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Modern approach to hard-surface modeling for games

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Abstract

The modern game development cycle requires high standards for art and technical solutions but has limited time resources for iterations and error corrections. Artists are using new approaches to the typical tasks to optimize the development pipeline and enhance the 3D models.

The objective of this thesis was to provide a knowledge base and technical description of the workflow used to create the highpoly hard-surface assets for usage in game development. This report defines the ways in which an artist could apply general and hard-surface specific design principles to create a solid weapon model, along with the modeling pipeline using Autodesk’s Fusion 360.

With the aid of a practical approach and design theory, this thesis shows the creation of a concept and a high-poly model of a handgun according to specifications. The author explored the advantages and versatility of Fusion 360, along with a detailed description of the modeling process, instruments and best practices based on the author experience.

In conclusion, the thesis summarizes the results of the modeling and specifies the key advantages of the Fusion 360 and demonstrated the workflow used to create a highpoly model of a gun. Based on this research, the author successfully established the pipeline to efficiently approach various hard-surface modeling tasks for modern games.

Keywords

3D modeling, computer graphics, concept design, hard-surface modeling, game development

CONTENTS

LIST OF CONCEPTS

3D	3-Dimensional
2D	2-Dimensional
3D game asset	an object (also could be called mesh or model), that will be used in a video game
Highpoly	model, that has a lot of details and consist of many polygons
Low-poly	a model with lower number of polygons to use in a game
Polygon	a surface, made from at least 3 points, called vertices, used to visualize the 3D model
Vertex	An element of a polygonal mesh, a point with 3 coordinates in space
Mesh	The arrangement of the edges and vertices of a 3D object. Its polygonal structure

1 INTRODUCTION

3D modeling is one the main element of game development. 3D objects create the virtual world, directly defining the art style of the game, gameplay capabilities and, in the end, the overall success of the project. The value of the video games market is growing and expected to exceed 130 billion U.S. dollars by 2020, according to Statista (2018).

In the highly competitive industry, developers are looking for ways to implement the most efficient practices to shorten the production time, optimize the costs, while maintaining the modern level of quality and details in 3D assets.

For these reasons, game artists include CAD software into their pipeline. Foundational principles behind CAD software allow major changes in design, to be implemented at any stage of the modeling process.

The goal of the thesis project is to produce a highly detailed 3D model of a weapon, based on concept art and to present the modeling workflow and software used by the author. The thesis covers the stages from the idea and concept art to the highpoly 3D model, ready to be used in the next stages of game asset production pipeline.

The author will show the process, used to create the final asset, explaining the principles and restrictions. The contents are intended for artists already familiar with advanced 3D modeling techniques in polygonal modeling software, such as Autodesk Maya. Demonstrated methods were based on author’s experience along with analysis of modern hard-surface modeling pipeline for game and concept art.

2 HARD-SURFACE MODELING FOR GAMES

3D modeling can be divided into two main categories: organic and hard-surface. Organic models are defined by the natural flow of the topology with smooth shapes and wide angles. Characters, creatures, and vegetation are created using organic modeling techniques, such as sculpting in Pixologic Zbrush.

Hard-surface models include everything man-made or manufactured in general. Vehicles, weapons, hero props and buildings primarily consist of straight lines and sharp angles. They also include a large set of universal shapes found in almost every hard-surface asset (Warwick n.d.). Bolted and other types of joints, hinges, revolving surfaces, T-joint connections, Boolean surfaces, support pieces (nuts and bolts) are examples of these shapes, illustrated by Figure 1.

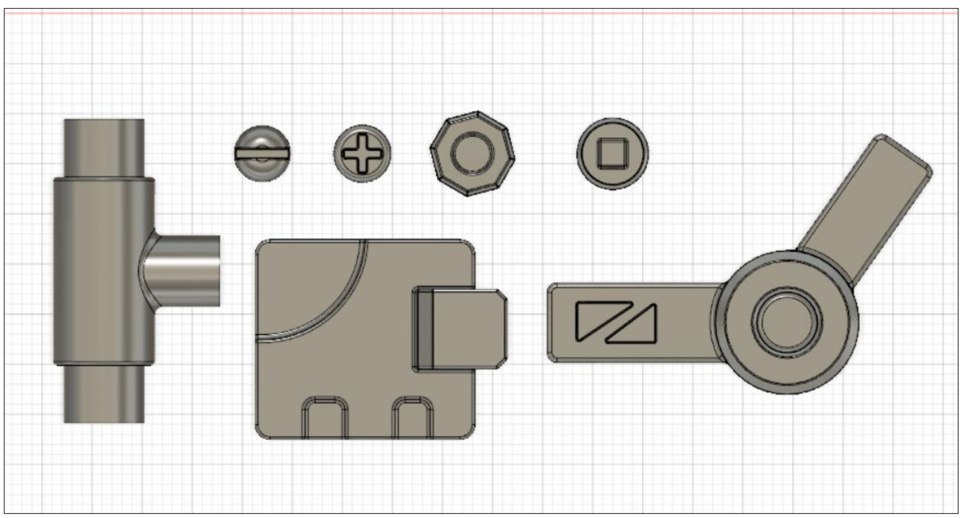

Figure 1. Hard-surface shapes (Kochetov 2018)

This allows 3D artists to reuse the parts of one model in another and write modeling guidelines for other team members to standardize the modeling pipeline and prevent topology mistakes.

2.1 Game asset production pipeline

Every game asset goes through the different production stages during the development process. The set of these stages is called the pipeline and may vary from studio to studio. Idea and concept are the initial stages of game asset creation when an artist is searching for references and planning on the visual style and look of an object.

The next stage is the actual modeling of objects. Depending on the pipeline, adapted in the studio, modeling could start from creating a highpoly object and then the game-ready low-poly version or in reverse order.

After the modeling has been completed, the artist starts UV mapping process for low-poly object. Lowpoly objects with UV maps then are transferred to texturing software, such as Substance Painter. At the final stage of game asset creation, finished textures and the low-poly object are imported into the game engine.

2.2 Software for production

Polygonal modeling software is the main instrument for creating hard-surface assets. There are a variety of available commercial products and each studio chooses one, depending on their pipeline. Now, any of the popular 3D modeling packages could offer full production cycle from highpoly to low poly mesh with UVs. Autodesk’s Maya and 3Ds Max, Foundry Modo, Cinema 4D, and Blender are the most widely used in the games industry.

To perform specific modeling tasks, the artist may use other computer programs, such as Pixologic Zbrush for sculpting, Marvelous Designer for cloth simulations, Houdini for destruction simulation. The process of exchanging files between the software is based on the use of industry standard formats – OBJ and FBX. OBJ file can contain geometry information and UV coordinates, FBX could store animation data (Chakravorty 2018).

2.3 Design principles for hard-surface objects

This chapter describes the universal design principles applicable to all areas of creative work and specific principles for creating realistic hard-surface objects in games. All examples were created by the author.

Every manufactured object has initially gone through a design process. The major areas of design that a new product should pass are industrial design, interaction design and experience design (Norman 2013).

Industrial design covers functions and specifications, value and material solutions. Selecting carbon fiber instead of steel as a material for a smartphone frame is an example of an industrial design decision. *Interaction design* concentrates on the interactions with an object. Increased resistance of a gas pedal when the car accelerates is an example of interaction design. *Experience design* deals with the combined perception of the product. Glowing red light indicating low battery level is one of the methods to control the user experience (Norman 2013, 4-5).

The fundamental design principles for the artists to keep in mind when starting a new work are similarity, continuity, proximity, and closure. These principles are based on cognitive behavior and visual perception (Smashing Magazine 2015).

Similarity principle is illustrated in Figure 2. The observer perceives the objects as belonging to the same group if they share similar characteristics, like color or size. Circles with the red dots inside are related to each other, as they share the same aspect.

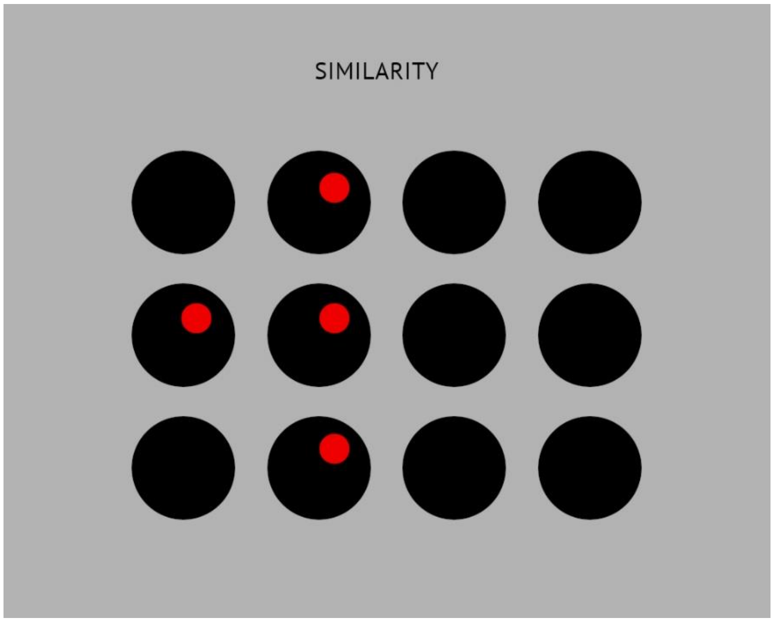

Figure 2. Similarity principle (Kochetov 2018)

Continuity principle implies that the human eye will follow the direction of something until it comes across another object or experiences a significant change in path. A set of horizontal lines in Figure 3 forms a guiding line which leads to the triangle shape.

