CLASS ID CP319398

Innovative Designs and Procedural Patterns with Fusion 360 and Maya

Alex Lobos – Rochester Institute of Technology
Keqing Song – Autodesk

Learning Objectives

1. Learn how to use Fusion 360 to create a wide variety of designs, including using the Generative Design tool.
2. Learn how to use Maya MASH to create procedural, algorithmic patterns and bring them into Fusion 360 for further development
3. Learn about how to easily import and export geometries between Fusion 360 and Maya
4. Learn how to generate innovative models that combine traditional CAD designs

Description

Automation tools like generative design, visual programming and procedural nodes are transforming the way that products are created by providing design solutions that are efficient, resilient and visually striking. When looking at the appearance created by these workflows, two types become evident. The first one resembles bones that provide structure with minimal use of material. The second one uses complex algorithmic patterns and procedural networks, similar to fractal geometries that can be used as bodies or applied to surfaces.

This class explores easy-to-follow workflows for the creation and combination of procedural structures and patterns in product design. Designs can start in a typical modeling workflow within Fusion 360. Maya's MASH tool will then be used to create intricate procedural networks, which are then brought into Fusion 360 for further refinement. The use of MASH is a novel and innovative approach, far easier to achieve than other tools such as Dynamo or Grasshopper, and with a completely different (yet complementary) process to Generative Design's simulations.

About the Speakers

Alex Lobos is an industrial designer and educator focused in sustainable design, emotional attachment and CAD applications. He is Graduate Director and Professor and Industrial Design at Rochester Institute of Technology, New York. At Autodesk, Alex is a Fellow in-residence in Strategic Foresight, Expert Elite for Fusion 360, member of Autodesk University's Advisory Council, AU Featured Speaker and recipient of Fusion 360's Education Award. For more information on Alex's work go to: https://www.rit.edu/artdesign/directory/aflfaa-alex-lobos

Keqing Song is a Fusion 360 Product Manager. He first joined the Inventor Fusion team, and has been with the product since he started working at Autodesk 7+ years ago. Keqing has a mechanical engineering and business management background. He's also a design geek, foodie, watch nerd, photography enthusiast, and vinyl junkie.

1 - Automation in digital design

Automation is a key tool in CAD. It frees users from having to perform tasks that are either too complex or tedious.[1] It also expands their capabilities to achieve results that are efficient, attractive, dynamic, and aligned with natural eco-systems.[2] In both of these cases, automation provides results that would be hard to obtain without the use of technology.

When using CAD tools in automated processes, there are two particular workflows that provide benefits in terms of how forms are created. On one hand is the use of procedural networks in order to create intricate patterns that resemble natural systems and have minimal use of geometric shapes.[3] Second is the use of generative design tools, where sets goals and criteria are provided to a computer, which takes over and develops large number of iterations that meet such criteria.[4] In both of these cases, humans and machines collaborate together and learn from each other as they create innovative design solutions.

Fusion 360 is a powerful CAD tool that provides a user-friendly interface and a robust set of tools for design, fabrication, simulation and visualization. Recently Fusion 360 added to its platform the Generative Design tool, which allows users to set goals for physical performance of a given design, such as supporting forces and loads. Generative Design uses these goals and a basic input geometry to create large iterations of potential solutions, all meeting the set criteria. This is a very powerful workflow for design creation, but it also limits the user in terms of their control over physical appearance of the resulting designs.

A complementary workflow to generative design is the use of procedural networks. This type of geometries provides a rich and intricate appearance, which can be edited to create interesting, progressive effects. In order to achieve these geometries, product designers use tools based in visual node patterns, typically Grasshopper and Dynamo. While these tools offer a wide range of capabilities and interesting outputs, they can be hard to learn for users without a strong foundation in coding and mathematical relations. This class proposes de use of Maya, particularly its plug-in MASH, as an alternative that is simpler to use. The key benefit of Maya-MASH is that users do not need to create complex nodes from scratch but rather select from a series of preset patterns that are easy to tweak in order to achieve a desired procedural pattern.

2 - Combining Fusion 360 and Maya

The use of procedural networks in Maya/MASH that can be imported into Fusion 360 is a useful tool for creating complex patterns in a user-friendly way. The result are intricate patterns where the designer has a high degree of control and influence, which can be used as appearance details in product design.

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[1] Gonçalo Castro, "TetraScript: A responsive pavilion, from generative design to automation," *Architectural Computing* 1, no. 10 (2012): 87-104.
[2] Alex Lobos, "Finding Balance in Generative Product Design." In *Proceedings of Norddesign Conference: Design in the era of digitalization*. 14-17 August, 2018. Linköping, Sweden.
[3] Alex Lobos, "Applying Generative Systems to Product Design." In *Proceedings of Generative Art Conference*. 19-21 December, 2019. Rome, Italy.
[4] Kristina Shea, et al. "Towards integrated performance-driven generative design tools," *Automation in Construction*, 14 (2005): 253-264.

The goal behind using procedural networks is to create design patterns that have a high degree of intricacy while still providing designers with enough flexibility to experiment with different aesthetic combinations. There are a number of existing workflows that have similar benefits, particularly Generative Design and Dynamo/Grasshopper. The combination of MASH/Fusion 360 provides some key differences, and in general easier to achieve and execute (See Table 1).

Differences between Generative Design and Fusion 360 + Maya workflows	Procedural networks focus on creating interesting patterns that enhance product appearance instead of focusing on physical performance.
	The process gives designers ample control and flexibility in terms of combining different types of procedural nodes, and finetuning each of them in a direct way. In generative design, the role of the designer stays in setting up goals and in selecting outcomes, with limited input on how the new forms are generated.
Differences between Dynamo/Grasshopper and Fusion 360 + Maya workflows	Dynamo/Grasshopper require users to setup complex node networks ahead of time, and needs significant knowledge on the right terminology, node creation and algorithm relations.
	MASH, in contrast, offers a user-friendly interface that is based on preset nodes, each with variables that are easy to adjust via sliders. This workflow is a lot more intuitive and liberating to designers, as they can experiment with different patterns and shapes freely, until they find the design that feels more appropriate.

