To the Graduate Council:

I am submitting herewith a thesis written by Bryan Douglas White entitled "Air Traffic Control Tower Siting Analysis Model, Integrating The Airport Master Plan." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Civil Engineering.

Frederick J. Wegmann, Major Professor

We have read this thesis
And recommend its acceptance:

Arun Chatterjee

N. Mike Jackson

Accepted for the Council:

Interim Vice Provost and
Dean of the Graduate School

AIR TRAFFIC CONTROL TOWER SITING ANALYSIS MODEL, INTEGRATING THE AIRPORT MASTER PLAN

A Thesis
Presented For The

Master of Science Degree

The University of Tennessee, Knoxville

Bryan Douglas White

May, 2001

DEDICATION

This thesis is dedicated to Kimberly Ann White

for support, friendship, and love.

ACKNOWLEDGMENTS

Thanks to Dr. Fred Wegmann, my major professor and friend, for helpful encouragement and support during both my undergraduate and graduate degrees as well as during my thesis. Thanks to Dr.'s Arun Chatterjee and N. Mike Jackson for all of their additional help and guidance. Thanks to Metropolitan Knoxville Airport Authority Department's of Engineering and Operations for professional knowledge as well as the use of departmental assets. Special thanks to L. Eric Williamson, a friend and colleague, for technical and philosophical assistance during the past year.

ABSTRACT

Airport Master Plans are the primary documents that airport managers and directors have available to plan growth and expansion at any given airport. Typically, on the air side, an airports master plan would offer several different possibilities for future growth or expansion. These growth or expansion possibilities include: existing runway lengthening, construction of new runways, and taxiway improvements.

Until recently, airport master plans did not evaluate the possibility that a new air traffic control tower facility might have to be constructed in order for the control tower to maintain line of sight visibility with all movement surfaces on or near the runway environment.

This thesis integrates the airport master plan document and an air traffic control tower siting analysis model to determine if a new control tower will be required to meet the airport's proposed or expected growth. The model can be applied to existing air traffic control towers or can be used to determine the best possible location and height for a newly constructed control tower based on line of sight criteria.

The model was demonstrated on the existing conditions at McGhee Tyson Airport in Alcoa, Tennessee. The model showed that the existing air traffic control tower has two areas of reduced line of sight visibility. Additionally, the model was run on the existing air traffic control tower assuming an 10-ft. increase in elevation. This assumed increase in the air traffic control tower's elevation did not significantly improve the line of sight projections.

TABLE OF CONTENTS

Chapter I – Introduction 1

Basic components of The Federal Airway System 1
What are Air Traffic Control Towers? 1
Line of Sight Importance to Air Traffic Control Towers 4
Objective 5

Chapter II – Literature Review 7

Chapter III – General Model Description 10

Introduction to Airport Master Plans 10
Air Traffic Control Tower Ownership 10
Flow Model Diagram 11

Chapter IV – Model Applied to McGhee Tyson Airport 18

McGhee Tyson Airport General Description 18
McGhee Tyson Master Plan Review 18
AutoCad Drawing Selection and Description 19
Problems Associated With The AutoCad Drawings 22
Existing Conditions Line of Sight 26
Area A Analysis With Existing ATCT at a Greater Elevation . 31
Three Dimensional Views of McGhee Tyson Airport 33

Chapter V – Conclusions and Discussion 36

References 38

Appendices 40
Appendix A 41
Appendix B 49

Vita 56

LIST OF FIGURES

Figure 1.1 – Aviation System Flow Diagram for Land and Air Side Operations 3

Figure 3.1 – Model Flow Diagram 12

Figure 3.2 – Analysis Flow Diagram 16

Figure 4.1 – McGhee Tyson Master Plan Drawing Knoxtopo.dwg 21

Figure 4.2 – McGhee Tyson Master Plan Drawing Knoxtopo-con.dwg 23

Figure 4.3 – Initial Line of Sight Projection Lines 27

Figure 4.4 – Line of Sight Area A-2 with ATCT at 84-ft. AGL 29

Figure 4.5 – Line of Sight Area A-2 with ATCT at 94-ft. AGL 32

Figure 4.6 – Three Dimensional View of McGhee Tyson Airport 34

Figure 4.4 – Three Dimensional View of Area A 35

Chapter I Introduction

Basic components of The Federal Airways System

The Federal Airways System consists of a network of navigational aids and air traffic control facilities, which provide for the safe separation and orderly flow of aircraft within the range of the system. The jurisdiction of control is divided into three parts, namely, en route, terminal, and airport (Horonjeff, McKelvey, 1983).

The Air Route Traffic Control Centers (ARTCC) have the responsibility of controlling the movement of en route aircraft along the airways, jet routes, and in other parts of the airspace. The Terminal Radar Approach Control (TRACON) facility controls traffic, arrivals and departures, from the boundary area of the air traffic control tower (ATCT) at an airport to a distance of 25 to 50 miles from the airport (Horonjeff, McKelvey, 1983). The airport control responsibilities are centered around the air traffic control towers and usually extends to a 5 mile radius around the given airfield and control tower.

What are Air Traffic Control Towers?

The air traffic control tower (ATCT) is the facility that supervises, directs, and monitors the traffic at the airport and in the immediate airspace, arrivals and departures, up to about 5 miles from the airport

(Horonjeff, McKelvey, 1983). These ATCT facilities are one of the most recognizable structures on any given airfield and are usually tall concrete and steel towers with tinted class enclosed cabins occupying from 1 to 4 acres of land (FAA, AC150/5300-13, ch.6). These control towers are the aviator's link between safely landing and departing the airfield environment. One of many roles for air traffic control tower personnel is that of directing the ground movements or taxi of arriving and departing aircraft (FAA, FAR 91.123). In order for the air traffic control towers to successfully direct all ground taxi's, "there must be a clear, unobstructed, and direct line of sight to the approaches, to all runways or landing areas, and to all runway and taxiway surfaces" (FAA, AC 150/5300-13, ch6).

Generally, any given airport operation is broken into two different categories; land side and air side. The air side is chiefly concerned with the safe arrival and departure of aircraft into and out of the airport and terminal area environments. Air traffic control towers are a function of the air side operations and a flow diagram of land side and air side operations is outlined in Figure 1.1 (Wegmann F., 2001).

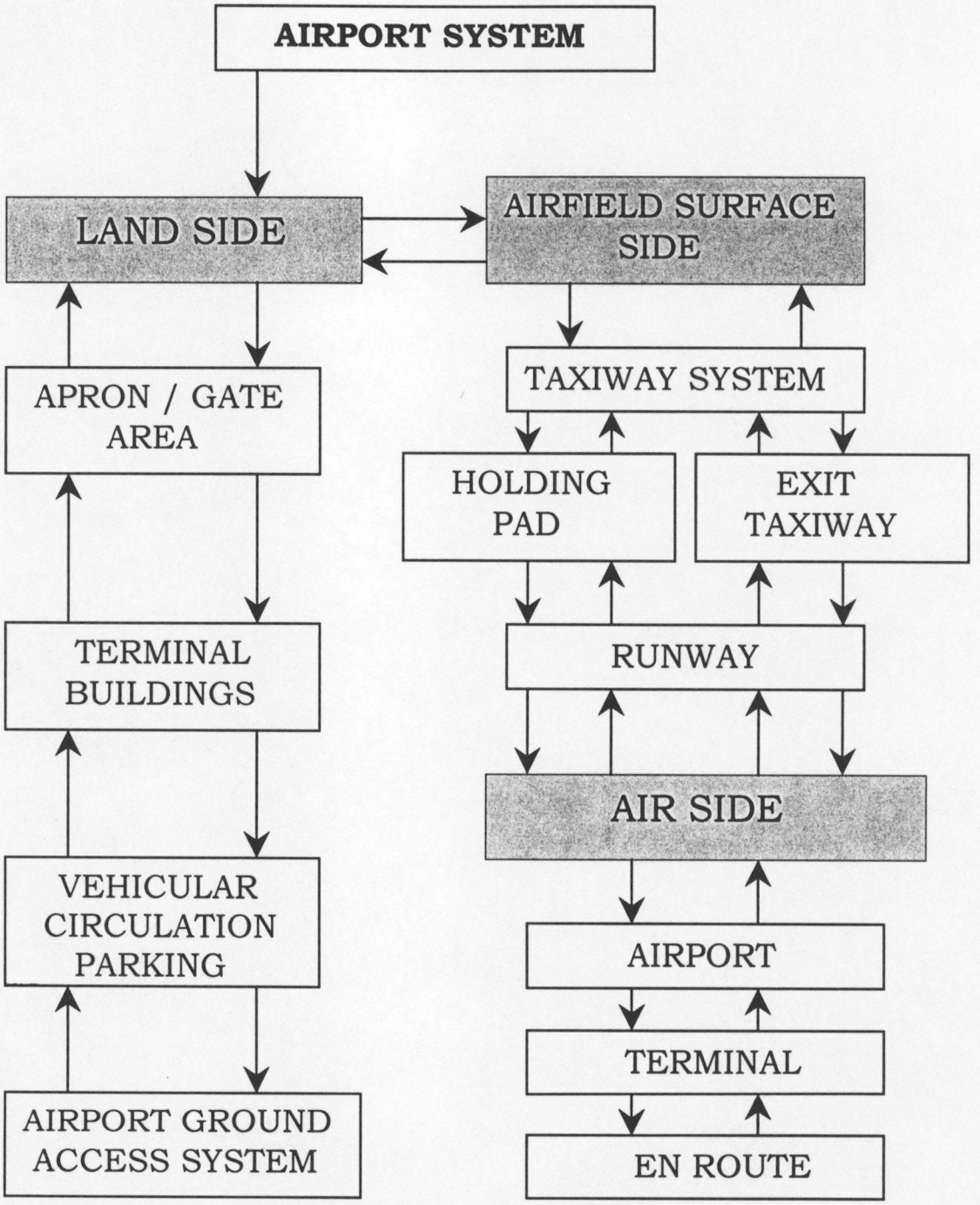


Figure 1.1 – Aviation System Flow Diagram for Land and Air Side Operations

Line of Sight Importance to Air Traffic Control Towers

The Federal Aviation Administration (FAA) defines runway incursion as "any occurrence at an airport involving an aircraft, vehicle, person, or object on the ground that creates a collision hazard or results in loss of separation with an aircraft taking off, intending to take off, landing, or intending to land (Runway Incursion, FAA's Office of System Safety)." Interestingly, the FAA only recognizes runway incursions as occurring at airports with operating air traffic control towers. Secondly, the National Transportation Safety Board list of "Ten Most Wanted Transportation Safety Improvements" (NTSB, ntsb.gov) shows airport runway incursions as the FAA's area of most needed safety improvements. In this list, the NTSB charges the FAA to "provide for safer more positive control of aircraft on the ground (NTSB, ntsb.gov)."

A properly sited air traffic control tower that maintains adequate line of sight with all areas of the airfield environment will enable control tower personnel to have positive visual control of all taxiing aircraft. Aircraft that are taxiing at a given airport would be less likely of having a runway incursion if the air traffic control tower personnel could see, identify, and stop a possible incursion before it happens. Visual line of sight with the entire airfield environment plays a key safety role in prevention of runway incursions by air traffic control personnel.

Objective

In order for air traffic control towers to meet the sight requirements set out in the Federal Aviation Administration's Advisory Circular 150/5300-13, chapter 6, proper tower placements and heights are critical. Typically, air traffic control towers are constructed with a 20-year life span (NTL, GAO/RCED-95-14, ltr 3.1). Therefore, a control tower must be situated as to obtain the maximum line of sight for the current airfield layout as well as any planned future layout changes due to growth and construction over the next 20 years

The objective of this thesis is to provide a model that will aid airport managers as well as FAA personnel in the siting of new ATCT or the analysis of existing ATCT for future growth or expansion. The model will address both the horizontal positioning as well as the vertical height of a given or proposed air traffic control tower. *ArcView Geographical Information System* (GIS), (ESRI,3.1,1996) will be used for the model and provides the user with a geographic view of the airfield and topography as well as the existing or planned air traffic control tower. The GIS model integrates *AutoCad* (Autodesk, Map 2000, 1999) drawings as the base topographic and airfield maps. The model will be demonstrated by specific example at McGhee Tyson Airport located in Alcoa, Tennessee. Again, the model can be used to analyze an existing

air traffic control tower as well as determine the best placement for an air traffic control tower to be newly constructed.

The basic analysis steps in this thesis are:

1. Review a given airports master plan to determine future growth and expansion of air side environment;
2. Analyze existing or proposed ATCT location;
3. Determination of *AutoCad* drawings required from master plan;
4. Preparation of selected *AutoCad* drawings that are to be added into *ArcView GIS*;
5. Integration and manipulation of *AutoCAd* drawings in *ArcView GIS*;
6. Run model to identify line of sight hazards;
7. Demonstrate a specific example by applying model to McGhee Tyson Airport in Alcoa, Tennessee.

Chapter II Literature Review

The Federal Aviation Administration uses the Department of Transportations Order # 6480.4 Appendix 1, Airport Traffic control Tower Siting Criteria, as the regulation that governs site and height criteria for ATCT's. The Order establishes the mandatory and non-mandatory requirements concerning site and height selection of airport traffic control towers to be established by the FAA (DOT Order 6480.4, 1972).

The Order's mandatory siting requirements states that complete visibility must be available to all airport surface areas utilized for movement of aircraft which are under the control of the airport traffic control tower. Primary consideration must be given to the air traffic ground control position of operation; however, all operating control positions should have this capability. A clear, unobstructed and direct view of taxiways and runway should be available (DOT Order 6480.4, 1972). Maximum visibility of airborne traffic patterns must be available. Primary consideration must be given to the local control position of operation; however, all operation positions should have this capability. A clear, unobstructed and direct view of the approach to the end of the primary instrument runway and all other active runways and landing areas should be available.

Importantly, DOT Order # 6480.4 states that consideration should be given to planned airport expansion as shown on the airport master plan. Particular attention should be given to future construction of building, hangars, new or extended runways and taxiways, etc. to preclude the necessity for relocation of the control tower at a future date.

The importance of the mandatory line of sight requirements stated above have become scrutinized due to the increasing occurrence of runway incursions. The National Transportation Safety Board (NTSB) public meeting dated 13 June 2000 specifically addresses four different runway incursion incidents that happened in 1999: 1 April 1999 at O'Hare International Airport, Chicago, Illinois; 27 June 1999 at John F. Kennedy International Airport, New York, New York; 22 November 1999 at Los Angeles International Airport, Los Angeles, California; and 6 December 1999 at Theodore Francis Green State Airport, Providence Rhode Island.

On 29 July 1991, A USAIR aircraft crashed into another aircraft at Los Angeles International Airport while attempting to land. The accident resulted in 34 passenger deaths and was later blamed on problems with the air traffic control system. According to the FAA, there have been

233 hazardous runway incursions; a 26 percent increase from the same period last year. The NTSB reports there were 322 runway incursions last year, a 75 percent increase over the past seven years. "Runway incursions are the number one aviation safety problem in the United States," says Jim Hall, chairman of the NTSB. Mr. Hall additionally states, "The situation, if not addressed, is not a subject of if there's going to be another accident, it's when there's going to be another accident."

Air traffic control tower siting plays a vital role in allowing FAA personnel to have proper line of sight views of the entire airfield environment. The specifics of the above runway incursions were not provided and no speculations will be made as to the exact causes leading to each incident. However, a properly sited ATCT with adequate line of sight visibility could not have been a detrimental factor leading to each incursion.

