Visualization of Earth Modeling System

PROJECT PLAN

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Contents

1 Introduction

1.1 PROJECT STATEMENT

The product we are to build consists of a web application that allows users to query and view various maps that represent "natural and anthropogenic stresses" (compounds that are added to the ecosystem). Our client (Prof. Chaoqun Lu) currently develops 2D .tiff images (see Appendix 9.1) that represent maps of various compounds and would like us to create a platform that would allow dynamic loading of her various maps onto a 3D space (see Appendix 9.2). Currently, our client analyzes compounds using a proprietary algorithm and creates a graph data stored in an ASCII (American Standard Code for Information Interchange) format. The client has two issues as stands: The first is the computation of this graph data takes several days or weeks for each model. The second is the client has no easy way to display this data for actors to view and interact with it. The goal of our project is to focus on the second issue: provide a way for interested parties to view data in a user-friendly and interactive 3D environment. If time permits, our secondary goal is to use our computer science knowledge to see if we can assist our client in speeding up her algorithm.

1.2 PURPOSE

The Visual Earth Modeling System will allow various policy makers (government, grant societies, etc.) and land managers (real-estate, governmental, farmers) to see, further analyze, and understand spatial patterns of various gas compounds, water discharges, and nutrient movement. Allowing these stakeholders to further understand the environment will aid them in making decisions in reference to pollution policy, development of land to be used for various crops, grant making, etc.

1.3 GOALS

In addition to helping our client bring her work to an interactive and 3D space:

- Create a platform which allows user to view monthly mappings of various compounds.
- Create a platform which allows users to forecast the effects of various compounds onto the environment.
- Build a tool that can be used as a global learning tool to help interested parties understand the implications of human procedures on the general ecosystem.
- Build a sound product that could be further implemented in the future (by us or others) if the client so wishes.
- Create a tool that automatically creates visual representations without additional effort necessary from the client.

2 Deliverables

The deliverables to meet the projects goals are as followed:

- Webpage that displays various layers of compounds onto a 3D space.
- 3D layering that can be dynamically loaded and chosen by the user for every available data model.

- Web-Hosted parser to allow client to parse ASCII maps into dynamically loading webpages.

3 Design

3.1 PREVIOUS WORK/LITERATURE

Since ArcGIS is the platform that we have chosen to develop on, the bulk of the informational material required to map this project will be provided by the ArcGIS API. Throughout the semesters, we will be able to go through and view, edit, and create various pieces onto which our client will be able to pick which data-type she prefers. Once semester two starts, we will likely have to look into dynamically creating ArcGIS layers using the ArcGIS API (3). We have also contacted an Iowa State ArcGIS analyst, named Josh Obrecht, who has said he would be happy to share his expertise if we require it.

One of the similar products that we looked into was Landmark's DecisionSpace Earth Modeling (see Appendix 9.4). In a nutshell, this program not only displays 3D graphical data to the user, but also allows the user to further understand the values that are being placed (4). It also allows for the dynamic elements that we may have to incorporate in semester two, which is why this program may be of help to us moving forward. If we are able to utilize the physics and pixel-to-pixel communication of dynamic objects, this would be another possible implementation.

There is currently similar work being done by the United States Geological Survey (USGS). Their site provides real-time data on current and past conditions and how this impacts current predictive observations of Earth. An example of data processing that is similar to work done by our client is related to water discharge. Specifically, from the USGS site one can see that a map of the U.S. that shows daily streamflow percentages. Dynamically loading data is provided through the ability to click on a specific state for more details (see Appendix 9.5).

3.2 PROPOSED SYSTEM BLOCK DIAGRAM

See Appendix 9.3.

3.3 ASSESSMENT OF PROPOSED METHODS

In terms of how we can go about tackling the project: we can do one of two things, start bottom-up or go top-down. Bottom-up would be starting with the easier components (plotting the clients data, storing the data, and creating the tool for her display) and then moving into custom generation of user interaction. Top-down would essentially be the same methods, but reversed.

Due to our unfamiliarity with the platform, we have chosen to start bottom-up and follow an agile-like approach. By completing the client's platform requirements first, we will be able to better understand the platform further and gain valuable domain knowledge.

