On Modeling FAA Surfaces for Airspace Analysis Using Geopak

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Abstract

This paper discusses an innovative approach to evaluating airspace obstructions of Federal Aviation Administration (FAA) approach/departure airspace surfaces utilizing Geopak Site grading software. The software was utilized in an unconventional way to produce extremely accurate elevations of any point on or along any path of various FAA surfaces. There are multiple benefits of this approach: it is relatively simple, necessary information is readily available, it is extremely cost effective, and non-disruptive to airfield operations. This modeling technique was recently utilized at Dallas Fort Worth (DFW) International Airport and has been reviewed by the FAA.

Introduction

An Object Free Zone (OFZ) is a theoretical boundary required to remain clear of obstacles to aircraft. The OFZ consists of the Runway OFZ, Inner-approach OFZ and the Inner-transitional OFZ. Most obstacles to aircraft occur away from the runway, in the direction of aircraft approach and departure. Both the inner approach and inner-transitional approach airspace are protected by approach and departure surfaces which define the OFZ in this area. Airspace studies are necessary to determine height restrictions for objects under an approach or departure surface. The FAA reviews mandatory airspace studies for object penetrations. Airspace studies submitted to the FAA must contain exact horizontal and vertical locations of objects under the airspace surface. When the object has yet to be designed, an independent airspace study must be conducted to facilitate the design.

An airspace study consists of first determining the boundaries of the surface according to specific FAA requirements. Mathematical formulas are then derived to determine the surface elevation at any given point. This conventional method becomes tedious and time consuming especially if information is required for multiple points along an alignment and also fails to electronically represent the surface in a usable way. Three dimensional (3D) modeling of the surface eliminates the need for multiple repetitive calculations and produces usable design data. The challenge presented to engineers at DFW International Airport was accurately modeling surfaces that are invisible and not affixed to any ground surface.

Engineers at DFW International Airport found a resourceful and simple solution to this problem. The modeling technique utilizes Geopak Site grading software in a unique way to model the airspace surfaces which produces accurate elevations of the FAA surfaces at any point or along any desired path. The Geopak Site models can be utilized to extract elevations and profiles of the surface, as well as TIN files for use in other design applications.
FAA Surfaces

There are many approach and departure surfaces which should be considered for analysis. Engineers at DFW International Airport recently completed analysis of Category I, Category II, III, TERPS Approach, TERPS Departure, One Engine Inoperative (OEI), and Glidepath Qualifying Surfaces (GQS). Most airspace surface descriptions provided by the FAA must be modified based on particular characteristics of each individual airport. Obtaining a thorough understanding of the specifics of each surface is challenging because the applicability, shape and location vary from airport to airport. Comprehension of the surfaces' shape is also hindered because the surfaces are theoretical boundaries with no tangible elements. For these reasons, design first requires a thorough analysis of each surface.

Surface Analysis

The FAA airspace surface descriptions are found in FAA Advisory Circular 150/5300-13 “Airport Design”. Some surfaces, such as the OEI and GQS, are required through specially issued FAA notices. One of the most common approach and departure surfaces is the Category II, III Inner-Transitional OFZ surface (CATII, III). The CAT II, III surface applies to runways with precision instrumentation for landing when visibility is less than 1200 meters (FAA 22-23). Due to its complex modeling challenges, this surface was chosen to be the example for the following discussion.

**CAT II, III Inner Transitional Object Free Zone**

The only variables required to determine the boundaries of the CATII, III surface are the runway end elevation (E) and the design aircraft wingspan (S). To determine the required surface variables the following equations found in the FAA Advisory Circular were utilized:

\[
H(\text{Feet}) = 53 - 0.13S(\text{Feet}) - 0.0022E(\text{Feet})
\]

\[
Y(\text{Feet}) = 440 + 1.08S(\text{Feet}) - 0.024E(\text{Feet})
\]

If an accurate runway end elevation is not provided by the airport, runway end elevations for commercial airports are available through online resources such as Airnav.com. FAA Advisory Circular 5300-13, Table 1-1 provides a list of design aircraft wingspans based upon the aircraft group classification. DFW International Airport is designed for a Group V aircraft wingspan of 214' and Runway 17C end elevation of 561.91. Figure 1 shows the surface shape and calculated variables of this surface.
Figure 1 – Multiple Views of the CAT II,III Inner Transitional OFZ Surface
The necessary first step in conducting an airspace analysis is determining which airspace surfaces must be analyzed for a specific runway and understanding the appearance of each surface. Drawing multiple surface views in CADD is recommended to organize pertinent information about the surface. Studying each of the applicable surfaces makes it possible to calculate the elevation of the surface at any particular location. Multiple repetitious calculations are required in order to plan the placement of an object near an airfield. The only way to avoid designing by repetitious calculation is to create a three-dimensional representation of the surface.

