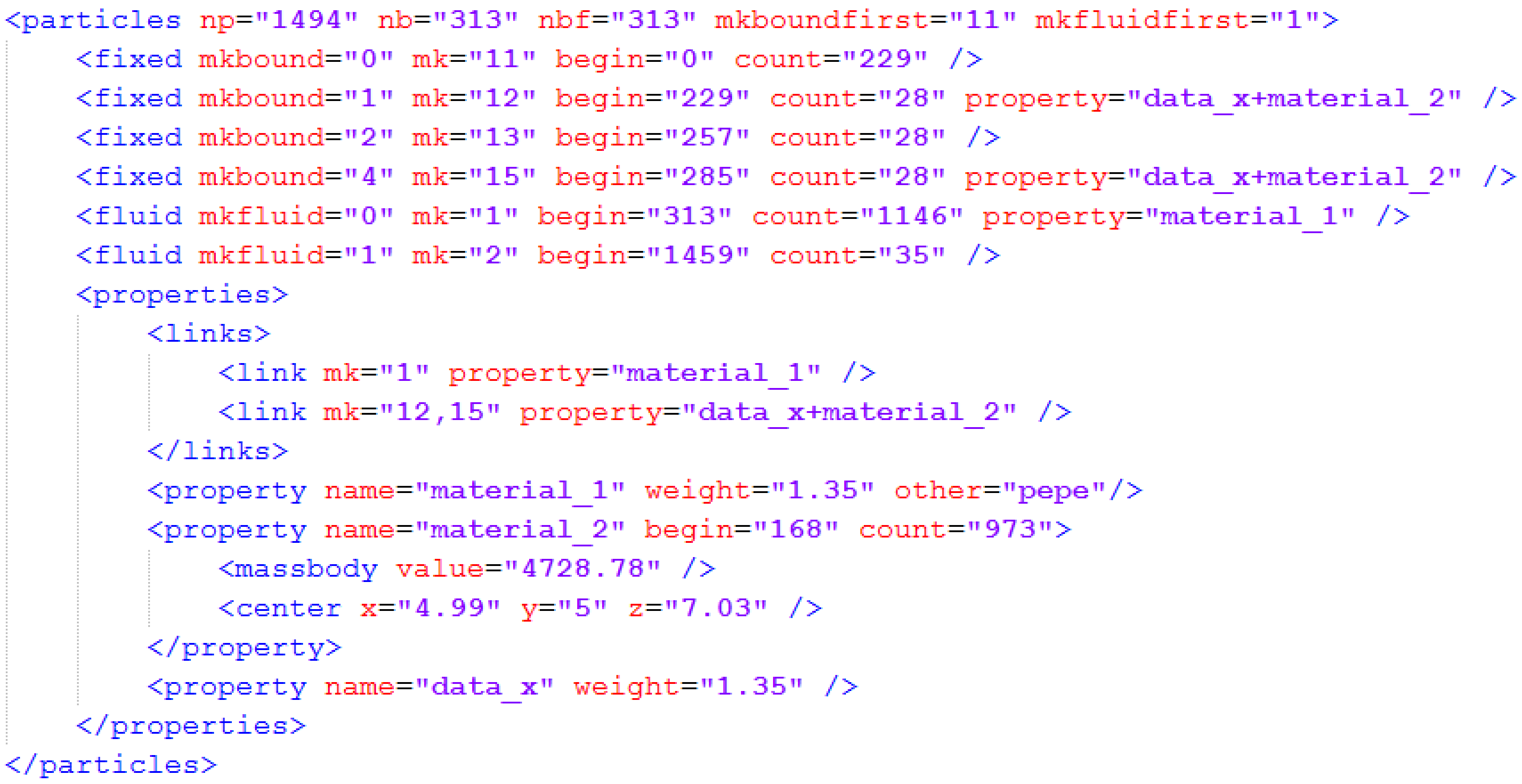
It is also possible to indicate one ***property*** directly in the definition of the ***floatings***:



```
<floatings>
    ...
    <floating mkbound="4" property="Material_2">
        <massbody value="1300" />
        <inertia x="20" y="22" z="24" />
    </floating>
</floatings>
```

CASEDEF-PROPERTIES

GenCase reads the information from ***case.casedef.properties*** and writes in ***case.execution.particles.properties***.

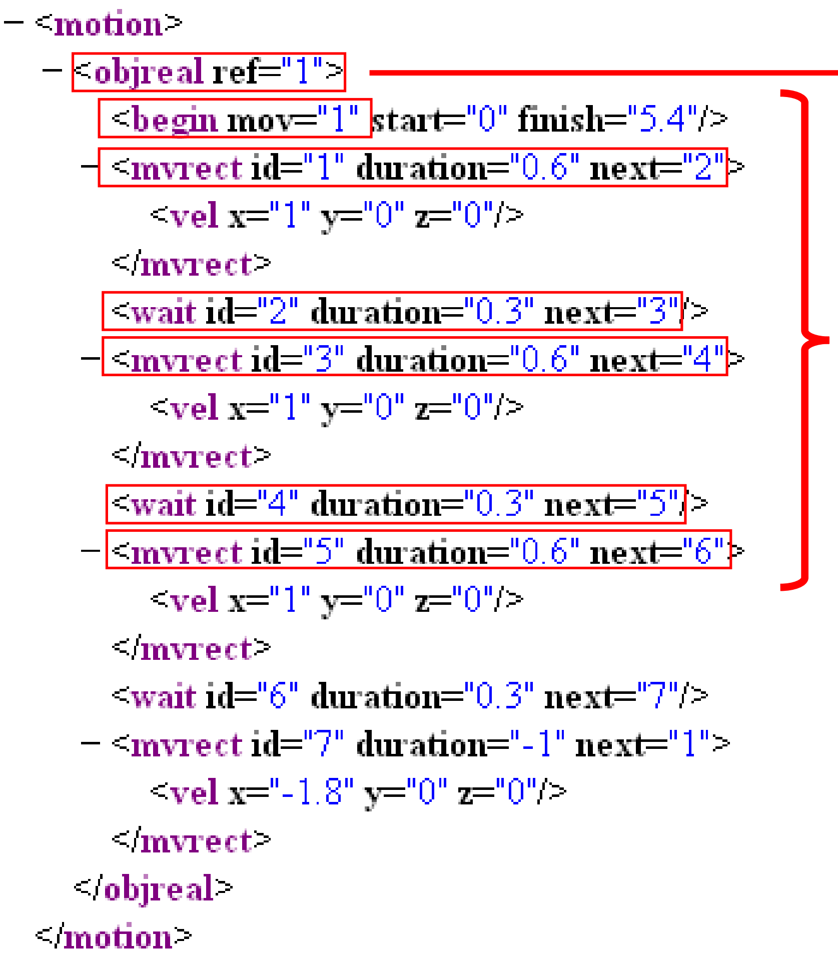


```xml
<particles np="1494" nb="313" nbf="313" mkboundfirst="11" mkfluidfirst="1">
    <fixed mkbound="0" mk="11" begin="0" count="229" />
    <fixed mkbound="1" mk="12" begin="229" count="28" property="data_x+material_2" />
    <fixed mkbound="2" mk="13" begin="257" count="28" />
    <fixed mkbound="4" mk="15" begin="285" count="28" property="data_x+material_2" />
    <fluid mkfluid="0" mk="1" begin="313" count="1146" property="material_1" />
    <fluid mkfluid="1" mk="2" begin="1459" count="35" />
    <properties>
        <links>
            <link mk="1" property="material_1" />
            <link mk="12,15" property="data_x+material_2" />
        </links>
        <property name="material_1" weight="1.35" other="pepe"/>
        <property name="material_2" begin="168" count="973">
            <massbody value="4728.78" />
            <center x="4.99" y="5" z="7.03" />
        </property>
        <property name="data_x" weight="1.35" />
    </properties>
</particles>
```

Thus, ***DualSPHysics*** can access to assigned values to each ***mk***.
The object of type JSpaceParts is used to obtain the assigned properties to each block of particles

CASEDEF-MOTION

•*Motion01*: uniform rectilinear motion (**<mvrect />**) that also includes pauses (**<wait />**)



```
- <motion>
  - <objreal ref="1">
      <begin mov="1" start="0" finish="5.4"/>
    - <mvrect id="1" duration="0.6" next="2">
        <vel x="1" y="0" z="0"/>
      </mvrect>
      <wait id="2" duration="0.3" next="3"/>
    - <mvrect id="3" duration="0.6" next="4">
        <vel x="1" y="0" z="0"/>
      </mvrect>
      <wait id="4" duration="0.3" next="5"/>
    - <mvrect id="5" duration="0.6" next="6">
        <vel x="1" y="0" z="0"/>
      </mvrect>
      <wait id="6" duration="0.3" next="7"/>
    - <mvrect id="7" duration="-1" next="1">
        <vel x="-1.8" y="0" z="0"/>
      </mvrect>
    </objreal>
  </motion>
```

movement defined for the set of particles with *mk=1*

first mov=1 during 0.6s,
then wait=2 for 0.3s,
then mov=3 during 0.6s,
then wait=4 for 0.3s,
then mov=5 during 0.6s…

<mvrect>: uniform rectilinear movement

vel indicates the constant velocity vector

CASEDEF-MOTION

- *Motion01*: uniform rectilinear motion (<**mvrect** />) that also includes pauses (<**wait** />)

Time: 0.00 s

Time: 0.30 s

Time: 0.60 s

Time: 0.90 s

Time: 1.20 s

Time: 1.50 s

Time: 1.80 s

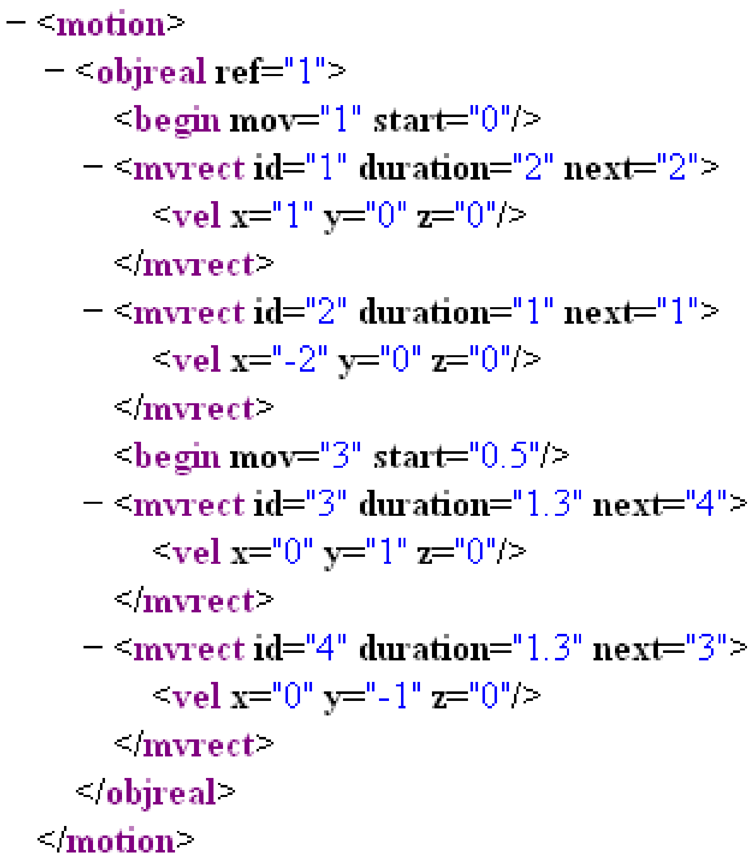
Time: 2.10 s

Time: 2.40 s

Time: 2.70 s

CASEDEF-MOTION

•*Motion02*: combination of two uniform rectilinear motions (**<mvrect />**)



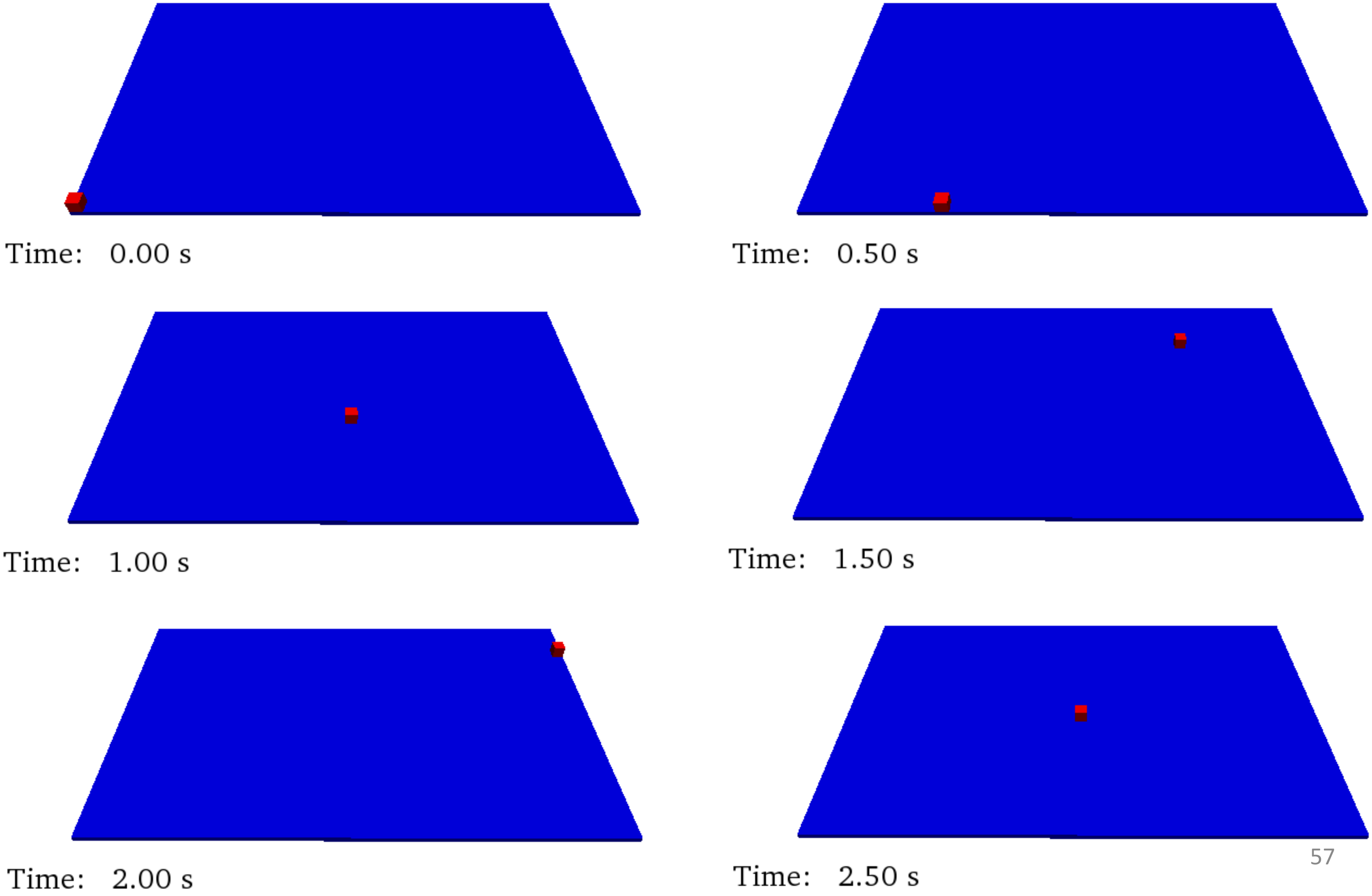
```
- <motion>
  - <objreal ref="1">
      <begin mov="1" start="0"/>
    - <mvrect id="1" duration="2" next="2">
        <vel x="1" y="0" z="0"/>
      </mvrect>
    - <mvrect id="2" duration="1" next="1">
        <vel x="-2" y="0" z="0"/>
      </mvrect>
      <begin mov="3" start="0.5"/>
    - <mvrect id="3" duration="1.3" next="4">
        <vel x="0" y="1" z="0"/>
      </mvrect>
    - <mvrect id="4" duration="1.3" next="3">
        <vel x="0" y="-1" z="0"/>
      </mvrect>
    </objreal>
  </motion>
```

<mvrect>: uniform rectilinear movement

vel indicates the constant velocity vector

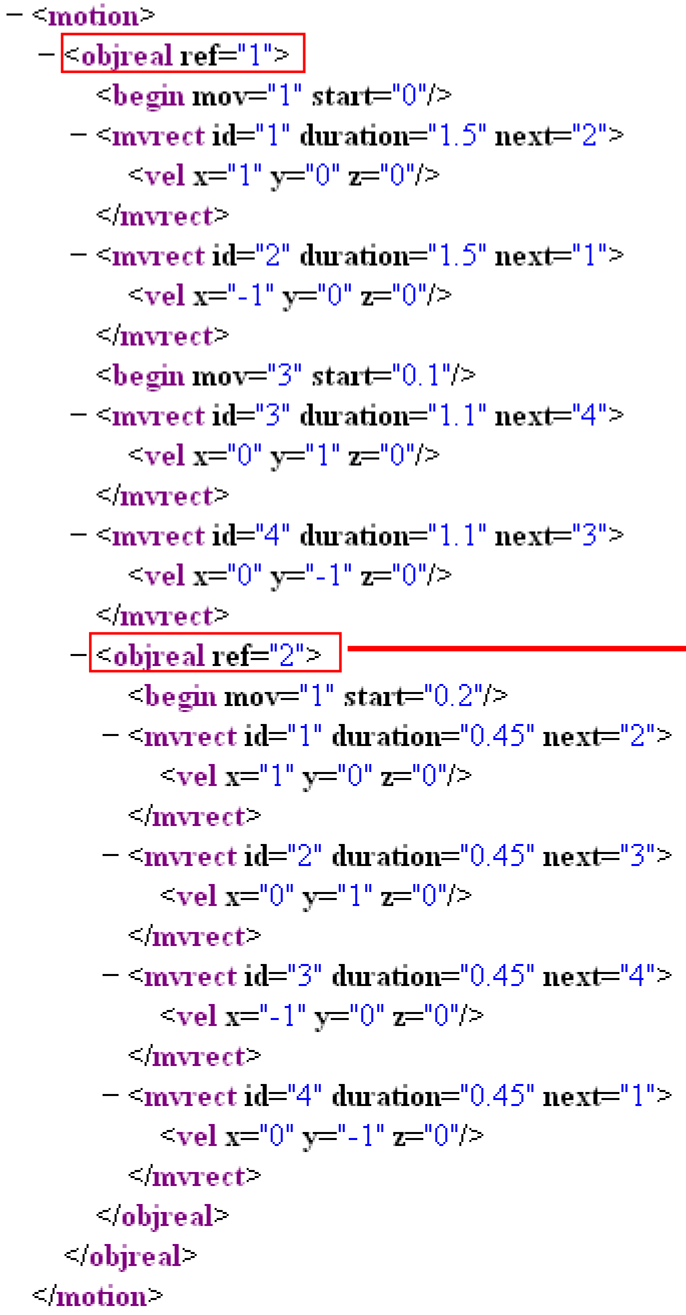
CASEDEF-MOTION

•*Motion02*: combination of two uniform rectilinear motions (<**mvrect** />)



CASEDEF-MOTION

- *Motion03*: movement of an object depending on the movement of another (hierarchy of objects)

