DIFFERENCES AND COMPARISON BETWEEN FAA AND ICAO OBSTACLE RESTRICTION REGULATIONS

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ABSTRACT

FAR Part 77 “Objects Affecting Navigable Airspace” is commonly only used in the US, whereas ICAO Annex14 “Obstacle Restriction and Removal” is accepted by all other countries. These two systems were constructed with a different baseline, restrictive area and height. Since government regulations or research publications usually adopt one of them exclusively, users and researchers may perceive ambiguous figures. The purpose of this paper is to compare safety airspaces and identify differences. The results indicate that the FAA imaginary surfaces system specifies a more extensive obstruction clearance than ICAO’s. We also show that airports which apply the FAA regulations restrict urban development around airports more.

Keywords: Obstacle restriction, Obstruction identification surfaces, Safety airspace, Airport design, Geo-spatial information science.

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1. INTRODUCTION

Airspace protection and obstacle clearance are vital to airport and aircraft operation. Restrictions should be established on the heights of buildings, antennas, trees, and other objects as necessary to protect the airspace needed for safe operation of the airport and aircraft. The most commonly used methods to determine the complicated airport imaginary surfaces are FAR Part 77 “Objects Affecting Navigable Airspace” (FAA, 1993) and ICAO Annex14 “Obstacle Restriction and Removal” (ICAO, 2004). Both of them are used to identify potential aeronautical hazards thus preventing or minimizing adverse impacts to the safe and efficient use of navigable airspace.

The imaginary surfaces, which depict the ICAO Annex14 or FAR Part 77 regulations, are used to identify objects that penetrate these imaginary surfaces, to evaluate hazardous effects and to ensure the safe separation between aircraft and obstructions. While FAR Part 77 is commonly used only in the US, ICAO Annex14 is accepted by all countries except the US. These two imaginary surface systems were constructed using different criteria, dimensions, slopes, and even calculation units. Since government regulators or academics usually adopt one of them exclusively, airport planners or researchers may perceive ambiguous figures without clear comparisons. Especially for airports inside highly populated urban areas, the airspace size of the restrictive area and restrictive height may be critical to the degree of adverse impact on urban development. The purpose of this paper is to compare the differences between the ICAO and FAA systems and analyze their safety airspaces for facilitating future airport planning and management.