As our team consists of software and computer engineers, we believe in developing in short, iterative cycles. Validation involves demoing what we've worked on in each "sprint" to our client and asking for input. By only working on small segments at a time and prompting the client for feedback at each stage along the way, we can ensure that the client gets what she wants without spending extended time dealing with problems like incorrect design or changing requirements.

3.4 VALIDATION

Our product will be finalized when end users are able to queue up the 3D environment, interact with the environment, and dynamically load all of the data that the client currently has in 2D visuals, onto a 3D space. The client will also be able to upload all future calculated mappings using the previous format demonstrated in her ASCII files. These mappings will be uploaded to the server and be selectable by any end user. For extended life-cycle demonstrations, the plan is to provide users with the ability to introduce various selectable compounds to the 3D environment.

4 Project Requirements/Specifications

4.1 FUNCTIONAL

Demonstrate climate change dynamics across space: A website that projects the ASCII data given to us by the client on a 3D model of a globe (visual data modeling).

Automated generation of webpages: The client should be able to easily upload an ASCII file and the system would have to convert that input into the necessary format to create the 3D model. Additionally, the system would have to automatically generate the corresponding webpage/CSV file.

Display selective years/months: The system would need to provide a way for people to view data for other years and months. As it currently stands, we plan to have a CSV valued static webpage for each month of every year, so any given webpage will need to provide functionality to forward a user to the relevant webpage via a drop down menu.

Cross-time animation: finally, the client would like to be able to introduce pixel-to-pixel communication that will allow for further examination of values.

4.2 NON-FUNCTIONAL

Page speed: Since this project deals with client-side processing of graphics, the website should be able to load in sufficient time. We define sufficient time to be 2 seconds to initial page load, and 5 seconds till full generation of the page. This assumes a modern processor (i5-6600K, for example), a graphics processing unit with full WebGL support, and a client that is on the University's gigabit Local Area Network.

Generation speed: The automatic generation of webpages should be viewable on the live website within 15 minutes of the client starting the process. In other words, depending on implementation, the server should poll for newly uploaded ASCII data at least every 15 minutes.

Display Size: When values are toggled, the values should be appropriately sized to the point that they will not cascade, or billboard, toward the user. The user should be able to differentiate between various points / layers not only through color, but by size.

5 Challenges

Some of the early challenges our team came across with was that the original plan for the project was to use Google Earth as our main platform. Unfortunately, our team quickly came to the realization that Google Earth is deprecated, and we had to look for alternative methods to model the data. Once our team found a suitable replacement came our hardest task to date: creating an Earth Visualization Model from scratch.

Currently, we are utilizing ArcGIS for JavaScript 4.1 to model the data. While we have made significant progress in this regard (that our client is satisfied with), we are still working on transposing the ASCII data into a format readable by the ArcGIS API. Another issue that we are working on is making sure that the data displayed is accurate to the actual position of the data on the map. In other words, the demo that we created in our last sprint creates points relative to screen pixels and we are currently trying to use the ArcGIS API to figure out how to create point sizes relative to map coordinates. This is something that has been a challenge for us as we are trying to avoid using a map service, which would increase costs (currently free, as the ESRI CDN for ArcGIS is free to use) and cause much additional work at the automation stage.

In addition to our projection system and possible system costs, we are faced with the problem of learning an entire new API/Framework (ArcGIS). As none of our group members have interfaced with this type of software, it is a bit of a challenge to learn due to the lack of examples online. In addition, most people that work on ArcGIS software use various GUIs/tools to do all of their development, so this decreases our example size even further for incremental learning.

Finally, we will have the problem of attempting to plot very large data sets. Due to the massive size of the data samples given to us by Professor Lu, we will have to minimize the amount of objects placed on a map at any given time. Too many objects being placed will not only slow down the load time, it may crash the browser. Therefore, in addition to parsing the original input data, we will have to turn it into smaller objects. Should load time sensitivity become a greater issue later on in our project, we will have to switch map layers and publish on a map server. This is because that is the only way ArcGIS provides server-side functionality to rasterize constant “fill” content.

6 Timeline

6.1 FIRST SEMESTER

Our plan for the remainder of the semester is to gain more experience with ArcGIS so that we may continue to add pieces of our project little by little. We were successful in test plotting corner points onto an Earth 3D space model. The points that were constructed, however, stayed the same size while the user zooms in and out. This requires us to better format the points so that when we apply all data points it is not clustered and you are capable of visibly seeing the map during the month of October (see Appendix 9.6.a).

