Methods and Implementations of Historically Accurate Game Design for First Person Shooter Video Games

by

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Abstract

Video games have become a common and often consumed medium to portray and to learn about history. Building on the work done by historians to understand historical accuracy on film, I design and built a first person shooter (FPS) video game that could be considered historically accurate by the historical community. The game centres on Operation Deadstick, an opening mission of the Normandy landings on D-Day, 6 June 1944. To portray accurately the historical content I designed the game using a Mechanics-Dynamics-Aesthetics (MDA) game design framework. This framework guided the implementation of the historical elements in all aspects of the game's design including its cosmetics, gameplay mechanics, and themes. I evaluated the game by examining its historical content through these same elements. Although the game was incomplete, I believe it represents a positive first step towards the design of historically accurate interactive content.

Preface

This is an original work by David Holmes. No part of this thesis has been previously published.

For Lawrence Holmes who inspired my love of history and Lundy Sanderson who inspired my love of technology. For my parents and for Ashley.

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Chapter 1: Introduction

At 0005 hours, six gliders hovered silently behind the bombers towing them above the English Channel. Inside, one hundred eighty men sat, singing songs, and joking about whether their commanding officer, Major John Howard had been airsick yet. They were the men of D Company, the 2d Oxfordshire and Buckingham Light Infantry, a part of the Air Landing Brigade of the 6th Airborne Division of the British Army. At 0007 hours, the glider jerked, the singing stopped, and there was nothing to be heard but the sound of wind rushing over the wings of the wooden Horsa glider.

The gliders navigated by compass, stopwatch, and flashlight. The navigators eyed the stopwatch, and at the appointed time, called out for the pilot to execute the next stage in the maneuver. The glider's targets were two small triangular fields, about 500 metres long, next to two bridges that crossed the Caen canal and the Orne river.[1] D Company's objective was to capture the bridges, intact, and hold them until they could be relieved by paratroopers arriving behind enemy lines.[2]

The operation was conceived as a surprise assault behind enemy lines.[3] D Company, which consisted of four platoons, would receive two additional platoons from B Company, as well as a detachment of Royal Engineers.[4] The landing force would be split into two groups: one going to Landing Zone X by the bridge over the Caen Canal, and the other going to Landing Zone Y by the bridge over the River Orne in the vicinity of Bénouville, France.[5]

The German troops defending against D Company at the bridges would be the 736th Grenadier Regiment of the 716th Infantry Division. The 736th was filled with mostly conscripts from German occupied territories in Europe and was under the command of Major Hans Schmidt. Should the bridges come under assault, defending forces could expect reinforcement

[1] Ambrose, 11
[2] Ambrose, 160-163
[3] Ambrose, 40
[4] Ambrose, 42
[5] Ambrose, 161

from the 125th Panzer Grenadier division of the 21st Panzer Division, under the command of Colonel Hans von Luck.[6]

The gliders hit their marks, and the British Commandos, in a matter of minutes, captured and secured both bridges, subduing any enemy resistance. The commandos would hold the bridges for hours without reinforcements, and in the process survive an armoured vehicle assault, a small scouting raid, an aircraft bombing run, and a gunboat assault.[7] All of this, with only two dead and twelve casualties out of a company of approximately one hundred eighty men.[8] Although it sounds like a mission from the latest incarnation of the *Call of Duty* franchise, this is history. The date was 6 June 1944 — D-Day. This was "Operation Deadstick" and as the wings of the gliders crossed the French coastline the Allied invasion of Normandy began.[9]

Events like the battle at the Caen Canal bridge are fodder for the latest Hollywood blockbuster, or the next AAA video game from a large publisher. In fact, this battle was featured in the original *Call of Duty* as playable levels in two parts, called "Pegasus Night" and "Pegasus Day;" the term "pegasus" is used because after the invasion, the canal bridge was renamed to Pegasus Bridge in honour of the British Airbourne who liberated it.[10] This representation of the game has been criticized for misleading players about the nature and the reality of the battle.[11] It can also be criticized for its counterfactual history. One instance that stands out is the use of the "Flak88" gun to attack and destroy the tank that assaults the bridge. While the bridge was attacked by a tank, or modified armoured vehicle as there is some historical debate about the nature of the vehicle that assaulted the bridge, it was not destroyed by the 75mm anti-tank weapon that was present. The vehicle was instead destroyed by a Piat grenade launcher in what is generally described as a lucky shot.[12] Further, the anti-tank weapon was put in use later in the day by Private Wally Parr, but it was while D Company was under sniper fire, and not used against armoured vehicles. Aside from Pvt. Parr, the company generally felt this was a bad idea and Parr was subsequently ordered to stop firing the weapon on what was believed to be a maternity hospital.[13]

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[6] Fowler, 10-11
[7] Fowler, 30-54
[8] Ambrose, 106
[9] Ambrose, 5-6
[10] Infinity Ward, 2003
[11] Campbell, 197
[12] Fowler 43-44
[13] Ambrose, 112

This example of history being used in video games or films troubles historians with its blatant disregard of or respect for the historical record. For example, James Campbell in his discussion of World War II first person shooter (FPS) games as a form of ludic nostalgia, describes these games as the domestication of violent history into a simulacrum of other violent video games. He goes on to say that "FPS games as a genre reflect and relate to one another at the expense of their relation to history."[14] While plenty of work has been done in the area of historical film by historians like Robert Rosenstone, the inclusion of the missions at the Caen Canal bridge in video games begs the question: can video games be historically accurate?

In my opinion, yes, they can. For my thesis, I aim to design, create, and evaluate a video game using the events at the Caen Canal on 6 June 1944 to demonstrate that video games can be historically accurate. I call my game, appropriately, *Operation Deadstick*.

To do so, I will approach the creation of the game from the perspective of a game developer who is producing a serious game. Although the term has some ambiguity that I will need to solve by coming up with my own definition, I can generally state that a serious game is a game whose purpose moves beyond that of entertainment. *Operation Deadstick* will be designed as a game using the mechanics, dynamics, and aesthetics or MDA framework for game design. This method of game design focuses on iterative improvement of the game by viewing the creation of the game, its systems, and its content through distinct lenses. This perspective emphasizes knowing how a change to one part of the game impacts the whole media object. I will then look at a successful serious game as a case study in order to determine how to create a successful and meaningful interactive product that moves beyond entertainment.

In order to properly integrate the historical content of Operation Deadstick into its virtual and interactive simulacrum, I shall investigate how film has already encountered and moved beyond this problem. My analysis of historical accuracy in film shall reveal that through the use of compression, condensation, alteration, and metaphor in the development of a video game I can accurately present historical content.

[14] Campbell, 188 – 189

Operation Deadstick will be created as a first-person shooter video game using the Unreal Development Kit. This will allow me to take advantage of large amounts of existing commercial work done in the area so I can focus on the design and implementation of the historical content. The timeframe of the game will focus on the events that took place between 0016 and 0030 hours at the Caen Canal bridge. I shall outline my methodology and design for the game including the game's scale and its environment. I shall also outline my design for the game's mechanics, including movement, weapons, physics, player and character health, the user interface, and game over.

I shall then consider whether *Operation Deadstick* the game can be considered historically accurate. To do this, I will first determine whether or not the game can be considered a historical object that is making a historiographical argument. Then I shall investigate the game and its content through a framework for the evaluation of historical accuracy in the game. This framework has its roots in work done for the evaluation of historical accuracy in film and subsequently applied to games. This framework breaks down the evaluation of historical content into three areas: cosmetics, issues of strategic importance, and game systems and balance.

I shall conclude by identifying future work that can be done in this area. Further, if I were to continue development of *Operation Deadstick*, I outline areas for future work that I believe would be necessary to realize the vision of a historically accurate video game. I believe video games present an exciting opportunity for historians and academics to provide new avenues to present history and inform the players of these games.

Chapter 2: Theory

Towards a Definition for Serious Games

In 1970, Clark Abt stated that for a game to be considered serious it needed to move beyond the simplistic need for entertainment and have an explicit and carefully thought out purpose.[15] Although Abt was writing at a time before the emergence of video games as a cultural phenomenon, the definition also applies to games within the digital realm. Video games that are meant to have a serious purpose — that is a purpose other than the pure entertainment of its player, have (usually) been carefully thought out by their designers in order to properly convey a message that is extends beyond the game itself. Ultimately though, this definition is too broad for my purpose. Many games have carefully thought out purposes that are not meant for the sole entertainment of the player, but either do not explicitly state their goals, or have other purposes that work against the players interest. *September 12th*[16] is a decidedly serious game — one where the player tries to guide missiles to strike terrorist targets whilst minimizing civilian casualties — and leaves its message to be discovered by the player the longer they play. “Games” created by companies in order to drive higher sales have a very thought out purpose, but would not be considered a serious game, because their purpose is mainly an economic one.

Recognizing that Abt’s definition fails to accurately portray serious video games, many have sought to create a new definition that accurately reflects the spirit of a video game that is not primarily for entertainment. In a 2005 IEEE paper, Michael Zyda stated that a serious game is a mental contest, played with a computer in accordance with a specific set of rules that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives.[17] This definition also fails to fully capture the essence of a serious video game. In *Virtual Peace,*[18] players seek to send humanitarian aid to Honduras following the devastation of Hurricane Mitch. This is not done as a mental contest, but as a social collaboration to maximize the aid delivered with the resources at hand. Simultaneously, this game does not use entertainment to convey its information, but it uses the equipment of the commercial game industry to create an appropriate simulation.

Given the taxonomic vagueness of “serious game”, a new definition is required to fit my

[15] Abt, 9
[16] Newsgaming.com
[17] Zyda, 26
[18] Virtual Peace

needs using the previous two examples as inspiration. Defining a serious game as a mental contest does not accurately describe the activity of a player in a serious game; it can be more accurately defined as a player's actions through their interaction of the game system with their mental faculties. This interaction is rewarded with the serious information the game is trying to convey. The term that seems the most appropriate description for this activity would be a mental exercise. Since entertainment is also not required in order for a game to be considered serious a more accurate description of how serious games further their objectives is required. Fun, and by extension, entertainment, has been shown to be a byproduct of engagement with the game system.[19]

I can elaborate upon Zyda's work to create a new definition for a serious game: a serious game is a mental exercise, done either alone or in collaboration with others, with the aide of a computer in accordance with a specific set of rules that uses engagement to further pedagogical, academic, health, training, public policy, or strategic communication objectives.

Serious Games vs. Simulations

It would be useful for me to clarify the difference between a serious game and a simulation in the the context of my definition. Frasca defines a simulation as a model of a system as depicted through a different medium that presents to someone the behaviour of the original system.[20] In relation to my own definition of serious games, we can say that the rules that the player uses during their play is, itself the simulation that the player is interacting with. The underlying architecture and algorithms of the game, the metaphors the game uses in order to represent concepts, abstractions and reality, are a simulation that the player engages with in order to discover the serious content that is being depicted in the game.

Woods sums this up best, by saying that a simulation gives players the opportunity to engage with the system. This system then offers the possibility of many experiences to the player.[21] This is distinctly different from the experience of a serious game, where the player has already chosen to engage with the system to realize the content that the game contains, itself which is an attempt at conveying a particular experience on the part of the game's designer. Frasca would seem to agree, given his comparison of a simulation to a kaleidoscope, where we

[19] Sweetser and Wyeth, 23; Chen, 6
[20] Frasca 2003, 225
[21] Woods, http://www.gamestudies.org/0401/woods/, accessed 29 July 2017

do not consider the kaleidoscope to be a collection of many possible images, but a device that produces images according to a set of mechanics.[22]

However, I feel Frasco is perhaps too dogmatic in his view of games as simulations. Certainly, a serious game with a specific set of rules can create many different experiences and many different narratives for its many different players; but viewing the game solely as a vehicle for players' own narratives is in my view short sighted. The narrative that the designers include in the game is itself part of the rules of the game that will help to communicate the game's serious content. This means that the simulation the game uses to depict its realistic analogue represents only part of the rules that the player must abide by during their play session.

The non-serious game *Mass Effect*[23] can be used to demonstrate this more clearly. Each player will leave the game with different experiences and their own narratives, however each player has the experience of the game's protagonist, Commander Shepard. This is because the story of Commander Shepard is one of the immutable rules of the game. Although players may make different choices, each player will have the experience of Commander Shepard because the protagonist's narrative represents a rule that players have no option to ignore.

How to Design a Game

There are numerous methods for the design and evaluation of games. Some of these are formalized into systems for the creation of a creative product. Others are more relaxed - they start with a core idea and build around it. Put another way, the most relaxed methods for game development "find the fun" and then figure out what to do with it, while most structured methods know what they want to do, and assume it will become fun as it develops. Given my desire to design a game that can participate in historiographical debate about a real event, I will need to take an approach that finds a middle ground between these two perspectives.

The MDA Framework is a method for designing and understanding a game by breaking its system down into separate components: Mechanics, Dynamics, and Aesthetics. Each component corresponds to a different part of the design of the game:

- "Mechanics describes the particular components of the game, at the level of data representation and algorithms.
- Dynamics describes the run-time behaviour of the mechanics acting on player inputs and each other's outputs over time.

[22] Frasca 2001
[23] Bioware

- Aesthetics describes the desirable emotional responses evoked in the player, when she interacts with the game system."[24]

Mechanics are the abilities the player has at their disposal within the context of the game.[25] Mechanics can be considered the "guts" of the dynamics that determine how the game functions. A player would consider them to be the rules which make up how the game is played. A designer would view mechanics as the means in order to produce particular interactions. Mechanics are the rules of the game so that the player knows how it works. Things like rolling 2 six sided dice in *Monopoly*, cards having a particular cost to play in *Hearthstone: Heroes of Warcraft*, or heroes having 6 basic statistics in *Dungeons and Dragons* are mechanics. Mechanics are the specifics a game developer uses in order to generate the basis for the game system. For my purpose of designing a historically accurate game, the mechanics are the underlying systems that I will develop that provide the basis for the player's experience inside the virtual world.

Aesthetics give us a vocabulary to describe a particular game. It allows us to talk about not only how designers want the player to feel, but also the key pillars of the game and the content to be conveyed. From players' perspective, aesthetics describe the emotion and experience of the game being played. In other words, these are what players consider to make the game "fun." From designers' perspective, aesthetics describe the core components of the game that build the experience the designer is trying to convey. Put another way, the aesthetics define the goals of a game.[26] These descriptions allow us to define the model for gameplay dynamics and mechanics.[27] When designing and developing my historically accurate game, the aesthetics are what defines my interpretation of the historical record. This interpretation forms the basis of my historiographical argument and forms the basis of the player's experience when he or she plays the game.

Dynamics give us the tools required in order to make aesthetic constraints a reality. They are the expressions of the mechanics through which aesthetics are produced.[28] Dynamics can be thought of as the elements of the game with which the player interacts to produce an experience. Elements like turns, characters, or resources can be considered dynamics. A player views dynamics as the pieces and parts which makes up the game itself. A designer views

[24] Hunicke, LeBlanc and Zubek, 2
[25] Hunicke, LeBlanc and Zubek, 3
[26] LeBlanc
[27] Hunicke, LeBlanc and Zubek, 3
[28] Hunicke, LeBlanc and Zubek, 4

dynamics as the mechanisms which generate play and create players' experience. These dynamics allow players to interact with the underlying mechanics of a game, and through these interactions create the aesthetics of the game.[29] Dynamics also allow us to create feedback systems that can identify how changes affect overall interaction with the system. For example *Monopoly* is a game that consists of turns, movement of players, and different positions on a board. In order to determine the amount of time it will take for a single player to traverse the board (that is, take one revolution of the board), the number of squares on the board can be divided by the average movement of a player per turn. When a change is made to the mechanics of the game (the size of the board or the system of movement) this is reflected in the dynamics, such as the amount of time it takes to make one revolution of the board, and in return the experience of the player is simultaneously affected. If a developer wants to increase the speed of the game, they can reduce the number of squares, or increase the average movement of the player per turn.

It can be difficult to differentiate between what is a mechanic and what is a dynamic, as the two have overlapping properties. In describing the two, LeBlanc states that game systems have behaviours that are direct consequences of the rules and some behaviours that are created indirectly. Dynamics are behaviours that are emergent through the interaction with the rules, but not because of them.[30] In *Monopoly* players roll the dice, move their piece, interact with the property they land on, makes deals, and hand the dice over to the next player. These mechanics create the dynamic of a turn. For a designer, the MDA Framework emphasises the importance of iterating game design — tuning the relationship between the mechanics, dynamics, and aesthetics until the game is balanced.[31]

A Serious Game that Works - Contextualization

One of the major criticisms of serious games is that they do not contextualize information presented to the player.[32] The game teaches the player how to play the game but does not adequately provide sufficient knowledge transfer of the topic in question. Squire expands on the work of Rieber to say that in order for a game to properly represent its content, it needs to "put players *inside* game systems...games where the context *is* the game play."[33] This itself is an

[29] Hunicke, LeBlanc and Zubek, 3
[30] LeBlanc
[31] Hunicke, LeBlanc and Zubek, 4
[32] Graesser, 83
[33] Squire, 25

extension of Marshall McLuhan's idea that "the medium is the message."[34] An excellent example of a game that contextualizes its information and has its serious purposes reflected throughout the entirety of the game's system and content is *Rocksmith 2014*.[35] The game was designed and promoted as a way for players to learn to play the guitar or to improve upon their existing guitar playing skills. The game lets players connect any electric, electroacoustic, or bass guitar to the game and features an impressive integration of the game's serious content with the overall game content as well as the game system. This integration gives the player an experience that contextualizes the information presented, so when the player leaves the game, they retain their skills – in other words, they can still play the guitar when they are no longer playing the game.

The game is separated into four major sections: Lessons, Learn-A-Song, Session Play, and Arcade Mode. In Lessons, the player is instructed in the various techniques involved in playing a guitar. Each lesson is split into two different parts – videos showcasing the technique, its purposes, and how the player can achieve it and then sections where the player takes what they have learned from the videos and apply them. The game evaluates whether or not the player has achieved proficiency with the particular skill. If they are not, it provides tips and corrections to the player's technique. Once the player has demonstrated their proficiency with a particular skill it presents them with a longer and more involved track in order to demonstrate the skill. This test takes into account the player's individual proficiency level and familiarity with the skill – the more familiar and proficient the player, the more difficult the test. This allows the player to be introduced to and develop particular skills at their own pace.

Learn-A-Song allows the player to learn popular songs and apply the skills they have learned. When playing a song, the game breaks the song into different sections and assign a difficulty to the section based on the user's skill level and the player's familiarity with the guitar techniques in that particular section. As the user plays the game and the song, and thus the guitar, more and more, the game increases the difficulty to the player's skill level. This not only takes place over the user's play sessions, but during the song itself. If the game evaluates the player's skill to be of a certain proficiency at a particular section and for certain techniques, it will increase the difficulty of the song to compensate over the course of the song. The inverse is also true, if the game evaluates the player to be having difficulty at a particular section or technique, it will reduce the difficulty in following sections and similar techniques so not as to

[34] McLuhan, 8
[35] Ubisoft

discourage the user. In this way, it is impossible to “fail” a song in the Learn-A-Song section.