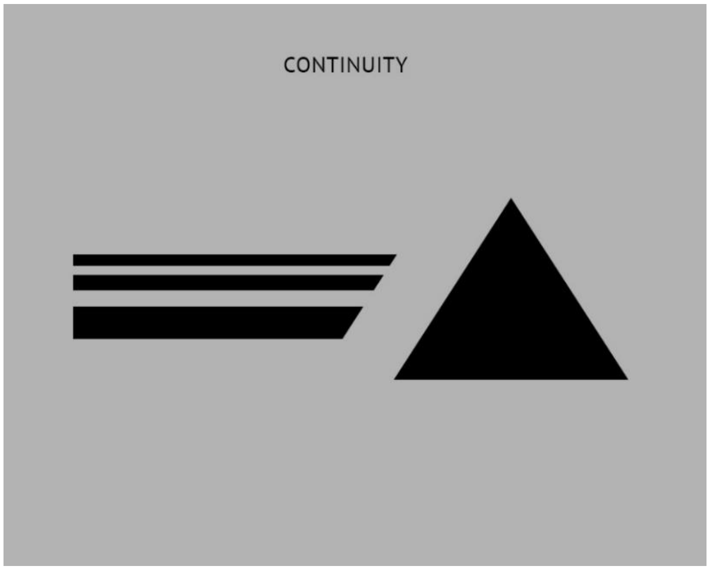

Figure 3. Continuity principle (Kochetov 2018)

Proximity principle means that the objects located next to each other belong to the group. As seen in Figure 4, triangles and cubes clearly identify as a separate cluster from the rectangular shapes.

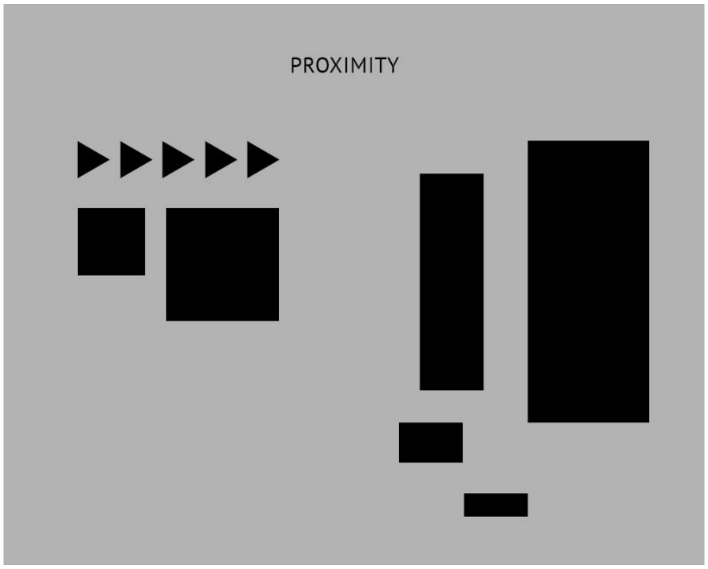

Figure 4. Proximity principle (Kochetov 2018)

The closure has a similar effect as continuity. This principle is based on the ability of a human eye and brain to complete the missing information using the parts of an object. In Figure 5 letter T forms from the 3 staple-like shapes.

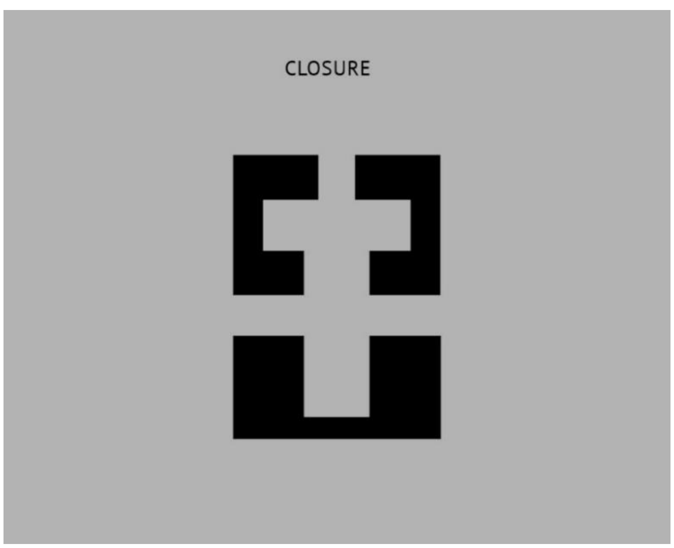

Figure 5. Closure principle (Kochetov 2018)

When speaking about specific principles applied to hard-surface objects, it is worth mentioning the idea “Form follows function”. Formulated by an American architect Louis Sullivan, this idea was the subject of controversy. Designers argued whether creative issues should be primary or secondary to functional issues (Craven 2018).

In game art, “Form follows function” idea serves as a prompt and a starting point to work on a concept. Most of the video games take place in a fully or partially fictional world. Game artists must create imaginary objects that will be believable and will have clearly defined functions.

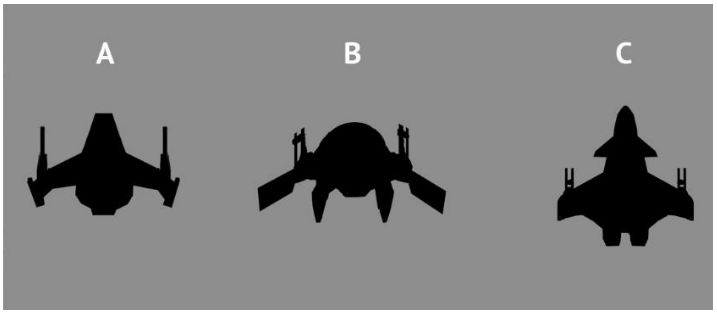

Figure 6. Form and function in spaceship design (Kochetov 2018)

Figure 6 provides an example of how the functions of a game object will affect its forms. There are three types of spaceships in the game: interceptor, armored and heavily-armed. *Spaceship A* has a stream-lined triangular form as its primary functions are rapid attacks. *Spaceship B* has round shape to provide the structural straight. *Spaceship C* is based on a rectangular shape – a stable base to carry heavy guns.

Game artists may borrow ideas for hard-surface objects from nature.
This is a common way amongst engineers then the product needs a performance optimization (Hill 2015). Figure 7 shows how Japanese engineers created the famous nose dome shape for Shinkansen train using a bird called Kingfisher as a reference (JNCC n.d.).

Figure 7. High-speed train and the bird (Wikimedia, JJ Harrison, July 2011)

The nose dome of the train was designed to mimic the bird's beak, resulting in better aerodynamics on high speeds.

Historical period, trends in social and cultural aspects may also influence the design of industrial products. This is important to consider when working on games that take place or have references to a specific time.
In 50's space exploration and rocket science was a prominent theme in society. Car manufacturers in the United States used allusions to rocket and aircraft shapes in their designs, as can be seen in Figure 8 (Koch 2014).

Figure 8. Car designs (Ziemnowicz, Wikimedia 2010, Kochetov, 2018)

The tailfins design of the Plymouth Savoy 1958 on the left of the figure has parallels to the forms of the launch rockets of that time. Here, author used a photo of Soviet rocket *Vostok* to show the similarities.

Then the artist remembers about the silhouette it helps to thoughtfully add details to hard-surface objects. Cuts into a form or protruding parts affect the silhouette and create points of attention (Richards 2009). It is impractical to spend polygonal budget and computational resources on aspects that the player will not see. Figure 9 provides an example of the usage of details in a silhouette.

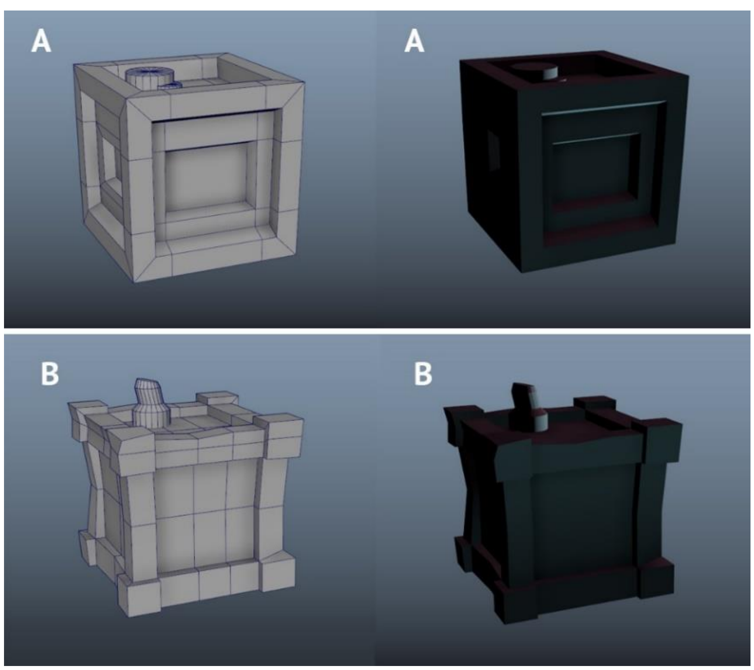

Figure 9. Silhouette and details (Kochetov 2018)

Cube *A* has numerous details, but all of them exist within the shape and they do not change the way this object is perceived at first sight or from the distance. Cube B is an illustration of a clever usage of details. Each new part modifies the silhouette, making it distinctive from another object in the scene.

