OBSTACLE IDENTIFICATION SURFACE CALCULATION TOOL (OIS-CT) FOR AIRPORT AIRSPACE OBSTRUCTION ANALYSES AT CIVIL AIRPORTS IN THE UNITED STATES

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Introduction to the Obstacle Identification Surface Analyses

This research paper is focused on development of an Obstacle Identification Surface Calculation Tool for ESRI Arc GIS v10 that provides an airport planner with Airport Airspace Obstruction Analysis capability in a 3D GIS environment and presentation of analysis results.

This is a continuation of Dr. Panayotov's research in Airport Airspace Obstruction Analyses previously presented at ESRI UC 2009. This research article will cover the basics of a new Obstruction Identification Surface Calculation Tool (OIS-CT) tool developed to help airport planners and consultants fulfill Runway End Siting Requirements in (AC150/5300-13 Chg. 18, Airport Design Appendix 2. Runway End Siting Requirements) for <u>creating new runways, protecting existing runway procedures and/or identifying airspace issues that reduce runway capacity for air carrier certificated airports in the United States</u>. The OIS-CT tool was developed to work within the data schema required for all U.S. obligated National Plan of Integrated Airport System (NPIAS) airports who must comply with Federal Aviation Administration airport geospatial data survey requirements for Geographical Information Systems.

Runway End Sitting Surfaces created by OIS-CT tool:

- FAR Civil PART 77 Surfaces (Visual, Non-Precision and Precision),
- Glide Slope Qualification Surface (GQS) for Screening Approach Procedure with Vertical Guidance (APV),
- Straight In Instrument Landing System (ILS) CAT I, II & III Straight In Approach and Missed Approach Surfaces
- W Obstacle Clearance Surface
- X Obstacle Clearance Surface
- Y Obstacle Clearance Surface
- Missed Approach Sections 1a, b, c & Section 2
- Clearway Surface
- Runway Obstacle Free Zone Surfaces (CAT I, II&III) (ROFZ)
- Straight Out Instrument Departure Surface 40:1 Terminal Instrument Procedures
- Straight Out Air Carrier Departure One Engine Inoperative (OEI) Obstacle Identification Surface (OIS) 62.5:1
- Precision Runway Obstacle Free Zone (POFZ)

By harnessing the capabilities of ESRI Arc Map and Arc Scene Version 10.0, the Obstruction Identification Surface Calculation Tool (OIS-CT) creates Runway Siting Surfaces that can be screened against any known man-made and natural objects surrounding the runway environment. The primary purpose for this airspace screening is to protect the airport's current and future runway capacity by identifying what local conditions restrict optimal procedure development. By identifying what objects reduce runway capacity, airports working in sync with local planning agencies can take steps to improve future or current runway capacity. Another often hidden benefit to aeronautical users is also an improvement to safety by reducing the complexity of Standard Terminal Arrival Routes (STARS) and Standard Instrument Departures (SIDS) by identifying and taking corrective steps whenever feasible to eliminate controlling objects from the airport terminal airspace environment.

The OIS-CT was designed to leverage Federal Aviation Administration (FAA) mandated airport geospatial data based on AC150/5300-18b, General Guidance and Specifications for Submission of Aeronautical Surveys to NGS: Field Data Collection and Geographic Information System (GIS) Standards). Airport runway spatial data conforming to FAA Mandated Airport Surveys provide compliant data required for OIS-CT tool (Table 2-1. Survey Requirements Matrix AC150/5300-18b):

- Category II/III Precision Approach Operations Development
- Navigational Aid Siting-Precision
- Airport Layout Plan
- Airport Obstruction Chart
- Instrument Procedure Development
- Airport Mapping Database

If an airport has not completed any airport spatial survey following AC150/5300-18b, then the OIS-CT tool provides a list of what spatial data is necessary for input. It is highly recommended that a licensed professional surveyor collects or verifies any airport geospatial data used in the OIS-CT. The airport surveyor should follow standards contained in AC150/5300-16 General Guidance and Specifications for Aeronautical Surveys: Establishment of Geodetic Control and Submission to the National Geodetic Survey as this has become the airport survey standard replacing National Geodetic Survey (NGS) Airport 405 Survey Requirements. Spatial data concerning the runway environment is considered a safety critical to the FAA and at minimum an airport should submit any runway survey data with the FAA Airports GIS program (https://airports-gis.faa.gov/public/index.html) before using it for any runway siting analysis.