This is done implicitly – when the user is playing, they will not be informed of a change to the skill level, and they will only notice that new sections of the song are not as complex as the preceding sections. There does exist a difficulty meter at the top of the screen that corresponds to the chosen difficulty level, so players who are paying attention will notice when the game decides to reduce the difficulty in certain sections. If the player is not satisfied with the game’s choice of difficulty level, they are able to alter the difficulty level through the pause menu. When the player completes a song they are evaluated on both their accuracy on hitting the notes of the song, as well as their proficiency with techniques used in the song. The game then maintains a record of their performance and uses this to gauge the player’s change in ability over time and successive attempts at the song.

Once the evaluation is complete, the game then analyzes potential areas for the player to improve and suggests different actions the player can take in order to improve their performance. For example, the game may suggest the player review a particular lesson, look up a chord that might be featured in new attempts of the song as the difficulty increases, or replay different sections of the song to improve specific areas the player may be encountering difficulty with. While playing different sections the user can manipulate different variables to allow them to better attempt a particular section. These variables include difficulty, speed, and the game’s forgiveness level when evaluating the player’s performance on specific actions (for example if the player hits a particular note early or late).

In Session Play, the game provides the player with a virtual band that will play along with the player in an artificial “jam session.” This allows the player the freedom to experiment with new techniques, be creative and spontaneous, as well as how different guitar setup configurations affect the sound of the instrument. The player can have a maximum of four different instruments accompany him or her. These instruments are of different types (percussion, brass, etc.) and can be changed to have different musical textures; for example the player can be accompanied by an electric, or an acoustic guitar.

Arcade Mode is split into two different parts: Scored play and the “Guitarcade.” In scored play, the player can play different songs at three different difficulty levels and their performance is then evaluated and given a score by the game similar to games like Rock Band or Guitar Hero. If during scored play the player makes three mistakes, they “fail” the song and may try again. The player’s final “score” on the song is then pushed out to a leaderboard, which

encourages the player to improve in order to compete with their friends and other players of similar skill levels.

The “Guitarcade” is a much more interesting feature of Arcade play. It features a variety of mini-games that the player can attempt in order to improve fundamental guitar skills. There are mini games for shifting up and down the fretboard, sliding with the fretting hand, hammer-ons and pull-offs, and more. These games do not improve the player’s ability to play a particular song, but do provide an interesting and engaging way to practice particular playing techniques. For example in “Star Chords” the player is tasked with destroying enemy ships by playing an appropriate chord when prompted. If the player does not remember the name of the chord, it slowly reveals the “tab” of chord for the player. If the player cannot play the chord, the enemy space ship fires at the player decreasing his or her health. As the player gets further in the mini-game, the rate at which the enemy will attack decreases, so if the player cannot hit the proper chord quickly, he or she will receive more damage. When the player’s health reaches zero, the player receives a “game over.” The speed at which the player strums the proper chord gives the player more points giving the player incentive to learn the name of the chords. When the player ends, they are given a score and shown a leaderboard again reinforcing a competitive spirit.

Rocksmith 2014 starts with the user inputting their experience level into the game in order to tailor the experience to the user’s skill level. If the user is a novice or beginner, the game directs the player to the more novice sections like Lessons, Learn-A-Song, and Guitarcade. If the player is proficient, they are directed to more advanced sections like Session Play, Scored Play, or Learn-A-Song’s “master” mode which aids the player memorize a particular song they may be interested in playing in order to play it outside of the game.

This is not to say that *Rocksmith 2014* is not problematic with regards to its serious content. One of the key issues with the approach is the matter of the playing “style” of the learner. In other words, is the game teaching habits that would be problematic outside of the virtual environment? As an example – the cable the game uses to interface between the guitar and the system contains a digitizer to convert the analog guitar signal to a digital signal that the game can treat as an input device. For the player to get the game to correctly interpret the guitars input, they may have to play the note louder than normal, causing them to play louder on average. Is this behaviour optimal for casual play? Will it require more guitar maintenance? These are issues that game has introduced and the player has to think about. Further, although the game teaches the player how to hold the guitar, it does not provide any feedback on the

actual technique that the player is using. As a result, if the player is holding the guitar too high, they may injure their elbow. If they play the guitar too low, they may injure their wrist. These are items which can have lasting and profound consequences for the player, and there is no mechanism by which the game can correct any unintentional mistakes on the part of the player.

A serious game like *Rocksmith 2014* that properly contextualizes its content and successfully transfers this knowledge to the player is a useful case study for serious games in disciplines other than music. It provides a template and a blueprint in order to understand how to develop an interactive media object that can successfully present its content to a player. For the purposes of history, it shows us that for a game to be considered historically accurate, the historical content must be diffused throughout the mechanics and dynamics of the game. In doing so, the historical aesthetic that is produced can successfully present its content to the player.

Historical Films

Before I can consider how to design and develop serious games with accurate historical content, it is beneficial to consider an example of a medium that has already encountered this problem — film. As historian Robert Rosenstone has bluntly stated, historical films trouble those who study history.[36] The transference of history onto a visual medium that must be contained within specific time limitations has resulted in many films that not only distort the historical record, but in some cases disregard it altogether. That being said, history has not been able to escape the medium as historical films can be considered one of the principle ways of conveying the past to a public audience.[37]Consequently, a debate has emerged within the historical community on the importance of historical film. The post-modernist perspective argues for the value of historical films and how their portrayal of the past can provide a perspective beyond that of conventional mediums.[38] An opposing view decries the move to embrace visual and oral histories and encourages embracing traditional texts.[39]

The roots of criticisms for historical films lie mainly in the difference of agendas between historians and filmmakers. Although historians strive to produce a balanced, critical, and reasonably informed account of the past, filmmakers aim to entertain their viewers with stories that may be based on real events and people. Academic historians strive to embrace the

[36] Rosenstone 1995, 45
[37] P. J. Beck, 171
[38] Rosenstone 2012
[39] Windschuttle

evidence contained within the historical record and dispel false impressions and myths. Conversely filmmakers rely heavily upon myth and invention in order to increase dramatic effect and viewer interest. In this way, historical films present a constructed past that may be largely fiction.[40]

What evidence constitutes the historical record, and indeed what could reasonably be considered evidence is under debate, but I suspect few historians would argue that the basis of the conception of the past should not be based on discussed and debated evidence. Historians strive to understand the past within its own context and eliminate the presentism that filmmakers embrace in order to make films more appealing to a modern audience. Most filmmakers will have an important (if not primary) goal of generating revenue in order to profit from their work or at the very least recover the cost of the films production. Historians prefer to write in an effort to appeal to the academic historical community, and as a general rule, their livelihood is not dependent on the revenue performance of their work.[41] As one historian put it, Hollywood movies inspire and entertain, but "they do not provide a substitute for history that has been painstakingly assembled from the best available evidence and analysis."[42] At this point it is difficult for one to resist making a similar comparison between historians and game developers, but I am getting ahead of myself.

Arguments against the validity of historical film as a valuable method for either communicating or debating the historical record mainly centre on the issues of how film presents history in comparison to how it is presented in text. Such an approach to historical film is erroneous, given that printed history is not itself solid and unproblematic. History on film is a thought process - a way of presenting the past by using visuality and historical traces to make it relevant to the present. Film shows us that there more than a single way to understand the past and more than one medium in which to present it.[43] Film will always violate the norms of written history, because film itself creates and exhibits a view of the past distinct from the one that is presented on the written page.[44] Film cannot represent a literal historical "truth," but neither can the written word. As Rosenstone states, "historical recounting has to be based on what literally happened, but the recounting itself can never be literal. Not on the screen, and not, in fact, in

[40] P. J. Beck, 172
[41] P. J. Beck, 173
[42] P. J. Beck, 172
[43] P. J. Beck, 190
[44] Rosenstone, 65

the written word."[45] Text generalizes, symbolizes, and abstracts large concepts that do not exist except on the printed page. Film also does these things through images and motion, as well as other things that the written word never could – it emotionalizes and dramaticizes the past, shows us its look and feel, and presents history as a process.[46] Film and the written word are not rivals for the authority of the past; they are complementary methods by playing off each other's strengths.[47]

Historical Accuracy on Film

Film have value in the conveyance of history to their audience, but that does not mean they do so with strict adherence to historical accuracy.[48] This itself is a strawman argument since films like *Braveheart*, *U-571*, and *Mississippi Burning* or television shows like *The Tudors* or *The Borgias* are historical in the sense that they are based on real people and events, but their presentation of history on the screen is so distorted and manipulated that no historian could reasonably consider them to be accurate to the historical record.[49] These distortions include techniques like invention, inaccurate compression of timelines, factual alterations, inaccurate imagery, or outright factual inaccuracy.[50] However, through the proper and careful use of the technique of invention films like *Glory, Schindler's List, Tora! Tora! Tora!*, and *La 317éme Section* provide examples of films that give healthy portrayals of history. Learning to judge, debate, and criticize the use of invention in film, historians can gain a new toolset to debate the historical record. Rosenstone outlines four methods of invention in order to generate historical accuracy: compression, alteration, condensation, and metaphor.[51]

When a film uses condensation it can, for example, take people with similar experiences from the historical record and group them together as a single character to represent a specific stereotypical experience. Alteration can be used to generalize what happened in the past in order to better convey an overall experience to the audience. Compression can be used to compress timelines into manageable scales. Without it an event like the Battle of Stalingrad, which lasted months, can be condensed into a reasonable two-hour time frame. Metaphor can be used to illustrate complex ideas and abstractions without distortion of the historical record

[45] Rosenstone, 70
[46] Rosenstone, 55-61, 70-71
[47] P. J. Beck, 191
[48] P. J. Beck, 175
[49] P. J. Beck, 177-178
[50] P. J. Beck, 179-180
[51] Rosenstone 1995, 68

similar to how it is used in text.[52] Take Kerensky's entrance to the private quarters within the Winter Palace in Eisenstein's *October*: the comedic sequence is used not only to showcase the pompousness of the man, but also the farce of his government.[53] The resulting product can be entered into the historical debate. At this point, peer-review can be used to decide whether the film is a valid historiographical artifact through ongoing historiographic discourse.

Games and History

Historians and Games

Historians who espouse the use of games in history, including myself, will frequently refer to traditional or conservative historians who will froth at the mouth when confronted with the notion that games can be used to accurately and academically portray history to its players. Frequently, this is used as a rhetorical device in order to set up a historian's argument in favour of games, but it appears that this may be nothing more than a strawman argument. There seems to be a lack of published articles or verifiable comments of historians raging against the infringement of their sacred ivory towers by game developers to be found. That isn't to say that these historians don't exist, but it would appear that the stories of angry historians shaking their tomes at games are anecdotal at best.

I surmise that this is mainly because historians who reject the use of games to convey historiographical opinions and representations of events would not even deign to write about the use of games, let alone engage in a discussion about their usefulness. This is most likely because these historians are ideologues who oppose the use of poststructuralism and cultural theory on principle and do not think film, games, or oral histories have a place in historical scholarship.[54]

Beyond the partisan historical traditionalists lie those that have interest in the study of games and their representation of history, but are apprehensive about the potential for games to be historical objects. Central to these trepidations is the concept of player control and agency from within the game. Among these academics are Galloway and Apperley, who argue that the control and agency afforded to the player only have meaning in relation to the underlying systems and architecture of the game; the actions and choices the player makes are therefore

[52] Rosenstone 1995, 72-75
[53] Rosenstone 2012, 72
[54] Windschuttle

meaningless outside of the context of playing the game.[55] This is derived from the argument Galloway makes that history itself cannot be modeled in a game, because the underlying architecture and systems of the game replace history with "...the synchronic homogeneity of code."[56]

I would argue that Galloway is troubled by the way a game like *Civilization III* represents history, not because of the underlying systems, architecture, and algorithmic components that define how the player interacts with the game's concept of history, but that the game itself embodies a fundamentally flawed approach to history that vexes the post-structuralist historian. *Civilization III* takes a purely structuralist argument towards history, with rigid concepts of technology, progress, city states, and warfare. This viewpoint is rigid and comparatively easy to model when compared with the messy, chaotic, and fractured viewpoint of the postmodernist historian. The game's architecture, systems, and algorithms thus become a scapegoat for the conservative and outdated historical viewpoints of the game's creators; this has the effect of making the game the embodiment of the conservative structuralist strawman that game embracing historians such as myself love to invoke in order to aid our own arguments.

Standing in opposition to these historians are those, such as myself, Chapman, and Kee, who consider games to be a medium and a vehicle for historiographical thought. These historians embrace the idea that history as a discipline is not limited to text, but that all mediums, including games and film, can represent historical forms of thought.[57] These historians are interested in the different tensions that are created by the modeling of history in an interactive setting and seek to understand how to make full use of the medium as a method for historical scholarship. Personally, I seek to understand how to model and represent historical traces in the interactive medium in order to fully model and represent historical events.

Historical Accuracy in Games

Historical film provides an entrée into an examination of history in games, but it is missing an important element that is necessary to understand historical games — interactivity. Games can provide an experience that films cannot through their direct interaction with the player. While movies are content to passively showcase their interpretation of the past, games can allow players to explore the past and interact with it to build a broader and more nuanced understanding. The question remains, however, how can a game be created that is accurate in

[55] Apperley, 133–134
[56] Galloway, 91–92
[57] Chapman

its portrayal of history while dealing with the question of interactivity? Rosenstone's methods of invention certainly aid one's ability to make a game that deals with historical content in an academically and historically responsible way. These methods are based in their representation of content and make it hard to deal with the interactive mechanics of a game. Is it impossible to portray history in a medium that introduces the constraint of interactivity? Bluntly, no.

Hunicke, LeBlanc, and Zubek in their 2004 definition of the MDA Framework approach to game design and research specified that in order to better understand games a developer must separate the game's content from the game's system (the mechanics and "program" of the game).[58] However, the authors also specify that in order to gain a broader understanding of the game, you must understand how each part of the game interacts with and affects each other part of the game. In other words, how does the game's content affect the game's system and vice-versa.[59] Additionally, a developer must also understand how the game's system as well as the game's content affects themselves. By creating a historical game where the content is reflected in the system, the system is reflected in the content, and the content and system do not contradict themselves, developers can ensure an accurate and positive portrayal of the historical record; one that represents an argument in the historiographical debate regarding a particular event.

One of the important points the MDA framework makes is that when designing or interpreting games, it is helpful to do so from two perspectives: from the designer and from the player.[60] For my purposes, I shall add a third — the historical perspective. Design decisions should not only observe the impact these decisions have on the system or the experience, but also the influence they have on the historical record and the historical perspective that the designer is trying to convey. This is because each choice that is made in the creation of a historical game affects not only the gameplay and the content, but also the historicity of the game itself. While the historical and players' perspectives may be similar, one cannot eliminate for the other because they are both required for different reasons. The players' perspective is necessary to ensure the engagement afforded by the play experience, or put another way, helping the media retain its ability to be a successful game. The historical perspective is required to ensure the validity and legitimacy of the presentation of the historical record. By keeping these differing (and at times competing) methods in my mind as I progress through my

[58] Hunicke, LeBlanc and Zubek, 3
[59] Hunicke, LeBlanc and Zubek, 1
[60] Hunicke, LeBlanc and Zubek, 2

iterative process I can ensure a mechanically solid, consistently entertaining, and, most importantly, academically rigorous interactive product.

Historical Accuracy in Game Content

Condensation in games can be used the same way as in films. Designers can not only compress historical personalities into character stereotypes in order to convey a variety of historical experiences, but can also compress comparable events into single scenarios to provide a more refined and engaging experience. This not only reduces playtimes to something manageable, but it allows game designers the ability to create a wider variety of experiences for the game. This gives players more choice in the content they wish to experience, but also allow them to progress at their own pace.

Compression can be used to summarize and consolidate historical events into reasonable timeframes. Although games today have total playtimes ranging from four to over one hundred hours, spending extended periods of time on the same event makes it hard to maintain player engagement when the same experience can be conveyed accurately within the span of a few hours. A game that did not compress would be incredibly expensive to produce both in time as well as fiscal resources. Combined with condensation compression can be used to take a lengthy, complex event and break it down into key events and characters in order to present an experience of a much more appropriate length. Compression can also be used to compress space; since the environment of the player is constructed, a game developer can shrink it to a manageable scale in order to reduce not only the size of the game (both in terms of the environment and the physical disk space on the computer), but they can also create the space to provide a more engaging experience while maintaining the spirit of the historical record.

Alteration is understandably the most controversial way of maintaining the historical record in an interactive piece, but used responsibly it is essential to maintaining the presentation of the historical record. Using alteration, developers can better relate historical content to the game system in order to reduce the amount of tension that exists between the historical content and the interactive mechanics. This reduction of tension gives game designers greater freedom to create meaningful historical content while simultaneously increasing the intrinsic value of gameplay. A designer could alter a map in order to deliver a tuned and engaging player experience. Alteration can also be used to give the player greater control over their own actions by giving them more choice in gameplay. Although this seems like it would inevitably distort the historical record, a design can maintain tight control over the choices offered to the player and

ensure that each choice is responsible and accurate to the presentation of the historical record. In the words of Nicholas Iuppa and Terry Borst a designer, "[gives] the illusion of freedom, but maintains a grasp on the linear design."[61]

Metaphor is an understandably complex and difficult to use tool in the maintenance of the historical record as it is portrayed in an interactive medium. An excellent example of the use of metaphor in games is in *Metal Gear Solid*, a game by Japanese game publisher Konami in 1998 for the *Sony Playstation* game console. The game features a protagonist, Solid Snake, and an antagonist, Liquid Snake, twins who are the genetic clones of a previous character from the franchise, *Big Boss*. Throughout the game Liquid Snake is presented as a representation of destiny, whereas Solid Snake is presented as a representation of free will, and the contrast of the two characters gives us a reasonable depiction of the concept of Nature versus Nurture.[62] The struggle between the two characters gives the player a discourse culminating on the game's commentary of the debate – Solid Snake's victory (whose actions are governed by the player's choice) over his brother Liquid (whose actions are governed by the system) informs us that free will (nurture) has the ability to win over fate (nature).[63] Taking this concept rather shamelessly to a historical game allows us to showcase the debate over the historical record between two characters. They become the digital embodiment of the historiographical debate over a given event.

Historical Accuracy in the Game System

A discussion of Rosenstone's methods for invention are useful when discussing how to integrate the historical record into the content of an interactive medium, but is less useful when discussing how to create the game system itself. However, one area of invention, perhaps the most important, when discussing historical accuracy in the game's system, is the use of metaphor. The underlying systems created for the game are themselves models of the real world. The algorithms and structure of these mechanics are themselves metaphors for the points of view with regards to the historical event being presented.