2.4 Design principles for weapon concepts

The key element of weapon design is that the author named *the intersection point*. This concept was formulated based on author's practical experience in weapon modeling and researches on weapon structure. Every firearm has common major components necessary for the operation. *Barrel* of gun directs the bullet; *Bolt* locks the shell and place it inside the barrel; *Recoil spring* participate in reloading and cartridge extraction process; *Extractor window* is used to remove the fired cartridge and magazine and *Magazine* holds the ammunition (Guns & Accessories 2016).

Figure 10 shows the way to implement the *intersection point*. Central lines of the magazine, barrel and extractor window should intersect in one point. This arrangement of elements makes it possible for a cartridge to get to the barrel and shell to be extracted after the firing.

Figure 10. Intersection point (Kochetov 2018)

The application of the rule of thirds will assist in creating a better overall composition of the weapon and organize the elements (Rowse n.d.). First, the artist needs to enclose the object in a rectangle.

Then the rectangle should be divided into three parts vertically and horizontally. The resulting line crossings will give four focal points, which will be the guides for the weapon shapes. Figure 11 illustrates how the author used this rule.

Figure 11. Rule of thirds in weapon design (Kochetov 2018)

The feeling of continuity in weapon design can be attained by means of the shape flow. In Figure 12, the red lines show how the form flows from one detail to another. This creates the aesthetically pleasing look and gives a perception of a believable object, where every part has been constructed to work together. In addition, elaborate line flow will navigate the player’s eye to the points of interest.

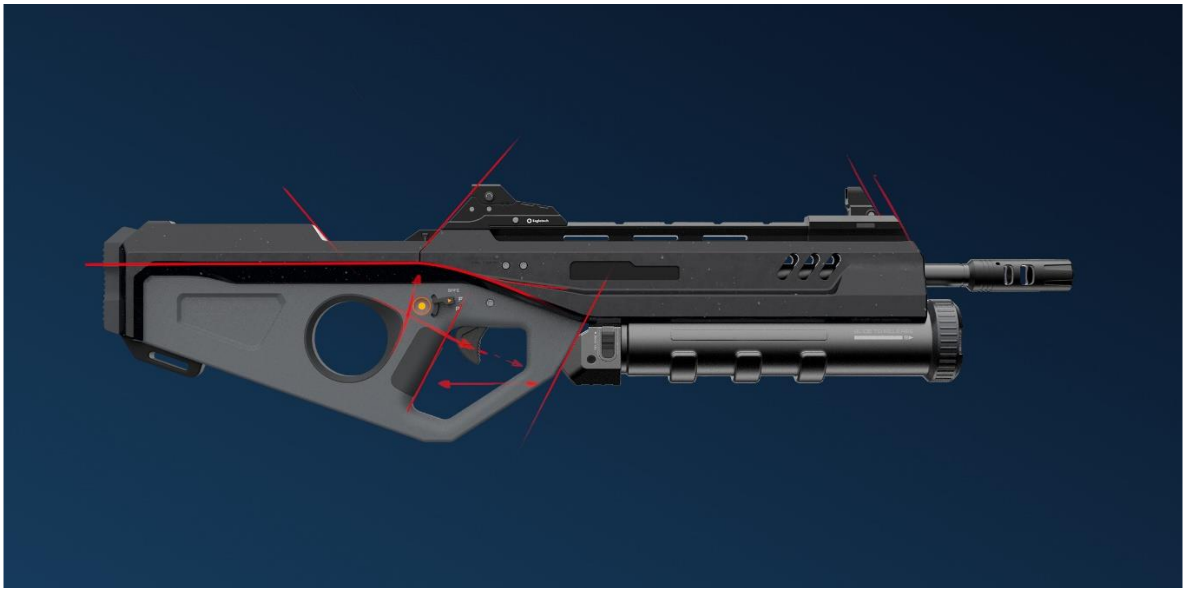

Figure 12. Continuity in weapon design (Kochetov 2018)

When working on weapon design for first-person shooter games, the effect of perspective foreshortening should be considered (Kubas n.d.). Figure 13 shows how the perspective distortion makes the grooves near the barrel area merge together, producing visual noise. Figure 14 introduces the solution on how to compensate the deformation by reducing the amount of repeating details and increasing the distance between them.

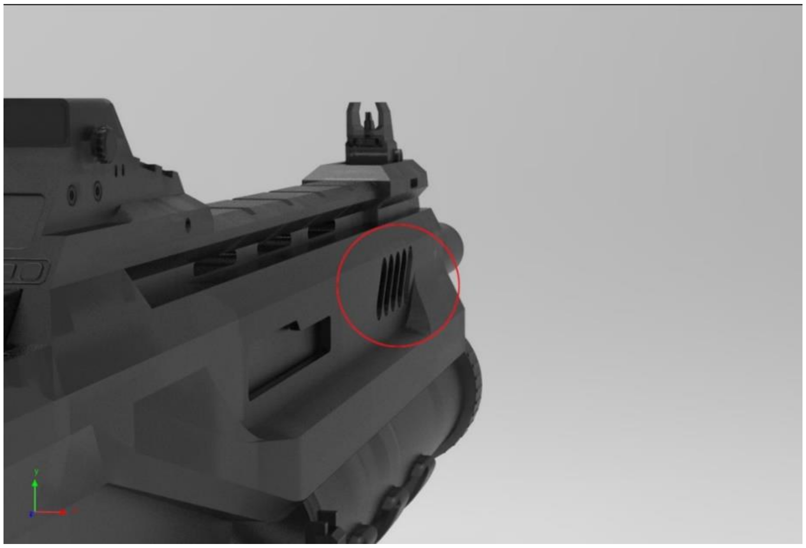

Figure 13. Foreshortening distortion (Kochetov 2018)

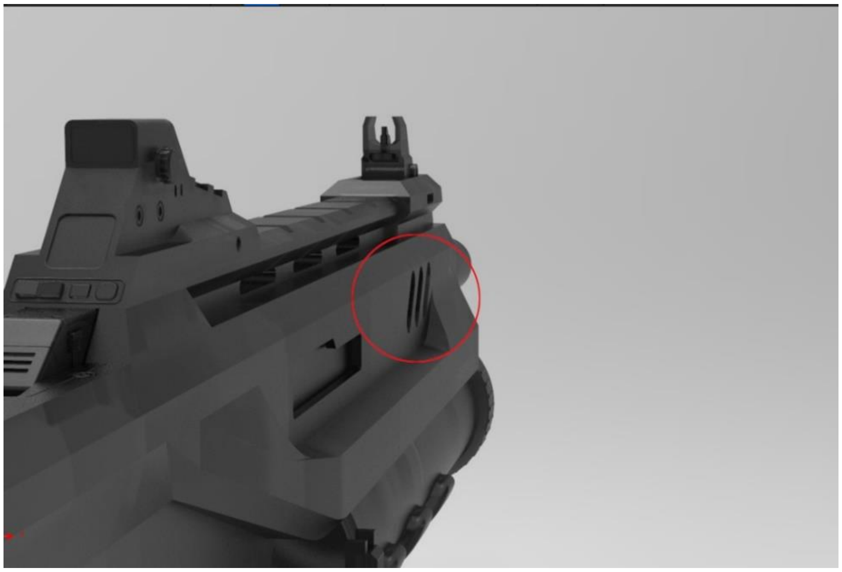

Figure 14. Solution for foreshortening distortion (Kochetov 2018)

3 FUSION 360 IN GAME DEVELOPMENT

Fusion 360 is a CAD software, developed by Autodesk and used mainly for product design. CAD or Computer-aided design is the concept of using computers to expand designer’s toolkit, promote the quality of design and communications (Bethany 2017).

The defining characteristic of any CAD software is the concept of parametric modeling. Parametric modeling provides an opportunity to modify objects by changing their original parts. The software keeps the construction history, allowing artists to transfer to a certain point in the design timeline if needed. Other substantial difference between CAD software and regular 3D modeling program, like Autodesk Maya, is the modeling workflow applied then creating 3D assets (Alba 2018).

There are two main modeling workflows used in programs like Autodesk Maya or Autodesk 3Ds Max: box modeling and edge modeling. *Box modeling* starts with the rectangular box, next artists add new edges, perform extrude operations or add other geometric primitives to shape the future model. Figure 15 illustrates the box modeling technique.

