OPTIMIZATION OF OBSTACLE LIMITATION SURFACES ON THE EXAMPLE OF A SPORT AIRPORT IN PARAĆIN

Marjan Matić [1]
Slobodan Šupić [2]
Miloš Šešlija [3]
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Summary: *This paper work presents a part of the research work in the definition segment of obstacle limitation surfaces around the airport, and for improvement of the airport Paracin. It is a sport airport designed for the needs of landing and launching of new types of airplane which meets the set requirements in terms of technical characteristics. These are the so-called STOL (Short Take Off and Landing) airports,with the length of the runway from 800 m to 1200 m.The research part mostly refers to the proving of comfort passability and safe maneuvering of STOL airplane in the airport zone, preventing the increase in building costs and environmental protection. In accordance with the legal regulations of the Republic of Serbia, solutions for these types of airports have been suggested.*

Keywords: *Airport, STOL,obstacle limitation surfaces , airplane, runway.*

1. INTRODUCTION

A safe flight of an airplane around the airport, or a safe taking off, landing and circulation of airplane in the airport zone, is provided with a well-chosen terrain for the construction of the airport and a good orientation of the axis of the runway. This is achieved by placing a set of surfaces that determine the limitary heights of objects that can be placed in the airport zone. In such a well-defined area around the airport, it is necessary to eliminate all natural or atificial obstacles, which could pose a potential danger to airplanes maneuvering [2].
Also, if there is a need to improve the airport, namely, the need arises for the acceptance of larger airplanes than those for which the original airport is designed, it is necessary to redefine obstacle limitation surfaces around the airport.

[1]Marjan Matić, MSc CE, University of Novi Sad, Faculty of Technical Sciences, Trg Dositeja Obradovića 6, Novi Sad, Serbia, tel: +381648267824, e – mail: marjangrmatic@gmail.com
[2]Slobodan Šupić, MSc CE, University of Novi Sad, Faculty of Technical Sciences, Trg Dositeja Obradovića 6, Novi Sad, Serbia, tel: +381640914861, e – mail: ssupic@uns.ac.rs
[3] Miloš Šešlija, MSc CE, University of Novi Sad, Faculty of Technical Sciences, Trg Dositeja Obradovića 6, Novi Sad, Serbia, tel: +381653990089, e – mail: sele@uns.ac.rs

If this space was not defined, airport would become unusable, regardless of the fact that the reconstructed runway would be longer. Also, in addition to fulfilling all conditions for safe maneuvering in the airport zone, it is necessary to pay attention to the environment of the airport from the aspect of environmental protection, which can be directly endangered by the condition to remove all natural obstacles that enter the protected area of the airport. The problem that arose during the reconstruction (improvement) project of the existing airport in Paracin, is inroading natural obstacles in the protected area of the airport. This paper provides a solution to this problem.

2. OVERVIEW AND DEFINITION OF AIR SPACE IN THE IMPROVED STOL AIRPORT ZONE

2.1 Terrain configuration in the airport zone

Topographic and meteorological conditions have an impact on choosing the airport location [3]. This paper presents the analysis of topographic conditions.
Based on the data collected from the meteorological station at the airport, it can be concluded that meteorological conditions (wind, fog, clouds and temperatures) do not have a significant impact on the development of air traffic in the zone of the existing airport Paracin, and the current orientation of the runway GEO course: (102.52 ° - 282.52 °) do not need to be changed. Topographic maps of 1:50 000 proportion were used for the survey of topographic conditions, and in the approach-exit area where problems with physical obstacles were present, analysis was carried out on a more detailed map, that is, the proportion of 1:25 000. The airport "Paracin" is located on approximately horizontal and slightly inclined terrain with low level of groundwater, while in the immediate vicinity of the airport is a hilly terrain (*Figure* 1 and *Figure* 2). The reference point of the airport is located in the geometric center of the summer-runway and it is amount 165 m.n.m.
As the reconstruction and improvement of the existing airport is concerned, the first step, namely, defining of the airport location, that we have practically skipped as airport location has already been defined by the position of the existing airport. There remained space for possible local correction of the runway and its orientation, position and eventual length increase.

Figure 1 – runway, view in the direction of 102.52 ° (from threshold 10 to threshold 28)

Figure 2 – runway, a view in the direction of 282.52 ° (from threshold 28 to threshold 10)

The exact definition and exploration of the best variant for orientation and the position of the runway was achieved by forming a Digital Terrain Model (DTM) within a radius of approximately 4.5 km around the airport (*Figure* 4). DTM was formed based on the defined georeferenced topographical background with iso-posts (*Figure* 3), which coordinates were adopted from the RS Geodetic Network website [4]. With the Iterative setting of the axis of the runway and its micro-movements, various variant solutions were formed, and the final orientation and position of the axis of the runway were defined.