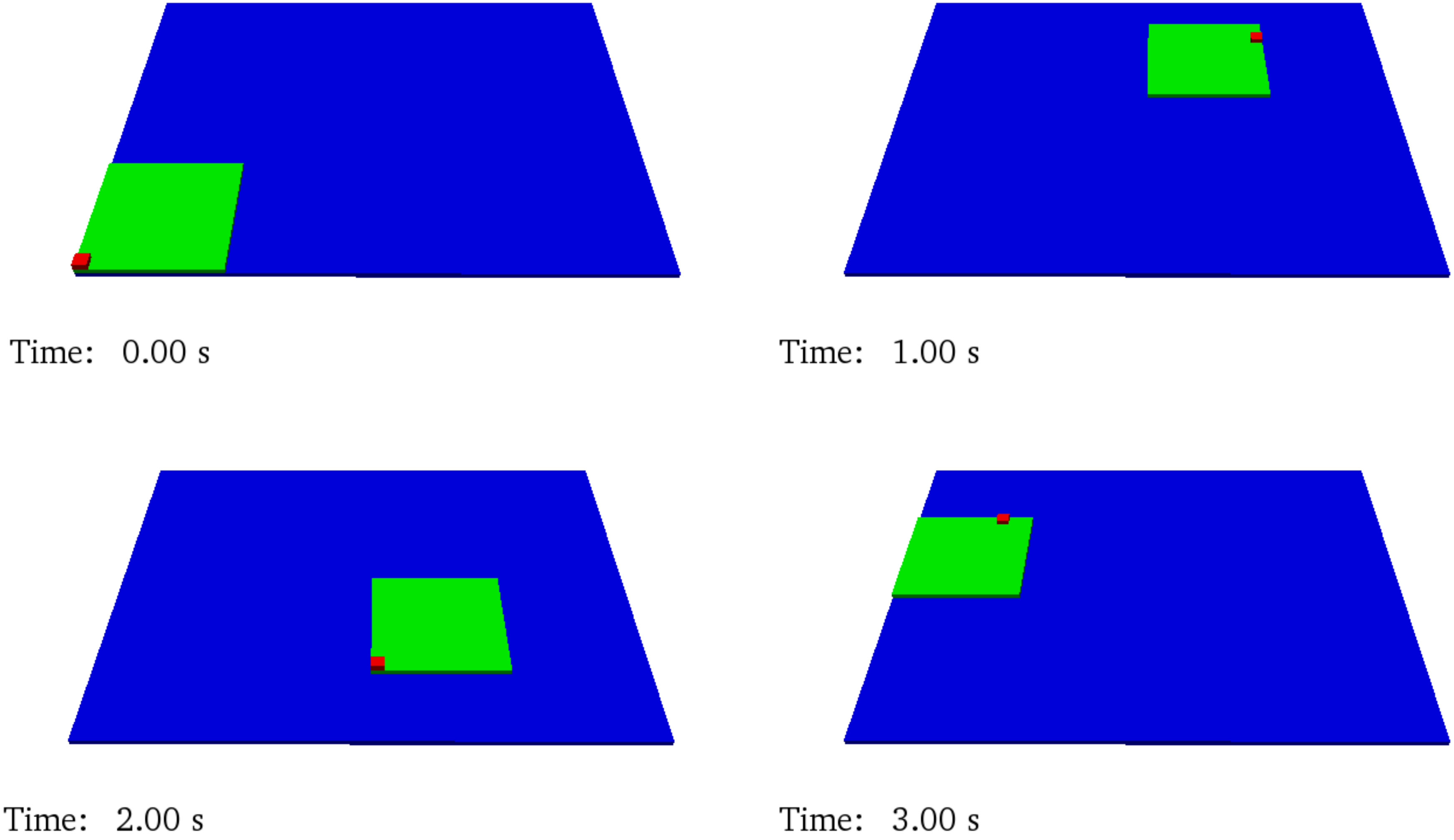


```
- <motion>
  - <objreal ref="1">
      <begin mov="1" start="0"/>
    - <mvrect id="1" duration="1.5" next="2">
        <vel x="1" y="0" z="0"/>
      </mvrect>
    - <mvrect id="2" duration="1.5" next="1">
        <vel x="-1" y="0" z="0"/>
      </mvrect>
      <begin mov="3" start="0.1"/>
    - <mvrect id="3" duration="1.1" next="4">
        <vel x="0" y="1" z="0"/>
      </mvrect>
    - <mvrect id="4" duration="1.1" next="3">
        <vel x="0" y="-1" z="0"/>
      </mvrect>
    -<objreal ref="2">
        <begin mov="1" start="0.2"/>
      - <mvrect id="1" duration="0.45" next="2">
          <vel x="1" y="0" z="0"/>
        </mvrect>
      - <mvrect id="2" duration="0.45" next="3">
          <vel x="0" y="1" z="0"/>
        </mvrect>
      - <mvrect id="3" duration="0.45" next="4">
          <vel x="-1" y="0" z="0"/>
        </mvrect>
      - <mvrect id="4" duration="0.45" next="1">
          <vel x="0" y="-1" z="0"/>
        </mvrect>
      </objreal>
    </objreal>
  </motion>
```

movement defined for the set of particles with *mk=2* that also moves according to the movement defined for *mk=1*

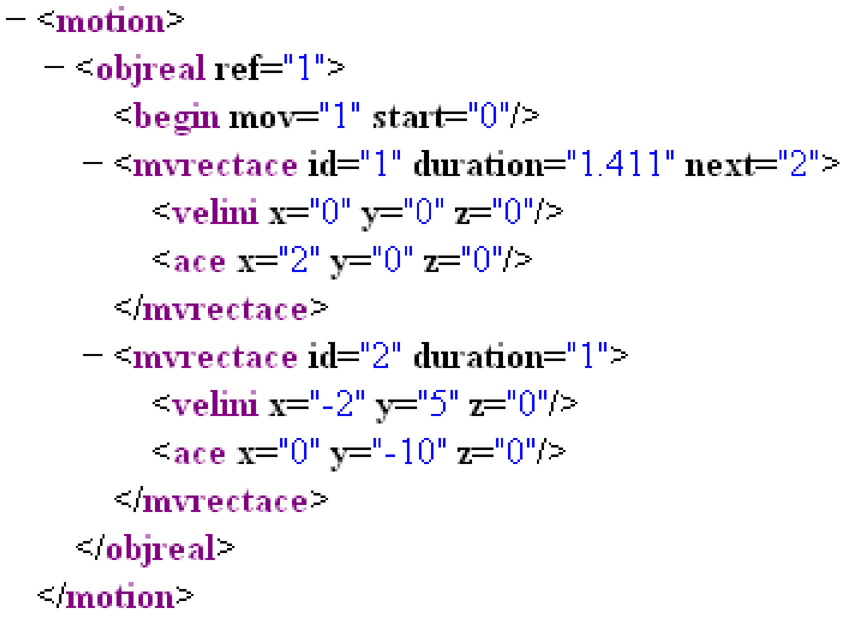
CASEDEF-MOTION

- *Motion03*: movement of an object depending on the movement of another (hierarchy of objects)



CASEDEF-MOTION

•*Motion04*: accelerated rectilinear motion (<**mvrectace** />)



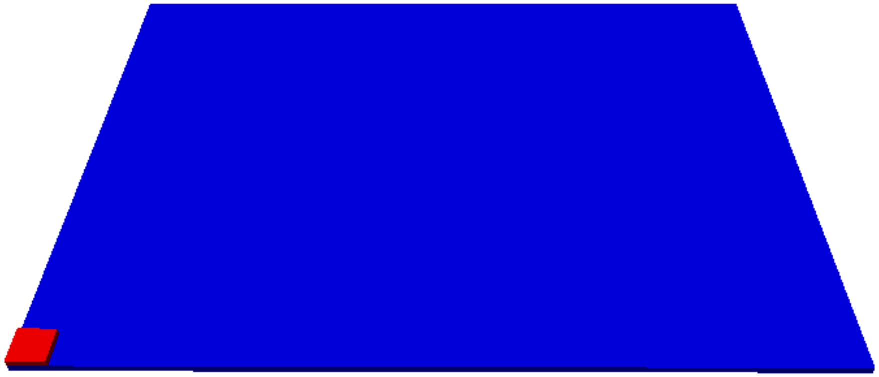
```
– <motion>
  – <objreal ref="1">
      <begin mov="1" start="0"/>
    – <mvrectace id="1" duration="1.411" next="2">
        <velini x="0" y="0" z="0"/>
        <ace x="2" y="0" z="0"/>
      </mvrectace>
    – <mvrectace id="2" duration="1">
        <velini x="-2" y="5" z="0"/>
        <ace x="0" y="-10" z="0"/>
      </mvrectace>
    </objreal>
  </motion>
```

<mvrectace>: accelerated rectilinear movement

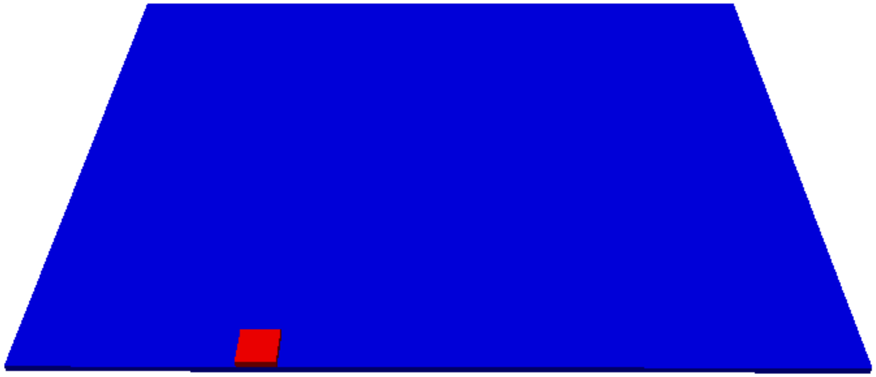
velini indicates the initial velocity vector
ace indicates the acceleration vector

CASEDEF-MOTION

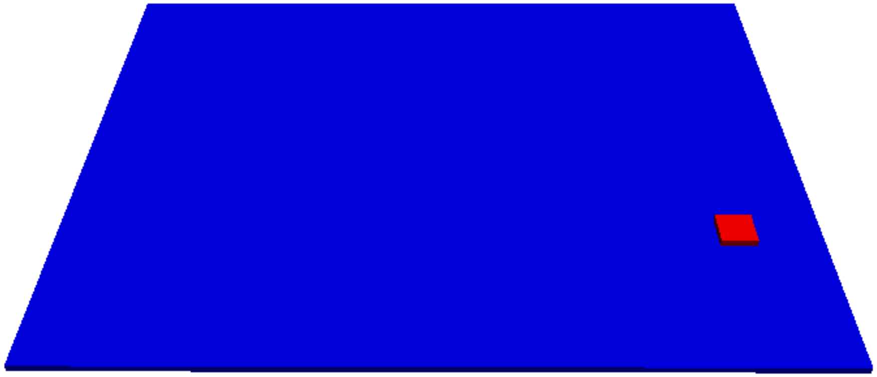
- *Motion04*: accelerated rectilinear motion (<**mvrectace** />)



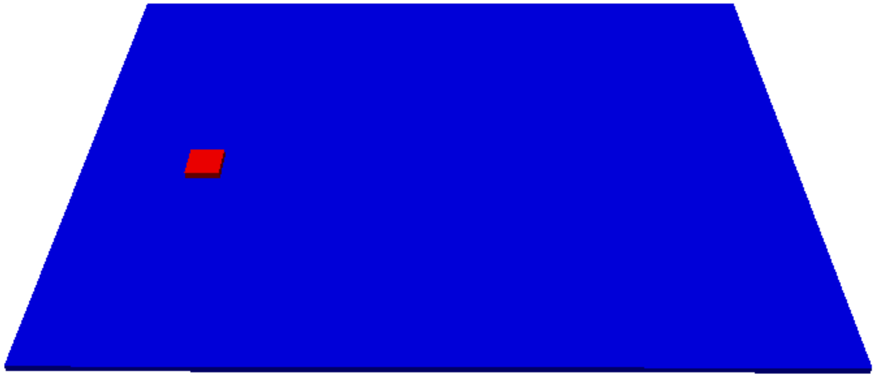
Time: 0.00 s



Time: 0.75 s



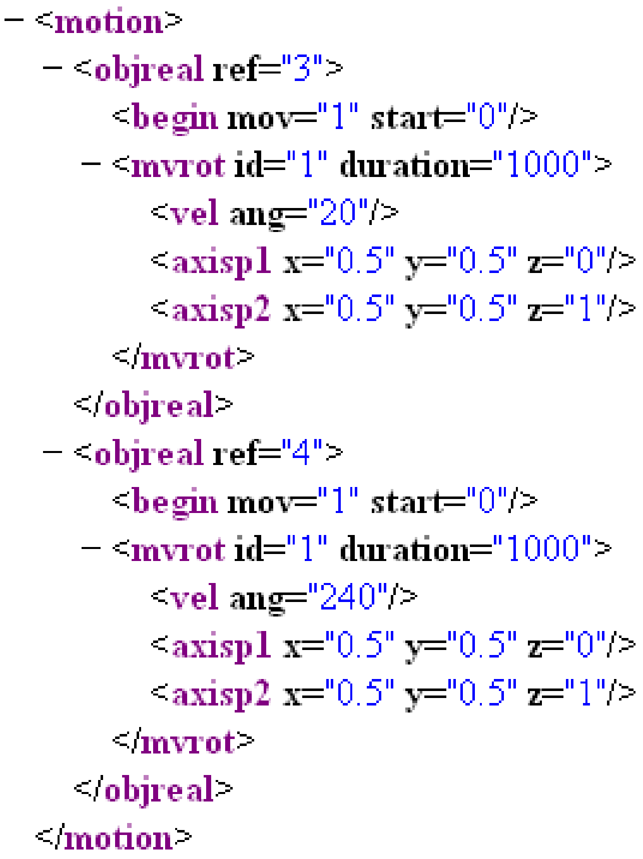
Time: 1.50 s



Time: 2.25 s

CASEDEF-MOTION

•*Motion05*: rotational motion (**<mvrot** />)



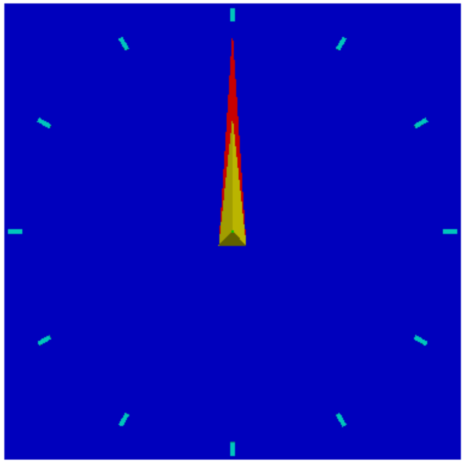
```
- <motion>
  - <objreal ref="3">
      <begin mov="1" start="0"/>
    - <mvrot id="1" duration="1000">
        <vel ang="20"/>
        <axisp1 x="0.5" y="0.5" z="0"/>
        <axisp2 x="0.5" y="0.5" z="1"/>
      </mvrot>
    </objreal>
  - <objreal ref="4">
      <begin mov="1" start="0"/>
    - <mvrot id="1" duration="1000">
        <vel ang="240"/>
        <axisp1 x="0.5" y="0.5" z="0"/>
        <axisp2 x="0.5" y="0.5" z="1"/>
      </mvrot>
    </objreal>
  </motion>
```

<mvrot>: rotational movement

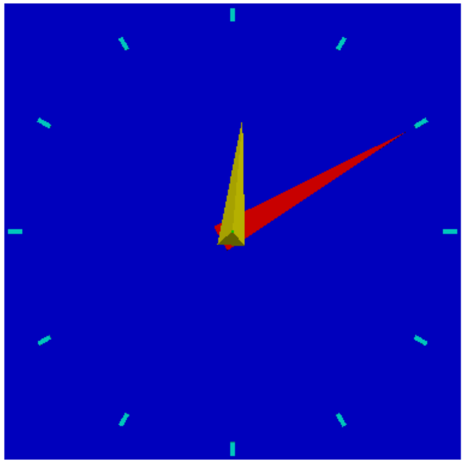
vel indicates the angular velocity
axisp1 first point of the rotation axis
axisp2 second point of the rotation axis

CASEDEF-MOTION

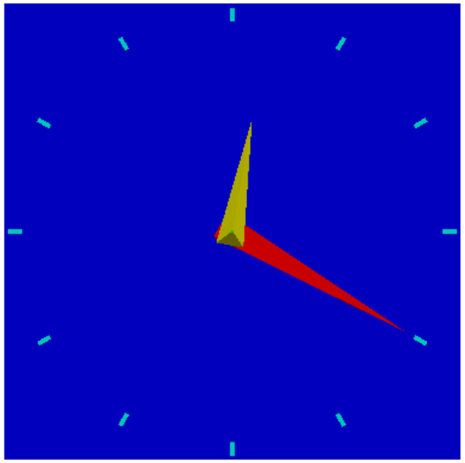
•*Motion05*: rotational motion (**<mvrot** />)



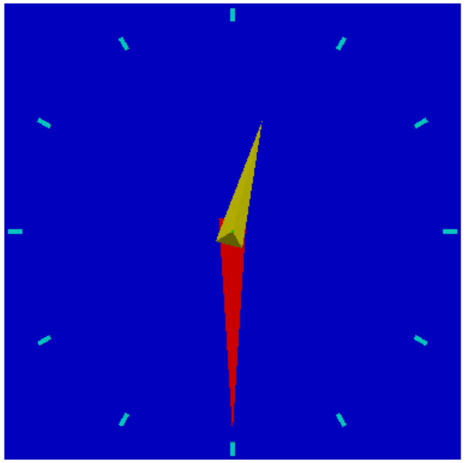
Time: 0.00 s



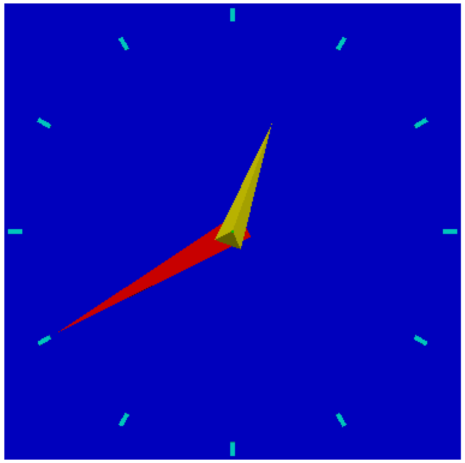
Time: 0.25 s



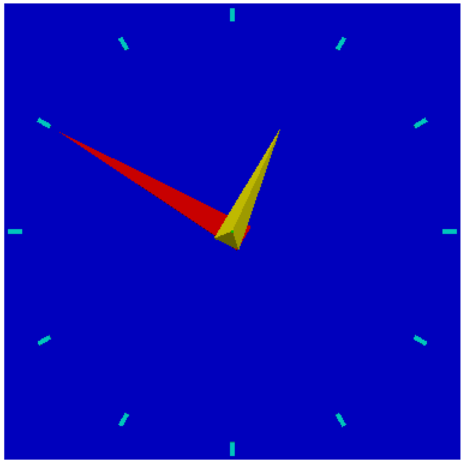
Time: 0.50 s



Time: 0.75 s



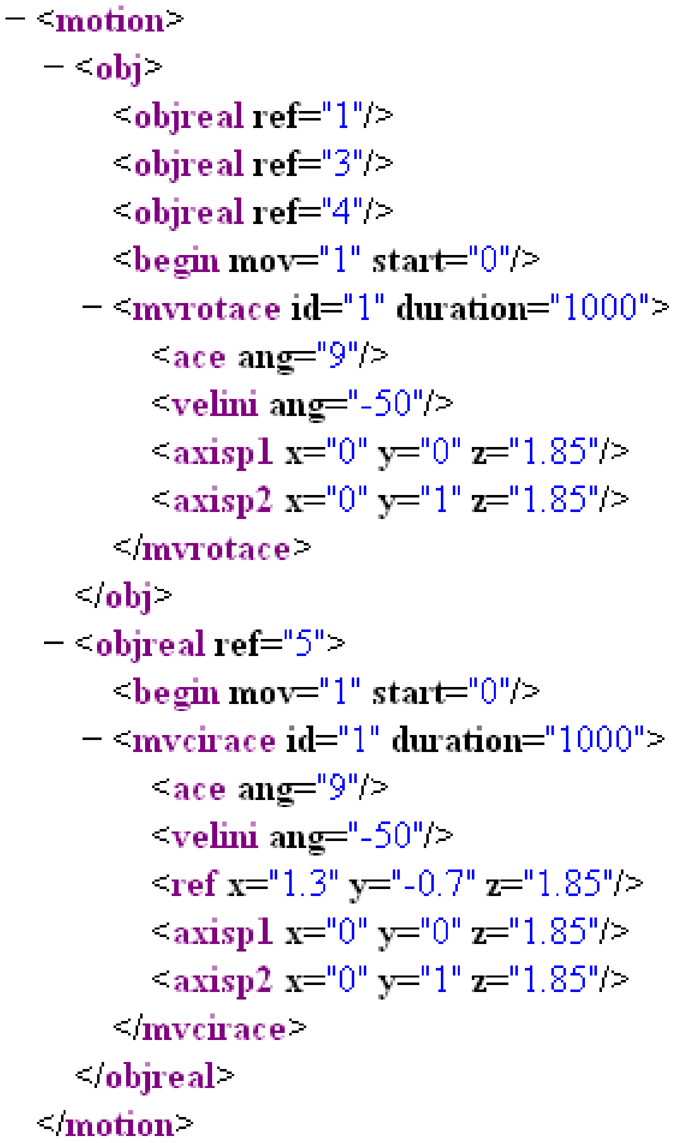
Time: 1.00 s



Time: 1.25 s

CASEDEF-MOTION

- *Motion06*: accelerated rotation motion (<**mvrotace** />) and accelerated circular motion (<**mvcirace />**).



```
- <motion>
  - <obj>
      <objreal ref="1"/>
      <objreal ref="3"/>
      <objreal ref="4"/>
      <begin mov="1" start="0"/>
    - <mvrotace id="1" duration="1000">
        <ace ang="9"/>
        <velini ang="-50"/>
        <axisp1 x="0" y="0" z="1.85"/>
        <axisp2 x="0" y="1" z="1.85"/>
      </mvrotace>
    </obj>
  - <objreal ref="5">
      <begin mov="1" start="0"/>
    - <mvcirace id="1" duration="1000">
        <ace ang="9"/>
        <velini ang="-50"/>
        <ref x="1.3" y="-0.7" z="1.85"/>
        <axisp1 x="0" y="0" z="1.85"/>
        <axisp2 x="0" y="1" z="1.85"/>
      </mvcirace>
    </objreal>
  </motion>
```

<mvrotace>: accelerated rotational movement

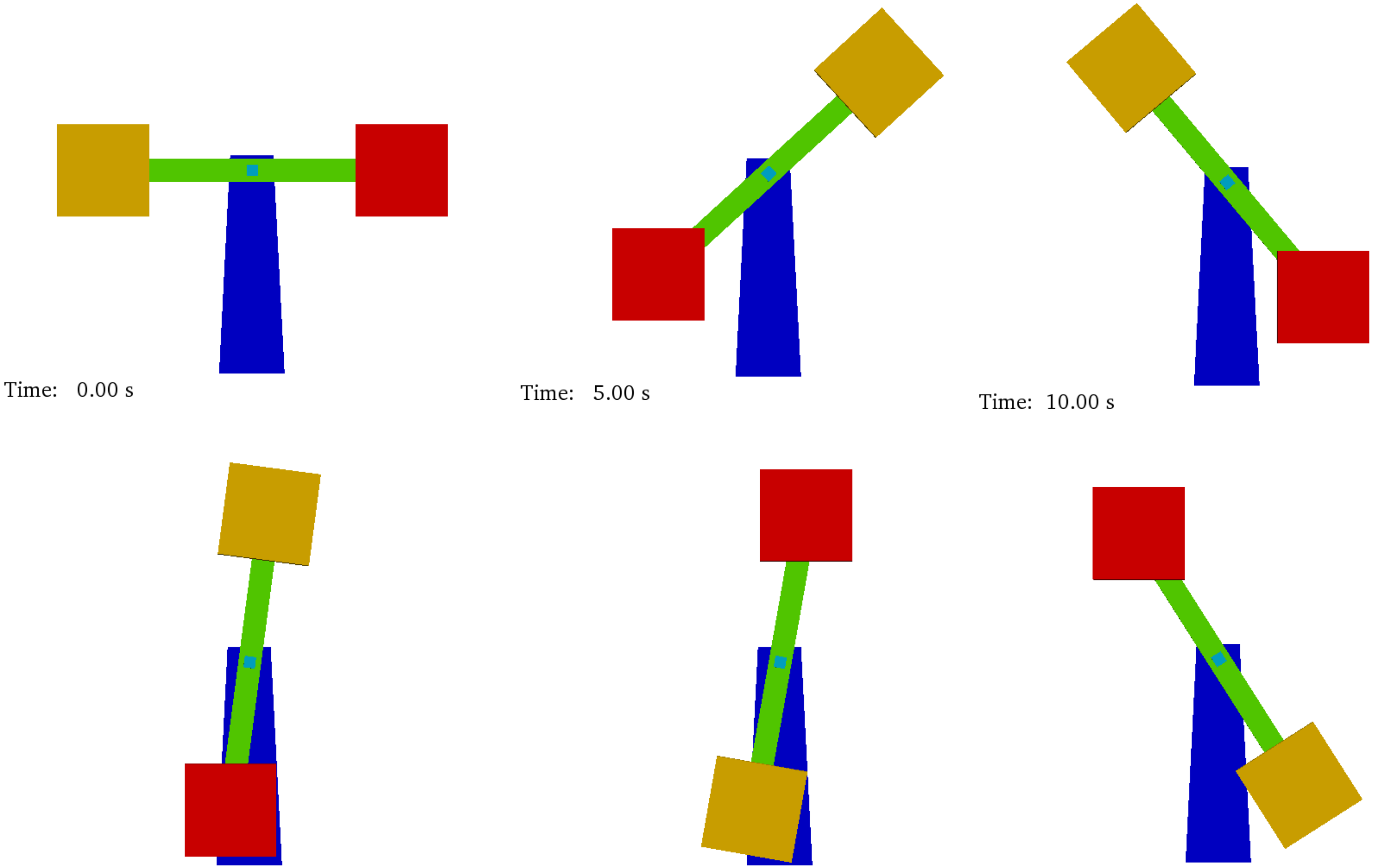
ace indicates the angular acceleration
velini indicates the initial angular velocity
axisp1 first point of the rotation axis
axisp2 second point of the rotation axis

<mvcirace>: accelerated circular movement

ace indicates the angular acceleration
ref indicates the point of the object that rotates with the axis
velini indicates the initial angular velocity
axisp1 first point of the rotation axis
axisp2 second point of the rotation axis

CASEDEF-MOTION

- *Motion06*: accelerated rotation motion (**<mvrotace** />) and accelerated circular motion (<**mvcirace />**).



