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**Faculty of Engineering and Sustainable Development**

# Comparison of Shatter Effects in Autodesk Maya with nCloth and DMM Plugin

*Caroline Irwin*  
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**Examiner: Sharon Lazenby**  
**Supervisor: Torsten Jonsson**

# **Comparison of Shatter Effects in Autodesk Maya with nCloth and DMM Plugin**

by

Caroline Irwin

Faculty of Engineering and Sustainable Development  
University of Gävle

S-801 76 Gävle, Sweden

Email:

*maple\_hawk@msn.com*

## **Abstract**

In today's society, movies and videogames with a great deal of visual effects that contain objects that break, shatter or explode are popular. They are created from a number of different kinds of 3D programs and plugins. This time Autodesk Mayas nCloth is compared with the new built-in Digital Molecular Matter (DMM) Plugin to see which technique is easiest to use, as well as delivers the best result. A modeled sculpture was shattered using both nCloth and DMM and a set of predefined areas were studied. The results reveals that both techniques can be employed however the DMM technology has several advantages where less time consumption is one of them.

**Keywords: Autodesk Maya, 3D, shatter effects, DMM Plugin, nCloth, Shards, Tetrahedral Elements**

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# 1 Introduction

In today's society Computer Graphics are used frequently; when producing movies and other similar media productions. It is a good tool for making effects that accomplish that little extra something which, later on is appreciated by the viewer. There are massive amounts of different kinds of effects that can be achieved, however in this project the focus is on what is Dynamic Effects that destroys objects. Examples are effects, which crack, is crushed, explodes, crashes or in some method is destroyed.

These different types of effects often exist in movies and videogames. They are repeatedly created in Computer Graphics because it is easier or cost less to create in the computer, than making the effect in reality. Destruction effects can be produced in the three dimensional (3D) program Autodesk Maya [1] but also in other programs or plugins, such as the Digital Molecular Matter plugin (DMM Plugin) [2]. Because this area is quite extensive, this thesis is aimed towards one distinct area. My research project is about finding out whether or not the DMM Plugin for Autodesk Maya is a better alternative than Maya's built-in nCloth system, while making shatter effects. Both functions can be used for making explosions and similar effects, however perhaps one of them is a better option. The DMM Plugin is a newer feature in Autodesk Maya; therefore it will be examined and compared in this thesis.

## 1.1 Aim

The main idea is to study the two methods of making shatter effects with nCloth and DMM Plugin and comparing both the effectiveness of the process and also the quality of the result. The results can also demonstrate that the two methods are good for different purposes. One of the methods might be more efficient during the production of the effect however the result might not be as acceptable and vice versa.

## 1.2 Purpose

The final results of this thesis might assist animators in selecting between Maya nCloth and DMM for creating shatter effects. The effectiveness of the learning process of the tools in the two different techniques is also a target.

## 1.3 Objectives

There are two objectives which this thesis includes:

- Is DMM Plugin more efficient to use than nCloth? In that case, how?
- What is the quality of the results with DMM Plugin compared with nCloth?

These questions are described in Chapter 4 where they are specified in more detail and

the results can be found in Chapter 5.3. The project is also established to investigate the possibilities of the following hypotheses.

- DMM Plugin is easier to operate with straightforward settings.
- The quality of the results with DMM Plugin is better than the results with nCloth.
- The render time with DMM Plugin will take a little longer than with nCloth.

## **1.4 Expected result**

Both nCloth and DMM Plugin can be used to make a shatter effect. nCloth has been a component of Autodesk Maya for a longer period than the DMM Plugin. The expectations are that the DMM Plugin will produce some degree, of a better result than the nCloth. This is based upon the thought that if a new feature is added to a program, it should have some level of upgrade or improvement of an already existing element to elevate the performance and product of a creation. The other thought is that if DMM Plugin generates better looking creations, it might take a longer time to render, than it would with nCloth, which would be a disadvantage.

## **1.5 Problem limitation**

Since the time limit for this thesis is only ten weeks, the contents of the research and experiments are bound to have some limitations. For starters, there will not be enough time to try all the types of shatter effects such as cracks, explosions, crashing etc. The experiments are restricted to trying out shatter effects that include some sort of crashing that causes the shattering effect.

Another limitation is that only one type of material will be used and animated in the effect. Endless types of materials could be used for these types of effects, however for this research a stone material will be examined in the experiments.

Lastly, a major issue to think about is rendering. There will not be enough time for the investigation of the best options and settings, where the phase of rendering is concerned. Both the nCloth and DMM Plugin will be rendered with the same settings. If one of the functions performs better with a different setting than the plugin which will be chosen, it could then generate misleading results.

Also, Autodesk Maya's attribute fields will not be tested in the experiments.

## **2 Related work**

With help from the current technology within computer graphics and animation, very realistic scenes can be constructed in the computer which might have been impossible

to accomplish in the real world or maybe just cost too much. Computer graphics is also a very handy tool for shaping and testing different processes before they are applied in real life [3].

Methods to simulate deforming objects have been used and researched persistently for more than twenty years [4]. 1987 was the year that new approaches were presented which meant that not only static objects could be modelled but also dynamic materials with elastic qualities and also be affected by their surroundings [5].

Today it is more and more common, within movies and video games to construct destructive scenes. There are many different methods and techniques to take advantage of, all of which provide good results with great qualities. Many are unfortunately difficult to manage and need great amounts of computational capacities [6]. In both the movies “Cars” [7] and “Sucker Punch” [8] there are destructive scenes, however they have been produced with separate approaches within the computer graphics. For the movie “Cars,” Particle Dynamics in Autodesk Maya was treated for a scene where the asphalt becomes torn and demolished. For “Sucker Punch” a simulation tool called Kali was used, which was developed from Pixelux Entertainments DMM technology. It was used for many different scenes, one of which was a Japanese Pagoda is demolished both on the exterior and interior. This system allowed them to simulate materials, such as stone, brick, wood and metal that could break and be damaged more realistically than other traditional tools would handle [7] [8].

