Northern Arizona University

Flagstaff, Arizona 86011

October 27th, 2016

Dr. Elmer Grubbs

NAU Faculty Member

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Flagstaff, Arizona 86011

Dr. Grubbs,

On behalf of the both of us, Liam Burke and John Miscevich, we would like to, once again, extend our gratitude and appreciation for your presentation of this capstone project, as well as your flexibility and leniency in allowing us to undertake it, despite our unorthodox two man team. Additionally, in the numerous interactions and meetings we have had, you have served as a phenomenal resource as our faculty advisor and for that, we would also like to thank you.

The project being discussed is, of course, the virtual reality and big data integration project. The project, as a whole, seeks to integrate large data sets and data analysis into a virtual world using emerging virtual reality technologies, as well as motion based controls. Using intuitive gestures and an inviting virtual environment, the user will be able to view and analyze large data sets, providing an alternative option to existing, less engaging data analysis software.

As with all endeavors that the two of us undertake, we are incredibly excited for the project and will dedicate our fullest efforts to its completion. We understand that because our team is half the size of a traditional capstone team, certain accommodations will be made in regards to how much is expected of us, but it is our goal to not only meet the set expectations, but to pleasantly surprise you by exceeding them. If you choose to accept the presented proposal, you will receive the time, effort, and skillset of two electrical and computer engineering undergraduate students, driven both by their self interest in the project and by their desire to satisfy you, the client.

As previously discussed in person, in regards to budgetary concerns and finances, both the capstone team, as well as yourself, seem to hold the same prediction that purchases for this project will most likely not be necessary; however, in the event that a necessary expenditure does arise, it will be handled through the proper channels, namely, the university.

Included in this client proposal document is an array of critical components that will serve to ensure that both our team, as well as yourself, have congruent ideas and goals in regards to the project. These components, while briefly mentioned here, can be referenced and located more readily via the table of contents section of this document. Some of the components of this attachment include an executive summary of the project, an overview of the project, research conducted, a design section, a budgetary section, a deliverables timeline, and an acceptance document on the final page.

Of the listed component, one that we would like to highlight is the acceptance document, attached as the final page of the proposal. As the name implies, the acceptance document serves as a mutual agreement between both parties in regards to the work that will be done, as well as when and how it will be done. Although we understand the necessity to careful read over and review this proposal, we ask that, should you accept, you return the acceptance document to us at your earliest convenience. In the event that you choose not to accept the terms presented in this proposal, please contact us so that we may begin an open discussion and negotiation on terms that you would like to see amended.

Thank you for your time, assistance, and for granting us your confidence in this project.

Sincerely,

Liam Burke and

John Miscevich

**CC Distribution:** Dr. David Scott, Capstone Instructor and NAU Faculty Member



Northern Arizona University

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EE476C

Virtual Reality and Data Analysis

Client Proposal

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**Executive Summary**

This executive summary seeks to provide a comprehensive summation of the project, including completed work, proposed design concepts, deliverables, and budgetary information.

Currently, the majority of the work done on the project has been solely preparatory. One component of this preparatory stage has been research, to be discussed further in a following section. However, a substantially larger portion of the preparatory stage has been attaining knowledge and developing experience with all of the critical software that will be used for the project. This includes, for example, creating multiple minor projects in Unity 3D, developing simple apps with Android Studio, and working with the Microsoft Kinect SDK. Although the described projects do not immediately and directly affect the status of the capstone project, they are still critical, in that they provide the capstone team with practice in using common strategies, functions, and troubleshooting common issues with the software that the project relies on.

Although the majority of the work on the project has been preparatory, there has been positive advancement in the actual development and implementation of the project. Namely, advancements have been made in using Unity 3D to develop the virtual world where the user will interact with icons and graphical data. Currently, the primary selection page is completely functional, wherein the user can choose which militaristic equipment they would like to see data on, complete with interactivity and head tracking. However, it should be noted that physical motions not relating to sight have not yet been implemented. Additionally, the graphical user interface (GUI) that the user will interact with for selecting data is being designed and developed. Overall, although the implementation phase has been modest, it is quickly growing and lends itself to further advancement.