Chapter III General Model Description

Introduction To Airport Master Plans

The primary objective of an airport master plan is to develop and maintain a long-term development program which will yield a safe, efficient, economical, and environmentally acceptable air transportation facility (McGhee Tyson Master Plan, 1994). The accomplishment of this objective requires the evaluation of the existing airport and a determination of what actions should be taken to maintain an adequate, safe, and reliable airport facility to meet the needs of the area.

The master plan provides a phased, step-by-step, outline of the indicated developments, and gives advance notice to responsible officials of pending needs to aid in future scheduling and budgeting. An airport master plan is a planning document that allows for orderly and timely development of the airport. Airport master plans are partially funded by the Federal Aviation Administration's *Airport and Airways Improvement Act of 1982*, Section 505, as amended.

Air Traffic Control Tower Ownership

Until recently, the air traffic control tower facility was solely owned and maintained by the FAA. The parent airport would provide the FAA with

a long-term land lease and the FAA would design, construct, and operate the ATCT facility. For example, the FAA would do a site analysis to determine a desirable location to construct an ATCT facility. The FAA would select a location and ask the parenting airport to provide a long-term land lease for the ATCT facility construction and placement. The parent airport would provide a long-term land lease that would allow the FAA to construct and operate its ATCT facility.

Due to limited budgets at the federal level, air traffic control tower facilities ownership has seen a change as of recent. Air traffic control tower facilities are being funded at the local level and in turn, leased back to the FAA. The funding is varied and not limited to: issuance of municipal bonds, industrial revenue bonds, and airport cash reserves (Marrison, B., 2001). Traditionally, the airport owned the land and the FAA solely owned the ATCT facility. More recently, the ownership of the ATCT facility is not necessarily that of the FAA.

Model Flow Diagram

The basic flow diagram for the model is given as Figure 3.1. In general, most established airports would have a working master plan. The importance of the master plan is described above and is the basis for understanding the future growth and expansion of the airport. It is the

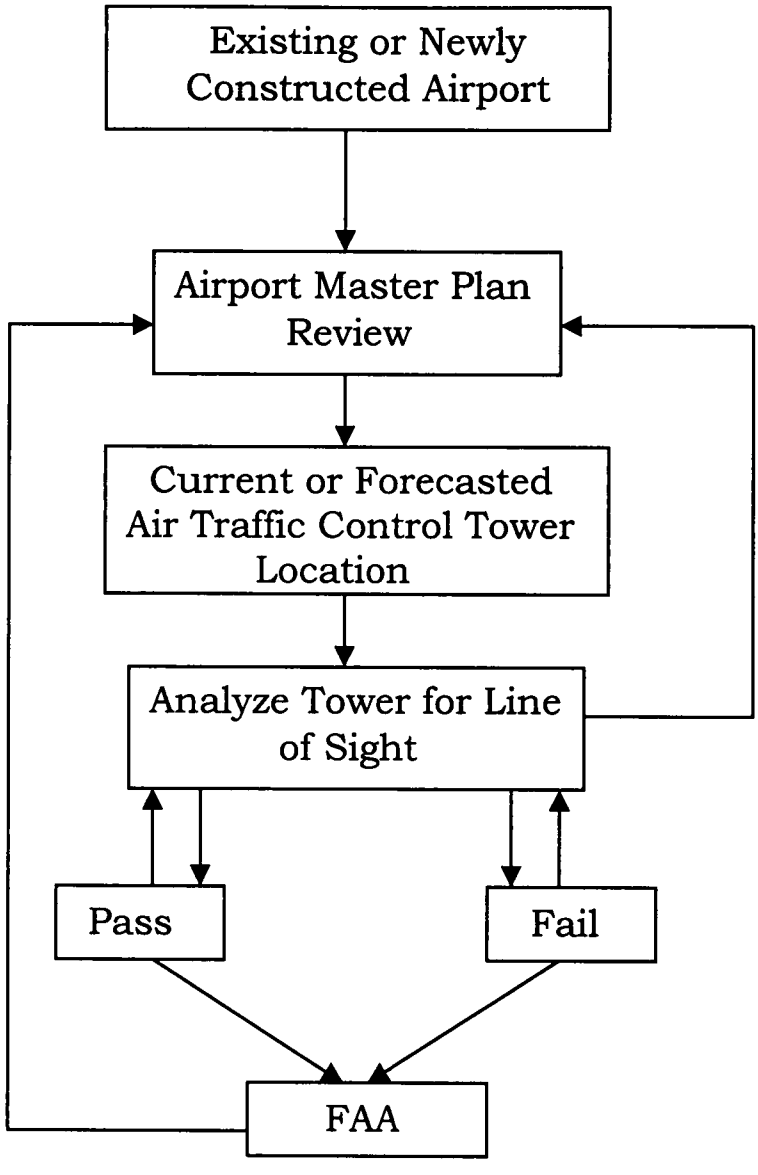


Figure 3.1 - Model Flow Diagram

growth and expansion forecast that forms the basic necessity under which this model was conceived.

The first and likely most important step in this model is to fully understand the airport's master plan. Usually, several alternatives are offered in the master plan for airside growth and expansion. The likelihood of having two or more options for runway relocation and/or expansion is to be expected. Until recently, airport master plans did not evaluate the possibility that a new ATCT facility might be required based on forecasted airport expansion (Swancey, C., FAA, 2001). The line of sight requirements are addressed in Chapter I and it is these requirements that would determine the need to construct a new ATCT facility based on the airports forecasted expansion.

Once the master plan forecast for growth and expansion is identified, two options become available for evaluation. The first being to analyze the existing ATCT to determine if the line of sight requirements are met and the second being an analysis of differing locations for line of sight requirements for future ATCT placement. The more immediate action would be to analyze the existing ATCT for line of sight compatibility with forecasted growth or expansion. If line of sight requirements cannot be

maintained with the current ATCT location, differing sights can be selected and analyzed.

Airport master plans are usually updated every five years and should reflect any changes that have happened and any new or expected planning changes in the future. The model flow diagram (See Figure 3.1) reflects this continual updating of the master plan by showing the connection between "Analyze Tower for Line of Sight" and "Airport Master Plan Review" entries. If for example, a new airside expansion is required that was not projected in the previous airport master plan, airport managers could use this model to determine if a new ATCT is required. In turn, both the need for new airside expansion and the ATCT analysis could be entered in to the next airport master plan.

The FAA plays an integral role in the execution of an airports master plan. The Airways Facilities Division (AFD) is the department of the FAA that provides expertise as to the development and content of the master plan. In practice, the FAA could be placed as one of the initial entries on the Model Flow Diagram (See Figure 3.1) as easily as placed at the end. The importance of the FAA is not diminished due to placing the entry at the end of the flow diagram.

The "Pass" or "Fail" entries refer to the line of sight requirements set out in Chapter I. If an existing ATCT is analyzed for line of sight and passes, the information can be presented to the FAA and included in the airports master plan. The FAA would be informed as to the future possible need of a new tower when the airport constructs its proposed new runway, taxiway, etc. Additionally, the airports master plan would reflect the analysis performed and show the possible need for a new ATCT.

The "Analyze Tower for Line of Sight" entry on the model flow diagram (See Figure 3.1) can be broken into several steps and is included as Figure 3.2. The flow diagram given as Figure 3.2 is similar to the flow diagram given as Figure 3.1 with the addition of two entries; "Computer Aided Drafting Maps" and "ArcView GIS."

Airport Layout Plans (ALP) are generally produced as part of an airport's master plan. These ALP's are computer generated layout drawings of the given airfield's land side and air side facilities. Generally, ALP's are produced with a computer aided drafting program and are intended to provide the airport managers with a electronic file that accurately represents the actual locations and dimensions of the entire airfield layout. A given airport's ALP drawing is the electronic

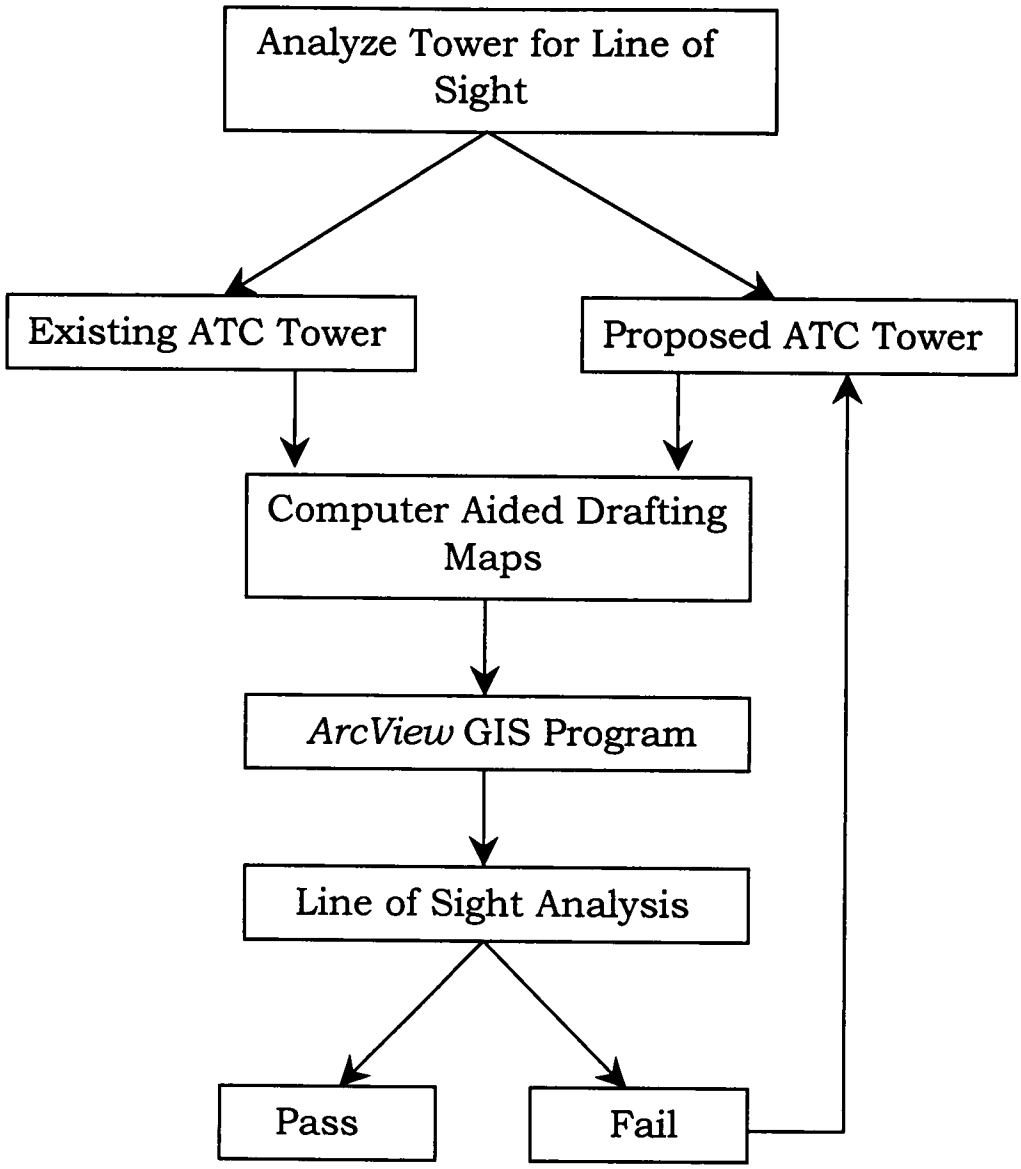


Figure 3.2 - Analysis Flow Diagram

map that is used to form the base information for the GIS line of sight analysis.

The line of sight analysis procedure for this thesis is performed in *ArcView GIS*. Once a given airport's master plan ALP map drawing has been properly prepared, the map can then be added to *ArcView GIS* as a separate theme. Additionally, *ArcView Spacial Analysis* extension has been used to further augment *ArcView GIS's* capabilities. Line of sight profile graphs can be generated to give the airport managers a graphical tool to analyze a given ATCT's line of sight. The implication of the line of sight graph analysis is the selection criteria for the "Pass" or "Fail" entries given in Figure 3.1.

Chapter IV – Model Applied to McGhee Tyson Airport

McGhee Tyson Airport General Description

McGhee Tyson Airport (TYS) is the premier air facility in East Tennessee, serving the commercial airline industry, air cargo, military aviation and general aviation. With parallel 9,000-feet runways, McGhee Tyson Airport can accommodate any size aircraft in today's inventory. Located 12 miles south of downtown Knoxville, the airport occupies more than 2,000 acres of land with space for additional air cargo facilities or economical development (TYS,16 Feb 01). McGhee Tyson Airport is classified as a small hub primary commercial service airport and accommodates airline passenger needs for destinations within 500 to 1,500 miles (McGhee Tyson Master Plan, 1994)

McGhee Tyson Master Plan Review

McGhee Tyson's annual service volume (ASV) is currently 284,000 operations, and the airport is presently operating at approximately 46.1 percent of its ASV. By the year 2015, 224,500 aircraft operations are forecast to represent 86 percent of the airport's annual service volume of 262,000 operations. FAA Order 5090.3B *Field Formulation of the National Plan of Integrated Airport Systems* (NPIAS) indicates that improvements should be considered when operations reach 60 percent of the airfield's annual capacity. Examples of improvements, which

improve airfield capacity, include additional runway entrance/exit taxiways, navigational aids, and/or new runway development (McGhee Tyson Master Plan, 1994).

One of the Alternatives that McGhee Tyson Airport has established is the addition of a new 8,000-foot runway to the existing two 9,000-feet runways. In the McGhee Tyson Master Plan, there is no reference to analyzing the existing ATCT in order to determine if the line of sight requirements set out in Chapter I will be maintained. This thesis model will be ran to analyze existing line of sight conditions as well as the proposed additional 8,000-foot runway.

AutoCad Drawing Selection and Descriptions

Two *AutoCad* drawings were selected from the McGhee Tyson's Master Plan and used in the generation of the McGhee Tyson GIS model. Both *AutoCad* drawings are part of the Metro Knoxville Airport Authority's 1995 Master Plan (McGhee Tyson Airport Master Plan, 1994). In order to extract relevant data, neither of the two drawings have been used in their entirety. Multiple layers have been removed or deleted from both drawings. Typically, *AutoCad* drawings store different types of information on different layers within one drawing file. For example, surface parking could be on one layer while garage parking on another

layer. The deletion of unneeded layers was necessary in order to produce a GIS map with less visual clutter and a clean view showing only the airfield environment.

Knoxtop.dwg (McGhee Tyson Master Plan, 1994) is an *AutoCad* drawing (5,115kb) showing both airside and landside facilities at McGhee Tyson Airport. The airside facilities shown include runways, taxiways, parking ramps, aprons, hangars and maintenance facilities. The landside facilities shown include access streets, roadways, automobile parking, land surrounding TYS, and The Tennessee Air National Guard facilities (TNANG). Additionally, a third runway and center field terminal are shown as a 20-year expansion plan.