Take the common game element known as "game over." When players interacting with a game have failed to achieve the win conditions within the specified limits (perhaps they ran out of time or failed to bypass a particular obstacle), the game system will commonly tell the player they failed ("Game Over"), and the player is welcome to restart from an earlier point and try

[61] Iuppa and Borst
[62] Yap, 10
[63] Yap, 12

again. Such a technique fails when trying to engage with historical content because of the lack of a real life do over. This is not to say the technique is not entirely without merit – in perhaps one of the best integrations of this mechanic and the historical record in a video game, *Assassin's Creed* tells the player they have "desynchronized" from history when they have failed to obey the constraints for success. Taken to a sufficient rigorousness, this could easily be adapted into a historiographic game. Such a technique is adequate for certain situations (the player is only dealing with a single character or perhaps the player is exploring space within the game environment and reaches an area before their character is supposed to according to the historical record), but in other situations a different approach is required.

Consider a theoretical game that showcases the history of European exploration in western Canada. Should the player have a "game over" simply because they explored a particular branch of a river in favour of another? Imposing such a constraint would not only frustrate the player by reducing their lack of choice, but it would also run against the spirit of exploration that the game would be trying to convey. A better design choice might be to create incentives for the player to follow a specific route, or (if absolutely necessary to restrict the player's choice) create a storm to blow the player off course. Such decisions not only reinforce the historical record, but also help to convey some of the harsh realities faced by explorers of the day.

Because the game system is itself a model, the validity of the model can be maintained through the use of the MDA framework and a constant cycle of iteration that consistently views the game through the historical lens. This means constant evaluation of the aesthetic, dynamic, mechanic amalgamation with an eye towards maintaining the rigidity of a historiographical document. Each design decision must be weighed and evaluated not only to ensure it does not conflict with the historical record, but also that it does not invalidate another part of the model or create tension between the game's content.

Aesthetics viewed through the eyes of a historian would be used to discuss the specific pillars and ideas of a historical event that they are trying to convey through the game. Designers need to ask themselves questions in order to know the aesthetics they are trying to produce: What about the event makes it worthy of study? Is it an exemplar of a particular period? What makes it that way? How were the people within the event experiencing and how can they convey that through interactivity? Because the game is asserting an historiographical position, what argument is it trying to make? How can they illustrate different viewpoints on the event? The exploration game from the point of the explorers could have aesthetics like discovery,

fellowship, and competition. The same exploration game from the point of aboriginal peoples could have aesthetics like: invasion, challenge, and community.

A historian can use dynamics as mechanisms to convey the experience that they are trying to showcase through the game. They form the basis of the model being used to showcase the historical event being portrayed. A game where the European explorers have dynamics like spatial movement, treasure, and time pressure compared to indigenous peoples who have dynamics like co-operative play, resource management, and territory makes an argument about the past. That argument itself can be viewed as a critical contribution to the historiography about the exploration and colonization of foreign lands by the Europeans.

Mechanics act as constraints that the historian uses in order to produce an experience that maintains historical accuracy within the game system. When implemented, they create the actions and the interactions with the game system that can be considered faithful to the historical record. As a developer continues to iterate upon the mechanics of the game throughout the development process with the purpose of maintaining consistency of the historical record they can ensure that they produce a game system does not contradict the historical record. By also ensuring that they reduce the tension between the game's system and its content a developer can also guarantee that the final product does not contradict itself and the historical event it is presenting.

Chapter 3: Design

Operation Deadstick is a game in the first person shooter genre. This means that the game features a camera from the first person perspective or that the player sees from their character's perspective. It also places an emphasis on actions that can be accomplished by an individual, rather than actions by a group, or more abstract actions that exist only in the context of the game. Actions such as running, jumping, looking, shooting, and the operation of machines and devices are completed. This is opposed to something like a strategy game, where the player thinks in high level abstract concepts such as group movement and coordination, economic and resource management, as well as a heavy emphasis on the analysis and prediction of opposing actions. This makes *Operation Deadstick* more similar to games like *Battlefield 1942*[64], *Half-Life*[65], or *Call of Duty*[66] than to games like *Company of Heroes*[67], *Starcraft*[68], or *Civilization*[69].

The game takes place during the opening of Operation Deadstick on 6 June 1944. This is the roughly fifteen minute period between when the first glider crash lands at LZ X and when Major Howard sent the “bridges captured” code phrase, “Ham and Jam.” The game focuses on the area of the canal bridge and not the river bridge. The reasons for both the timeframe and the area of gameplay are discussed in more detail below.

The objective of *Operation Deadstick* was to create a game that can be considered by historians to be an accurate representation of the events that took place in fourteen minutes at the Caen canal between 0016 and 0030 hours on 6 June 1944. It will inform players about the events of Operation Deadstick as well as try to convey an historical interpretation and perspective of the larger events of the Normandy landings of Operation Overlord. Academically, I hope that *Operation Deadstick* can be a starting point to show that interactivity is not in opposition to the historical record and that interactive objects can present a historiographical argument that showcases a well-thought out and accurate portrayal and perspective of historical events.

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[64] Digital Illusions CE
[65] Valve L.L.C.
[66] Infinity Ward
[67] Relic Entertainment
[68] Blizzard Entertainment, 1998
[69] MPS Labs

Tools

When making *Operation Deadstick*, I chose to use modern game design tools. This was an effort on my part to both minimize work required to create the game, but also to ensure that a modern gameplay experience would be conveyed to players. A side effect of this decision was that gameplay would be familiar and instantly recognizable to established players. One of the key decisions that I needed to make before starting the game's development is was which game engine to use during production. This is an important decision because the selection of a game engine not only reduces the technical overhead in the creation of the game, but it can also influence the design decisions made based on the affordances provided by the engine.

A modern game engine provides backend technical support such as a graphics rendering engine, a physics engine, networking support, audio engine, as well as integration with other third party programs such as three dimensional modeling and two dimensional texturing programs (such as 3DS Max by Autodesk, Inc. and Photoshop by Adobe Systems Incorporated), and more. Modern engines usually also include basic tooling support to aid the developer in the creation of their game. These tools include (but are not limited to) level editors to allow the developers to create environments for players directly inside the engine itself without having to move between the engine and a third party application; scripting languages and interfaces for developers to code complex experiences without worrying about adversely affecting the underlying architecture; and editing tools to make limited edits to textures, 3D models, audio clips, and visual effects.

When I started *Operation Deadstick*, there were a handful of competing engines that could have worked for my purposes. *Unity3D* (since renamed to *Unity*) is a 3D and 2D game engine created by Unity Technologies that emphasizes ease of use, third party support, and multi-platform compatibility. At the time this project was started, *Unity* was rapidly increasing its market share, but had few high profile titles under its belt. Today, *Unity* has been involved in the creation of multiple high profile games including *Hearthstone: Heroes of Warcraft*[70], *Cities: Skylines*[71], and *Kerbal Space Program*[72]. *Unreal Engine* is a 3D and 2D game engine made by Epic Games that emphasizes graphical fidelity and performance. Originally created for Epic*'s* own *Unreal* series, the *Unreal Engine* has been involved in some of the most well known and

[70] Blizzard Entertainment, 2014
[71] Colossal Order
[72] Squad

popular games of the past two decades including *Mass Effect*[73], *Red Orchestra 2: Heroes of Stalingrad*[74], and *America's Army*[75]. The *Source* Engine created by Valve Corporation is a 3D game engine that has been used to make games such as *Half-Life 2*[76], *Portal*[77], and *Day of Defeat: Source*[78].

In the end, I selected the *Unreal Engine* in the form of the *Unreal Development Kit* (also known as *UDK*) to create *Operation Deadstick*. *UDK* is a stripped down version of the full Unreal Engine that removes some capabilities, but is designed to allow a basic platform for entry level game developers as well as academics to develop software. The engine has an established track record for creating First Person Shooter games, and allowed me to take advantage of large amounts of an existing and modern code base in order to set up the game. By using *UDK* I immediately received a robust and extensible method for the implementation of advanced first person shooter mechanics. I created a movable and interactive player quickly with little setup.

The robust input control system allowed me to easily create a customizable control scheme. The design for my Graphical User Interface (or GUI) was meant to be lightweight and minimalist; the flexibility that the *Unreal* Engine GUI system gave me in comparison with *Unity* was very appealing. The lighting system was an attraction because of its high graphical fidelity in addition to being performant.

The ease to make realistic outdoor 3D maps was also attractive, with the ability to both create a map of terrain from a heightmap, but also the ability to create realistic environments from scratch using geometric shapes and pre-made 3D models. Another factor in my decision to use the *Unreal Engine* was its ability to easily integrate external 3D models. This was the key factor in the selection of *UDK* over the *Source* engine, as *Source*'s *Hammer Editor* for level design was not as user friendly as *UDK*'s level editor.

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[73] Bioware
[74] Tripwire Interactive
[75] United States Army
[76] Valve Corporation, 2004
[77] Valve Corporation, 2007
[78] Valve Corporation, 2005

The Game

I chose to make the game as a first person shooter for a number of reasons. First, I wanted the player to focus on the individual experiences of the soldiers involved in the operation. Most of the account taken of the raid itself was given by individuals sharing their experience of the events.[79] Logically, it seemed to be the correct direction for the game if it emphasized the actions and personal narrative of the player, since they were based on the actions and stories of those involved. This does not mean that I would place the focus solely on individuals and not the collective action of the group, as I will address later on.

Second, the most common type of game that focuses on the Second World War focuses on individual actions, and many of them are also first person shooters. When asked about games that focus on World War II, it is easy and natural to conjure images of *Call of Duty, Battlefield 1942,* and *Medal of Honor*[80]. It thus also seemed logical that *Operation Deadstick* should also be a first person shooter since it would inevitably be compared to these other games that focused on the same historical period and events. This is not to say that all games about the Second World War are first person shooters, and it would be foolish to think so. A game like *Company of Heroes* is a squad based strategy game which focuses on more abstract actions than the individual ones that can be seen in first person perspective or more individualistic games.

Third, and most pragmatically, using a first person shooting format allowed me to take advantage of a large amount of pre-existing infrastructure for the creation of one of these games. The Unreal Engine itself was created specifically for the development of first person shooters and gave me affordances for the creation of a first person shooter out of the box. It set up a gameplay framework involving objectives, characters, and objects without the need for me to find a solution to a solved problem. This approach not only reduced the workload required to create the game, but also allowed me to start confronting important design problems from the beginning of development.

[79] Ambrose, preface, xiii
[80] DreamWorks Interactive

Gameplay Framework

My original plan for development was to have gameplay cover the period of time from 0000 hours to just before 0200 hours on 6 June, 1944. This was to incorporate the mood and action of the gliders, the chaos of the crash landing, the capture of the bridges, establishment of defenses at the bridges, the capture of a German Major who tried to assault the bridge, and the destruction of a tank coming to assault the bridge and the subsequent retreat of the rest of the tanks and reinforcement infantry coming to the canal bridge. Originally, the area for the game was going to cover both bridges and up the road from the bridge to the T-Intersection to the west of the canal bridge.

The focus of gameplay was narrowed over development to focus on the timeframe of 0016 hours and 0030 hours at the canal bridge. This was done to allow me to be able to pursue development without a team of developers assisting me. I selected the timeframe because it begins with the first glider crash landing, which provided an natural start to the operation and ends with the signal being sent by Major Howard that both bridges had been captured intact. The location of the canal bridge was determined because it is the primary source of action during the operation, given the river bridge was unmanned and captured with minimal activity.[81] This provides players with numerous events to explore and keep them engaged. The player can play exclusively as the British Commandos.

At 0016 hours, glider one, carrying Major Howard crash lands into the ground. The precise time of the crash is known because both Howard's and one of the private's watches stopped at the exact same time.[82] At the moment of the crash, the soldiers inside were momentarily knocked unconscious. Meanwhile, on the canal bridge, a German infantryman, Private Romer was patrolling the west side of the bridge and turning around to head back east. At that moment, Corporal Bailey and two others set off to clear a pillbox next to the bridge while Lieutenant Brotheridge and the rest of his squad set off for the canal bridge.[83]

At 0017 hours, glider two touches down. The pilot, determining the glider was moving too fast and about to run into the back of the first glider, swerved and in the process broke the glider in two. Lieutenant Wood, who was thrown from the glider, rallies his platoon around him

[81] Ambrose, 81
[82] Ambrose, Preface, xiv
[83] Ambrose, 72-73

and meets Major Howard at the perimeter of the barbed wire who was taking cover after being shot at from the trenches. Howard orders Wood and his men to clear the trenches beyond the pillbox on the northeast side of the canal.[84]

Meanwhile on the bridge, Private Romer had passed his fellow sentry halfway across the bridge when he saw Brotheridge and his platoon running towards him. Romer, who was sixteen and frightened, turned away from the commandos and ran towards his comrade shouting, "Paratroopers!" The other sentry brought out a flare pistol and fired it into the air. Brotheridge brought out his Sten and emptied a clip at the sentry who fell down dead. At the same time, Bailey and the two others with him throw grenades into the pillbox. Checking inside after the smoke clears, they find no one left alive inside and run to join the rest of their platoon on the bridge.[85] As the grenade goes off, Brotheridge throws his own grenade at one of the machine gun pits before being hit in the neck with a bullet. Private Gray passes him as he falls over and shoots with his Bren gun, along with others crossing the bridge, and clear out a second machine gun pit as Brotheridge's grenade takes out its target.[86]

Glider three touched down in the landing zone at 0018. Dr. John Vaughn as well as Lieutenant Sandy Smith were thrown through the cockpit of the glider. Lt. Smith recovered, while Dr. Vaughn was knocked unconscious for approximately thirty minutes. Several of Smith's platoon were still in the glider when Smith, with a wretched knee, made for the bridge with the soldiers that had rallied around him.[87] Tragically, Lance Corporal Greenhalgh landed face down in a nearby pond semi-concussed and drown.[88]

At this time German Sergeant Heinrich Hickman approached the bridge with four privates. Seeing the British commandos, he started firing his weapon at Gray, who returned fire. They both shot an entire clip of ammunition at each other without a single hit on their intended target. Private Gray took cover in a barn on his right as Sergeant Hickman fired another clip at the approaching troops on the bridge, before running out of ammunition and retreating with the privates who were with him.[89] As Hickman turns to leave, Lt. Smith arrives at the west side of

[84] Ambrose, 75
[85] Ambrose, 76
[86] Ambrose, 77
[87] Ambrose, 76
[88] Fowler, 39
[89] Ambrose, 78-79

the bridge and fired his Sten at a German defender hopping over the wall in front of the café. The man slumped over the wall, but the grenade he was holding went off, tearing the flesh from Smith's wrist. At this point, the owner of the café Gondrée, Georges Gondrée looked out the window. Smith, undoubtedly in shock, mistook him for a German soldier and fired at the window. His aim was high and Gondrée woke his family and took them into the basement.[90]

By 0021 D Company had mostly cleared the machine gun nests and the trenches. It was at this point that the men began to clear the bunkers using phosphorous grenades and high explosive grenades along with their Sten and Bren guns. By this point combat had started to take its toll on the British troops. Some soldiers lost their composure and were unable to continue; reportedly, some sat down, prayed, and refused to get up.[91]

Between 0022 and 0026 Major Howard set up his command in a trench at the north east corner of the bridge. Runners kept Howard informed of the situation — Brotheridge was dead and there were multiple injuries reported. The engineers informed Howard that there were no explosive charges planted under the bridge; it had been rigged for detonation, but the explosives hadn't been loaded. In order to be safe, the sappers had removed the firing mechanisms. It soon dawned on Howard that he had captured the canal bridge and as he was coming to this realization he also received word that the river bridge had been captured intact.[92] D Company had achieved their objective to capture the bridges, but Operation Deadstick wasn't over. Now they had to hold the bridges and wait for reinforcements to arrive.

Gameplay Objectives

The objectives that the player has to complete in order to complete the game were determined based on the mission objectives given to Major Howard's company and his instructions to his officers as well as key events identified during historical research. In order to win the game, the player must:

1. Clear the pillbox to the north of the road on the east side of the canal bridge.
2. Capture the Bridge.
3. Remove the explosives from underneath the bridge.

[90] Ambrose, 79
[91] Ambrose, 83-84
[92] Ambrose, 85-86

4. Fight off Sgt. Hickman and his privates returning from town on the west side of the bridge.
5. Clear the trenches and bunkers on both sides of the bridge of enemy forces.
6. Clear the machine gun nests on both sides of the bridge.

The “win condition” of the game is when all of the objectives are completed. When an objective is completed, a boolean variable, one that can be either true or false, but nothing else, that keeps track of whether or not the task has been completed is marked as true. After this is done, all of the variables are checked to see whether or not an objective completion is still marked as false. If all variables are true, that is to say, if all objectives has been completed, Major Howard will send the “Ham and Jam” signal and the game will end. It is intentional that the objectives were left to be completed in an order at the player’s discretion. There is clearly a defined order that was done according to historical records, but in an effort to build the player’s motivation and engage the user, the option to complete the tasks was left up to them.

There is no “failure state” in the game. The player is free to idle or interact with the game as they wish. If the player idles in the game, the game waits for the player to continue. If they run “out of bounds” their perspective is switched to a character that is controllable in bounds. The only way that the player can “fail” the scenario is if they manually exit the program before the simulation ends. I did not expend effort into making a way for the player to exit the game, so the only way to accomplish this goal is either to finish the scenario, or use the operating system to exit the program. This was not done as a concerted design decision on my part, but was decision to allocate resources to the development of areas that were more inherently valuable to the development of the game.

Scale

One aspect of game development that I needed to determine immediately was the scale that the game used during its development. This scale will be applied to everything from objects and characters, to the map and environment that the player will interact with. In the end, I abided by the UDK advisory that one Unreal Unit (or UU) should be equal to two centimetres. A UU is a unit of measurement within the game engine to measure virtual space inside the game’s environment. This was the scale used by Epic Games during the production of their game

Gears of War.[93] I suspect that this unit of measurement was chosen because it is roughly equivalent to one inch, since Epic Games is American, and the units used for Unreal Tournament 3 was one UU is equal to one inch.

To illustrate the importance of the scale, during production I was setting up the position of the player's weapon on the screen according to industry and genre conventions. Traditionally in the first person shooter genre, the game assumes the player is right handed and shows the weapon in the bottom left corner of the screen.

During my setup of weapon placement for the player's character, I made the player's weapon 200 UU long, with an offset of 200 UU to the left, 250 UU to the ground, and 400 UU in front of the player. While the position of the weapon looked accurate according to the player's perspective, in reality the weapon was four metres long and eight metres in front of the player's position. This became evident when the player's character dropped the weapon on being removed from play, and a weapon larger than the character itself was dropped onto the ground several metres in front of the player's last position. I rectified the size of the virtual weapon to be comparable to its real life counterpart, such as the Sten gun, which had a virtual size of 33.1 UU, that corresponded to its real life size of 76.2 cm long.[94] I also set the offset position of 5 UU to the left, 5 UU down, and 1 UU towards the camera. Although it is not customary to hold a firearm in this location, I positioned the weapon at this point to maintain consistency with other first person shooter games and I do not believe that it disrupts the accuracy of the user interface. When people hold a rifle or another type of gun, they have a sense of its orientation and if they pulled the trigger where it would fire. This is harder to achieve in a medium where tactile sensation is not possible and the user does not have a sense of proprioception. Therefore some spatial distortion is required in order to visually convey the same information a person would have outside of a virtual world within the game itself.