Time: 0.00 s

Time: 5.00 s

Time: 10.00 s

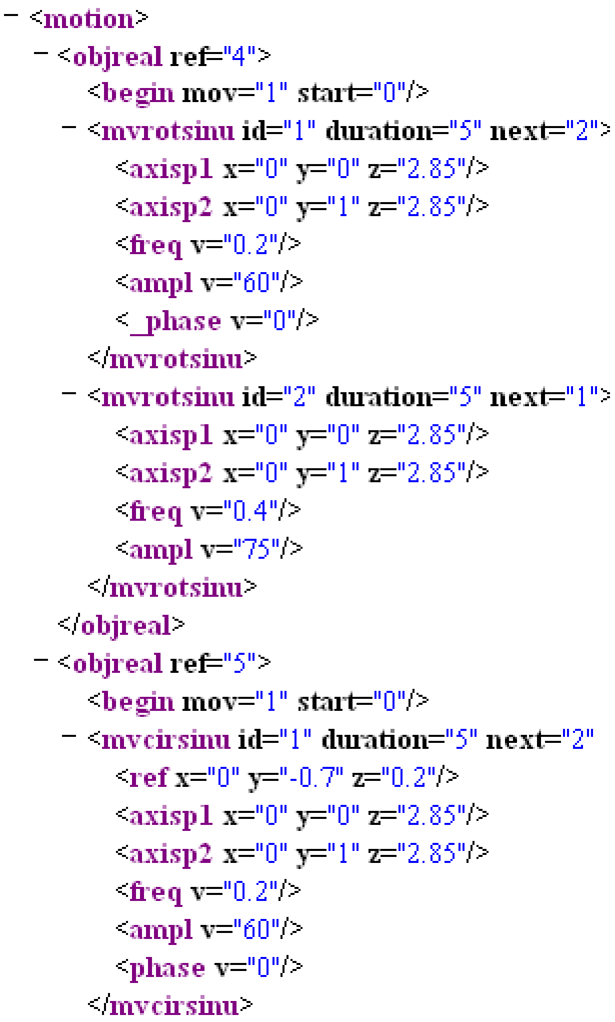
Time: 15.00 s

Time: 20.00 s

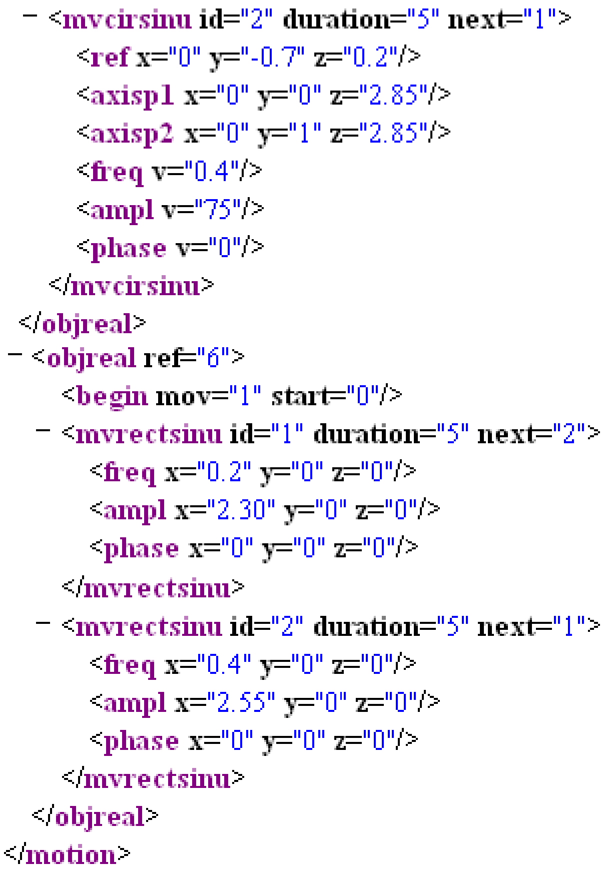
Time: 25.00 s

CASEDEF-MOTION

•*Motion07*: sinusoidal movement (**<mvrectsinu />, <mvrotsinu />, <mvcirsinu />**)



```
- <motion>
  - <objreal ref="4">
      <begin mov="1" start="0"/>
    - <mvrotsinu id="1" duration="5" next="2">
        <axisp1 x="0" y="0" z="2.85"/>
        <axisp2 x="0" y="1" z="2.85"/>
        <freq v="0.2"/>
        <ampl v="60"/>
        <_phase v="0"/>
      </mvrotsinu>
    - <mvrotsinu id="2" duration="5" next="1">
        <axisp1 x="0" y="0" z="2.85"/>
        <axisp2 x="0" y="1" z="2.85"/>
        <freq v="0.4"/>
        <ampl v="75"/>
      </mvrotsinu>
    </objreal>
  - <objreal ref="5">
      <begin mov="1" start="0"/>
    - <mvcirsinu id="1" duration="5" next="2"
        <ref x="0" y="-0.7" z="0.2"/>
        <axisp1 x="0" y="0" z="2.85"/>
        <axisp2 x="0" y="1" z="2.85"/>
        <freq v="0.2"/>
        <ampl v="60"/>
        <phase v="0"/>
      </mvcirsinu>
```



```
    - <mvcirsinu id="2" duration="5" next="1">
        <ref x="0" y="-0.7" z="0.2"/>
        <axisp1 x="0" y="0" z="2.85"/>
        <axisp2 x="0" y="1" z="2.85"/>
        <freq v="0.4"/>
        <ampl v="75"/>
        <phase v="0"/>
      </mvcirsinu>
    </objreal>
  - <objreal ref="6">
      <begin mov="1" start="0"/>
    - <mvrectsinu id="1" duration="5" next="2">
        <freq x="0.2" y="0" z="0"/>
        <ampl x="2.30" y="0" z="0"/>
        <phase x="0" y="0" z="0"/>
      </mvrectsinu>
    - <mvrectsinu id="2" duration="5" next="1">
        <freq x="0.4" y="0" z="0"/>
        <ampl x="2.55" y="0" z="0"/>
        <phase x="0" y="0" z="0"/>
      </mvrectsinu>
    </objreal>
  </motion>
```

<mvrectsinu>: sinusoidal rectilinear movement

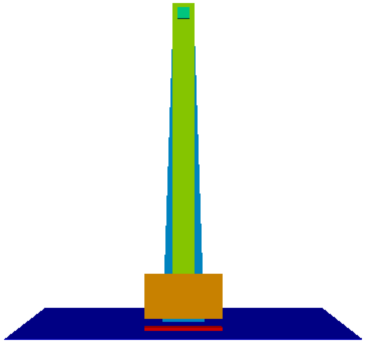
<mvrotsinu>: sinusoidal rotational movement

<mvcirsinu>: sinusoidal circular movement

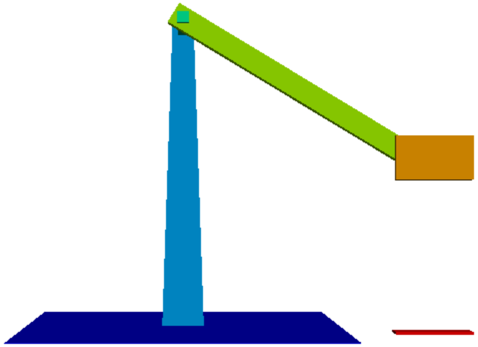
axisp1 first point of the rotation axis
axisp2 second point of the axis
freq frequency
ampl amplitude
phase phase

CASEDEF-MOTION

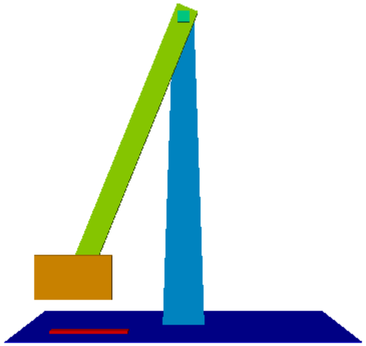
•*Motion07*: sinusoidal movement (**<mvrectsinu />, <mvrotsinu />, <mvcirsinu />**)



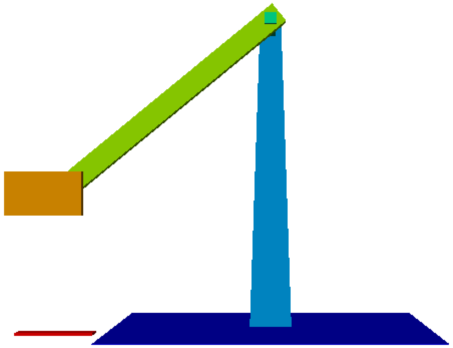
Time: 0.00 s



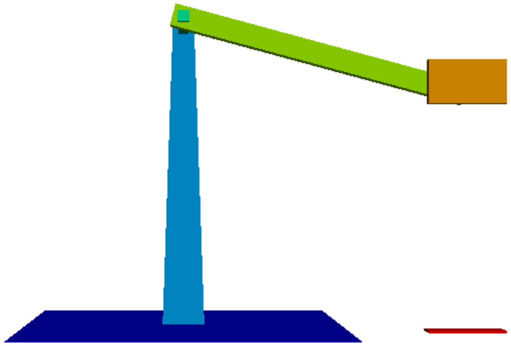
Time: 1.40 s



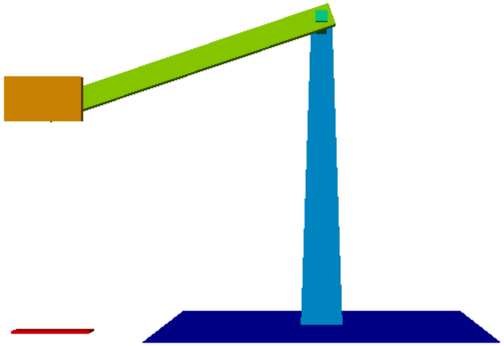
Time: 2.80 s



Time: 4.20 s



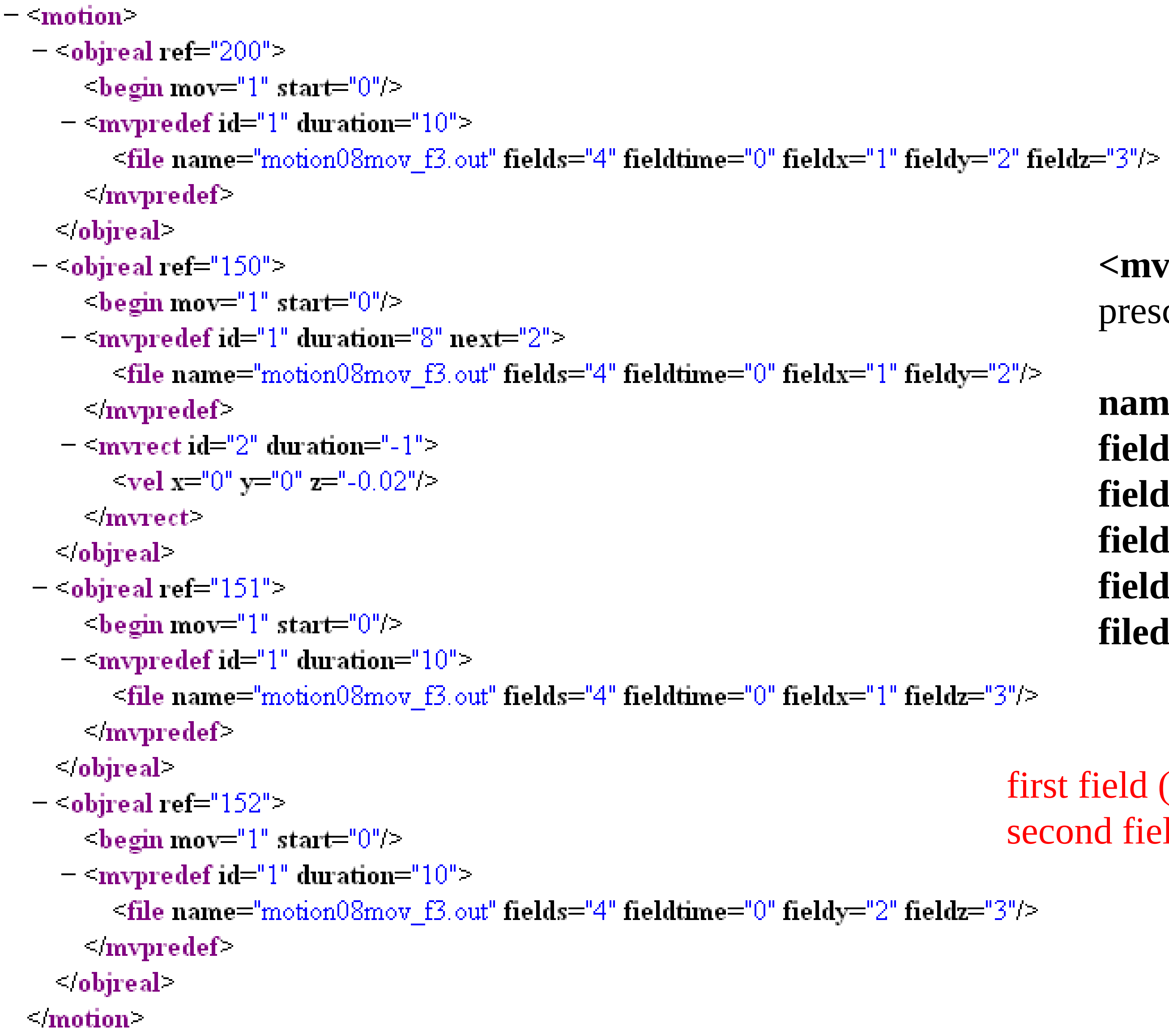
Time: 5.60 s



Time: 7.00 s

CASEDEF-MOTION

•*Motion08*: predefined movement with data from an external file (**<mvpredef /> or <mvfile />**)



```
- <motion>
  - <objreal ref="200">
      <begin mov="1" start="0"/>
    - <mvpredef id="1" duration="10">
        <file name="motion08mov_f3.out" fields="4" fieldtime="0" fieldx="1" fieldy="2" fieldz="3"/>
      </mvpredef>
    </objreal>
  - <objreal ref="150">
      <begin mov="1" start="0"/>
    - <mvpredef id="1" duration="8" next="2">
        <file name="motion08mov_f3.out" fields="4" fieldtime="0" fieldx="1" fieldy="2"/>
      </mvpredef>
    - <mvrect id="2" duration="-1">
        <vel x="0" y="0" z="-0.02"/>
      </mvrect>
    </objreal>
  - <objreal ref="151">
      <begin mov="1" start="0"/>
    - <mvpredef id="1" duration="10">
        <file name="motion08mov_f3.out" fields="4" fieldtime="0" fieldx="1" fieldz="3"/>
      </mvpredef>
    </objreal>
  - <objreal ref="152">
      <begin mov="1" start="0"/>
    - <mvpredef id="1" duration="10">
        <file name="motion08mov_f3.out" fields="4" fieldtime="0" fieldy="2" fieldz="3"/>
      </mvpredef>
    </objreal>
  </motion>
```

<mvpredef /> or <mvfile />:
prescribed motion loaded from a file

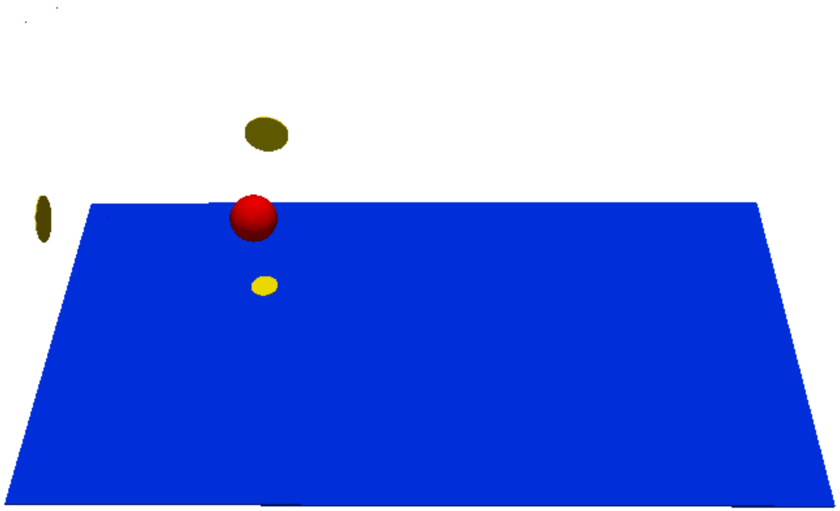
name name of the file
fields number of columns of the file
fieldtime column with time
fieldx column with X-position
fieldy column with Y-position
filedz column with Z-position

first field (or column) has reference "0"
second field (or column) has reference "1"

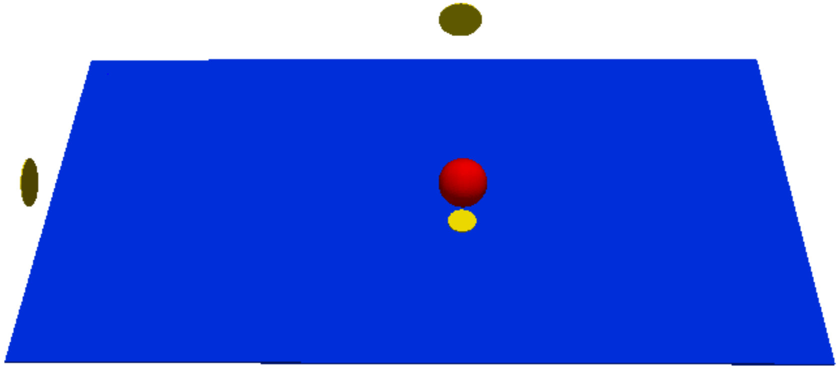
CASEDEF-MOTION

- *Motion08*: predefined movement with data from an external file (**<mvpredef /> or <mvfile />**)