In the McGhee Tyson Airport model, Knoxtopo.dwg (See Figure 4.1) was used to generate the GIS map showing the runways, taxiway, landside buildings, TNANG building, and the Air Traffic Control tower (ATC). Knoxtopo.dwg was originally produced using x and y coordinates only. In other words, Knoxtopo.dwg is a two-dimensional drawing having no vertical elevation associated with any given x and y coordinate. Knoxtopo.dwg was used in the McGhee Tyson GIS Model to generate the

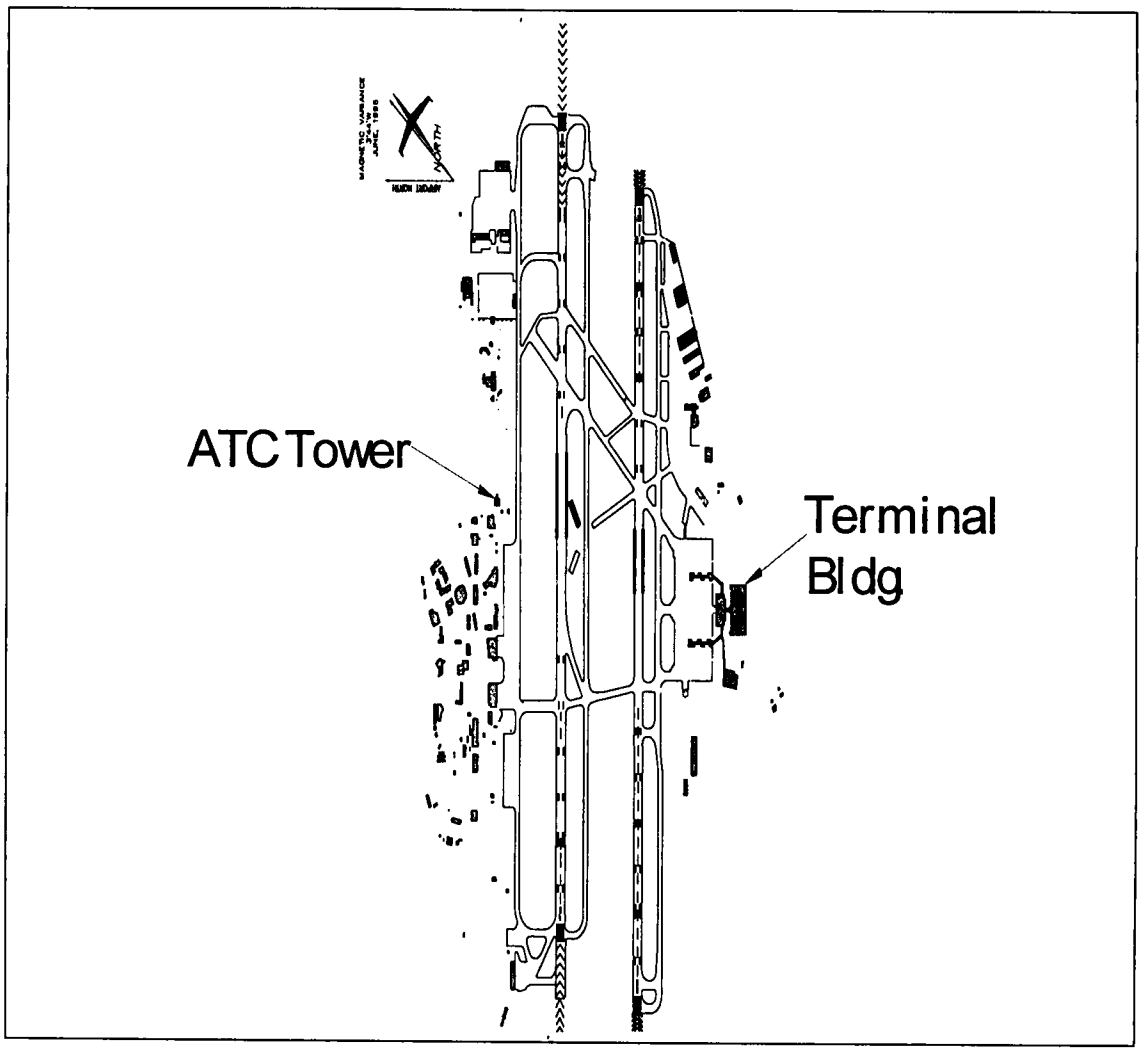


Figure 4.1 – McGhee Tyson Master Plan Drawing Knoxtopo.dwg

Runways and Taxiways, Fixed Facilities, and ATC (air traffic control) Tower themes.

Knoxtopo-con.dwg (See Figure 4.2) (McGhee Tyson Airport Master Plan, 1994) is an *AutoCad* drawing (3,199kb) showing contour lines at 10-ft. intervals of McGhee Tyson Airport and the surrounding area. Knoxtopo-con.dwg is a three-dimensional drawing with a vertical z-axis elevation associated with any given x and y coordinate. In generating the McGhee Tyson GIS Model, Knoxtopo-con.dwg was used to create the TYS Topo (topographic) and Topo Lines themes.

Problems Associated With The AutoCad Drawings

In the McGhee Tyson GIS model and within the Fixed Facility theme, the building elevations are shown at 35-ft. above ground level. The 35-ft. elevation was chosen as an average building height and does not reflect the actual building heights on the airfield. In order to reflect actual building heights in the GIS model, each building would have to be added as a separate theme. In general, none of the buildings at McGhee Tyson were obstructions in the line of sight from the ATC tower and thus not added as separate themes. In use, the actual building height would be desirable for the GIS model but the limited *AutoCad* data makes actual heights impractical. If for example, Knoxtopo.dwg

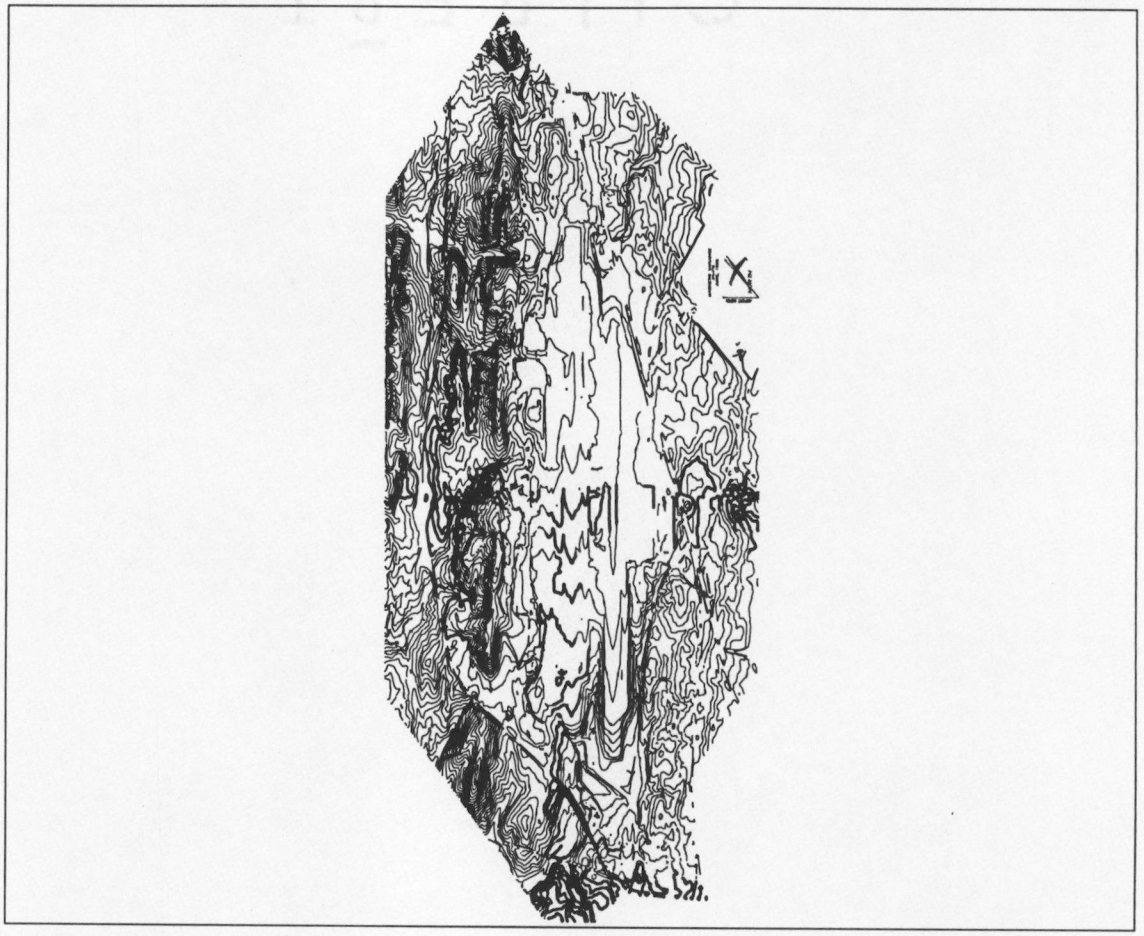


Figure 4.2 – McGhee Tyson Master Plan Drawing Knoxtopo-con.dwg

had been drawn with a z-elevation, each building would be at its actual height above ground level in the McGhee Tyson model. The McGhee Tyson ATC tower was added as a separate theme in the GIS model thus allowing the tower to be extruded to its actual height of 84-ft. above ground level.

In addition, the McGhee Tyson Airport's terminal building is not correctly represented. The Terminal shown in the model no longer exists and has been replaced with a new terminal building. The Metropolitan Knoxville Airport Authority is presently updating its master plan *AutoCad* drawing (Lindquist T., 2001) to reflect the new terminal building as well as other recently constructed buildings on the airfield.

Knoxtopo-con.dwg was added to the McGhee Tyson model as a separate theme. The theme was then converted from an *AutoCad* dwg file to a TIN (triangulated irregular network) file. *ArcView* redraws the dwg file as a TIN file and adds the TIN drawing as a new theme to the currant view. *ArcView* draws a network of triangles based on z-elevation associations and assigns colors to each elevation contour. The user can select the contour intervals or *ArcView* will default the intervals based on equal interval spacing. The continuity of the z-elevations associated

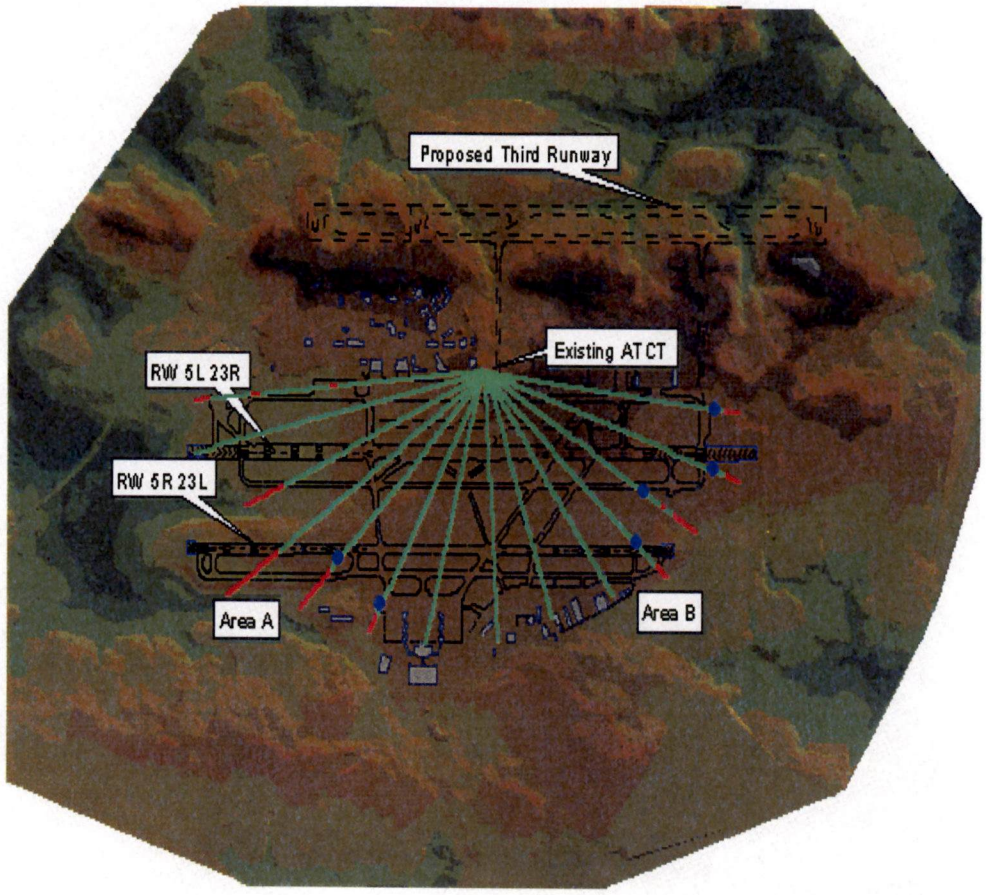
with Knoxtopo-con.dwg was somewhat problematic with the McGhee Tyson model. When Knoxtopo-con.dwg was initially added to *ArcView* and converted to a TIN file, numerous defects existed in the surface of the TIN drawing. The defects appeared as cone-shaped depressions on the surface penetrating through to 70-ft. below ground level in some cases.

The problem stemmed from errors in the z-elevations within the Knoxtopo-con.dwg drawing. The contour lines drawn in Knoxtopo-con.dwg were drawn using multiple connected poly lines. Each segment of the poly line has a z-elevation association. Many of the segments were found to have differing elevations. For example one contour poly line was found to have a z-elevation of 980.0 ft. mean sea level. The adjoining poly line's z-elevation was 910.0 ft. mean sea level. *ArcView* interpreted the abrupt change in elevation as a near vertical depression on the TIN drawing surface. In order to correct the cone-shaped depression problem on the TIN drawing surface, the Knoxtopo-con.dwg drawing had to be thoroughly checked and corrected in order to give each contour line a continuous z-elevation.

Existing Conditions Line of Sight

The model was run to analyze the existing line of sight conditions at McGhee Tyson Airport (See Appendix A, Initial Line of Sight Projection Lines) with the results shown in Figure 4.3. Fourteen line of sight projection lines with approximately 12.5-degree rotations between each projection was initially performed to determine possible existing areas with line of sight difficulties. Two areas, Area's A and B, were identified as marginal and Area A will be examined in further detail (See Figure 4.3, Initial Line of Sight Projection Lines).

Six line of sight projection lines were produced to provide a detailed examination of Area A. From each of the six line of sight projections, a profile graph was generated with distance in feet on the x-axis and elevation in feet given on the y-axis (See Appendix A, Line of Sight Area's 1-6). The profile graphs show the line of sight projection as a dashed line and the surface or terrain projection shown as the solid line. Visible surface terrain is shown as green while the surface terrain that is not visible is shown in red. Each of the dashed projection lines originates from the existing ATCT facility at a height of 84-feet above ground level and terminates at ground level.