Background on developing the OIS-CT

America's air transportation system has grown significantly over the past 30 years. In 1980, the system carried 281 million passengers. In 2010, the US handled nearly 713.6 million passengers, and the number of passengers carried annually is expected to grow over time despite recent short term declines in traffic capacity issues in our nation's airspace are the driving principle behind a National Airspace System redesign (http://www.faa.gov/airports/planning_capacity/passenger_allcargo_stats/passenger/). However, aviation needs for environmental stewardship, security, safety, and open access are also substantial secondary drivers.

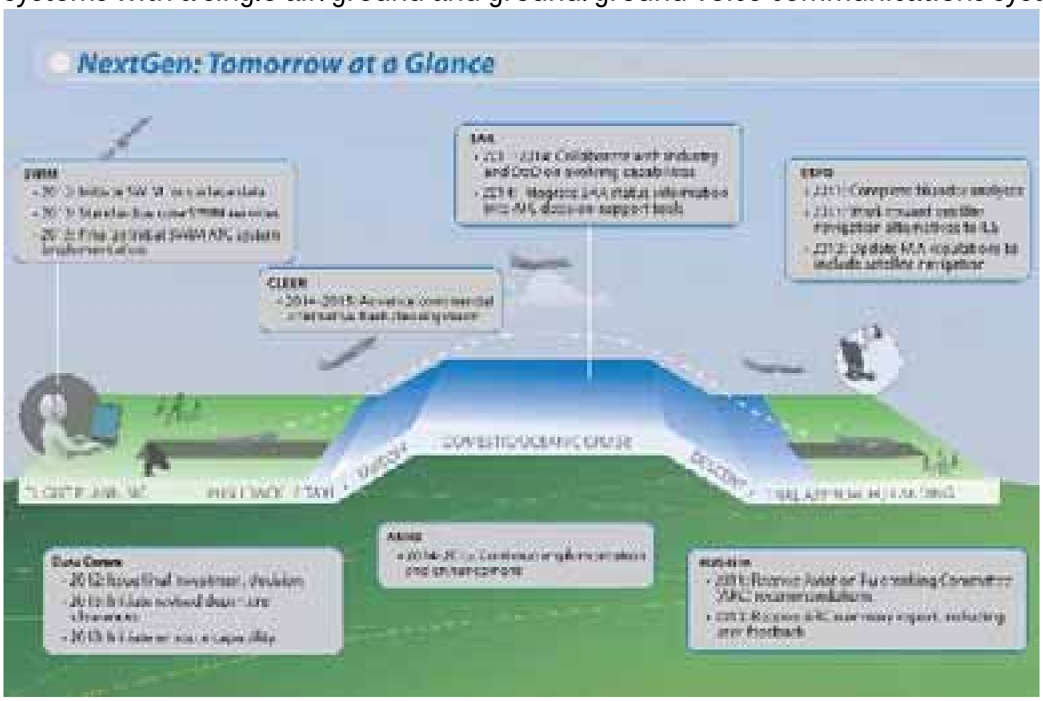
Passage of Vision 100 — Century of Aviation Reauthorization Act in 2003, instructed the Federal Aviation Administration to work within the Department of Transportation's multi-agency framework to develop a new system of air traffic management system that would take aviation through 2025. The Federal Aviation Administration Next Generation Air Transportation System (NextGen) is a series of inter-linked programs, systems, and policies that implement advanced technologies and capabilities to dramatically change the way the current aviation system is operated. This is a comprehensive initiative that not only involves the development of new technology, but also the leveraging of existing technologies to enhance capacity in the mid-term (2010-2018). NextGen includes satellite navigation and control of aircraft, advanced digital communications, and enhanced connectivity between all components of the national air transportation system. The satellite-based system responds quickly as the types of aircraft change and congestion occurs. Hazards are identified and their associated risk mitigated before they result in incidents or accidents. NextGen combines changes to the way aircraft are routed, and with new technology, moves compartmentalized air traffic control towards integrated air traffic management.