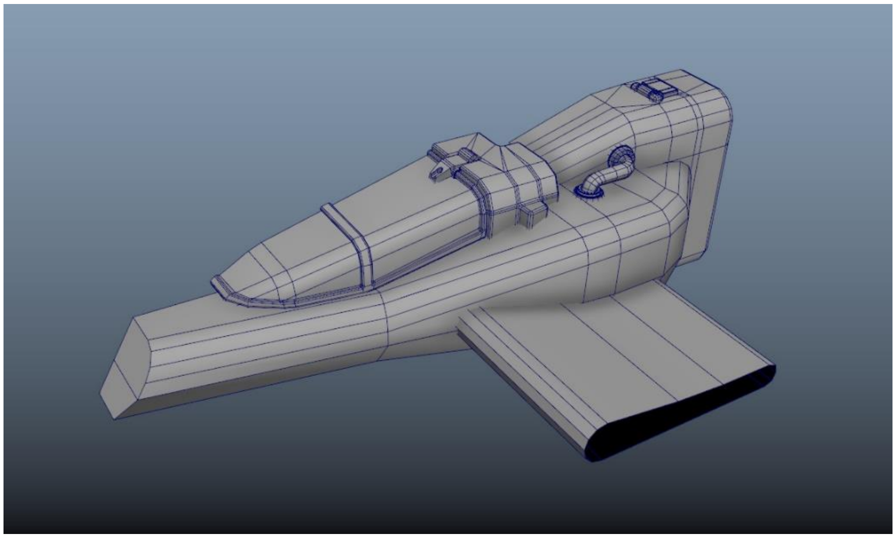

Figure 15. Box modeling (Kochetov 2018)

This method is most frequently used when creating the objects based on concept art and there is no direct real-world reference to the size and forms.
In such manner, the artist has control over the forms and proportions. The body of the spaceship started from the box, then it was cut in half and upper edges were beveled. Additional edges in the middle helped to create narrow part of the nose. The same techniques were applied to other parts of the model.

Edge modeling starts with a plane, placed in 3D space. Then the artist starts to extrude the edges of the plane along the guide mesh or referring to the blueprint images. Figure 16 illustrates the edge modeling technique.

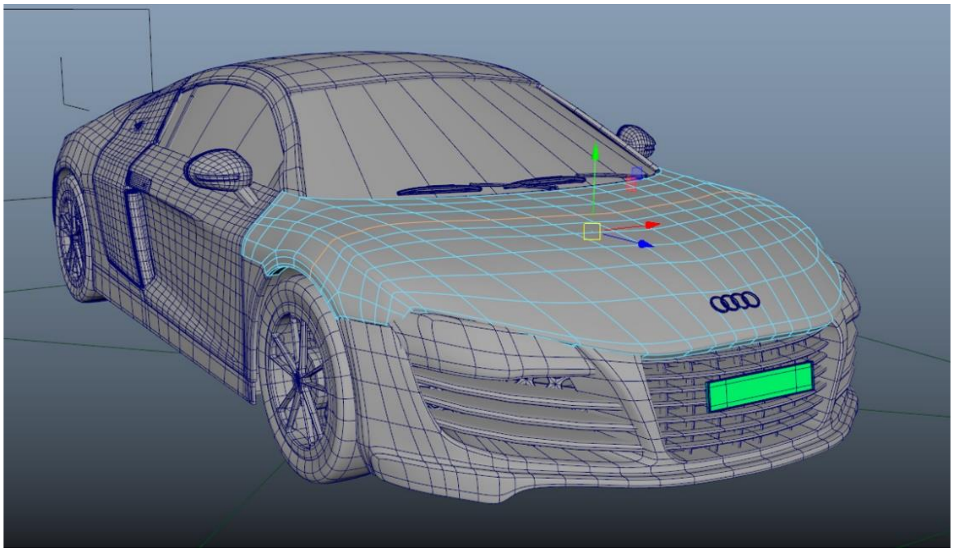

Figure 16. Edge modeling (Kochetov 2018)

This is the popular method of car modeling. Automotive parts have complex shapes with a lot of curvatures and flow direction changes in forms. Using edge modeling gives the ability to quickly reorient the modeling plane.

CAD programs implement Boolean workflow, where each object is treated as a solid peace and changing the shape of the model is done by join, cut or intersect operations. By combining the parts involved in these operations, an artist can create complex details. In Figure 17 the author has shown the examples of Boolean operations within Fusion 360.

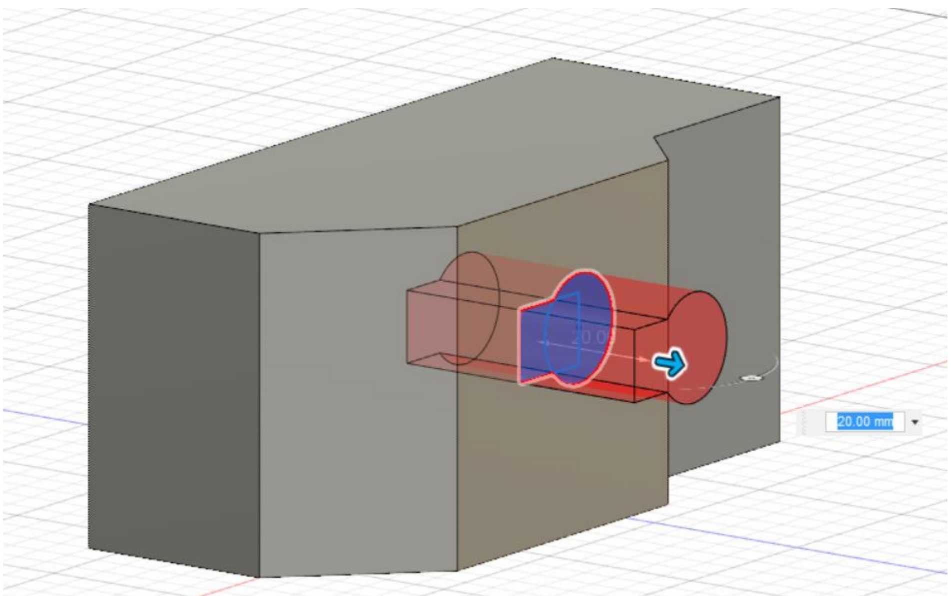

Figure 17. Boolean modeling (Kochetov 2018)

3.1 CAD software in game development

The progression of computer graphics technologies and hardware made it possible to perform real-time rendering for a large amount of highly detailed 3D models. The modern game development cycle is constantly accelerating, and studios must adapt and optimize their production pipeline. Various game and concept artists applied Fusion 360 and another CAD software in their personal and commercial work. CAD was mainly used to produce high-poly models of weapons and smaller industrial elements. (Kopka 2017)

CAD software can perform complex Boolean operations with objects and allow edits in previously made operations. These features are beneficial for game artists and concept artists, giving them further control, variability, and speed in the modeling process. In addition to that, users can save different parts of the model into a separate file and use them in other designs or create the assembly kit to quickly concept the ideas.

MoI3D and Fusion 360 are the most common among artist. MoI3D, developed by Triple Squid Software, has simplified the user interface and typical toolset with Boolean operations. MoI3D supports exporting into OBJ and FBX file formats. Fusion 360, developed by Autodesk, is a lightweight version of another Autodesk program – Inventor. The advantages of Fusion 360 are a high performance on average computers, clear learning curve, an editable timeline of operations, cloud synchronization and a free student version. Cloud synchronization function automatically installs updates and creates file and user preferences backups (Autodesk n.d.). This way users can have access to files on any machine with Fusion 360 installed by logging in with the account data.

3.2 Fusion 360 modeling principles

This chapter is based on author’s practical experience combined with the recommendations form the software developer. It introduces the main notions and instruments of the software in question.

There are the foundational concepts in Fusion 360, that the artist should be familiar with then planning the process of 3D modeling. The work can be divided into the following steps: importing reference images and setting up the scale, creating main 2D sketches, extruding solid objects from the sketches, adding fine details and preparing for the export.

The sketch is the main element of any model in Fusion 360. Sketches could be considering a flat projection from one of the sides of a 3D object (Autodesk n.d.).

It should be clarified that Fusion 360 cannot create the sketches from the reference images, they could be used only as a size guide.

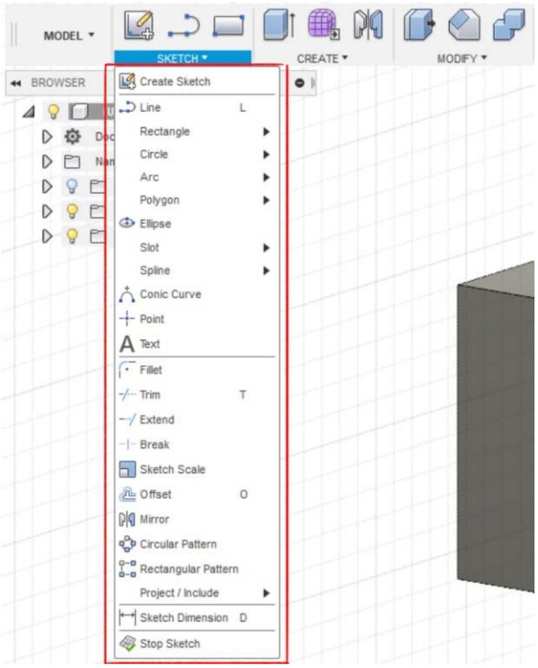

Figure 18. Sketch menu (Kochetov 2018)

Figure 18 shows the available operations and tools in Sketch sub-menu. Line tool is the basic tool, suitable for drawing prime shapes and details of a sketch. Complex drawings are created by combining lines with rectangle, arc, circle and polygon tools (Autodesk n.d.)