2. LITERATURE REVIEW AND METHODOLOGY

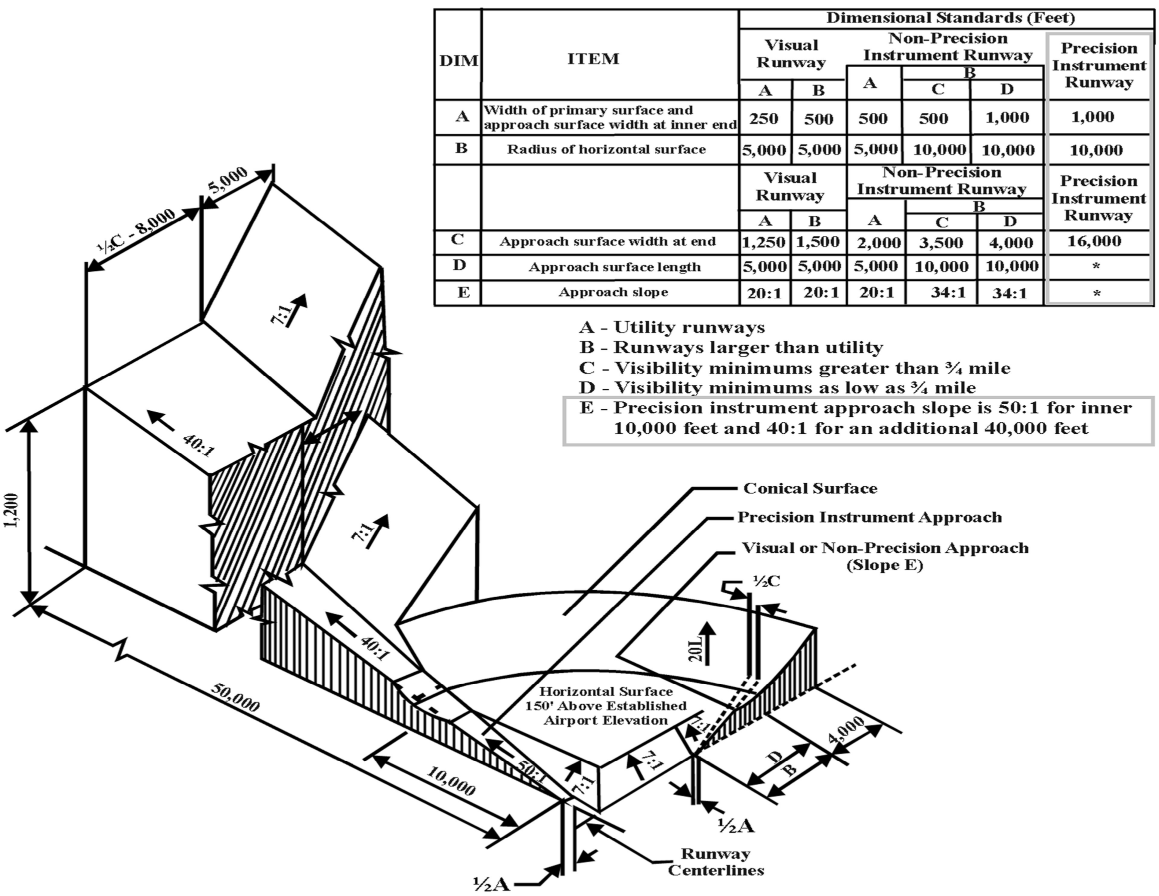
Horonjeff (1994) argues that the ICAO requirements are similar to FAR Part 77 with the exception of the approach surfaces, circular horizontal surface, and conical surface distance (Horonjeff et. al, 2010). In contrast, Kazda and Caves (2007) adopt the ICAO regulations without further discussion of the differences between the ICAO and FAR. Panayotov and Georgiev (2008) point out that the ICAO Annex 14 determines and establishes the standards to prescribe the physical characteristics of Obstacle Limitation Surfaces (OLS). Based on this document each country establishes detailed standards and regulations that are more restrictive than ICAO standards and are more appropriate for the specific country. FAA specifies the standards and regulations for the airports in the United States of America. Ulubay and Altan (2002) present an overview of spatial data integration from different aspects and explore the role of visualization. In the paper, they mainly use the ICAO Annex 14 regulations "Obstacle Restriction and Removal" and OLS, which is slightly different from FAR Part 77 "Objects Affecting Navigable Airspace" and OIS. Finally, Litsheim and Xiao (2009) comment that the most commonly used criteria to determine complicated airport obstacle surfaces are FAR Part 77 imaginary surfaces, TERPS, and the one engine inoperative obstacle identification surface for air carriers. That paper addresses the differences and relationships among these three criteria but only within the scope of FAA Regulations.

After examining the extant literature, we found that no journal or book draws up a clear picture of the differences between these two sets of regulations. By applying the analytical method in this paper, the design criteria of imaginary surfaces will be addressed, the imaginary surfaces along 3D coordinates will be re-constructed, the critical points will be identified, the volume of decomposed surfaces along critical points will be calculated, and the safety airspace of each imaginary surface will be analyzed and compared.

The characteristics of imaginary surfaces are specified on the basis of types of airports (transport, general aviation, heliports, etc.) and are related to the intended use of the runway in terms of take-off, landing and the type of approach (non-instrument approach, non-precision or precision approach). Within the scope of this paper, the comparison between FAR and ICAO Obstacle Restriction Regulations only focuses on major airports with large transport runways and precision instrument facilities which provide minimum visibility approaches as low as 3/4 mile.

3. OBSTACLE RESTRICTION REGULATIONS

Figure 1: FAR Part-77 imaginary surfaces (FAA, 1993)



DIM	ITEM	Dimensional Standards (Feet)					
		Visual Runway		Non-Precision Instrument Runway			Precision Instrument Runway
		A	B	A	B: C	B: D	
A	Width of primary surface and approach surface width at inner end	250	500	500	500	1,000	1,000
B	Radius of horizontal surface	5,000	5,000	5,000	10,000	10,000	10,000
		Visual Runway		Non-Precision Instrument Runway			Precision Instrument Runway
		A	B	A	B: C	B: D	
C	Approach surface width at end	1,250	1,500	2,000	3,500	4,000	16,000
D	Approach surface length	5,000	5,000	5,000	10,000	10,000	*
E	Approach slope	20:1	20:1	20:1	34:1	34:1	*

