

Airport 3-D Visualization Final Report

Prepared by Geo Solutions, Inc.

for

The City of New Braunfels, Planning Department

5/4/2012



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ABSTRACT

The key to an economically progressive and viable airport is protecting the land around it and especially the airspace. To protect the safety of incoming planes as well as the people underneath, the Federal Aviation Administration (FAA) created the Airport High Hazard Zoning Districts, limiting the height of structures in critical areas around airports. Unfortunately, these zoning districts have a complex geometry making it difficult to calculate the maximum building height at a specified point; and even more difficult to visualize the zones in real life.

The purpose of this project is to employ 3-D modeling and Geographic Information System (GIS) capabilities to create visual representation of the New Braunfels Regional Airport Hazard Zones (See Appendix I), so they may be easily understood by city staff and the public. The results of this project will be used by the City of New Braunfels (CONB), Planning Department for public communication and more efficient decision making.

The following document will discuss the development, execution, and implications of 3 principal objectives aimed at fulfilling the visualization needs of the New Braunfels, Planning Department. The objectives are as follows:

- (1) Create a 3D model of restricted airspace zones.
- (2) Turn the 3D model into a web-based, interactive tool that can be used by the public
- (3) Develop an interactive mapping tool to be used by city staff to identify maximum building heights at any given point.

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1. INTRODUCTION

1.1 BACKGROUND

The key to an economically progressive and viable airport is protecting the land around it and especially the airspace. To protect the safety of incoming planes as well as the people underneath, the Federal Aviation Administration (FAA) created the Airport High Hazard Zoning Districts, limiting the height of structures in critical areas around airports. Unfortunately, these zoning districts have a complex geometry making it difficult to calculate the maximum building height at a specified point; and even more difficult to visualize the zones in real life.

1.2 PURPOSE

The purpose of this project is to employ 3-D modeling and Geographic Information System (GIS) capabilities to create visual representation of the New Braunfels Regional Airport Hazard Zones (See Appendix III.), so they may be easily understood by city staff and the public. The results of this project will be used by the City of New Braunfels (CONB), Planning Department for public communication and more efficient decision making.

1.3 OBJECTIVE

As presented in the original project proposal, we identified 3 principal objectives for fulfilling the visualization needs of the Planning Department:

- (1) Create a 3D model of restricted airspace zones.
- (2) Turn the 3D model into a web-based, interactive tool that can be used by the public

(3) Develop an interactive mapping tool to be used by city staff to identify maximum building heights at any given point.

1.4 SCOPE

The scope of this project, including both the 3D visualization and the interactive map tool, incorporates portions of three Texas counties: 1) Comal, 2) Hays, and 3) Guadalupe; however, the analysis and modeling will be limited to the Airport High Hazard Zones as specified by the FAA (See Figure 1). These zones include all areas within approximately 3.5 miles of the airport and extend approximately 9.5 miles to the north toward San Marcos, 9.5 miles to the south toward Seguin, and 9.5 miles to the northwest toward Canyon Lake.

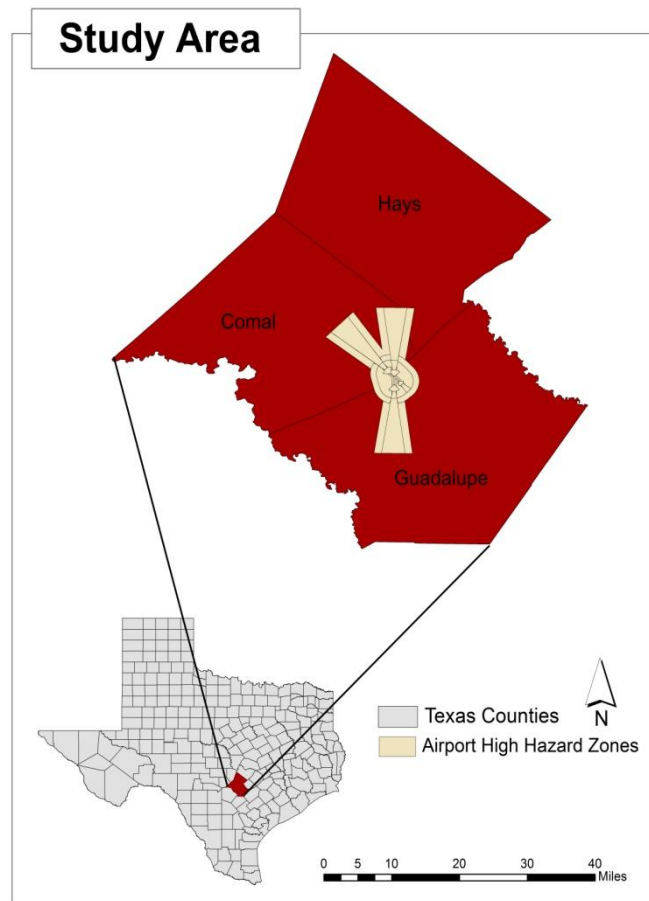


Figure 1. Study Area

2. LITERATURE REVIEW

To gain a better understanding of our capabilities and limitations we reviewed similar projects of airspace and general 3D visualization techniques. Through this research we found the best models were created by companies who specialize in 3D visualization, such as BridgeNet and GeoFusion Industries. However, the ESRI software did occur among the various software programs used in creating the models we examined. In this section we will discuss one of these studies to show how we arrived at our final methodology.