Our proposed design concept is relatively unchanged from what was suggested by you, as well as what was presented for the midterm status update. Due to the heavily software oriented nature of this project, the design concept has been firmly set from the beginning. The user will utilize an Oculus Rift DK2 virtual reality headset to immerse themselves in a virtual world, run by the Unity 3D game engine. The Microsoft Kinect will be integrated to allow the user to utilize physical motions to control their experience. The design of the virtual world, however, will vary per each individual scene, depending on your specific requests.

Upon completion of the project, it is estimated that there will be 3 distinct, large deliverables from the project team to the client. These deliverables are as follows: a zipped folder containing every piece of code necessary to make the project function on any computer, a cell phone application that will track the user’s accelerometer data and coordinate with the on-computer software, and a user manual that can be utilized and referenced by anyone seeking to use the project in its final form.

Throughout the duration of the project, there will be numerous key milestones, marking significant accomplishments as the project progresses. This list is tentative, as new desired milestones may be added at any time, or perhaps milestones will be removed as design decisions are made, but the following list can serve as a useful guideline. The first milestone, already completed, was to develop a “main” page, wherein the user selects what type of military technology they would like to view. The second milestone, currently in progress, is to develop the “selection” scene and GUI, wherein the user chooses the model and the type of testing they would like to see data for. Upon the completion of these milestones, you will be presented with the progress, so that he may judge the functionality, interactivity, and aesthetics of each scene. Per your requests, we can revisit those milestones and make amendments to them, if necessary. Once all of the necessary scenes are completed, the next milestone will be the proper implementation of graphical data within the virtual world. Next, and potentially the most arduous task, will be the integration between the user’s physical motions to control the virtual world around them. Then, proper documentation and writing of the user manual will follow. Finally, if timing of the semester and graduation permits it, a mobile phone application will be delivered that can perform numerous varying tasks, linked to the software at all times.

Regarding budgetary matters, both you and the capstone team are in agreement that expenditures will most likely not be necessary. From this prediction, it follows that the current estimated budget is zero dollars. However, you have expressed your openness and flexibility in the matter, should a critical necessity for purchase arise, granted it is approved by both members of the team, as well as yourself.

#

**Project Overview**

Presently, the project overview and system depiction has remained unchanged. Fortunately, the knowledge and discoveries gained through research and experimentation have not led to the necessity to restructure the project in any way. In fact, the project has been progressing quite smoothly as it was originally planned, and thus the original project overview and the original system depiction still serve to be accurate and complete.

As a general overview, the aim of the project is to utilize virtual reality to view and analyze large sets of data.

To view the project on a narrower scope, this entails breaking the project into three smaller subtasks, and then coordinating those three subtasks so that they operate together as one, cohesive project.

Task one consists of developing and displaying the virtual world that the user sees. For this, the desire is that the user can sort the data through simplified visions and icons, instead of dense, uninteresting text. For instance, if a user wanted to see data sets regarding flight testing, instead of navigating to the data through text and “point-and-click” operating, they would simply be able to select a 3D image of an airplane to see such data. Task one for the team is to create the world and the icons that the user sees in the Unity game engine, and provide it functionality.

Task two consists of tracking and linking the user’s physical movements to the virtual world. Although a virtual reality headset allows the user to “look around” the created world, the motion tracking affiliated with them is rather primitive. Because of this, a Microsoft Kinect will be utilize to track the user’s motion in an immensely specific and detailed way. This motion tracking will then allow the user to now see, interact, and move within the virtual world developed in the first task.

The third task would be to implement the data aspect of the project. This specific task contains two subtasks within itself. The first of these subtasks is to visualize the data in graphical form within the virtual world. This means showing the user graphs, charts, or figures from big data sets, within the Unity Engine. The second subtask consists of developing gestures and programming the Microsoft Kinect, so that certain motions the user makes can directly alter the contents of the data they are seeing. This includes zooming in or out on certain portions of the graph, scaling the graph differently, and highlighting certain points.