3.1 Far Part 77 Objects Affecting Navigable Airspace

Subpart C of FAR part 77 establishes standards for determining obstructions to air navigation. The standards apply to existing and constructed objects, trees, and terrain. The Obstruction Identification Surfaces (OIS), depicting the standards, are used to ensure the safe separation between aircraft and obstructions. The dimensions of imaginary surfaces for the major airport with a large transport runway and precision instrument approach navigation aids are shown in Figure 1 and described below.

- Primary surface: Extends 500 feet on each side of the runway centerline and extends 200 feet beyond each end of the runway.
- Horizontal surface: Constructed by swinging arcs of 10,000 feet radii from each end of the primary surface and connecting each arc by tangent lines, with 150 feet above the established airport elevation.
- Conical surface: Extends outward and upward from the horizontal surface at a slope of 20 horizontal to 1 vertical for a distance of 4,000 feet.
- Approach surface: Extends outward and upward, diverging from the inner width of 1,000 feet to outer end width of 16,000 feet, at slopes of 50:1 for the first 10,000 feet of horizontal distance (nearest the runway) and then 40:1 for the next 40,000 feet of horizontal distance.
- Transitional surface: Extends outward and upward at a slope of 7:1 from the primary surface up to the 150 feet horizontal surface, and from the approach surface over a horizontal distance of 5,000ft.
- Obstruction to air navigation: These reach a height of 200 feet above the airport elevation up to 3 nautical miles from the Airport Reference Point (ARP) and increase by 100 feet for every nautical mile up to 500 feet at 6 nautical miles from the ARP. These standards for determining obstructions to air navigation are also contained in FAR Part 77, in addition to

the imaginary surfaces.

3.2 ICAO Annex 14 Obstacle Restriction And Removal

The objectives of the ICAO Annex 14 Obstacle Restriction and Removal are to define that the airspace around aerodromes is maintained free from obstacles so as to permit the intended airplane operations at the aerodromes to be conducted safely and to prevent the aerodromes from becoming unusable by the growth of obstacles around the aerodromes. This is achieved by establishing a series of Obstacle Limitation Surfaces (OLS) that define the limits to which objects may project into the airspace (ICAO, 2004). ICAO recommends that the following obstacle limitation surfaces shall be established for a precision approach runway category II or III. Even though ICAO uses different terminology, we try to categorize those OLS into groups with FAA's OIS by interpreting their design features.

- Runway strips: Similar to FAR's primary surface but with different calculation units.
- Conical surface: Similar to the FAR design feature but with a vertical dimension of 100 m, which is different from the horizontal distance of 4,000 feet in FAR.
- Inner horizontal surface: ICAO specifies that its shape is not necessarily circular, whereas in FAR it is constructed directly by swing arcs and tangent lines.
- Approach surfaces and inner approach surface: ICAO separates arrivals and departures and specifies dimensions for the approach surfaces and takeoff climb surfaces for departures. The takeoff climb surface has a smaller width, slope and divergence angle than the approach surface. If runway direction is intended to be used for approach and takeoff, whichever dimensions are more restrictive, such as the 2% slope, 15% divergence angle and 300 m length of inner edge must be adopted to meet both requirements. The inner approach surface is a rectangular portion of the approach surface for category II or III runways.

- Transitional surface: Similar design feature to that in FAR.
- Inner transitional surface: Similar to the transitional surface but closer to the runway, and intended to be the controlling OLS for navigation aids, aircraft and other vehicles near the runway.
- Balked landing surface: An inclined plane located at a specified distance after the threshold, extending between the inner transitional surfaces.
- Outer horizontal surface: An outer horizontal surface is a specified portion of a horizontal plane around an aerodrome beyond the limits of the conical surface. Its design concept is similar to the obstruction to air navigation of FAR but with only one criteria height of 150m.