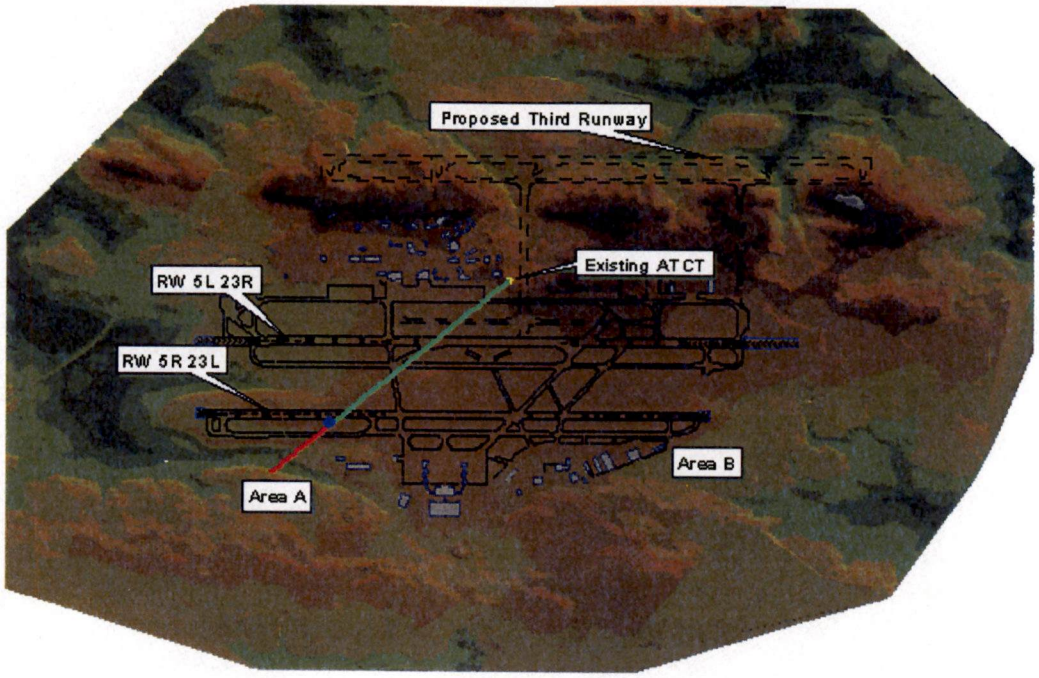


GILBERT
100% COTTON

Figure 4.3 - Initial Line of Sight Projection Lines

The determination of whether a section passes or fails a line of sight analysis depends on the interpretation of the line of sight profile graphs. If for example, a profile graph was produced that showed sections of a runway or taxiway as not visible from the existing ATCT, then the line of sight requirements given in Chapter I have been violated. However, if a profile graph was produced that showed sections of a general aviation parking apron or ramp as not visible from the existing ATCT, then the line of sight requirements given in Chapter I have not been violated. McGhee Tyson Airport has several locations in the center sod area between runways 23L/5R and 23R/5L that are not visible from the existing ATCT. Due to the fact that these areas are not a runway, taxi, or movement surfaces, a violation of the requirements in Chapter I has not occurred.

Based on the six profile line of sight graphs generated for Area A, Taxiway A, that runs parallel to Runway 5R/23L, has a line of sight problem (See Appendix A, Area A). Of the six profile line of sight graphs, five show portions of Taxiway A as not being visible from the ATCT. Figure 4.4, Line of Sight Area A-2 graph (See Also Appendix Area A-2) appears to be the most problematic with approximately 10-ft. of vertical separation from the line of sight projection. This 10-ft. vertical separation is not necessarily a concern when larger commercial aircraft



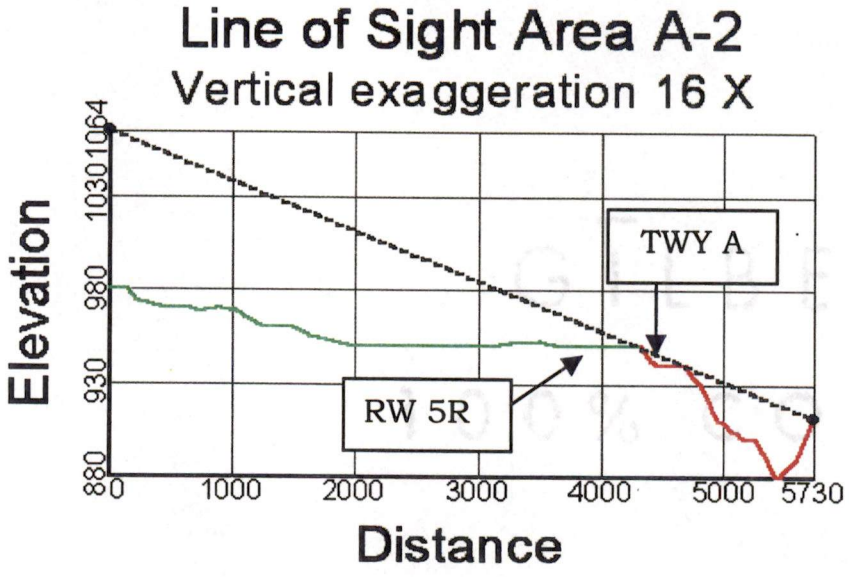


Figure 4.4 - Line of Sight Area A-2 with ATCT at 84-ft. AGL

are taxiing through the area. Larger commercial aircraft are normally taller than 10-ft. and will extend into the ATCT line of sight and thus maintain visual contact with the ATCT. However, smaller commuter or private aircraft that are less than 10-ft. in vertical height could pass though a non-visibility zone with the ATCT. Additionally, any airfield maintenance vehicle could easily be out of line of sight contact with the ATCT. The model shows Area A would potentially be at risk for a runway incursion any time a maintenance vehicle and small aircraft were operating in the vicinity of each other.

Analysis of Area B would be the same procedure as Area A and thus has not been demonstrated. Initially, an analysis of the proposed third runway at McGhee Tyson Airport was to be performed (See Appendix A) however, insufficient data existed for the finish elevation of the proposed runway. The large volumes of earthwork required to construct the proposed runway would drastically change the topography north of the existing ATCT. Due to this fact, a valid and objective analysis of the proposed third runway at McGhee Tyson Airport was not practical.

Area A Analysis With Existing ATCT at a Greater Elevation

In order to determine the full extent of the low visibility of Area A, the existing ATCT elevation has been extended 10-ft. for a total height of 94-ft. above ground level. Six line of sight graphs have been produced with the line of sights approximately the same as the six previous (See Appendix Area's A 1-6) graphs for Area A with the ATCT at 84-ft. above ground level. The six line of sight graphs for Area A with the ATCT elevation at 94-ft. are given in Appendix B.

Figure 4.5 is the line of sight graph for area A-2 with the ATCT at 94-ft. above ground level (AGL). When compared to Figure 4.4, no apparent improvement has been made. Both Figure's 4.4 and 4.5 identify Taxiway A as having a reduced line of sight visibility. When further examining the Figure 4.5, it becomes apparent that Taxiway A has an approximate 15-ft. vertical elevation difference from the Approach end to Runway 5R (RW 5R). When examining Figure 4.5, Taxiway A is located were the green terrain projection line becomes red. Due to the abrupt change in elevation between the approach end of RW 5R and Taxiway A (Area A), increasing the ATCT elevation to 94-ft. AGL did not significantly improve the line of sight visibility from the existing ATCT.

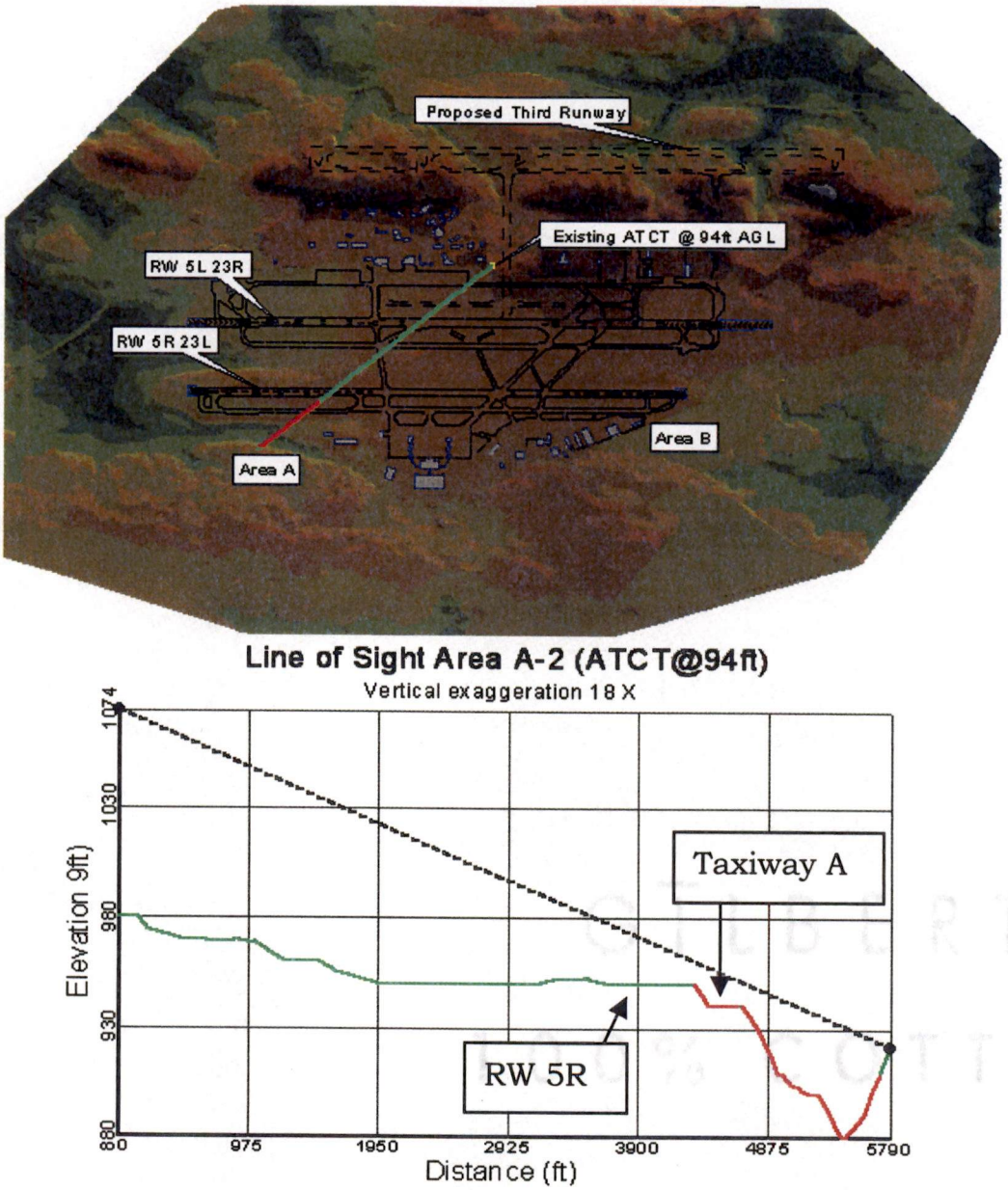


Figure 4.5 – Line of Sight Area A-2 with ATCT at 94-ft. AGL

Three Dimensional Views of McGhee Tyson Airport

The model is also capable of rendering three-dimensional views of the McGhee Tyson Airport and the surrounding topography. Figure 4.6 is a three-dimensional view of both the land side and air side facilities at McGhee Tyson Airport. Figure 4.6 has 10-ft. contour elevations that are represented as differing colors. Additionally, Figure 4.6 has a two to one vertical exaggeration. From the perspective of Figure 4.6, the reduced line of sight visibility Area A is visible and more pronounced than on the two-dimensional views. Figure 4.7 is given as a more close up view of Area A. Figure's 4.4 and 4.5 line of sight projections coincide with the noticeable contour change shown in Figure 4.7 Area A. This contour change is located on the previously described approach end of 5R and Taxiway A.