Figure 3 – Georeferenced topographic background [4]

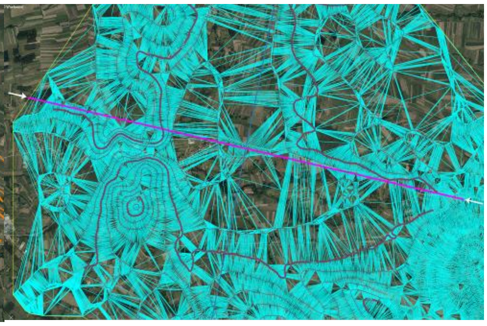

Figure 4 – Digital terrain model in the area of the airport

The new runway was adopted with dimensions of 900x23 m, orientation (GEO course: 102.52 ° - 282.52 °) with modern road structure made of asphalt.

2.2 Reference airplane design

The airport is designed for the needs of a reference (critical) aircraft. According to reference airplane, all maneuvering areas at the airport, as well as the security zones around the airport, are defined. In order to define the safety zones, the physical characteristics of the aircraft were not of great importance, but rather its technical and mechanical characteristics. Based on them, a more realistic insight into the minimum space required for the safe movement of airplane in the airport zone was achieved.

A plane L 410 UVP-E20 Turbolet was adopted for the newly designed airport Paraćin Airport for the reference airplane (Figure 5). However, as there are cases indicating that the airplane is not always reference for the definition of absolutely all elements at the airport, it was necessary to compare each other's technical characteristics with the operations expected at the airport, thus achieving the definite border parameters.

Figure 5 - Appearance of the L410 UVP-E20 Turbolet

In order to be able to realistically assess the required space in the airport zone, it was necessary to know the minimum technical requirements of the airplane which landing and taking-off are expected at the airport. As the problem arose with the configuration of the terrain affecting the protected area of the airport in the area of approach and departure surfaces observed in the direction (GEO course: 282.52 °), it was necessary to know, from the technical characteristics, the smallest rate of flight of the airplane in order to define the real inclination of the runway surfaces. Table 1 presents the technical characteristics of the airplane, which are the most important in terms of defining the realistically required inclination of the runway.

Table 1 - Technical characteristics of the airplane adopted by the air fleet [5,6,7,8]

Airplane type	Vb (km/h)	Climb rate		
		v/t (m/s)	α (°)	i_N (%)
Piper PA-31 Cheyenne	120	14,2	18,31	47,09
Beechcraft King Air 200	160	12,5	16,33	29,31
De Havilland DHC-6 Twin Otter	155	5,74	7,66	13,45
L 410 UVP-E20 Turbolet	155	5,51	7,35	12,90

Based on the comparison of the technical characteristics of the airplane adopted by the air fleet, the measuring aircraft with the lowest rate of rise is also in this case L 410 UVP-E20 Turbolet. As the average climbing rate of the relevant airplane is 5.51 m / s, and the minimum speed at which the relevant airplane wings is 155 km / h [9], the angle that covers the runway surfaces with the horizontal is 7.35 °, ie the required slope is 12, 90%. As the defined safety factor for the slope Fs = 1.50 (50%), the final slope of the approach-departing surface could be 8.60%, i.e. this slope represents the limit value of the slopes of the approach-departing surface for all airplanes. Figures (Figure 6 and Figure 7) show the diagrams of the longitudinal slopes of the approach and take-off climb surfaces for different cases.

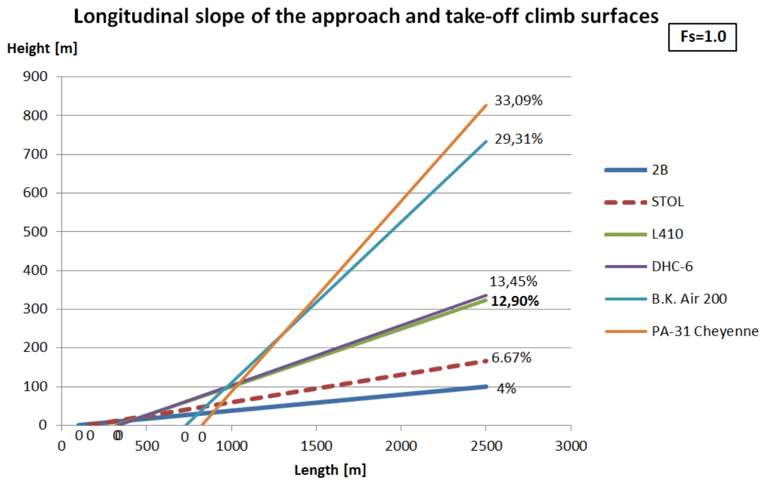

Figure 6 - Display of the longitudinal slope of the approach and take-off climb surfaces for airport code tag 2B, for STOL airport and for each airplane of the air fleet individually. With safety factor Fs = 1.0