4. COMPARISON BETWEEN ICAO AND FAR

After exploring the design criteria of two imaginary surface systems by applying the analytical method, the imaginary surfaces with similar design criteria can be categorized into groups for calculation. Table 1 shows the process as well as the results of categorization, conversion and calculation. Column 2 shows the imaginary surface dimensions of the ICAO regulations in the metric system. Since the definitions of some imaginary surface are noticeably different, conversion and calculation are necessary. Column 3 displays the dimensions after conversion to the imperial/USA system of measurement. Those values without an asterisk are specified dimensions, while others with an asterisk are the calculation results. It was found that the dimensions of some imagery surfaces, such as the conical and approach surfaces, are significantly different. Column 4 shows the FAR imaginary surfaces dimensions: most are specified while others are calculated. From columns 3 and 4 in Table 1, it is easy to compare the similarities and differences between ICAO and FAR imaginary surfaces. This table can be a useful reference tool to promote future studies and trade-off analysis to facilitate airport planning.

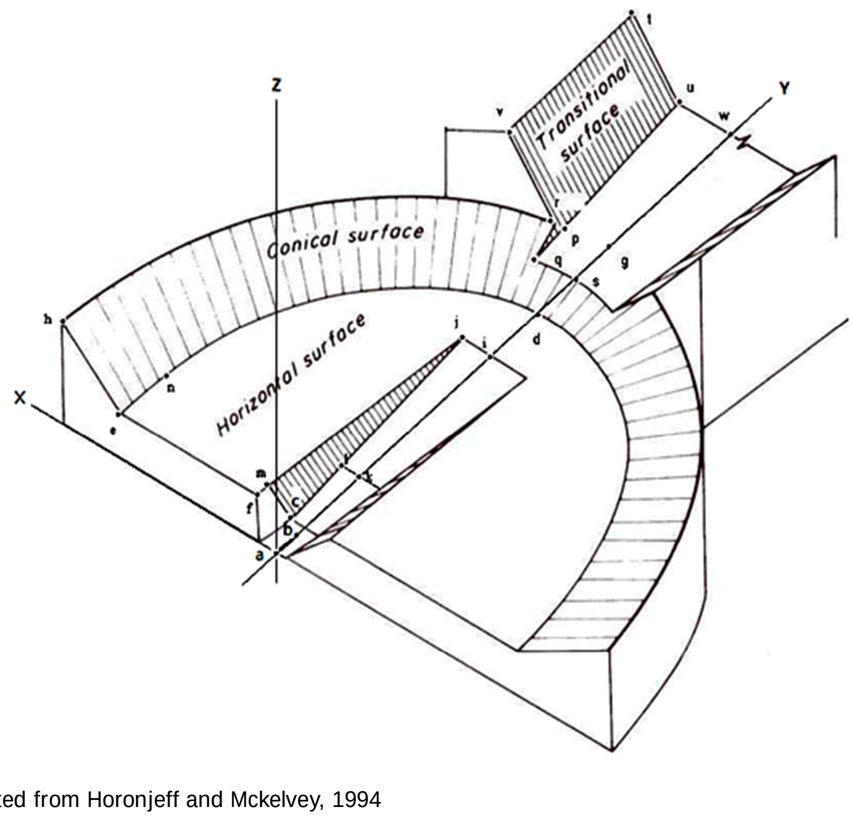
Table1: Comparison between ICAO and FAR

Surfaces	ICAO(m)	ICAO(feet)	FAR(feet)
Inner horizontal			Horizontal surface
Height	45	147.6	150
Radius	4,000	13,123.2	10,000
Conical			
Slope	5%	20:1	20:1
Horizontal distance		6,562*	4,000
Height (Total height)	100	328.1(475.7)	200*(350)
Inner approach			
Width	120	393.7	400
Distance from threshold	60	196.8	200
Length	900	2,952.7	3,000
Slope	2%	50:1	50:1
Approach			
Width of inner edge	300	984.2	1,000
Distance from threshold	60	196.8	200
Divergence (each side)	15%	15%	15%*
Width in final end	4,800*	15,747.8*	16,000
First section			
Length	3,000	9,842.4	10,000
Slope	2%	50:1	50:1
Second section			
Length	3,600	11,810.9	40,000
Slope	2.5%	40:1	40:1
Height		492.1	1,200
Horizontal section	(Limited by outer surface)		(Obs to air navigation)
Height	150	492.1	500
Length (Total Length)	8,400	27,558.7(49,212)*	(50,000)
Transitional			
Slope	14.3%	7:1	7:1
* - Calculated dimensions			

The safety airspace in this study is defined as the airspace provided by the imaginary surfaces system surrounding an airport in which the aircraft can takeoff, approach, land and operate safely. That is a measurement of volume which is calculated by multiplying the restrictive area with the restrictive height.