2.1 FORT WAYNE 3D AIRSPACE AND LAND USE COMPATIBILITY ANALYSIS TOOL

PBS&J is a company employed by the Fort Wayne – Allen County Airport Authority to create a GIS tool for visualizing and assessing the impacts of the obstructions caused by existing zoning and land use regulations to the Fort Wayne International Airport airspace. The purpose for having such an assessment tool is to enable the Allen County Airport Authority (ACAA) to make decisions more efficiently regarding the airspace affected by land use around the airport. ArcView and ArcScene are the two ESRI software tools that PBS&J used to create their tool

Although the specific methodology of this project was not published, it is clear that they were able to achieve an objective similar to ours, regarding the Interactive Mapping Tool. Furthermore, they were able to accomplish it using the same software programs as we will use.

PBS&J created a raster map with a graduated color scheme of the runways. The colors represent the level of impact land use will have on the airspace, as defined by the Federal Airspace Administration (FAA) based on the classification (size) of the airport. PBS&J made their final product viewable in 2D and 3D within the ESRI software. “Once completed, the Airspace Analyst provided crucial visual information to improve the decision making process of

the Fort Wayne-Allen County Airport Authority, which in turn improved short, medium, and long-term planning to satisfy the Airport's needs" (PBS&J, 2006). This particular study gave our team insight into the capabilities of the ESRI ArcGIS software.

3. DATA

The most essential component of the project was the data we incorporated, which came from multiple sources and in a variety of formats. In this section we discuss the types of data used, the sources of the data, and how they contributed to our overall results.

3.1 AIRPORT HAZARD ZONING-DRAFT ORDINANCE

One of the most important data components used in this project was the draft ordinance concerning Airport Hazard Zoning (CONB 2012). We received this paper document directly from the CONB, Planning Department at our initial meeting. The ordinance clearly defines each individual hazard zone and provides a detailed description of the building height restrictions of each. This datum acted as the foundation for constructing 3-D polygons for the 3-D model and conducting the raster analysis. From it we were able to delineate the extent and geometry of each zone in 3-dimensional space.

3.2 HAZARD ZONE POLYGONS

Another crucial dataset employed in our process was a digital, geospatial dataset, consisting of 2-D polygons for each of the zones as they relate to the New Braunfels Regional Airport. This was also provided by the City of New Braunfels, Planning Department and created specifically for use in this project. This datum delineated the extent of each zone, so that we

could conduct our analysis accordingly. Originally the dataset consisted of vector shapefiles that we later converted to raster grids for the purpose of conducting analysis.

The dataset was not completely accurate, however. When we compared the boundaries of digital polygons to the boundaries defined by the ordinance, we found an inconsistency of about 2,000 feet for an Inner Precision Approach Zone. Fortunately, we identified the inconsistency and were able to correct it early on.

3.3 DIGITAL ELEVATION MODELS

Digital Elevation Models (DEM) were used in two ways throughout the project. First, a DEM was used to create a 3-Dimensional surface for the 3-D model that produced the Fly-Through video. This DEM was contained within ArcGlobe and required no further processing.

Another DEM was used to develop the Interactive Map Tool. For this task, the DEM was a 1/3 Arc-second raster grid, retrieved from the USGS Seamless Data Warehouse. Once we converted the DEM from meters to feet it was ready to be used in analysis. We used this data to assign elevation values to the 2-D polygons and to conduct analysis.

3.4 WORLD STREET MAP AND COUNTY BOUNDARIES

Additional data used in creating the Interactive Map Tool include a World Street Map and a Texas county boundaries layer. The World Street Map was a digital ESRI basemap, retrieved from ESRI, ArcGIS Online Map Services. This was included for use as a basemap for general reference. The county boundaries layer was downloaded from the Texas Natural Resources Information Systems (TNRIS) website in the form of digital vector polygons. This layer was included for general references purposes only.

4. METHODOLOGY

4.1. 3-DIMENSIONAL MODEL

We realized early on that our original method for creating a 3-dimensional model was not going to work as well as we had hoped. Fortunately, we were able to address the problems and adapt quickly. Ultimately, we decided to use ArcGlobe, instead of ArcScene, for the 3D model. With this method, we no longer had to render a Digital Elevation Model (DEM) because a 30 meter DEM was already provided in ArcGlobe. As a final deliverable we have provided the City of New Braunfels with the file so that it may be viewed on the CONB website. Below is a complete outline of the process.

4.1.1. 3-Dimensional Model Process

- 1) Create a terrain in ArcGlobe
- 2) Create individual polygons of the restricted zones in Google SketchUp based on their respective geometries in real life.
- 3) Merge polygons to establish heights of lowest value. In other words, in the case of overlapping zones, we want to make sure that the height restriction is based on the zone with the lowest height value. As stated in the draft ordinance, “An area located in more than one of the following zones is considered to be only in the zone with the more restrictive height limitation.” (CONB 2012).
- 4) Import the Google SketchUp model containing the individual zone polygons into ArcGlobe so they may be seen over the terrain.
- 5) Create a fly-through animation in ArcGlobe.