Game Map

The creation of the game map underwent significant changes over the course of production. Given the real life and outdoor nature of the area of operation for Operation Deadstick, my first instinct was to use satellite mapping data of the area in order to generate a heightmap of the area that could be imported into UDK. One of the key reasons that I originally decided on this

[93] Epic Games
[94] Hogg, 89

course of action was to simplify the action of making the environment. If I can import most of the map through automated means, I can focus most of my efforts on cleaning it up and adding structures to the environment.

A heightmap is a monochromatic image that describes the elevation of terrain by the colours of pixels in the image. Typically, the image is in grayscale, that is, that the colours used in the image are shades of gray between pure black and pure white. Typically, heightmaps are arranged such that lighter colours indicate higher points of altitude in the terrain, whereas darker colours indicate lower points in the terrain. Heightmaps used for games are typically squares with sizes corresponding to the powers of two (eg. 256 pixels wide and 256 pixels high) to correspond to texturing requirements within the game engine.

Figure 3.1: A heightmap

To this end, I received educational access to the Institut Géographique National (IGN) satellite mapping data. The IGN is a French public administrative organization under the Ministry of Sustainable Development. Its primary aim is to gather information about the surface of French territory from a geographic standpoint.[95] As part of this, they gather satellite data about the terrain of France. Ultimately, the data that was made available to me was unusable. The best resolution of the data was twenty five metres, or put another way, there was a datapoint for every twenty five metres of geography. This resolution is adequate for a general picture of the geography of the French countryside, but not when creating a digital application that needs information down to a resolution of two centimetres. It may have been eventually possible to get

[95] http://www.ignfi.fr/en/content/ign-summary, retrieved 2 June 2016

access to data with a resolution of one metre, but this is still far off from the scale that the game requires. For this approach to work adequately, data with a much higher resolution would have to become more publicly accessible for it to be valid. In the end I decided to recreate the area using a more traditional level development approach using a combination of modern maps, maps and aerial photographs of the area contemporary to the event, and information found through traditional historical research. This allowed me to create a comprehensive model of the area that I was then able to recreate in the game.

The game centered on the Caen Canal bridge. I modelled roughly one square kilometre of terrain surrounding the canal bridge. Key features of the area that were modelled include the canal, the surface of the bridge, and the roadway. The ultimate goal was to model not only the surrounding terrain, but also the pillbox, bunkers, cafe, and barn, however challenges that appeared in production given the timescale of work available made this difficult. When creating the base map that would be used as the modelling reference, an emphasis was placed on scale and positioning of structures and objects in order to accurately reproduce the area.

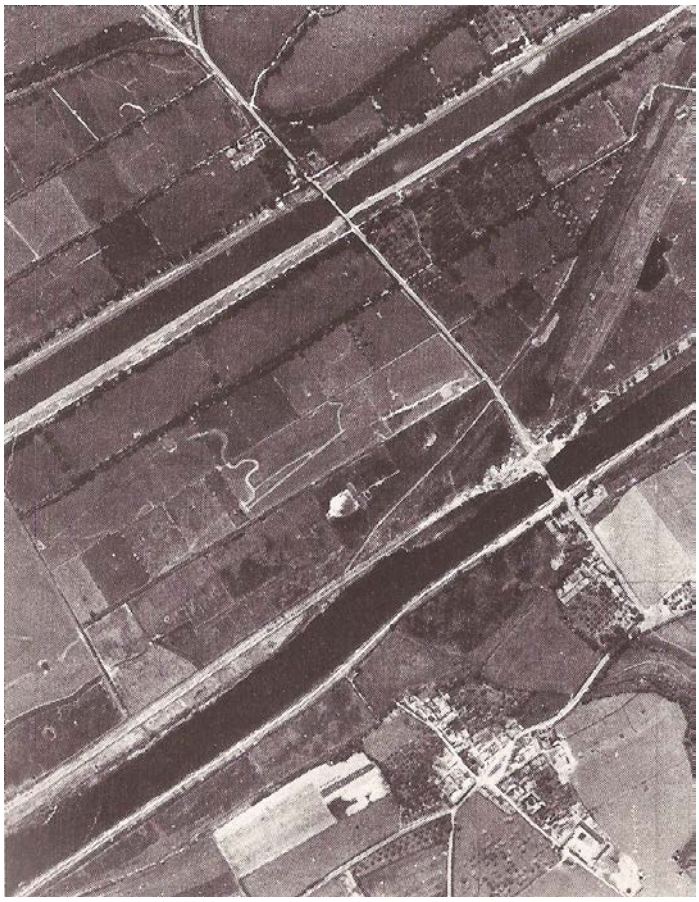

Figure 3.2: Aerial reconnaissance photograph of the Caen Canal bridge

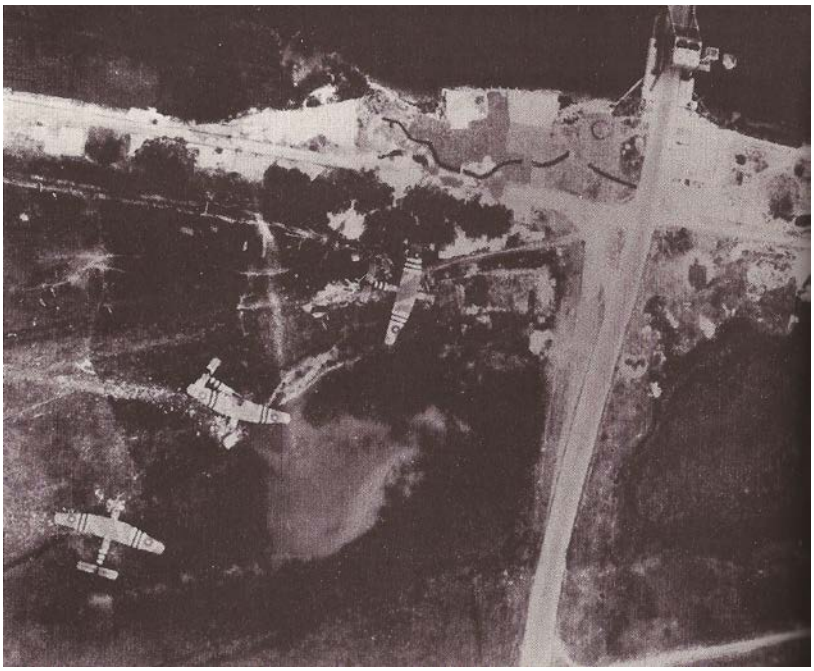

Figure 3.3: Aerial reconnaissance photograph of the positions of the crashed gliders

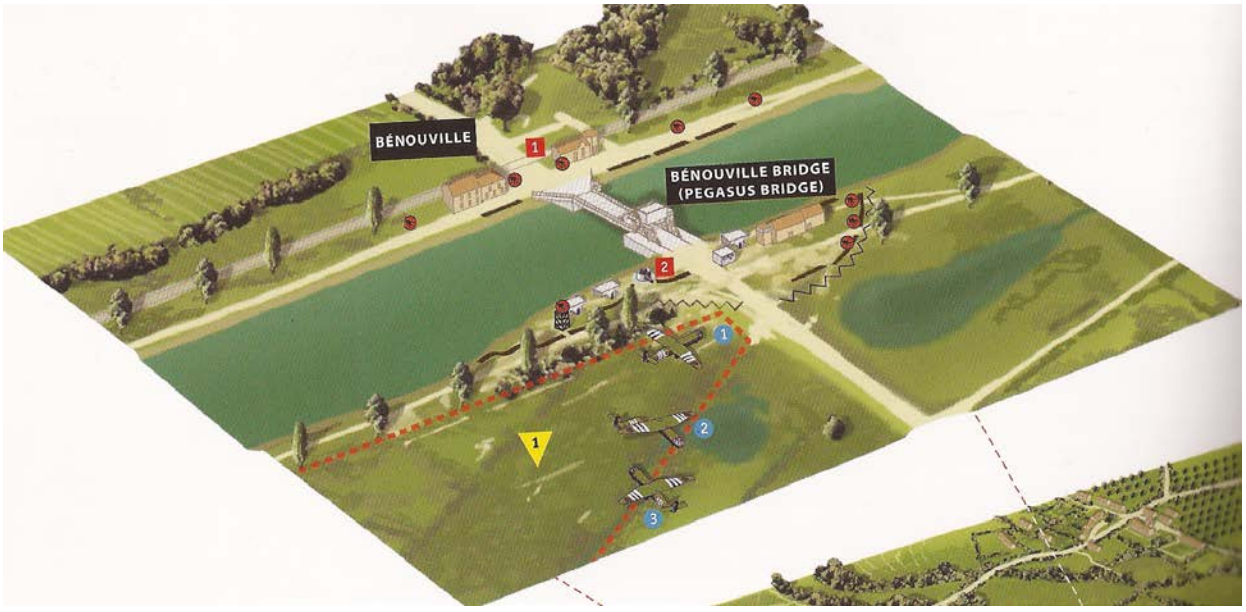

Figure 3.4: Modern day reconstruction of the area surrounding the Caen Canal bridge

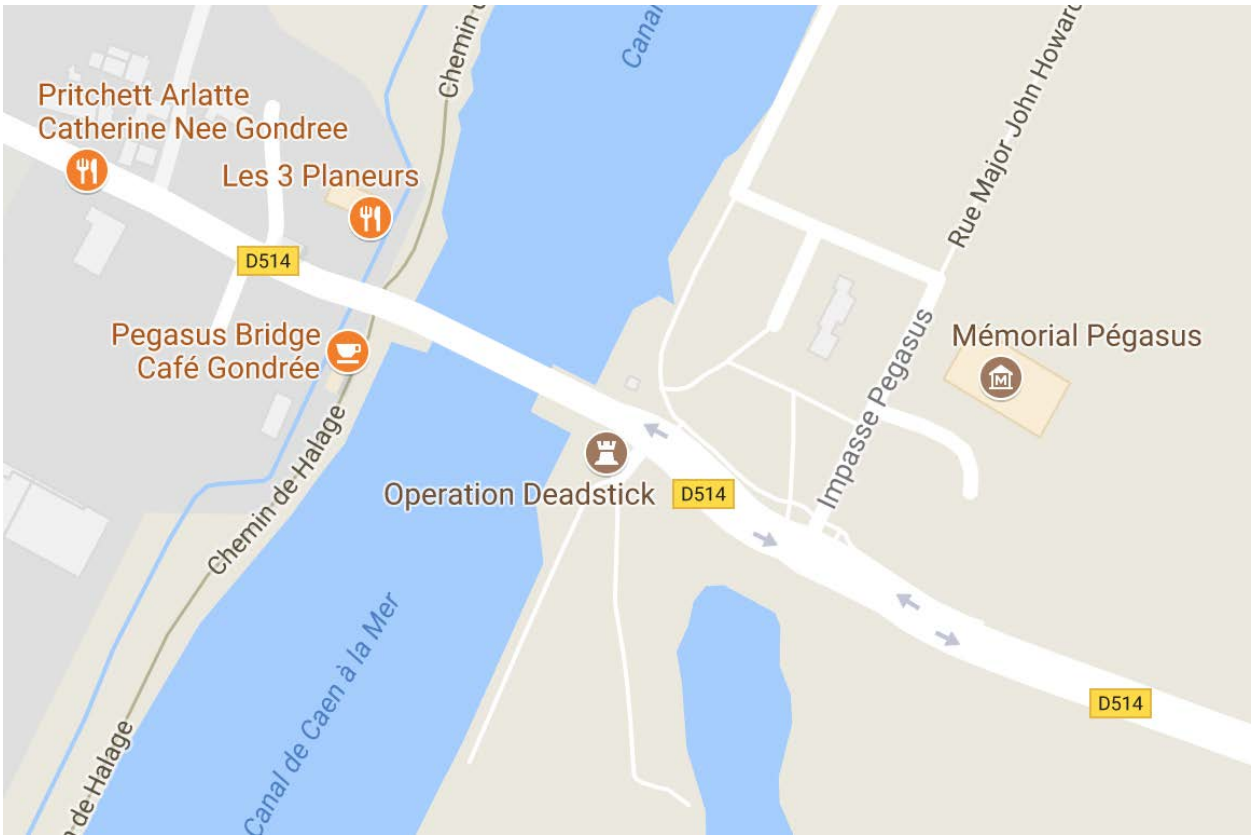

Figure 3.5: Modern day digital map of the Caen Canal bridge

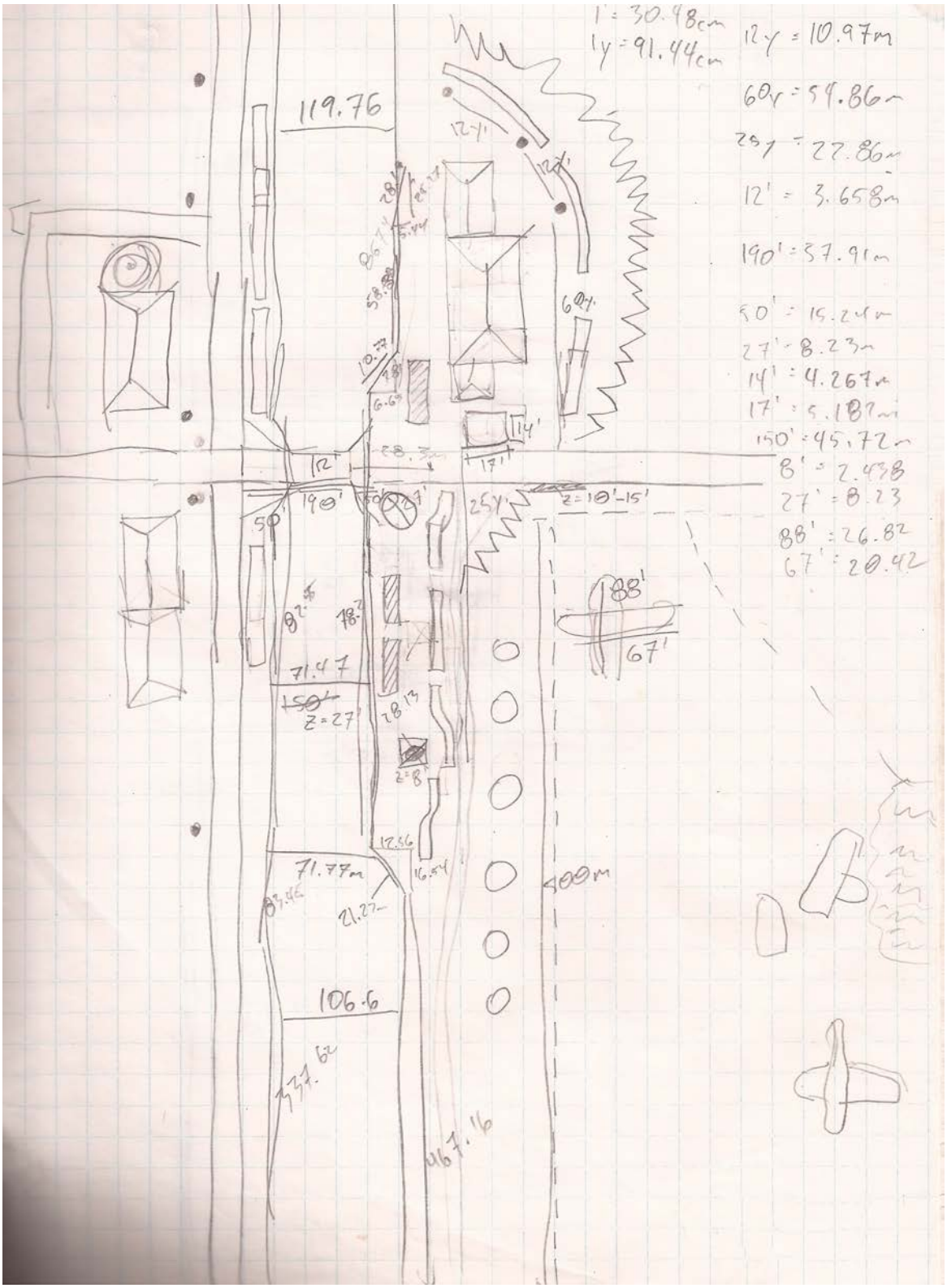

Figure 3.6: Reference map created for environment modeling for *Operation Deadstick*
Map not to scale

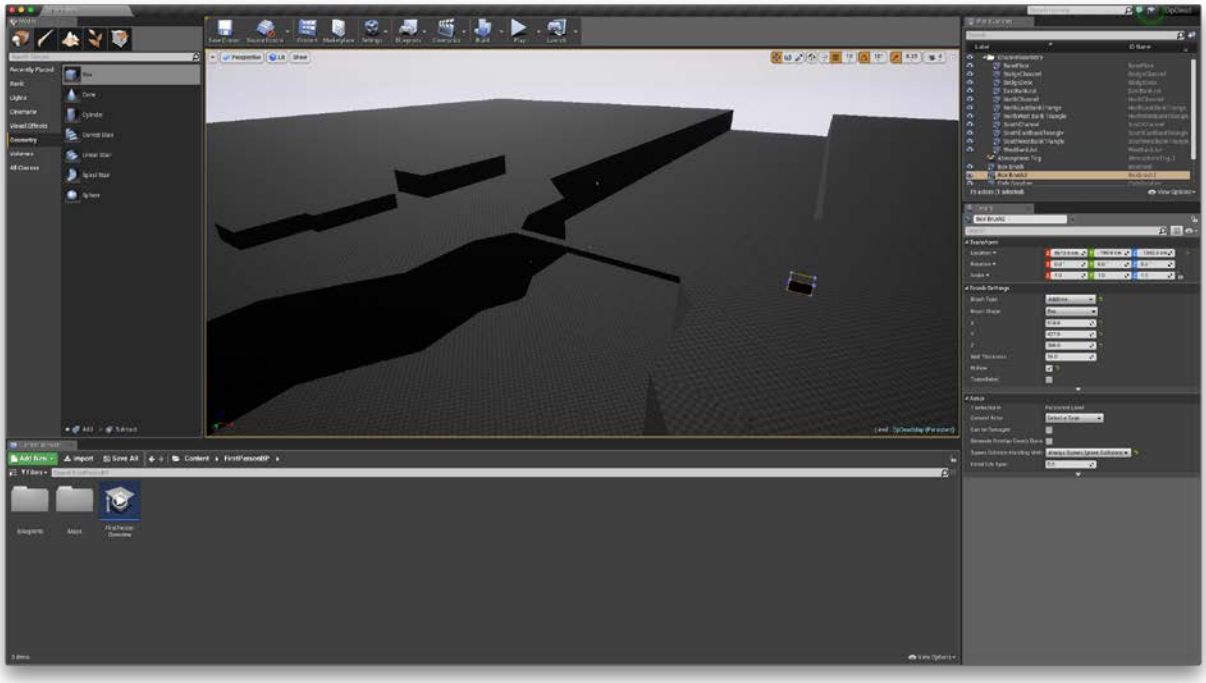

Figure 3.7: Modeling the Caen Canal in *Operation Deadstick*

Ultimately, my knowledge of the toolset, or more precisely my lack of knowledge, proved to be the largest challenge to creating the model of the environment. Gathering the materials for the creation of map proved to be a relatively straightforward task. Given the abundant source materials available on the Second World War, as well as the ease of use of modern digital mapping applications, data collection was time-consuming, but not difficult.

