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Original Paper

Improving the Bitola Aerodrome Category through the Ana Lazarovska's, Codex on the Sustainable Aerodrome Development "Parallel to Leonardo da Vinci's, Codex on the Flight of Birds"

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Abstract
Parallel with the global increase in air traffic for better aerodrome coverage in the Republic of Macedonia, sustainable growth of the aerodrome "Logovardi" in the vicinity of Bitola city is necessary. At present conditions, this aerodrome is intended for sport, pilot school, sightseeing, and medical urgency flights. The paper is presenting sustainable development according to Ana Lazarovska's notebook and parallel to Leonardo da Vinci's notebook. "Codex on the sustainable aerodrome development" is written parallel to the "Codex on the flight of birds" and is left for all engineers who are working with aerodrome infrastructure. The proposed notebook works with the process of „step by step" showing the necessary level of category development and improvement of the present aerodrome infrastructure in this article for Bitola aerodrome. The main focus is on the equilibrium theory as a basic solution for related problems. The evaluation must satisfy the possibilities of extension runway and aerodrome including the further necessary development into the Annex 14 border.

Keywords
Bitola Aerodrome Development Process, Bitola aerodrome design; "Codex on the sustainable aerodrome development", ICAO signalization, sustainable aerodrome development, equilibrium representation

1. Introduction

The City of Bitola has one aerodrome for general aviation. The main purpose of this aerodrome development includes every aerodrome infrastructure in R. Macedonia for future sport-school goals. The process of category development and further improvement is based on standards and criteria of the ICAO Annex 14 and sustainable development goals. Using the acquired knowledge of multidisciplinary analysis and theoretical evaluation, the most suitable aerodrome category was proposed.

The process of determining the necessary category development is given with the conditions and long-term aerodrome development in accordance with the Strategy and the Physical Planning Program of the Republic of Macedonia and Municipality of Bitola Regional Planning.

The category evaluation is going through the elaboration of the existing aerodrome in Bitola based on meteorological, topographic, and navigation parameters and taking into consideration the geological, traffic urban, and ecological conditions. In the selection of further categories that would have the most favorable conditions for development, with obstacles regarding the surrounding of Bitola city with urban and regional space plans taken into account.

The Bitola aerodrome is located as 17R/35L with 305m with constructive surface and 17L/35R classified up to 1200m length of runway with a grass surface of the finally selected location as non-instrumental. The coordinated of the Bitola aerodrome are 41°01′24.76″N 021°25′32.10″E. [1]

2. Literature for Sustainable Development and Signalization for Non-Instrumental USS of View Review

2.1 Sustainable Development for Aerodrome View Review

Human pressure has caused changes in the basic processes of the Earth system and led to: water shortages, climate changes that are reflected in extreme weather conditions, the disappearance of plant and animal species, rising sea levels, population growth to increased poverty and hunger in the world that poses a great danger to humanity and the environment and can result in humanitarian crises around the world. Sustainable development deals with a global conflict that on the one hand requires economic development, production, and profit, and on the other hand limited resources that question the ability to meet the needs of future generations (Drljaca, 2012). According to Drljača (2012, p. 20), sustainable development is "the relationship between dynamic human-made economic systems and larger dynamic ecosystems that change slowly and must be in ecological balance." Griggs (2013, p. 306) defines sustainable development as "development that meets the needs of the present while preserving the Earth's life support system on which the well-being of present and future generations depends." "Sustainable development is defined as managing resources for our generation as the first part of sustainable development" (Asheim, 1994).

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The goal of sustainable development is to ensure the sustainable use of natural resources at the national and international levels (EPEEF, 2019) with models of sustainable use that focus on the scarcity of natural resources. The successful implementation of the concept requires its incorporation into the documentation infrastructure and institutional frameworks, such as the UN, WCED, ISO, and others involved in the resolution of this global conflict through numerous environmental conferences and important documents (Harrow, 2012) to create guidelines for sustainable development in EU.

Drljača (2012) states three important elements in the concept of sustainable development according to Crnjar (2002):

1) The concept of development with the qualitative elements of development at the beginning,

2) The concept of basic resources needs to achieve the quality of life,

3) The concept of future generations is the essence of sustainability and deals with the question of the legacy of current and future generations.