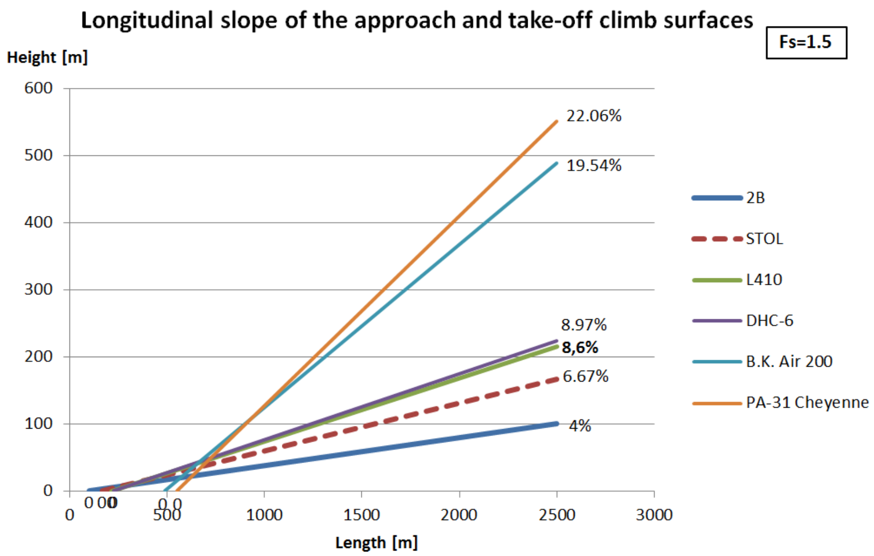

Figure 7 - Display of the longitudinal slope of the approach and take-off climb surfaces for airport code tag 2B, for STOL airport and for each airplane of the air fleet individually. With safety factor Fs = 1.5

Based on these diagrams, the picture of the required space in the zone of approach and take-off surfaces is clearly defined, ie, based on these slopes, the limit values of the height of physical obstacles (natural and artificial) can be accurately defined.

2.3 Defining the security zones around the new STOL airport in Paracin

Based on the rule book of the airports [9], a system of obstacle-restriction surfaces, which together form the security zones of the newly-designed Paraćin airport, with a non-instrumental runway, code mark 2B was defined .
The code mark 2B, as we see, consists of a code number and a code letter. The code number is determined based on the length of the runway, and the code letter is based on the wingspan and the range of the landing gear of the reference airplane. Based on this defined code mark, the rule book provides recommendations and restrictions for all maneuvering areas at the airport and for defining the security zone around the airport. However, in the code tag, the parameters of the technical and mechanical characteristics of the airplanes that are the most important to define the airspace in the airport zone are not defined. The defined safety zones do not pose a problem if the physical obstacles do not hit the protected area of the airport. However, in this project, as mentioned earlier, there is a certain physical problem (in the area of approach-take-off climb surfaces in the direction of 280 °), if guided by the rule book of the airports. If guided by the fact that the airport exists and is used around 65 years at this location, and this is an improvement

of the airport, which will in the future be landed by morden airplane with STOL characteristics, it would be logical that in the future there would also be no problem with physical obstacles. This was proven in the previous section of the paper (Figure 6 and Figure 7). Due to this problem, it was necessary to compare (Table 2) recommendations with an amendment to STOL aerodromes with our rule book and international recommendations of ICAO [11,10,2].

Table 2 – Comparative dimensions of the security zones for airport code mark 2B and for STOL airports [10, 11]

Obstacle limitation surfaces		**2B**	**STOL**
Inner horizontal	Height	45 m	75 m
	Elevation	210 m	240
	Radius	2.500 m	2.500
Conical	Slope	5 % (1:20)	5 % (1:20)
	Height	55 m	55 m
	Elevation	265 m	295 m
	Distance in horizontal plane	1.100 m	1.100 m
Approach/ take-off climb	Slope	4 % (1:25)	6,67 % (1:15)
	Inner edge	80 m	1.100 m
	Divergence	10 %	15 %
	Length	2.500	2.500
Transitional	Slope	20 % (1:5)	20 % (1:5)

When we defined safety zones according to airport rules (Table 2 and Figures 8 and 9), two natural physical obstacles that hit the protected area of the airport appeared.