Table 1: Differences between Fusion 360 + Maya workflows vs generative design or visual node patterns.

Another benefit of using MASH is the ability to export files in a number of formats, particularly FBX. This file format creates bodies with a relatively low size, which can be imported easily into Fusion 360 and converted to B-Rep or T-Spline bodies. This easy conversion makes it possible to combine geometry originally created in Maya/MASH to be further edited in Fusion 360 and even to merge it with native bodies.

3 - Typical workflows between Maya/MASH and Fusion 360.

3.1 – Create freestanding network in MASH and import to Fusion 360.
Process overview: Create network in MASH > Export as FBX > Import into Fusion 360 and convert to B-Rep or T-Spline.

Example (Figure 1): A box was replicated into a square grid, and then altered with a "noise" node to create a random effect. The result was imported from Maya into Fusion 360 and used as a decorative lamp.

Figure 1: Table lamp concept

3.2 – Attach MASH network to a body created in Fusion 360 (Figures 2, 3, 4).
Process overview: Create geometry in Fusion 360 > Export as STL > Import into Maya and attach a MASH network to it > Export as FBX > Import into Fusion 360 and convert to B-Rep or T-Spline.
Example (Figures 2-4): A Bluetooth speaker/lamp was designed in Fusion 360. The shade was then exported to Maya, where a series of procedural networks were attached to it. The resulting geometry was then imported back into Fusion 360.

Figures 2, 3 and 4: A Bluetooth speaker/lamp.

3.3 – Use a MAYA network to "stamp" a body in Fusion 360
Process overview: Create network in MASH > Export as FBX > Import into Fusion 360 and convert to B-Rep or T-Spline > Use network to stamp (Boolean union, cut or intersect) a body created in Fusion 360.

Example (Figure 5): A network with a progressive pattern was created in Maya. The pattern was then brought into Fusion 360 and used as stamping tool for a detail portion of a chair.

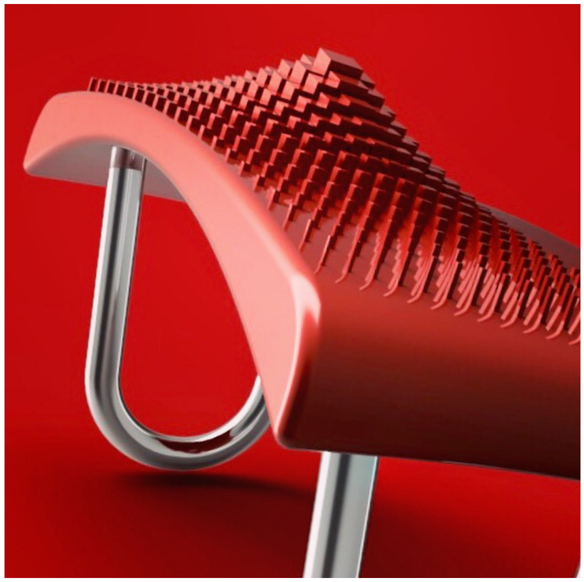
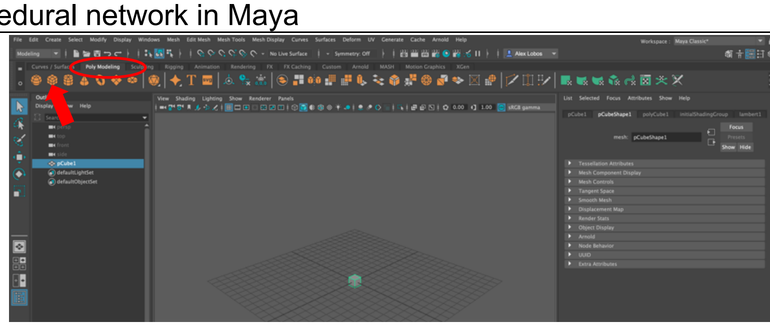


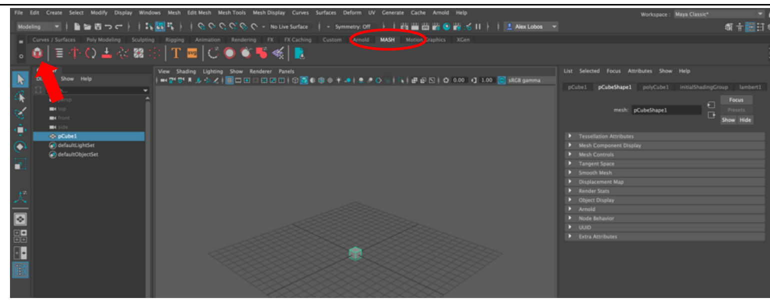
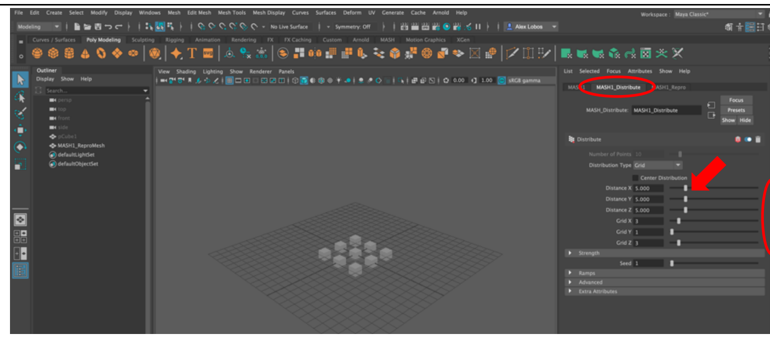
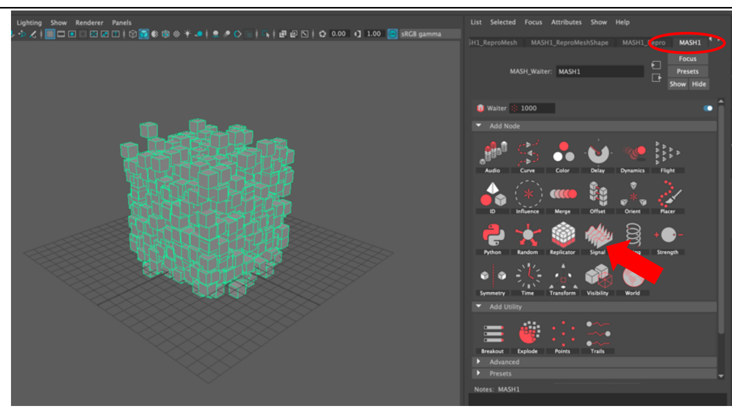
Figure 5: Chair detail