In the simulation tool Kali, the Rigid Body Solver which is a solver that alters the aspects of the dynamic animation when the settings are changed [9], has been exchanged with a Finite Element Solver [8]. Finite Element Method (FEM) or Finite Element Analysis (FEA) as the technique often is called [10], is a method of solving differential equations and is used for analysis and other physical problems within science and engineering [11]. The technique has been around since the 1940’s and was used in the 70’s and 80’s in manufacturing, but has lately found its directions to Computer Graphics and Visual Effects [12].

Other movies that also have used the Kali system are “Sherlock Holmes: A Game of Shadows,” “X-Men: First Class,” “Harry Potter 7 part 2” and “Wrath of the Titans” [13].

For the movie “Mission Impossible Ghost Protocol,” Autodesk Maya’s DMM technology was utilized when shattering a window in a scene where Tom Cruise is climbing the Burj Tower in Dubai. In the scene, he breaks the window, pushing through it with his feet and the help of his weight. In reality his body movements were filmed first and later composed with the fake glass [14].

In the movie “Mirror Mirror” from year 2012, the queen’s cottage is demolished. Prime Focus took the benefit of using DMM for that scene [13].

### **3 Technical background**

There exist endless numbers of 3D programs and plugins to make destruction effects that include shattering. Below is a short introduction to how 3D geometry is assembled, followed by some information of the functions found in Autodesk Maya and can be used to construct shatter effects. Some information about collisions and particle systems will also be covered.

#### **3.1 3D geometry**

In Autodesk Maya, there are three different fundamentals in the construction of 3D objects and they are: Polygons, Non-Uniform Rational B-Splines (NURBS) and Subdivision surfaces. A Polygon is assembled by three or more straight edges that are joined with points called Vertices. The area trapped inside these boundaries is called a Face. One separate polygon is usually referred to as a face and when several faces are put together it is called a Mesh [15].

Surfaces and 3D curves can be shaped with NURBS and are suitable for organic arrangements [16]. A NURBS curve is created and edited with control vertices (CVs) which control the shape [17].

Subdivision surfaces is a combination of both Polygons and NURBS since it has the CVs from NURBS that makes it easy to create smooth shapes while it also has the features from polygon surfaces as its faces can be extruded [18].

#### **3.2 Shatter**

In Autodesk Maya, there is a shatter function that can be used to crack or crush a mesh into several polygonal pieces. In the settings for creating shatter, the user chooses one of three settings that best fit with the animation. These are Surface shatter, Solid shatter and Crack shatter. Surface shatter makes it possible to crush either a NURBS or polygon surface where the outer shell is shattered. It is possible to extrude this surface to achieve the impression that it has a thickness. Solid shatter breaks the mesh into fragments in a method that makes the object appear solid. Every piece/ Shard has a thickness and does not appear as a shell. With Crack shattering, the user chooses a vertex or a CV which later will be the starting point of a crack. This function is well suited with Rigid Body Dynamics when trying to simulate a more credible collision [19].

Even if Autodesk Maya's shatter function is useful during some occasions, it has several downsides. It is for example difficult to make animations, when cracks occur, to look good. Also extra time needs to be spent on making the Shards collide with each other in a realistic matter, if they are converted to Rigid Bodies [20].

### 3.3 Rigid body

Rigid Body is a function used for simulating that an object is and has the abilities of being hard and stiff. Objects that are difficult to animate with only keyframing, such as bowling pins, colliding cars or collapsing bridges, Rigid Bodies are a suitable field of appliance [1]. There are two types of Rigid Bodies called Active and Passive. An Active Rigid Body is, with help from other forces affected while a Passive Rigid Body does not react on outer factors. A Passive Rigid Body would therefore not move while colliding with another object [21].

This standard Rigid Body function is a good alternative when working with fairly complex scenes with Dynamic forces [1]. On the other hand it can take quite some time to simulate scenes that have many nearby polygon splinters. This is caused by all the self-collisions where the velocities and directions of the splinters change and new calculations need to be generated [3].

### 3.4 nCloth

It is possible to simulate Rigid Bodies with another function called nCloth. It is a type of Dynamic system that is constructed by linked particles that are used for simulating several Dynamic materials such as clothing, balloons, dividing surfaces and elastic objects [22]. A Dynamic mesh is composed by a network of particles connected together with links and crosslinks to stabilize the nCloth material and can be viewed in Figure 1. In the settings for nCloth, different values can be changed in order to make a material appear like it has the realistic qualities. This is also how an nCloth can act similar to a Rigid Body [1].

In Autodesk Maya 2012, there is a new feature for making objects Rigid and Deform Resistant. It is included in the nCloth system and called Rigid nCloth Shells. It is helpful when creating simple destruction scenes or collision effects. In order for this function to affect the Shards, which are going to shatter, they first need to be assembled (Mesh > Combine) before it is converted to nCloth. The attribute Use Polygon Shells holds settings for Rigidity and Deform Resistance that can be changed [23].

Paint Effects strokes can also be used to make polygon shells by first converting them to polygons. While using nCloth shells it is not possible to change values of Rigidity and Deform Resistance for each individual polygon shell; they are set globally for all the polygons [24].

At the same time as a polygon is converted to an nCloth, a Nucleus Solver is created (the n in nCloth means Nucleus). This is a node that acts similar to a motor for all Dynamic Effects in Autodesk Maya. It defines global settings, such as Direction and Strength of Gravitation, Wind Direction and what quality the effect will have [25].

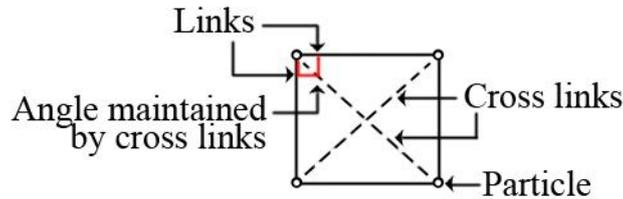


Figure 1. Part of an nCloth network (based on a picture from Autodesk Maya).