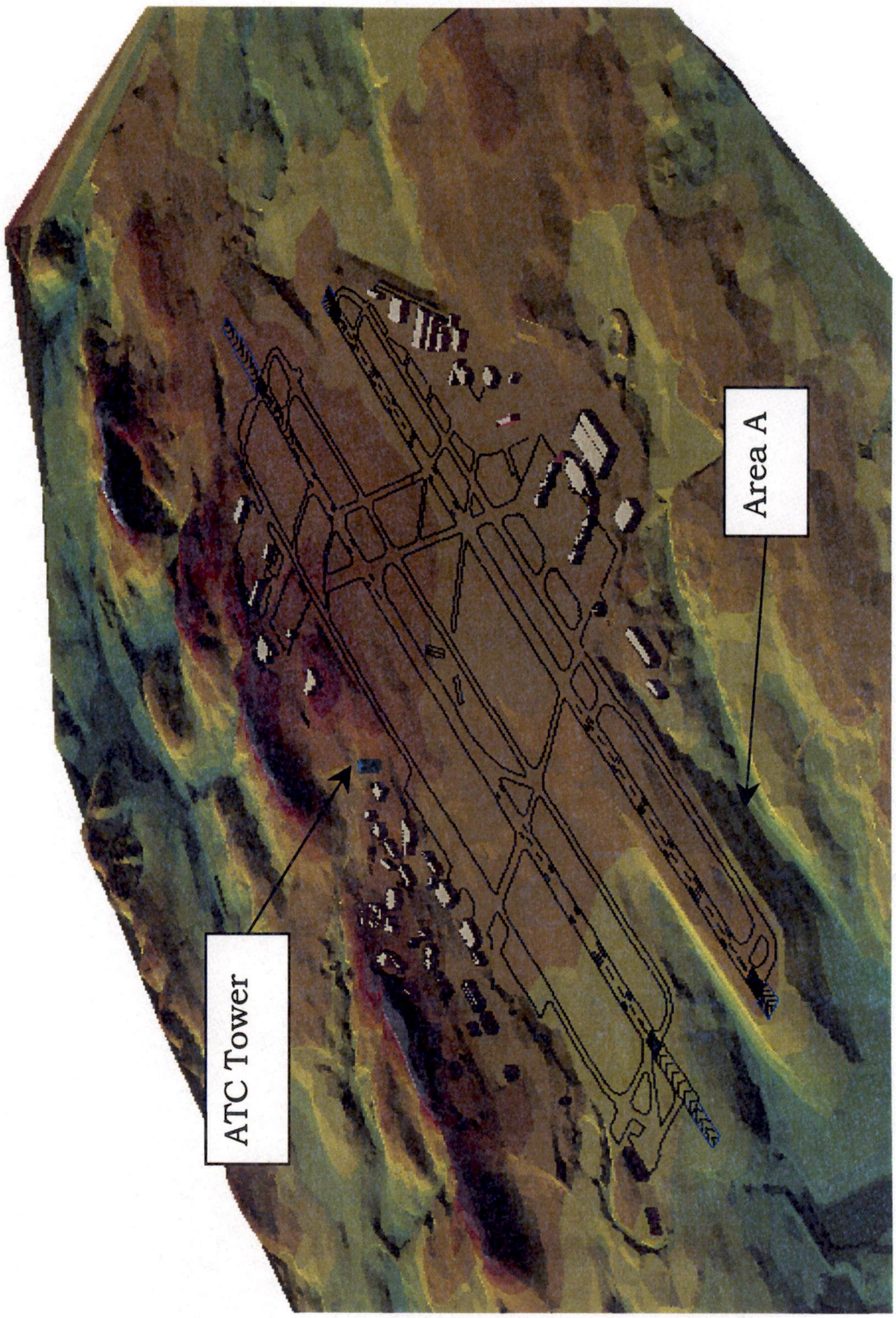


Figure 4.6 – Three Dimensional View of McGhee Tyson Airport

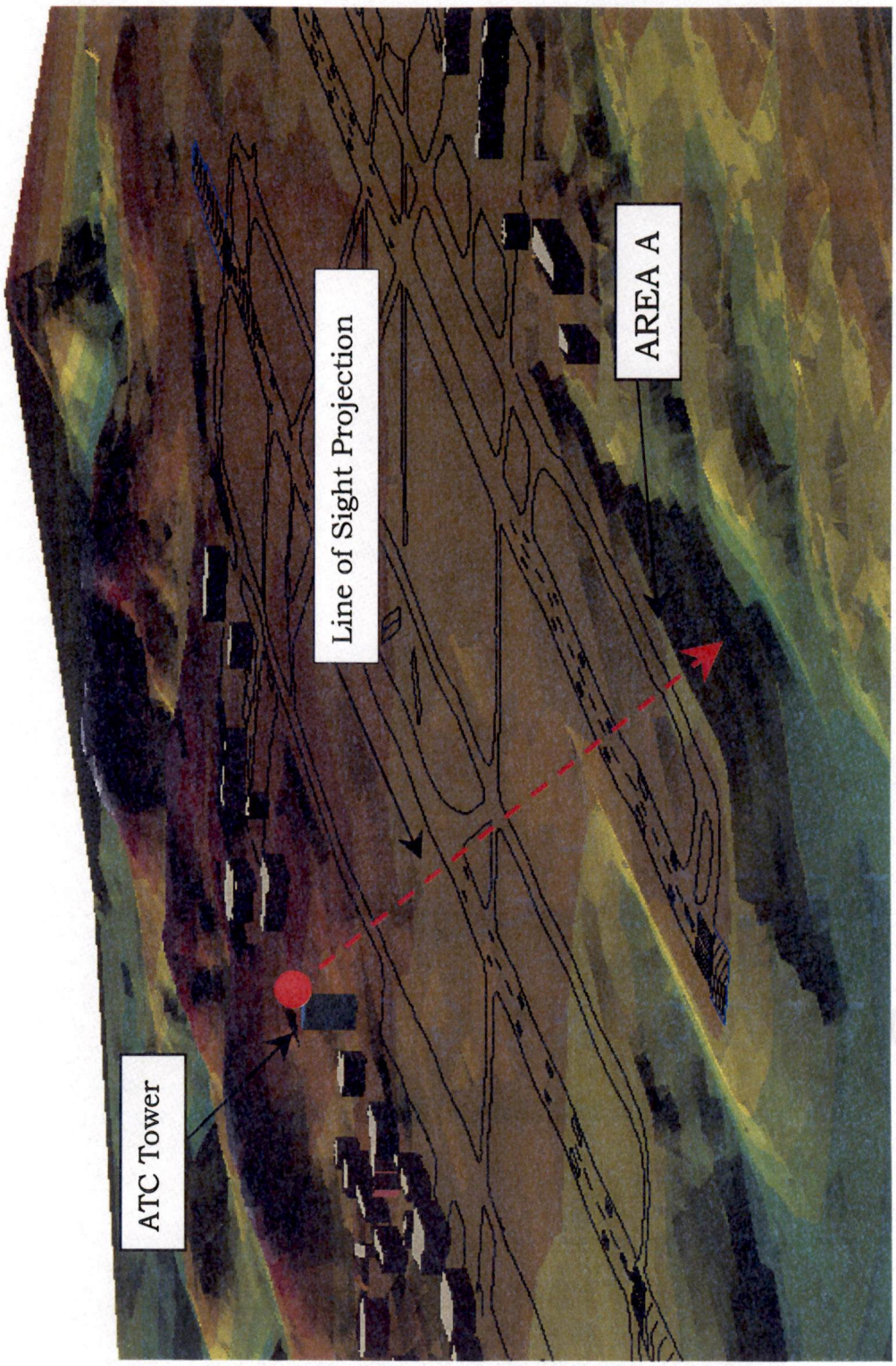


Figure 4.7 – Three Dimensional View of Area A

Chapter V Conclusions and Discussion

The main objective of this thesis was to provide airport managers as well as FAA personnel with a model to analyze an existing or proposed ATCT for line of sight requirements based on the Federal Aviation Administration's Advisory Circular 150/5300-13, Chapter 6. A specific example demonstration was performed on McGhee Tyson Airport. The model showed that McGhee Tyson Airport has two specific areas that have line of sight difficulties from the existing ATCT. These two areas are shown in Appendix A as Area's A and B.

In order to determine if the model accurately represented areas that could be problematic for the existing ATCT at McGhee Tyson Airport, the model results were shown to Randy Rogers, FAA Tower Supervisor. Mr. Rogers stated that both the areas have line of sight difficulties with Area A being more severe that Area B. Mr. Rogers also agreed that Area A is more of a problem with smaller commuter aircraft, private aircraft, and maintenance vehicles than with larger commercial type aircraft. Because of the possibility of an incursion happening in Area A, McGhee Tyson Airport ATCT personnel are extra vigilant when aircraft are taxiing in and out of the area.

As the model was being developed the importance of the master plan was not readily evident. However, the importance and understanding of the master plan became more prominent as the model progressed. A properly and thoroughly prepared master plan is one of the most important documents that airport managers or directors should have. The master plan insures that the FAA fully understands a given airport's direction for the future. Again, as stated in Chapter III, the first and likely most important step in this model is to fully understand the airport's master plan.

The accuracy and completeness of an airports computerized records and maps (See Chapter III ALP discussion) should be of high priority. As shown in Chapter IV, McGhee Tyson Airport's maps were lacking in several aspects and should be updated as soon as practical. The more accurate and detailed the digital maps, the more accurate and detailed the line of sight projection model will be. Simply stated, the better the data going into the model the better the data coming out of the model.

REFERENCES

Autodesk, Inc., AutoCAD Map 2000 Release 4. 1999

Department of Transportation, Federal Aviation Administration, Order Number 6480.4. November 1972.

Environmental Systems Research Institute, Inc., ArcView GIS Release 3.1. 1996

Federal Aviation Administration, Federal Aviation Regulation Part Part 91.123. May 2000

Federal Aviation Administration, Runway Incursions Pamphlet. March 2001.

Horonjeff, McKelvey, Planning and Design of Airports. Third edition, New York, 1983.

Lingqist, Director of Engineering, Metropolitan Knoxville Airport Authority. March 2001

Marrison, Director of Operations, Metropolitan Knoxville Airport Authority. March 2001.

McGhee Tyson Airport Authority, www.TYS.org. 16 February 2001

Metropolitan Knoxville Airport Authority, McGhee Tyson Airport Master Plan. July 1994.

National Transportation Library, Government Accounting Office, Letter Report, Letter 3.1, RCED-95-14. December 1994.

National Transportation Safety Board, Ten Most Wanted Transportation Safety Improvements. May 2000.

Swancey, Federal Aviation Administration, Airways Facilities Division, Memphis, Tennessee. March 2001

U.S. Department of Transportation, Federal Aviation Administration, Advisory Circular 150/5300-13, Chapter 6. November 1996.

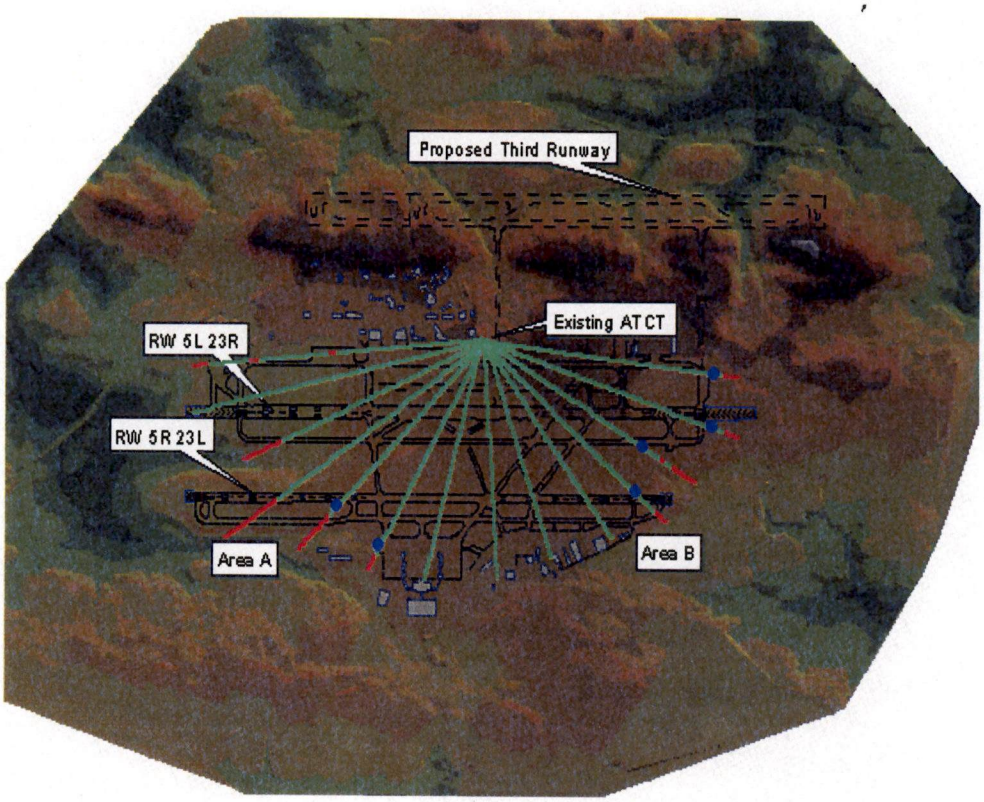
Wegmann, Professor of Civil Engineering, University of Knoxville, TN. February 2001.