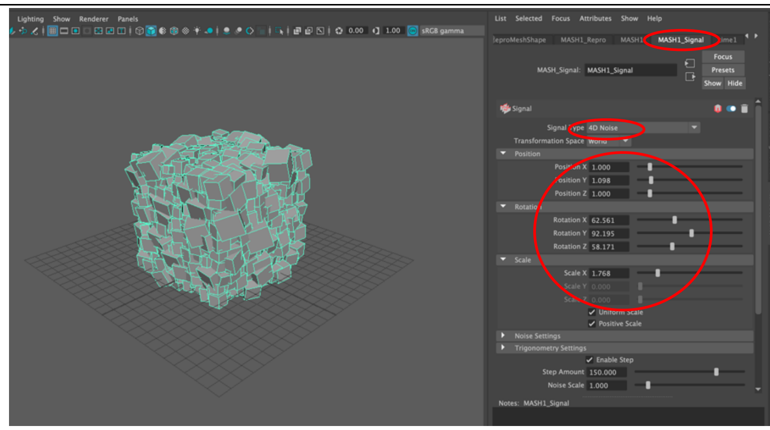
4 - Tutorials

Below are a set of tutorials that provide guidance on how to develop these workflows. This is not intended to be a comprehensive list of workflows but rather a starting point of directions so that designers and engineers start exploring possibilities between Fusion 360 and Maya. As with other modeling and visualization tools, the exploration and experimentation of tools is highly encouraged, in order to discover innovative and efficient ways of creating new designs.

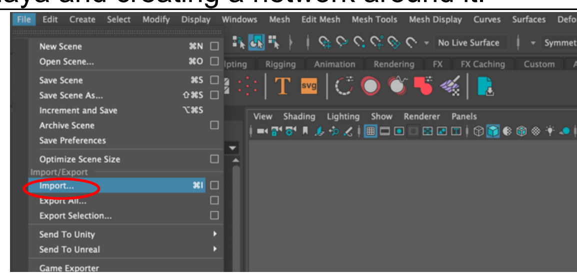
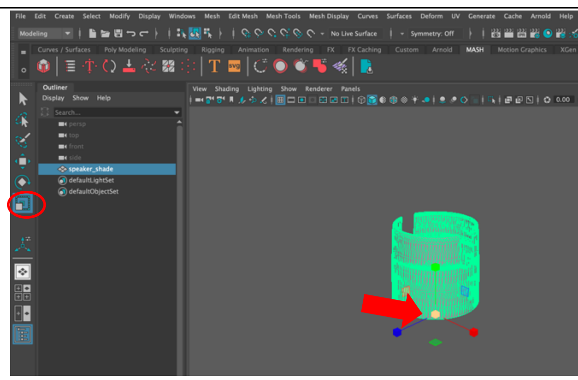
4.1 – Workflow 1: Creating a Procedural network in Maya

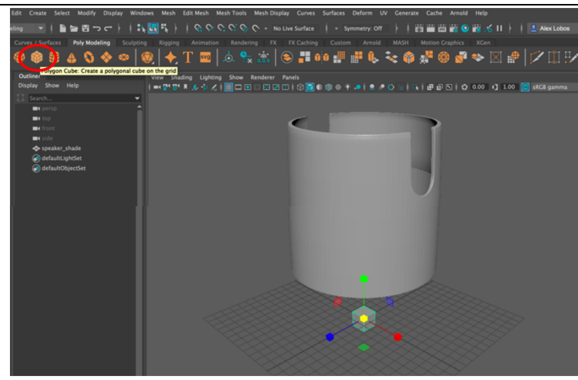
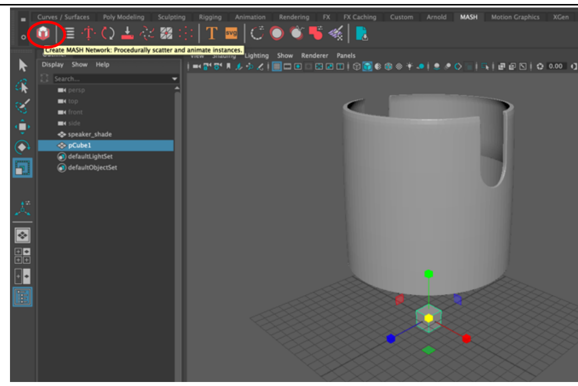
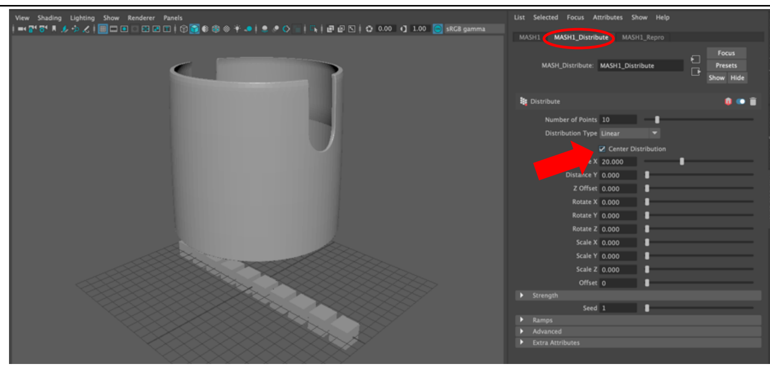
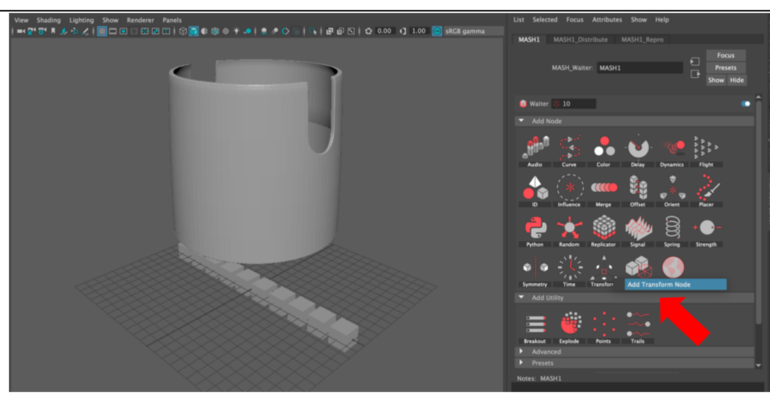
Create base body	In the top-tab “Poly Modeling”, select “Polygon Cube”. In the right-tab “Attribute Editor”, go to “PolyCube1”. Under “Poly Cube history” make sure that subdivisions are set to: W=1, H=1, D=1.	