NextGen also must extend beyond our domestic airspace and be an integral part of the global aviation system. This requires ongoing collaboration between the FAA's international counterparts, private industry, airports, air traffic organizations, and International Civil Aviation Organization (ICAO). In the future, all aviation users connected to US airspace will be connected to NextGen's advanced infrastructure and will continually share information in real-time to improve air transportation's safety, speed, efficiency, and environmental impacts, while absorbing increased demand levels. There are five technology innovation pillars central to the FAA NexGen Program:

1. **Automatic dependent surveillance-broadcast (ADS-B)**. ADS-B will use the Global Positioning System (GPS) satellite signals to provide air traffic controllers and pilots with much more accurate information that will help to keep aircraft safely separated in the sky and on runways. Aircraft transponders receive GPS signals and use them to determine the aircraft's precise position in the sky. This, along with other data is then broadcast to other aircraft and air traffic control. Once fully established, both pilots and air traffic controllers will, for the first time, see the same real-time display of air traffic, substantially improving safety. The FAA is in the process of fully mandating the avionics necessary for implementing ADS-B.
2. **System Wide Information Management (SWIM)**. SWIM will provide a single infrastructure and information management system to deliver high quality and timely data to many users and applications. By reducing the number and types of interfaces and systems, SWIM will reduce data redundancy and better facilitate multi-user information sharing. SWIM will also enable new modes of decision making as information is more easily accessed.
3. **Next Generation Data Communications**. Current communications between aircrew and air traffic control, and between air traffic controllers, are largely realized through voice communications. Initially, the introduction of data communications will provide an additional means of two-way communication for air traffic control clearances, instructions, advisories, flight crew requests and reports. With the majority of aircraft data link equipped, the exchange of routine controller-pilot messages and clearances

via data link will enable controllers to handle more traffic. This will improve air traffic controller productivity and enhance capacity and safety.

4. **Next Generation Network Enabled Weather (NNEW)**. Seventy percent of NAS delays are attributed to weather every year. The goal of NNEW is to cut weather-related delays by at least 50%. Tens of thousands of global weather observations and sensor reports from ground-, airborne- and space-based sources will fuse into a single national weather information system, updated in real time. NNEW will provide a common weather picture across the national airspace system, and enable better air transportation decision making.
5. **NAS voice switch (NVS)**. There are currently seventeen different voice switching systems in the NAS, some in use for more than twenty years. NVS will replace these systems with a single air/ground and ground/ground voice communications system.



Source FAA NextGen Program (http://www.faa.gov/nextgen/)

NextGen is more complex and more ambitious than any other previous program undertaken by the Federal Aviation Administration in its history. It is the twenty first century equivalent of landing a man on the moon. Digital airport data collected under NextGen's Airports GIS program is used for obstruction analyses (AOC), Notices to Airmen (eNOTAMs), electronic flight bags, Airport Layout Plans (eALP) and flight procedure development using the GPS (LVP, LNAV,/VNAV, RNP-RA, RNAV).

The FAA Airports Geographic Information System (AGIS) is a component of NextGen's SWIM Program, improving the management and maintenance of airport information by providing a real time, integrated electronic database over the internet. The FAA's central database for AGIS data enhances sharing of both safety-critical data (such as runway end points or the location of navigational aids) and non-safety-critical data (such as the location of a building on an airfield). In addition to providing users with current airport data, it will improve airport planning efforts with more efficient reviews of airport layout plan submittals in which Runway End Siting analysis is a component.

Technology Development

Accurate 3D airport spatial data of the Air Operations Area using the National Spatial Reference System is an important step necessary for GPS enabled procedure development at US airports. GPS air navigation capability is slated to replace many existing ground based navigation aids (NAVAIDS) for Instrument Flight Rules (IFR). Hence, it is critical that airports plan for and promote GPS enabled procedures for their current and future runway(s) in line with FAA NextGen goals.

Almost all commercial service airports in the United States are public and comprise the National Plan of Integrated Airport Systems (NPIAS). Airports within the NPIAS are deemed important to U.S. national interest and are eligible to receive Federal funding for specific projects which serve national aviation priorities. Public Use Airports who accept Federal Funds are obligated to Federal Airport Grant Assurances under provisions of Title 49, U.S.C., Subtitle VII (http://www.faa.gov/airports/aip/grant_assurances/). Airport Grant Assurances: 5. Preserving Rights and Powers, 19. Operation & Maintenance and 20. Hazard Removal & Mitigation requires obligated airports to take a proactive role in protecting their airport as its defined role in the NPIAS. This includes:

- Protecting visual and instrument operations to the airport including established minimum flight altitudes from objects that would interfere with air navigation in the terminal airspace. All objects in the airport terminal airspace must be adequately cleared by removing, lowering, relocating, marking, lighting, and or mitigating the restrictive controlling obstacle.
- This includes both current terminal procedures as well as any future procedures that might be developed at the airport. By taking a proactive role in mitigating conflicts to the airport terminal airspace environment, airports can ensure the least restrictive arrival/departure procedures, thus maximizing airport capacity and runway availability.