The first affects the protected area of the airport over the inner horizontal surface, and the other (more problematic) over the approaching-taking off climb surface. A solution to this problem would be to remove physical barriers, or to profile the terrain according to a defined template of protected zones. Such a solution could cause big consequences for the disruption of the eco-system of this area and the increase in construction costs. However, the solution for the first physical obstacle would be to ban flight operations in this zone [12].

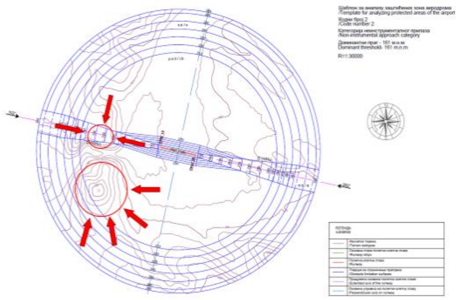

Figure 8 - Pattern for the analysis of protected areas of the Paracin airport, with marked natural obstacles that engulf the airspace of the airport.

The solution for the second obstacle is found in the amendment to STOL airports and this is additionally confirmed by the research of the physical and technical characteristics of the air fleet (required slope of the approach-taking off climb surface). If we would accepted the required airspace according to the airport regulations and ICAO Annex 14, it would be necessary to remove approximately 3.9 million cubic meters of land, or 35.5 hectares of forest, directly threatening the entire ecosystem of this area, and the cost of building the airport would be 12 times higher which indicates an absolutely unprofitable investment. By accepting amendments to STOL aerodromes these problems would be successfully avoided (Figure 9).

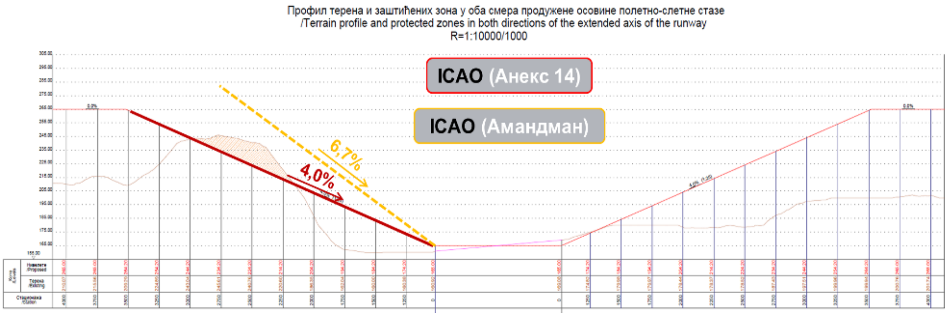

Figure 9 - Display of the longitudinal inclination of the runway surface, according to Annex 14 (red color) and according to the Amendment to STOL airports (red color). [6,7]

3. CONCLUSION

Since Paracin Airport has been used for approximately 65 years for sporting purposes, pilot training, parachute jumps and panoramic flying, and given the fact that no accidents have occurred yet [13], the proposed design method would safely enable the safe use of the new STOL airport , ie. an airport for landing of modern types of airplanes.

In engineering practice, this kind of design would contribute to reducing the space of airport infrastructure and would significantly influence the awareness of environmental protection and economics in the construction of large infrastructure facilities.

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ОПТИМИЗАЦИЈА ЗОНА СИГУРНОСТИ НА ПРИМЕРУ СПОРТСКОГ АЕРОДРОМА У ПАРАЋИНУ

Резиме: *У овом раду приказан је део истраживања у сегменту дефинисања зона сигурности око аеродрома, а за потребе унапређења аеродрома Параћин. Реч је о спортском аеродрому који се пројектује за потребе слетања и полетања нових типова ваздухоплова који испуњавају постављене захтеве у погледу техничких карактеристика, то су такозвани STOL (Short Take Off and Landing) аеродроми, са дужином полетно-слетне стазе од 800 до 1200 м. Истраживачки део се највећим делом односи на доказивање комотне проходности и безбедно маневрисање СТОЛ авиона у зони аеродрома, такође спречавање повећања трошкова грађења и заштита животне средине. Самим тим је неопходно било ускладити се са законском регулативом Републике Србије и предложити решења за овакве типове аеродрома.*

Кључне речи: *Аеродром, СТОЛ, зоне сигурности око аеродрома, авион, писта*