Time: 0.00 s



Time: 3.00 s



Time: 6.00 s

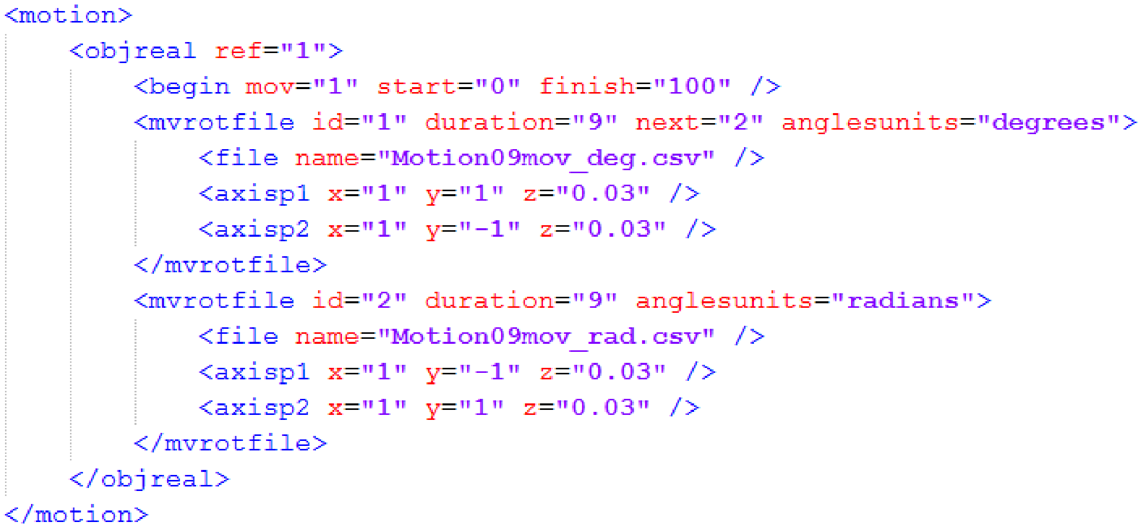
Time: 9.00 s

CASEDEF-MOTION

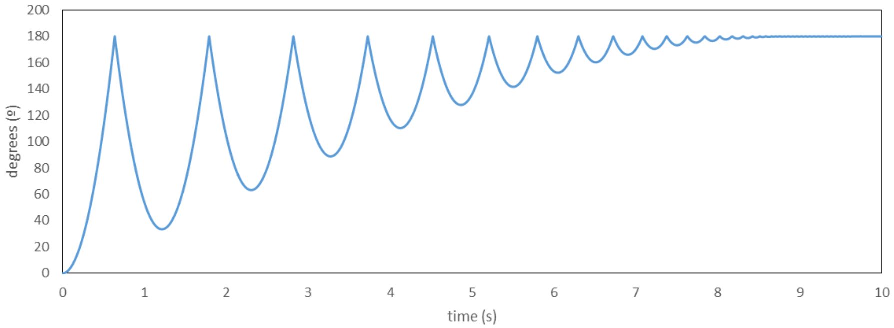
- *Motion09*: predefined movement with data from an external file (**<mvrotfile />**)

<mvrotfile />: prescribed motion loaded from a file *with degrees*

name name of the file
axisp1 & axisp2 two points to define the axis of rotation

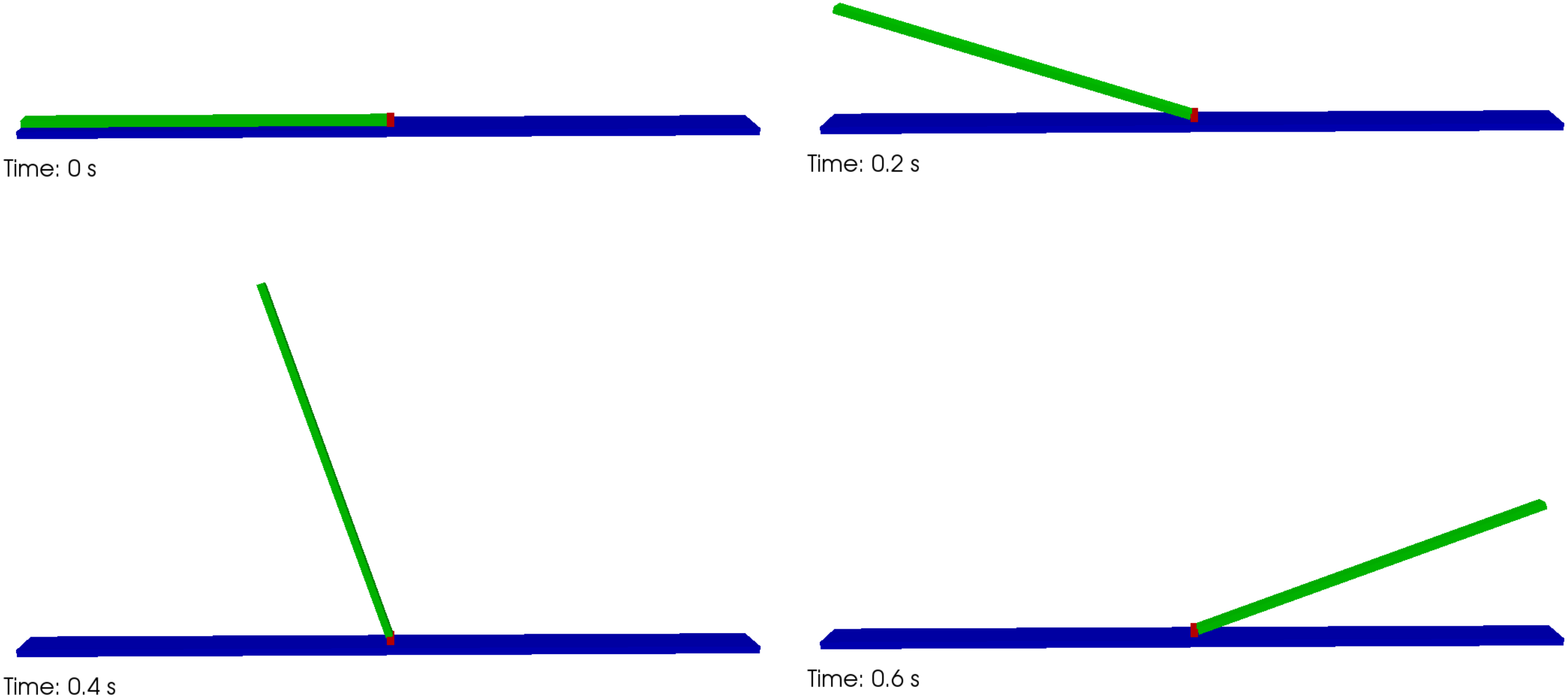


```xml
<motion>
    <objreal ref="1">
        <begin mov="1" start="0" finish="100" />
        <mvrotfile id="1" duration="9" next="2" anglesunits="degrees">
            <file name="Motion09mov_deg.csv" />
            <axisp1 x="1" y="1" z="0.03" />
            <axisp2 x="1" y="-1" z="0.03" />
        </mvrotfile>
        <mvrotfile id="2" duration="9" anglesunits="radians">
            <file name="Motion09mov_rad.csv" />
            <axisp1 x="1" y="-1" z="0.03" />
            <axisp2 x="1" y="1" z="0.03" />
        </mvrotfile>
    </objreal>
</motion>
```



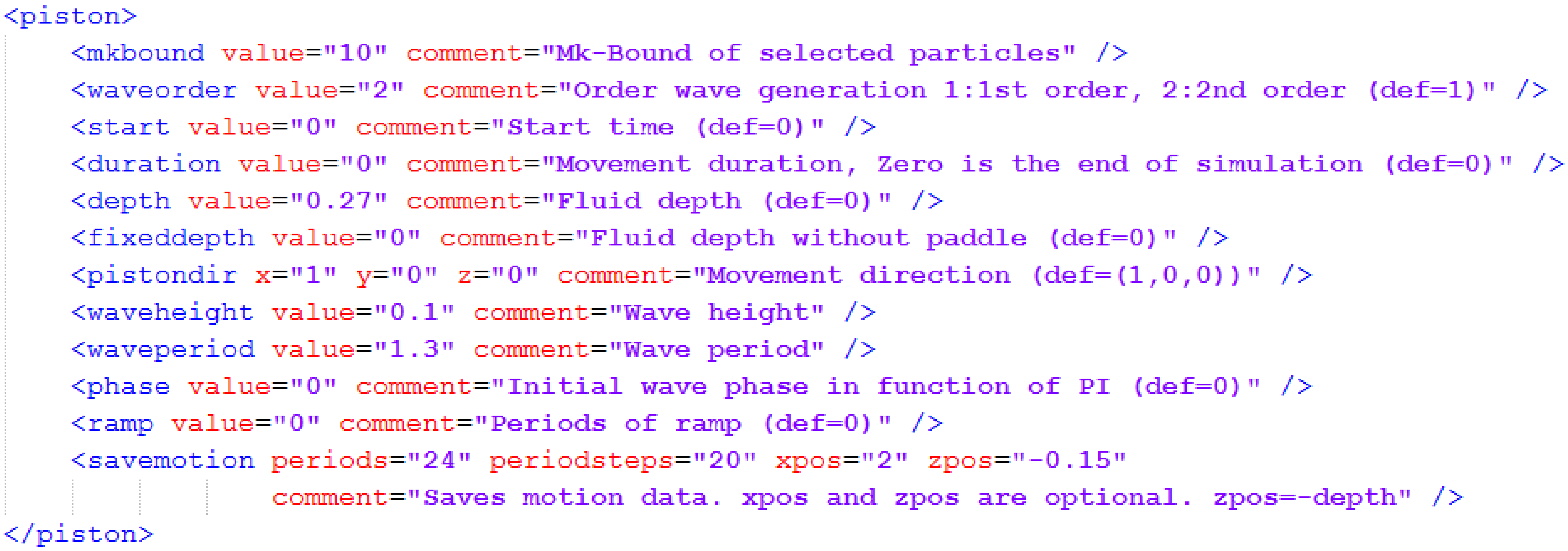
CASEDEF-MOTION

•*Motion09*: predefined movement with data from an external file (**<mvrotfile />**)



XML file EXECUTION-SPECIAL-WAVEPADDLES-PISTON

Generation of regular waves



```
<piston>
    <mkbound value="10" comment="Mk-Bound of selected particles" />
    <waveorder value="2" comment="Order wave generation 1:1st order, 2:2nd order (def=1)" />
    <start value="0" comment="Start time (def=0)" />
    <duration value="0" comment="Movement duration, Zero is the end of simulation (def=0)" />
    <depth value="0.27" comment="Fluid depth (def=0)" />
    <fixeddepth value="0" comment="Fluid depth without paddle (def=0)" />
    <pistondir x="1" y="0" z="0" comment="Movement direction (def=(1,0,0))" />
    <waveheight value="0.1" comment="Wave height" />
    <waveperiod value="1.3" comment="Wave period" />
    <phase value="0" comment="Initial wave phase in function of PI (def=0)" />
    <ramp value="0" comment="Periods of ramp (def=0)" />
    <savemotion periods="24" periodsteps="20" xpos="2" zpos="-0.15"
                comment="Saves motion data. xpos and zpos are optional. zpos=-depth" />
</piston>
```

- *waveorder*: order of wave generation (1st order or 2nd order)
- *depth*: depth at front of the piston
- *waveheight*: wave height H
- *waveperiod*: wave period T
- *ramp*: number of periods to smooth the movement of the piston
- *savemotion*: saves theoretical results of elevation and orbital velocities at xpos and zpos (being zpos=-depth of the measuring point)

XML file

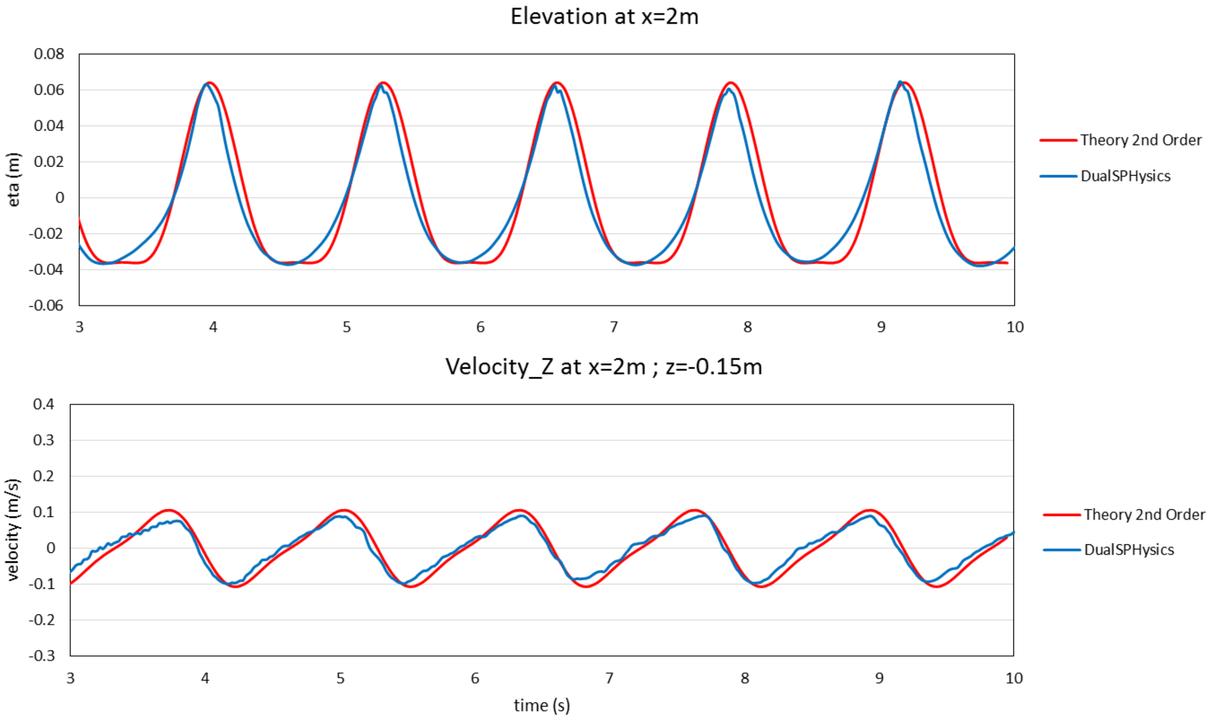
EXECUTION-SPECIAL-WAVEPADDLES-PISTON

Generation of regular waves

- *waveorder*: order of wave generation (1st order or 2nd order)
- *depth*: depth at front of the piston
- *waveheight*: wave height *H*
- *waveperiod*: wave period *T*
- *ramp*: number of periods to smooth the movement of the piston
- *savemotion*: saves theoretical results of elevation and orbital velocities at *xpos* and *zpos*

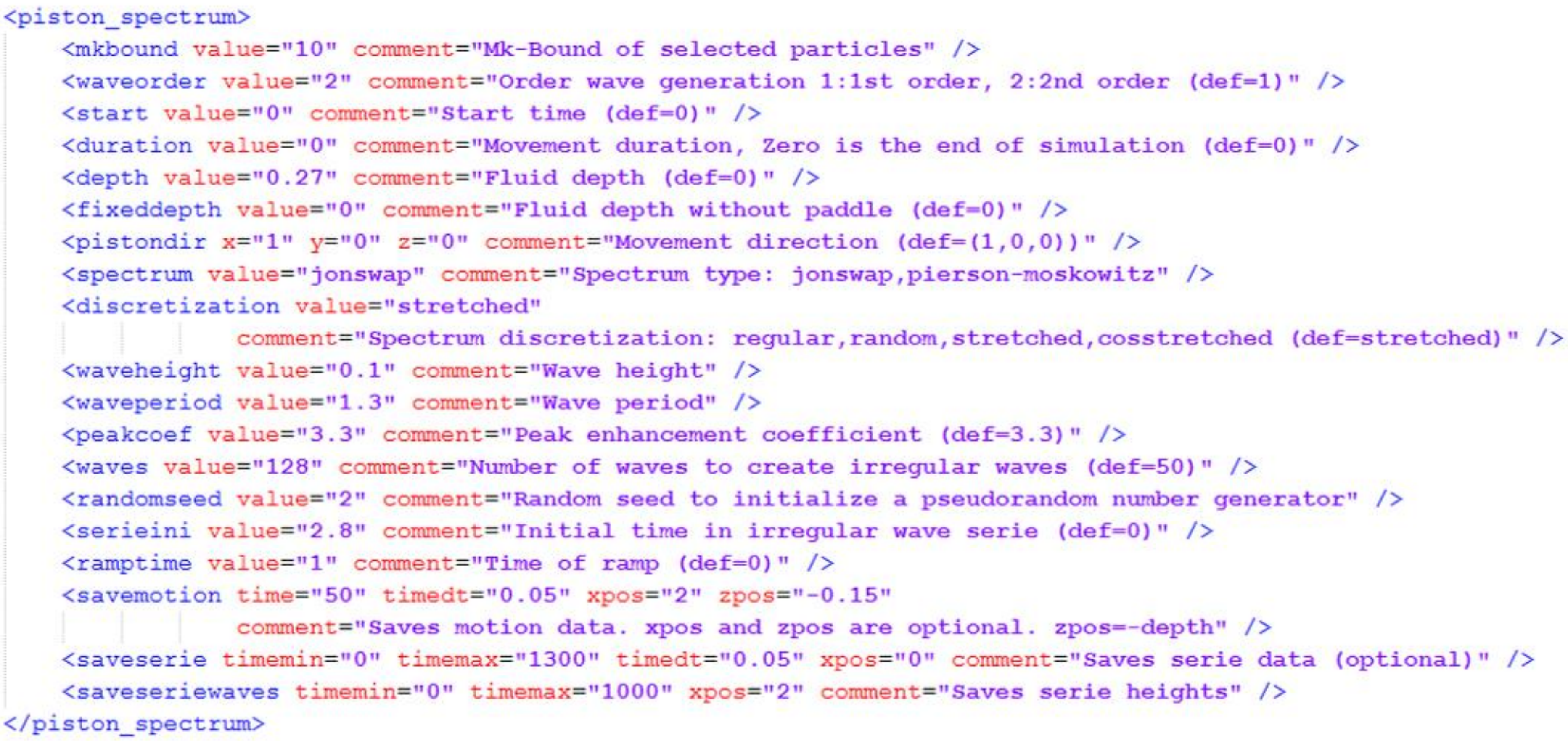
(being *zpos*=-*depth* of the measuring point)

```
<savemotion periods="24" periodsteps="20" xpos="2" zpos="-0.15" />
```



EXECUTION-SPECIAL-WAVEPADDLES-PISTON_SPECTRUM

Generation of irregular waves



```
<piston_spectrum>
    <mkbound value="10" comment="Mk-Bound of selected particles" />
    <waveorder value="2" comment="Order wave generation 1:1st order, 2:2nd order (def=1)" />
    <start value="0" comment="Start time (def=0)" />
    <duration value="0" comment="Movement duration, Zero is the end of simulation (def=0)" />
    <depth value="0.27" comment="Fluid depth (def=0)" />
    <fixeddepth value="0" comment="Fluid depth without paddle (def=0)" />
    <pistondir x="1" y="0" z="0" comment="Movement direction (def=(1,0,0))" />
    <spectrum value="jonswap" comment="Spectrum type: jonswap,pierson-moskowitz" />
    <discretization value="stretched"
                comment="Spectrum discretization: regular,random,stretched,cosstretched (def=stretched)" />
    <waveheight value="0.1" comment="Wave height" />
    <waveperiod value="1.3" comment="Wave period" />
    <peakcoef value="3.3" comment="Peak enhancement coefficient (def=3.3)" />
    <waves value="128" comment="Number of waves to create irregular waves (def=50)" />
    <randomseed value="2" comment="Random seed to initialize a pseudorandom number generator" />
    <serieini value="2.8" comment="Initial time in irregular wave serie (def=0)" />
    <ramptime value="1" comment="Time of ramp (def=0)" />
    <savemotion time="50" timedt="0.05" xpos="2" zpos="-0.15"
                comment="Saves motion data. xpos and zpos are optional. zpos=-depth" />
    <saveserie timemin="0" timemax="1300" timedt="0.05" xpos="0" comment="Saves serie data (optional)" />
    <saveseriewaves timemin="0" timemax="1000" xpos="2" comment="Saves serie heights" />
</piston_spectrum>
```

EXECUTION-SPECIAL-WAVEPADDLES-PISTON_SPECTRUM

Generation of irregular waves

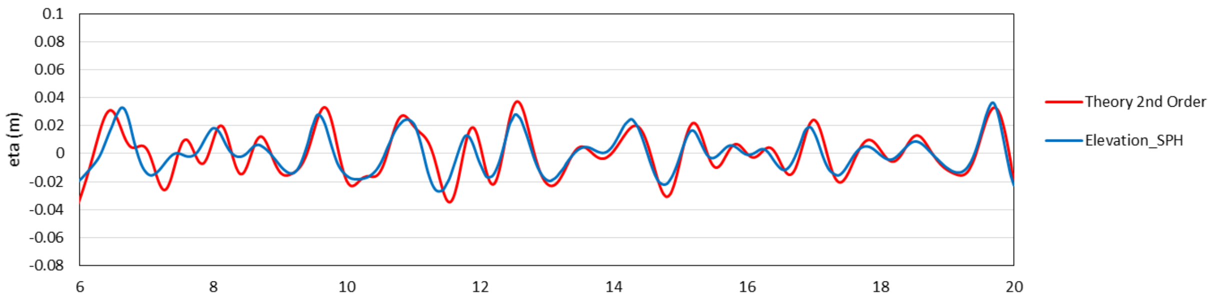
- *waveorder*: order of wave generation (1st order or 2nd order)
- *spectrum*: type of spectrum (Jonswap or Pierson-Moskowitz)
- *waveheight*: significant wave height H_s
- *waveperiod*: peak wave period T_p
- *serieini*: initial series of the irregular train is chosen from "WavePaddle_mkb0010_Serie.csv"
- *ramptime*: time to slowly start a smoothed movement of the piston

(being *zpos*=-*depth* of the measuring point)