4.2 ONLINE INTERACTIVE 3-D MODEL

As discussed in our original proposal, we researched several ways to make the 3D model interactive on the New Braunfels website. We concluded that the only way to do this without purchasing costly software is to provide the Planning Department with a Google Earth file, containing the 3D model. When the Planning Department makes the file available on the CONB website, anyone who already has, or chooses to download Google Earth, can open the 3D model in Google Earth and use it interactively. This will allow the user to navigate over, under and through the restricted zones as they please. Figures 5 and 6 provide examples of how this will look to the user. This process involved exporting the Google SketchUp model as a Google Earth file. See Figure 2 for a work flow diagram illustrating that process. As a final deliverable we have provided the Google Earth file containing the model and instructions for viewing the model in Google Earth. These instructions may be posted on the CONB website for users, along with the Google Earth file.

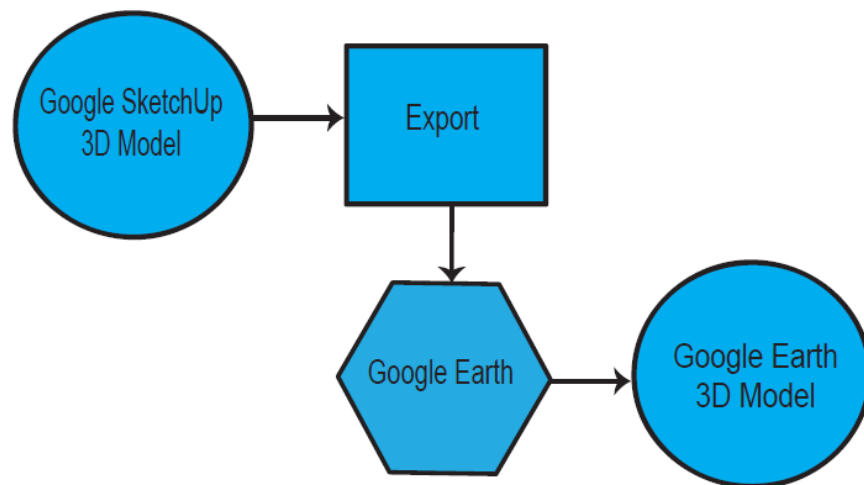


Figure 2. Interactive 3-D Model Methodology

4.3 INTERACTIVE MAP TOOL

In short, our method for developing the Interactive Map Tool involves converting the original 2-D “zone” polygons into 3-D shapes, and from there, calculating the difference between the elevation of the zones and the elevation of the DEM.

We did have a bit of a rocky start on this particular task. Although, fundamentally nothing changed about our methodology here, we did encounter some trial and error regarding our initial approach. For example, we thought the first step was to convert the data from vector to raster format, but quickly realized that didn’t work. Furthermore, we did have to go back and edit our original data to account for some error. After running the model again we were pleased with the final result. Below we have provided a step by step description, as well as an illustration (Figure.3) of our process. .

4.3.1 Interactive Map Tool Process

- 1) Import “hazard zones” polygons and DEM into map
- 2) Convert DEM layer from meters to feet using *Raster Calculator* (DEM x 3.2808399)
- 3) Assign “z”, or height, values to “zone” polygons using *Interpolate Shape* tool.
- 4) Delete vertices of each polygon until a manageable number of vertices remain
- 5) Measure the length of each polygon and divide it according to the ratios established by the CONB ordinance for Airport High Hazard Zoning Districts (CONB 2012).
- 6) Create a slope surface for each polygon based on the ratios above using the *Create TIN* tool.

7) Convert each individual zone from polygon to raster using the Polygon to Raster tool.

8) Use *Raster Calculator* to subtract the DEM from each of the newly created zone rasters to produce new raster layers, representing maximum available building height.

(Zones – DEM=Available Building Height)

9) Mosaic all Available Building Height layers together (*Mosaic to New Raster* tool)

to create one Master layer representing Available Building Height. We used “Minimum” as the mosaic operator so that the output raster would represent the minimum value of any overlapping layers.

10) Assign NoData values to all cells with a value less than or equal to zero, using *Raster Calculator*. (SetNull(“mosaic” <= 0, “mosaic”)

11) Use the *Polygon to Raster* tool to convert a polygon of the Primary Zone from polygon to raster with a value of 0.

12) Mosaic the new Primary Zone raster into the existing mosaic layer so that the primary surface would be equal to zero instead of NoData.

13) Use a conditional statement in *Raster Calculator* to fill in small gaps produced by mosaicking multiple, non-overlapping layers together. Any empty cell was assigned a value that represented the mean of a small set of neighboring cells.

(Con(IsNull(“finalmosaic”), FocalStatistics(“finalmosaic”, NbrCircle(1, “CELL”), “MEAN”), “finalmosaic”)

14) Apply a graduated color scheme for better visual representation of differences in Available Building Height.