**Modeling**

Designing airport infrastructure to comply with FAA regulations for airspace surfaces has proven to be a challenging task for engineers. Because airspace surfaces are conceptualized objects with no finite real-world boundaries there is no way to see the location of potential penetration sites. Three-dimensional models of the surfaces allow the designer to visualize and determine spatial relationships. Engineers at DFW International Airport used an inventive approach to modeling airspace surfaces and determine the spatial relationships. This modeling technique adapts Geopak Site grading software, typically utilized to modify ground surfaces, to create visual representations of various airspace surfaces. Utilizing Geopak Site, as opposed to other 3D software such as ArcGIS, has its advantages. The software comes equipped with many design capabilities useful for creating construction documents. Since its initial application in 2005 at DFW International Airport, this technique has been reviewed and validated by the FAA and can now be prevalently used by design engineers.

The benefits of this modeling technique are numerous. Utilizing Geopak Site to model the surfaces eliminates the need for repetitive calculations and produces extremely accurate elevations of the FAA surfaces at any point or along any path. Geopak Site is commonly utilized in engineering design and is less expensive than more specialized software packages. Necessary model inputs are readily available from the FAA and, in most cases, are publicly available through online sources, such as Airnav.com. The Geopak Site models can be utilized to extract spot elevations and generate profiles of the surface, as well as TIN files utilized for contour generation.

Among the benefits of this technique is non-invasiveness and relative simplicity when compared to conventional methods. In years past, techniques for detecting airspace object penetrations have included LIDAR applications and the use of telescopic cross-hair cameras placed on the airfield. Only limited knowledge of Geopak Site is required to build the airspace surfaces. It also eliminates the need for activities that can be disruptive to airfield operations such as placing detection equipment on the airfield.

The following sections include guidance and suggestions for utilizing Geopak Site to model the CAT II,III airspace surface. The sections are written for engineers with a basic understanding of Geopak Site.

**Geopak Site Modeling**
The Geopak Site model has four basic components consisting of a project, model, objects, and elements. The number of elements is object specific and will vary depending on the type of surface modeled. Figure 2 below presents a diagrammatic representation of the Geopak Site model.

![Diagram of Geopak Site model]

**Figure 2 – Modeling Structure for Geopak Site**

Geopak Site is typically utilized to design retaining walls and proposed grading for various site development/infrastructure projects. In this application of the software, the objects built are the airspace surfaces and the elements are the edges and break lines of the surface.

Utilizing Geopak Site’s help tutorials benefit in the creation of the project, model and object. When creating a new model, it is useful to assign names to the objects that are representative of the specific surfaces being modeled in order to easily reference them. In addition, it is preferable to have an existing ground surface in the model for comparison with the airspace surfaces that will be created. The help tutorials explain how to import surface data.

**Building an Airspace Surface from Elements**

As previously mentioned, it is necessary to have the boundaries and break lines of the airspace surface prior to modeling. Each airspace surface presents a unique set of challenges for the engineer. Before attempting to design the model, the engineer should plan out the best approach to build each surface. The typical method would be to start with the closest parallel line to the end of the runway, building the middle section of the surface first, and then adding the side sections onto the middle section. The order and method of adding elements to the surface object is important and many times trial and error can lead to a good modeling
solution. If elements are added incorrectly they can always be modified to undo any adverse effects on the modeled surface.

**Choosing the Method of Adding Elements**

There are four especially useful methods in Geopak Site for adding elements to airspace surfaces, including:

1. Constant Elevation
2. Drape on Object
3. Element from Point
4. Slope/Offset from Site Element

The correct method to utilize will depend upon available input data and constraints imposed by the specific airspace surface. The Constant Elevation method, as the name suggests, can be utilized for surface boundary lines that remain at a constant elevation along a line. The Drape on Object method is appropriate for the addition of break lines along the inside of the shape requiring dependence upon the airspace surface being created. The Along Element from Point method allows you to specify a slope along a line from any given point. This method can also create an object with a certain elevation difference between vertices. The Slope/Offset from Site Element method allows for the creation of an element with a specific elevation or slope offset from another element.