### 3.5 DMM

DMM (Digital Molecular Matter) is a separate physics engine that can be implemented in other programs and game components. For example, it has been used in Xbox 360 and in the PS3 versions of the video game Star Wars: The Force Unleashed [4]. According to Pixelux Entertainment, the creators of DMM Plugin, the quality increases and the time consumption decreases, with simulation of deformation and destruction with their DMM Plugin. This technique can work in correlation with Autodesk Maya's attribute fields and also with animated kinematic movement [2].

Pixelux Entertainment was established year 2004, with the vision of developing and expanding the game industry. That same year, Pixelux created the tool called DMM Plugin. In basic terms, it is a real time material physics simulator. In year 2008, the first version of a plugin for Autodesk Maya with DMM technology was released. Later in the Autodesk Maya 2012, the first built-in DMM Plugin is accessed [13]. This DMM Plugin version comes with a 2500 Tetrahedra limit [26]. A license for the full featured DMM Plugin can be bought from Pixelux Entertainment [2].

### 3.6 Collision algorithms

During simulations, calculations are continually being repeated to locate if moving objects are intersecting with other objects. This is called Collision Detection and it is a vital element in a physical simulator but also in real-time simulations [27]. When simulating both self-collisions and collisions with other objects, when it comes to dynamic objects, all contact points need to be studied. However when using Rigid Bodies, self-collisions can often be neglected and in the calculations only one contact point is measured [28].

The system also needs to calculate how the objects are constructed regarding position of impact or interacting areas and also consider friction. It needs to take in account for the locations of the objects and know when in time the actions occur [27]. To accomplish as realistic collisions as possible, it is also important to take account of the penetration depth during collisions with other objects [28]. All of these different parts are essential in order for the subsystem to be able to calculate the following movement or response that is trustworthy [27].

## 4 Method

The two main objectives in this thesis, from Chapter 1.3, were revealed while experimenting on a 3D model. Beginning with the first objective:

- Is DMM Plugin more efficient to use than nCloth? In that case, how?

While testing the 3D model with both nCloth and DMM Plugin, knowledge of how easy or difficult the settings were to use and adjust; was discussed for both techniques. If the adjustment settings were easy to operate and if there were not too many of them to handle, the making of a shatter effect would generate a smoother and faster process which always is ideal. Also the render time was studied, to see how long time it would take for the two techniques to render. The topics that were considered were these:

- Easy/Difficult
- Default settings
- Quantity of settings
- Clear user interface
- Help texts
- Rendering time

The second objective to the answer was:

- What is the quality of the results with DMM Plugin compared with nCloth?

The finished rendered results were studied at this stage. The important views to observe were how the splinter shapes appeared and what their qualities were. It was essential that the Shards reacted like stone in order to create a believable effect. How the Shards fell to the ground was also reflected. The areas that were considered here were:

- Splinter shapes
- Splinter qualities
- Gravity
- Credibility

In the beginning of the project both methods nCloth and DMM Plugin were tested to obtain more understanding for the systems and their usage. Meanwhile tutorials have also been an advantage in order to acquire some pointers and advice. Then, the 3D model, of which the experiments were going to be applied, was created and arranged in Autodesk Maya, in order to answer the two questions that this thesis is researching. It consisted of a statue and a chain with a weight on the end which crashed into the statue and caused the shatter effect which is displayed in Figure 2. The intended appearance of the shatter effect was that the sculpture would break into quite large pieces and have the feeling of being very heavy.

For the experiments a computer with the following performance was used.

Manufacturer: HP

Model: z600

Processor: Intel Xeon Quad-core 2,0 GHz

Graphics card: Nvidia quadro FX4800

Memory: 8 GB



*Figure 2. The 3D model on which the experiments were implemented.*

#### **4.1 nCloth**

In order to convert the polygon object into an nCloth that will shatter, the first item that had to be executed was to separate the object into the pieces that later would break in the effect. When all the pieces had the desired shape, all of the pieces were selected and combined to form one object. This object was converted to an nCloth and settings were adjusted to achieve desired qualities.

#### **4.2 DMM Plugin**

With DMM Plugin, there was no need to cut up the object in advance, as was necessary with the nCloth. Therefore, the object was directly converted to DMM material. Afterwards, the decision was made of whether or not to use a Splinter Cage (see Chapter 5.2) or the default Tetrahedral for the splinter elements. In this case, the Tetrahedral Elements were chosen. As with the nCloth, setting precisions and other preparations for the 3D model was the next phase.

## 5 Result

During experimenting with the nCloth and DMM Plugin, both positive and negative aspects arose and these will now be presented. The rendered outcome was prepared with Mental ray and a preset setting for the quality, called Production [29]. The only setting that was altered from this preset was the Multi-Pixel Filtering which is an attribute that blends neighboring pixels into a coherent unit [29]. It was changed from Gauss to Lanczos to obtain a better quality.

### 5.1 The results from the nCloth model

The first thought that occurred was how the object, in this case the statue, would be split up into the different shards in the simplest form. Trying to define the pieces by extruding different areas and putting in new edges “by hand” seemed very time consuming and challenging. Trying this felt impossible and it would take a great deal of time to prepare and ready the task. Therefore, some type of helping medium was needed in order to get the pieces arranged. A plugin for Autodesk Maya called Rock Shatter was employed [30]. This was a very useful assistant, but the outcome of the splinters revealed very flat inner sections without any irregular surfaces. Although, it was possible to go in and move vertices and apply more of them in order to achieve a more varied appearance of the Shards. While choosing each Shard and selecting to work in vertex mode, Autodesk Maya would most often open another Shard in that mode instead. This came to be quite frustrating after a time. Altogether, this preparative work was very time consuming and even more time would have had to be spent in order to make the Shards look more realistic.