Once we are able to plot the points of a set of data successfully, we will move on to plotting multiple data sets and organizing it in a way that it can display all times of data one at a time first, then all together. Our goal is to be able to display and month-to-month set of data (see Appendix 9.6.b) that will be regularly updated. This will then sum up our first semester's progress, as we will present our work thus far at the end of the semester and begin planning further for the second semester (see Appendix 9.6.c).

6.2 SECOND SEMESTER

As the second semester is still farther into the future, plans are not as easy to come up with at this time, largely due to our current limited knowledge with the ArcGIS API (and its associated server-side mainframe add-on functionality). In our estimation, the second semester will largely revolve around allowing the users to customize their experience with the product. By allowing the user to toggle values, or giving various points the ability to “talk” to one another, we will be able to create an environment which allows users to “sandbox” mode and forecast compound readings. We will begin by allowing users to toggle values (9.7.a), and then lead into pixel-to-pixel communication (9.7.b) before we begin refinement and allowing the client to add extra requirements. As we cannot project how long the times for (9.7.a) and (9.7.b) will take, we have allowed extra room in the timeline in case we need to extend our time frame. These times will likely expand in the future once more-detailed implementation begins. To see the full timeline for semester two, see (9.7.a – 9.7.f).

7 Conclusions

In summary, our project will revolve around plotting the work of Professor Lu and allowing various end-users to view this work in a revolutionary space, with the ultimate goal of allowing the same end-users to simulate their own data. We plan to work largely in a series of small iterative cycles, which will allow us to demonstrate each iteration to the client, in case we need to make adjustments. Additionally, working in these small iterative cycles will allow us to continue to analyze the ArcGIS API as a reference point, give us ample time to contact experts (Josh Obrecht) in the field, and simultaneously keep our project moving forward. Our long term goal is for us to complete these iterative cycles and steps to produce a well-designed product that is clear, well-constructed, easy to access and navigate, and allow free use for our client and to the public. By the time the product is finished, users will be able to understand the effects of coinciding compounds upon the environment in a space that is not only visually pleasing, but informative due to the contributions of Dr. Crystal Lu.

8 References

(1) Landmark DecisionSpace Visual. Digital image. *World Oil*. World Oil, 1 Sept. 2010. Web. 18 Oct. 2016. <http://www.worldoil.com/news/2010/9/1/halliburton-s-landmark-announces-release-of-decisionspace-desktop-software-suite>.

(2) "USGS Current Water Data for the Nation." *USGS Current Water Data for the Nation*. N.p., n.d. Web. 18 Oct. 2016. <http://waterdata.usgs.gov/nwis/rt>.

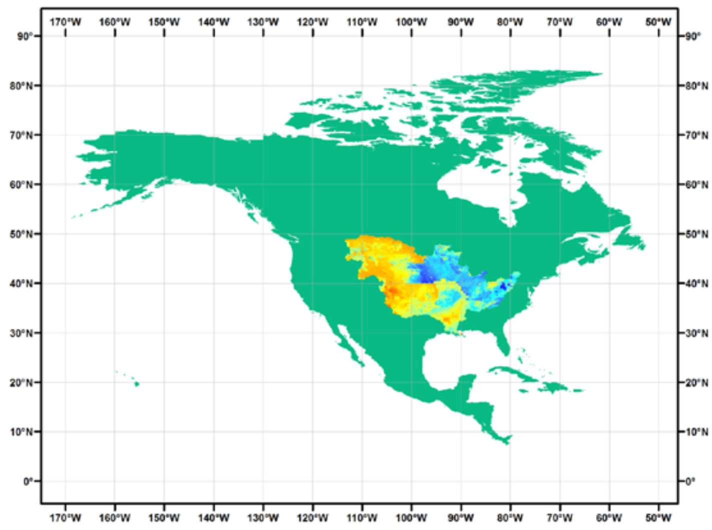
(3) "ArcGIS API for JavaScript." *ArcGIS for Developers*. Esri, n.d. Web. 18 Oct. 2016.

(4) "DecisionSpace Earth Modeling." Landmark Solutions E&P Software. Halliburton, n.d. Web. 18 Oct. 2016.