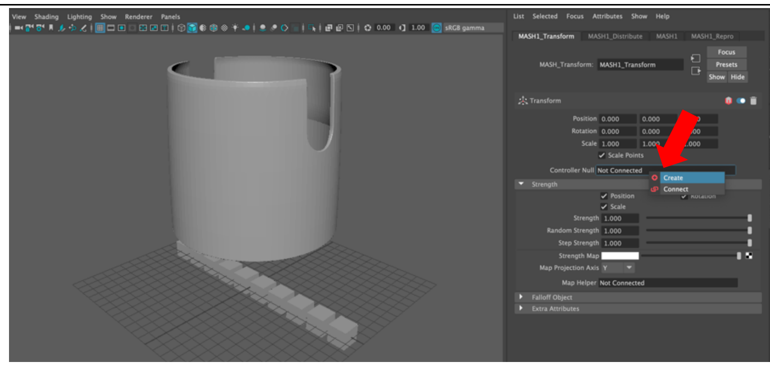
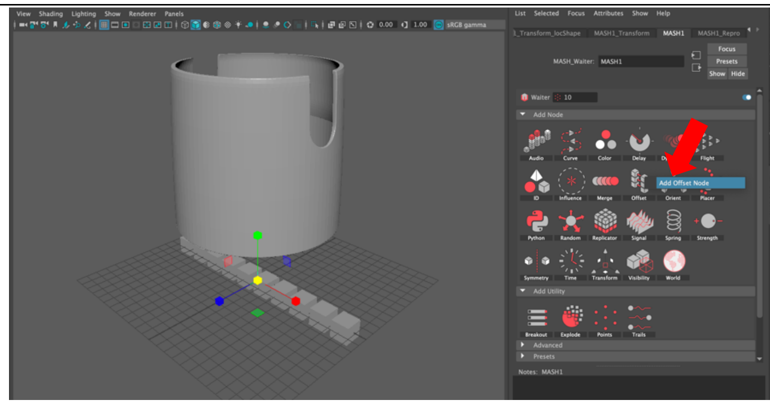
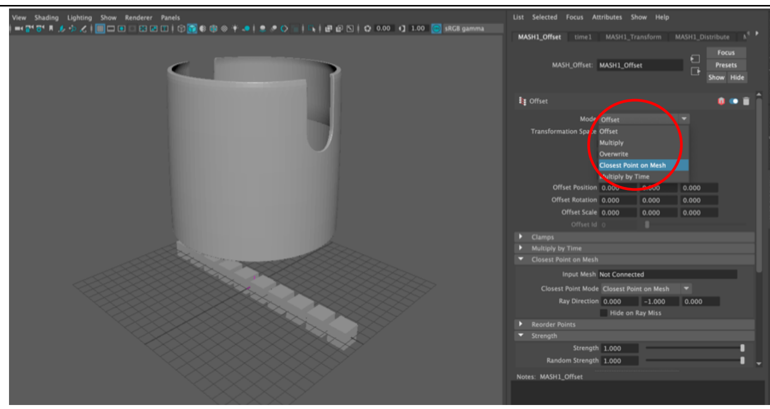
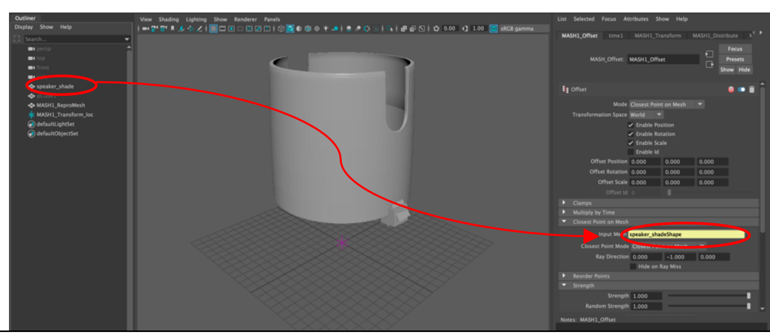
Create MASH network	In the top-tab “MASH”, select “Create MASH network”.	
Edit MASH network	In the right-tab “Attribute Editor”, go to “MASH1 Distribute”. Under “Distribute”, change the Distribution Type to “Grid” Adjust the distribution settings to: Distance X: 9 Distance Y: 9 Distance Z: 9 Grid X: 10 Grid Y: 10 Grid Z: 10	
Add extra effects	In the right-tab “Attribute Editor”, go to “MASH1”. *>Feel free to explore different Nodes to achieve a wide variety of patterns.* Click on “Signal” and select “Add Signal Node”. This should turn the cube grid into a random network.	