The culmination of these three tasks will yield a cohesive project, wherein the user can see graphical data within a virtual world, and then use his or her real life, physical motions to better modify the visual representations.

The following page contains a high-level visualization of the capstone project:

##

**Image 1. A Visual Overview of the Capstone Project**

The image above provides a brief, high-level visualization of how the project will work. A virtual reality headset, a Microsoft Kinect, and a graphing software will all three be coordinated and constantly working in conjunction with one another to provide the user with easy to manipulate, interactive data visualizations that encompass the entirety of the user’s (virtual) reality. All three of the subsystems involved will be concurrently running and constantly “communicating” with each other, as these three subsystems will be co-dependent upon one another in the final implementation of the project.

**Research**

**Liam Burke**

The research phase began with a group meeting consisting of both team members and the project supervisor, Dr. Elmer Grubbs. This meeting provided an opportunity for both members to not only ask any questions regarding the software that will be used on the capstone project, but a somewhat casual tutorial of each of the components to the project from an individual who has been working on said project for over a year up to this point. He demonstrated several tools that would be of use in the Unity Engine, how the Kinect system would work, specifically how it could be used to read hand gestures (specific to the project) and other bodily movements, and finally, allowed each member to personally test the Oculus Rift VR headset. This allowed each member to see how the 3D environment was transferred to the interactive headset. This first step quickly allowed immersion into the software that will be used for the duration of this project. From this point, research on the Kinect, Unity Engine, and Oculus Rift was done separately. First came a bit of research on the Oculus Rift, which dealt with reading the manual for the hardware and simply understanding how to properly use the VR headset and make sure if we ever run into a simple problem, it can be dealt with quickly and easily. [1] For the Unity Engine, there is a very helpful website, https://unity3d.com/learn/tutorials, which includes many different tutorials covering example projects, ranging from beginner difficulty to some more complex projects. Each tutorial is fairly extensive, including not only an introduction and specific tasks to complete the given project, but general concepts to help acquaint individuals with the given software. [2] In terms of the Kinect, besides downloading the IDE and attaining the existing source code, extensive research in regards to the functions and uses of the Kinect software has yet to be done. Finally, all existing code was transferred to a personal computer so that it could be examined line-by-line to see exactly how the code operates and the functions that it possesses. Inspection of the current code is still minimal, but more shall be done in the near future, especially with the design phase coming upon us. Until now, the research that has been done has been to become familiar with the Kinect, Unity Engine, and Oculus Rift before diving into the code already written for the capstone project.

In terms of the current technology being used for this project, there are upgrades or other options to be considered. For example, the Oculus Rift in our possession is an original test model that still runs on Windows 8 rather than the most current update of Microsoft Windows. There are newer models of the Oculus Rift to look into, as well as others such as Samsung Gear VR and Google Glasses. At this point, because of monetary constraints and how much has already been completed with the current Oculus Rift, it does not seem beneficial to find a new VR headset and start from the beginning. However, this is a possibility that will be revisited in the future. In addition, the existing code was written for Unity software that has since been slightly changed and updated. As discussed with our advisor, we will be updating to the most recent version of Unity and making changes to the existing project as necessary. In terms of more creative or efficient ways of solving the problem given to us, it seems the best way to handle this project is to use the tools already given to us because of the great deal of existing source code that we already have at our disposal. If problems are encountered that cannot be solved because we are limited by the technology given to us, only at that point will we seek alternative solutions in our software and technologies.

**John Miscevich**

Due to the rather unconventional nature of the two-man capstone team, and because both team members are expected to equally and fairly contribute the same amount of work to the project, please be warned that there will be large amounts of research and information overlap between both partners, so that they may be equally as useful to completion of the capstone.

Because this project is the expansion upon a previously existing, previously worked on project, the first and foremost piece of research consisted of a meeting between both team members, as well as the Client/Faculty Advisor, Dr. Elmer Grubbs. During this meeting, Dr. Grubbs made clear the expectations, desires, technologies, and current progress on the project.