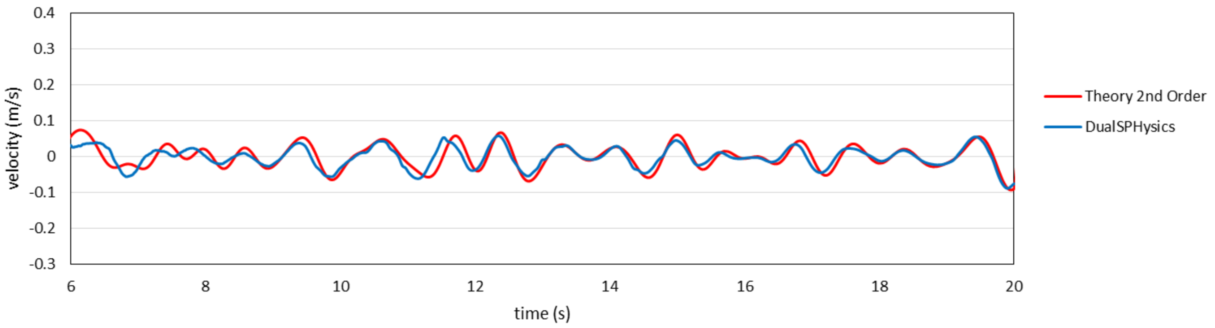
- *savemotion*: saves theoretical results of elevation and orbital velocities at *xpos* and *zpos*

```
<savemotion time="50" timedt="0.05" xpos="2" zpos="-0.15" />
```

Elevation at x=2m



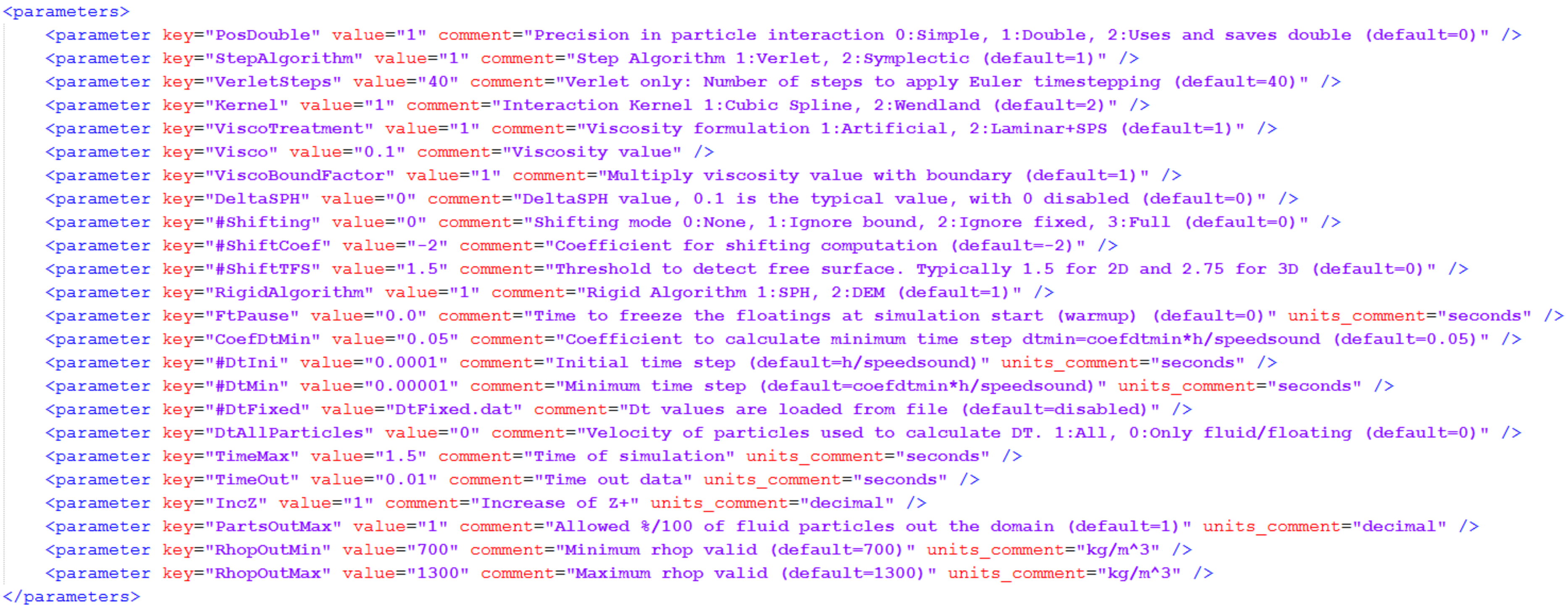
Velocity_Z at x=2m ; z=-0.15m



XML file

EXECUTION-PARAMETERS

Parameters for execution in DualSPHysics



```
<parameters>
    <parameter key="PosDouble" value="1" comment="Precision in particle interaction 0:Simple, 1:Double, 2:Uses and saves double (default=0)" />
    <parameter key="StepAlgorithm" value="1" comment="Step Algorithm 1:Verlet, 2:Symplectic (default=1)" />
    <parameter key="VerletSteps" value="40" comment="Verlet only: Number of steps to apply Euler timestepping (default=40)" />
    <parameter key="Kernel" value="1" comment="Interaction Kernel 1:Cubic Spline, 2:Wendland (default=2)" />
    <parameter key="ViscoTreatment" value="1" comment="Viscosity formulation 1:Artificial, 2:Laminar+SPS (default=1)" />
    <parameter key="Visco" value="0.1" comment="Viscosity value" />
    <parameter key="ViscoBoundFactor" value="1" comment="Multiply viscosity value with boundary (default=1)" />
    <parameter key="DeltaSPH" value="0" comment="DeltaSPH value, 0.1 is the typical value, with 0 disabled (default=0)" />
    <parameter key="#Shifting" value="0" comment="Shifting mode 0:None, 1:Ignore bound, 2:Ignore fixed, 3:Full (default=0)" />
    <parameter key="#ShiftCoef" value="-2" comment="Coefficient for shifting computation (default=-2)" />
    <parameter key="#ShiftTFS" value="1.5" comment="Threshold to detect free surface. Typically 1.5 for 2D and 2.75 for 3D (default=0)" />
    <parameter key="RigidAlgorithm" value="1" comment="Rigid Algorithm 1:SPH, 2:DEM (default=1)" />
    <parameter key="FtPause" value="0.0" comment="Time to freeze the floatings at simulation start (warmup) (default=0)" units_comment="seconds" />
    <parameter key="CoefDtMin" value="0.05" comment="Coefficient to calculate minimum time step dtmin=coefdtmin*h/speedsound (default=0.05)" />
    <parameter key="#DtIni" value="0.0001" comment="Initial time step (default=h/speedsound)" units_comment="seconds" />
    <parameter key="#DtMin" value="0.00001" comment="Minimum time step (default=coefdtmin*h/speedsound)" units_comment="seconds" />
    <parameter key="#DtFixed" value="DtFixed.dat" comment="Dt values are loaded from file (default=disabled)" />
    <parameter key="DtAllParticles" value="0" comment="Velocity of particles used to calculate DT. 1:All, 0:Only fluid/floating (default=0)" />
    <parameter key="TimeMax" value="1.5" comment="Time of simulation" units_comment="seconds" />
    <parameter key="TimeOut" value="0.01" comment="Time out data" units_comment="seconds" />
    <parameter key="IncZ" value="1" comment="Increase of Z+" units_comment="decimal" />
    <parameter key="PartsOutMax" value="1" comment="Allowed %/100 of fluid particles out the domain (default=1)" units_comment="decimal" />
    <parameter key="RhopOutMin" value="700" comment="Minimum rhop valid (default=700)" units_comment="kg/m^3" />
    <parameter key="RhopOutMax" value="1300" comment="Maximum rhop valid (default=1300)" units_comment="kg/m^3" />
</parameters>
```

XML file

EXECUTION-PARAMETERS

Double precision

```
<parameter  key="PosDouble" value="2"
 comment="Precision in particle interaction 0:Simple, 1:Double, 2:Uses and saves double" />
```

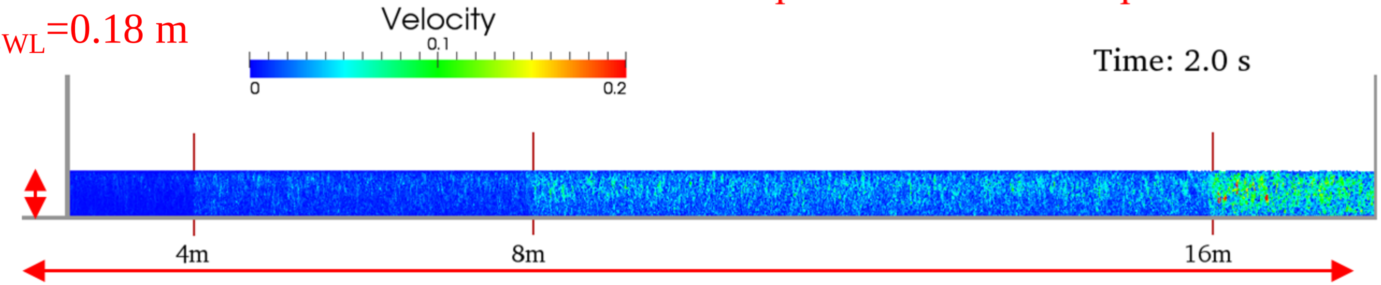
DualSPHysics v4.0 includes now implementation with double precision.
Precision in particle interaction (the most time consuming part) can be:

0: particle interaction is performed using simple precision for variables of position

Necessary when “dp” is much smaller than size of the domain:
1: particle interaction is performed using double precision for variables of position but final position is stored using simple precision
2: particle interaction is performed using double precision for variables of position and final position is stored using double precision

distance of particle interaction: dp= 0.012374m

depth: h_{SWL}=0.18 m



length=18 m

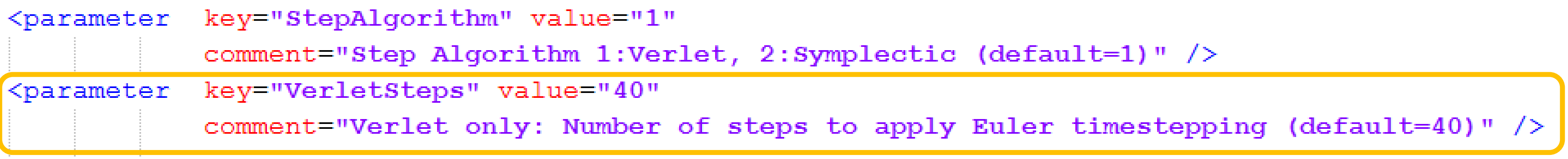
The problems of precision mainly appear when the domain is huge in comparison to the distance of interaction between particles

length>depth>>dp

XML file

EXECUTION-PARAMETERS

Time integrator scheme



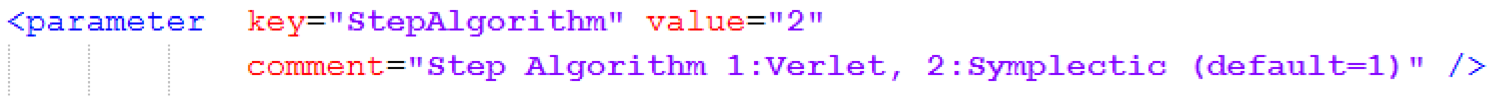
```
<parameter  key="StepAlgorithm" value="1"
            comment="Step Algorithm 1:Verlet, 2:Symplectic (default=1)" />
<parameter  key="VerletSteps" value="40"
            comment="Verlet only: Number of steps to apply Euler timestepping (default=40)" />
```

Verlet algorithm

$$\boldsymbol{v}_a^{n+1} = \boldsymbol{v}_a^{n-1} + 2\Delta t \boldsymbol{F}_a^n$$
$$\boldsymbol{r}_a^{n+1} = \boldsymbol{r}_a^n + \Delta t \boldsymbol{V}_a^n + 0.5\Delta t^2 \boldsymbol{F}_a^n$$
$$\rho_a^{n+1} = \rho_a^{n-1} + 2\Delta t D_a^n$$

once every M time steps

$$\boldsymbol{v}_a^{n+1} = \boldsymbol{v}_a^n + \Delta t \boldsymbol{F}_a^n$$
$$\boldsymbol{r}_a^{n+1} = \boldsymbol{r}_a^n + \Delta t \boldsymbol{V}_a^n + 0.5\Delta t^2 \boldsymbol{F}_a^n$$
$$\rho_a^{n+1} = \rho_a^n + \Delta t D_a^n$$



```
<parameter  key="StepAlgorithm" value="2"
            comment="Step Algorithm 1:Verlet, 2:Symplectic (default=1)" />
```

Symplectic algorithm

$$\boldsymbol{r}_a^{n+\frac{1}{2}} = \boldsymbol{r}_a^n + \frac{\Delta t}{2} \boldsymbol{v}_a^n$$
$$\rho_a^{n+\frac{1}{2}} = \rho_a^n + \frac{\Delta t}{2} D_a^n$$

Predictor

$$\boldsymbol{v}_a^{n+1} = \boldsymbol{v}_a^{n+\frac{1}{2}} + \frac{\Delta t}{2} \boldsymbol{F}_a^{n+\frac{1}{2}}$$
$$\boldsymbol{r}_a^{n+1} = \boldsymbol{r}_a^{n+\frac{1}{2}} + \frac{\Delta t}{2} \boldsymbol{v}_a^{n+1}$$

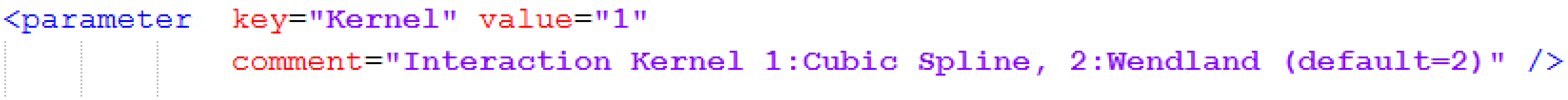
Corrector

XML file

EXECUTION-PARAMETERS

Kernel function

$$\frac{d\boldsymbol{v}_a}{dt} = -\sum_b m_b \left(\frac{P_b + P_a}{\rho_b \cdot \rho_a} + \Pi_{ab} \right) \boxed{\nabla_a W_{ab}} + \boldsymbol{g}$$



```
<parameter  key="Kernel" value="1"
            comment="Interaction Kernel 1:Cubic Spline, 2:Wendland (default=2)" />
```

Cubic Spline

$$W(r,h) = \alpha_D \begin{cases} 1 - \frac{3}{2}q^2 + \frac{3}{4}q^3 & 0 \le q \le 1 \\ \frac{1}{4}(2-q)^3 & 1 \le q \le 2 \\ 0 & q \ge 2 \end{cases}$$

where α_D is equal to $10/7\pi h^2$ in 2-D and $1/\pi h^3$ in 3-D

Wendland

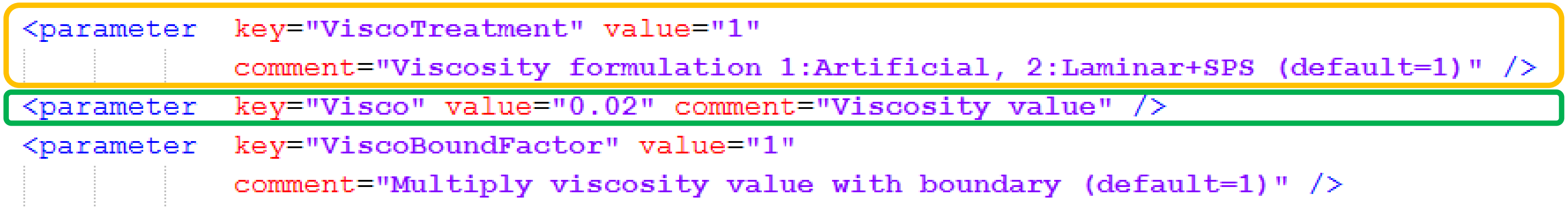
$$W(r,h) = \alpha_D \left(1 - \frac{q}{2}\right)^4 (2q+1) \qquad 0 \le q \le 2$$

where α_D is equal to $7/4\pi h^2$ in 2-D and $21/16\pi h^3$ in 3-D

XML file

EXECUTION-PARAMETERS

Viscosity treatment



```
<parameter   key="ViscoTreatment" value="1"
             comment="Viscosity formulation 1:Artificial, 2:Laminar+SPS (default=1)" />
<parameter   key="Visco" value="0.02" comment="Viscosity value" />
<parameter   key="ViscoBoundFactor" value="1"
             comment="Multiply viscosity value with boundary (default=1)" />
```

$$\frac{d\mathbf{v}_a}{dt} = -\sum_b m_b \left(\frac{P_b + P_a}{\rho_b \cdot \rho_a} + \boxed{\Pi_{ab}} \right) \nabla_a W_{ab} + \mathbf{g}$$

$$\Pi_{ab} = \begin{cases} \dfrac{-\boxed{\alpha}\,\overline{c_{ab}}\,\mu_{ab}}{\overline{\rho_{ab}}} & \mathbf{v}_{ab} \cdot \mathbf{r}_{ab} < 0 \\ 0 & \mathbf{v}_{ab} \cdot \mathbf{r}_{ab} > 0 \end{cases}$$

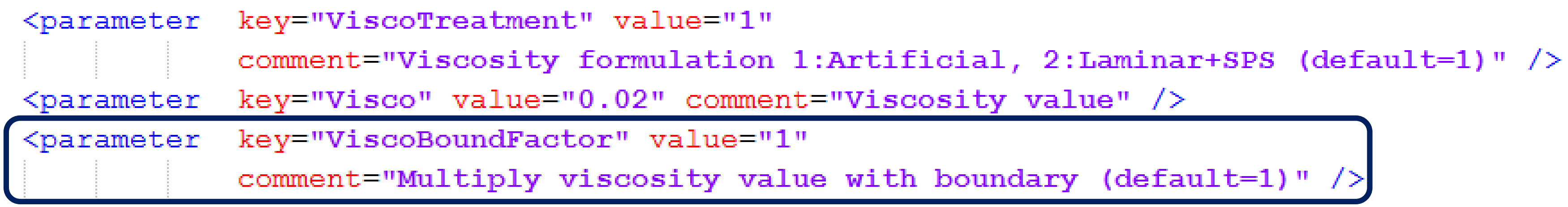
α=0.01 for wave tanks

higher values of *α* for dam-break (depends on *dp*)

XML file

EXECUTION-PARAMETERS

Viscosity treatment



```
<parameter  key="ViscoTreatment" value="1"
            comment="Viscosity formulation 1:Artificial, 2:Laminar+SPS (default=1)" />
<parameter  key="Visco" value="0.02" comment="Viscosity value" />
<parameter  key="ViscoBoundFactor" value="1"
            comment="Multiply viscosity value with boundary (default=1)" />
```

$$\frac{d\mathbf{v}_a}{dt} = -\sum_b m_b \left(\frac{P_b + P_a}{\rho_b \cdot \rho_a} + \Pi_{ab} \right) \nabla_a W_{ab} + \mathbf{g}$$

$$\Pi_{ab} = \begin{cases} \dfrac{-\alpha\,\overline{c_{ab}}\,\mu_{ab}}{\overline{\rho_{ab}}} & \mathbf{v}_{ab} \cdot \mathbf{r}_{ab} < 0 \\ 0 & \mathbf{v}_{ab} \cdot \mathbf{r}_{ab} > 0 \end{cases}$$

$\boldsymbol{\alpha}_{FF}$ *for interaction fluid-fluid*

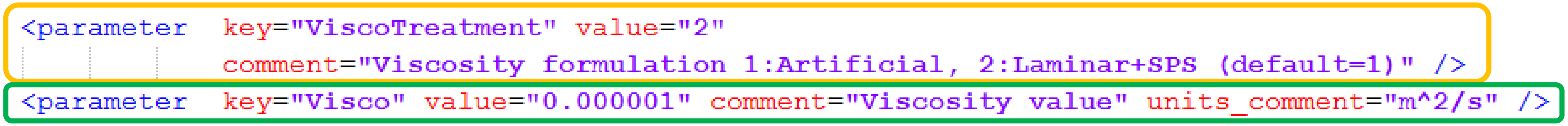
$\boldsymbol{\alpha}_{FB}$ *for interaction fluid-boundary*

$\boldsymbol{\alpha}_{FB}$= ViscoBoundFactor · $\boldsymbol{\alpha}_{FF}$

XML file

EXECUTION-PARAMETERS

Viscosity treatment



```
<parameter  key="ViscoTreatment" value="2"
            comment="Viscosity formulation 1:Artificial, 2:Laminar+SPS (default=1)" />
<parameter  key="Visco" value="0.000001" comment="Viscosity value" units_comment="m^2/s" />
```

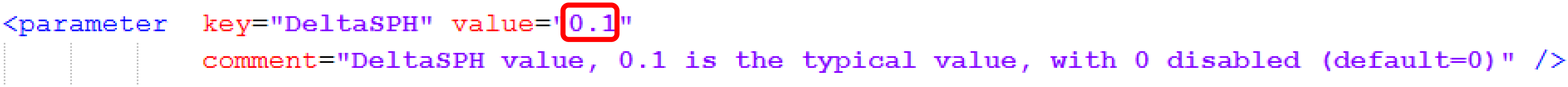
$$\frac{d\mathbf{v}_a}{dt} = -\sum_b m_b\left(\frac{P_b}{\rho_b^2}+\frac{P_a}{\rho_a^2}\right)\nabla_a W_{ab} + \boldsymbol{g} \boxed{+\sum_b m_b\left(\frac{4\boxed{\upsilon_0} r_{ab}\cdot\nabla_a W_{ab}}{(\rho_a+\rho_b)(r_{ab}^2+\eta^2)}\right)\mathbf{v}_{ab} + \sum_b m_b\left(\frac{\vec{\tau}_{ij}^{\,b}}{\rho_b^2}+\frac{\vec{\tau}_{ij}^{\,a}}{\rho_a^2}\right)\nabla_a W_{ab}}$$