Changes must occur in all segments of human activity, with a thorough revision and change of the value system (Drljača, 2012) in order to achieve a balance with nature that can only be disturbed by civilization. In addition to nature, Western civilization has created a gap in the balance with the underdeveloped world or other civilizations that are indispensable when talking about a new balance with demands (Crnjar, 2002, p. 189):

- conservation of natural resources,
- greater fairness in the distribution of resources and wealth,
- introduction and application of new technologies,
- distinguishes between the concept of growth and the concept of development,
- giving up activities that could threaten the interests of future generations,
- acceptance of sustainable development as a philosophical approach and pragmatic action.

Global environmental goals are focused on terms of material use, clean air, nutrient cycles, hydrological cycles, ecosystems, biodiversity, and climate stability.

According to Griggs, the goals of sustainable development are focused on both people and the planet, and they are as follows (Griggs, 2013, p. 306):

1) Successful lives and livelihoods: ending poverty and improving well-being through access to education, employment, and information, better health and housing, and reducing inequalities while moving towards sustainable consumption and production.

2) Sustainable food security: ending hunger and achieving long-term food security, including better nutrition, through sustainable production, distribution, and consumption systems.

3) Sustainable water security: Achieving universal access to clean water and basic sanitation and ensuring efficient allocation through integrated water resources management.

4) Universal clean energy: improving universal access to clean energy that minimizes local pollution and health impacts and mitigates global warming.

5) Healthy and productive ecosystems: Sustaining biodiversity and ecosystem services through better management, evaluation, measurement, conservation, and restoration.

6) Governance for sustainable societies: Transforming governance and institutions at all levels to meet the other five sustainable development goals.

The goals defined by the UN at the 2012 conference are described in the 2030 Agenda for Sustainable Development, adopted by all member states in 2015, and a program that provides a common plan for peace and prosperity for people and the planet, now and in the future. and focuses on 17 objectives.

The whole process of the previously mentioned question to develop a key role here (Kates, Paris, & Leiserowitz, 2005) can be described through the three dimensions shown in Figure 1, namely society, economy, and environment. The economic dimension is often the main focus that often needs to be regulated in relation to development policies and indicators but depends on the sustainability of the other two dimensions. Given the negative impacts that economic activity has on social and ecological systems, it can be said to undermine the conditions for long-term stability (O'Connor, 2006) while simultaneously satisfying quality and performance objectives on all three dimensions.

Figure 1. Three Dimensions of Sustainable Development

Source: ODRAZ, 2015.

The roles of each dimension can be contradictory and incompatible, depending on the other two to reach a consensus on the management of society, the environment, and the economy. This action of organizations leads to the need for a fourth—the political dimension—which is constituted through the emergence in society of conventions, rules, and institutional frameworks for regulating the economic and social dimension, and indirectly the environmental dimension (O'Connor, 2006).

The diagonal elements as shown above describes the area of action of a particular dimension, while the other elements describe the interactions between the dimensions with a focus on the interactions and interdependence of the economy, society, and the environment.

The European Union adopted a ten-year strategy Europe 2020, whose goal is to reform the European economy and ensure Europe is a priority player on the world stage with a plan for economic progress with a component of social and environmental sensitivity (Grgurić, 2011).

The EU has set five ambitious targets for employment, innovation, education, social inclusion and climate/energy to be achieved by 2020. The specific objectives are (European Commission, 2015): [10]

1) to ensure an employment rate of 75% for persons aged between 20 and 64,

2) invest 3% of European GDP in research and development,

3) reducing greenhouse gas emissions by 20 or even 30% compared to 1990, meeting 20% of energy needs from renewable sources, and increasing energy efficiency by 20%.

4) to reduce the dropout rate to less than 10% and to ensure that at least 40% of people between the ages of 30 and 34 will complete higher education,

5) reducing the number of people on the edge of poverty and social exclusion by 20 million (European Commission, 2015).

The achievement of the national goals of the Europe 2020 strategy (Government of the Republic of Macedonia, after joining the EU) should be:

- Stability or convergence program and
- National reform program.

Globally, the 2030 Agenda for Sustainable Development encompasses three dimensions and focuses on the Sustainable Development Goals adopted by the Paris Climate Agreement and the Addis Ababa Action Plan, as an integral part of the 2030 Agenda for Sustainable Development, and the Sendai Framework for Reduction of disaster risk (European Commission, 2016) in line with Europe's visions. The program as a component of 17 goals for sustainable development and related 169 short-term goals interconnected and universally applicable for the realization of all developed and underdeveloped countries is described by all 17 goals of the Program for sustainable development until 2030.