Refinements to the sketch are made by a fillet, trim, extend and pattern creation operations. The fillet is a widely used technique in Fusion 360, it transforms the intersection of two lines into the arc with the smooth transition. Figure 19 represents the sketch, created by the author with the tools mentioned above.

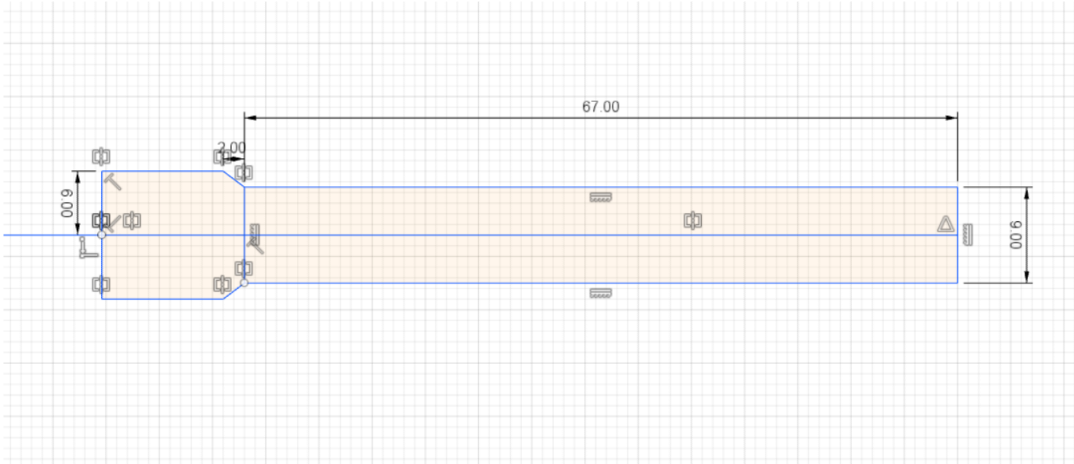

Figure 19. Sketch in Fusion 360 (Kochetov 2018)

The sketches are then used to extrude the 3D objects and shape the forms of the future model, applying Boolean operations. The general principle at this stage is to work with bigger shapes to construct the silhouette of a final asset. This principle helps to reduce the number of steps needed to create the general look of an asset and, therefore, eases the possible edits. Optimization is an important criterion of the modeling process in Fusion 360, as an excess amount of operations significantly affects performance and stability of the software (Autodesk 2018).

There are several principles to efficiently approach modeling. The first principle is to represent most of the major shapes and details of the model at the sketch stage. By working in this way, the artist will have a set of interrelated parts with specified dimensions. Any adjustment in one of the parts will affect and recalculate other parts.

The second principle is to use *Revolve* function to create cylindrical objects by rotating the profile around the axis. This method is the most frequently utilized to model car suspension elements, landing gear or other cylinders with a variable radius. Figure 20 shows the suspension strut made using the previously mentioned technique.

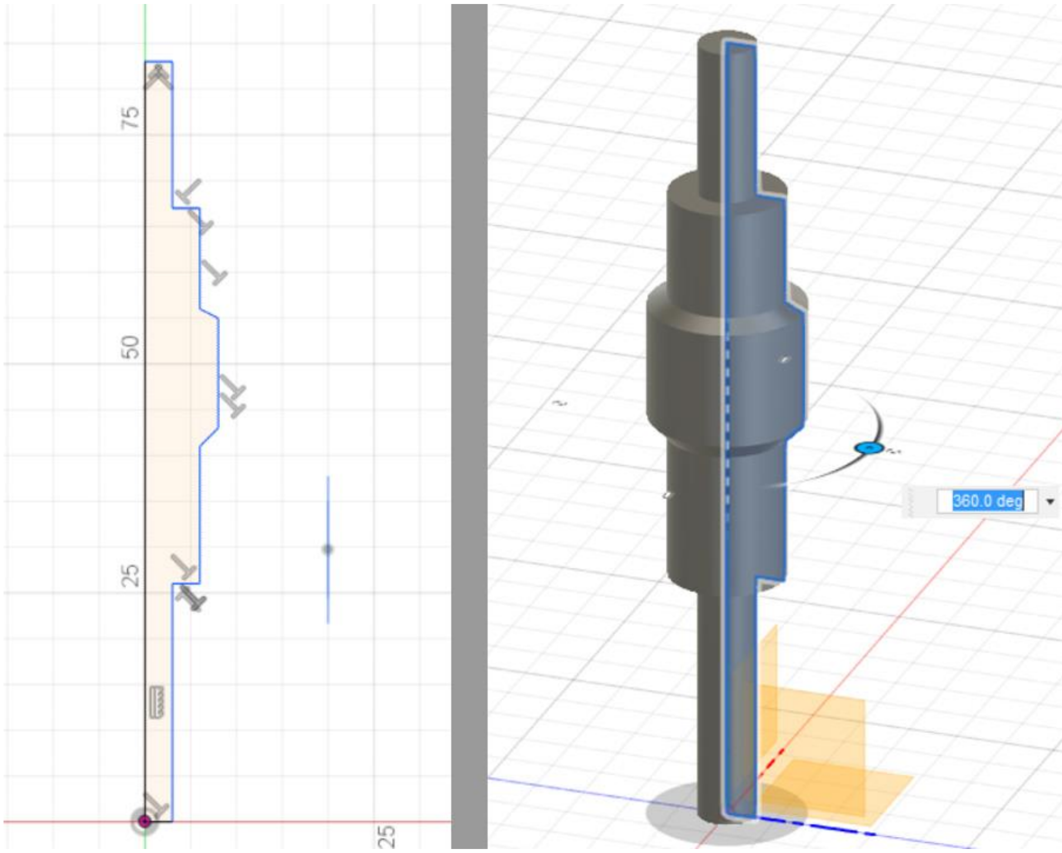

Figure 20. Revolve function (Kochetov 2018)

Fillet operation can be applied not only to sketches but also to extruded 3D objects. It is a common way to add details to the model and could serve as a modeling instrument if using fillets with the big radius that can notably alter the forms. In hard-surface objects fillets serve for load and stress distribution over connected parts or they make the corners of the product less sharp and fragile (Kupiec 2016). In the games industry, fillets are used for artistic purposes. The object, that has rounded edges, will have more surfaces for light to bounce off from and emphasize the silhouette.

The left half of Figure 21 shows the cube that has no fillets and it is losing details at a certain angle of light. The cube on the right half of Figure 21 has fillets and it is more readable for a viewer’s eye.

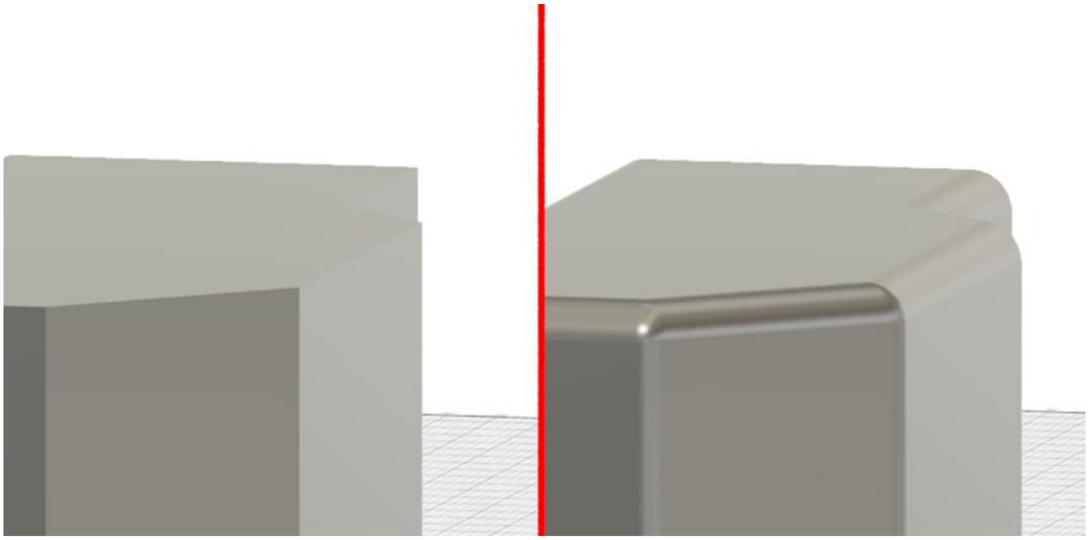

Figure 21. Fillets (Kochetov 2018)

3.3 Basic limitations of Fusion 360

Fusion 360 has no functionality to directly manipulate the vertices, edges or faces of 3D objects, as it implemented in Autodesk Maya or similar software. Therefore, Fusion 360 is generally suitable to model existing manufactured objects or imaginary hard-surface objects designed in realistic style and unable to perform organic modeling tasks. The completed model could be exported in SAT or STL file formats, which should be sent to Autodesk Maya or Pixologic Zbrush to convert into FBX or OBJ format for later use in other software.