9 Appendices

9.1

The client's current solution to her visualization need:

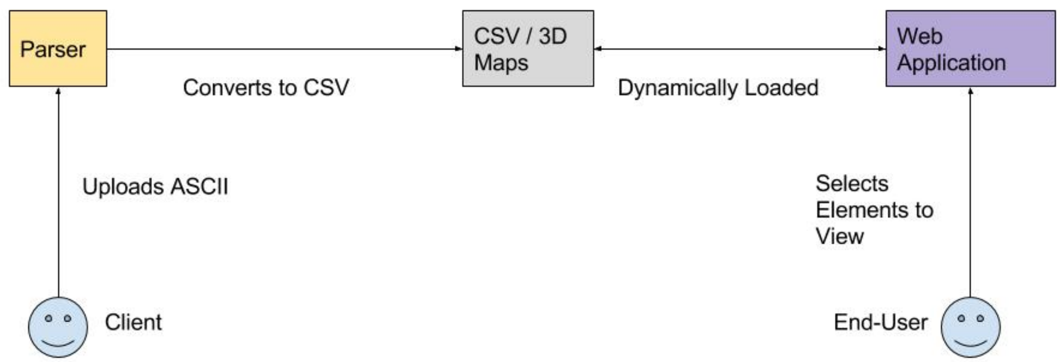


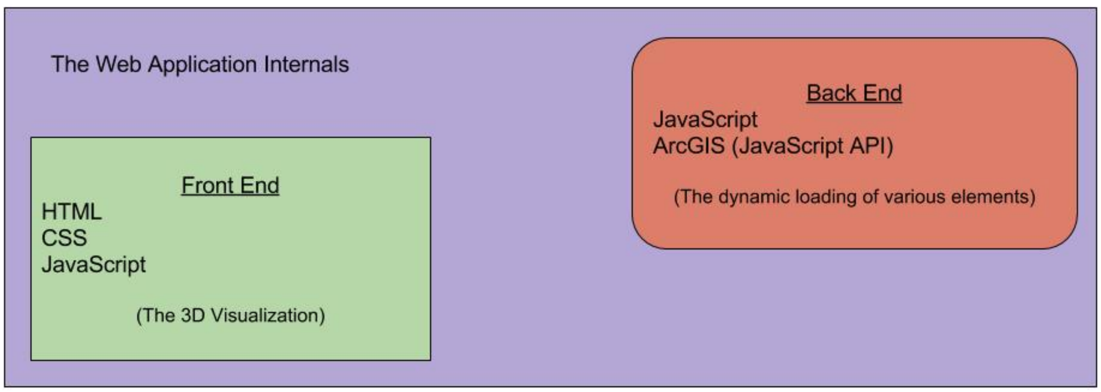
9.2

The sample 3D space onto which we'd like to project our client's work:

9.3

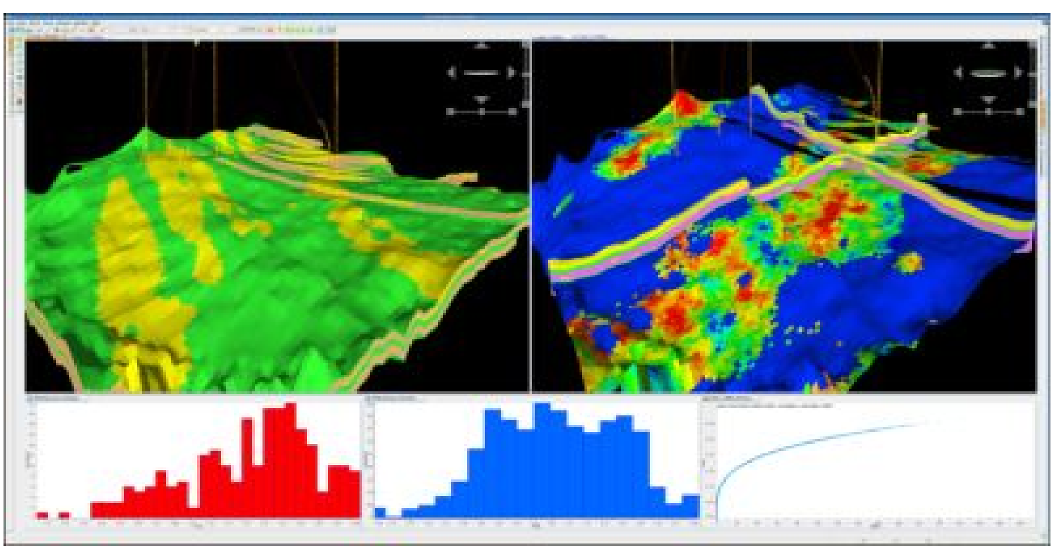
The proposed Block Diagram of the end product:





9.4 (1)

Halliburton's Landmark DecisionSpace Visual Example. (World Oil):



9.5 (2)

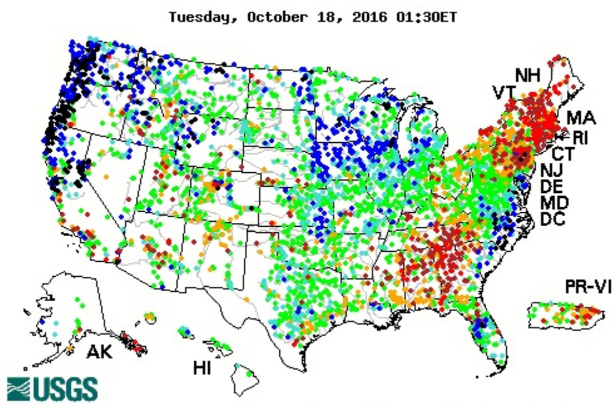
USGS streamflow data. (USGS):

USGS Current Water Data for the Nation

--- Predefined displays ---

Introduction go

Daily Streamflow Conditions

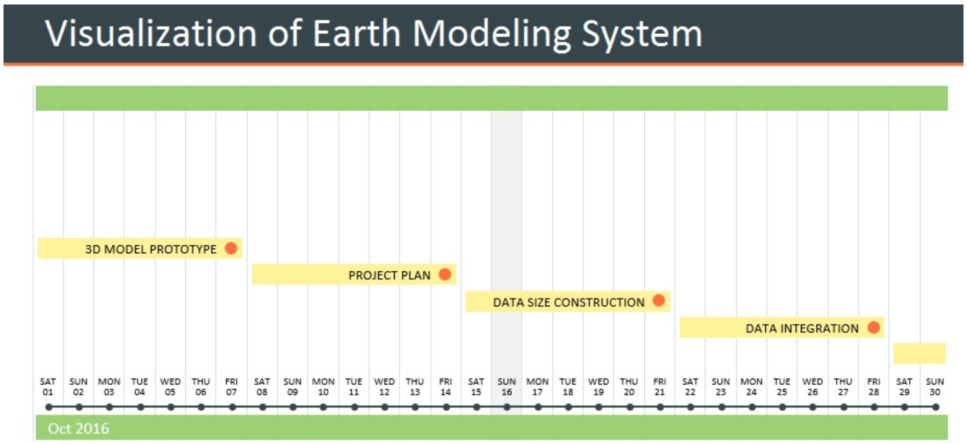


Explanation

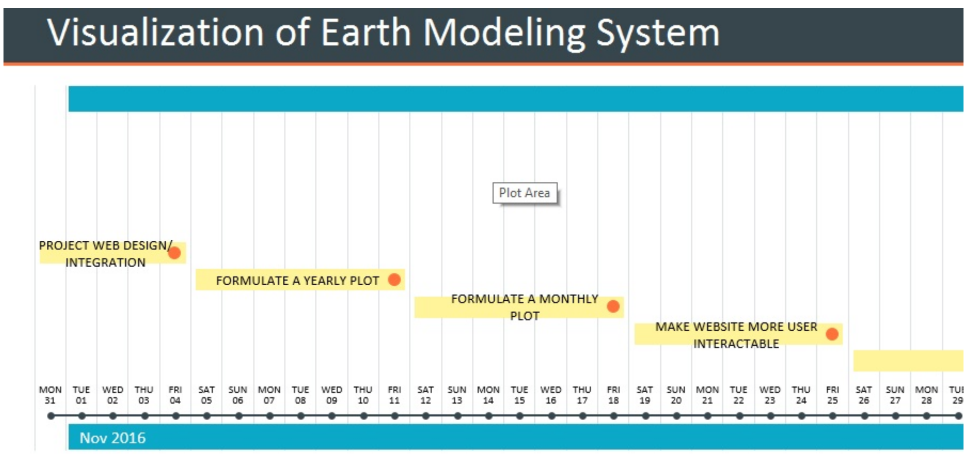
- High
- > 90th percentile
- 76th - 90th percentile
- 25th - 75th percentile
- 10th - 24th percentile
- < 10th percentile
- Low
- Not ranked