After converting a mesh into an nCloth it is important to remember that the Nucleus Solver is created at the same time. When a Passive Collider object is in the scene and will come in contact with the nCloth, it needs to have that specific Nucleus Solver assigned to it. If not, the nCloth will neglect that the Passive Collider exists. In this case, the swinging weight, the floor and the block beneath the sculpture were Passive Colliders and they had to be assigned the same Nucleus Solver of the nCloth in the stone sculpture.

When the nCloth was created, its default state was a soft and deformable material. Therefore, the next priority was to find a method to make the material stiffer and imitate the conditions of a stone material. There were a few Presets that could be chosen as in Figure 3 however none of them were stone. When the decision of which Preset to take has been made, a little square further down in the Attributes Editor was filled with some help text. It contained some information

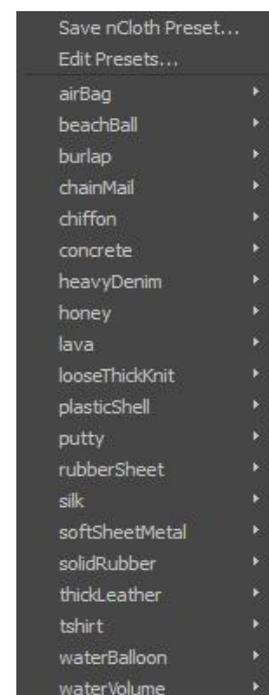


Figure 3. Presets for nCloth materials. 9

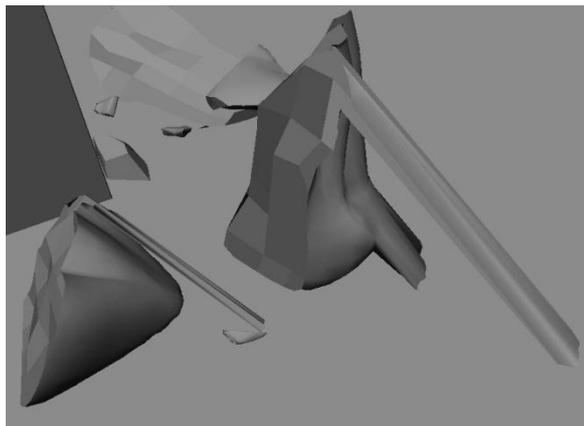
about the chosen material and also revealed a tip on which setting to change, in order to obtain a slightly different quality as in Figure 4. The most similar selection to stone in the Presets was the Concrete material; however it would not break at all. The Burlap material was a little springy but seemed as good or better a choice as any, to begin with.

```
Burlap is rough, non-stretchy, moderately heavy and very damped. One may yet need to increase the stretch resistance further for high gravity or fast moving objects. If the material seems too springy try increasing the damp value.
```

*Figure 4. Information of nCloth material preset.*

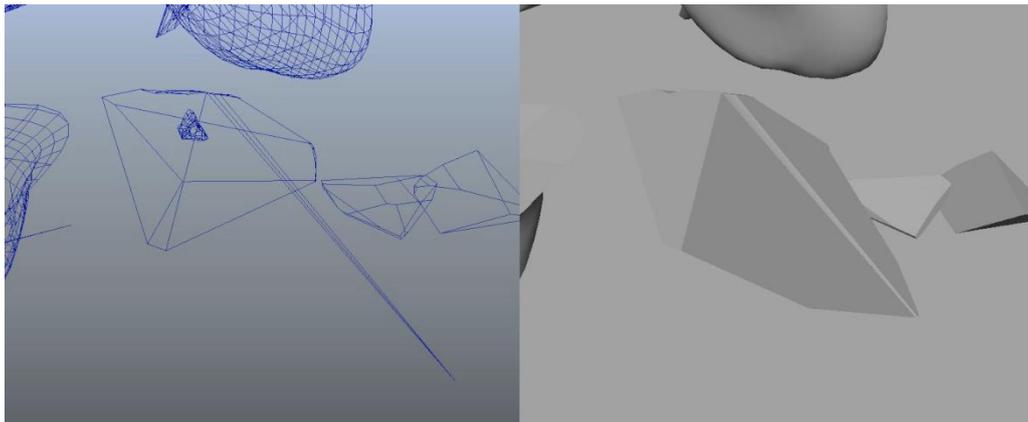
Another approach that was tried out was the Rigid nCloth Shells. When these were used, it was all about getting the mix of the two attributes, Rigidity and Deform Resistance, in the right balance. The weakness this function seemed to have was that it did not always feel or consider that the object beneath, in this case the stone block, was a Passive Collider. Instead, it started sinking through this object as if it was not there. Although sometimes it worked, however the solution to this problem is still unknown. The attempt of making the Passive Collider object into an nCloth shell and pushing up the values to simulate a Rigid object, would not work either.

A further issue with the Rigid nCloth Shells was that the different Shards could develop strange deformation errors when they collided and would stick to each other for a few moments. These elements seemed to push out a part of itself, appearing as if it had grown legs or thorns, which is displayed in Figure 5.



*Figure 5. Deformation errors in the nCloth objects.*

Some of the elements were also deformed in such a manner that they appeared to look larger during the sequence compared the beginning of the sequence. In Figure 6, this was revealed as the wireframe, to the left, shows how the Shard in the middle is compact but a vertex must have flung out. This caused the mesh to change its initial appearance, as seen in the right picture.



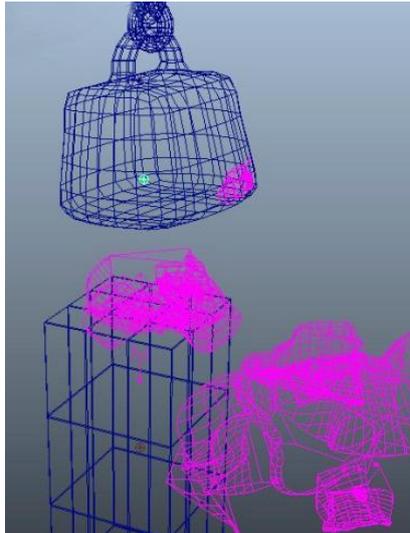
*Figure 6. Deformation causing the mesh to commit a new appearance.*

The Shards acted a bit springy at the impact with the floor but when the values of the Rigidity and the Deform Resistance were increased, several of the elements wanted to slip down through the floor and deform more like a cloth material.