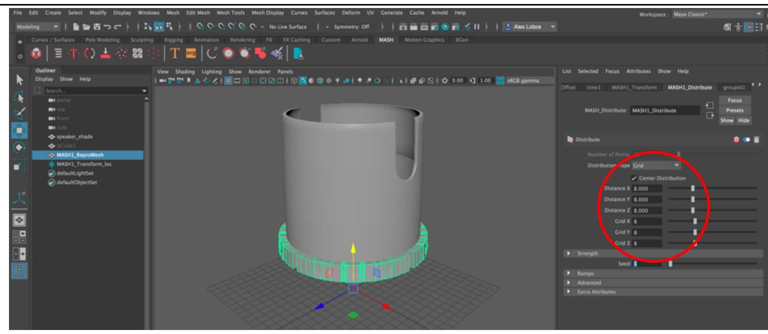
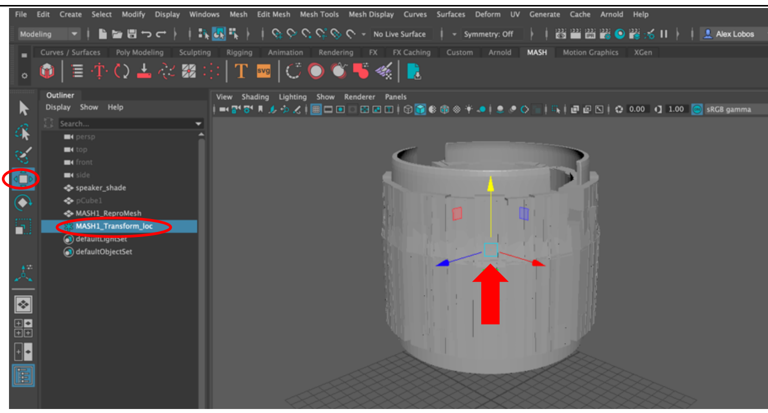
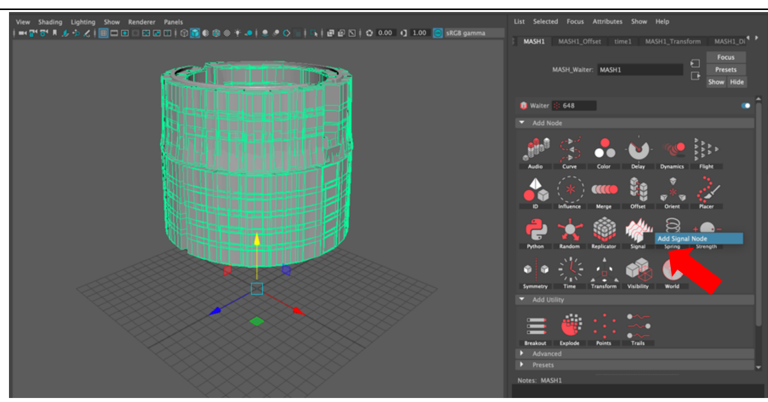
	In the right-tab "Attribute Editor", go to "MASH1_Signal". *>Scroll through different signal types in order to achieve various effects.* Under "Signal Type", select "4D Noise" and move the sliders under "Position", "Rotation" and "Scale" to further edit the network.	

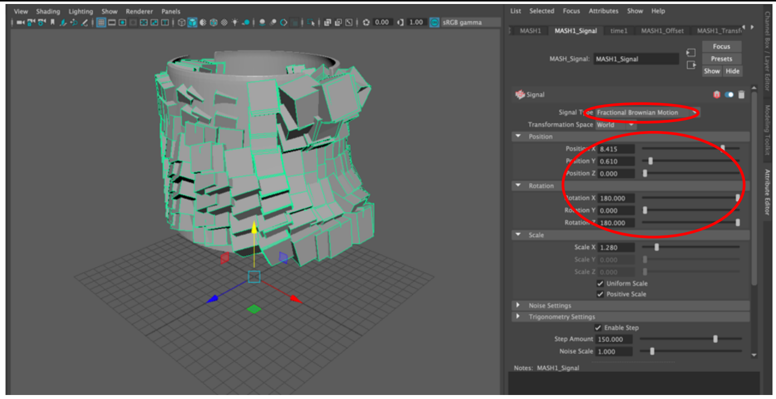
4.2 – Workflow 2: Importing a body into Maya and creating a network around it.

Import STL	In the top menu, go to: File > Import Select STL file.	
	If the STL body is not visible, zoom out. In the left toolbar, select "Scale". Click on the body and scale it down until it fits in the grid.	

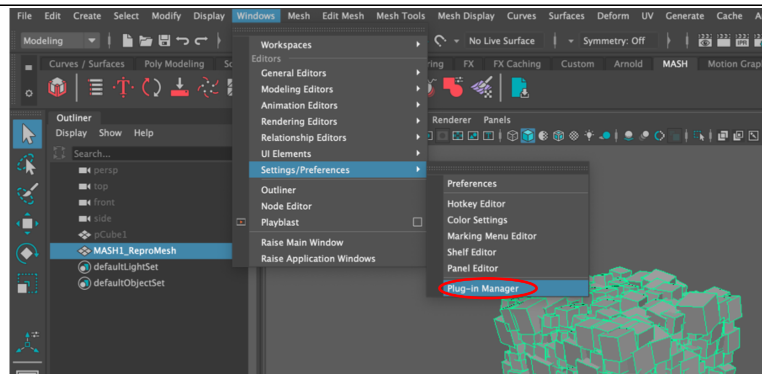
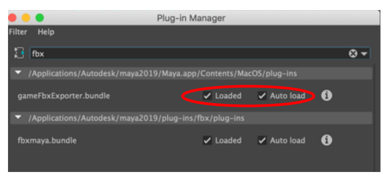
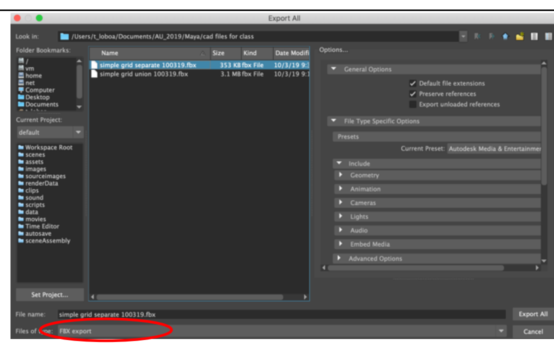
Create base body	In the top-tab “Poly Modeling”, select “Polygon Cube”. In the right-tab “Attribute Editor”, go to “PolyCube1”. Under “Poly Cube history” make sure that subdivisions are set to: W=1, H=1, D=1.	
Create MASH network	In the top-tab “MASH”, select “Create MASH network”.	
Add a distribution to the network	In the right-tab “Attribute Editor”, go to “MASH1 Distribute”. Right under “Distribution type”, make sure that “Center Distribution” is selected.	
Add a Transform Node	In the right-tab “Attribute Editor”, go to “MASH1”. Click on “Transform” and select “Add Transform Node”.	