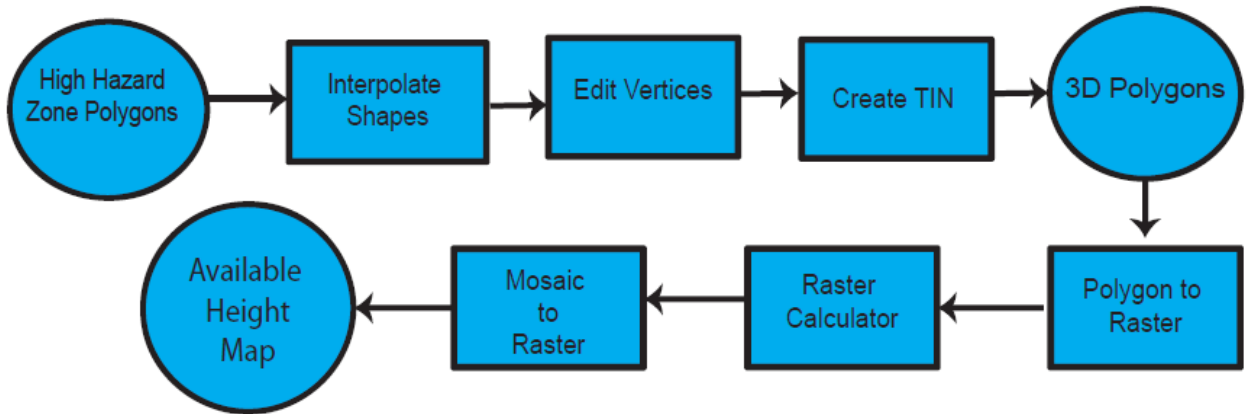


Figure 3. Interactive Map Tool Process

5. RESULTS

Upon completion of the project, the Geo Solutions team has successfully created several 3-dimensional visualization tools to meet the needs of the New Braunfels, Planning Department. Our goal was to design products that could be used interactively and intuitively in a variety of scenarios, and we believe that is what we have achieved.

First, we developed a 3-D model of the hazard zones within the New Braunfels Regional Airport. The model can be viewed by the public either in the fly-through video or from the Google Earth file produced by Geo Solutions. By downloading the Google Earth file users can interactively navigate over, under and through the hazard zones as they please (See Figure 4). The CONB will be provided with the files containing the model itself, a fly-through video, and the Google Earth file containing the model. Additionally, the Planning Department may edit the model in Google Earth, Google SketchUp, or ArcGlobe.

Secondly, Geo Solutions has developed an Interactive Map Tool to be used by city staff to quickly and accurately identify the maximum available building height anywhere within the hazard zones. The map tool is easy to use and compatible with city's existing ESRI software. Once the map is opened in ArcMap, staff can simply point and click to obtain the information needed (See Figure 5). Several other layers that have been provided for reference purposes may be turned on or off as seen fit.

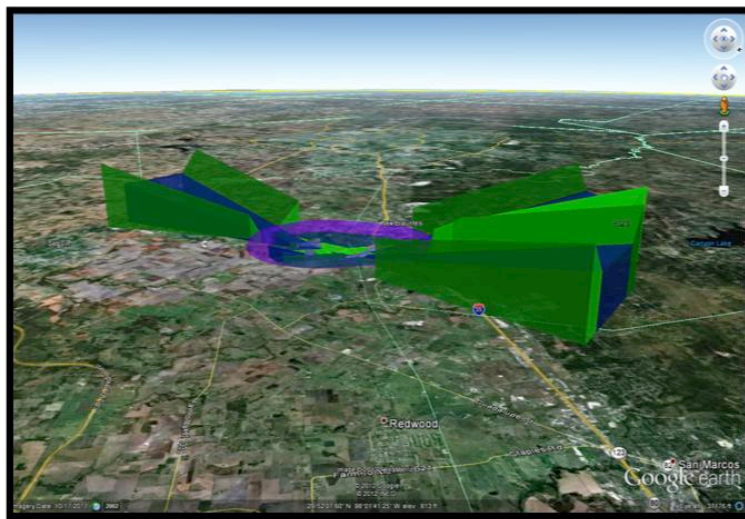


Figure 4. Google Earth File

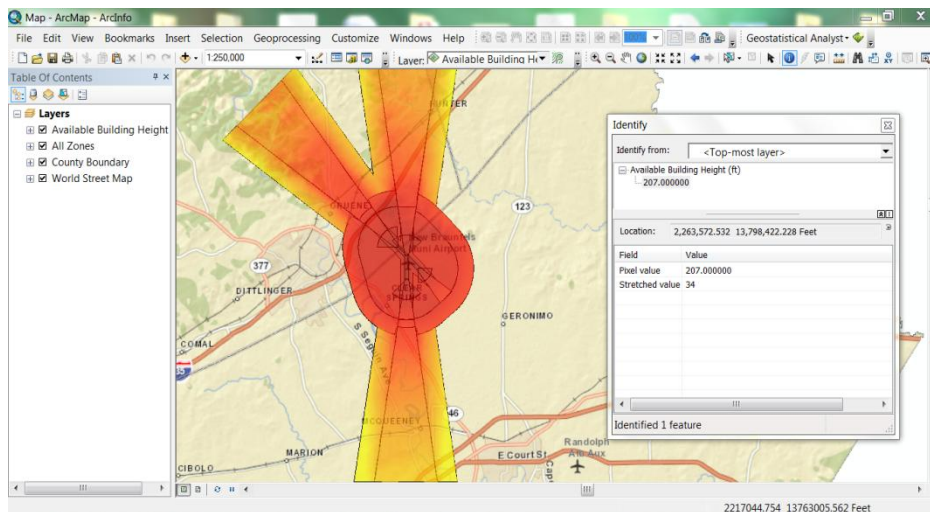


Figure 5. Interactive Map Tool

Finally, our team has provided the city with several 2-D maps to more effectively communicate airport hazard zones to the public and other city officials. For example, Figure 5 shows a color coded map of each the hazard zone. Figure 6 shows a map that uses a graduated color scheme to show relative differences in building height restrictions throughout the zones. These maps may be displayed on the website, in office buildings, or incorporated into presentations.