Goal 1 - „ A world without poverty "

Goal 2 - „ A world without hunger "

Goal 3 - „ Health and well-being "

Goal 4 - „ Quality education “

Goal 5 - „ Gender equality “

Goal 6 - „ Clean water and sanitation “

Goal 7 - „ Affordable clean energy “

Goal 8 - „ Decent work and economic growth “

Goal 9 - „ Industry, innovation, and infrastructure “

Goal 10 - „ Reducing inequalities “

Goal 11 - „ Sustainable cities and communities “

Goal 12 - „ Sustainable consumption and production “

Goal 13 - „ Climate Protection “

Goal 14 - „ Preserving the aquatic world “

Goal 15 - „ Preserving life on Earth “

Goal 16 - „ Peace, justice, and strong institutions “

Goal 17 - „ Partnership for all “.

Taking this evaluation in mind, especially these goals have to be taken into consideration that developing the aerodrome infrastructure for Macedonia where the traffic system is presenting the key for this country, is more than necessary. According to the location of this country, the traffic system needs to be most developed and most important for all future generations, because traffic is the only solution for the country's development and satisfaction. The author believes that the future generation will take this constatation as credible and the authorities will pay attention to this sector more realizing the obstinacy of the overall country situation. [15]

*2.2 Signalization for the Non-Instrumental Aerodrome according to the ICAO-Annex 14 for Revision*The use of obstacle marking means is intended to reduce the danger to aircraft by indicating the presence of obstacles. The objects are marked and illuminated in accordance with Annex 14, Volume 1, Chapter 6, 6.2. or 6.3. depending on need and applicability. According to certain regulations, a permanent barrier over an accessible, transitional or immovable surface 3000m from the inner edge of the USS must be marked, unless the defined obstacle is obstructed by any other permanent obstacle or the defined obstacle is illuminated during flight by sufficient light intensity.

Permanent obstacles above the internal horizontal surface must be marked and illuminated, except when

a. the defined obstacle is protected by another permanent obstacle,

b. for the defined obstacle, a circular procedure is prescribed that provides vertical division under the circular flight trajectories,

c. for the defined obstacle, the competent authority determined that it has no operational significance,

d. the sign is illuminated with high intensity during the day.

The following signalization is mandatory for every aerodrome planning or existing. Not having this equipment means closing the aerodrome until the acquisition of the necessary signalization. [11]

2.2.1 Aerodrome Identification Sign and Beacon

Smaller aerodrome, such as Bitola Aerodrome, due to the need for greater visibility from the air, must be visually equipped with an identification mark or lighting. The marking was determined keeping in mind the fact that the aerodrome in Bitola has to fulfill the operational requirements. The identification mark is positioned so that it is visible and legible from all angles above the horizontal. The color used should be such as to allow easy legibility that is not used for other purposes and at a height of up to 3 m. Since the Bitola Aerodrome is intended for visual flying during the day, the rules for the use of the aerodrome and the identification sign will be omitted.

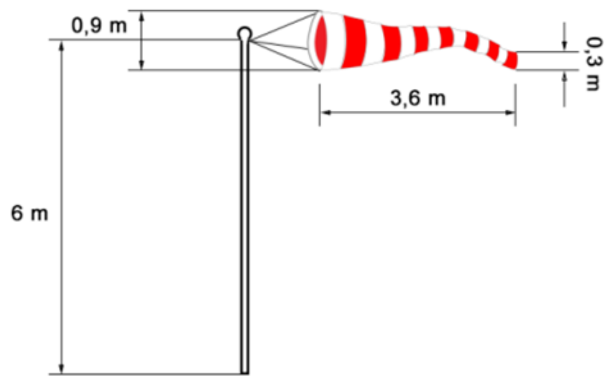

Figure 2. Wind Direction Indicator Source

The specifications for wind direction indicators and aerodrome sausages are shown in Annex 14, Summary 1, Chapter 5 and as such will be directly applicable to the selected Bitola Aerodrome. The wind direction indicator must be in the form of a truncated cone, made of fabric, with a length of at least 3.6 meters and a diameter of the widest part of 0.9 meters. Its construction and installation must also fulfill its purpose of use which is clear and should identify the direction of the wind as well as indicate its strength. The colors used (orange and white, red and white, or black and white), as well as the placement, must be clear from the pilot's point of view from 300 m. [12]

2.2.2 Indicators and Signals

The use of visual signals on the ground is conditioned by the fact that Bitola Aerodrome does not have a control tower and flight information services, or when the aircraft using Bitola Aerodrome does not require aerodrome control services. The information to be marked visually is the same as that published in the Aeronautical Information Act as well as NOTAM. In the case of a closed Bitola Aerodrome, closure markings should be placed at each end of the rollers, drawn on the surface if permanently marked, or labeled if temporarily. According to the regulations, the markings are in the form of letters X, the length of the arm is 6m and the width is 0.9m.