In order to plan for future airport expansion, development or alteration airport planners need to run different types of airport airspace analyses to weigh impacts early on in the process. Filing a 7460-1 notification form to the FAA is required of any NPIAS airport which proposes new construction or alteration of the Airport Layout Plan. 7460-1 filing is required for any changes on airport property regardless of location or height that can be depicted on the ALP. This includes changes to the Airport Layout Plan of future planned construction (both near term and long term). Non airport developers are also required to notify the FAA of proposed construction or alteration if certain requirements are met. Requirements become more height restrictive the closer the construction is to a runway. CFR Title 14 Part 77.9 states that any person/organization who intends any of the following construction or alterations must notify the FAA:

1. Any construction or alteration exceeding 200 ft. above ground level
2. Any construction or alteration:

3. Within 20,000 ft. of a public use or military airport which exceeds a 100:1 surface from any point on the runway of each airport with its longest runway more than 3,200 ft.
4. Within 10,000 ft. of a public use or military airport which exceeds a 50:1 surface from any point on the runway of each airport with its longest runway no more than 3,200 ft.
5. Within 5,000 ft. of a public use heliport which exceeds a 25:1 surface
6. Any highway, railroad or other traverse way whose prescribed adjusted height would exceed the above noted standards
7. When requested by the FAA

The FAA has developed a screening tool to assist non-airport developers determine if their project requires filing a 7460-1 notification (https://oeaaa.faa.gov/oeaaa/external/gisTools/gisAction.jsp?action=showNoNoticeRequiredToolForm).

The FAA also requires airports report changes to a landing area through Notice of Landing Area Proposal 7480-1 form. 7480-1 notifications include the following changes which can affect airport terminal airspace including:

1. Constructing or otherwise establishing a new airport or activate an airport.
2. Constructing, realigning, altering, or activating any runway, or other aircraft landing or takeoff area of an airport.
3. Constructing realigning, altering, or activating a taxiway associated with a landing or takeoff area on a public-use airport.
4. Deactivating, discontinuing using, or abandoning an airport or any landing or takeoff area of an airport for a period of one year or more.
5. Deactivating, abandoning, or discontinuing using a taxiway associated with a landing or takeoff area on a public-use airport.
6. Changing the status of an airport from private use (use by the owner or use by the owner and other persons authorized by the owner) to an airport open to the public or from public-use to another status.
7. Changing the status from IFR to VFR or VFR to IFR.
8. Establishing or changing any traffic pattern or traffic pattern altitude or direction.

With significant money invested in any capital development planning, airports can provide runway sitting analyses prior to preparing and submitting a proposal to the FAA for review. Since FAA airspace review can take 3-4 months to complete for either 7460-1 or 7480-1 notifications; most development projects do not have the luxury of time to wait to find out if the initial plans (typically 30-60% design plan set) have significant issues with runway end siting requirements. It is prudent, regardless of the development timeline, to have a clear picture of potential runway siting impacts before waiting for the FAA to flag them.

Airspace analyses are based on the following standards and specifications contained in advisory circulars issued by Federal Aviation Administration (FAA). These documents describe protective and restrictive surfaces that need to be clear of obstruction in order to keep navigable space safe.

- Title 14 Code of Federal Regulations (CFR) PART 77
- United States Standards for Terminal Instrument Procedures (TERPS) Order 8260.3B

- Advisory Circular (AC) 150/5300-13- Airport Design
- AC150/5190-4- A model zoning ordinance to limit the height of objects around airport

Generally speaking most airports and airport consultants still use Computer Aided Design & Drafting (CADD) platforms for obstruction analysis. There are also third party software products available for the CADD environment which assist in completing airspace analysis. The Three-Dimensional Airspace Analysis Program by Planning Technology, Inc. is an example of one such CADD platform tool. However, the FAA Office of Airport Planning & Programming (APP) disseminated a Policy Guidance Letter (PGL) in 2007 establishing the Airports GIS Program ((https://airports-gis.faa.gov/public/) in which GIS would become the primary spatial data platform for all future Airport Layout Plans (eALPs) in support of the FAA's NextGen initiative.