One such technology is the game development software to create the 3D virtual world. Although there is a vast array of 3D game development engines, the one that is currently in use is the Unity Engine [3]. Between the Unity Engine and the other potential game development softwares, there are many trivial, minute differences between them. However, these differences are so small, that it would serve no benefit to utilize another software and, in fact, might actually serve as a detriment to the project. The source of this detriment to the project stems mainly from the fact that there is already existing code that functions well in Unity. Utilizing C#, the Unity Engine has played a firm role in the existing project, and to change the selection of game development engines would mean not only having to entirely redevelop what has already been done, but having to port the existing C# code to different languages to accommodate the different engines (such as Lua for CryEngine, or C++ for Unreal Engine). Fortunately, the use of the Unity Engine is entirely free, and its open source nature negate any issues of patenting or market conditions. Conclusively, more research into this specific sect of the project will entail learning, examining, and developing a proficiency in the Unity Engine game development software (including the necessary C#).

The second piece of technology that is associated with this project is the Microsoft Kinect. Motion sensing and motion controlled technologies are a (somewhat) recently emerging technology, and are found in many facets of life. Perhaps most noticeably is in the world of video games. For example, Sony’s PlayStation utilizes motion sensing technology for their PlayStation Move, and the Nintendo Wii is an entirely motion based gaming console. However, a major drawback to these types of motion sensing devices is that they sense motion based on a controller, not the user’s body and physical actions. Different from the Xbox Kinect, the Microsoft Kinect (a distinction that must be made, as it is easy to confuse the two), is a motion tracking device that tracks the user’s body and body data, designed for a more intensive, “data dense” tracking. In all regards, the Microsoft Kinect best fits as the hardware to utilize for this project, and to change it would cause a large setback and delay in development. Not only would it not be feasible to purchase a new motion detection device due to budgetary restraints, but, as with the Unity Engine, it would set the project back because it require use of new software and code, independent of what has already been developed. Development for the Microsoft Kinect is done via the Microsoft Kinect SDK, and coding is done most heavily in C# and C++ [4]. Thus, extensive research into this technology will include (as with the Unity Engine, above) learning, examining, and developing a proficiency in the Kinect SDK (including the necessary C# and C++).

The third and final piece of technology that is currently affiliated with the capstone project is the virtual reality headset. Although there is a considerable (and ever growing) market for virtual reality headsets, the one currently in use is the Oculus Rift DK2 [5]. Although there are competitors in the virtual reality headset industry, all with minor variances in the hardware and software they use, the currently utilized headset is the best choice for this project. The Oculus Rift company is the most well-known, most thoroughly established VR company to date, and the DK2 is their most up-to-date version of their product. Additionally, it offers massive benefits, such as being directly integrated into the Unity Engine, so ease of development is a large advantage. However, perhaps the largest advantage of the current headset, as well as the main disadvantage of attempting to utilize a new solution would be availability. As with other components of this pre-existing project, the Oculus Rift is already in our possession. Thus, in addition to being impossible due to budgetary restrictions, purchasing a new headset would require completely redoing and redeveloping everything that has currently be done.

Conclusively, for this project, hardware (and even the choice of development tools) is an unwavering, hard constraint. This constraint produces an interesting development in the project, in that all research has taken, and will take, the form of simply analyzing code and development tools. Rather than the traditional capstone style of researching hardware, developing schematics, and potentially producing mechanical output, this project and its research will consist almost solely of developing software and programming.

Any research included below the horizontal line, above, is research that has been conducted following the midterm status update. Because the time period between the midterm status update and the current proposal deliverable was a brief two weeks, the research conducted during this time is less extensive than prior to the midterm deadline.

The majority of the research conducted during this period was done in regards to understanding and gaining familiarity with the necessary software. This includes video tutorials, experimentation, support and help forums, and creating my own minor projects. I understand that this research is not entirely “traditional” research that can be cited and referenced, but I still believe it to be a vital part of completing the capstone project, for if I did not have a firm competency in the software that is utilized in this project, we would be unable to make any progress.