4 MODELING

4.1 Pre-production

At the initial stage, the artist should define the direction of work in which he plans to move. The decisions on the style of the model, technical requirements, design ideas, and reference sources must be made at this point.

4.1.1 Idea and references

The author’s idea was to create a handgun model from near future in realistic style. The gun should use standard pistol rounds and operate using mechanical movements. The author decided that the handgun is from the same series as the previous weapon he modeled and will have common parts such as protruding sides of the frame. The final model should convey the feeling that it could be produced in near future. This description has established the scope for references and design decisions. Figure 22 shows the part of the image board, that the author made for the project.

Figure 22. Imageboard (Kochetov 2018)

The primary origin of the design ideas were modern handguns from various gun manufacturers. In addition to them, the author added several concept guns and weapon schematics to get a better understanding of internal structure.

4.1.2 Concept design

Silhouette sketches are the common way to concept the look of the weapon. Artist could draw the flat shapes or cut out the parts of the guns from photographs and create different combinations to find the pleasing shape.

The most appealing silhouettes are then refined with shading variations, as seen in Figure 23.

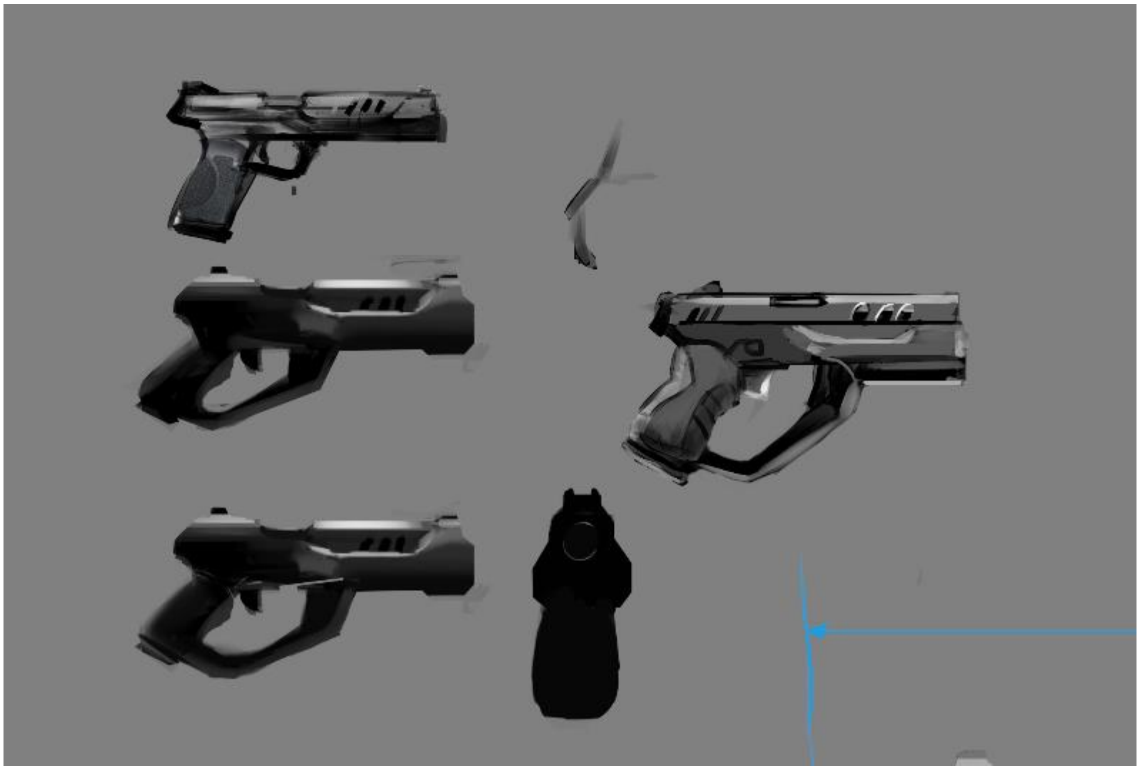

Figure 23. Refined silhouettes (Kochetov 2018)

To get a better understanding of how the shapes of the model will work in 3D, the author did a rough sculpt in Zbrush. The draft model was made from the primitive shapes with the minimum of details.

The author took a set of screenshots from different angles and made a final reference image with dimensions form the side view, as illustrated in Figure 24.

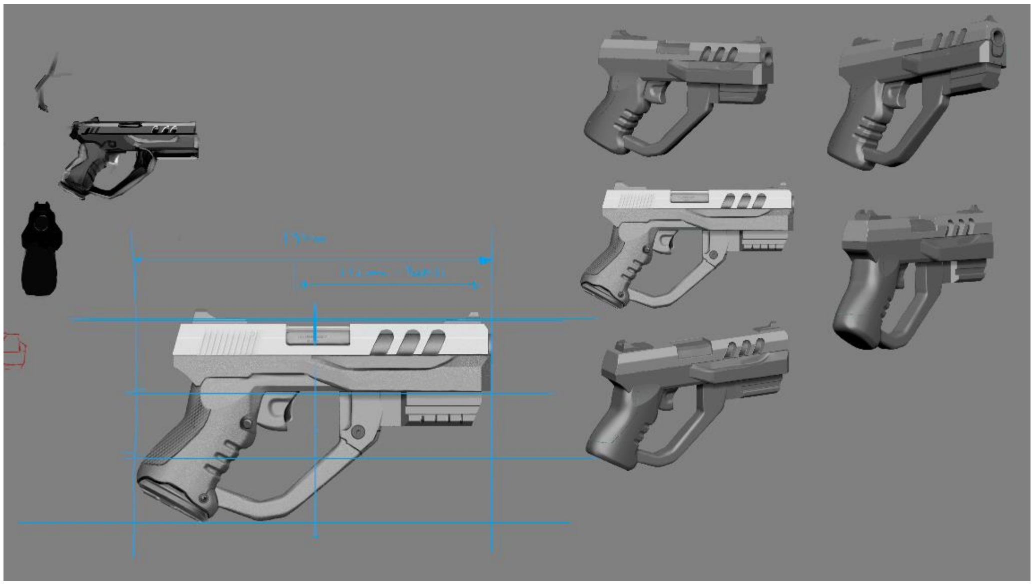

Figure 24. Zbrush drafts (Kochetov 2018)

4.2 Asset base

Prepared reference image of a gun was imported into the Fusion 360 project. The author determined the dimensions of the model to be 196 millimeters long with the barrel of 112 millimeters. Using the *Calibrate* tool, the imported image was scaled to match the 196-millimeter length. This chapter describes the key points of the modeling process. A 9-millimeter pistol round was created to have a size reference for the gun's parts, as seen in Figure 25.

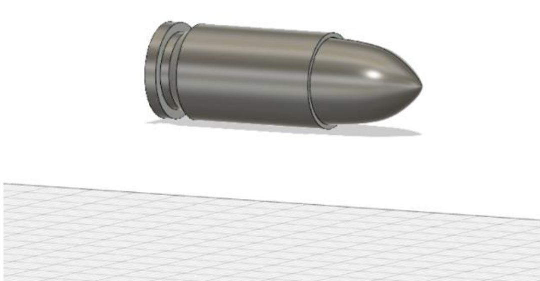

Figure 25. Pistol round (Kochetov 2018)

The gun barrel should be at least the length of three rounds to operate. The longer the barrel, the more powerful the weapon becomes. In this case, the barrel is about 4 times the length of the round, which is a typical value.

The base of the receiver sketch was made using *Line* tool and details were added on the same drawing.