$\boldsymbol{\upsilon_o}$ is kinematic viscosity (typically 10^{-6} m^{2}s for water

XML file

EXECUTION-PARAMETERS

DeltaSPH formulation



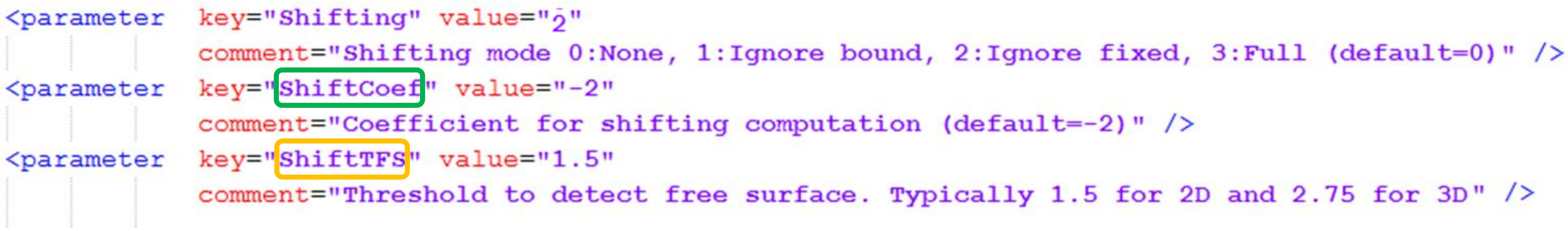
```
<parameter   key="DeltaSPH" value="0.1"
             comment="DeltaSPH value, 0.1 is the typical value, with 0 disabled (default=0)" />
```

$$\frac{d\rho_a}{dt} = \sum_b m_b \mathbf{v}_{ab} \cdot \nabla_a W_{ab} + 2\boxed{\delta} h \sum_b m_b \overline{c_{ab}} \left(\frac{\rho_a}{\rho_b} - 1 \right) \frac{\mathbf{r}_{ab}}{\mathbf{r}_{ab}^2 + \eta^2} \cdot \nabla_a W_{ab}$$

XML file

EXECUTION-PARAMETERS

Shifting algorithm



```
<parameter   key="Shifting" value="2"
             comment="Shifting mode 0:None, 1:Ignore bound, 2:Ignore fixed, 3:Full (default=0)" />
<parameter   key="ShiftCoef" value="-2"
             comment="Coefficient for shifting computation (default=-2)" />
<parameter   key="ShiftTFS" value="1.5"
             comment="Threshold to detect free surface. Typically 1.5 for 2D and 2.75 for 3D" />
```

$$\delta\mathbf{r} = D \cdot \nabla C_i$$

$$D = \boxed{A_s} h \|\mathbf{u}\|_i \Delta t$$

Shifting update

$$\nabla C_i = \sum_j \frac{m_j}{\rho_j} \nabla W_{ij}$$

Concentration gradient

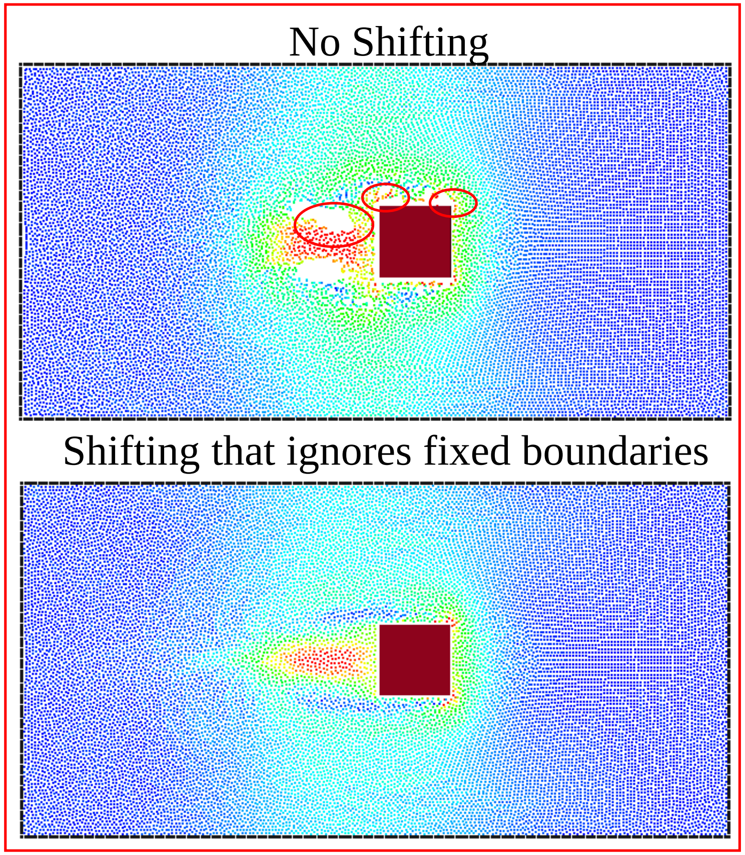
SHIFTING

SHIFTING IN THE NORMAL DIRECTION IS NOT APPLIED FOR PARTICLES AT THE FREE SURFACE

$$\nabla \cdot \mathbf{r} > \boxed{1.5}$$

Particle divergence

$$\nabla \cdot \mathbf{r} = \sum_j \frac{m_j}{\rho_j} \mathbf{r}_{ij} \cdot \nabla_i W_{ij}$$



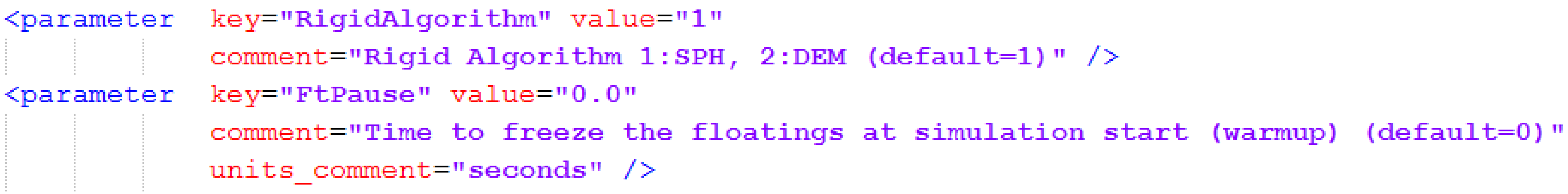
No Shifting

Shifting that ignores fixed boundaries

XML file

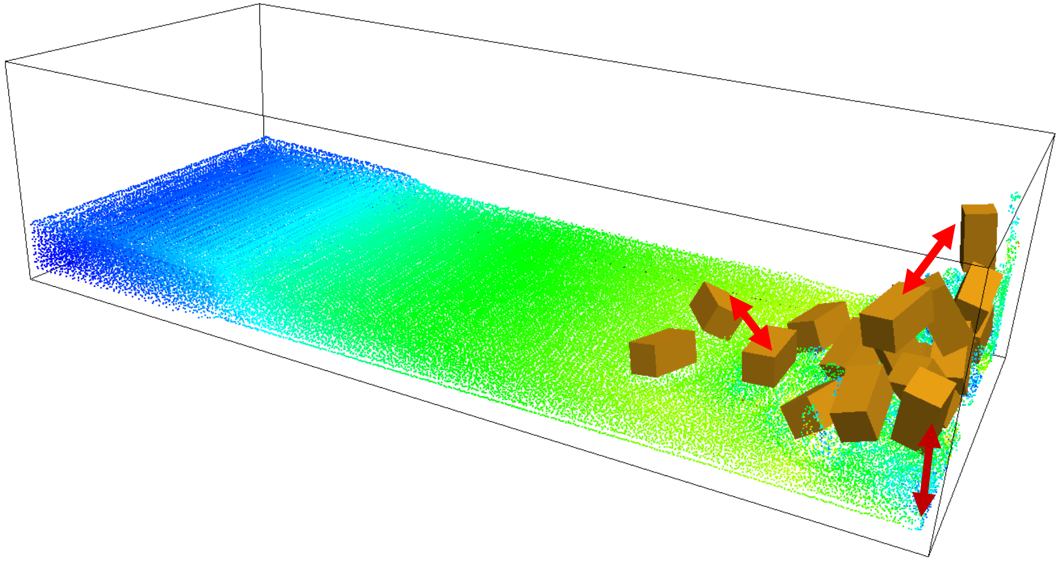
EXECUTION-PARAMETERS

Interaction between solids



```
<parameter  key="RigidAlgorithm" value="1"
            comment="Rigid Algorithm 1:SPH, 2:DEM (default=1)" />
<parameter  key="FtPause" value="0.0"
            comment="Time to freeze the floatings at simulation start (warmup) (default=0)"
            units_comment="seconds" />
```

DEM is recommended

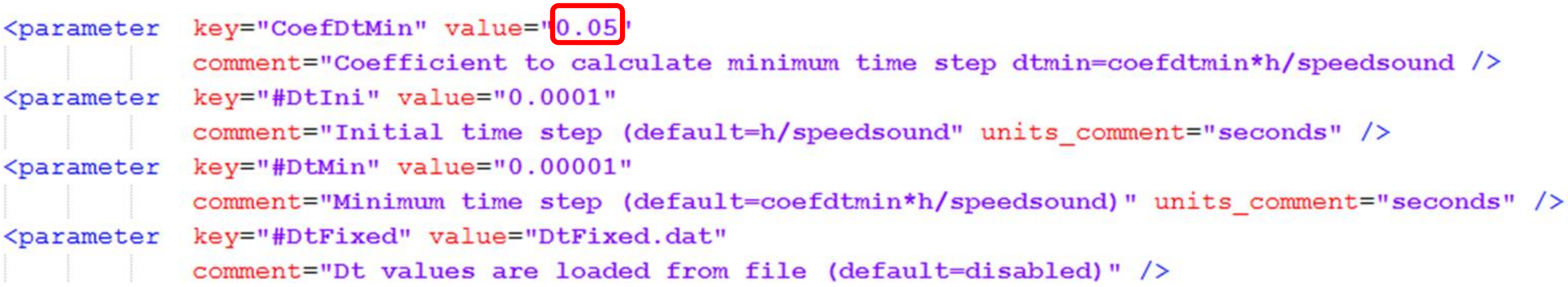


Interaction between floatings
SPH or DEM

Interaction between floating and bottom
SPH or DEM

EXECUTION-PARAMETERS

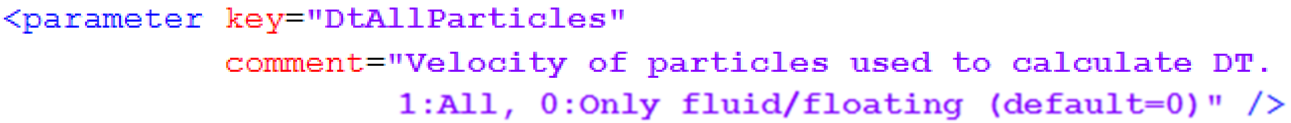
Time step computation



```
<parameter   key="CoefDtMin"  value="0.05"
             comment="Coefficient to calculate minimum time step dtmin=coefdtmin*h/speedsound />
<parameter   key="#DtIni"  value="0.0001"
             comment="Initial time step (default=h/speedsound" units_comment="seconds" />
<parameter   key="#DtMin"  value="0.00001"
             comment="Minimum time step (default=coefdtmin*h/speedsound)" units_comment="seconds" />
<parameter   key="#DtFixed"  value="DtFixed.dat"
             comment="Dt values are loaded from file (default=disabled)" />
```

$$\Delta t_{minimum} = \boxed{0.05} \cdot \frac{h}{c_s}$$

$$\Delta t_{init} = \frac{h}{c_s}$$



```
<parameter key="DtAllParticles"
           comment="Velocity of particles used to calculate DT.
                1:All, 0:Only fluid/floating (default=0)" />
```

$$\Delta t_f = \min_a \left(\sqrt{h / \left| f_a \right|} \right)$$

$$\Delta t = 0.3 \cdot \min\left(\Delta t_f, \Delta t_{cv}\right)$$

$$\Delta t_{cv} = \min_a \frac{h}{c_s + \max_b \left| \frac{h \mathbf{v}_{ab} \cdot \mathbf{r}_{ab}}{\mathbf{r}_{ab}^2} \right|}$$

0: b ϵ fluid/floating

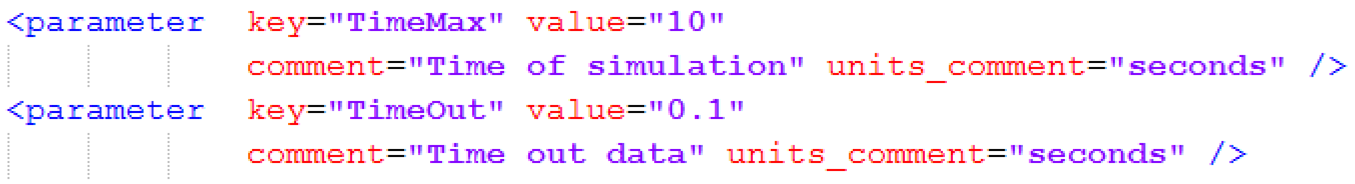
OR

1: b ϵ fluid/floating + boundaries

XML file

EXECUTION-PARAMETERS

Physical time and frequency to store data

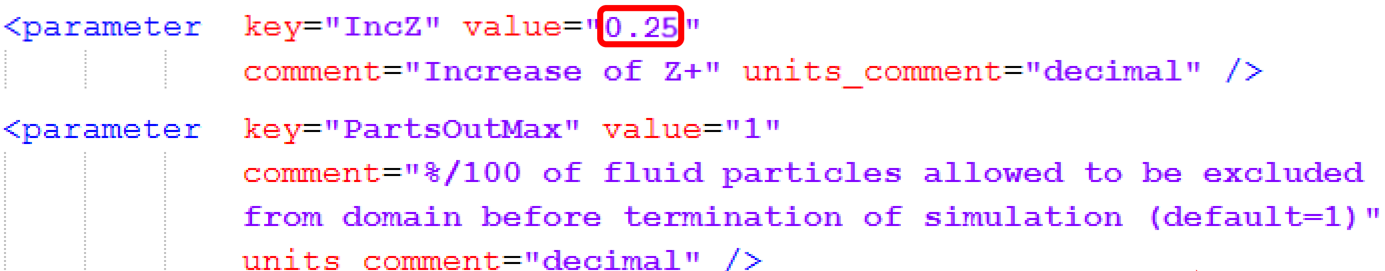


```
<parameter  key="TimeMax" value="10"
            comment="Time of simulation" units_comment="seconds" />
<parameter  key="TimeOut" value="0.1"
            comment="Time out data" units_comment="seconds" />
```

Number of output files = TimeMax / TimeOut
= 10 / 0.1 = 100 files

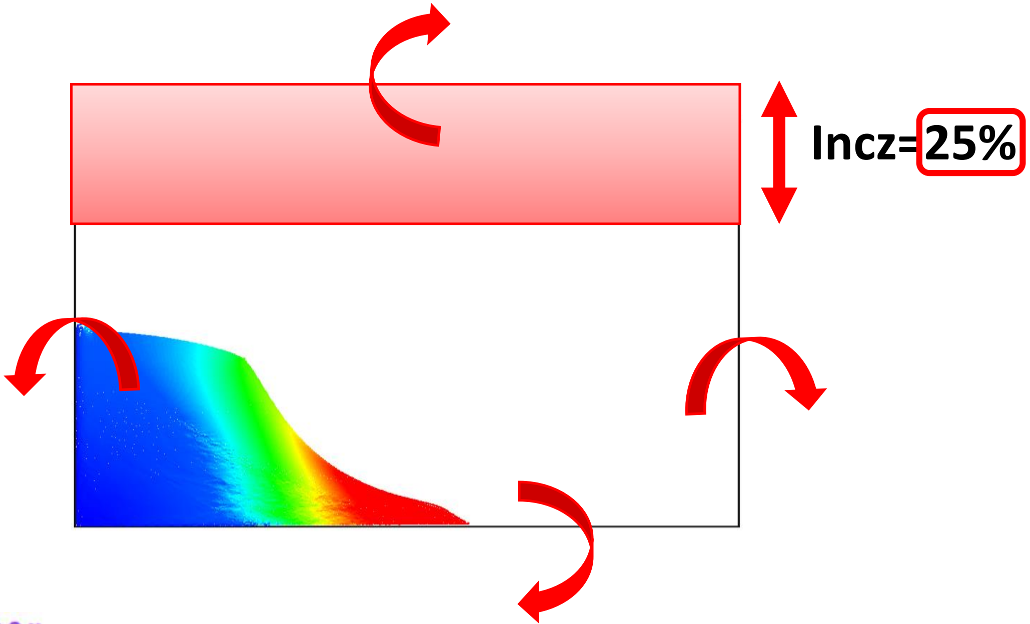
XML file

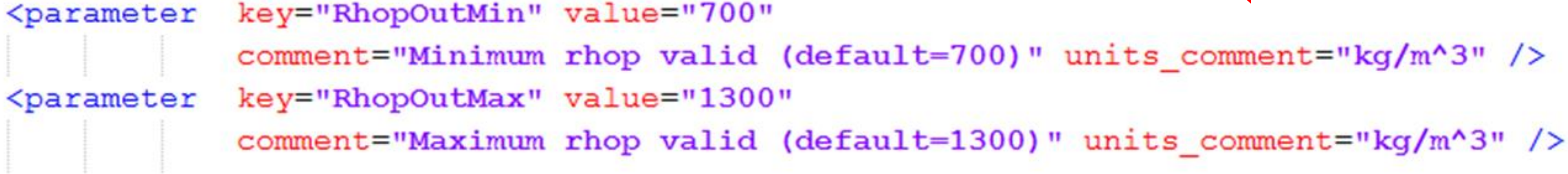
EXECUTION-PARAMETERS



```
<parameter   key="IncZ" value="0.25"
             comment="Increase of Z+" units_comment="decimal" />
<parameter   key="PartsOutMax" value="1"
             comment="%/100 of fluid particles allowed to be excluded
             from domain before termination of simulation (default=1)"
             units_comment="decimal" />
```

Excluding particles by position





```
<parameter   key="RhopOutMin" value="700"
             comment="Minimum rhop valid (default=700)" units_comment="kg/m^3" />
<parameter   key="RhopOutMax" value="1300"
             comment="Maximum rhop valid (default=1300)" units_comment="kg/m^3" />
```

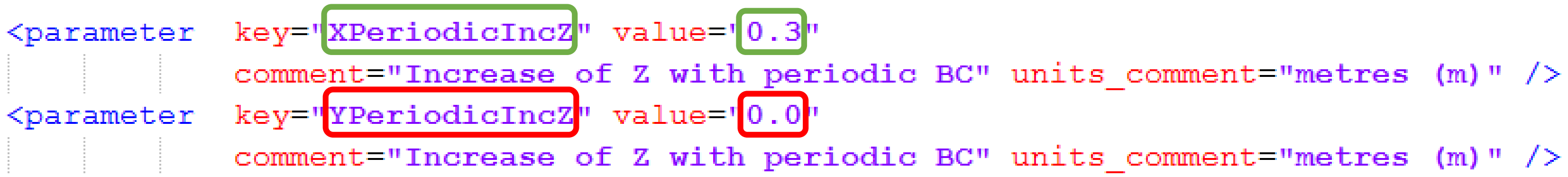
Excluding particles by density

$$700 < \rho_0 < 1300$$

XML file

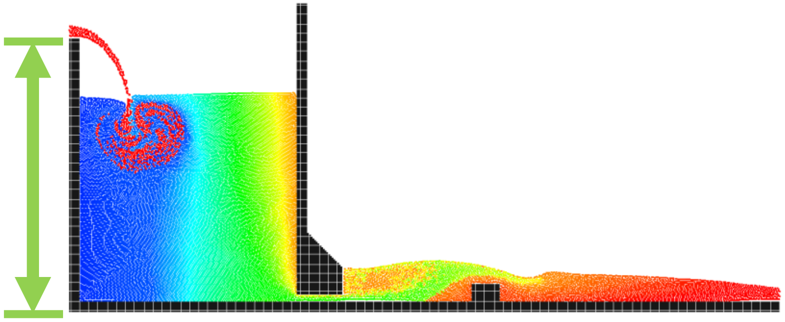
EXECUTION-PARAMETERS

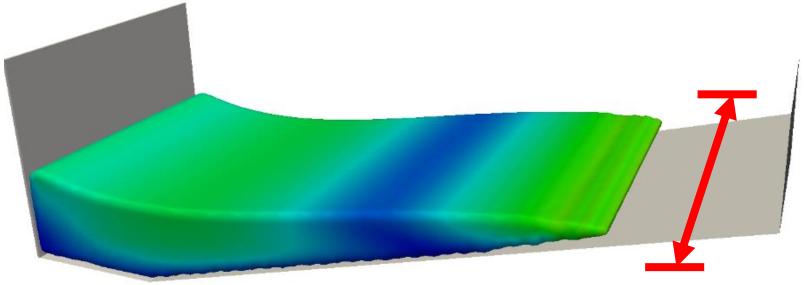
Periodicity



```
<parameter   key="XPeriodicIncZ" value="0.3"
             comment="Increase of Z with periodic BC" units_comment="metres (m)" />
<parameter   key="YPeriodicIncZ" value="0.0"
             comment="Increase of Z with periodic BC" units_comment="metres (m)" />
```