I did not have sufficient knowledge of the process that UDK uses in its level creation workflow. Unreal uses geometric shapes, such as cubes, spheres, and cones, in the process of level creation. These shapes are used to create individual three dimensional meshes in Unreal. In other engines, these shapes are treated individual meshes that can be combined to create complex shapes. In the Unreal Development Kit, these shapes are used through additive and subtractive volume generation to create a single three dimensional mesh. This means that to create a cube, you use a cube “brush” to create the size of cube you wish to create and then add the volume to the level. If this intersects with another mesh, it can be joined together to create a single mesh. Similarly, if you wish to remove volume from a mesh in order to create an open space, such as a door or a stairwell, you modify the size of the geometric “brush” and subtract the volume from the existing mesh. This alters the mesh and creates a single unified shape in the level. This method is quite similar to traditional three dimensional modelling

programs, so it can be used to generate a level in a similar fashion for those who have experience with these programs.

This was different than the workflow I was accustomed to, so it took some time to get up to speed. Ultimately I decided upon using flat two dimensional planes to build the mesh for the map. This was a similar process to map creation in Unity, where I had experience, whereby you insert and manipulate pre-existing geometric shapes (called “prefabs”) instead of using volumetric brushes to build the map. In addition to being a workflow that I was more familiar with, this made it easy to layout large areas very quickly in a way in a way that accounted for height, without requiring additional manipulation. These two dimensional planes have co-ordinates in three dimensional space (that is they are comprised of four vertices that are placed on the three dimensional grid), but do not have any height.

Like most virtual three-dimensional objects, the map was constructed out of polygons. A polygon consists of a set of vertices whose positions are tracked through three dimensional space when the vertices are “coplanar;” that is to say, there exists a plane in three dimensional space that connects all the vertices. Each vertex is connected to other vertices through an “edge.” Each vertex in a single polygon is connected to two other vertices. This creates an enclosed triangle. The enclosed area of the triangle is called a “face.” When two of these triangles are conjoined on the hypotenuse, the result is a quadrilateral face. UDK only supports triangular and quadrilateral polygons, so three dimensional models that attempt to have a polygon that consists of more than three or four vertices will be broken down into its constituent triangles. When a set of polygons is used to generate a three dimensional model, the underlying arrangement of its polygons is called a three dimensional mesh.

In order to optimize the performance of the game, the faces of most polygons are only rendered, or displayed, on the side facing the camera. This is done through a process of geometric “normals.” A normal is the orientation of a surface towards a light source in order to determine its shading. Normals can be double sided, but they are commonly single sided, since it reduces the amount of work the computer is required to do to present the three-dimensional model to the player. If the normal for a polygon is not being rendered on the side that the game’s camera is facing, the camera will not see the face for that particular polygon, effectively rendering that polygon invisible to the eyes of the player.

Because Unreal is used to model both indoor and outdoor environments in the same scene, or both sides of the same wall, it gives the developer the ability to choose the side of the polygon that will display the normal. The developer can either choose to display the normal on the outside of the model, the inside of the model, or both. This gives the developer a startlingly large amount of control over the map, but with the computational burden of added complexity. One challenge in generating the three dimensional mesh for the environment is unknowingly choosing to display the normal on the wrong side of the mesh. This problem is called “reversing” the normal, and was one of my biggest obstacles in the creation of the map. It required careful attention to detail during the development of the environment mesh, and I frequently had to go back and fix reversed normals.

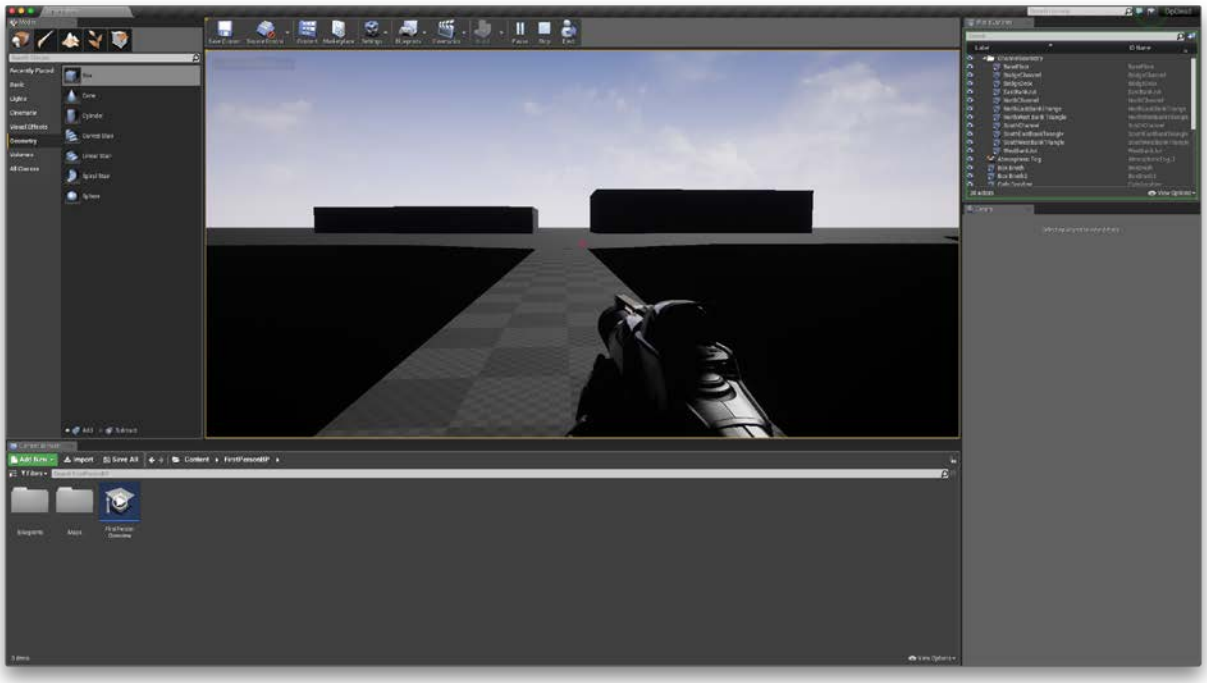

Figure 3.8: Standing on the canal bridge facing the Café Gondree and barn

However, the largest challenge in creating the map was due to a technical quirk of the engine that was not discovered until the map had been completed. My decision to use two dimensional planes in three dimensional space was an effort by myself to create a workflow that was similar to what I was used to in the Unity game engine. However, while these two dimensional planes were expedient for me, there is a fundamental difference between two dimensional planes in UDK and Unity. In Unity, collision geometry, that is to say, invisible geometric objects that interact with the physics system, are included by default on these planes; in UDK, planes are

incapable of having collision geometry. This means that characters can not only walk through walls on my map, but it also means that as soon as they step off the model of the Caen canal bridge, they fall through the ground, because there is no physical object on top of the mesh to stop characters from falling into a bottomless abyss. As might be imagined, this was a problem. It had the added burden of not being historically accurate.

Game Mechanics

As I brought forth in my discussion about the theory of designing historically accurate video games, a developer such as myself walks a fine line when dealing with the historical and the interactive content of a game like *Operation Deadstick*. This is because each choice that is made in the production of the game is both a game design decision, but also a historiographical one. When implementing *Operation Deadstick*'s game mechanics, I had to consider not just the impact that this would have on the player and how they thought about the game, but also the consequences my decisions would have on the player's interpretation of the historical content present in the game. The game's systems, and the underlying mechanics and algorithms that define those systems, are metaphors not only for the game's model of reality, but also the historiographical argument that I am making.

Movement Mechanics

When considering how character's in *Operation Deadstick* move, I was considering the model for how the soldiers who took part in the operation were able to move. This may seem like a banal topic, but it introduces interesting decisions that need to be made: when the player initiates movement does a single character move in response, or does a group of soldiers move? Does the player indicate a position or a direction for movement, and the characters move on their own, or is the player responsible for all character movement directly. This also gets into slightly more abstract issues when considering virtual mediums and modeling movement behaviour on the real world — for example, its possible to allow characters to fly in a video game, but a British commando would certainly not have the ability to fly without the assistance of a machine.

Movement controls in *Operation Deadstick* are based on a standard first person shooter control scheme. This was included out of the box with UDK, and I saw no need to change it. Movement of the player's character is bound to the "w," "a," "s," and "d" keys. The player can move

forwards or backwards by using the “w” and “s” keys, respectively. In order to move to the left or right, called “strafing,” the player uses the “a” and “d” keys, respectively. In order for the player to observe their surroundings and change where their character is looking, “mouse-looking” is used.

This is a system whereby movement of the camera is governed by the movement of the move. If the player moves their mouse to the left or right, the camera pans in the respective direction. If the player moves their mouse up, the character looks up; if the player moves their mouse down, the character moves down. This is not an “inverted” look scheme which can be commonly found where the player would move their mouse down for the character to look up, and their mouse up to pan their character’s view down. The inverted control scheme was made popular by flight-simulators as moving a joystick down or up pitches a plane’s nose up or down. This is largely included as a “legacy” feature for players who prefer it, but was not implemented because of time constraints.

Weapon Mechanics

Overview

Because the game is a part of the first-person shooter genre, there is an emphasis that must be placed on the mechanics of the firearms in the game. To that end, I tried to reuse as much code from the mechanics of the Unreal engine as possible. Given Unreal’s position in the industry as a leading game engine, and the critical and commercial success of many of Epic Games’ first person shooters (including the renowned Unreal Tournament), the reuse of existing code gives players familiar with the genre a familiar and consistent play experience. I did this through a computing concept known as polymorphism, whereby existing code can be expanded and changed as needed in object-oriented programming.

The weapons I am modeling in the game are based on the weapons that were used in the raid itself. The British troops were primarily carrying Lee-Enfield No. 4 Mk. I rifles, however they were also carrying the Sten Mk. V submachine gun, and the Bren Mk. IV Light Machine Gun.[96] The Lee-Enfield Rifle was a reliable designed bolt-action rifle that had existed in some form or another since the late 1800s. The number four rifle used .303 calibre bullets, was 1132

[96] Ambrose, 25

millimetres long, weighed 3.71 kilograms, and had a ten round box magazine.[97] The Sten Mk. V was a nine millimetre calibre submachine gun that could be fired single shot or in full automatic, but was prone to both jamming and spontaneous discharge.[98] It was 762 millimetres long, weighed 3.45 kilograms, had a thirty two round box magazine, and a firing rate of five hundred seventy rounds per minute.[99] The Bren Light Machine Gun was 1150 millimetres long, weighed 10.15 kilograms, had a thirty round cylindrical magazine, and had a firing rate of five hundred rounds per minute.[100]

My first order of business to accomplish this task was to create a new base weapon class that extends the existing `UTWeapon` class, that I called `ThesisWeapon`. Within the `ThesisWeapon` class, I established the core tenants of the weapons in the game. This class was then expanded into subclasses for each weapon featured in the game: `ThesisWeap_LeeEnfieldNoIVMkI`, `ThesisWeap_StenMkV`, and `ThesisWeap_BrenMkIV`. These subclasses for the Lee Enfield, Sten gun, and Bren gun do not contain any overwriting of code themselves, but merely exist as a data container to tell the rest of the game code the properties of the weapon themselves. For example, the contents of the `ThesisWeap_StenMkV` class, with the contents omitted, is:

[97] Hogg, 131-133
[98] Ambrose, 25
[99] Hogg, 89
[100] Hogg, 229

```
class ThesisWeap_StenMkV extends ThesisWeapon;

const STARTING_CLIPS = 4;
const AMMO_MAX = 32;
const RELOAD_TIME = 1.5;
const WEAPON_SPREAD = 0.013922;
const FIRE_INTERVAL = 0.1;

DefaultProperties
{
	WeaponColor=(R=255,G=255,B=255,A=255)
	FireInterval(0)=+0.1
	PlayerViewOffset=(X=5.0,Y=5.0,Z=-1.0)
	Spread(0) = WEAPON_SPREAD
	Begin Object class=AnimNodeSequence Name=MeshSequenceA
		bCauseActorAnimEnd=true
	End Object
	Begin Object Name=FirstPersonMesh
		SkeletalMesh=SkeletalMesh'Thesis_Weapons.Meshes.sten_skinned_fbx'
		Scale=0.05
		FOV=60.0
	End Object
	Begin Object Name=PickupMesh
		SkeletalMesh=SkeletalMesh'Thesis_Weapons.Meshes.sten_skinned_fbx'
		Scale=0.05
	End Object
	FireOffset=(X=5.0,Y=5.0,Z=-1.0)
	WeaponFireTypes(0)=EWFT_Projectile
	WeaponProjectiles(0)=class'ThesisProj_StenBullet'
	WeaponEquipSnd=SoundCue'A_Weapon_Link.Cue.A_Weapon_Link_RaiseCue'
	WeaponPutDownSnd=SoundCue'A_Weapon_Link.Cue.A_Weapon_Link_LowerCue'
	WeaponFireSnd(0)=SoundCue'A_Weapon_Link.Cue.A_Weapon_Link_FireCue'
	PickupSound=SoundCue'A_Pickups.Weapons.Cue.A_Pickup_Weapons_Link_Cue'
	MuzzleFlashSocket=MuzzleFlashSocket
	MuzzleFlashPSCTemplate=ParticleSystem'WP_LinkGun.Effects.P_FX_LinkGun_MF_Primar
		y'
	MuzzleFlashLightClass=class'UTGame.UTLinkGunMuzzleFlashLight'
	MuzzleFlashColor=(R=120,G=255,B=120,A=255)
	MuzzleFlashDuration=0.33;
	iClipCount= STARTING_CLIPS
	iDefaultClipAmmoNumber = AMMO_MAX
	iReloadTime = RELOAD_TIME
	bIsReloading=false
	AmmoCount= AMMO_MAX
	MaxAmmoCount= AMMO_MAX
	iFireMode = FULL_AUTO
}
```

This defines metadata about the weapon for the engine and the rest of the game code to properly represent the virtual weapon. This metadata includes the 3D model used to render the weapon when held or dropped, the sound it makes, the visual effects to display when fired, the amount of ammunition per clip, the time it takes to reload the weapon, or its firing mode. How the firing mode works, how the reloading system works, or how the weapon is displayed is not included directly inside the weapon class.

Firing Weapons

To fire the weapon, I adhered to standard first person shooter controls, whereby the action taken by the player to fire the weapon in the virtual world is pressing the left mouse button. This activates the `StartFire` function. The `StartFire` function first checks to make sure that now is a valid time for the player to be firing the weapon. My extension to this code checks to ensure that only the player character fires (as opposed to all characters currently in the game), the player is not currently reloading their weapon, or the user is not currently checking how much ammunition they have remaining in their current clip (which will be discussed in greater detail below). If the game determines that it is an appropriate time for the weapon to be firing, it starts firing the weapon. The weapon is considered to be firing constantly until it stops according to its firing mode, or the player calls the `StopFire` function, which is done by releasing the left mouse button.

When the weapon starts to fire, it decrements the amount of ammunition in the clip and fires the weapon according to its fire mode, whether it is a hitscan weapon, a projectile weapon, or a more customized firing mode. For this game, all weapons fire projectiles instead of using a hitscan system. The projectile fired from a weapon is a virtual object that exists in the game world and has its trajectory simulated, instead of instantaneously drawing an imaginary line from the point of fire, through the environment, and applying effects on any virtual object that intersects with this line. Once the projectile is fired, the game determines if the weapon should refire, as in the case of automatic weapons as opposed to semi-automatic or manual weapons. If the weapon should refire, the game determines when the weapon refires according to its firing interval, and repeats the code path. If the weapon should not refire, or the player decides to Stop Firing, the weapon exits the firing state.

Fire Spread

After the call is made for the projectile to be fired, I take the direction of the players aim and store it in a variable. This vector, that is, where the player is looking from the point they exist in three dimensional space, is then adjusted by the weapons defined spread. The spread is calculated by picking a random number on the vertical and horizontal axis of the unit circle, that is, a circle with a radius of one. The line from the centre of the unit circle to this randomly selected point (its spread radius), is then multiplied by the weapon's spread modifier. This modifier limits the possible spread of the weapon by ensuring that the length of the spread radius is always less than the possible length of the spread. A spread modifier of one will mean the weapon can hit at any point in front of the player, while a spread radius of zero will mean that the weapon will always hit precisely where the player is aiming. After the ammunitions path has the spread applied to it, I calculate the vector from the point of the weapon's muzzle in three dimensional space to the newly calculated adjusted aim point. The projectile then fires along this path travelling at a velocity as determined by the weapon. Below is the code used to calculate the spread of the weapon:

```
simulated function rotator AddSpread(rotator BaseAim)
{
	local vector X, Y, Z;
	local float CurrentSpread, RandY, RandZ;

	CurrentSpread = Spread[CurrentFireMode];
	if (CurrentSpread == 0)
	{
		return BaseAim;
	}
	else
	{
		// Add in any spread.
		GetAxes(BaseAim, X, Y, Z);
		RandY = FRand() - 0.5;
		RandZ = Sqrt(0.5 - Square(RandY)) * (FRand() - 0.5);
		return rotator(X + RandY * CurrentSpread * Y + RandZ *
CurrentSpread * Z);
	}
}
```

As illustrated, if the current weapon has no spread, the `BaseAim` of the player is returned. The spread amount is determined by the different firing modes as defined on the weapon. Random

points are selected on the Y axis for vertical spread, and the Z axis for horizontal spread. The Z axis is chosen, because the player's X axis, or their local rotation along the X plane, is the direction the character is currently facing. By choosing a random point on the Z axis, I am ensuring that the horizontal spread of the weapon is perpendicular to the direction that they are currently facing in three dimensional space.