	Inside the "MASH1_Transform" tab, go to "Controller Null", right-click and select "Create" The Transform node will be useful later for moving the network across the STL body.	
Add an Offset node	In the right-tab "Attribute Editor", go to "MASH1". Click on "Offset" and select "Add Offset Node".	
	Inside "MASH1_Offset" tab, go to "Mode" and select "Closest Point to Mesh" Go to the left "Outliner" tab and look for the STL file. Using the mouse's MIDDLE button, click-and-drag the STL file into: Closest Point on Mesh > Input Mesh. This action connects the MASH network to the STL surface.	 

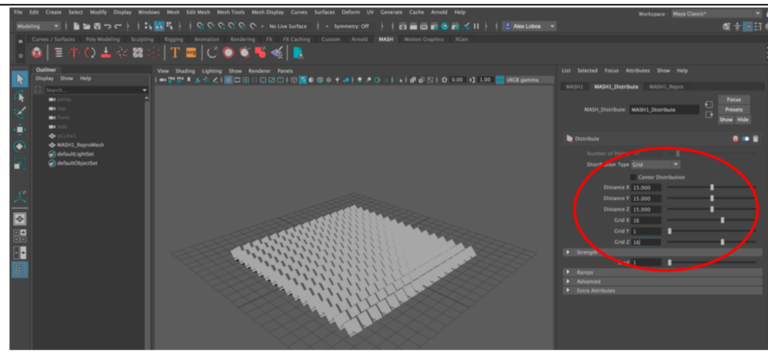
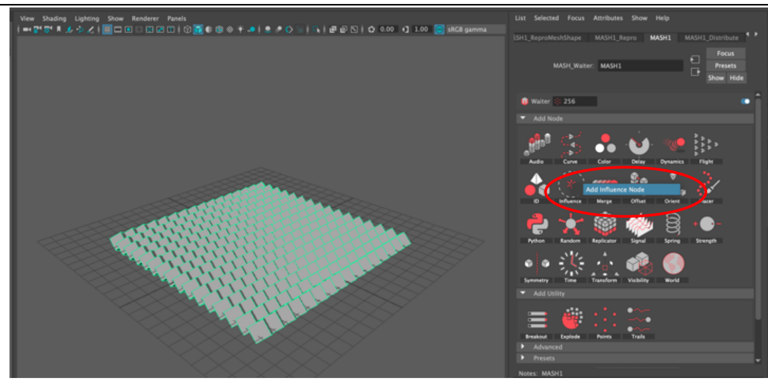
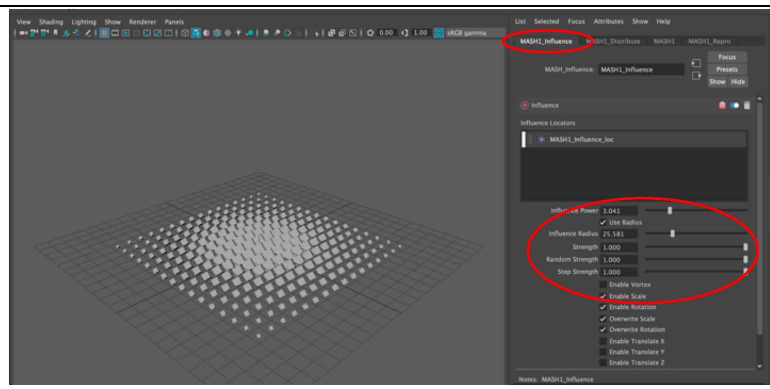
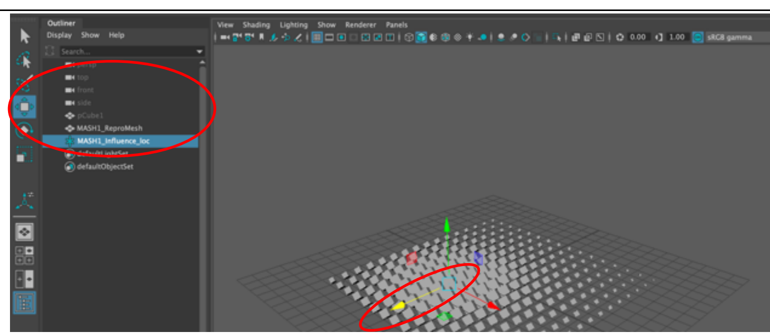
Edit the Distribution type	In the right-tab “Attribute Editor”, go to back to “MASH1 Distribute”. Change the “Distribution type” to “Grid”. Adjust the distribution settings to: Distance X: 8 Distance Y: 8 Distance Z: 8 Grid X: 8 Grid Y: 8 Grid Z: 8	
Move up the MASH network	Go to the left “Outliner” tab and select the “Transform” locator. In the left-side toolbar, select the “Move” tool and use the arrows in the workspace to move up the MASH network. Once the network is in place, adjust “Distribution Settings” to obtain a desired coverage.	
Add extra effects	In the right-tab “Attribute Editor”, go to “MASH1”. Click on “Signal” and select “Add Signal Node”. This should turn the cube grid into a random network running across the STL body.	