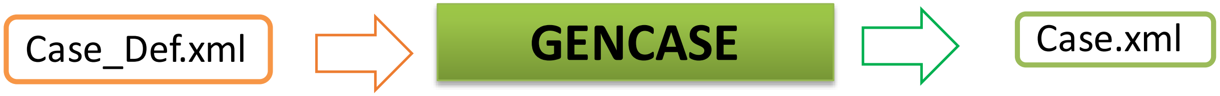
Δz=0.3 m

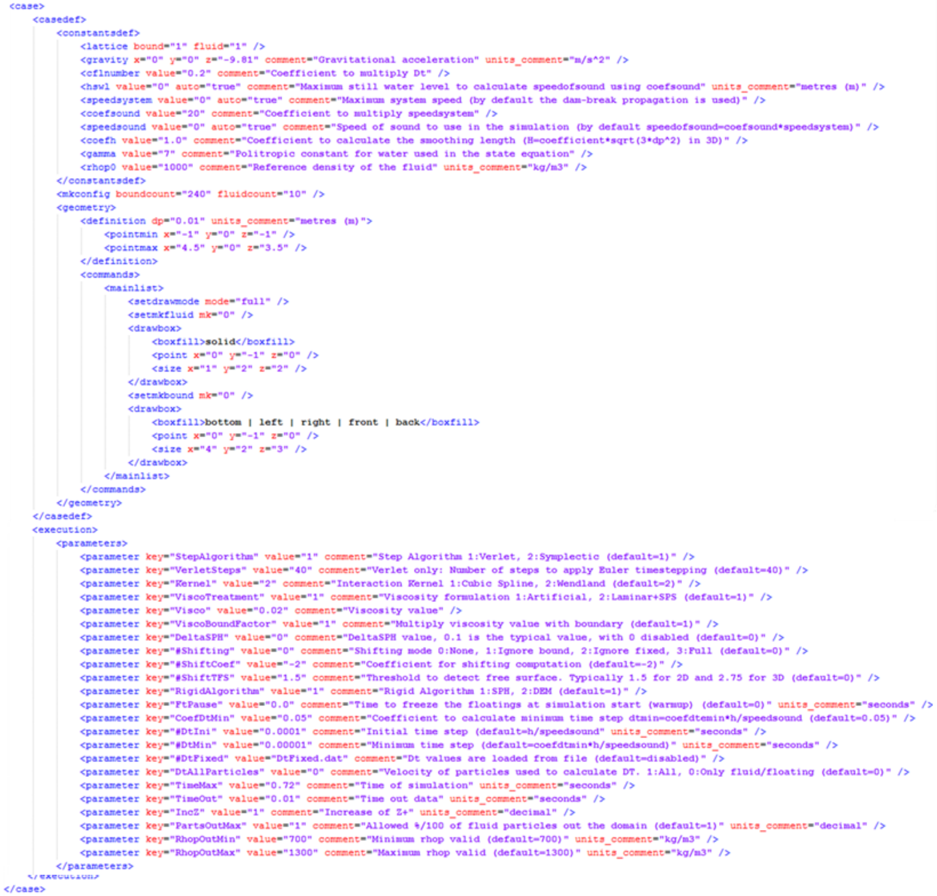




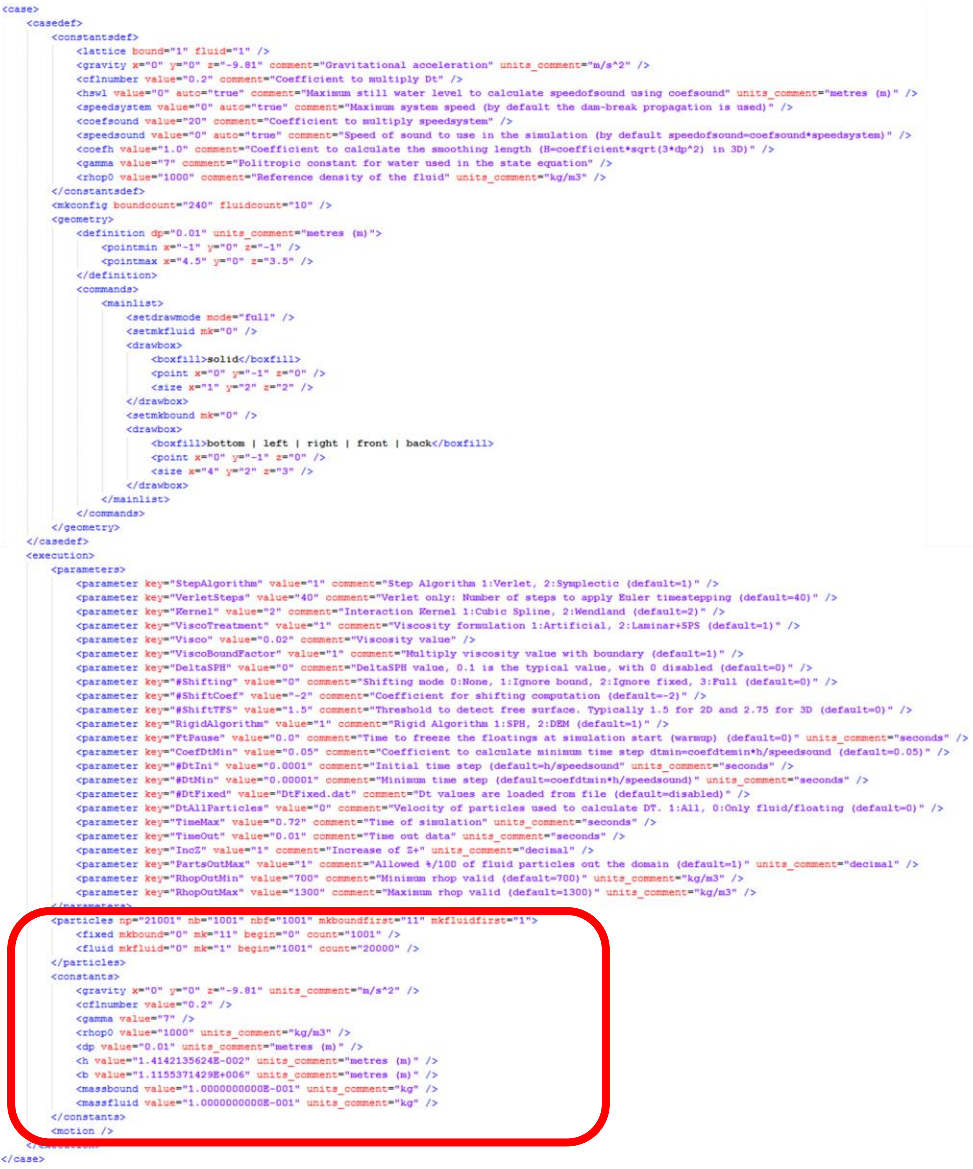
Δz=0 m

XML file





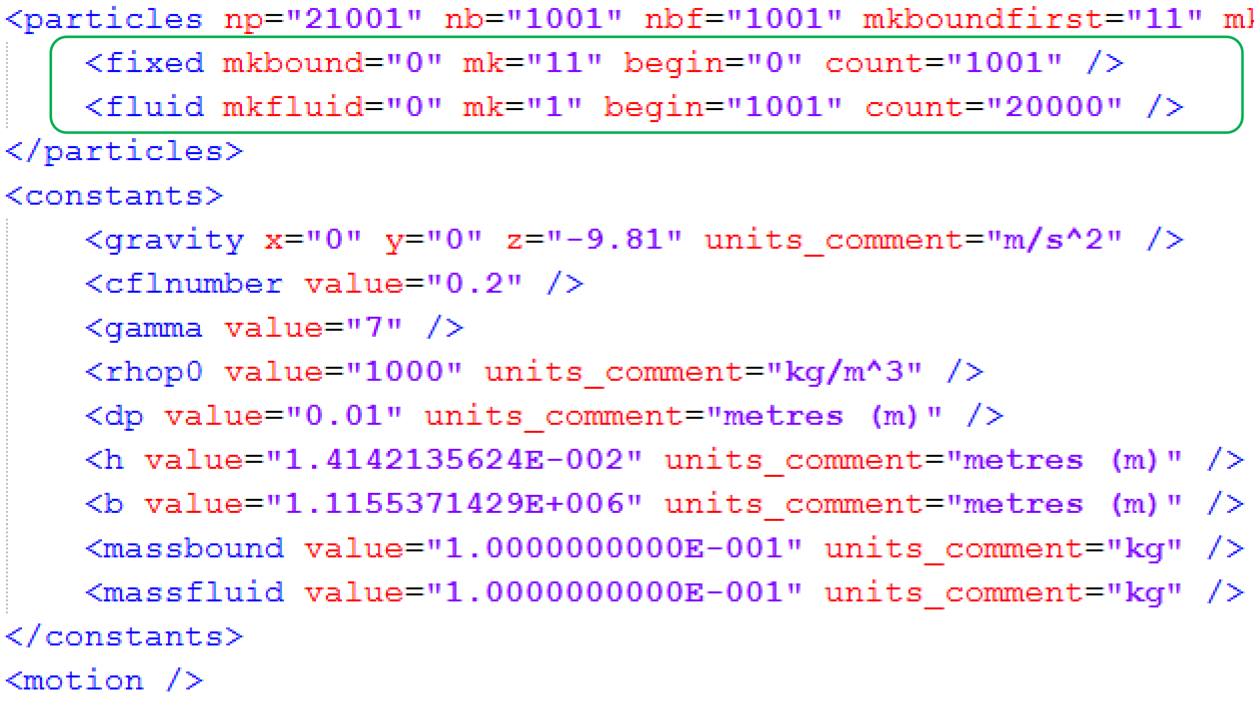
```xml
<case>
    <casedef>
        <constantsdef>
            <lattice bound="1" fluid="1" />
            <gravity x="0" y="0" z="-9.81" comment="Gravitational acceleration" units_comment="m/s^2" />
            <cflnumber value="0.2" comment="Coefficient to multiply Dt" />
            <hswl value="0" auto="true" comment="Maximum still water level to calculate speedofsound using coefsound" units_comment="metres (m)" />
            <speedsystem value="0" auto="true" comment="Maximum system speed (by default the dam-break propagation is used)" />
            <coefsound value="20" comment="Coefficient to multiply speedsystem" />
            <speedsound value="0" auto="true" comment="Speed of sound to use in the simulation (by default speedofsound=coefsound*speedsystem)" />
            <coefh value="1.0" comment="Coefficient to calculate the smoothing length (H=coefficient*sqrt(3*dp^2) in 3D)" />
            <gamma value="7" comment="Politropic constant for water used in the state equation" />
            <rhop0 value="1000" comment="Reference density of the fluid" units_comment="kg/m3" />
        </constantsdef>
        <mkconfig boundcount="240" fluidcount="10" />
        <geometry>
            <definition dp="0.01" units_comment="metres (m)">
                <pointmin x="-1" y="0" z="-1" />
                <pointmax x="4.5" y="0" z="3.5" />
            </definition>
            <commands>
                <mainlist>
                    <setdrawmode mode="full" />
                    <setmkfluid mk="0" />
                    <drawbox>
                        <boxfill>solid</boxfill>
                        <point x="0" y="-1" z="0" />
                        <size x="1" y="2" z="2" />
                    </drawbox>
                    <setmkbound mk="0" />
                    <drawbox>
                        <boxfill>bottom | left | right | front | back</boxfill>
                        <point x="0" y="-1" z="0" />
                        <size x="4" y="2" z="3" />
                    </drawbox>
                </mainlist>
            </commands>
        </geometry>
    </casedef>
    <execution>
        <parameters>
            <parameter key="StepAlgorithm" value="1" comment="Step Algorithm 1:Verlet, 2:Symplectic (default=1)" />
            <parameter key="VerletSteps" value="40" comment="Verlet only: Number of steps to apply Euler timestepping (default=40)" />
            <parameter key="Kernel" value="2" comment="Interaction Kernel 1:Cubic Spline, 2:Wendland (default=2)" />
            <parameter key="ViscoTreatment" value="1" comment="Viscosity formulation 1:Artificial, 2:Laminar+SPS (default=1)" />
            <parameter key="Visco" value="0.02" comment="Viscosity value" />
            <parameter key="ViscoBoundFactor" value="1" comment="Multiply viscosity value with boundary (default=1)" />
            <parameter key="DeltaSPH" value="0" comment="DeltaSPH value, 0.1 is the typical value, with 0 disabled (default=0)" />
            <parameter key="#Shifting" value="0" comment="Shifting mode 0:None, 1:Ignore bound, 2:Ignore fixed, 3:Full (default=0)" />
            <parameter key="#ShiftCoef" value="-2" comment="Coefficient for shifting computation (default=-2)" />
            <parameter key="#ShiftTFS" value="1.5" comment="Threshold to detect free surface. Typically 1.5 for 2D and 2.75 for 3D (default=0)" />
            <parameter key="RigidAlgorithm" value="1" comment="Rigid Algorithm 1:SPH, 2:DEM (default=1)" />
            <parameter key="FtPause" value="0.0" comment="Time to freeze the floatings at simulation start (warmup) (default=0)" units_comment="seconds" />
            <parameter key="CoefDtMin" value="0.05" comment="Coefficient to calculate minimum time step dtmin=coefdtemin*h/speedsound (default=0.05)" />
            <parameter key="#DtIni" value="0.0001" comment="Initial time step (default=h/speedsound" units_comment="seconds" />
            <parameter key="#DtMin" value="0.00001" comment="Minimum time step (default=coefdtmin*h/speedsound)" units_comment="seconds" />
            <parameter key="#DtFixed" value="DtFixed.dat" comment="Dt values are loaded from file (default=disabled)" />
            <parameter key="DtAllParticles" value="0" comment="Velocity of particles used to calculate DT. 1:All, 0:Only fluid/floating (default=0)" />
            <parameter key="TimeMax" value="0.72" comment="Time of simulation" units_comment="seconds" />
            <parameter key="TimeOut" value="0.01" comment="Time out data" units_comment="seconds" />
            <parameter key="IncZ" value="1" comment="Increase of Z+" units_comment="decimal" />
            <parameter key="PartsOutMax" value="1" comment="Allowed %/100 of fluid particles out the domain (default=1)" units_comment="decimal" />
            <parameter key="RhopOutMin" value="700" comment="Minimum rhop valid (default=700)" units_comment="kg/m3" />
            <parameter key="RhopOutMax" value="1300" comment="Maximum rhop valid (default=1300)" units_comment="kg/m3" />
        </parameters>
    </execution>
</case>
```



```xml
<case>
    <casedef>
        <constantsdef>
            <lattice bound="1" fluid="1" />
            <gravity x="0" y="0" z="-9.81" comment="Gravitational acceleration" units_comment="m/s^2" />
            <cflnumber value="0.2" comment="Coefficient to multiply Dt" />
            <hswl value="0" auto="true" comment="Maximum still water level to calculate speedofsound using coefsound" units_comment="metres (m)" />
            <speedsystem value="0" auto="true" comment="Maximum system speed (by default the dam-break propagation is used)" />
            <coefsound value="20" comment="Coefficient to multiply speedsystem" />
            <speedsound value="0" auto="true" comment="Speed of sound to use in the simulation (by default speedofsound=coefsound*speedsystem)" />
            <coefh value="1.0" comment="Coefficient to calculate the smoothing length (H=coefficient*sqrt(3*dp^2) in 3D)" />
            <gamma value="7" comment="Politropic constant for water used in the state equation" />
            <rhop0 value="1000" comment="Reference density of the fluid" units_comment="kg/m3" />
        </constantsdef>
        <mkconfig boundcount="240" fluidcount="10" />
        <geometry>
            <definition dp="0.01" units_comment="metres (m)">
                <pointmin x="-1" y="0" z="-1" />
                <pointmax x="4.5" y="0" z="3.5" />
            </definition>
            <commands>
                <mainlist>
                    <setdrawmode mode="full" />
                    <setmkfluid mk="0" />
                    <drawbox>
                        <boxfill>solid</boxfill>
                        <point x="0" y="-1" z="0" />
                        <size x="1" y="2" z="2" />
                    </drawbox>
                    <setmkbound mk="0" />
                    <drawbox>
                        <boxfill>bottom | left | right | front | back</boxfill>
                        <point x="0" y="-1" z="0" />
                        <size x="4" y="2" z="3" />
                    </drawbox>
                </mainlist>
            </commands>
        </geometry>
    </casedef>
    <execution>
        <parameters>
            <parameter key="StepAlgorithm" value="1" comment="Step Algorithm 1:Verlet, 2:Symplectic (default=1)" />
            <parameter key="VerletSteps" value="40" comment="Verlet only: Number of steps to apply Euler timestepping (default=40)" />
            <parameter key="Kernel" value="2" comment="Interaction Kernel 1:Cubic Spline, 2:Wendland (default=2)" />
            <parameter key="ViscoTreatment" value="1" comment="Viscosity formulation 1:Artificial, 2:Laminar+SPS (default=1)" />
            <parameter key="Visco" value="0.02" comment="Viscosity value" />
            <parameter key="ViscoBoundFactor" value="1" comment="Multiply viscosity value with boundary (default=1)" />
            <parameter key="DeltaSPH" value="0" comment="DeltaSPH value, 0.1 is the typical value, with 0 disabled (default=0)" />
            <parameter key="#Shifting" value="0" comment="Shifting mode 0:None, 1:Ignore bound, 2:Ignore fixed, 3:Full (default=0)" />
            <parameter key="#ShiftCoef" value="-2" comment="Coefficient for shifting computation (default=-2)" />
            <parameter key="#ShiftTFS" value="1.5" comment="Threshold to detect free surface. Typically 1.5 for 2D and 2.75 for 3D (default=0)" />
            <parameter key="RigidAlgorithm" value="1" comment="Rigid Algorithm 1:SPH, 2:DEM (default=1)" />
            <parameter key="FtPause" value="0.0" comment="Time to freeze the floatings at simulation start (warmup) (default=0)" units_comment="seconds" />
            <parameter key="CoefDtMin" value="0.05" comment="Coefficient to calculate minimum time step dtmin=coefdtemin*h/speedsound (default=0.05)" />
            <parameter key="#DtIni" value="0.0001" comment="Initial time step (default=h/speedsound" units_comment="seconds" />
            <parameter key="#DtMin" value="0.00001" comment="Minimum time step (default=coefdtmin*h/speedsound)" units_comment="seconds" />
            <parameter key="#DtFixed" value="DtFixed.dat" comment="Dt values are loaded from file (default=disabled)" />
            <parameter key="DtAllParticles" value="0" comment="Velocity of particles used to calculate DT. 1:All, 0:Only fluid/floating (default=0)" />
            <parameter key="TimeMax" value="0.72" comment="Time of simulation" units_comment="seconds" />
            <parameter key="TimeOut" value="0.01" comment="Time out data" units_comment="seconds" />
            <parameter key="IncZ" value="1" comment="Increase of Z+" units_comment="decimal" />
            <parameter key="PartsOutMax" value="1" comment="Allowed %/100 of fluid particles out the domain (default=1)" units_comment="decimal" />
            <parameter key="RhopOutMin" value="700" comment="Minimum rhop valid (default=700)" units_comment="kg/m3" />
            <parameter key="RhopOutMax" value="1300" comment="Maximum rhop valid (default=1300)" units_comment="kg/m3" />
        </parameters>
        <particles np="21001" nb="1001" nbf="1001" mkboundfirst="11" mkfluidfirst="1">
            <fixed mkbound="0" mk="11" begin="0" count="1001" />
            <fluid mkfluid="0" mk="1" begin="1001" count="20000" />
        </particles>
        <constants>
            <gravity x="0" y="0" z="-9.81" units_comment="m/s^2" />
            <cflnumber value="0.2" />
            <gamma value="7" />
            <rhop0 value="1000" units_comment="kg/m3" />
            <dp value="0.01" units_comment="metres (m)" />
            <h value="1.4142135624E-002" units_comment="metres (m)" />
            <b value="1.1155371429E+006" units_comment="metres (m)" />
            <massbound value="1.0000000000E-001" units_comment="kg" />
            <massfluid value="1.0000000000E-001" units_comment="kg" />
        </constants>
        <motion />
    </execution>
</case>
```

XML file

Summary of the number of created particles and computed constants



```
<particles np="21001" nb="1001" nbf="1001" mkboundfirst="11" mkfluidfirst="1">
    <fixed mkbound="0" mk="11" begin="0" count="1001" />
    <fluid mkfluid="0" mk="1" begin="1001" count="20000" />
</particles>
<constants>
    <gravity x="0" y="0" z="-9.81" units_comment="m/s^2" />
    <cflnumber value="0.2" />
    <gamma value="7" />
    <rhop0 value="1000" units_comment="kg/m^3" />
    <dp value="0.01" units_comment="metres (m)" />
    <h value="1.4142135624E-002" units_comment="metres (m)" />
    <b value="1.1155371429E+006" units_comment="metres (m)" />
    <massbound value="1.0000000000E-001" units_comment="kg" />
    <massfluid value="1.0000000000E-001" units_comment="kg" />
</constants>
<motion />
```

np=total number of particles
nb=boundary particles
nbf=fixed boundary particles
and final ***mk*** of the objects