Since the Burlap preset did not make the statue material appear as stone on the first try and neither would the Rigid nCloth Shells, it was necessary to mix and match the settings until something more appropriate was accomplished.

One of the main issues with the falling Shards was that they stuck together or fell through each other. The Collide Width Scale in the settings could be increased but at the cost of having the elements shatter more outwards from each other which was not the aim in this scene. The goal was to make the elements feel heavy and falling fast to the ground. This was not easy to accomplish, but by increasing the Gravity from 9.8 to 43 helped immensely.

The fact that the smallest Shards from the sculpture became stuck inside the weight mesh, as in Figure 7, was confusing and frustrating for a long time. The problem was; the nCloth in the sculpture was animated to have its dynamics off on frame 23 and on by frame 24. This meant that the weight came bashing into the sculpture before it had its dynamics active and the small pieces from the sculpture became captured inside the weight. After much trial and error, the problem was solved “easily” by moving the animation by making the nCloth active, a frame earlier.



*Figure 7. Small pieces of nCloth is trapped inside the weight mesh.*

Many times the nCloth elements which landed on the ground appeared as if they landed in an unrealistic manner where their center of gravity should have made them fall as if lying down. Instead, it seemed as if they were standing up and somehow managed to keep their balance.

While working with the scene, it was very slow through playbacks. For that reason Caches were created after almost every change in the settings. This was a handy tool which helped to obtain a good look at the quality of the shatter effect [31]. It was on the other hand very irritating to be dependent of using it over and over for every little change being made. The other option was to make a Playblast which also is a method of seeing the animation in full speed, although, it would take about the same amount of time as making a Cache.

It is also important to use “Play Every Frame” in the Animation Preferences instead of “Real-time” while playing through the animation in the time slider. The “Real-time” setting causes the playback to skip many frames as it does not have time to wait for all calculations to be made in the subsystem.

The conclusion that Autodesk Maya 2012 must have a problem with nCloth was accepted after opening the nCloth scene on two separate days and finding that the nCloth and Nucleus would not function and play the effects. If a Cache was saved before closing the file, it would work to import that Cache next time the file was opened. The negative part was that it was not possible to make any alternations to it leading to be stuck with the cached version or start from the beginning. While reading on the web, information could be found of other people having the same problem.

Default settings		Used settings	
<b>Dynamic Properties</b>		<b>Dynamic Properties</b>	
Stretch Resistance	20.000	Stretch Resistance	40.000
Compression Resistance	10.000	Compression Resistance	40.000
Bend Resistance	0.100	Bend Resistance	3.000
Bend Angle Dropoff	0.000	Bend Angle Dropoff	0.603
Shear Resistance	0.000	Shear Resistance	0.000
Restitution Angle	360.000	Restitution Angle	360.000
Restitution Tension	1000.000	Restitution Tension	1000.000
Rigidity	0.000	Rigidity	3.584
Deform Resistance	0.000	Deform Resistance	4.566
<input type="checkbox"/> Use Polygon Shells		<input checked="" type="checkbox"/> Use Polygon Shells	
Input Mesh Attract	0.000	Input Mesh Attract	0.000
Input Attract Damp	0.500	Input Attract Damp	0.500
Input Motion Drag	0.000	Input Motion Drag	0.000
Rest Length Scale	1.000	Rest Length Scale	1.000
Bend Angle Scale	1.000	Bend Angle Scale	1.000
Mass	1.000	Mass	3.931
Lift	0.050	Lift	0.050
Drag	0.050	Drag	0.050
Tangential Drag	0.000	Tangential Drag	0.400
Damp	0.000	Damp	7.052
Stretch Damp	0.100	Stretch Damp	0.100

Figure 8. Showing the dynamic settings that were changed.

The settings used with nCloth are primarily the Dynamic Properties and Collision Properties of the nCloth and the Gravity and Wind settings in the Nucleus. The Dynamic Properties have already been mentioned and the settings that ended up being used in the model were those that can be seen in Figure 8. In the collision settings mainly the Self Collide Width Scale was changed from value 1 to 3. The only setting changed in the Gravity and Wind settings was the Gravity, as mentioned earlier. When a Passive Collider is added, the main settings to observe are the Collision Properties. The main property which was changed was the Thickness setting. The floor was a Passive Collider and the Thickness needed to be decreased to value 0, otherwise the Shards would land a little up in the air which obviously is not the intended idea in this model.

It is possible to add an extra field in the scene for example Air, Gravity or Turbulence but none of these were used.

By typing nClothShape in the Search field, in the Maya Help Documents, information about all the attributes in the Dynamic Properties are described.

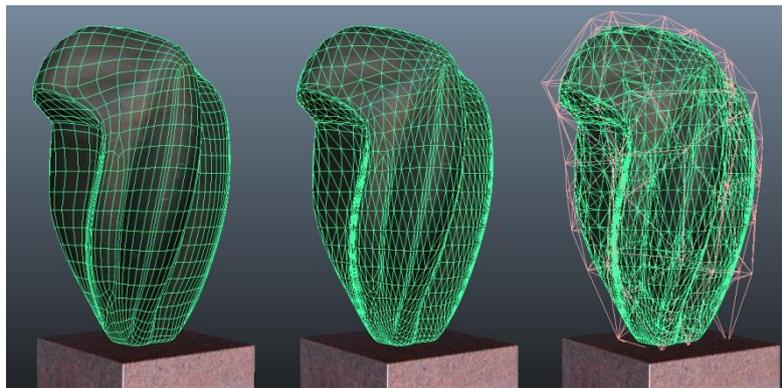
## 5.2 The results from the DMM Plugin model

At the beginning of the experiment period, the Tetrahedral limit was a hindrance while

trying to find a suitable amount of Shards to shatter. If the limit pop-up sign raised saying that there were too many live simulation elements in the scene, the natural thing to do seemed to be to change the settings and lower the amount. This was however not the way to go about it as the object became distorted and pressing the undo button did not help either. In this situation, the file had to be reopened or disassemble the DMM object and then convert it into a DMM again. The Tetrahedron count is found in the DMM Asset Manager and it is a good idea to keep track on the amount of the count to avoid that distortion problem.