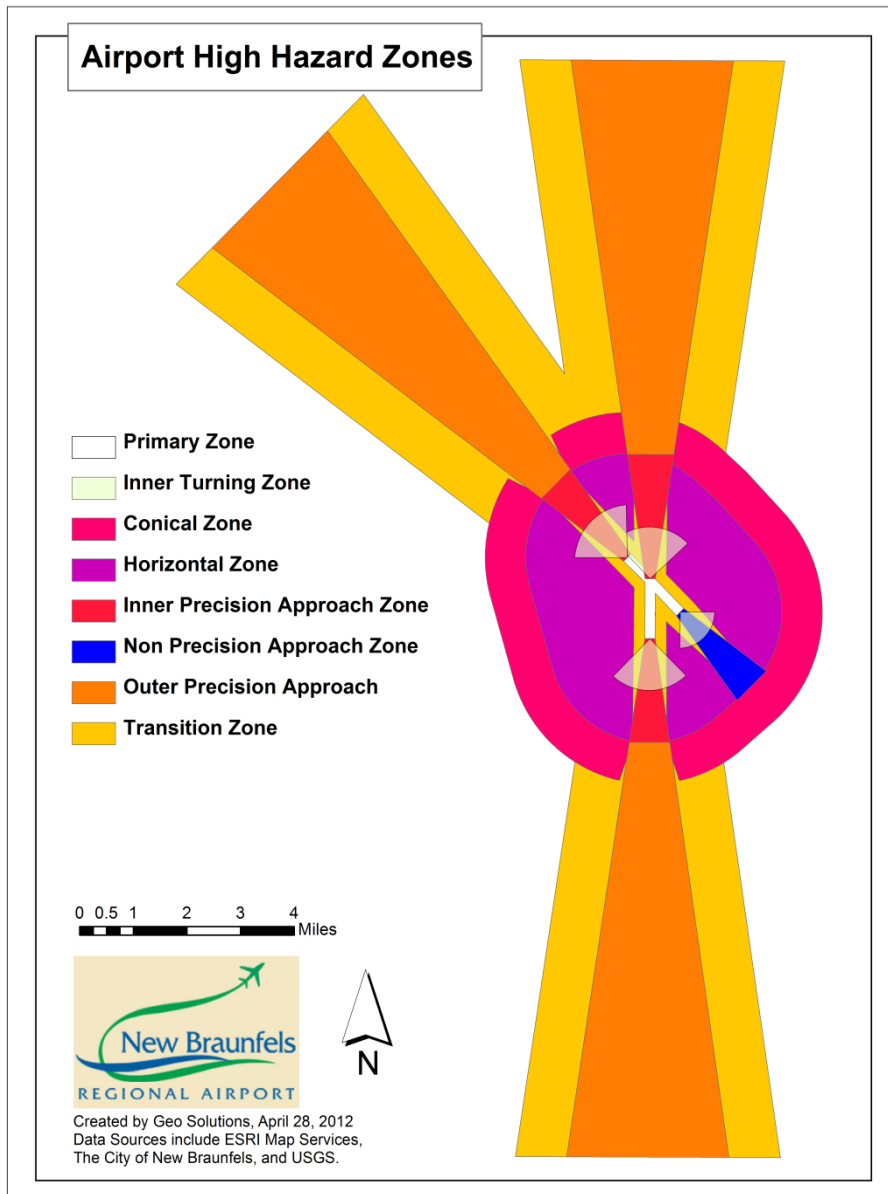


Figure 6. Airport High Hazard Zones

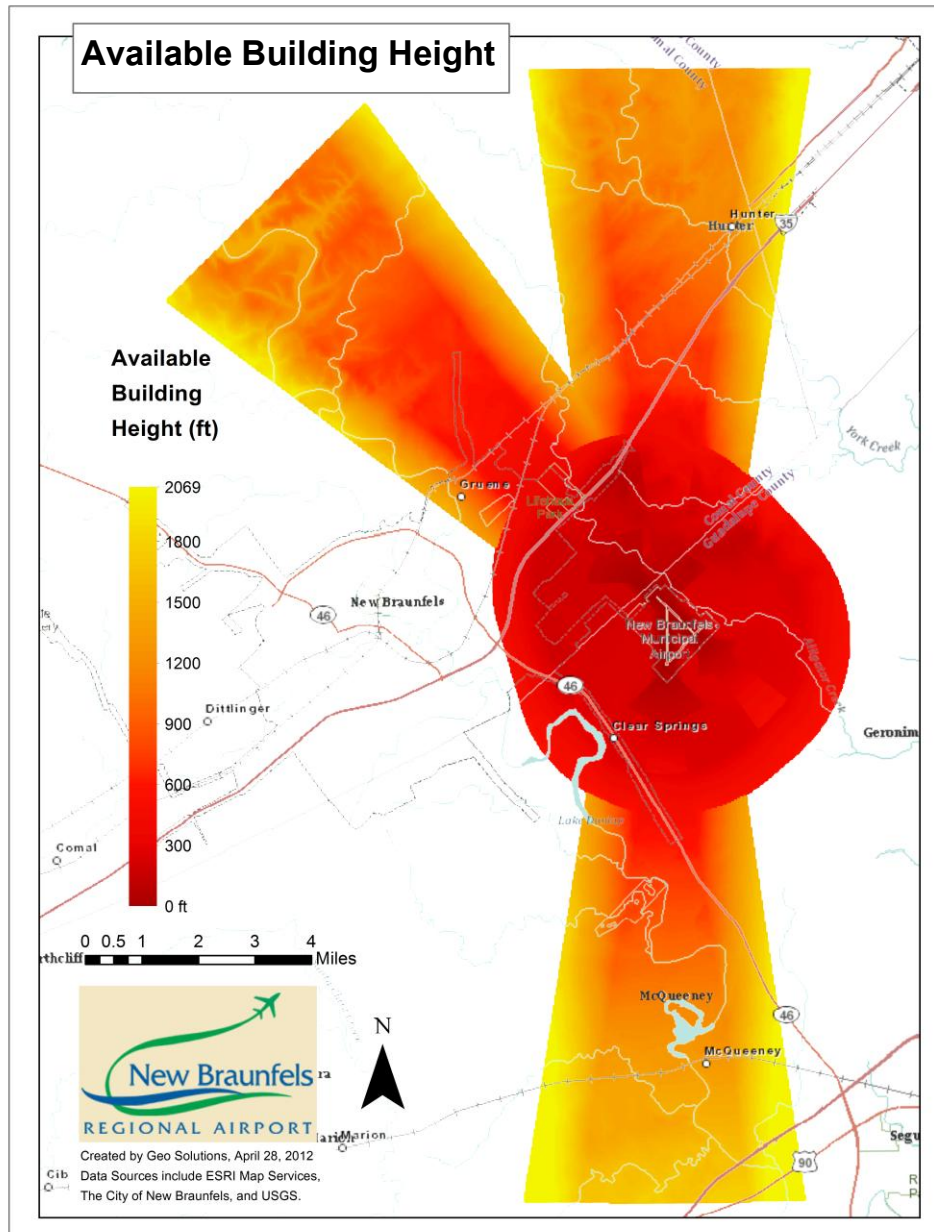


Figure 7. Available Building Height

Overall, we are confident that the maps, models and tools we have developed will facilitate a more efficient decision making process for city staff members, and improve communication between the planning department and the public. With a more accessible, intuitive, and user friendly system the department can make the best use of staff resources; ultimately saving valuable time and money.

6. DISCUSSIONS

6.1 CAPABILITIES AND LIMITATIONS

The results of this project have proven that visual representation of airspace is well within the capabilities of a GIS. Our models allow us to see maximum building height within restriction zones more clearly than before. These models will also give planners insight into locating places to build apartments, hotels so that noise from airplanes will not affect the residents. By incorporating other datasets, building height restrictions can be viewed in relation to other aspects such as land use.

For the most part the results we acquired were consistent with our expectations. Initially, we believed that the further one travels away from the airport, the less restriction one would have on building. Not surprisingly, that is what our final output confirmed, with the exception of a few places where the elevation was higher.

There are a few things that would the Interactive Map Tool more accurate. For example, if we have had access to 1/9 Arc-second DEM, which is based on a 3x3 meter resolution, then our elevation would be a little more precise. Unfortunately, this dataset was not available for the study area. Instead, we were forced to use the 1/3 Arc-second, or 10x10 meter resolution, that was available. This resulted in an accuracy of +/- 7 meters.

6.2 SIMILAR STUDIES

Looking back at our Literature Review, we can see similarities, regarding the raster analysis, between the Fort Wayne project and our own. Geo Solutions also created a raster based model that identifies the areas within and around the restricted airspace zones. One difference is