In general, the easiest method is to start with the inner section of the surface and build outward to the edges; however, this is not recommended when the surface being modeled is not an approach or departure surface. The inner section can usually be built easily by adding the boundary lines by constant elevation and then adding break lines to the side using the drape on object method. The remaining boundary edges of the surface can be created by multiple methods depending upon the shape of the surface. Figure 3 shows the boundary and break lines for the CATII,III surface, labeled alphabetically in the suggested order of addition to the model. The method used to add the element to the object is also indicated.

Some surfaces are more complex than others and present unique modeling challenges. Creativity can be exercised in determining how to achieve an effect like the vertical rise in the CATII,III surface. The engineers at DFW International Airport were able to accurately model the vertical rise by utilizing the aforementioned method and by creating additional line work. Figure 3, Detail A depicts the line work created to support the vertical rise. Additional line work would not necessarily be required if another modeling method were chosen.
Figure 3 – Line/Element Labels and Method Designations
After adding the surface boundary lines and break lines as elements of the surface object the three dimensional surface will be visible in the drawing file. Figure 4 shows a 3D contoured view of the modeled surface. The appearance of the 3D surface can be modified to be utilized as a visual aid in plan and profile drawings.

![Figure 4 – CATII,III OFZ Surface in 3D](image)

**Modifying the Surface View for 2D Applications**

The 3D surface can be utilized to visually depict contour elevations of the surface in plan view drawings. The contours of the surface are automatically created, but specific characteristics, such as intervals, labels, and text size, should be modified prior to exportation. The surface can also be modified to display triangles instead of contours. The Site Modeler toolbar allows for modification of all attributes with standard Microstation editing options prior to placement on design drawings.

Another application for the 3D model is to depict accurate profile information for design or plan preparation. Profile sections can be created with the utilization of analysis tools. Objects are selected and profiles are generated at any user defined section of the model. This creates a profile that can be easily modified and placed into the design file.

With the plan and profile views created it is practical to create construction documents containing depictions of the modeled surface. The plan and profile representations can also be utilized for design purposes to insure airspace penetrations were adequately avoided; however, when designing it is often necessary to export data of the modeled 3D surface for use in other design applications.

**Exporting Surface Data from Geopak Site**

The Site Modeler toolbar allows the user the ability to export the 3D contours of the surface into 2D line work. This allows for the creation of a two dimensional contour set for use in either Microstation or AutoCAD. It is important to create a graphic group when exporting line work for ease of use in the design file.
The final and arguably most valuable exporting tool is the ability to export the three dimensional data to a .TIN file or LandXML file. This Site Modeler tool allows the 3D data to be utilized in various other design software applications. Any object created within a particular model can be exported into various file types. Creating a TIN file or LandXML file has proven beneficial for multiple design applications. The exported TIN file can be utilized to create coordinate geometry profiles and easily confirm surface elevations in other Geopak software applications.

**Benefits and Applications**

This modeling technique can be utilized for any design or research application dependent upon knowing specifics of any FAA surface. Recently, the modeling technique was utilized to design an end-around taxiway system at DFW International Airport. Multiple airspace surfaces were modeled for the proposed taxiway design to insure all FAA guidelines and restrictions were met; Figure 5 shows a modeled surface along one proposed taxiway alignment.

![Figure 5 – Plan and Profile Drawing Using Geopak Modeled Surface Data](image)

The ability to create three dimensional surface models allowed engineers to set control points for the elevation of the proposed taxiways. By determining the lowest elevation of the airspace surface along the proposed alignment, engineers were able to determine the required taxiway elevation for a predetermined tail height. This design procedure can also be utilized for roadway design in the proximity of an airport.
The modeling technique would also benefit applications where the control points are not along a particular alignment but are specific points or areas. This would be applicable to airspace studies with a variety of objectives including tree trimming studies, placement of above ground appurtenances on an airfield, or various construction activities.

Concluding Remarks

Determining height restrictions for objects within airspace surface boundaries has been simplified by the adaptation of Geopak Site grading software to model airspace surfaces. This technique greatly aides the design applications and provides usable electronic files for plan production. The modeling technique is relatively simple and results in a thorough understanding of the airspace surfaces as well as Geopak Site software.

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References