The spread modifier (ie. the variable `CurrentSpread`) is the ratio of the maximum angle of deviation from the firing vector against the perpendicular axis to the firing vector. In effect, this limits the maximum deviation of the projectile's path. This modifier for each weapon in *Operation Deadstick* is determined by the weapon's effective range, as defined by the manufacturer. For the purposes of the game, I defined the maximum effective range by the modern definition as defined by the NATO: the maximum distance at which a weapon may be expected to be accurate and achieve the desired result.[101] This is interpreted to mean that the weapon will hit a roughly man sized target 50% of the time. I define a man sized target to be an oval target that is two metres high and one metre wide. Following the formula for the area of an ellipse, I determined that the area of this target is 2π:

$$A = (r_w \cdot r_h)\pi$$
$$A = (1 \cdot 2)\,\pi$$
$$A = 2\pi$$

Given an area of 2π it can be assumed that a point selected in an area of twice the size will produce hits on the target 50% of the time. This means that for each weapon I can assume that the maximum effective range of the weapon is where the radius of the spread is two metres as determined by the following:

$$A = \pi \cdot r^2$$
$$4\pi = \pi \cdot r^2$$
$$\frac{4\pi}{\pi} = \frac{\pi \cdot r^2}{\pi}$$
$$4 = r^2$$
$$\sqrt{4} = \sqrt{r^2}$$
$$2 = r$$

[101] NATO Standardization Agency, 2-M-3

I can therefore determine the spread modifier for a weapon by taking the tangent of the angle of a right angle triangle where the length of the adjacent side is the maximum effective range (in metres) and the opposite side of the triangle is two metres.

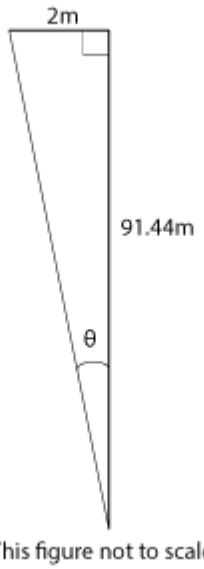

Figure 3.9: Graph of spread angle

$$tan(\theta) = \frac{opposite}{adjacent}$$

$$tan(\theta) = \frac{2}{91.44}$$

$$tan^{-1}(tan(\theta)) = tan^{-1}(\frac{2}{91.44})$$

$$\theta = tan^{-1}(\frac{2}{91.44})$$

$$\theta = 0.02186\,rad$$

$$\theta = 1.253°$$

$$S_{modifier} = \frac{\theta}{90°}$$

$$S_{modifier} = \frac{1.253°}{90°}$$

$$S_{modifier} = 0.013922$$

When the angle θ is discovered, I can determine the spread modifier by taking the angle and dividing it by ninety degrees, giving me the ratio of the angle of spread to a perpendicular axis to the firing plane.

For example, the Sten Mk. V has an effective range of one hundred yards, which is equivalent to 91.44 metres. The maximum spread angle is therefore 1.253° with a target radius of two metres. This gives me a maximum spread ratio of 0.013922. This process was completed for the Bren Light Machine Gun and the Lee–Enfield Rifle and produced spread modifiers of 0.002321 and 0.002475 respectively.

Ammunition

Ammunition in the game is based off the model of having clips filled with bullets. The player has a finite number of weapon clips that can be held at any given time. Each clip is filled with a particular number of bullets. The number of bullets that can be held by a weapon's clip at any

time is defined in the weapon's data file. For example, in the Sten Mk. V weapon definition above, the weapon can hold a maximum of 32 bullets in a clip. The ammunition in a clip is not a virtual object that can be manipulated or interacted with in the game world, but is a token counter attached to the Weapon class. Likewise, the number of clips that the player is holding is also a token counter that is attached to the weapon the player is holding. When the weapon is fired, this counter is decreased by one. When the counter is zero, or in other words, when there is no more ammunition in the clip, the game automatically initiates a weapon reload, where a new clip is entered into the weapon, and the user can fire again.

If the user has fired all of their clips, they switch to the backup weapon on the character. If the user has no ammunition left for any weapon on their character, they must pick up new ammunition in the environment by picking up a weapon of the same type as a weapon they are currently holding, or pick up a new weapon. This is to account for ammunition not being standard across all weapons. For example, a British Bren Mk. IV fires a .303 inch bullet[102] and a German MG34 fires a 7.92mm bullet[103] and are thus incompatible.

The user can also initiate a manual reload of the weapon they are currently using by pressing the "R" key. The total amount of time it takes to reload a weapon is defined in the weapon's data file. While the weapon is reloading, the player is unable to fire the weapon, just as a person who is reloading a weapon would, in reality, be unable to fire the weapon they are reloading. When reloading ends, the number of clips the player is holding is decremented by one, and the ammunition counter is refreshed to be the maximum number of bullets that can be contained in a clip.

Unlike other modern first person shooters, ammunition that is in a clip that is discarded is not returned into the player's weapon cache. That is to say, if a player discards a partially empty clip, the ammunition in that clip is no longer available to be used by the player. The player's total ammunition is tracked by the number of clips they are holding, and not the total number of bullets that the player is carrying. If the player wishes to carry more ammunition, they need to pick up more clips for their weapon.

[102] Hogg, 227
[103] Hogg, 215

Other games, such as Counter Strike, have one clip that is in the weapon, and the clip's ammunition is refreshed from a pool of ammunition that the player has. If the player initiates a manual reload of the weapon, ammunition left in the clip is not discarded, but the clip is "topped up" from the ammunition pool that the player has up to the maximum number of bullets that can be held in the weapon's clip. For example, if the player is using an FN P90, the weapon's magazine can hold a maximum of fifty bullets, and the player has a pool of ammunition totaling one hundred bullets. If the player then shoots fourteen bullets and reloads, only fourteen bullets are deducted from the player's total ammunition pool, resulting a full magazine of fifty bullets and a remaining ammunition pool of eighty-six bullets. This has become a common convention of modern first person shooters and is used in games like Unreal Tournament, Call of Duty, and Medal of Honor.

Projectile Velocity

The velocity of the projectile determines how fast a bullet travels through the virtual environment. This is necessary because it relates to the model of how soldiers reacted to the tensions of battle. A slow moving projectile could be physically dodged by the player and creates a different experience for the player than a bullet that a player cannot see in movement because it is moving too fast. In order to create an experience for the player that is historically relevant, I need to recreate the conditions that soldiers in *Operation Deadstick* themselves experienced as best I can.

The speed of the projectile was determined by taking the muzzle velocity of the weapon (converting it to metric if necessary), and multiplying the velocity in metres per second by fifty in order to get the velocity in UU per second. This ensures that the projectiles firing through the virtual environment do so at an accurate speed according to the game's scale. Speed of a projectile is set according to the projectile itself, so each gun will instantiate a different virtual projectile object as it is fired and as this projectile is created in the virtual environment, the projectile object's data structure will determine the speed that the bullet will travel through the virtual environment. The effect of this architecture is that I am required to define a projectile class for each gun, and the speed for each projectile will be defined in this class.

Character Health and Player Character Death

One of the biggest questions that emerges when considering the creation of a historically accurate video game is how to handle the death of the player's character. Death has been a

standard feature of games, almost since their very inception. The game *Spacewar!*, developed in 1962 at the Massachusetts Institute of Technology, featured two player controlled spaceships engaged in a dogfight near a star.[104] Later, games from *Space Invaders*[105], to *PAC-MAN*[106], to *Donkey Kong*[107] and the Mario series would all contain variations on the theme of giving the player multiple lives, and once the player had used their allotment of lives, would experience a "Game Over."

This concept of lives was continued forward into the first person shooter genre by games like *Wolfenstein 3D*[108] and *Doom*[109], which also included the concept of player health, or a counter that indicates how injured the player's character is. This concept has been refined and iterated upon, including gameplay concepts such as regenerating health as well as checkpoints, but still exists in modern first-person shooters.

This concept of character health, player death, and game-over do not conform to creating an accurate representation of historical events. In reality, soldiers only have one life, a person's health is not a measured percentage that can regenerate within moments, and the stresses of armed combat extend beyond physical wounds. Furthermore, deaths related to combat, though they may be difficult to accurately report, are fixed; for cases where the total number of deaths is known with an amount of certainty, this can prove problematic for a traditional video game health system. To this end, a new method was needed to determine when a player's character gets removed from play and what to do when this occurs.

Health

The first step in realizing a more accurate model for player health in *Operation Deadstick* is to account for both the physical and mental well-being for soldiers. First hand accounts from the events of the operation describe soldiers who, unable to maintain their mental state, sit down and remove themselves from combat even though they are physical uninjured.[110] To do this, I established two token counters for characters in the game: a physical health counter and a

[104] Steve Russell
[105] Taito
[106] Namco
[107] Nintendo Research & Development 1
[108] id Software, 1992
[109] id Software, 1993
[110] Ambrose, 84

mental health counter. Both counters have a maximum possible value of one hundred. If either counter is reduced to zero or below, the character is removed from play.

Mental Health

Mental Health Counter and Mental Health Modifier

The mental health counter is a regenerative token counter that has a variable maximum value. Each character will have a maximum value between seventy five and one hundred chosen when the character is spawned into the game environment. The variation between characters is to show that different people can tolerate variable amounts of mental stress in combat situations. The maximum value of the mental health counter can be reduced over time. This means that when a character is spawned, they could have a maximum mental health value of one hundred, but by the time the game has ended or the character is removed from play, they could have a different maximum mental health value. This is important, because the mental health value is regenerative; in other words, if the player has not experienced an injury to their mental health for a period of time, their mental health state can improve. The decrementing maximum value of their mental health is an attempt to model that there is a colloquial understanding that mental stresses can have a sustained impact on the mental well-being of a person. This is not a complete depiction of mental health in combat by any means; there are clear cases of soldiers in combat who, when under sustained combat, soldiers' mental health deteriorated the longer they were in battle.

In addition to each character having a variable maximum to their mental health counter, each character is also assigned a random mental health modifier. This modifier is a value between 0.75 and 1.25. The goal of this modifier is an attempt to illustrate that different people have variable reactions to mental stresses. Like the maximum value of a character's mental health counter, this value also changes over time. As the character experiences more combat stresses, their reaction to these stresses grows more severe. So even though a character may start with a mental health modifier of 0.75 and can tolerate more mental stresses than other characters in the game, by the time the game ends, or the character is removed from play, their modifier may have changed to 0.95 or 1.1, in effect increasing the mental stresses that the character experiences.

Because the game is a depiction of short term combat and does not provide the time or methods that characters can use to address psychological trauma, the changes to both the maximum mental health value as well as the mental health modifier are irreversible. However, if in the game's next iteration it is extended beyond the given timeframe, games like *Spec Ops: The Line*[111] and *Darkest Dungeon*[112] can provide good examples on how to approach the implementation a system that simulates the long term mental stresses of combat.

Affecting Character's Mental Health

A character's mental health can be affected in a variety of ways. The first, and most obvious, is the mental toll that physical injuries place on a character. Sustaining physical damage not only decreases the physical health counter of a character, but also decrements the character's maximum mental health counter and increases the mental health modifier.

In addition to affecting a character's mental health state when hit by a bullet, the character is also affected when bullets pass within close proximity to the player. This is done by placing an invisible secondary trigger sphere around each character in addition to the collider that is used to detect ordinary collisions (like those for detecting whether or not the character has been hit by a bullet, or when the character's path is blocked by level geometry). When a projectile enters this trigger area, a message is sent to the character informing them that the mental health counter is to be decremented. All bullets do the same amount of damage to the mental health counter, regardless of the weapon they were fired from.

Being in the vicinity of another character that is removed from play also reduces the character's mental health, as well as reducing the maximum mental health counter. The mental health counter is damaged regardless if the character being removed from play is an enemy or an ally. This is done by finding all of the characters within a radius of ten metres from around the character being removed from play via a spherecast. The radius of ten metres was picked as an arbitrary value by myself in an attempt to denote an area close to the main character, but one that excludes events outside of the players awareness. This value can be changed depending on further research. After the physics spherecast, the game then notifies each character in the radius that damage is being done to their mental health, and the maximum value of their mental

[111] Yager Development
[112] Red Hook Studios

health counter should be decremented. The amount of damage done to both the maximum amount of mental health and the mental health counter is fixed.

If the character does not sustain mental health damage for 60 seconds, the mental health counter will start to increment up to its maximum value. The value will not regenerate more than its current maximum value, and if the maximum value decreases below the current mental health counter value, the mental health value is reduced to be the new maximum value.

Physical Health

A character's physical health is represented by a non-regenerative integer counter with a value between one and one hundred. All characters start with the maximum physical health counter of one hundred; this is meant to illustrate that all soldiers, when entering combat, are considered to be healthy. The physical health of a soldier in the game cannot be replenished, if the character takes physical damage, then the soldier is injured until the end of the scenario. Even though physical damage in reality is more severe than is generally depicted in video games, people still retain the ability to continue, even if they sustain a severe injury. During *Operation Deadstick*, soldiers recounted having flesh torn away from their hands, leaving nothing, but the bone and still continuing the fight.[113] In this sense, the ability for a soldier to receive serious damage and continue fighting is an example of the intersection of both historicity and game design. I can provide a clear and accurate portrayal of how some soldiers can deal with serious wounds. This is in contrast to an argument made by Campbell, who states that a soldier hit by a bullet or a weapon ends the ability for a soldier to remain in combat.[114] In reality, the truth is somewhat in the middle – a soldier wounded in combat will go down with one or two injuries. However, my design I believe provides an accurate metaphor for how soldiers react in combat. Most combatants in *Operation Deadstick* will be removed from play with one or two physical injuries; however, just as in real life, there are always exceptions.

A character's physical health is damaged if a projectile comes into contact with their primary physical collider. If this occurs, the projectile informs the character that they have been physically damaged and then destroys itself so it does not continue. The amount of damage done by a projectile is determined by the projectile itself. The projectiles are in turn only fired by a particular weapon, so each gun has variable amounts of damage, but the amount of physical

[113] Ambrose, 79
[114] Campbell, 194

damage they can inflict is high, approaching or exceeding 50 points. This means that a character could only take one or two direct hits before being removed from play.

Removing Characters From Play

A character is removed from play if either their mental or physical health counters reach 0 or below. For the game made, the effect is the same, the character falls down and is eventually culled from the field in order to maintain adequate performance levels. When a player character is removed from play, it is not game-over, and the game does not restore to a previous save point. Instead, the player inhabits another character nearby that has enough health that they will not be immediately removed from play. If no suitable character is found within a fifty metre radius, then the player respawns at the original spawn point of the level. The code that executes this is below:

```
function bool Died(Controller Killer, class<DamageType> damageType, vector
HitLocation) {

	local NavigationPoint respawnPoint;
	local Vector respawnLocation;
	local Rotator respawnRotation;
	local UDNPlayerController myController;
	local ThesisPawn myNewPawn;

	if (Self.Controller != None && Self.Controller.bIsPlayer) {
		myController=UDNPlayerController(Self.Controller);
		if (Super.Died(Killer,DamageType,HitLocation)) {
			//Code for respawn goes here
			//1. Find Optimal replacement pawn
			ForEach OverlappingActors ( class'ThesisPawn', myNewPawn,
deathSearchRadius ) {
				if (myNewPawn.Health > 75) {
					break;
				}
			}
			if (myNewPawn == None) {
				respawnPoint = WorldInfo.Game.FindPlayerStart(None);

	myController.ReSpawnUDNPlayerController(Self,respawnPoint.Location,respawnPoint
.Rotation);
			} else {
			//2. Clear replacement pawns controller
				myNewPawn.DetachFromController(true);
				myNewPawn.ZeroMovementVariables();
				respawnLocation = myNewPawn.Location;
				respawnRotation = myNewPawn.Rotation;
			//3. possess new pawn
				myController.Possess(myNewPawn,false);
		}
			return true;
		}
	} else {
		if (Super.Died(Killer,DamageType,HitLocation)) {
			return true;
		}
	}
	return false;
}
```

This first checks to see if the character being killed is a player character. If it is, it initiates the code it is supposed to upon death. As part of this, the player detaches from the current character it is inhabiting. It then locates a suitable replacement character (one that is within 2500 UU and has more than 75 health. If no character is found with these parameters, then a new character is spawned at the starting point of the level. Otherwise, the player detaches the AI controller from the new character, and takes possession of the new character's body. In the event that the character executing the code was not a player, it runs the code it is supposed to on death as normal. My approach to handling player death was a way to demonstrate that although my game is focusing on individual player actions, the unit, as a whole, is what is able to accomplish the objectives put forward instead of a single soldier.

This approach, though novel at the time of *Operation Deadstick*'s creation, has since proliferated into the commercial games industry. The game *Battlefield 1*, for example, makes use of this scheme. When a player dies in the single player campaign, they drop to the ground, the camera zooms out, the soldier's name, birth, and death dates flash on the screen, and the player inhabits another soldier somewhere else on the battlefield.

User Interface

The game was created from the outset to have as minimal of a graphical user interface, or GUI, as possible. This was done intentionally in an effort to provide an experience that gives the user a similar experience as the soldiers in the war. Common first person shooter video game GUI tropes that players may be expecting are notably absent from view. These include virtual objects like a minimap that the player can refer to during active gameplay, a health meter, a permanent on screen ammunition display indicator including how many rounds are left in the current ammunition clip, or an aiming reticle. If the player executes the action to check their available ammunition as described above, a small display indicator will appear at the bottom of the screen detailing how much ammunition is left in the current clip, as well as the number of clips left.

When an objective is completed a message is displayed in the middle of the screen detailing the time the current in-game time (that is to say, the current time in the mission) and the objective that was just completed. This allows the game to maintain historical synchronicity, or the matching between the player's time and the virtual time of the historical event being modelled.

Even if the player takes longer or shorter amounts of time to execute them than in reality, the pop-up that indicates the game time creates a reference frame for the player, and orients them to their position in the virtual timeline.

If the player wishes to improve their aim, they are able to hold their weapon up to the camera to use the weapon's "iron sights." As mentioned above, there is no system that currently reduces weapon spray for this action. Otherwise, the player has no on screen mechanism for evaluating where their bullets will land. This means the player will have to rely on the trace of their ammunition in order to get a sense for the path of their ammunition. In reality, aiming in the heat of battle can be a difficult task, and soldiers can empty entire clips of ammunition without hitting their intended target once.[115]

[115] Ambrose, 78

Chapter 4: Evaluation

Two considerations shape the assessment of *Operation Deadstick*: first, whether or not the game is an academic object and worthy of inclusion of the historiography surrounding the event depicted; and second, the fidelity of the depiction as part of the evaluation of a scholarly object must be evaluated. These are two distinct, but important aspects of a historically accurate game.The first consideration is whether or not the game can be considered a mode of historical thought. Regardless of the accuracy of the object being presented, if it is unworthy of submission into the historiographical discussion of the events of 6 June 1944 in Caen, France, than it may as well be considered a work of pure fiction. In this case, the object's merits can be debated as a piece of historical fiction, as an interactive entertainment object, or as a toy, but any serious historical discussion of its merits becomes moot. As Rosenstone points out in his discussion of historical film, individual historical objects are not evaluated on the correctness of their presented facts, but through how the representation accounts for the traces of the past that are known and how this interpretation engages with the larger discourse of history.[116]

If the game passes the first test, then an evaluation of its historical accuracy is not only an exercise in scholarly debate as the historical community would have with any other text or historical object, but the object can be evaluated the viewpoint of its author and its contribution to the historical conversation. This allows the use of the tools afforded to scholars in the evaluation of a game as they would have from the discipline of game studies, but it also affords them the benefit of critical analysis that the community has created for the evaluation and debate of history. This allows scholars to evaluate the depiction of the game through the information and facts that they can gather about the presented event and determine whether or not the game has faithfully accounted for this data.