that we did not use land-use as a criterion in defining impact extremes. Another difference is that we created two separate deliverables for the airspace model: an Interactive Map Tool and a 3D visualization model. While differences exist, the importance of both projects is clear: both clients wanted a visualization tool that was easily comprehensible to non-technical staff, and that showed the level of restriction according to federally designated airspace zones for future land use planning.

6.3 FUTURE PROJECTS

The 3-D visualization models we have developed for the City of New Braunfels illustrate a very small fraction of how a GIS can be applied to support airport planning, operations, and maintenance. At Geo Solutions, we believe that it would be very beneficial to the CONB to invest in future projects to improve the function of the New Braunfels Regional Airport. Some other possible applications include (ESRI 2003):

- Noise Modeling
- Land Acquisition
- Facilities Management
- Airport Layout Planning
- Flight Path Management

This is not an exhaustive list. The capability of GIS as applied to airports and aviation is extensive and should be taken full advantage of.

7. CONCLUSION

Overall, we are very pleased with the outcome of this project. We see this as a huge success for the Geo Solutions team, and more importantly, a huge success for the City of New Braunfels. As the City of New Braunfels grows, there is great potential for economic growth near the New Braunfels Regional Airport. The adoption of an ordinance that enforces FAA regulated height restrictions near airports will help promote such economic growth.

We have provided quality products that are technologically advanced, yet user-friendly and intuitive. One such product is a 3-D visual representation of airport zoning to better inform the public of building height restrictions. Additionally, we have provided an Interactive Map Tool that will allow staff to obtain information quickly and make decisions efficiently. It is our hope that the visualization tools, now at the city's disposal, will take the New Braunfels Regional Airport to the next level.

8. REFERENCES

City of New Braunfels (CONB). 2012. *Airport Hazard Zoning Ordinance-Draft*. New Braunfels, TX: The City of New Braunfels.

ESRI. 2003. *GIS Solutions for Airports and Aviation*. Washington, D.C.: U.S. General Services Administration.