There are two different techniques of creating a DMM object out of a polygon mesh. One method is to “Create DMM Object with AutoCage.” This creates the DMM object with a cage around it [32]. The settings, regarding the amount of Tetrahedral Elements that are made on this cage, are then projected on and perceived by the object. In Figure 9, the first statue is an ordinary polygon mesh, the second statue is a DMM from Polymesh and the third statue is a DMM with AutoCage.

The other method is to use the “Create DMM Object from Polymesh” where the placement and distribution of the Shards, are located directly on the mesh also shown in Figure 9. With this second method, it seems to be quite difficult to change the amount of Shards with precision. The settings needed quite large adjustments in order to change the amount of Tetrahedral Elements, and when doing this, it appeared as if the amount went over the Tetrahedron limit very easily. The 3D model ended up having the first technique on the sculpture, the block beneath and on the weight while the second technique was used on the flooring. The reason for using the DMM cage method on the sculpture was because it was easier to have control over the amount of Tetrahedral Elements.



*Figure 9. The statue is converted to DMM with different methods.*

There is an attribute in the DMM Asset Manager called Driven Tet Mesh that can be unchecked which means that the cage becomes invisible and will not block the view [32].

Same as with the nCloth the DMM sculpture was animated to first being Passive at frame 22 and not Passive at frame 23, which caused it to stay in place before the weight came and hit it.

Depending on what type of material an object has; the appearance of the elements that are scattered from the object is different. Glass has one type of appearance when it is broken and concrete or wood has another. Instead of only having the choice of using the default appearance of Tetrahedral Elements as Shards, the user actually has the ability to choose and change the Shards to obtain the effect that is wanted.

The tool to accomplish this is called a Splinter Cage and the cage appears different depending on what the outcome should be. There is a selection of pictures in Autodesk Maya in format bmp, that can be chosen, and this picture generates how the Splinter Cage is shaped. It is also possible to make a Splinter Cage from polygons and convert it into a Splinter Cage. The Splinter Cage is then applied to the DMM object which will break into the pieces that are requested by the cage's structure [32].

Making a Splinter Cage from scratch was attempted several times with different appearances but none of them delivered a suitable appearance for the Shards. For that reason, the default Tetrahedral Elements was the preferred approach.

There are many different Presets that could be used as material as in Figure 10. Several candidates were found but ultimately they also needed several adjustments. The first ones to be chosen were those of stone, granite, concrete, brick and similar materials. The Preset which finally ended up being the foundation for the settings was the "strongskelton."

Aside from the big chunks of stone braking from the sculpture, a few smaller pieces were also desired to achieve a more credible effect. This was not the easiest of missions to achieve. There is the possibility to add a Density Region which creates an orange box that can be changed in size and applied at desired place [32]. When the DMM Density Scale, in the Extra Attributes of the Density Shape is increased, the detail of the resolution becomes finer [32]. However the DMM object needs to have enough Tetrahedral Elements generated into the sculpture in the first place in order for it to work. Because the model has been tested and appears to project better looking Shards when the Tetrahedral count is low, this tool did not benefit this model.

Another helping tool for the DMM technique is the possibility of adding a DMM Passive Region. This is another box that can be applied to a DMM object where it is not

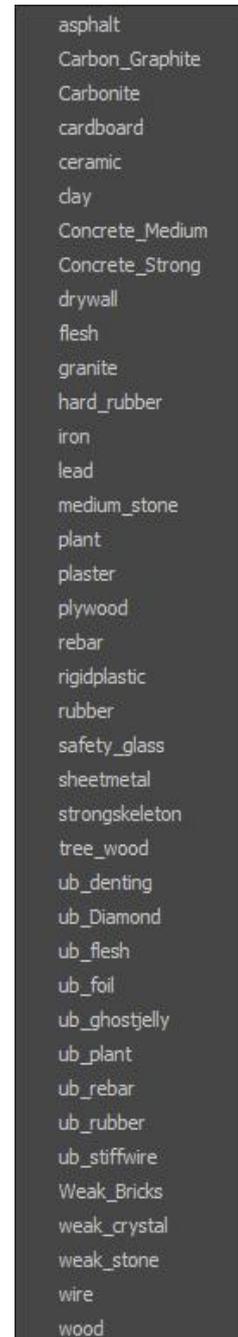


Figure 10. Preset Materials for DMM.

supposed to be affected of external influences and therefore would not break [32]. This tool was initially used at the base of the sculpture forcing the bottom part stay on the surface of the block. Unfortunately, either the element remained on the block however it was too tall and did not fit with the animation of the weight, or else the bottom part flew away with the rest of the Shards as if it ignored the Passive region. Eventually, the decision of not using this tool for the effect was made.

When the Shards started flying from the impact of the weight, they tended to move quite a distance from the starting point. This felt overly exaggerated and tended to strengthen the impression that the stone fractures were light instead of heavy as intended. The Gravity was raised from 9.8 to 40 in order to make the Shards drop to the floor much sooner.

One of the most difficult and peculiar problems with the shattered Shards were most of them would not land on the floor; instead they placed themselves a little above it, which is displayed in Figure 11.

With the default material all pieces land directly on the floor. It also turned out that if the amount of Tetrahedron would be increased while also decreasing the Stiffness, Toughness and Creep in the DMM Material Attributes, the elements would rest on the floor.



*Figure 11. Many of the Shards are stuck in the air instead of on the floor.*

Unfortunately, the resulted appearance with the sculpture ending up to be destroyed in so many pieces as in Figure 12 was not the intended appearance for this model.