The FAA AGIS program supports data submittals in .DGN, .KML, .SHP, .DWG formats; however, the airport data itself will be stored by the FAA as ESRI GIS feature classes. While CADD will remain a part of airport design engineering for years to come, airport planning and analysis will move away from CADD into GIS over the next decade. ESRI's technology suite has been a major component supporting the FAA's AGIS program from its. According to FAA Airport Safety and Standards (AAS-100) presentation made at the 2012 AAAE Airports GIS Conference airport GIS eALP surveys will be complete for all U.S. Large & Medium Hub airports by 2015, all Small & Non-Hub airports by 2017 and all Non-Primary Hub airports by 2020.

The emerging of satellite based GPS navigation has forced improvements in data accuracy. All spatial data on airport property and surrounding environment must satisfy the accuracy standards set in FAA Advisory Circulars:

- AC 150/5300-16 *General Guidance and Specifications for Aeronautical Surveys: Establishment of Geodetic Control and Submission to the National Geodetic Survey*
- AC 150/5300-17 *Standards for Using Remote Sensing Technologies in Airport Surveys*
- AC 150/5300-18 *General Guidance and Specifications for Aeronautical Surveys: Airport Survey Data Collection and Geographic Information System Standards*

(http://www.faa.gov/airports/resources/advisory_circulars/)

According to FAA AC 150/5300– 8b, the surveyor conducting data collection must also run AC150/5300-18b Airport Airspace Analysis Survey as described in Section 2.7 of this document. This section deals with development of Airport Survey Surfaces. The Airport Survey Surfaces are used to identify the "*possible hazard to air navigation and critical approach/departure obstructions within the vicinity of the airport*"18B.sec2.7. Section 2.7 identifies new screening surfaces for identifying vertical objects of interest for AGIS. These AGIS Airport Airspace Analysis Surfaces are not used by airport planners before the implementation of AC150/5300-18b and does not supersede Runway End Siting Requirements.

To run airspace analyses on Runway End Siting Requirements, one needs at least three different data sets: Existing ground terrain, Existing Man-made features, and Imaginary protective surfaces described by FAA regulations.

The ground surface and man-made structure data already exists or will be collected as required by the FAA AGIS program. It is collected accurately and in accordance with FAA AC

150/5300 -18B, and 16A. The database has AC150 schema structure and it is a complete data set needed to develop eALP. Therefore, the only missing part is a GIS database or feature classes for imaginary protective surfaces described Appendix 2 of AC150/5300-13 chg18 Airport Design.

There are two ways of developing these surfaces. The first and the most common way is to use runway end points and disregard the rest of runway centerline points collected as it is described by current industry methodology. The second way is to use all the points from the runway centerline. Both ways have their advantages and disadvantages. The first model using runway end points is simpler and relatively accurate; moreover, there is no specific requirement from FAA on which way to build Runway End Siting Surfaces. The second way, using the runway centerline profile is very accurate but requires more complicated mathematical and GIS functions in creation.

Currently ArcGIS has an AERO tool that can build all FAA FAR PART77 and ICAO Annex 14 and 15 imaginary surfaces. However, other important Runway End Siting surfaces are not covered by the ESRI tool. In order to fill this gap the OIS-CT computational software and ArcGIS OIS toolbox were developed.

The OIS-CT software tool uses runway centerline points to calculate and describe Runway End Siting Surfaces as 3D polygons. The tool uses a simple comma delimited file with runway centerline points in X,Y,Z,I format as input. The user then needs to select which surface or surfaces would like to compute. Some surfaces require more information which is runway specific and should be entered by the user. In order to help users when this extra information is required, a pop-up window or flash will show up, asking for more data. Then, OIS-CT tool exports simple text file with 3D polygons description in terms of X,Y,Z coordinates. The tool also has the capability of exporting extra information as runway azimuth and distance, horizontal or transitional surface length and elevations and etc. Then these polygons are imported into ArcGIS and custom developed OIS-CT toolbox which is employed to complete the development of desired restrictive and protective surfaces. The custom designed Arc GIS OISCT toolbox creates a polygon's feature class comprising all polygons from the output file, a TIN and raster file for each surface and for each runway. The tool also automatically combines the surfaces if required. When all necessary surfaces for each runway are developed then they can be combined and blended in desired way to create the most critical surface for a particular area of interest. The benefit of OIS-CT tool and customized Arc Toolbox OISCT can be summarized as following:

- It takes few minutes to develop a wide range of Runway End Sitting surfaces with great accuracy and this is already available for use; well ahead of the OIS tool suite under development by the FAA AGIS Program team (est. 3-5 yr lead)
- Saves time and money
- It has a simple workflow, easy to use and does not require a specific skills or knowledge. Even a entry level GIS user can run the tool
- All calculations are hardcoded avoiding user error. The only possible mistakes are to select wrong surface or enter wrong value when the user type required extra runway data
- Developed surfaces can be stored in one place

- The three component used for analyses are developed at once: Polygon, TIN and raster data for each surface

Future Research Development

The OIS-CT tool addresses an initial start in creating a great many protective surfaces required by airport planners in screening potential impacts that changes to the airport can make on aeronautical utility and procedure development. There are a great many other protective surfaces which have not, as of yet, been developed mathematically for the ESRI GIS environment. Future research and development is planned for future presentation at the ESRI Users Conference in 2013. These include further development of more screening surfaces for development evaluation (both on and off airport property) and tool enhancements to include but not limited to following ones:

1. AC150/5300 - 18B - Airport Airspace Analysis Surfaces,
2. Expand the OIS-CT tool to create FAR Part 77.21 Department of Defense (DOD) airport imaginary surfaces as well as FAR Part 77.23 Heliport imaginary surfaces for use by Joint Use Airports or Mixed Use Airports that share facilities with the U.S. Department of Defense. Airports which also serve as a Heliport(s) would also benefit from an automatic tool that would create screening criteria for protecting the approach/departure paths of helicopter operations.
3. Airport NAVAID Screening Tools enhancement for GIS OIS-CT tool. Allows airport planners to ascertain the impacts of proposed construction on signal interference on airport NAVAIDS. Not all of the siting or clearance surfaces for all airport NAVAIDs are complex, nor do they require a specialized tool to provide benefit. Research has shown to include these screening surfaces in GIS as a benefit to save time and decrease complexity
4. Further enhancements and development of TERPs screening surfaces to include more NextGen capability terminal approach and departure procedures using GPS.
5. Develop a compatible OIS-CT add-in for Arc GIS. This add-in will work in synergy with AC150 and read/write the data from/to GIS feature class or dataset
6. Increase the capability of OISCT toolbox to run most common analyses
7. Automatic export function of developed surfaces in different formats

REFERENCES (In Order of Appearance):

1. FAA Advisory Circular Airport Design AC150/5300-13 Chg. 18, Airport Design Appendix 2. Runway End Siting Requirements). http://www.faa.gov/airports/resources/advisory_circulars/index.cfm/go/document.current/documentNumber/150_5300-13/

2. AC150/5300-18b, General Guidance and Specifications for Submission of Aeronautical Surveys to NGS: Field Data Collection and Geographic Information System (GIS) Standards. https://airports-gis.faa.gov/public/surveyorsIntro.html

3. Table 2-1. Survey Requirements Matrix AC150/5300-18b. https://airports-gis.faa.gov/public/surveyorsIntro.html

4. PGL Guidance Letter on purpose of FAA Airports GIS program (https://airports-gis.faa.gov/public/index.html)

5. FAA Passenger Boarding (Enplanement) and All-Cargo Data for U.S. Airports http://www.faa.gov/airports/planning_capacity/passenger_allcargo_stats/passenger/

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8. Title 14 F.A.R. Part 77 Objects Affecting Navigable Airspace. http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=f7780e4d527cd2a76a520fe6606ebc9d&rgn=div5&view=text&node=14:2.0.1.2.9&idno=14

9. FAA Airports Advisory Circular Search Engine. http://www.faa.gov/airports/resources/advisory_circulars/

10. US Terminal Instrument Procedures FAA Order 8260.3B http://www.faa.gov/regulations_policies/orders_notices/index.cfm/go/document.information/documentID/11698

11. FAA Advisory Circular Airport Design AC150/5300-13 chg.18 http://www.faa.gov/airports/resources/advisory_circulars/index.cfm/go/document.current/documentNumber/150_5300-13/