APPENDICES

APPENDIX A

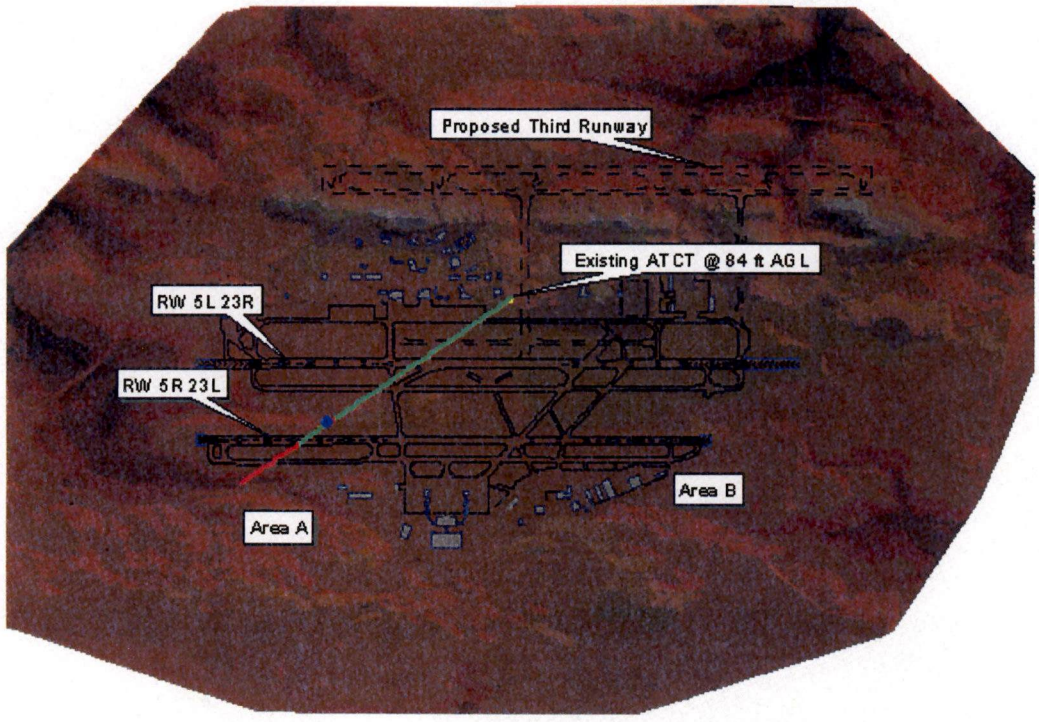
LINE OF SIGHT PROJECTIONS FOR AREA A

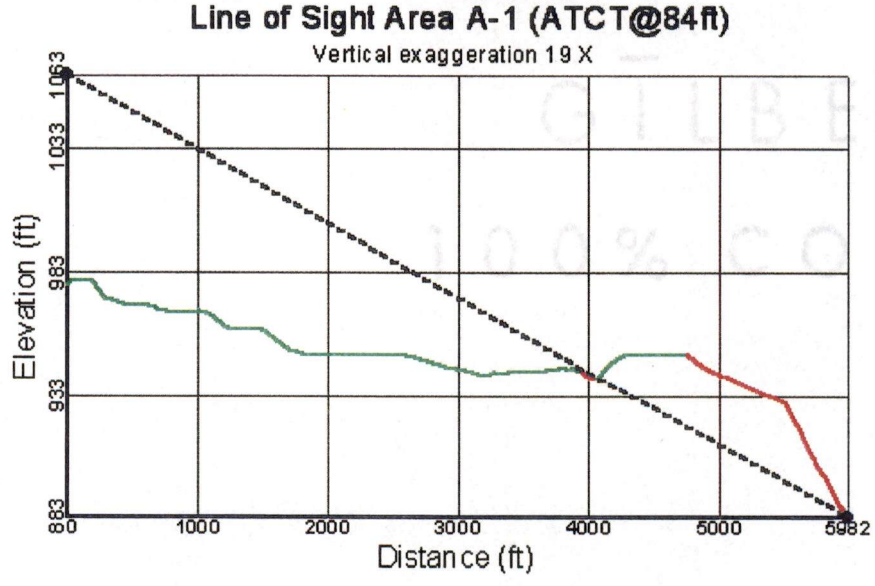
WITH EXISTING ATCT AT 84-ft AGL

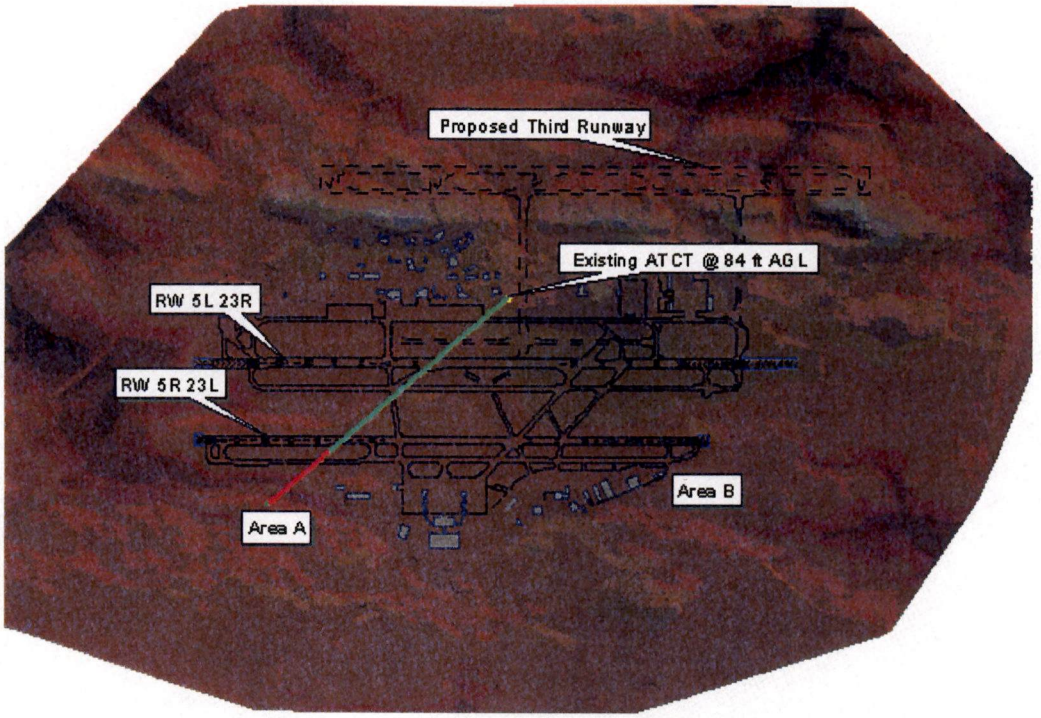


Initial Line of Sight Projection Lines

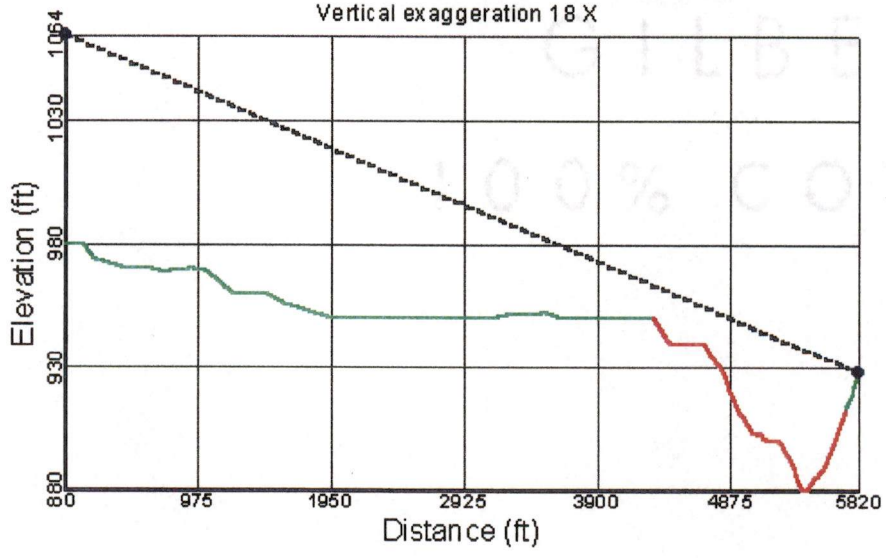
GILBERT
100% COTTON

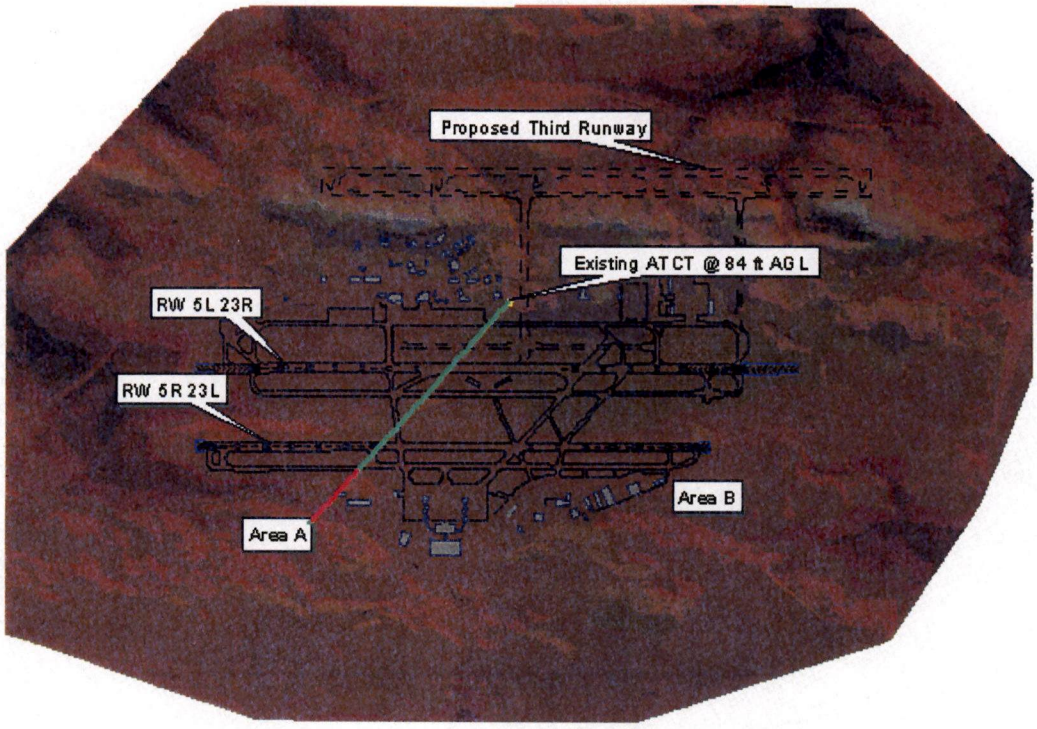

Proposed Third Runway
Existing ATCT @ 84 ft AGL
RW 5L 23R
RW 5R 23L
Area B
Area A

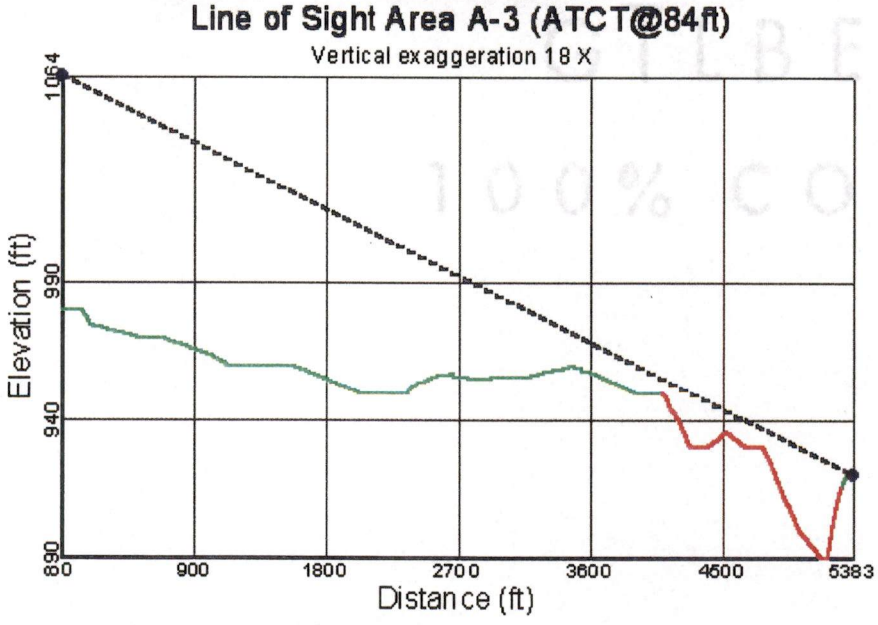

Line of Sight Area A-1 (ATCT@84ft)
Vertical exaggeration 19 X
Elevation (ft)
1063
1033
983
933
883
800
1000
2000
3000
4000
5000
5982
Distance (ft)

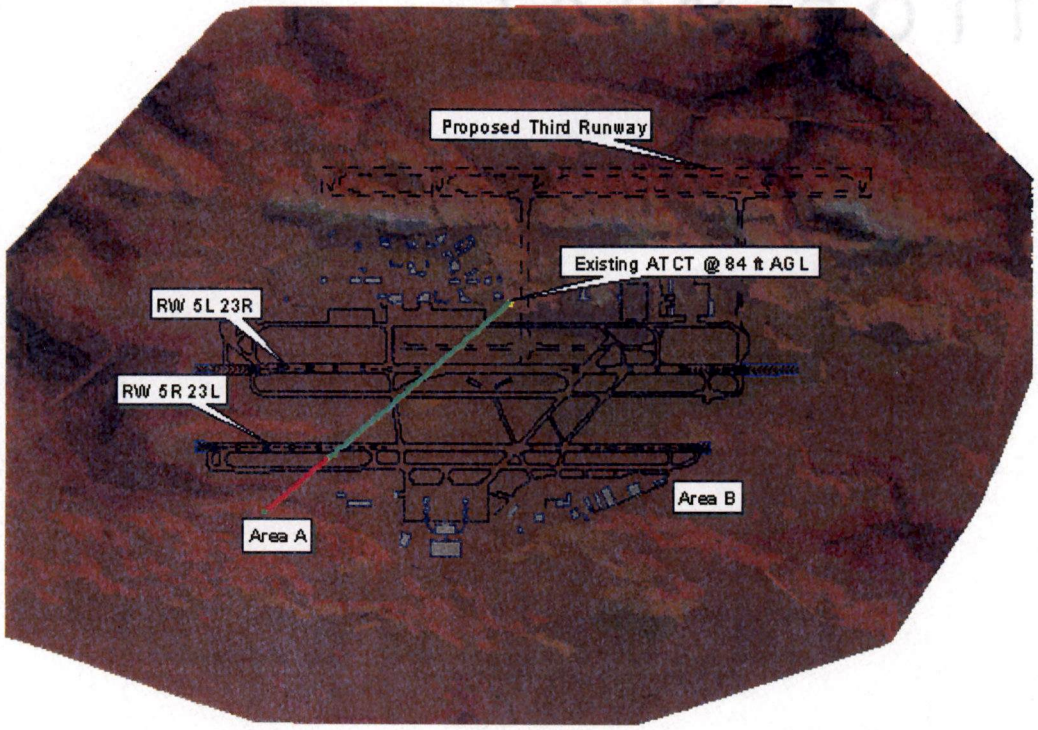


Line of Sight Area A-2 (ATCT@84ft)

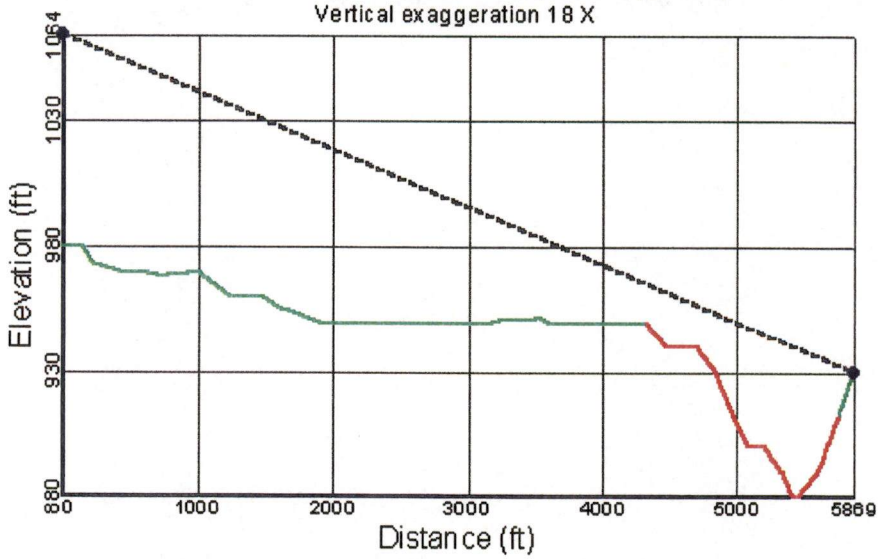


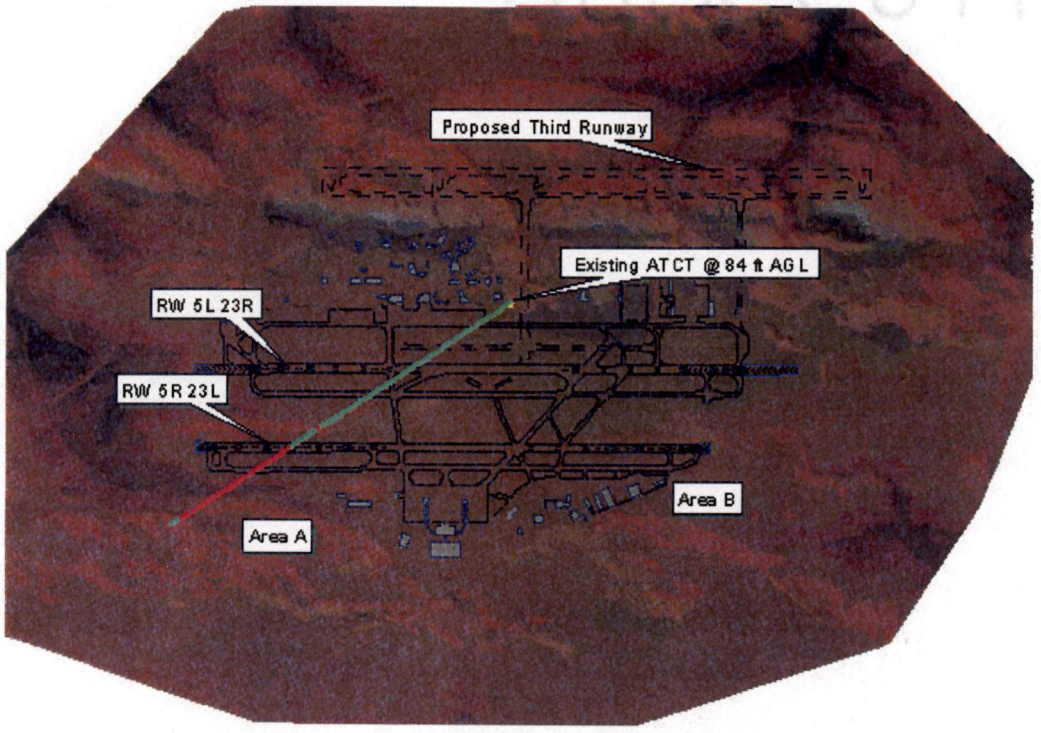

Proposed Third Runway
Existing ATCT @ 84 ft AGL
RW 5L 23R
RW 5R 23L
Area B
Area A


Line of Sight Area A-3 (ATCT@84ft)
Vertical exaggeration 18 X
Elevation (ft)
1064
990
940
890
80
900
1800
2700
3600
4600
5383
Distance (ft)