A returning dilemma was the fact that some Shards fell through the block after the impact and ended up getting stuck to it. Under the circumstances, the block should appear solid and this was not one modest fault that could be overlooked. This question was presumed to have the same origin as the problem with the hovering Shards. If the Tetrahedron count was increased in the scene, it was more unusual to find that the Shards fell through the block.



Figure 12. Shards are on the floor but there are too many of them for the effect.

Some experiments with the block beneath the sculpture were made; this involved converting the block into a DMM object. At first there was no problem with it, however later on some problems cropped up with the texture. The block consists of two textures, the one on every side except the front which has another texture assigned to it. When the mesh was converted into DMM, it removed the front texture and changed it into the texture that covers all the other sides. Later on, it worked fine again and the front texture would stay as it was meant. The assumption is that the problem is somehow related to another method that can be used to make the object have another texture on the surfaces inside that are revealed when it is shattered. This can be prepared by adding two textures to an object and DMM will take the texture that covers the mesh the least and places it on the inner surfaces.

One of the satisfying parts about DMM is that it is not too slow during Playback in the Time Slider and there is no need for making Caches in between every change of the settings.

There is a User Guide under the DMM Help menu which contains handy information when trying to learn about DMM.

Default settings		Used settings	
DMM Material Attributes		DMM Material Attributes	
Youngs (stiffness)	800000	Youngs (stiffness)	39500000
Youngs Damp	0	Youngs Damp	0
Poissons (vol. preserv.)	0.0000	Poissons (vol. preserv.)	0.0000
Density	2500.00	Density	200.00
Toughness	200000	Toughness	7
Yield (plastic def. start)	0.0000	Yield (plastic def. start)	0.0000
Max Yield (def. limit)	0.0000	Max Yield (def. limit)	0.0830
Creep (plastic def. speed)	0.0000	Creep (plastic def. speed)	1.0000
Friction	0.6000	Friction	1.0000

Figure 13. Showing the attribute settings that were changed.

Figure 13 reveals which settings were changed to achieve the quality results of the elements. The settings in the Asset Manager that set the amount of Tetrahedral Elements were also changed. The value 100.0 on Target Face Count and value 1.0 on Scale Gap resulted in a Tetrahedron count of 269 as the default setting for this model. These settings were replaced with the value 15.0 on the Target Face Count and value 9.6 on Scale Gap. These values lead to a Tetrahedron count of 106. Depending on how the settings are arranged in the Material Attributes, the sculpture actually could break into 106 pieces. The Material Attribute settings were however set in a method that made the material qualities harder and more difficult for all the Tetrahedral Elements to reveal themselves. Instead, some of them stayed together and formed a larger piece.

### **5.3 Comparing results**

The following information compares how the results of the experiments with nCloth and DMM Plugin are associated with each other.

#### **5.3.1 The working process**

When judging the main and most significant settings that are needed to create and operate both DMM and nCloth objects, the DMM settings are fewer in quantity. The DMM Material Attributes are easy to embrace and the settings in the DMM Asset Manager are easy to keep track of. With nCloth, it is primarily the Collisions and Dynamic Properties to regard, however there are few more settings to consider as well. Both techniques have settings that are obvious for what they can accomplish and others that are difficult to understand what they might be used for. Information about the settings for nCloth can be found in the Maya Help and the DMM is to be found in the DMM Help User Guide. An extra plus to the nCloth was information about the Presets was found and also provided tips on which settings could be changed to obtain a slightly different property. Both techniques deliver a soft material as default. The nCloth acts like cloth just as the name indicates while DMM delivers more of a soft and squashy material that keeps its volume inside the object.

The techniques have had the same proportion of difficulty, as well as some of them having been in the same areas. For example with nCloth, there were problems with the nCloth Shells where the Shards would fall through the block, while with DMM, the Shards became stuck to the block. Also with nCloth, it was difficult to achieve the accurate qualities of the elements. With DMM, it was challenging to balance the settings to achieve the accurate qualities as well as the right amount of elements.

While using the Time Slider and playing through the animation DMM was most efficient. Making Caches was necessary when working with nCloth however with DMM it was not essential which made the job flow easier.

When comparing the render time on these two systems, it is discovered that they are very similar. Both models were set to render 150 frames. The nCloth took twelve

minutes and twenty two seconds to render whereas the DMM took twelve minutes and thirty nine seconds; a small difference of seventeen seconds.

### **5.3.2 The appearance**

The shape of the Shards in nCloth would mostly depend on how the object is modeled or what plugin is operated to make them. This all depends on the work that is prepared in advance, before the object is converted into an nCloth. With this approach the size and amount of Shards were created beforehand and the results would show the shape of the shards as they were created. DMM has its benefit with Splinter Cages to get a certain style on the elements that can be very time rewarding. If instead the Tetrahedral Elements are used, the size and shapes are arranged with the settings which can take a while to learn. Although with DMM, the access to the Density Region tool can be beneficial. Also, it is significant when smaller pieces are desired in the shatter effect. This is easy to use and can be applied at a later stage if sudden need appears. If the same requirement for smaller pieces would emerge when working with nCloth, the process would have to be started from the beginning by applying more fragments and converting the mesh into nCloth a second time. In other words DMM Plugin allows more freedom to change the initial appearance without having to start over and lose time.

The Shards from both techniques look similar to flat surfaces, though nCloth is not the system taking credit for the shape of its Shards.

With nCloth it was difficult to make the Shards seem hard without elastic features. The Rigid nCloth Shells could not readily be relied upon because they sank through Passive Colliders for some reasons. If this had not been an issue, it would have been easier to create hard materials that would not be springy. Without the nCloth Shells, the material was either bouncy or too stiff making it unbreakable. With DMM Plugin it was easy to adjust the elements to appear Rigid by changing the Stiffness or Toughness settings. The Self-collisions worked best with DMM because with nCloth they stuck to each other and even went through each other. On the other hand, the Shards had the ability to attach themselves to the block with DMM, possibly because the Shards were big and not having as many Tetrahedral Elements as preferred for it to work in the scene.