Although a majority of the research was simply experimentation and taking a “hands on” approach with the software, we did conduct a small amount of research into pertinent topics that will arise later on in the project.

The main topic that was researched was how the graphical data would be displayed within the virtual world. There has been a great deal of discussion as to how to accomplish this, be it through Unity 3D’s engine, itself, or if an external graphing program would have to be referenced. However, there have been multiple online sources that are being looked into further that claim that graphing can be implemented within Unity, using C# scripts [7][8]. Specifically, these sources claim that particle systems can be used to produce both two dimensional and three dimensional graphs. If these claims serve to be true and if we can properly implement these concepts into our virtual world, that would be a phenomenal way to keep the project firmly coupled, as we would not have to reference or run a third party graphing software.

Because the graphing phase of the project is some time in the future, this research was incredibly superficial and preliminary. However, as the time to implement graphing in the project grows closer, the team will delve into these concepts more and do even more extensive research. Creating and utilizing graphs within the Unity 3D engine, itself, was quickly glossed over, for now, but it is sure to be revisited, as it is a very promising concept that our team would love to implement in our own project, if possible.

One final facet of research that will begin and will remain ongoing throughout the course of the capstone project will be in regards to newer, upcoming virtual reality technologies and products, as they become available. Although these newer technologies will not be utilized for this specific project, necessarily, looking into future and upcoming developments will allow both the capstone team, as well as yourself, to be as knowledgeable as possible in the field and produce a product that will remain relevant for as long as possible. In a word, the studying and research of upcoming technologies will allow the team to prepare and improve the longevity of the final product.

References

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Additional References

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[7] "Graphs, a Unity C# Tutorial." Graphs, a Unity C# Tutorial. N.p., n.d. Web. Nov. 2016. <http://catlikecoding.com/unity/tutorials/graphs/>.

[8] Textcube. "Unity 3D Box Chart Graph Quick Making." YouTube. YouTube, 07 July 2013. Web. Nov. 2016. <https://www.youtube.com/watch?v=ilwtKe4CFIU>.

**Requirements and Specifications**

As with the project overview and the project depiction, the information gained via research has not led to any major necessity for restructuring requirements and specifications, and fortunately, the project has been progressing smoothly enough that no additional, hindering restraints have emerged. Because of this, the below requirements bear heavy similarity to the original requirements posed in the midterm status update documentation. However, the section containing the most alterations to it is the “Software/GUI Requirements” section.

**Mechanical Requirements**
For this capstone project, we are limited by the wired Oculus Rift VR headset, along with the precision and accuracy of the Kinect system. Because the VR headset is wired, there is only so much distance that a user can put between themselves and the computer it is drawing power from. Along with distance, the user could potentially have issues when “circumnavigating” the virtual room, becoming entangled in the chords connecting the headset to the computer. Although this may detract from the experience, it should not hinder the overall purpose of the program, which is to allow an individual to enter a virtual room filled with different weapons and technologies, and allow them to gain information on all of the following with specifications, graphs, and more provided to the group by the advisor. Another mechanical constraint is how precise and accurate the Kinect system will be when reading the hand and body gestures of the user. Placement of the Kinect camera, along with any surrounding items potentially blocking the movements of the user, are all potential limitations for the Kinect Camera, but not necessarily a guaranteed constraint. In addition, there must always be a concern, from an organizational standpoint, as to how the user moves. Because there is a physical tether to the VR headset, the designs of the motion must be such that the user never tangles themselves in any of the physical wires coming from the hardware. Finally, whenever not in use, the hardware must be adequately and properly stored in an indoor environment, as to prevent degradation to the hardware.

**Electrical Requirements**
The setup for this project will be as follows: the Oculus Rift VR headset will be connected to a personal computer, which will be running the Unity program we devise, and the Kinect camera will also be connected to the computer and facing the user. After finding that the Oculus Rift draws 5V of power while the Kinect typically draws about 12V, power consumption will not be a problem for this design. However, aging is a constraint that the group must take into account. Our aging technology may not only become obsolete because of the ever changing and updating devices, but because over time, the VR headset and Kinect Camera may endure some wear and tear and not always be as efficient and reliable as when they were first used. One thing to keep in mind during the design and implementation of the project is to try and ensure the longevity as long as possible. This entails making the equipment and software as “universal” as possible, so that new releases of hardware or software will not instantaneously deem the project obsolete or non-functioning.