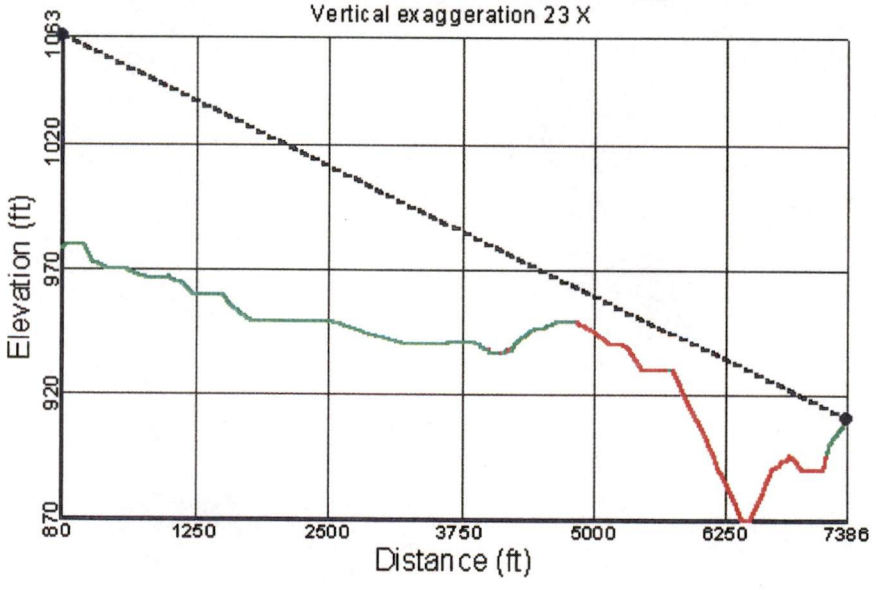


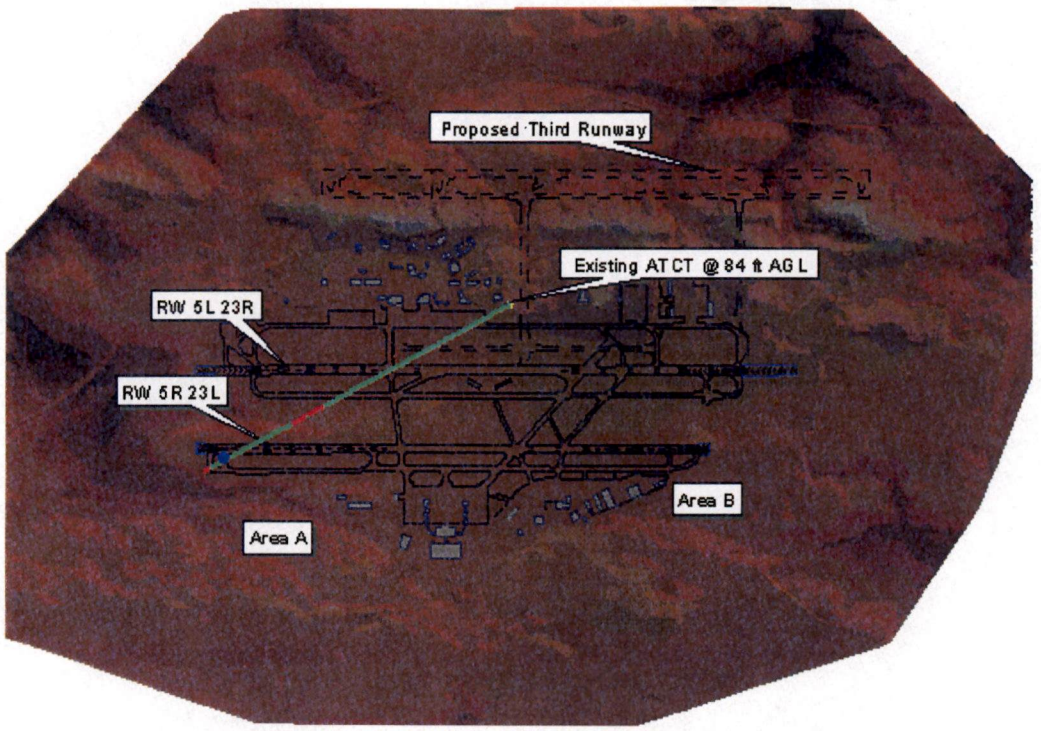
Line of Sight Area A-4 (ATCT@84ft)



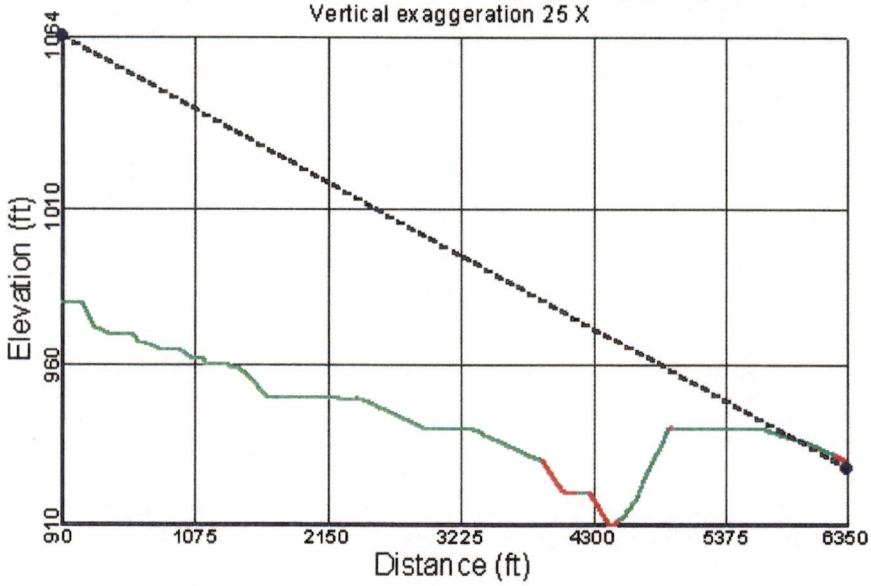


Line of Sight Area A-5 (ATCT@84)





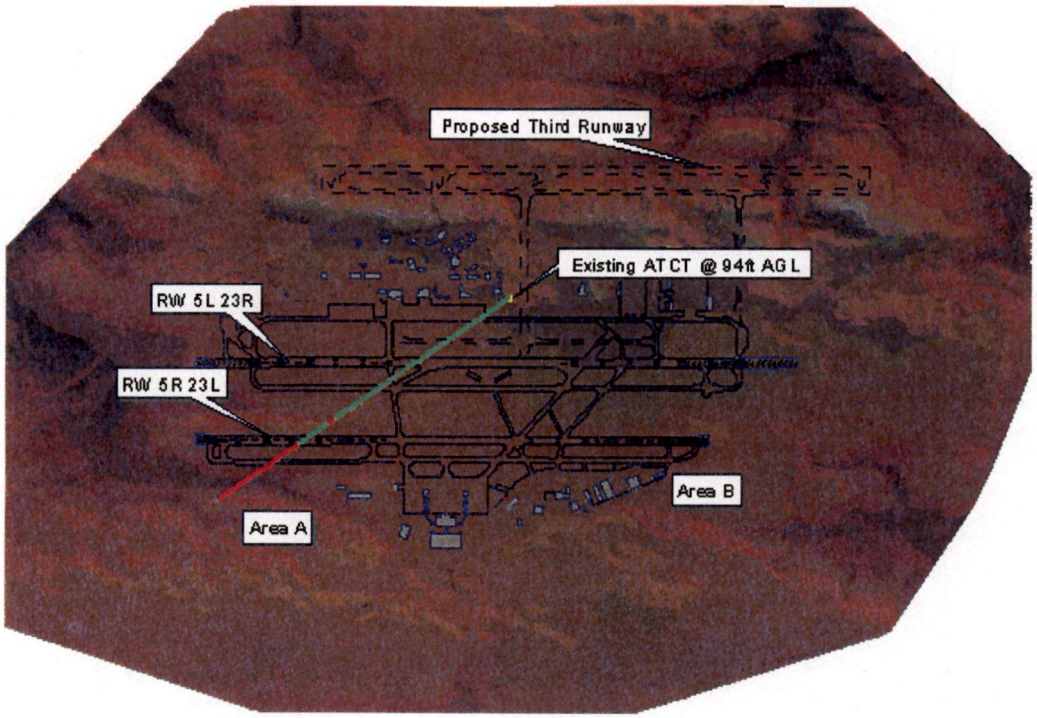
Line of Sight Area A-6 (ATCT@84ft)



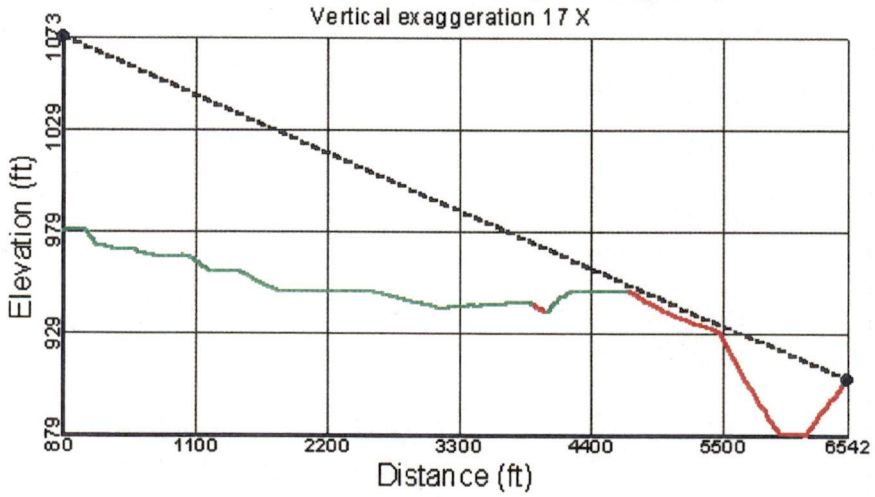
APPENDIX B

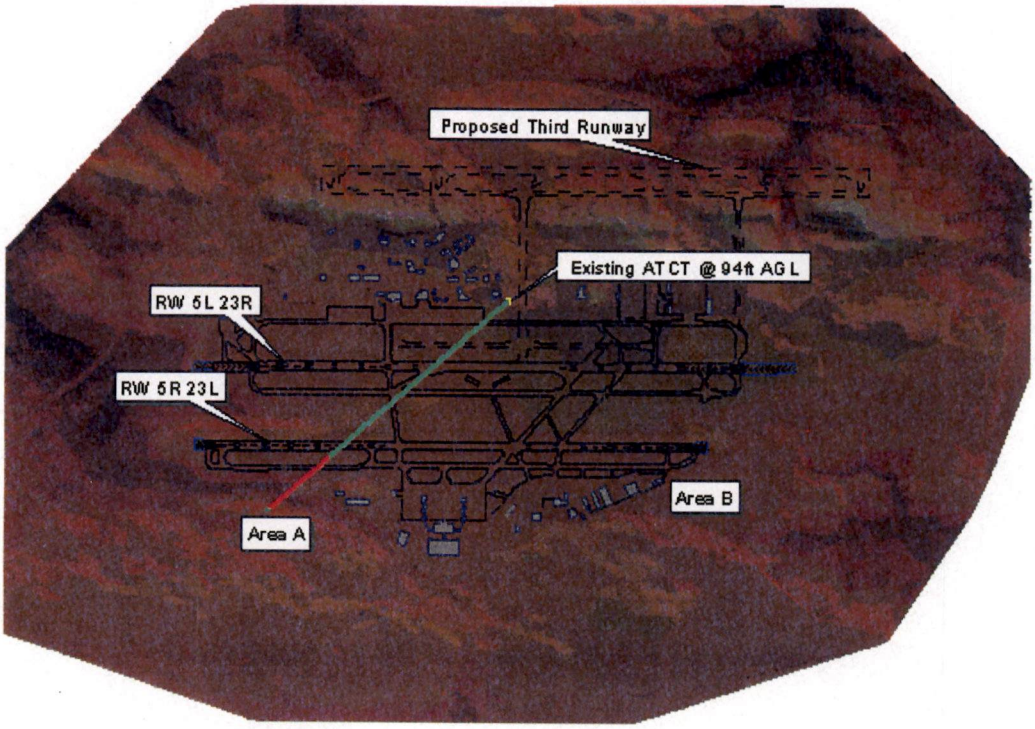
LINE OF SIGHT PROJECTIONS FOR AREA A

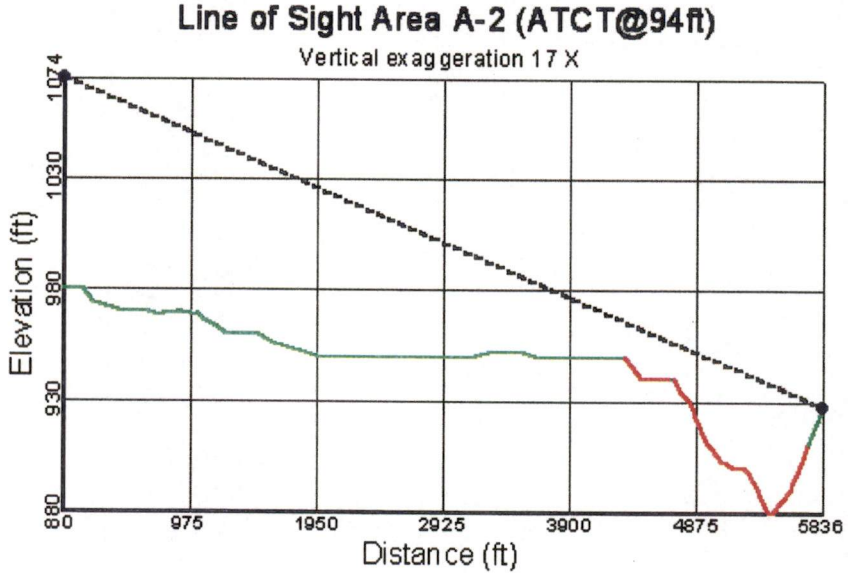
WITH ATCT AT 94-ft AGL

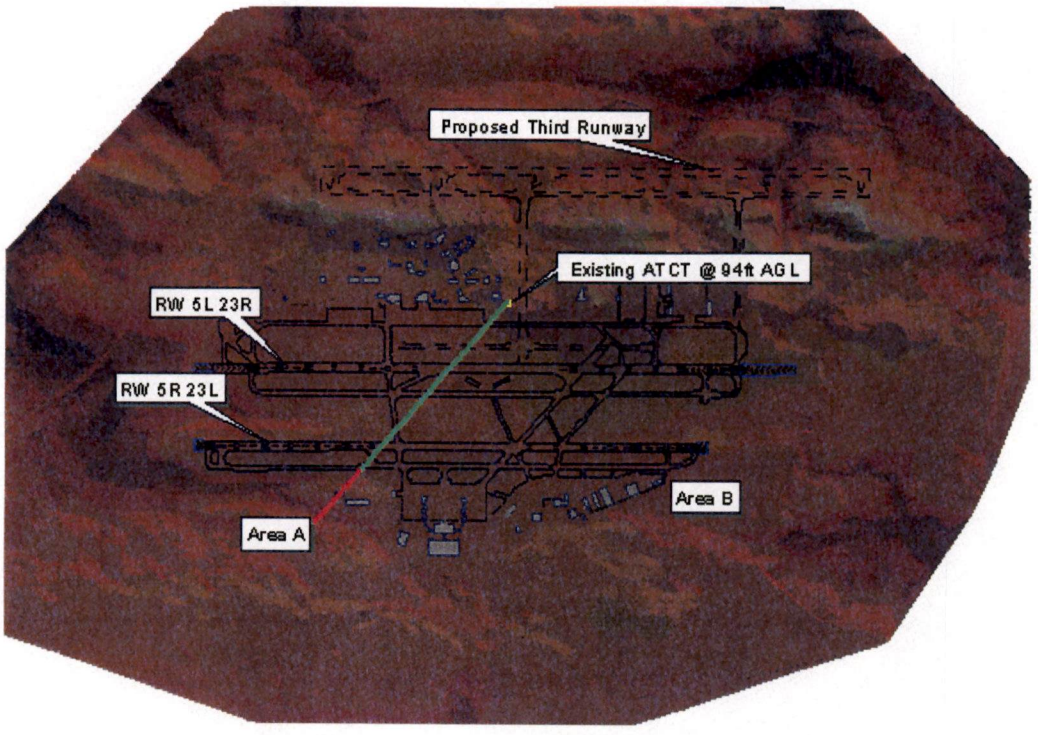


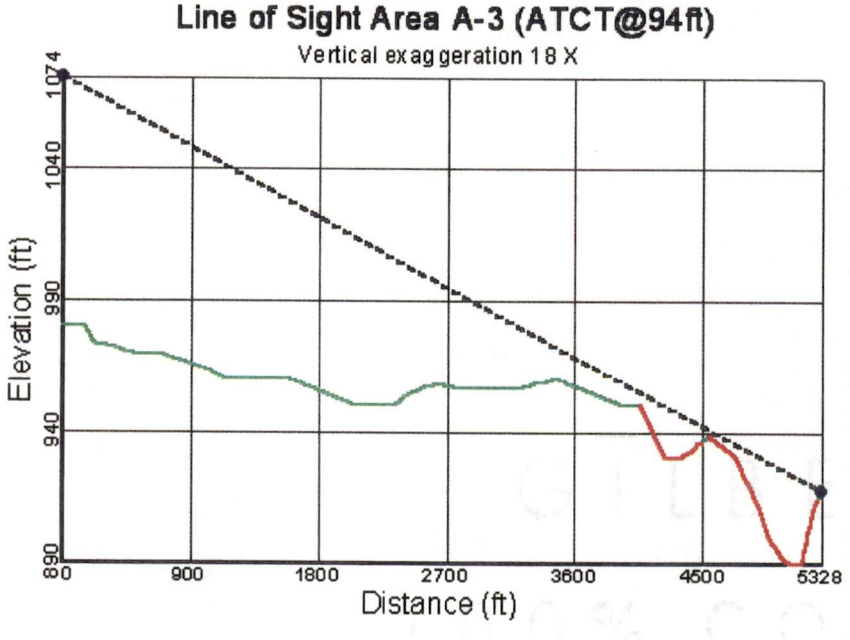
Line of Sight Area A-1 (ATCT@94ft)