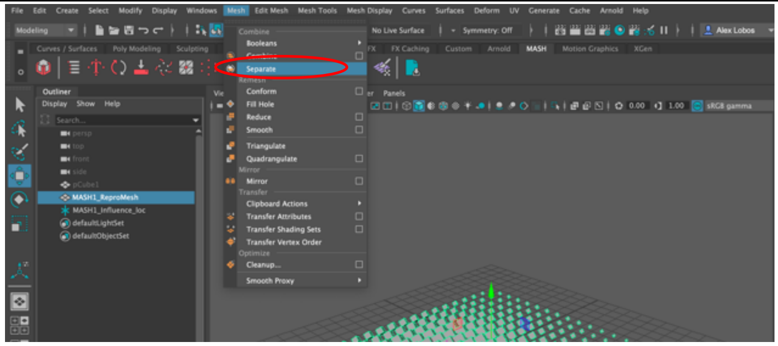
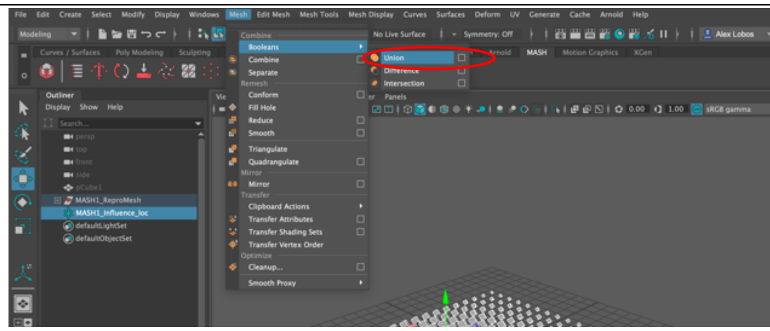
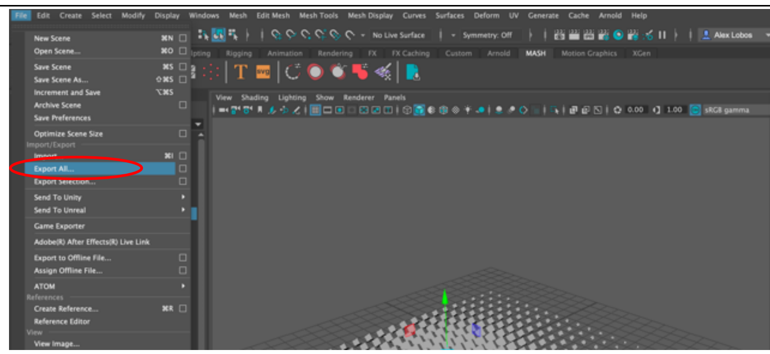
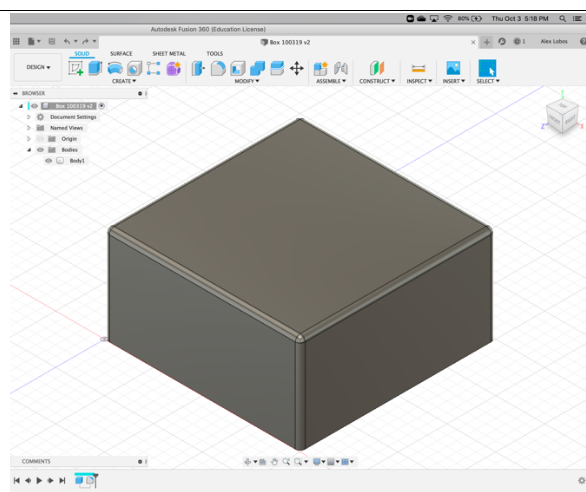
	In the right-tab “Attribute Editor”, go to “MASH1_Signal”. Under “Signal Type”, select “Fractional Brownian Motion” and move the sliders under “Position”, “Rotation” and “Scale” to further edit the network.	

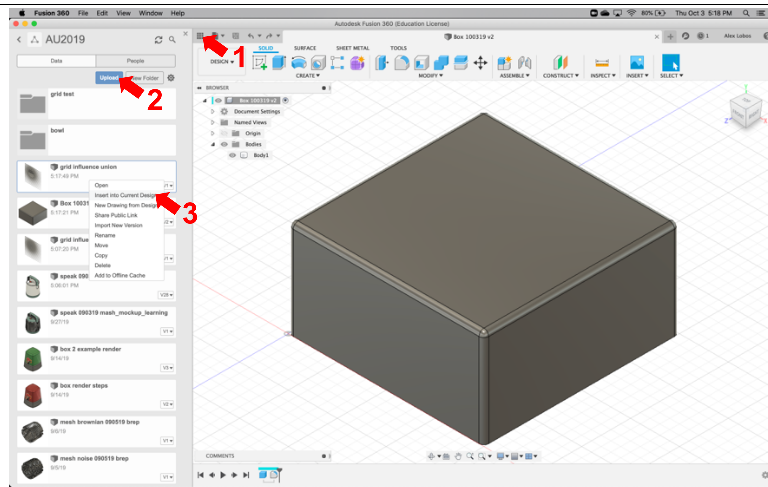
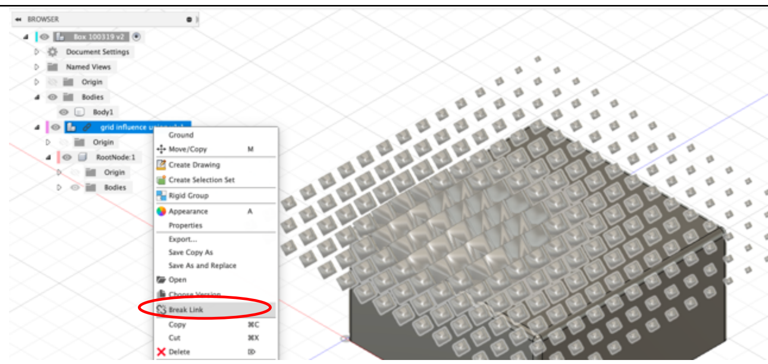
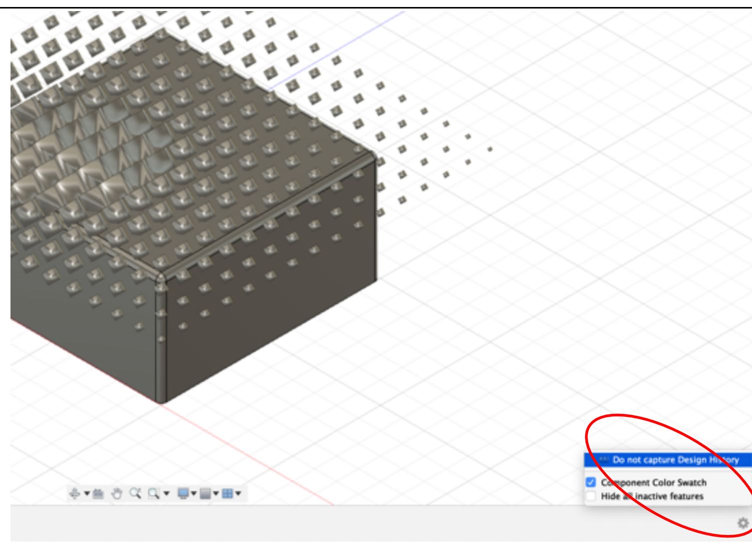
4.3 – **Workflow 3:** Exporting a Procedural network as FBX