**Environmental Requirements**
The hardware and software will, as of now, solely be subjected to conditions faced in an indoor environment, so it must be able to withstand these relatively tame conditions, both in use and in storage.

**Documentation Requirements**
The separate pieces of hardware and software (Oculus Rift, Kinect, and Unity Engine) each have their own User’s guides and Operator Manuals. This project will need to include its own user manual that shows how to setup the hardware used for this project, along with instructions on how a user can navigate the virtual 3D environment that we will be creating. Within the manual, there shall include guides on how the user can choose specific elements in the environment, how they can maneuver their way through different types of data (specifications sheets, data sheets, graphs, etc.), the hand gestures that can be used with the Kinect camera, and more.
 ●User Guide: This project will have a user guide that includes how to setup the hardware

provided with the design, along with how an individual would go about using the system developed in Unity.

**Software/GUI Requirements**

One major limitation of the project, currently, is the large graphics requirement that is associated with virtual reality. Namely, to keep the project portable and runnable on the given laptop, the laptop is constrained to the Windows 8 Operating System. Unity and Oculus are capable of running and, in fact, even run better on Windows 10. However, the laptop provided does not have the proper graphics card to run the necessary softwares on Windows 10. In addition, the group will be using the Unity Engine and Kinect SDK, as described by the project supervisor, and constraints will become more apparent as the project develops into further stages. As of this moment, it would appear that we are limited to what the Unity library offers us in terms of three dimensional figures to be placed in our virtual environment. We have decided, in terms of the Kinect, that we not only want to incorporate hand movements to this project for choosing elements in the virtual environment, but incorporate voice commands to the system using the Kinect.
● Unity Engine: Unity will be the software used to create the 3D virtual environment.
● Kinect: The Kinect will be used to allow the user to interface with the system using hand gestures, body movements, and voice commands.
● Oculus Rift: The Oculus Rift is the VR headset that will be used, allowing the user to have a more realistic connection to the 3D virtual world.

**General Requirements**
This project needs to have longevity, and be able to be easily updated and modified so that when new technologies are available for use, this project will not become completely obsolete. This project must also be easily understood and operated; for the user to get the most out of their experience with the program, it must be absolutely clear what can be done in the program, along with the ways the tasks can be accomplished. Finally, the experience for the user must be a comfortable one; an individual would not be able to enjoy a 3D virtual environment if they are not comfortable while working with the program. Overall, the general requirements are the desires of the client and advisor, Dr. Elmer Grubbs. Additionally, because the project is heavily software and user oriented, the concerns of the user must always be kept in mind. This includes making the project as intuitive, easy to learn, and comfortable as possible by utilizing principles of universal usability.

**Project Design**

**Design Description**

Many of the chosen design concepts and approaches are those that were provided by Dr. Grubbs, himself. For example, Dr. Grubbs has recommended that the Unity 3D game engine be used for designing the virtual world and the Microsoft Kinect SDK be used for tracking and logging motion. Through various research and experimentation, both of these suggestions have been proven to be the most viable options, and will thus be implemented in the project.

Additionally, the layout of the implemented project has been firmly set as a desired constraint, from the beginning. Namely, Dr. Grubbs, the client, has made it clear how he would like the user experience to progress. Specifically, he would like the users to begin by seeing iconic representations of military equipment, such as a tank, an airplane, and a missile. Upon the user selecting their desired equipment, they will be prompted for more information, such as the specific model of the equipment they selected, as well as the type of testing that was done. Once the user has selected these two parameters they will, of course, be taken to the scene that will display all of the testing done that meets those requirements. Once on this scene, the user can finally select from individual tests that were done, each of which will take the user to the graphical data, to be visualized and analyzed at their leisure.