The colored dots on this map depict streamflow conditions as a percentile, which is computed from the period of record for the current day of the year. Only stations with at least 30 years of record are used. The **gray circles** indicate other stations that were not ranked in percentiles either because they have fewer than 30 years of record or because they report parameters other than streamflow. Some stations, for example, measure stage only.

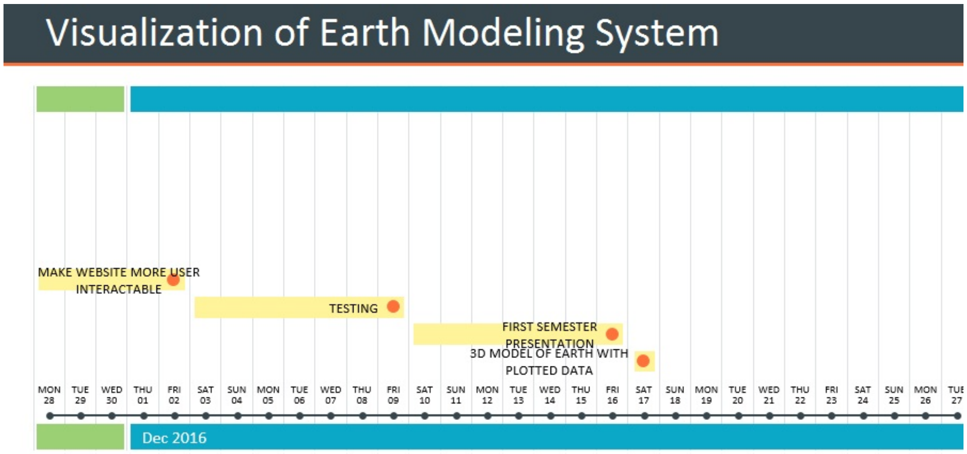
9.6 First Semester Timeline:



(a) October 2016



(b) November 2016

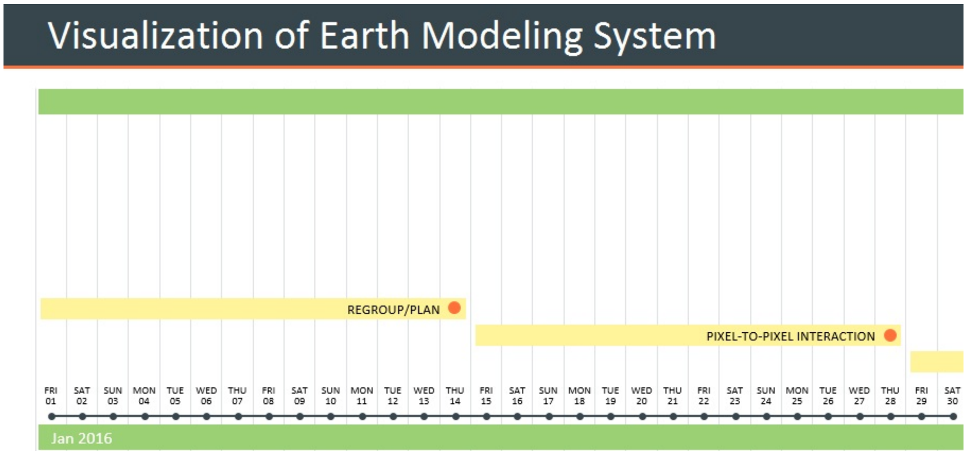


(c) December 2016

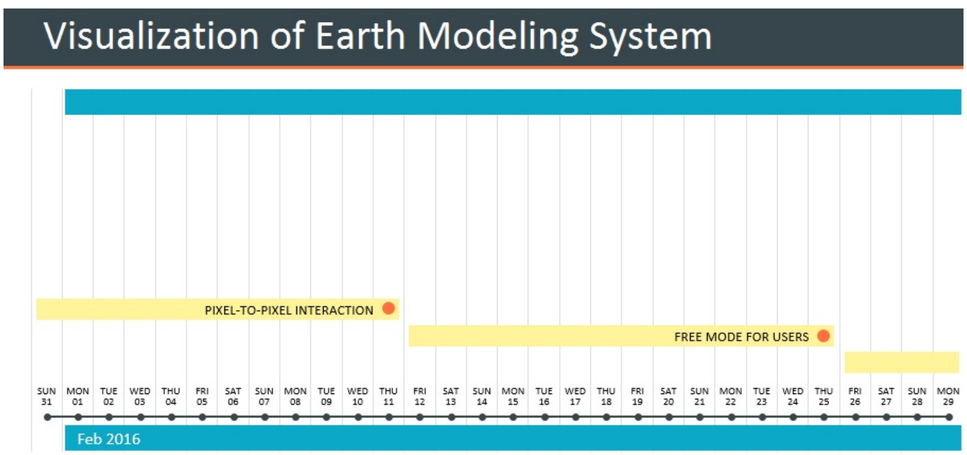
ACTIVITY	START	END	NOTES
3D model prototype	10/1/2016	10/7/2016	October: Week 1 - Began testing with arcGIS to become familiar with this program.
Project Plan	10/8/2016	10/14/2016	October: Week 2 - Write up the project plan and steps needed to complete the project. What needs to be done by the end of the first and second semester.
Data size construction	10/15/2016	10/21/2016	October: Week 3 - Determine what size to represent each value from ASCII table in order to represent a well scaled data point.
Data Integration	10/22/2016	10/28/2016	October: Week 4 - Begin to plot the points, applying the values from a 2D data set onto a 3D plane.
Project Web Design/ Integration	10/29/2016	11/4/2016	November: Week 1 - Integrate the 3D mdoel to the current project web page with data set prototypes. Create smooth transitions.
Formulate a yearly plot	11/5/2016	11/11/2016	November: Week 2 - Start with a yearly plot for a user to interact with on the 3D model.
Formulate a monthly plot	11/12/2016	11/18/2016	November: Week 3 - Move on to a more detailed and time specific set that can be viewed month-to-month.
Make website more user interactable	11/19/2016	11/25/2016	November: Week 4 - Allow for users to be more free with the 3D models, adding different layers of data.
Make website more user interactable	11/26/2016	12/2/2016	December: Week 1 -
Testing	12/3/2016	12/9/2016	December: Week 2 - Testing the website for customer usage, open to public.
First Semester Presentation	12/10/2016	12/16/2016	December: Week 3 - Present First Semester's work.
3D model of Earth with plotted data	12/17/2016		End of Semester

(d) First Semester Summary

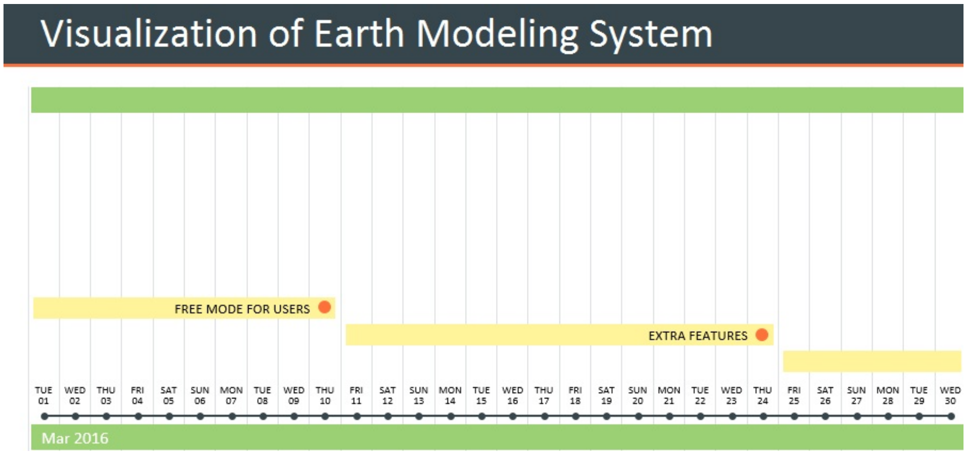
9.7 Second Semester Timeline:



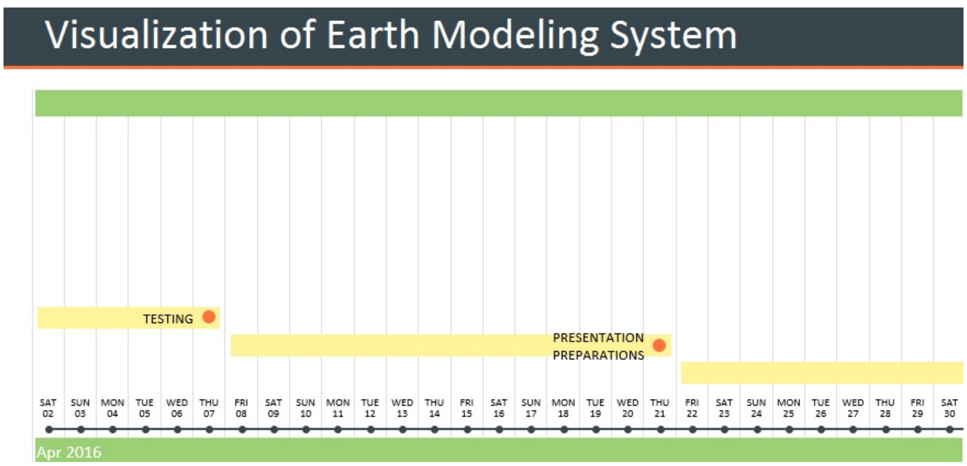
(a) January 2017



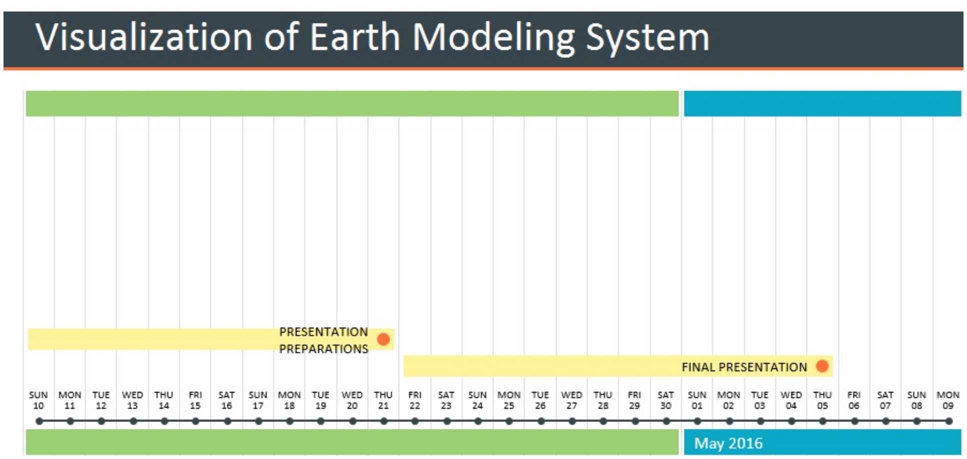
(b) February 2017



(c) March 2017



(d) April 2017



(e) May 2017

ACTIVITY	START	END	NOTES
Regroup/Plan	1/1/2016	1/14/2016	January: Week 1-2 - Regroup with the team and pick up where we left off
Pixel to Pixel Interaction	1/15/2016	1/28/2016	January: Week 3-4 - Begin work with pixel to pixel interaction in order to achieve a smoother picture.
Pixel-to-Pixel Interaction	1/29/2016	2/11/2016	February: Week 1-2 -
Free Mode for Users	2/12/2016	2/25/2016	February: Week 3-4 - Allow the users the freedom to mess with source data on the 3D model.
Free Mode for Users	2/26/2016	3/10/2016	March: Week 1-2
Extra Features	3/11/2016	3/24/2016	March: Week 3-4 - Come up with extra features if possible.
Testing	3/25/2016	4/7/2016	April: Week 1-2 - Test project and web design on public computers to see if everything works fine and users are capable of freely working on it.
Presentation Preparations	4/8/2016	4/21/2016	April: Week 3-4 - Preparations include, finsihed project, documentation, presentation prep.
Final Presentation	4/22/2016	5/5/2016	May: Week 1 - End of Semester, present project

(f) Second Semester Summary