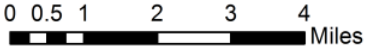
ESRI. 2012. *Common Questions*. "How can I share and distribute my work in 3D?". <http://www.esri.com/software/arcgis/extensions/3danalyst/common-questions.html>. Last accessed 22 February 2012.

PBS&J. 2006. *Fort Wayne 3D Airspace and Land Use Compatibility Analysis Tool*. Fort Wayne-Allen County Airport Authority. Fort Wayne, IN. http://northamerica.atkinsglobal.com/software_development_and_integration/Pages/default.aspx. Last accessed 30 April 2012.

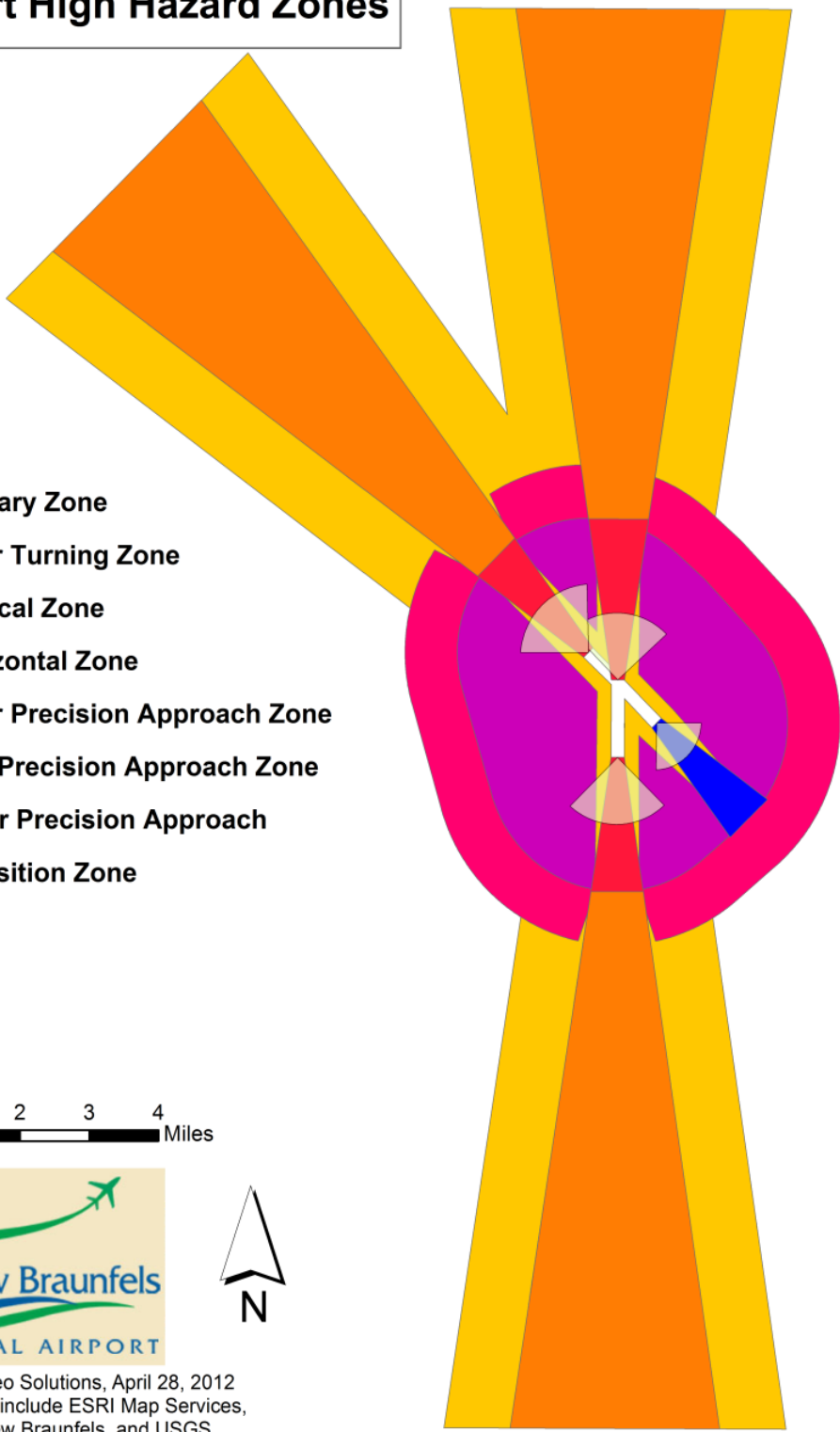
Appendix I: Map of Airport Hazard Zones

Airport High Hazard Zones

- Primary Zone
- Inner Turning Zone
- Conical Zone
- Horizontal Zone
- Inner Precision Approach Zone
- Non Precision Approach Zone
- Outer Precision Approach
- Transition Zone



Created by Geo Solutions, April 28, 2012
Data Sources include ESRI Map Services,
The City of New Braunfels, and USGS.