Because these are firm constraints set by the client, the design mentioned above will be utilized and implemented. However, there may exist some variation in the design of each individual scene, in terms of user interactivity and aesthetics. These design decisions, at the time of their implementation, will be presented to Dr. Grubbs, approved, and then implemented. Upon completion of each scene, Dr. Grubbs will experiment and prototype the existing project and make clear his satisfaction, or state improvements he would like to be made.

Due to the nature of this project, the design of each scene is very much tentative and can change per the client’s request. The client has made clear his desires in terms of what he wants and how he wants the project to function, so it is simply a matter of the capstone team implementing his wishes and ensuring that they meet his expectations, after they have been completed. Any time that the client’s expectations are met, the scenes and functionalities will be saved and improved upon for the final project. Any time that the client feels his expectations or his vision for the project are not congruent with what is delivered to him, the capstone team will revisit that portion of the project to make improvements upon it.

Although the design will be presented in a piecewise, constantly updating fashion, the capstone team would still like to present the current vision of the project, to ensure that it is congruent with what you had in mind.

* The user begins in a virtual environment. In front of them is a table with three pieces of military equipment. The user is able to look around and interact with all three items on the table via head or motion tracking.
* Upon selecting a piece of equipment, the user is taken to a virtual menu where the user selects two (2) parameters on the same page – the user selects the model of the equipment they desire information on, as well as the specific type of test they want to see data on.
* Once the user has selected the two parameters listed above, they are taken to one more virtual menu that contains numerous dates. These are the dates that the tests they have selected have taken place.
* Finally, once a date has been selected, the user is taken to the graphical data, the representation of which they can alter and modify via physical movements.

**Realistic Constraints**

**Budgetary Concerns**

Up to this point in the development of our system, there has only been one constraint that has impacted our design; cost. Because the team has already been provided with the necessary technological equipment to go about successfully completing this project, and because Unity has cost-free kits, packages, and models, the team has deemed it unnecessary to develop a budget on this project. With this being said, if a need were to arise, the team could contact you and discuss whether or not said need was worth the cost. But overall, the notion to keep the budget at zero has impacted both the design and the design process.

**Universal Usability and Ease of Use**

The team expects to be impacted by several other realistic constraints over the course of this project. Social constraints or obstacles would most likely impact the design and design process in the form of ease of use of the system. When initially discussing the design of the project, the team had decided that because this program is one that would be used by individuals of varying expertise and background knowledge, it would need to be both easy to comprehend and navigate. One way the team plans on making sure of this is by conducting surveys with the general public, finding, for example, what hand motions seem the most practical for accomplishing specific tasks when manipulating the virtual environment or the data that is displayed within it.

**Longevity and Sustainability**

The group has also recognized that sustainability and safety are two more constraints that must be recognized while planning in regards to our design and the design process. Developing a program that can be updated and revised in order to keep it from becoming stagnant and, eventually, extinct from the general population is definitely something to be kept in mind throughout the entirety of the design process. By using Unity, we have a software that is not only easy to access and change, but it is also not extremely difficult to update code when Unity itself has an update.

**Health and Safety**

Safety is also a constraint because, as with any design, the team would like to avoid injury to the users at all cost. The main idea that may pose a threat in terms of safety is the fact that the system utilizes virtual reality, which cuts off an individual's sight to their surroundings. Without being able to see what is going on around them, this could cause safety risks. The group plans to handle this by including disclaimers in the user manual, stating that this program is best used either seated or with another individual within the vicinity.

**Capstone Budget:**

You and the university have already provided the Virtual Reality Capstone project with a set of Oculus Rift virtual reality goggles, a Kinect camera, both a desktop and laptop, and all of the necessary software and kits to go about completing this project. As of right now, because of the fact that the Unity packages downloaded have been cost-free, this group expects to complete this project without having to be supplied with additional funds. This means that there is no expected bill of materials, services, software, or travel that will require payment or reimbursement.