In order to make the Shards appear heavier and fall to the ground, the Gravity settings were increased on both the nCloth and DMM Plugin. It might have been better to have put in a Gravity Field in the scene however it has not been focused on in the experiments.

The credibility of the rendered results is not the best in either one of the models. The fact that the nCloth pieces are a little elastic as they collide with the floor is not an expected performance. The circumstance that some of them disappear through the floor is not a good result. Neither does it look credible when the Shards go through each other. The DMM has its flaw with the hovering elements that does not want to collide directly with the floor. The second imperfection is the Shard that is stuck to the block and for that reason is incapable of falling to the floor.

### **5.3.1 Summary of the results**

The results of all the areas that were researched with the experiments have been gathered in Table 1. An equal sign means that both methods had similar results and a

plus sign means that one of the methods was better in that area.

Many of the fields were comparable and not that far off from each other. DMM received better results on the areas “quantity of settings,” “playback” and “splinter qualities” while nCloth had one advantage with the “help texts.” These results propose that DMM has an advantage of having fewer settings to keep in mind and needing positioning. The work process can be much faster with DMM than with nCloth considering that the Playback was less time consuming. The qualities of the Shards were also better with DMM.

**Table 1. Summary of the result of the criteria.**

	DMM	nCloth
<b>Working process</b>		
Easy/Difficult	=	=
Default settings	=	=
Quantity of settings	+	
Clear user interface	=	=
Help texts		+
Playback	+	
Rendering time	=	=
<b>The appearance</b>		
Splinter shapes	=	=
Splinter qualities	+	
Gravity	=	=
Credibility	=	=

## 6 Discussion

The information below is about the techniques that caused the process of making the effects both easier and difficult.

### 6.1 nCloth

One of the major disadvantages with the nCloth system is that it does not contain any technique that can create Shards. For this sculpture experiment, it was decided that the Shards would be too difficult and time consuming to make by hand. Therefore, it was determined that the process would take the liberty to benefit from another plugin called Rock Shatter. This plugin was very helpful but it does not say anything about nCloth other than it lacks this kind of feature.

There were high hopes about the Rigid nCloth Shells and that they were going to make the process of creating a shatter effect easier. Unfortunately, they did not live up to the expectations. They were not trustworthy when they would on one occasion work and on the next they would not. It was not really the shells that did not function but that they fell through the Passive Colliders.

Probably the worst weakness the nCloth system had was the fact that the Shards went through each other. It does not add any realism to the effect.

## **6.2 DMM Plugin**

The limit of 2500 Tetrahedral Elements seemed like a big obstacle at the beginning of the experiments. By choosing to work with the DMM that comes with a cage, the value became more controllable.

During the testing of the DMM Plugin other examples and models were created and explored. One of these models was a windowpane breaking because of a ball going through it. Another example was a brick wall being demolished from a large object. In these cases, the DMM Plugin was a great tool for making the effects. Also, the Splinter Cages revealed that they are an efficient technique that really is helpful, while making the task so much easier. The Splinter Cages that are prepared in Autodesk Maya and can be selected to operate on a mesh seem to work best on objects that are flat and thin as for example windows and bricks. If the object is thicker or has an odd structure, it would most likely be better to make the cage from scratch. This was proved with the sculpture model, where the outcomes of the shatter elements were not appropriate, when using one of the Splinter Cages that could be selected. Even several different cages put together would not do the trick. The effort of making one from polygons and converting into a Splinter Cage did not also work that well. The complicated part was to enable a cage that would produce both big sections of the stone, as well as small and tiny pieces.

It was quickly discovered that this plugin makes very good shatter effects quite quickly without having to adjust many settings to accomplish it. The system is easy to use and there are not many settings that need to be adjusted. The DMM Plugin also comes with certain tools, such as the Density Region and Passive Region to assist and simplify the process. These were really nice helping tools that many 3D models will benefit from. Unfortunately, their capacities were limited by other circumstances in the sculpture scene.

## **6.3 Other reflections**

The experiments were only applied to one 3D model. If several additional models of objects and materials had been tested, the results might have ended up different.

The attribute fields that can be employed in Autodesk Maya, was never tested. It would be interesting to see if one of them could be a solution to the hovering Shards or the ones that became stuck to the block. Maybe a Gravity Field or one of the other fields had been a better answer to make the Shards appear heavier, than changing the Gravity setting to the entire scene.

## 7 Conclusion

The summary in Table 1 displays that nCloth and DMM have many similarities. The areas that made DMM stand out are Quantity of settings, Playback and Splinter qualities. Meanwhile, nCloth had a small advantage on the Help texts. Generally, the summary implicates that DMM has a few advantages however overall the two systems nCloth and DMM are similar in the areas that are included in the working process and in the appearance.

DMM Plugin is a better tool when it pertains to creating hard materials. The user needs to give the system a chance and learn how the settings work together. Although, it seems as if this technique is more appropriate for explosive effects where the object breaks into many and smaller pieces; not as in the sculpture model where the pieces were going to be few but large and would not travel too far. The Passive Region and Density Region are helpful tools but were difficult to collaborate with the modeled sculpture. The time award is superior with DMM than nCloth.

nCloth is a good tool if the amount of Shards that are needed for an effect is known in advance. This technique would work best with Collision effects in thinner materials for example a brick wall or windowpane where there is not as big of a risk that the Shards are pushed into each other. With the sculpture model, the material was thick and several Shards in breadth, in the same path as the impact direction, meant that they stuck to each other. The Rigid nCloth Shells did not function as desired but would have led to better quality of the Shards, if it had.

### 7.1 Future Research

One area that has not been experimented is Autodesk Maya's Attribute Fields. It might be good to test and see how well they work on the two different techniques.

The rendering was not the priority this time. Investigating this area to see if there are any render settings that are better suited for these methods might also be an option.

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