In order to compare the safety airspace, imaginary surfaces must be re-constructed into 3D coordinates. The critical points, which are necessarily for calculating each surface's area and volume, will be identified and located along 3D coordinates. The values of critical points along the X, Y and Z axes will be determined. Based on the critical points, the restrictive area and height of each surface will be decomposed and calculated. Figure 2 illustrates the process of re-constructing 3D coordinates, identifying critical points and decomposing imaginary surfaces.

Figure 2: Imaginary Surfaces along 3D Coordinates and Critical Points



Source: Adapted from Horonjeff and Mckelvey, 1994

Table 2: Safety Airspace Analysis for ICAO and FAR Imaginary Surfaces

	ICAO			FAR		
Surfaces	Dimensions (feet)	Area ($Mile^2$)	Volume ($Mile^3$)	Dimensions (feet)	Area ($Mile^2$)	Volume ($Mile^3$)
Outer horizontal		167.75	15.63		172.62	13.14
Height	492.1			200-500		
Radius	49,212.0			50,000		
Inner horizontal		9.70	0.27		18.97	0.54
Height	147.6			150		
Radius	13,123.2			10,000		
Conical		12.13	0.72		13.90	0.66
Slope	20:1			20:1		
Height	475.7			350		
Horizontal distance	6,562.0			4,000		
Approach		15.06	0.89		15.35	1.19
Width of inner edge	984.2			1,000		
Distance from threshold	196.8			200		
Divergence (each side)	15%			15%		
First section		0.55	0.01		0.57	0.01
Length	9,842.4			10,000		
Slope	50:1			50:1		
Second section		2.70	0.11		14.78	1.89
Length	11,810.9			40,000		
Slope	40:1			40:1		
Width of inner edge	4,593			4,600		
Width in final end	8,136			16,000		
Horizontal section		11.81	0.77			-0.71
Length	27,558.7			25,926.6	(Obstructions to Air Nav)	
Height	492.12			500		
Width in final end	15,748			16,000		
Total length	49,212			50,000		
RCKH runway length:10330ft; Width: 200 ft; Precision instrument approach Cat II						

By applying the logic analysis and basic mathematics, the measurements of area and volume for each imaginary surface are calculated. Table 2 shows the results after calculations. The imaginary surface, which specifies a larger area and lower height, yields a more extended obstacle separation, safer airspace, larger land-use requirement and therefore has more adverse effect on neighboring urban development. Intuitively, the measurement of volume may not vary proportionally with the degree of safety airspace, because volume is the product of two opposing factors, area and height. In any respect, if height is constant, a larger area is more restrictive. On the other hand, if the area is constant, a lower height is more restrictive. Generally, if one of the factors is constant, the volume comparison is meaningful.

For the comparison of outer horizontal surfaces, the FAR requires less volume and safer airspace than ICAO, since it has nearly the same area but lower height. For inner horizontal surfaces, the ICAO has a longer radius but much smaller area than FAR, if the circular shape is intended to be used. With equal height and two times larger area, FAR has a much safer airspace than ICAO. If taking the horizontal section into account, the FAR approach surface also has a slightly safer airspace than ICAO. With all other surfaces which are not significantly different in size, FAR generally has a safer airspace than ICAO.

5. CONCLUSION

For the purposes of both airport engineering and airport planning, a better understanding of these different obstacle surfaces and their application is important. This paper compares the safety airspace of the FAR Part 77 “Objects Affecting Navigable Airspace” and ICAO Annex14 “Obstacle Restriction and Removal”. By applying the analytical method, the comparison of imaginary surfaces between ICAO and FAR was thoroughly investigated. The results can be a useful reference tool for promoting future studies and for use in tradeoff analysis to facilitate airport planning. By using basic mathematical calculations, the restrictive area and height for each imaginary surface were computed. It was found that FAA regulations of Objects Affecting

Navigable Airspace specify a more extensive obstruction clearance and presumably safer airspace and consequently has a more restrictive influence on urban development.

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