Appendix II: Metadata

Metatdata

Identification_Information:

Citation:

Citation_Information:

Originator:

Geo Solutions - Texas State University, GIS Project Team

Publication_Date: May, 2012

Title: Interactive Map Tool: Airport Building Restriction Zones

Geospatial_Data_Presentation_Form: raster data

Publication_Information:

Publication_Place: San Marcos, TX

Description:

Abstract: Layer comprised of elevation data and Airport High Hazard Zoning Districts

Purpose: This layer was created for the City of New Braunfels for the purpose of identifying available building heights within Airport High Hazard Zones

Status:

Progress: Complete

Spatial_Domain:

Bounding_Coordinates:

West_Bounding_Coordinate: -98.1902916256931

East_Bounding_Coordinate: -97.9899212553219

North_Bounding_Coordinate: 29.8480010235811

South_Bounding_Coordinate: 29.5562417643207

Keywords:

Theme:

Theme_Keyword: Airport zones, building restrictions.

Place:

Place_Keyword: Zoning Districts

Access_Constraints: none

Use_Constraints: This product is for informational purposes and may not have been prepared for or be suitable for legal, engineering, or surveying purposes. It does not represent an on-the-ground survey and represents only the approximate relative location of zoning districts. This product has been produced by the Texas State University Geo Solutions project team for the sole purpose of geographic reference. No warranty is made by the City of New Braunfels regarding specific accuracy or completeness.

Point_of_Contact:

Contact_Person_Primary:

Contact_Person: Crystal May

Contact_Organization_Primary:

Contact_Position: Project Manager

Contact_Voice_Telephone: (214) 641-6444

Contact_Electronic_Mail_Address: cmay292@gmail.com

Data_Quality_Information:

Attribute_Accuracy:

Attribute_Accuracy_Report:

Data has been visually inspected and adjusted accordingly.

Error can be introduced by: digitizing methods, source material, generalization, symbol interpretation, the specifications of aerial photography, aerotriangulation technique, ground control reliability, photogrammetric characteristics, scribing precision, resolution, processing algorithms and printing limitations

Logical_Consistency_Report: ESRI feature type: Simple, Geometry: Polygon, Topology

Completeness_Report: Complete.

Lineage:

Source_Information:

Type_of_Source_Media:paper and digital

Source_Contribution:

Original polygons created by Benjamin Campbell, City of New Braunfels Planning Technician.

Building heights are based on Airport High Hazard Zoning Districts, defined by the Federal Aviation Administration

Digital Elevation Model was acquired from USGS

Spatial_Data_Organization_Information:

Direct_Spatial_Reference_Method: Raster

Raster_Object_Information:

Raster_Object_Type: Grid Cell

Row_Count: 3,151

Column_Count: 2,164

Spatial_Reference_Information:

Horizontal_Coordinate_System_Definition:

Planar:

Grid_Coordinate_System:

Entity_and_Attribute_Information:

Overview_Description:

Entity_and_Attribute_Overview: Cells represent available building height, in feet

Distribution_Information:

Distributor:

Contact_Information:

Contact_Organization_Primary:

Contact_Organization: City of New Braunfels Planning Department

Contact_Address:

Address_Type: mailing address

Address:

424 S. Castell

New Braunfels, TX 78130

Contact_Voice_Telephone: (830) 221-4050

Contact_Electronic_Mail_Address: planning@nbtexas.org

Hours_of_Service:

Monday - Friday

8:00 am - 5:00 pm

Distribution_Liability: Although this layer has been used by the City of New Braunfels, no warranty, expressed or implied, is made by the City of New Braunfels as to the accuracy and functioning of the data and related program material nor shall the fact of distribution constitute any such warranty, and no responsibility is assumed by the City of New Braunfels in connection therewith.

Metadata_Reference_Information:

Metadata_Date: April 28, 2012

Metadata_Contact:

Contact_Person_Primary:

Contact_Person: Crystal May

Contact_Voice_Telephone: (214) 641-6444

Contact_Electronic_Mail_Address: cmay292@gmail.com

Metadata_Access_Constraints: None

Appendix III: Team Member Contribution

Team Member	Contribution
Crystal May	<p>Interactive Map Tool</p> <ul style="list-style-type: none"> • Worked with Cameron to develop analysis model • Created final map documents <p>Manifold</p> <ul style="list-style-type: none"> • Imported files into Manifold map and applied color schemes <p>Metadata</p> <ul style="list-style-type: none"> • Developed metadata for the raster layer we created <p>Final Report</p> <ul style="list-style-type: none"> • Assembled and organized <p>Contributed to PowerPoint Presentations and Reports</p>
Tory Carpenter	<p>3-D Model</p> <ul style="list-style-type: none"> • Created 3-D model in Google SketchUp and converted it to a file compatible with ArcGlobe • Created user instructions for uploading Google Earth file <p>Point of Contact for all client communications</p> <p>CD and Poster</p> <ul style="list-style-type: none"> • Worked with Nate to assemble CD and poster <p>Contributed to PowerPoint Presentations and Reports</p>
Cameron Frere	<p>Interactive Map Tool</p> <ul style="list-style-type: none"> • Worked with Crystal to develop analysis model • Responsible for the majority of raster model execution • Data Collection and processing <p>Poster</p> <ul style="list-style-type: none"> • Worked with Nate to design poster <p>Contributed to all PowerPoint Presentations and Reports</p>
Nate Stanley	<p>Logo Design</p> <p>Website Development</p> <p>3-D Model</p> <ul style="list-style-type: none"> • Responsible for the ArcGlobe portion of the 3-D model • Created Fly-Through video <p>Poster and CD</p> <ul style="list-style-type: none"> • Worked with Cameron and Tory to design poster and assemble CD <p>Manifold</p> <ul style="list-style-type: none"> • <p>Contributed to PowerPoint Presentations and Reports</p>