NOTE value of final "mk"
mk=mkbound+11
mk=mkfluid+1

mass=*rhop0*dp*dp*dp* in 3D
mass=*rhop0*dp*dp* in 2D

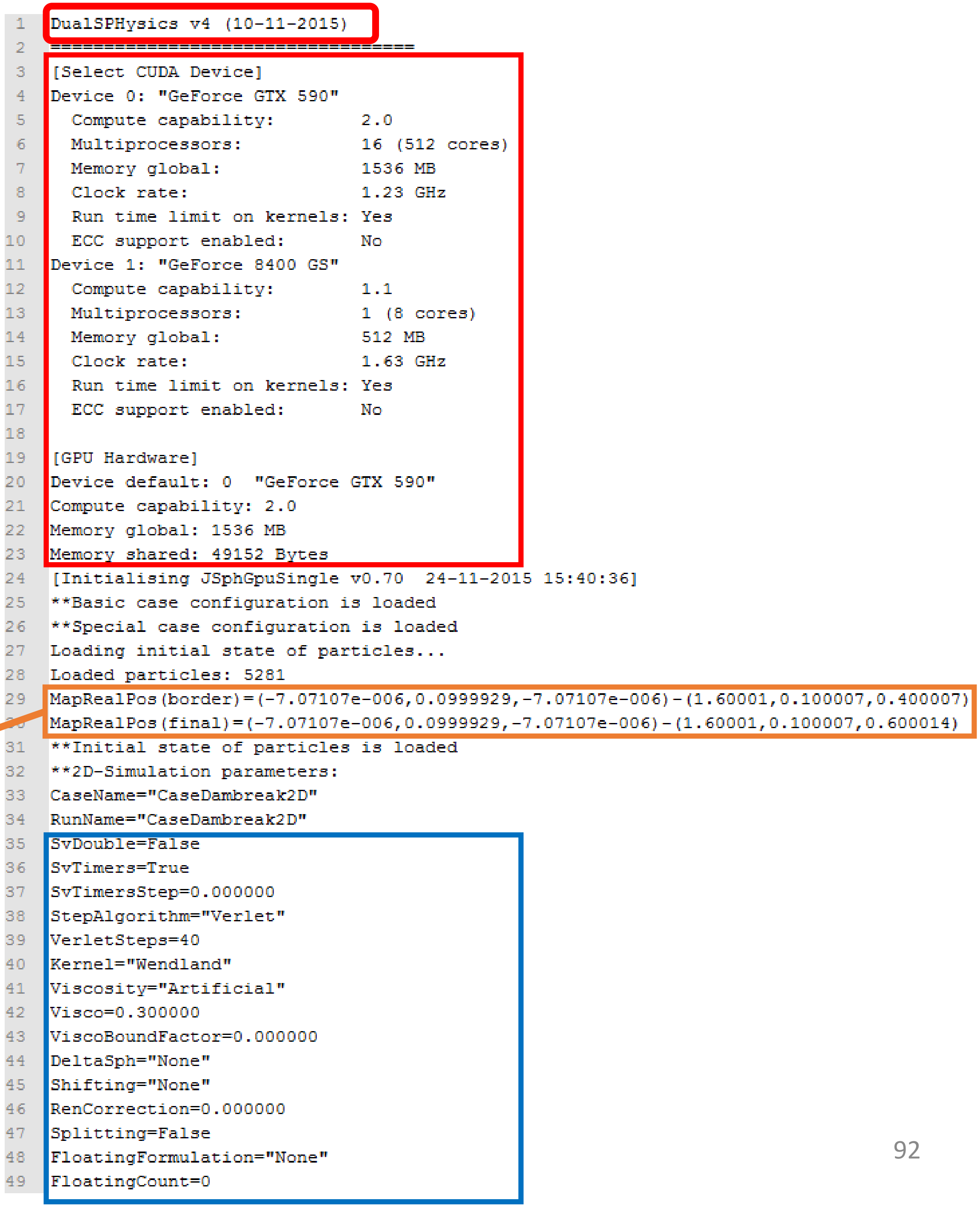
YOU SHOULD ALWAYS CHECK

Case_All.vtk, Case_Bound.vtk, Case_Fluid.vtk

Input & output files

Run.out

Text file with execution log



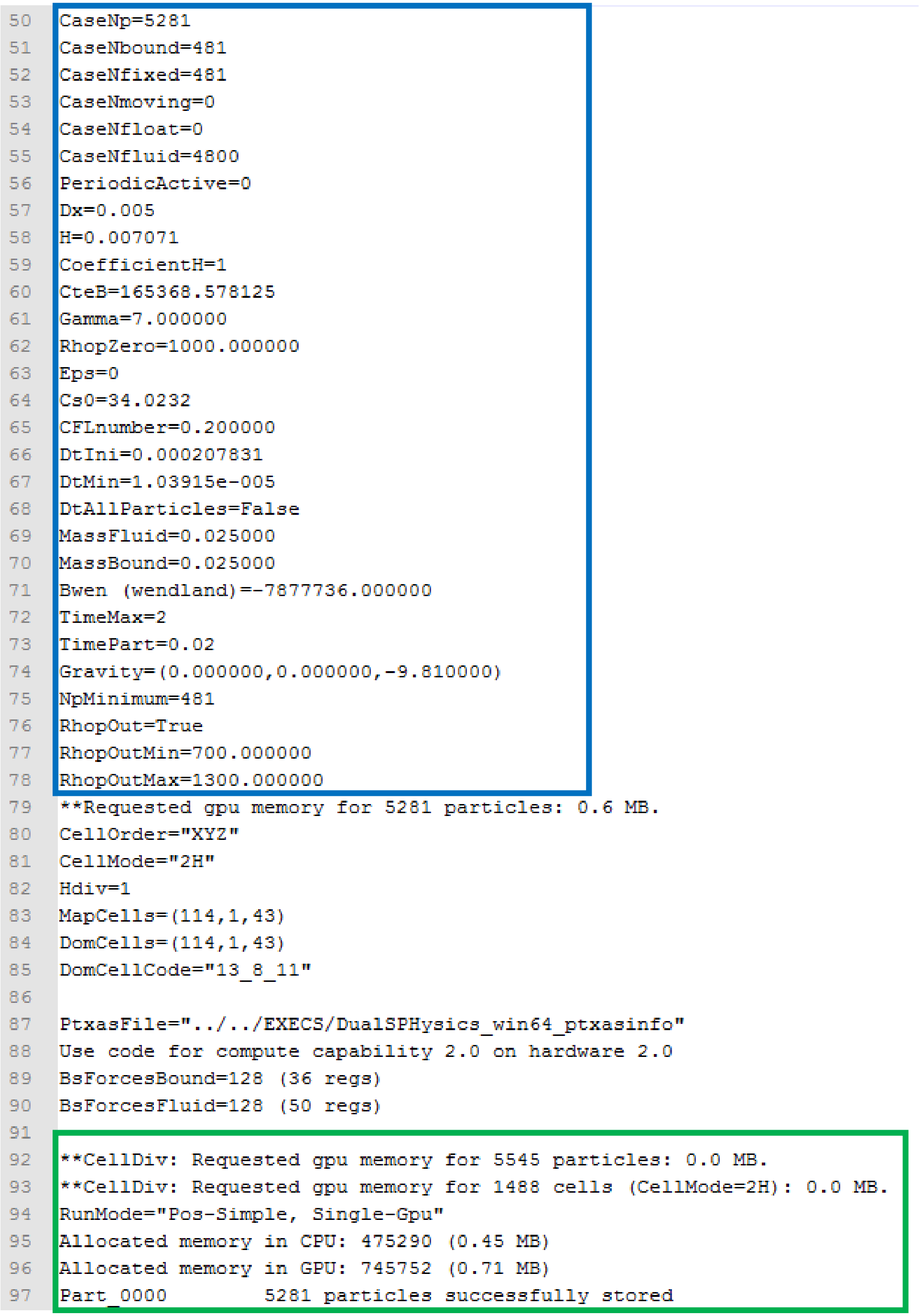
```
DualSPHysics v4 (10-11-2015)
==================================
[Select CUDA Device]
Device 0: "GeForce GTX 590"
  Compute capability:        2.0
  Multiprocessors:           16 (512 cores)
  Memory global:             1536 MB
  Clock rate:                1.23 GHz
  Run time limit on kernels: Yes
  ECC support enabled:       No
Device 1: "GeForce 8400 GS"
  Compute capability:        1.1
  Multiprocessors:           1 (8 cores)
  Memory global:             512 MB
  Clock rate:                1.63 GHz
  Run time limit on kernels: Yes
  ECC support enabled:       No

[GPU Hardware]
Device default: 0  "GeForce GTX 590"
Compute capability: 2.0
Memory global: 1536 MB
Memory shared: 49152 Bytes
[Initialising JSphGpuSingle v0.70  24-11-2015 15:40:36]
**Basic case configuration is loaded
**Special case configuration is loaded
Loading initial state of particles...
Loaded particles: 5281
MapRealPos(border)=(-7.07107e-006,0.0999929,-7.07107e-006)-(1.60001,0.100007,0.400007)
MapRealPos(final)=(-7.07107e-006,0.0999929,-7.07107e-006)-(1.60001,0.100007,0.600014)
**Initial state of particles is loaded
**2D-Simulation parameters:
CaseName="CaseDambreak2D"
RunName="CaseDambreak2D"
SvDouble=False
SvTimers=True
SvTimersStep=0.000000
StepAlgorithm="Verlet"
VerletSteps=40
Kernel="Wendland"
Viscosity="Artificial"
Visco=0.300000
ViscoBoundFactor=0.000000
DeltaSph="None"
Shifting="None"
RenCorrection=0.000000
Splitting=False
FloatingFormulation="None"
FloatingCount=0
```

Domain dimensions computed starting from minimum and maximum positions of the particles created initially

Input & output files

Run.out

Text file with execution log

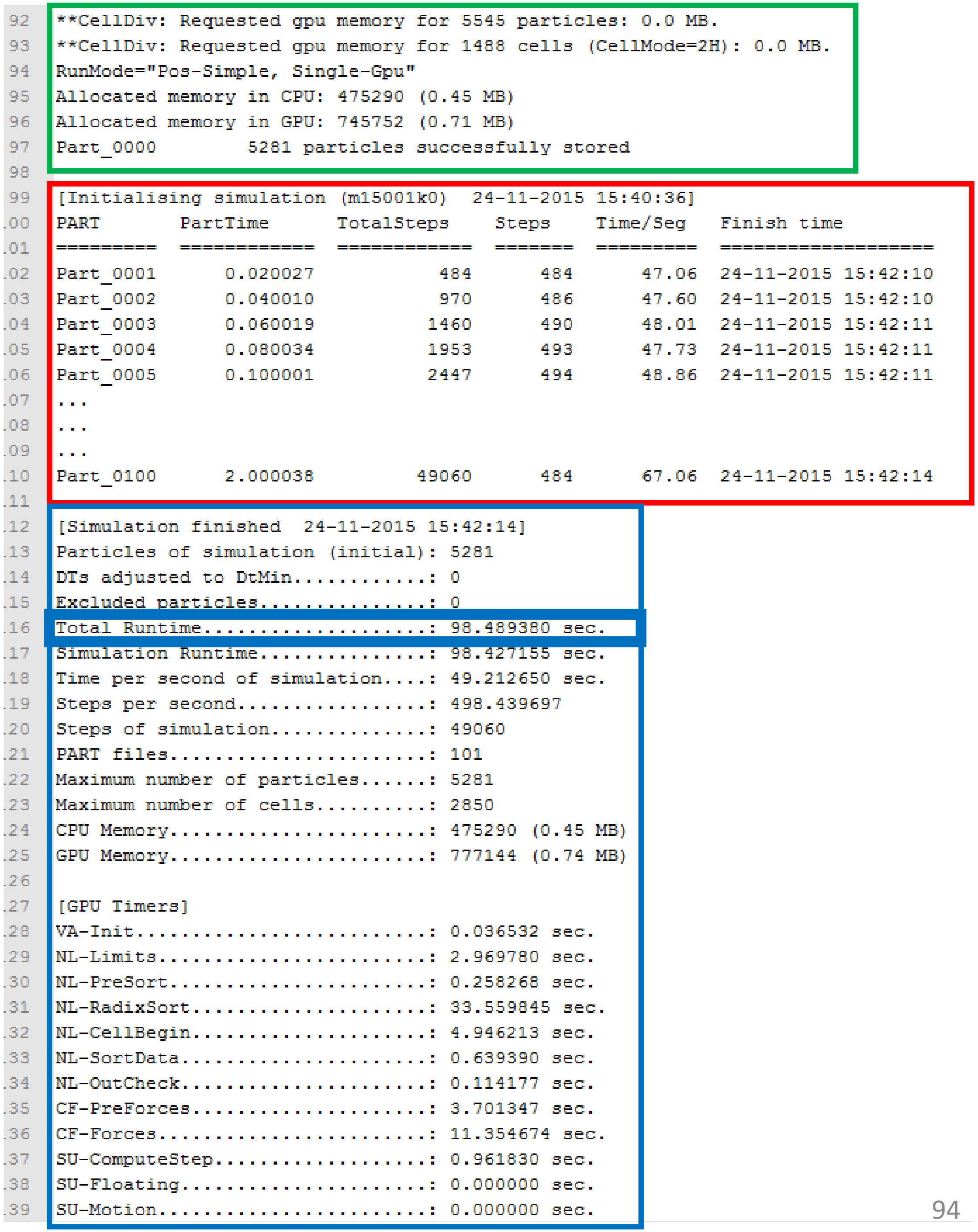


```
CaseNp=5281
CaseNbound=481
CaseNfixed=481
CaseNmoving=0
CaseNfloat=0
CaseNfluid=4800
PeriodicActive=0
Dx=0.005
H=0.007071
CoefficientH=1
CteB=165368.578125
Gamma=7.000000
RhopZero=1000.000000
Eps=0
Cs0=34.0232
CFLnumber=0.200000
DtIni=0.000207831
DtMin=1.03915e-005
DtAllParticles=False
MassFluid=0.025000
MassBound=0.025000
Bwen (wendland)=-7877736.000000
TimeMax=2
TimePart=0.02
Gravity=(0.000000,0.000000,-9.810000)
NpMinimum=481
RhopOut=True
RhopOutMin=700.000000
RhopOutMax=1300.000000
**Requested gpu memory for 5281 particles: 0.6 MB.
CellOrder="XYZ"
CellMode="2H"
Hdiv=1
MapCells=(114,1,43)
DomCells=(114,1,43)
DomCellCode="13_8_11"

PtxasFile="../../EXECS/DualSPHysics_win64_ptxasinfo"
Use code for compute capability 2.0 on hardware 2.0
BsForcesBound=128 (36 regs)
BsForcesFluid=128 (50 regs)

**CellDiv: Requested gpu memory for 5545 particles: 0.0 MB.
**CellDiv: Requested gpu memory for 1488 cells (CellMode=2H): 0.0 MB.
RunMode="Pos-Simple, Single-Gpu"
Allocated memory in CPU: 475290 (0.45 MB)
Allocated memory in GPU: 745752 (0.71 MB)
Part_0000        5281 particles successfully stored
```

Input & output files

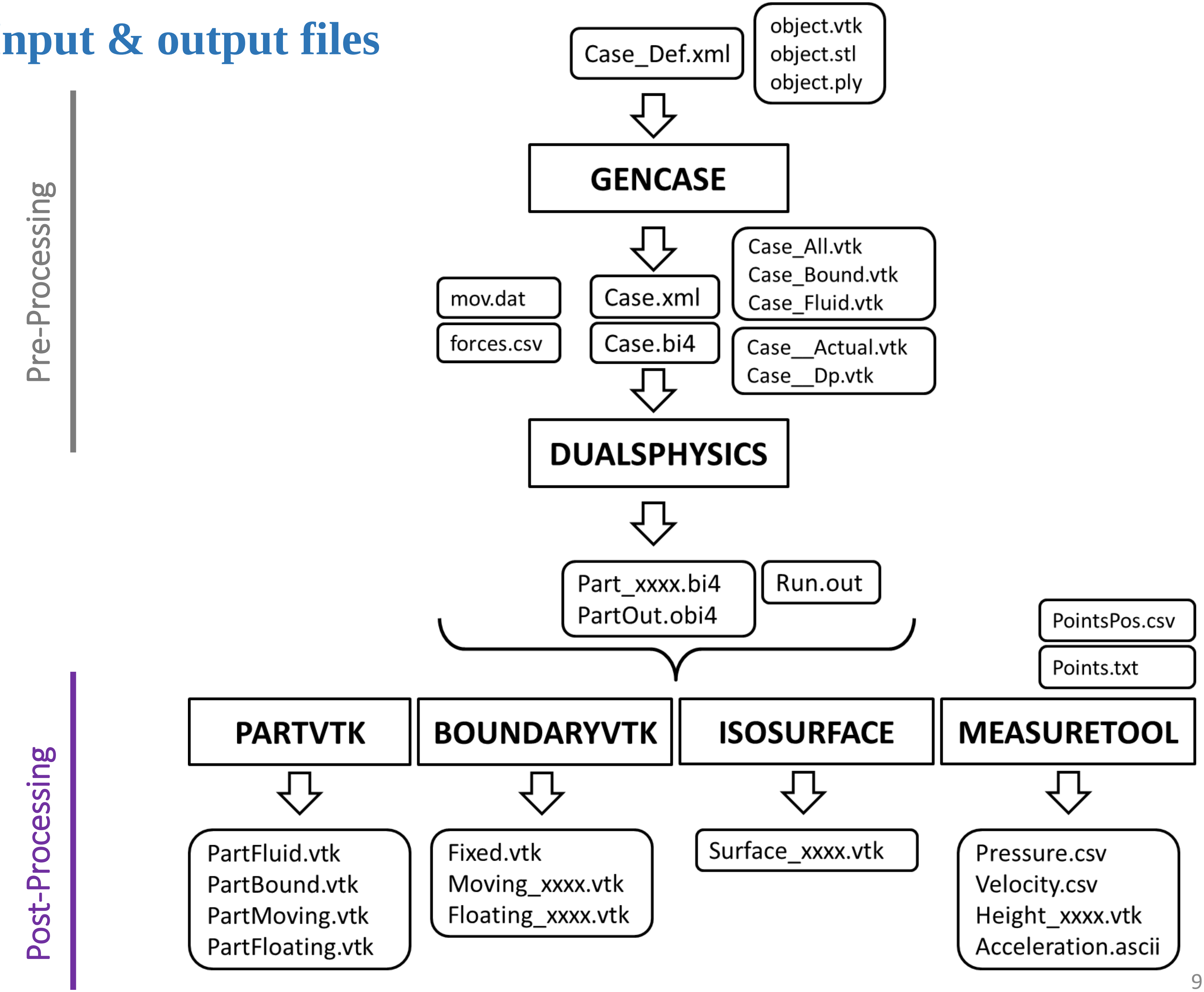
Run.out

Text file with execution log



```
**CellDiv: Requested gpu memory for 5545 particles: 0.0 MB.
**CellDiv: Requested gpu memory for 1488 cells (CellMode=2H): 0.0 MB.
RunMode="Pos-Simple, Single-Gpu"
Allocated memory in CPU: 475290 (0.45 MB)
Allocated memory in GPU: 745752 (0.71 MB)
Part_0000        5281 particles successfully stored

[Initialising simulation (m15001k0)  24-11-2015 15:40:36]
PART         PartTime      TotalSteps    Steps    Time/Seg    Finish time
=========    ============  ============  =======  =========   ===================
Part_0001        0.020027           484      484      47.06   24-11-2015 15:42:10
Part_0002        0.040010           970      486      47.60   24-11-2015 15:42:10
Part_0003        0.060019          1460      490      48.01   24-11-2015 15:42:11
Part_0004        0.080034          1953      493      47.73   24-11-2015 15:42:11
Part_0005        0.100001          2447      494      48.86   24-11-2015 15:42:11
...
...
...
Part_0100        2.000038         49060      484      67.06   24-11-2015 15:42:14

[Simulation finished  24-11-2015 15:42:14]
Particles of simulation (initial): 5281
DTs adjusted to DtMin............: 0
Excluded particles...............: 0
Total Runtime....................: 98.489380 sec.
Simulation Runtime...............: 98.427155 sec.
Time per second of simulation....: 49.212650 sec.
Steps per second.................: 498.439697
Steps of simulation..............: 49060
PART files.......................: 101
Maximum number of particles......: 5281
Maximum number of cells..........: 2850
CPU Memory.......................: 475290 (0.45 MB)
GPU Memory.......................: 777144 (0.74 MB)

[GPU Timers]
VA-Init..........................: 0.036532 sec.
NL-Limits........................: 2.969780 sec.
NL-PreSort.......................: 0.258268 sec.
NL-RadixSort.....................: 33.559845 sec.
NL-CellBegin.....................: 4.946213 sec.
NL-SortData......................: 0.639390 sec.
NL-OutCheck......................: 0.114177 sec.
CF-PreForces.....................: 3.701347 sec.
CF-Forces........................: 11.354674 sec.
SU-ComputeStep...................: 0.961830 sec.
SU-Floating......................: 0.000000 sec.
SU-Motion........................: 0.000000 sec.
```

Input & output files


Pre-Processing
Post-Processing
Case_Def.xml
object.vtk
object.stl
object.ply
GENCASE
mov.dat
forces.csv
Case.xml
Case.bi4
Case_All.vtk
Case_Bound.vtk
Case_Fluid.vtk
Case__Actual.vtk
Case__Dp.vtk
DUALSPHYSICS
Part_xxxx.bi4
PartOut.obi4
Run.out
PointsPos.csv
Points.txt
PARTVTK
BOUNDARYVTK
ISOSURFACE
MEASURETOOL
PartFluid.vtk
PartBound.vtk
PartMoving.vtk
PartFloating.vtk
Fixed.vtk
Moving_xxxx.vtk
Floating_xxxx.vtk
Surface_xxxx.vtk
Pressure.csv
Velocity.csv
Height_xxxx.vtk
Acceleration.ascii