However, as previously mentioned, should an unforeseen necessary expenditure arise, it has been discussed that the capstone team, in conjunction with yourself, will go through the proper channels via the university to cover any expenditures.

We understand that a lack of necessary expenditures is relatively uncommon for a capstone project, but we will do our best to ensure that the project is completed at the lowest cost to the university as possible. Ideally, we will seek to complete the project without the need for any purchases.

**Schedule & Deliverables:**

Over the coming months, as depicted in the Gantt chart in Appendix A, there are several major tasks to complete in order to successfully accomplish the capstone project. The group's first task will be completing the three-dimensional virtual environment using Unity, and this task has been broken down into several sub tasks. As of right now, the environment has been developed and the setting contains all of the necessary components. Next on the agenda is to develop the “selection” scene and set up the graphical user interface.

The deadline has been set to complete the “selection” scene and the “dates” scene by the end of the fall semester, and then starting in the spring semester, the group plans to spend two weeks implementing graphical data into the virtual world. Following this, the group will move on to implementing the Kinect camera to the system. As shown in the Gantt chart, the group plans to spend approximately 30 days focused on the integration of a user’s physical motions in order to control the virtual world around them.

By April 5th, the group hopes to have all components of the project completed, revised, and augmented to be as efficient as it can possibly be. With all of this work complete, all code used in the project can be zipped to a folder, allowing the program to be used on any computer system. The final component to be completed, which will be worked on throughout the spring semester, is the creation of a user manual that can be referenced by any user in need of aid while using the program designed. If time permits, the group also hopes to spend time developing a phone application for the system, which would hopefully be completed by the beginning of the month of May.

The deliverables for this project, as described in the executive summary, will be a zipped folder containing all of the necessary code and software to make the project function, a user manual that easily communicates to a non-technical user base how to utilize the project, and, potentially, a smartphone application that has linking capabilities with the project.

Through the duration of the semester, research of virtual reality advances, as well as the hardware and graphics card requirements to run those advances will take place. There exists no formal deadlines or deliverables for this aspect, but the research will be continuous and ongoing throughout the entire semester. As described in the research section, above, this will serve to provide the capstone team with better knowledge to improve the longevity of the project.

Additionally, throughout the semester, the capstone team will be presented with numerous assignments and deliverables in conjunction with the EE476C course. Occasionally, these assignments will be deliverables turned into yourself. However, for the most part, these assignments will be assigned by and turned in to Dr. David Scott. Although you are always welcome to view these completed assignments, unless instructed to do so, we will do our best to not inconvenience you with the minor assignments given as part of the capstone course. These assignments and class deliverables, although not explicitly included in the Gantt chart or outline for the project, will be completed and turned in on the days and times assigned by Dr. David Scott, the professor for the EE476 capstone course.

**Appendix A**



**Image 2: A Tentative Gantt Chart Outlining Desired Milestone and Accomplishment Deadlines**

**Acceptance Document:**



The above proposal outlines a tentative agreement that will bind both the capstone team and the capstone client, Dr. Elmer Grubbs, to the above listed expectations. This proposal, then, may be referenced at any time throughout the course of the project, to hold either parties accountable during the capstone process. Should the client be in disagreement with any of the above expectations or parameters set in the proposal, we ask that he contacts us at either jdm476@nau.edu or lwb32@nau.edu, so that we may arrange a formal meeting to discuss and negotiate terms.

In signing this agreement, please be aware of the liability. The capstone team undertaking your project is comprised of two undergraduate students and they do not yet hold the title or certification of “engineers”. The work they are providing, although it will be of the utmost effort and quality they can produce, is not to be taken as industrial or, even more rigorous, militaristic quality. Upon completion of the project, the client, Dr. Elmer Grubbs, will retain full ownership of the materials used in the development of the project, as well as the completed project, itself. Any and all uses and applications of the final, completed project are done so at the risk of the user.

By signing below, all parties acknowledge that they have read, understand, and agree to the terms and expectations laid out in the entirety of this proposal.

Member 1 Signature: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Member 2 Signature: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Client Signature: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_