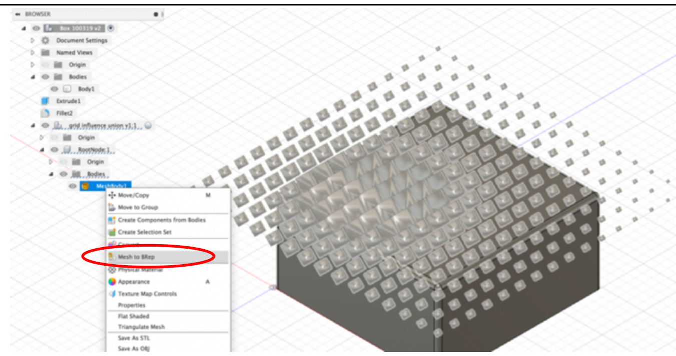
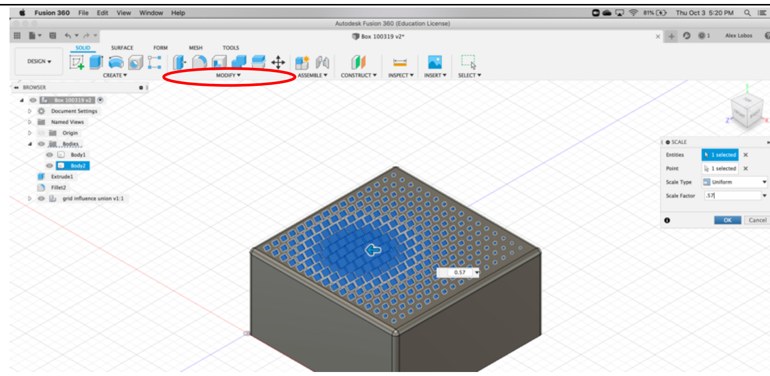
Activate FBX plug-in	Make sure that you can export as FBX file: In the top menu, go to: Windows > Settings/Preferences > Plug-in Manager In the search window, type “fbx” and look for the “fbxExporter” plug-in. Make sure that “Loaded” and “Auto load” are selected.	 
Export as FBX	In the top menu, go to: File > Export All Type a name for the file, select location for saving it, and make sure that you select “FBX” as export type.	

4.4 – Workflow 4: Importing a Procedural network into Fusion 360

Creating the network in Maya	In Maya, and Similar to Workflow 1, create a cube grid, and under "Distribute", use the values below: Distance X: 15 Distance Y: 15 Distance Z: 15 Grid X: 16 Grid Y: 1 Grid Z: 16	
Adding effects to the network	In the right-tab "Attribute Editor", go to "MASH1". Click on "Influence" and select "Add Influence Node". This should make the cubes scale up/down in relation to an influence point.	
	In the right-tab "Attribute Editor", go to "MASH1_Influence". Play with the values "Power", "Radius" and "Strength" to achieve the desired effect of influence.	
	In the left-tab "Toolbar", use "Move" to move the influence center point.	

Preparing the network for Export	In the top menu, go to Mesh >Separate, to break the grid into separate bodies.	
	In the top menu, go to Mesh >Boolean >Union to join the bodies into a single component. This will make the grid behave as a single body when imported into Fusion 360.	
Export network as FBX	In the top Menu, go to File >Export All. Export the grid as an FBX file to your computer.	
Create a box in Fusion 360	In Fusion 360, create a simple box and save the file. The FBX file will be used to “stamp” the pattern into this box.	

Importing FBX into Fusion 360	1- In Fusion 360's application bar (top left area of the screen), go to the “data panel” icon and click to expand. 2- In the data panel, click on the “upload” blue button and select the FBX file. 3- After the file has been uploaded to the data panel, right-click on it and select “insert into current design”	
Break FBX link	In the Browser (left side tree-structure), look for the FBX body, right-click and select “break link”. This selection will make it a stand-alone body, without any link to the original file that was uploaded in the data panel.	
Stop capturing history	In order to convert the FBX file into a B-Rep body (so that it can be edited), it is necessary to stop Fusion 360 from capturing history. This will stop the model from being parametric. Go to the lower-right corner, click on the “gear” icon and select “do not capture design history”	

Convert to B-Rep	Go back to the browser and look for the FBX's file under "bodies". Right-click and select "Mesh to B-Rep".	
Add the pattern to the box	Under "Modify", use "Scale" and "Move" in order to make the pattern lay on top of the box. Make sure that the lower half of the pattern overlaps with the box. This will allow to create a 3D stamping effect on the box.	
	Go to: Modify > Combine to create a Boolean operation between the two bodies. You can experiment with different operations such as "join" and "cut"