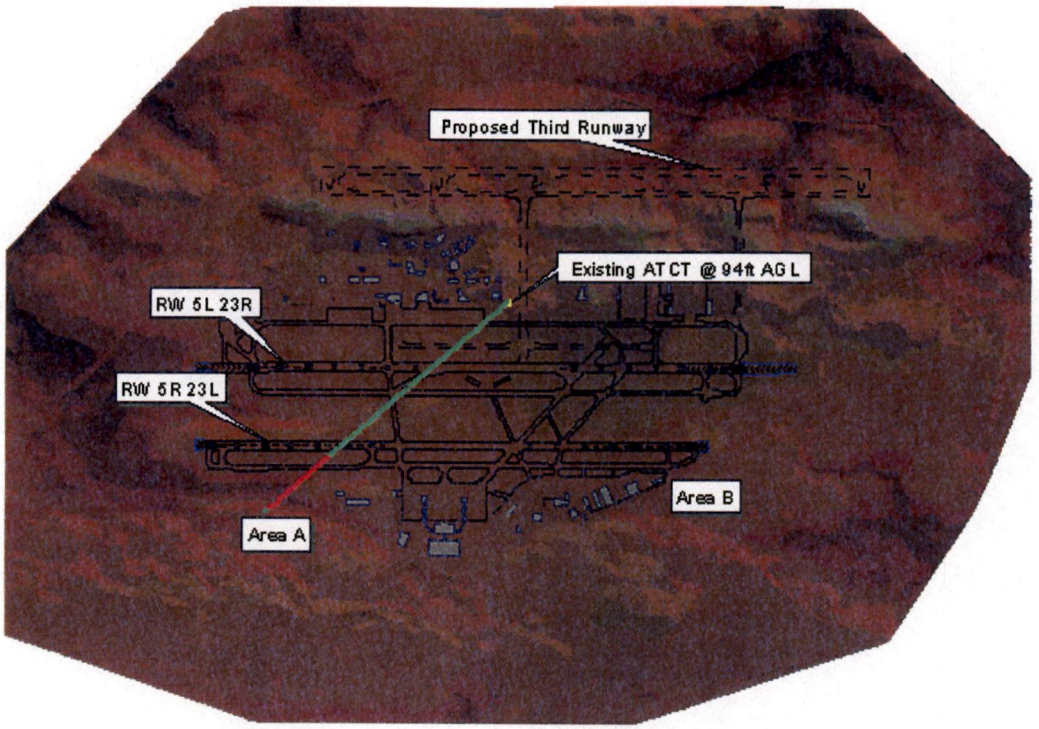



Proposed Third Runway
Existing ATCT @ 94ft AGL
RW 5L 23R
RW 5R 23L
Area B
Area A

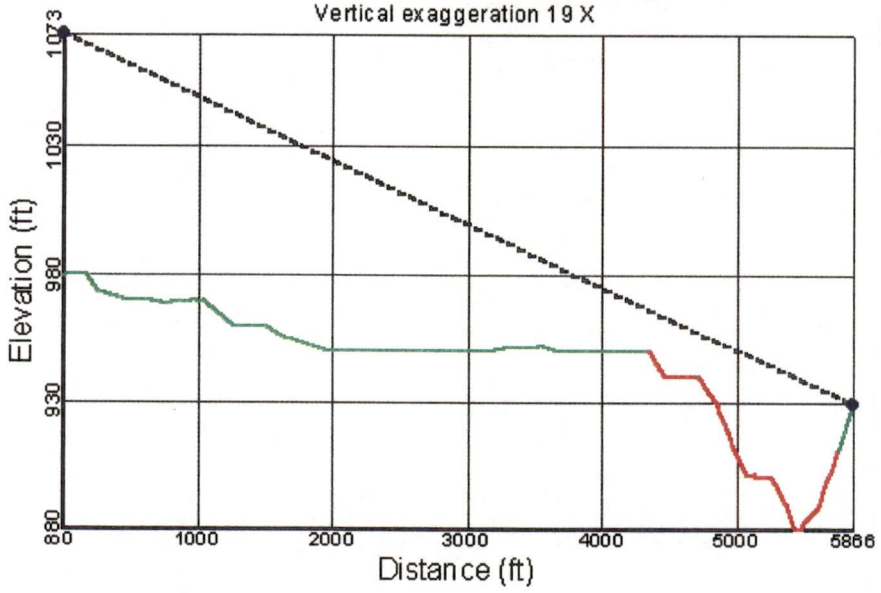

Line of Sight Area A-2 (ATCT@94ft)
Vertical exaggeration 17 X
Elevation (ft)
1074
1030
980
930
880
975
1950
2925
3900
4875
5836
Distance (ft)

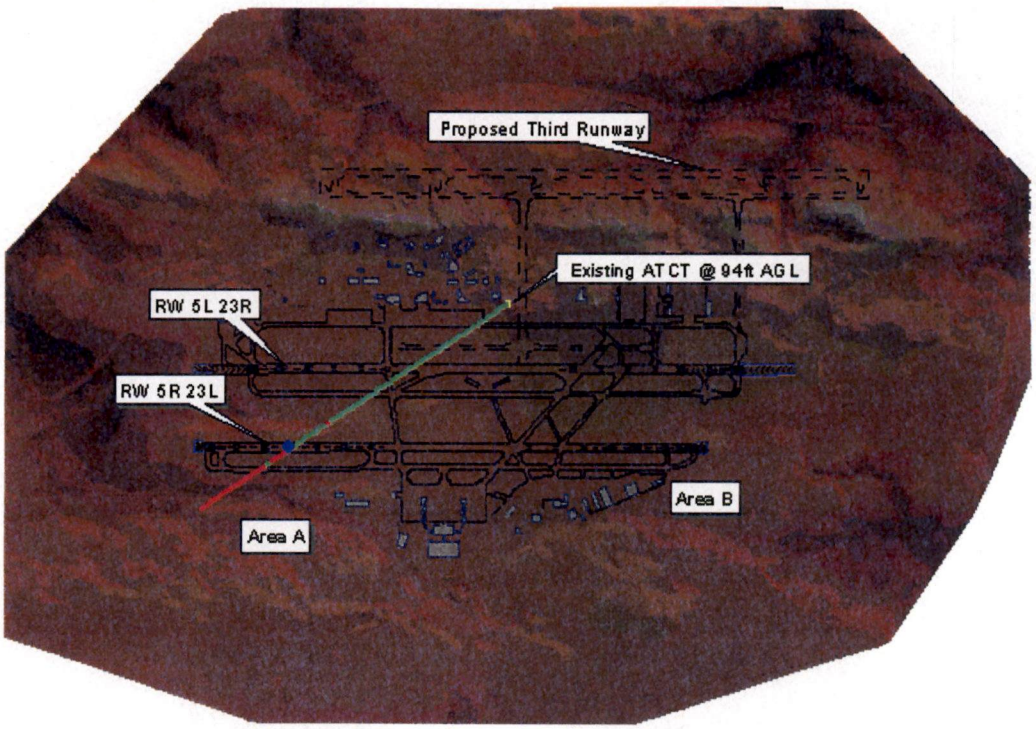

Proposed Third Runway
Existing ATCT @ 94ft AGL
RW 5L 23R
RW 5R 23L
Area B
Area A

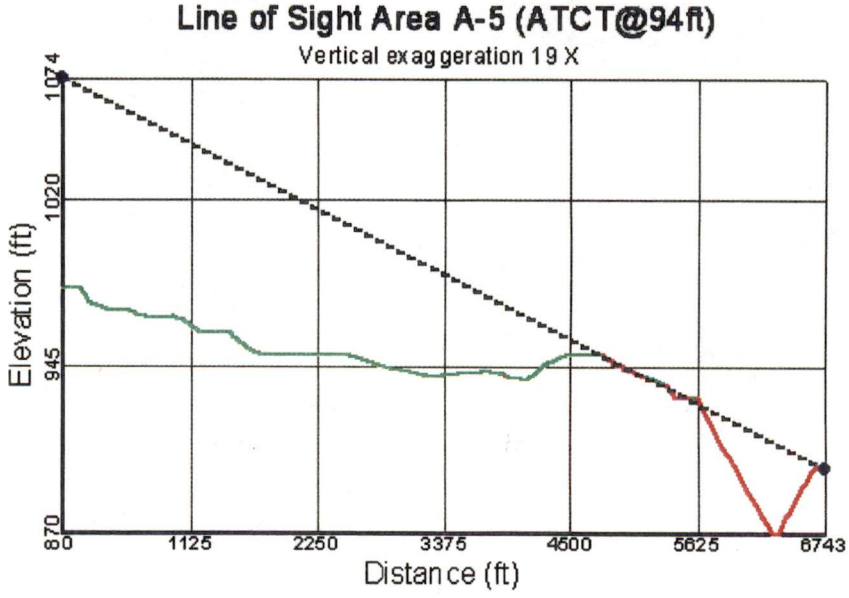

Line of Sight Area A-3 (ATCT@94ft)
Vertical exaggeration 18 X
Elevation (ft)
1074
1040
990
940
890
0
900
1800
2700
3600
4500
5328
Distance (ft)

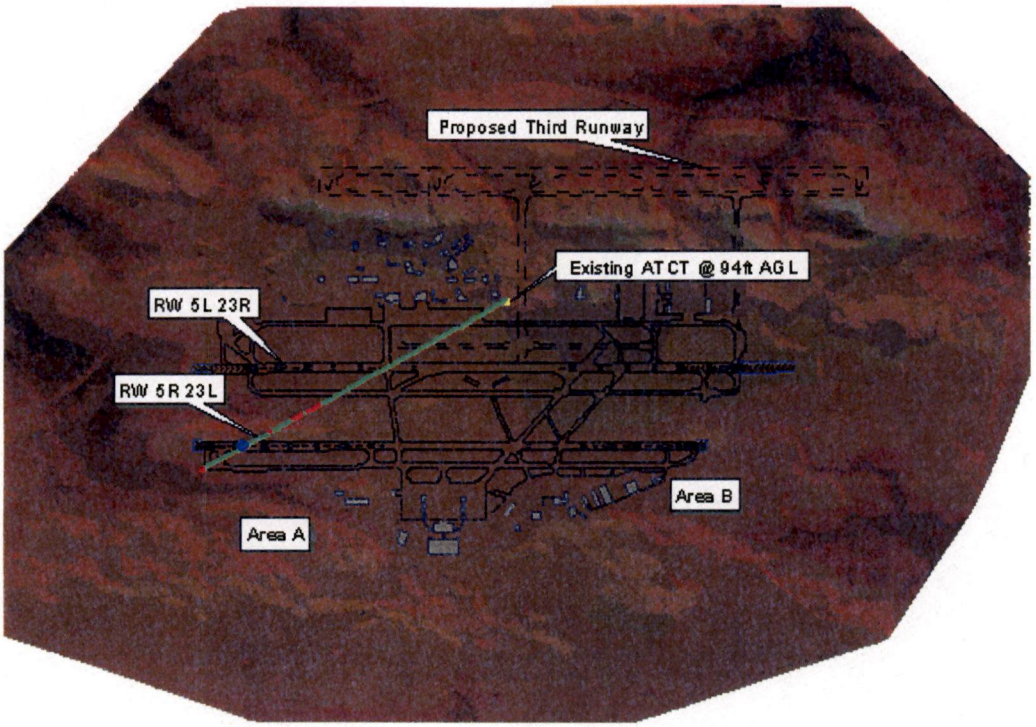


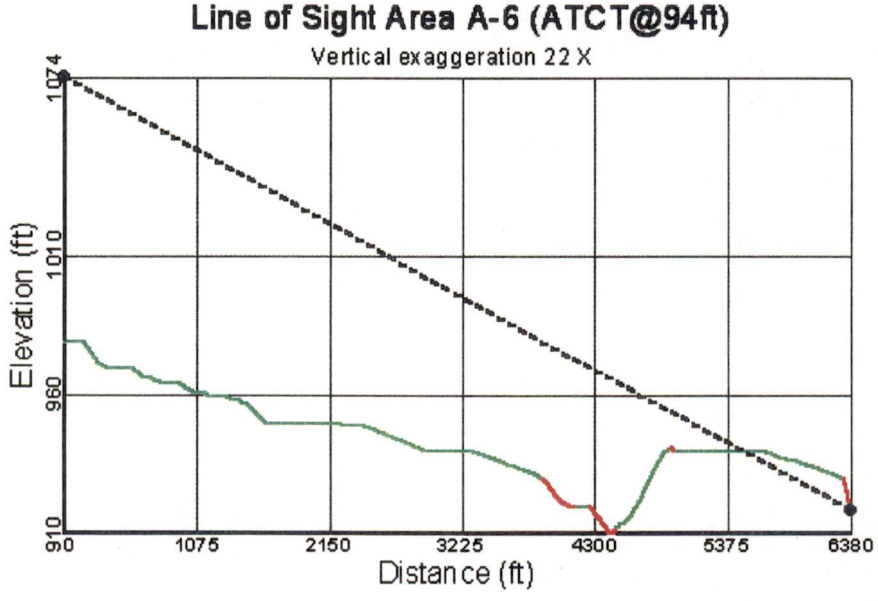
Line of Sight Area A-4 (ATCT@94ft)




Proposed Third Runway
Existing ATCT @ 94ft AGL
RW 5L 23R
RW 5R 23L
Area B
Area A


Line of Sight Area A-5 (ATCT@94ft)
Vertical exaggeration 19 X
Elevation (ft)
1074
1020
945
870
80
1125
2250
3375
4500
5625
6743
Distance (ft)


Proposed Third Runway
Existing ATCT @ 94ft AGL
RW 5L 23R
RW 5R 23L
Area B
Area A


Line of Sight Area A-6 (ATCT@94ft)
Vertical exaggeration 22 X
Elevation (ft)
1074
1010
960
910
910
1075
2150
3225
4300
5375
6380
Distance (ft)

VITA

Bryan Douglas White graduated from Heritage High School in 1983, located in his hometown of Maryville, Tennessee. Bryan entered the Air National Guard in 1986 serving as a KC-135 aircraft small systems specialist. He eventually entered active duty in the Army as a rotory-wing aviator. Bryan Served for six years as an Army Aeromedical Evacuation Pilot. In 1996 Bryan enrolled in the University of Tennessee, Knoxville as a student in Civil Engineering. In 1999, he graduated with a BS in Civil Engineering and entered graduate school the same year. Bryan has interned at the Metropolitan Knoxville Airport Authority's Department of Engineering for the past year and a half and is an Engineer in Training.