Operation Deadstick as a Historical Object

Historians are reluctant, at best, to regard mediums outside of the realm of text as possible avenues for the discussion of history. In his piece on "history films," Rosenstone posits this reluctance exists because of a belief on the part of historians that films are more a reflection of the present than a depiction of the past.[117] He suggests that this belief is tied to the education of historians: they are taught that history comes from books and a discussion of history is a

[116] Rosenstone, 2013, 83
[117] Rosenstone, 2013, 73

textual conversation borne out across journals and books.[118] In this, video games are likely to receive similar criticism, with one major addition: the interactivity. Traditional historians will argue vehemently that the existence of choice and the agency given to the player flies in the face of what it means to have a historical discussion. This attitude is borne both from education and ignorance. As game developers know, and I have argued in Chapter One, the interactions and mechanisms afforded to the player are devised, presented, and implemented with great thought by the designer.

Just as the depiction of history reflects the experiences of the creator, the design of the interactive mechanics of games are likewise based on the developer's understanding of the present and the past they are trying to present. The historian-as-game-designer embodies this and is best reflected in the quote by Hannu Salmi, "while writing describing the past, the author is simultaneously writing about his own world, consciously or unconsciously, implicitly or explicitly."[119] The interactive mechanics developed and given to the player represent the implicit arguments the historian is making about the event being depicted.

Given this, how can a game, designed and developed from a historical perspective, be a historical object, one that presents arguments and encourages historiographical debate? Robert Rosenstone, in his description and definition of the "history film" summarizes Donald L. Kelley's survey of western historical thought from his book *Faces of History* in four points:[120]

1. History preserves and celebrates the memory of notable events and persons.
2. History is didactic, providing moral or political lessons, usually on the grounds that human nature, despite different customs, is at the bottom the same.
3. History is a form of self-knowledge, or the search for self-knowledge.
4. History is a form of wisdom, a way of extending human horizons backward and forward in time, and beyond local experience and concerns.[121]

These points form the basis of western historical scholarship. Writing, filming, or programming a historical object that is part of the ongoing conversation of history should satisfy these conditions. Therefore, if *Operation Deadstick* fulfills these aims successfully, it can be said that the game is a historical object that may be evaluated and debated as other historical text.

Does *Operation Deadstick* fit these criteria? To the first point, the game celebrates the actions of D Company on 6 June 1944. It gives an insight into the events that took place at the Caen canal bridge that would set the stage for the successful invasion of Normandy by the

[118] Rosenstone, 2013, 73
[119] Salmi
[120] Rosenstone, 2013, 82
[121] Kelley, 12

Allied forces and mark the beginning of the collapse of the western front in western Europe during World War 2. This event was part of a larger, seminal event that defined the state of global affairs to the present day.

Secondly, the game seeks to educate, not only from an informational standpoint, but also from a moral and philosophical standpoint. It emphasizes the teamwork that is required for such an achievement. It provides lessons about the impact of battle on the mental state of people, and how this affects people differently.

Third, the inherent interactivity of the game forces a player to look inwards and challenge their own personal perspectives. It questions assumptions about war, combat, and violence. It presents the limitations of the individual and what solo actions can accomplish; it places a player's individuality in relation to those around them, and can cause them to question their own place amongst others and in society.

Finally, The game forces players outside of their local experiences and into a time and a place with values and goals that differ from their own. It gives players an experience that is out of time, something that they could never face in their own life, but can nevertheless influence their own perspective. This is the basis of what Alison Landsberg calls, "prosthetic memories:" experiences and memories that a person adopts, but did not live. These memories are transferred through their interaction with a recreation or depiction of a historical moment that the person did not experience first hand.[122] Through *Operation Deadstick*, players can experience an event removed from time, relate to it through their own personal histories and experiences, and reintegrate the event into their own memory; they internalize the events into their own life, learning and experiencing past events that they could never otherwise experience.

From this, I think the question is not whether or not *Operation Deadstick* is a historical object, but rather how could it not be? It presents a historical event through the lens of the facts that are known about the event, but brings forward its own perspective and viewpoint. It presents themes and asks questions in the same manner that all historical works do. With this matter settled, at least to my own satisfaction, I can turn my attention to the more important and pressing issue: is *Operation Deadstick* accurate?

The accuracy of *Operation Deadstick*

Given my ability to say that the game is a work of history and a mode of historical thought, I am then faced with the question of evaluation. As a work of history, as a part of the

[122] Landsberg

historiographical conversation, how well does *Operation Deadstick* measure up to the traces of the past that I have?

In his 1990 book, O'Connor breaks down the analysis of history on film into three key areas: content, production, and reception.[123] Analysis of content relates to the substantive "text" that exists in the object being studied. With regards to film, this means a careful analysis of the visual cues of the film, the aural elements present, such as music and sound effects, as well as the dialogue present in the film. O'Connor points out that these elements must be examined not only in their relation to history, but what the film is trying to say about the event being rendered through the use of the rhetoric of film; this is conveyed through elements unique to the film itself, such as editing and cinematography.[124] Likewise, any game that is being evaluated for the fidelity of its historical representation must have its constituent components evaluated as well. This includes its visual and aural elements, like in film, but also its interactive elements. No evaluation of the historical accuracy of a game would be complete without a close reading of its interactive system.

O'Connor uses his analysis of production as a way to not only investigate the people who made the film, but also the decisions that went into making the film. What were the points of view of the people who contributed to a film's development? What sort of financial support was being provided to the film? What were limitations that were imposed on the film? Similarly, why were some decisions made over others? These questions get at the heart of the underlying philosophy of a media object and its historicity. When considering games, these questions are important to ask, not simply to understand the viewpoints of those involved in the game's development, but also to understand the statement that the underlying game systems are making. The development of a game is an exercise in the application of judgement on the part of its creators. The decisions made in the production of the underlying game architecture, systems, and algorithms have a profound and lasting impact on the message the game conveys and how the player will interpret the history being portrayed.

When analyzing the reception of a media object, O'Connor suggests that historians are trying to uncover not only how that object was received at the time of its release, but also the messages that the object is making about the time that it was made, and also the interpretation of these messages by its consumer.[125] The experience the creator is trying to convey is central to the understanding and interpretation of history, and the interpretation of that message by

[123] O'Connor
[124] O'Connor
[125] O'Connor

those that engage with it is likewise an important part of how historians view the historicity of the object. This is not only a central element of how consumers engage with media, but it is likewise how historians interpret the work of other historians. The treatment of history in games must be interpreted in the same way.

O'Connor's ideas regarding the interpretation and evaluation of history in film have formed the basis for understanding the historicity of games. In his hunt for a lexicon to discuss the different methods used by games to depict history, Metzger used a framework to dissect and analyze historical games for the purposes of education. The three areas that were chosen to be examined were: environmental and playable elements, visual/aural representations of the past, and the (broadly defined) nexus of video games, academic teaching and learning, and ultimately broader historical consciousness.[126] These elements are iterations upon O'Connor's work. The visual and aural representations are extensions of O'Connor's content analysis method. The environmental and playable elements being investigated are not only content, but also an investigation of the production and underlying systems that constitute the game. And finally, Metzger's amorphous intersection of video games, education, and history is an ill-defined analysis of the reception of the history being portrayed.

Srivastava et al. go further in their investigation of the historical accuracy of *Supreme Ruler: Cold War*[127]. They define four categories for historical accuracy and how they impact the game. These four categories are cosmetic issues, strategically important issues, balance or system design issues, and legal or social issues.[128] These place more specific emphasis on the investigation of content and systems, which were lacking in Metzger's investigation. Cosmetic issues are defined as items that do not have a significant impact on gameplay.[129] Srivastava elaborates to say if any cosmetic items or objects are changed, the game plays no differently to the player. This is not to say that the player does not notice these issues or that these items do not have an impact on the experience of the player, but rather the substitution of these items for others does not change the mechanics or fundamental interactive design of the game. Things such as 3D character meshes, lighting, and sound effects would be classified as cosmetic issues. Cosmetic issues are perhaps the least problematic of all issues of historicity. As Sorlin argues, historical costumes, props, and settings do not do enough to point out the historicity of a particular film.[130] The same can be said of games. While these items must be considered when

[126] Metzger
[127] BattleGoat Studios
[128] Srivastava
[129] Srivastava
[130] Sorlin

designing a historical game, they rarely pose significant problems for the historicity of the historical depiction being presented. Although, as I discuss below, these issues can still pose significant challenges for historical accuracy.

Issues of strategic importance are defined as items that significantly impact both the historical accuracy of the game as well as its underlying gameplay and design.[131] Items that could be considered strategically important may be the underlying models that have been created for the purpose of representing abstract concepts, or items that can run counterfactually to history if traces of the past are not properly accounted for. Examples of these may be the mechanics of weapons fire or the virtual environment. Despite what Srivastava implies in the paper,[132] the existence of these models, or the simplified nature of the reality that they model do not represent a distortion of historical accuracy. Rather, they can be viewed as a use of Rosenstone's methods for invention that are used to accurately represent history. The understanding of the physical world and the models that are used to depict this understanding are constantly changing and evolving. Likewise, with regards to social and political structures and theories academics are constantly creating new models, iterating on established theories, and debating what methods of thought are no longer valid. The existence of a simplified model is a form of metaphor; when this metaphor properly accounts for the traces of systems that it seeks to represent, this is a healthy and accurate portrayal not only of history, but also the world around us. My job in evaluating the historical accuracy of a game comes in analyzing these systems, ensuring they are properly positioned within the game and that they take into account both historical traces and the social, political, and physical systems they seek to represent.

Issues that revolve around system and balance are problems that arise during development on the part of the designer in an effort to make the game more "fun." A game is unbalanced when a part of one system, or multiple systems working in conjunction, have an inherent advantage over other parts of the system or systems in the game.[133] When these issues arise, players may favour one mechanic or style of play over others. This makes the game less "fun" for its players as they may feel that the game is not fair. These unbalanced systems may themselves represent a distortion of historical accuracy, if the emergent gameplay from these systems creates a situation that runs counterfactually to history. The inverse of this situation can also be problematic: history and its representation in an interactive setting can be inherently unfair. This creates a situation where a designer may wish to "balance" the systems

[131] Srivastava
[132] Srivastava
[133] Srivastava

in an effort to make the game more fun. In this situation, where in the case of *Operation Deadstick* maintaining the player's engagement with the game is a key objective, "balance" must be introduced in such a way that does not distort the accuracy of the representation of the past. This could be as simple as tweaking constant values in the source code, as complex as an iteration of the abstract system being represented, or as involved as a complete overhaul of game mechanic architecture.

The final of Srivastava's issues of game design are legal and social issues. These are problems that have social and political repercussions outside of virtual space.[134] Srivastava gives multiple examples to illustrate his point: country borders and territorial disputes, trademark and copyright issues, and well as the depiction of non-fictitious people and organizations. In the case of an academic and historical object, some of these issues are bypassed on the grounds of academic freedom. Likewise, taking a position or creating a system that challenges and epitomizes real world issues can be interpreted as a viewpoint of the developers and a position that the game takes as a historical object. This does not mean that the game is entirely free from social and legal issues based solely on its status as a historical object; but the discussion of these issues is precisely what good historical objects seek to do in the historiographical discussion. By presenting these positions and viewpoints, a game, and its developers, can foster conversation amongst historians about why precisely a particular issue is poignant.

Issues of Cosmetics

Visual cosmetic Issues

The easiest place to criticize *Operation Deadstick* is its cosmetics. Having constructed a prototype, an emphasis was placed on mechanics, gameplay design, and flow rather than on visual and auditory fidelity. In an effort to prove that such fidelity is possible, I included a 3D model representation of a Sten Mk. V submachine gun. However, in order for a virtual simulation of the historical event to be considered accurate, many more accurate 3D models would have to be included. These include, but are not limited to: character models based off of period uniforms, a model for each weapon used in the game, the horsa gliders, as well as buildings and terrain. Many of the models that are in the game are default models that were included with the engine, and are a hodge-podge of aesthetic, from the futuristic to plain.

[134] Srivastava

Additionally, most of the 3D models in the game are currently untextured, which means that they look to be either pure white, or to have a checkerboard pattern attached to them. A texture is the way by which artists assign colours and visual properties to a 3D model. It consists of a flat virtual image that is wrapped around a three dimensional mesh. Given the lack of artistic resources on the project, the time that could have been spent creating realistic textures for the models was instead spent on design and mechanical considerations – the effect of which was a more robust prototype, but one that came at expense of sophisticated visuals.

There is much more that goes into the visual design of a game than just the inclusion of an accurate 3D virtual depiction of real objects. A key area where the game could benefit from more attention to cosmetic detail is the lighting of the scene. In the account of the battle, different members of both the German and British forces remarked at the importance of light, whether from sparks,[135] or the moon.[136] Additionally, the first glider had crashed landed fifty feet from the bridge without being noticed.[137] This is partially because of the relative frequency of aircraft debris landing on the ground allowed them to ignore the sound of the impact, but to not immediately notice three gliders landing only fifteen metres away demonstrates the low visibility. There is also accounts of British soldiers not noticing obvious obstructions at their feet, such as drainage ditches,[138] or being able to make out the progress of a firefight within fifty metres.[139]

The importance of lighting in the first hand accounts from those present during the operation paints a much different picture than the one depicted in the game. In the prototype, there exists only a single global illumination light – one that does not vary in its intensity or hinder in any way the ability of the player to distinguish the game state anywhere on the map. Furthermore, even though clouds are simulated on the skybox (the painted texture which fills the background of the virtual environment), the moon itself does not generate any light, and thus the player is not impeded in any way by clouds obscuring the moon. The “glow” that the moon provides is, in actually, a visual trick in order to simulate the appearance of a light, where not actually exists. This is done with a small visual program called a “shader.” This particular shader takes the lighting values of the moon’s pixels and extends them onto the surrounding pixels on the sky in a manner that fades between the colour of the moon and the colour of the sky, thus giving the appearance of light and glow.

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[135] Ambrose, 72
[136] Ambrose, 78
[137] Ambrose, 73
[138] Ambrose, 82
[139] Ambrose, 86

Shadows in the game also do not impede the player's vision in any way. The contrast between the shadow and the ground is enough for the player to distinguish that a shadow exists, but does not sufficiently obscure the detail of the surrounding terrain. The ability for game engine's to represent shadows and using lighting to effectively obscure the player's view has greatly increased over the course of the game's production, but I do not have the artistic or technical skills to implement these techniques. Additionally, while UDK can make use of these techniques, it cannot implement them easily enough for someone with my skill level to implement.

Auditory Aesthetic Issues

The acoustic quality of the simulation requires particular attention to detail. Multiple accounts of the event place an emphasis on the importance of auditory cues to the troops on the ground.[140] Soldiers describe the importance of speech and callsigns to their recollection of the events.[141] Other soldiers describe the importance of the texture of the gunfire; the Sten and the Bren had unique rapports that made them distinguishable from German weapons, which cued German troops to the fact that the British had landed.[142]

Sounds in *Operation Deadstick* played a small, verging on non-existent, role. Auditory cues were played to denote an action being accomplished, such as firing a weapon, rather than to contribute to the overall experience. However, the contributions of sound to an accurate simulation cannot be understated, especially when they are called out so clearly during the recounting of events. Any such experience should take into account the ability for loud noises such as explosions and gunfire to damage the player's ability to hear, as these were real consequences that were experienced by soldiers in the battle.[143]

Issues of Strategic Importance

Environment

One of the largest issues regarding the accuracy of *Operation Deadstick* was the placement of the bunkers and trenches lining the canal. The placement of the trenches is difficult. Primary and secondary sources, including aerial photographs, do reveal the presence

[140] Ambrose, 72, 76
[141] Ambrose, 76 – 78
[142] Ambrose, 77
[143] Ambrose, 83

of the trenches. In the absence of accurate secondary sources or primary source high resolution photographs, it becomes difficult to literally place the path of the trenches. As a result, during the development of the game, I made use of Rosenstone's methods of invention to line the canal walls. I believe this is accurate, since it places the trenches, and thus cements their place inside the logical consistency of the simulation, as well as accounting for the fact that they existed.

Numerous sources refer to the bunkers, both their existence, as well as how they fit into the overall plan for the capture of the bridge; however, the physical placement of the bunkers into the environment is unclear. Aerial photos do not clearly depict the position of the bunkers, and nor do secondary topographical sources place them other than to say that the bunkers existed. For the purposes of *Operation Deadstick*, I will make use of Rosenstone's methods of invention, and place them in even increments along the canal wall, with the entrances leading into the trenches themselves. The result of this is that the player will be required to enter the trenches to subsequently enter the bunkers.

Another issue of strategic importance, as it relates to historicity of events, is the placement of defending troops at the canal bridge. I know that all of the British commandos came from the three gliders, and I even have some reasonable ideas about which specific commando was in which glider, but the placement of the defending german troops in bunkers, in the trenches, in the machine gun nests, and in the pillbox northeast of the bridge are ambiguous. I know certain people were in certain places at specific times, such as Private Romer being on the bridge where he spotted the commandos approaching[144] or Sergeant Hickman being on the west bank of the canal with four privates approaching the bridge during the raid.[145] However, beyond this, the account gets much less clear. To this end, I believe that I can say that the machine gun nests were manned, troops were in the bunkers and in the trenches. One area that still proves problematic during the development of *Operation Deadstick* is the fact that I know defending troops were sleeping in the bunkers.[146] During development of the game I did not have the resources to program sleeping/rousing behaviour for these soldiers, and as a result, defenders in the bunkers as well as the trenches are on full alert and expecting attack when the player enters. This hinders the historical accuracy of the game, but I do not believe that this event causes any substantial deviation from history, as the player is still required to enter the bunkers and deal with enemy combatants inside.

[144] Ambrose, 76
[145] Ambrose, 77
[146] Ambrose, 103

Weapon Mechanics

It is commonly accepted knowledge that the German MP40 carbine and MG34 light machine gun were considered superior to the British Sten carbine and Bren light machine gun. The Sten was an inexpensive mass-produced weapon that had a well known jamming problem and would occasionally inadvertently discharge. The Bren LMG was heavy, had a slower rate of fire, and was also less dependable than its German counterpart.[147] British soldiers quickly abandoned their own weapons for a German counterpart when they landed.[148]

Unfortunately, I never implemented a system for the dependability of weapons. The player's weapons will not jam, and at the end of the game's production player's could not yet pick up a weapon from an enemy character. This, I feel, is an oversight on my part, but one that was borne from a lack of resources that could be put into the project. Being able to accurately represent that the German weapons would be superior and gave them an advantage in combat is a laudable goal. Further, the German weapons were never implemented, but I believe that by showing that the British weapons can be implemented, the German weapons can too; although this is not accurate, I believe it shows that the game could be made accurate given sufficient resources.