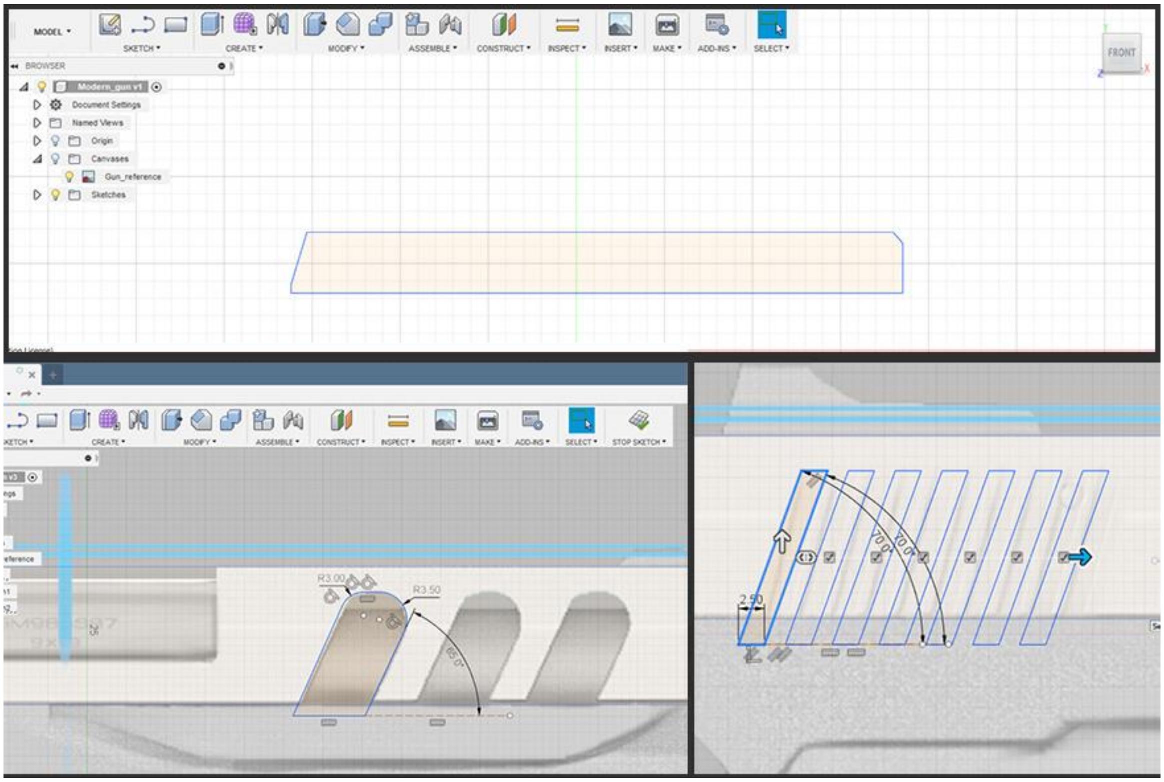

Figure 26. Base sketch (Kochetov 2018)

Barrel and handle area cutouts were multiplied with *Rectangular pattern* tool to keep the equal distance between elements (Figure 26). Frame, handguard, barrel, and sights sketches were made with the same techniques.

Fillets were added to the angles at this stage to streamline possible changes. Then the drawing process was completed, the author extruded the objects and performed Boolean operations with them. Additional objects were created on the sides of the receiver to add chamfers. The analogous principle was applied to taper the magazine (Figure 28).

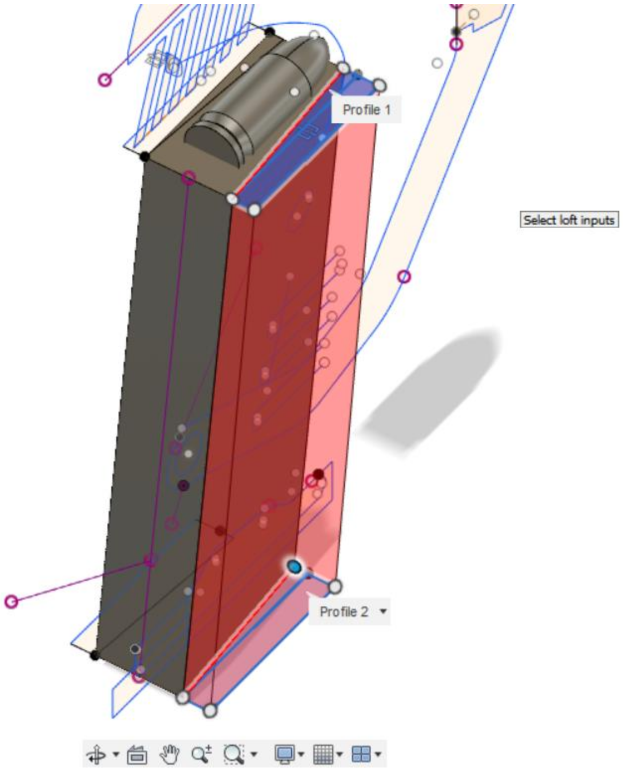

Figure 28. Magazine modeling (Kochetov 2018)

Figure 29 illustrates the process of working on the other parts of the gun.

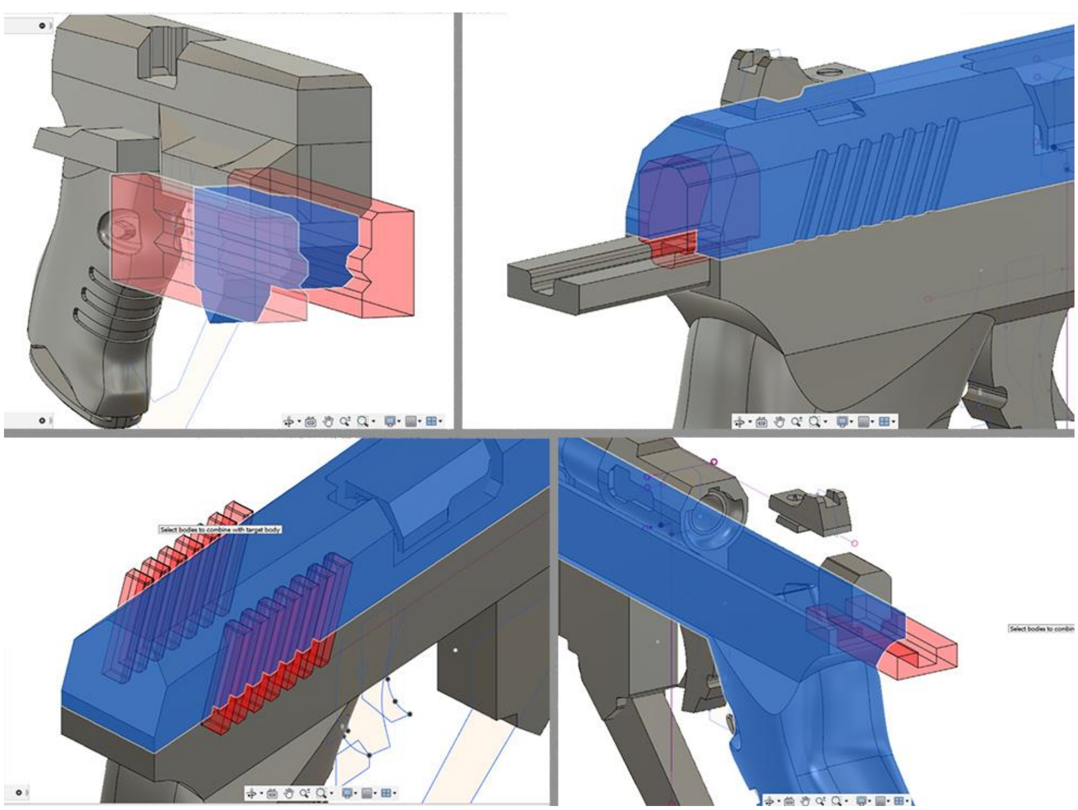

Figure 29. Detailing work (Kochetov 2018)

The handle of the gun has smoother, anatomical shape and *Create form* tool was used to model it. The base was made of a rectangular block with additional edges. Those edges were modified to match the contour of the handle. The front part of the block was narrowed, and bevels were added to all four facets (Figure 30). To add the rifling lead inside the barrel, *Coil* primitive was created and then cut from the barrel's geometry.

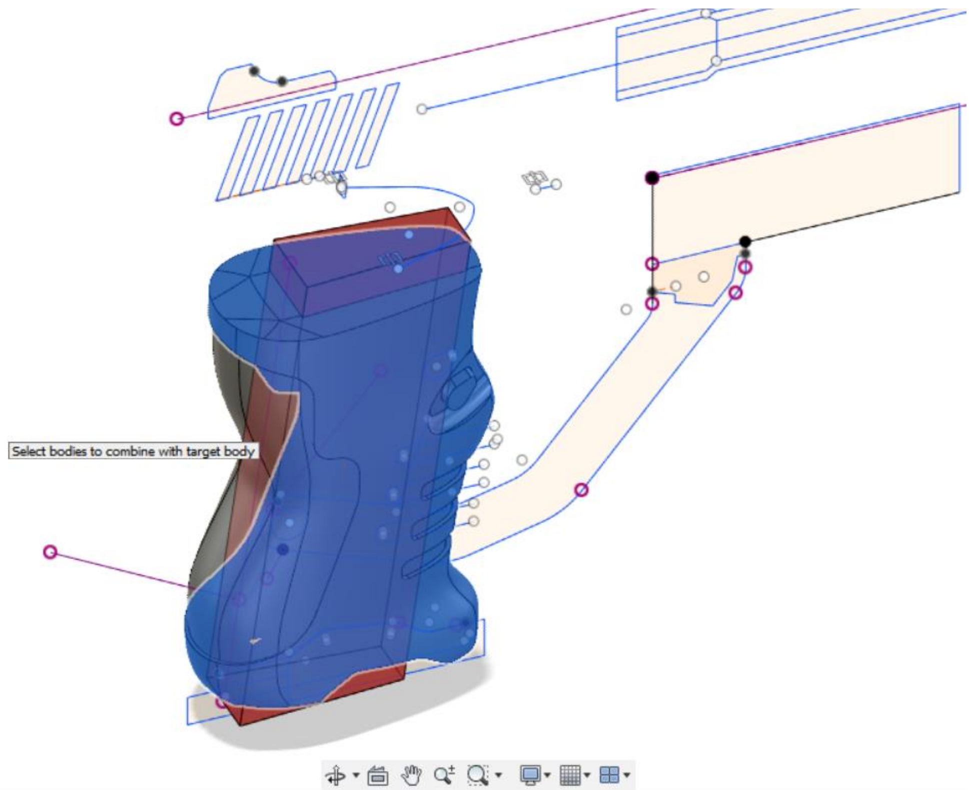

Figure 30. Handle modeling (Kochetov 2018)

4.3 Finalization

After all parts of the gun have been modeled, the finalization process starts. Small details, such as bolts, buttons, cuts, and fillets are added to basic forms. At this stage, mistakes may emerge regardless of comprehensive planning. In this case, the author had an issue with protruding frontal parts of the frame.