Additionally, explosives were not modelled in the game. I believe that any future version of the game would require explosive weaponry to be implemented because of the frequent number of times that they were brought up by soldiers at the battle. They played key roles to both the soldier's strategy, in terms of clearing bunkers, the pillbox, and machine gun nests, but also the explosions provided key moments that the soldiers recalled in their recollections of the battle. They would not provide a substantial technical challenge to implement, since they would function as an area of effect damage. This would be accomplished by giving the explosive a radius of damage, and then using the physics engine to calculate the overlap between the explosions radius and any characters caught within it. Once this list of characters is known, damage is applied to each character according to their distance from the centre of the blast.

[147] Ambrose, 25-26
[148] Ambrose, 127

Issues of Game Systems and Balance

Physics

I believe that the projectile physics in the game are an accurate representation of the mechanics that someone would experience. The weapon physics are not a literal representation of real-world projectile physics, in the sense that the ballistic paths are not affected by wind or gravity. The trajectory of these projectiles are thus not parabolas like a bullet from an actual gun would be. However, in the conditions and ranges at which the soldiers were fighting, it is my view that there there would have been little deviation from the trajectories of high velocity projectiles. The longest side of the modelled area was under 1km long, meaning a bullet, fired from the lowest powered weapon in the British arsenal, the Sten Mk. V, with a muzzle exit velocity of 381 m/s, could travel over the full distance of the area in under three seconds:

$$v = \frac{d}{t}$$

$$381\ \frac{m}{s} = \frac{1000\ m}{t}$$

$$381\ \frac{m}{s} \cdot t\ = \frac{1000\ m}{t} \cdot t$$

$$381 \frac{m}{s} \cdot t\ =\ 1000\ m$$

$$t = \frac{1000\ m}{381\ \frac{m}{s}}$$

$$t = \frac{1000}{381} s$$

$$t\ \simeq\ 2.62$$

Through derivation of the formula for vertical displacement of a parabolic projectile, I can determine that using a slight upwards angle, a soldier could fire across the entire modeled area with little to no vertical displacement:

$$y = v_0 t sin(\theta) - \frac{1}{2} g t^2$$

$$0 = (381 \cdot \frac{1000}{381}) sin(\theta) - \frac{1}{2} \cdot \frac{981}{100} \cdot (\frac{1000}{381})^2$$

$$0 = (\frac{381000}{381})sin(\theta) - \frac{981000000}{29032200}$$

$$0 = 1000 \cdot sin(\theta) - \frac{545000}{16129}$$

$$\frac{545000}{16129} = 1000 \cdot sin(\theta)$$

$$\frac{\frac{545000}{161291}}{1000} = sin(\theta)$$

$$\frac{545000}{16129000} = sin(\theta)$$

$$\frac{545}{16129} = sin(\theta)$$

$$\theta = sin^{-1}(\frac{545}{16129})$$

$$\theta \simeq 1.936º$$

Where y is the net vertical displacement of the projectile, v_0 is the initial velocity of the projectile, t is the time it takes for the projectile to travel the total distance, g is the vertical acceleration on the projectile due to gravity, and θ is the vertical firing angle, it can be determined that with only a slight 2º incline, the bullet would have no vertical displacement across the modeled area. This is such a slight incline, I believe the representation of the projectile physics provides an accurate representation of what soldiers in the battle would experience.

Environment

When modeling the environment, I decided on fabricating the surroundings by joining together two-dimensional planes to form a cohesive three dimensional mesh. This decision was made because of my previous experience in utilizing planes in the Unity 3D game engine to create performance optimized scenes very quickly. Additionally, the idea of welding together two-dimensional planes into a cohesive unit was similar to experiences I had engaging in creating 3D models of objects in programs such as 3DS Max. However, when I went to test my environment, my character proceeded to fall through the ground.

This was because of a key difference between Unity, which I had used previously, and Unreal, which I was using for the first time: Unity attaches physical colliders to two dimensional planes whereas Unreal does not. The effect of this difference is that in Unity, a character can stand, push against, and interact with a two dimensional plane in three dimensional space, but in Unreal, it does not generate a physical collision, causing the player to pass or fall through the

plane until it reaches a virtual object that does create a physical collision with the player. The reasoning for this difference is that Unreal chooses to use two dimensional planes in remote locations where the player cannot directly interact with them (for example, to display trees where they appear to the observer as two dimensional objects), whereas Unity chooses to use them in the event the developer wants the player to interact with the two dimensional object. I believe that Unreal's position was taken purely for the reasons of performance: a distant two dimensional plane is only a single quadrilateral polygon, whereas a mesh could be made up of several hundred or thousand polygons. Furthermore, if the plane is in remote location where the player cannot directly interact with it, the engine can save resources by not having to run physical calculations on the object. After much consultation with online resources and other developers who are more knowledgeable about the Unreal game engine, I was forced to acknowledge that it was not possible for me to add physical colliders to my environment after it had already been made.

This is not to say that it is impossible to render a real-life location in a three-dimensional environment. But in my case, it would be best to say that my recreation of the environment is incomplete. It is my belief that the base terrain was accurately modeled, but the environment is missing local flora and buildings. Additionally, the lack of physical geometry is not just a problem for the player, but also causes non-player characters to fall through the environment as well, since these characters likewise need the collisions generated by the physics system in order to maintain their place in the environment.

Character Health

One issue of systems and balance that was created due to a lack of resources is the inability for bullet projectiles to have scaling damage. By this I mean that a bullet that hits a character will do the same amount of damage whether it hits the character's hand or their head. This, I believe, is problematic, but not a major hinderance to the accuracy of the game. The damage of the bullets is likewise suitably high that a character could only take a few hits before they are unable to continue. This is also a reflection of historical accuracy, since there are stories from soldiers in the battle that they were wounded, but kept fighting.[149] Likewise, I would have preferred to set up a mechanism whereby bullets that pass the proximity of characters would do differing amounts of mental health damage the closer they were to the character. At

[149] Ambrose, 74

the end of development, bullets damaged the mental state of a character the same amount, regardless of how close the bullet was to the character.

AI

The artificial intelligence of the non-player characters likewise creates a problem. Basic Unreal search and destroy behaviour was used by non-player characters. For British soldiers, this means that the characters move through the entire environment looking for German defenders. For the German soldiers, this means that they will stay in their respective area waiting until they find a British soldier to engage in combat. Once a member of either faction comes across a member of the opposing faction, the character's will engage in a firefight until their enemy is removed from play. This type of behaviour was used because there was not enough resources in development to create more comprehensive behaviour models for the non-player characters. This provides a point of friction for the historical accuracy of the event, but I do not believe one that greatly harms the accuracy of the simulation. The events in *Operation Deadstick* are a battle, and a battle will be waged by the game's characters until the victory conditions are met.

Areas For Improvement

Any future iterations of *Operation Deadstick* will require additional work to be considered a complete product and a text that contributes to the historiography of the events at the Caen canal on 6 June, 1944. Substantial work will need to be done on the game's cosmetics, including additional three dimensional models, lighting work, and sound effects. The game does not currently utilize many accurate representations of characters, equipment, or the surrounding area. However, by implementing a model of the Sten gun, I can show that once an accurate representation of the equipment has been created, it can be attached to the characters.

The environment will also require a substantial amount of work. In addition to the collision geometry that is required to be added to the map, there are many buildings that need to be added as well. I know at least one instance of a soldier entering a barn, so any building represented in the game will also require its interior to be modelled as well.[150] Likewise, there are man made objects that were in the environment that are required to be modelled as well. These include, but are not limited to, machine gun towers, sandbags, and barbed wire. Likewise, the environment does not include any flora or fauna that may have been present. In

[150] Ambrose, 78

particular the flora could have provided a differing perspective, since it could obscure the view of characters in battle. Additionally, I know that the ground of the area was uneven, and soldiers needed to be on the lookout for dips and divots in the terrain.[151] The environment as modelled in *Operation Deadstick* consisted of perfectly flat ground.

Additional development of projectile physics will also be required. While I believe that the basic physics that were implemented in the game are accurate and do not create a distortion of historicity, a more realistic simulation of weapon physics and mechanics would provide a better environment for players. This includes the addition of gravity affecting bullets, and potentially other environmental conditions, such as wind. More weapons would also require to be modelled including: the German weaponry such as the MP40 and the MG34, a Verey flare pistol that would be used by sentries on the canal bridge, and the implementation of area of effect weapons such as grenades and the Piat grenade launcher.

[151] Ambrose, 82

Chapter 5: Conclusion

What is important about making a historically accurate video game? Do the moral lessons that are being conveyed through gameplay outshine other factors? Are visual and auditory fidelity to historical locales, objects, and people what makes a game historical? How do social and political change fit into a historical game? Does the mere chronicling of a historical event in an interactive format create a historical game? Is it technical excellence and a strict adherence to systematic rigor?

All of these questions are important, but at the same time, none of them are the most important. What gives myself, or any individual, the authority to judge these questions and decide on their validity? Through my thesis, I have tried to convey that the best way to discover whether or not a game can be considered historically accurate is through historiographical debate with the historical community. The ongoing dialogue and discourse between historians, game developers, and the consumers of this media will help to determine whether or not a game is considered to be historically accurate. This discussion is important because of the differing perspectives it brings to the table.

Historians will argue about the game's portrayal of history based on available historical traces when discussing a historical event. Do the events portrayed correspond to what we know about the past? Do the underlying systems of the game accurately portray and provide a proper metaphor for the mechanics and abstract forces at work in the event? Has the developer done their due diligence in the creation of the media object, or have they missed details and traces that would alter the portrayal of the event? Does the stance that the developer takes on the event being portrayed represent a valid historical viewpoint?

The players of the game also have an important role in this discussion. Their job, and the job the public at large, is to determine how the media object functions in relation to its medium. In other words, players must evaluate the game on the basis of it being a game. This evaluation is not as easy as it sounds, because it reaches the heart of key questions within the field of game studies: what is a game? Further, what makes a good game? Something that can't be described as a game, can no longer be considered a historical game. A static web page that describes a historical event may be interactive, but it certainly cannot be considered a game. If we're sure that what we're playing is, in fact, a game, does it fulfill its goal if no one wants to play it? Within the events modeled in *Operation Deadstick*, there is an account of a single soldier being thrown through the front windshield of the glider, being knocked unconscious in the process, and subsequently landing in a nearby pond, where he drowned. This event is an

entirely accurate account from the perspective of this soldier, but does it represent good game design?

Game developers have the most difficult and important role in this discussion. They must accept and try to best represent the work of historians, whilst making a game for the public. They are forced to balance the demands of their players, who want nothing less than ludical excellence, and the requirements of historians, who necessitate historical fidelity. This challenge is difficult, but not impossible. It requires meaningful investigation, thoughtful design, and creative experimentation. This is because each decision that a developer makes is not only a design decision that has an impact on the game, but a historiographical one that has an impact on the historical community.

Operation Deadstick

Operation Deadstick represents a positive step forward in the creation of historically accurate games. The creation of the game was not without its challenges, and more work still needs to be done before it could be entered into the historiography of the events surrounding the Caen canal bridge on 6 June 1944. Creating an accurate reproduction of the environment that factors in ambiguity surrounding certain elements of the terrain is the central factor at the end of the project's development. Likewise, additional work is required on a more realistic representation of weapon physics and reliability, as well as the inclusion of area of effect weapons, such as grenades and grenade launchers, and the inclusion of German weaponry that can be used by both non-player and player characters.

However the game does faithfully and accurately represent issues of historical importance to the player. We can come to this conclusion by examining the historical content of the game by using the framework introduced by Srivastava to investigate the game's aesthetics, game systems and balance, legal and social issues, and issues of strategic importance in the game. This examination reveals issues regarding the visual and acoustic representation of game, but that the fundamental approach to the inclusion of visual and auditory elements is sound and does not distort the historicity of the game. Likewise, although environmental and mechanical issues are encountered during the production of the game – the underlying philosophy of the game's production is historically sound.

Such an examination is rooted in the work done by Metzger in the examination of educational content in games, and O'Connor's work in the evaluation of historical accuracy in film. Further by examining the game through the lens of Kelley's four points of historical

scholarship, we can see that the game itself represents a historical object – one that can be entered into historiography, and its accuracy and value can be debated through the normal course of historical scholarship.

The design of *Operation Deadstick* is rooted in the first-person shooter genre. It was made using established and industry leading technology that allowed development to focus on historical content and maintaining historicity while maintaining consistent and familiar feel and mechanics with other games in the genre. The goals for the game were pulled directly from mission objectives. The environment was made to scale from both contemporary and modern source material. Weapon mechanics were made in an effort to replicate an experience that represents the experience of the soldiers on the ground of the operation. From the firing behaviour of weapons like the Sten submachine gun, or the bolt action Lee–Enfield, to the way the weapon's spread, considerable attention was paid to faithfully recreate an accurate experience.

When designing game mechanics, I focused on mechanics that addressed problems that interactivity as well as traditional first person shooter mechanics introduce to the historical accuracy of the game. With regards to player health, my system includes both the physical and mental health of the soldier. This is done through the use of two distinct, but related meters. Each meter reacts to damage differently than the other. Physical health is a non-regenerative counter that is decreased over the course of combat. Injuries are suffered when a virtual bullet collides with a character. At this point damage is applied to the character. As a general rule, characters can only sustain one or two injuries before being removed from play, like soldiers, who can suffer severe injuries.

Mental health is represented by a separate meter that has a maximum value. If a character is not engaged in combat for a period of time, their mental health state can improve up to the maximum value. However, a character's maximum mental health value can be permanently reduced through exposure to long term combat and physical injuries. In an effort to show that different people can tolerate different amounts of mental stress, the maximum value of the mental health meter is variable between characters. Likewise, each character reacts to mental damage differently, through the implementation of a mental damage modifier, in an effort to showcase that people react to stressful situations differently.

When either a character's physical or mental health is reduced to, or below, zero, the character is removed from play. This does not represent "death" as is the common game trope. It is instead a representation that a character may be too injured to continue fighting, or perhaps that they have reached a mental state which renders them unable to continue. If the character

being removed from play is a player character, they do not fail the mission and are forced to start again in a “game over.” Instead, the player leaves the current character and is transferred to a different character in the vicinity with a suitable amount of health. If no suitable character is nearby, they are transferred to a character at the starting point of the level.

The game features a minimal graphical interface that emphasizes player action to receive information. There are little or no passive informational GUI elements that are standard in first-person shooter games, such as aiming reticles or mini-maps. Elements that can present information to the player, such as ammunition counters, require the player to commit an action in order to receive this information. While this information is being presented, they are restricted in the actions they can take. This not only brings the player closer to reality, but it also increases the player’s tension by forcing them to consider when they take actions that they previously took for granted.

In an effort to maintain consistency between the player’s time and the mission time, or historical synchronicity, time presentation is dissociated from the player’s real timeline. This creates a dilation of time that is oriented whenever the player achieves an objective; this approach allows the player to explore the simulation at their own pace and simultaneously maintain historical authenticity.

The methodology for the creation of the game is rooted in the MDA framework. This approach focuses on breaking a game’s design into different components that all play a role in the design of the game. Mechanics represent the rules that the player must abide by in order to play the game; a designer views these elements as the foundations that generates player interactions. These are the constraints that the historian uses to produce their historical argument. Dynamics are the expressions of the game’s mechanics that the players interact with. These are the mechanisms by which historians allow players to experience history. Aesthetics are the results of players’ interaction with the game and represent the experience and emotions that are conveyed through the game’s content. These are the specific foundations of a historical event that are being conveyed through the game.

During the design of a historically accurate game, the historical content must be contextualized throughout the mechanics, dynamics, and aesthetics of the game. When the historical content is reflected throughout the entirety of a game’s design, it not only places an emphasis on the content being conveyed, but it more clearly transfers this knowledge to its player.

In order to properly contextualize the historical content into a historically accurate game’s mechanics, dynamics, and aesthetics, we can make use of Rosenstone’s methods of

invention for historically accurate films. Condensation is used to create characters and scenarios that embody specific historical viewpoints. Compression can be used to alter the player's perception and experience of time and events as well as collapsing space for the creation of manageable virtual environments. Alteration can be used to give players the illusion of choice, in an effort to build more engaging experiences for players. Metaphor can be used by designers and developers to not only convey complex and abstract historical and real world concepts to the player through both content and the development of the game's algorithms and underlying mechanical systems.

Future Work

This project can be continued further for doctoral study. This could be either as an extension of *Operation Deadstick* or the creation of a new historically accurate game with more abstract concepts. In either case, the development of such a game would not be able to be a one person effort; it would require the addition of multiple disciplines to the team, including those in fine arts and computing science.

The goal of such a project would need to be a complete game. Such a game would not have to be long, perhaps 10-15 minutes as is the case with *Operation Deadstick*, but it would need to be a complete game, including cosmetics, underlying technical systems, and design. This would no doubt breed interesting problems that would require interdisciplinary solutions.

Once the game is complete, we could go about evaluating not only its historical accuracy, but also its efficacy in the transmission of historical content. The evaluation of the historical content could be done by giving the game to a panel of historians, having them play and review the game, and then engage in a debate to determine the merit of the game as a historiographical object.

Working with those from education, this study could be used to determine the game's effectiveness as an educational tool when compared to traditional methods. — a long standing goal of those who create and evaluate serious games. This study would be randomized controlled trial; a population would be divided into one of three groups. Group A would be the control group who is assigned to read an article about a historical event. Group B is a group that plays a game that has been created for the purpose of portraying the same historical event. Group C would be a group that both reads the article and plays the game. After each participant has finished their assigned media objects, the could write a test consisting of standardized questions. The scores of these tests could then be compared to determine the efficacy of the

game both as a primary object for study, but also as a supplementary object. With regards to time, there are two different approaches that could be taken. The time that each group has to finish their content could be restricted to a fixed amount of time. So players in group A or B have thirty minutes to study the text or play the game, and players in group C have fifteen minutes to read the study material and fifteen minutes to play the game. Additionally, the participants may not have their time restricted, and instead be offered a high value reward for achievement on the test. In this case, players can also have their engagement with the object be studied as well. The work that would be done as part of doctoral research in the field of historically accurate game design could have serious and important implications in not only the field of history, and game studies, but also other fields of research.

Historians strive to create an understanding of a historical event through the examination and debate of historical traces. This has given rise to one of the central questions of history: can we ever really know what happened? As historians describe and discuss historical events through various mediums, including text, film, and games, we are striving to create an accurate representation and picture of the past. As Rosenstone has said, the account of history that historians present can itself never be literal. The drive for the creation of a historically accurate game is an effort to present a historical argument in a new medium. By creating a new channel for historiographic debate, we can consider new perspectives, discover new ideas, and entice new audiences. This diversity does not weaken the study of history through interactivity and novel approaches; it strengthens the historical community through debate, scholarship, and perhaps even attracting a new generation of historians.

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