The geometry of the element was too complex and *Fillet* operation gave errors. Using the advantages of Fusion 360's editing capabilities, the issue was solved by going back to the operation of joining the frame and the protruding part and removing this operation. Fillets were added separately to the frame and to the frontal parts and then the objects were combined. The general rule for the fillets was to have a wider radius on a large shape and narrower radius on a small shape. No further changes to the model were made at this stage and the result of the detailing job could be seen in Figure 31.

Figure 31. Model with fillets (Kochetov 2018)

4.4 Output set-up

There are a couple of steps to perform prior to exporting the ready model. First, the model is inspected form different angles to check if there are any errors. Every object is given a proper name and sorted into groups. Groups of objects were created to structure the model according to the components – receiver group, frame and handle, magazine parts and other (Figure 32).

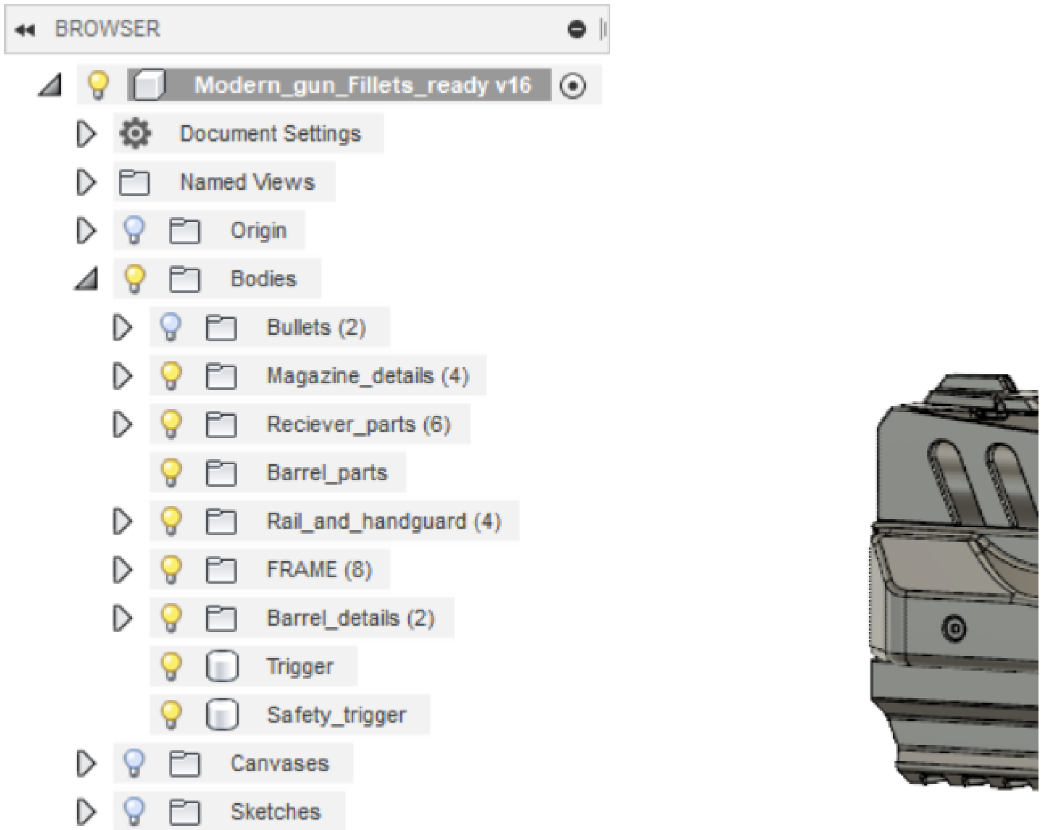

Figure 32. Scene structure (Kochetov 2018)

To showcase the different exporting options in Fusion 360, the final model was saved in two formats – *STL* and *SAT.* STL is the standard format to save the files for further usage in other 3D applications and 3D printing. Many polygonal modeling programs, like 3Ds Max, Maya or Modo can read *STL* files, but there are some drawbacks. STL file only holds the surface information and no shading data, which could result in shading errors after import. These errors are easily solved by unlocking and recalculating the normal data in the application, but it means extra work to be done.

To export the model, the artist should right click on *Document settings* in object's *Browser* panel and choose an option *Save as STL* (Figure 33).

Figure 33. STL export (Kochetov 2018)

There are various settings in Save as STL window. *The format* should be set to *Binary*, this setting is responsible for the file recording method. *Refinement* controls the level of details via the number of triangles for the model and their size. To achieve the best results, *Refinement* should be set to *High*.

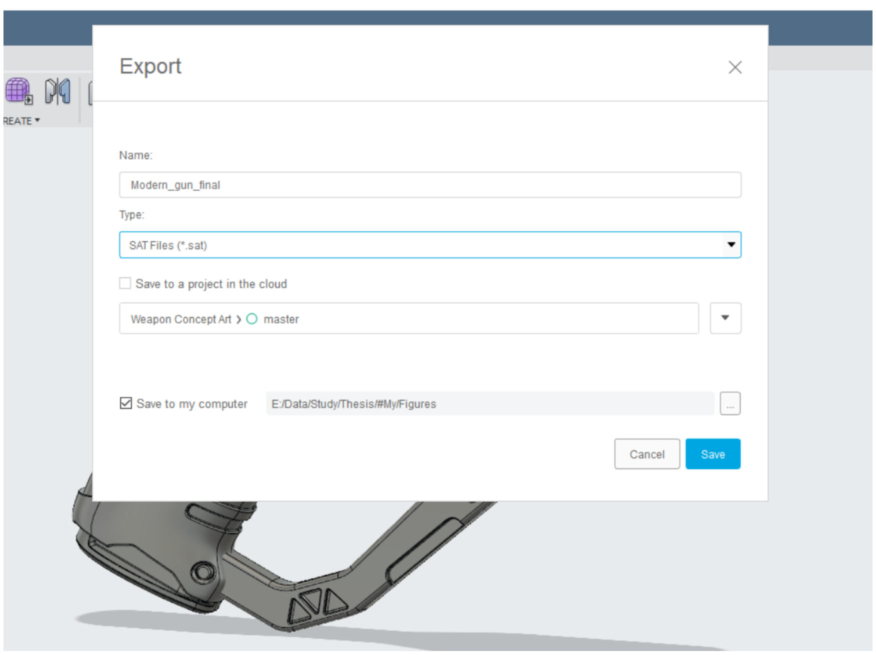

Figure 34. SAT export (Kochetov 2018)

Another solution is to save the file in SAT format. SAT files are guaranteed to be readable in Autodesk Maya of versions later than 2016. This format gives no shading mistakes and requires no exporting settings (Figure 34).

4.5 Asset verification

Various 3D programs could have differences in viewport and object display. To verify the exported model, the output file was imported from Fusion 360 into Maya, Keyshot and Marmoset Toolbag. Figure 35 shows the rendered view of the model in Toolbag. Marmoset Toolbag has a rendering system like the game engines, therefore the viewport produces the most reliable result.

Figure 35. Toolbag render (Kochetov 2018)

A shiny grey material was applied to the model to show the possible unwanted surface imperfections. Figures 36 and 37 show the viewport image from Maya and a final render from Keyshot accordingly. The Keyshot image was edited in Photoshop to add details and effects.

Figure 36. Maya viewport (Kochetov 2018)

Figure 37. Final image (Kochetov 2018)

5 CONCLUSION

Through the lens of design and modeling principles, the author has produced an authentic weapon model using the effective modern pipeline. The workflow shown in this thesis could be adapted for the variety of hard-surface modeling tasks within the game studios or by individual artists.

Fusion 360 has a compelling advantage in the context of rapid and iterative game development. Based on the author's and other 3D artists' experience, it is a fair assumption to say that most of the time during the modeling is spent on mesh editing. Artists must plan and arrange the positions of the edges, perform mesh cleaning and make corrections to the model. Fusion 360 solves those tasks automatically, therefore giving the time to work on creative tasks. Consequently, this leads to more developed designs that will be interesting and memorable to the player.

Artists who employ uncommon tools could benefit not only by acquiring unique features but with a new take on the creative process. In the case of Fusion 360, the software designed to solve engineering challenges guides the user to think and model realistically and functionally. By combining the design, knowledge and technical capabilities of the software artists can reach the expected level of quality and effectiveness in the modern game development pipeline.

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LISTS OF FIGURES