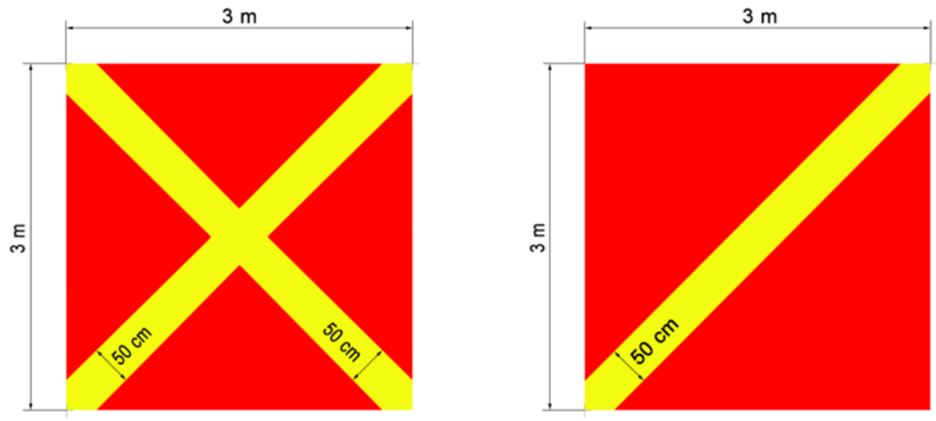

Figure 3. A) No-Fly Signal B) Need for Special Caution in Landing

Source: [12].

To ensure the safety and reliability of the lighting system, the visual inspection system must be controlled according to the specifications given in the Aerodrome Design Manual, Section 5. Bitola aerodrome should meet the needs of a spot/school aerodrome which will be used as needed if necessary, signs can be placed at the aerodrome to provide information and instructions. Signs should be placed closer to the USS, light, breakable, and placed at such a low level that they do not compromise the safety of aerodrome operations. Signage must be located to allow easy reading at a distance of 240m. Mandatory instruction signs consist of white lettering on a red background, intended to define a point through which aircraft and other vehicles should not proceed, and prohibit entry and exit to defined maneuvering areas. The use of signs and their meaning should follow the instructions of Annex 14, Volume 1, Chapter 5, 5.4.2.12. In the event of a change to already established standards for aircraft movement, signaling with informative signs in black on a yellow background should be published, and information on changes and additions to specific locations or destinations in the area of aircraft movement was properly defined piles. In situations of the use of gliding at the Bitola aerodrome, a signal for "flying a glider in progress" should be used, according to dimensions already defined by ICAO.

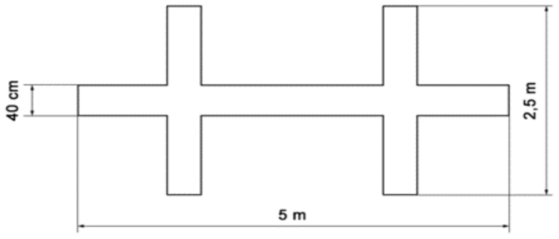

Figure 4. Glider Flying Signal in Progress

Source: [12].

The hangar is built with a steel structure, covered with a plasticized sheet, and equipped with electricity.

There is no fuel at the aerodrome, and the needs could be met with gas stations that are several kilometers away. The aerodrome should be equipped with fire fighting equipment, meteorological equipment such as wind direction indicators, medical assistance, and emergency services located in the city.

Due to the flat location of the aerodrome, there will be no restrictions and initial restrictions on the conduct of activities at the aerodrome, and in addition to aerodrome vehicles, the movement of other vehicles on maneuvering surfaces will be prohibited. The emergency plan at Bitola Aerodrome will be implemented according to the emergency plan for sports aerodromes approved by the ICAO authorities. [12]

2.2.3 Markers

In order to maintain the safety of the daily air traffic, as determined during the initial use of the aerodrome in Bitola, it is necessary to place the take-off markers on an unpaved runway. Due to the need to differentiate the runway from other maneuvering surfaces, fragile and sufficiently low markers should be placed. Non-structural pavement USS markers should clearly indicate the take-off boundary and be in the form of a flat rectangle or cone. Legal rectangular markers should have a minimum dimension of 1 × 3m and should be placed lengthwise parallel to the center of the course, while conical markers should be up to 50 cm high. To facilitate visual navigation, a runway center marker of green retro reflective material is recommended, and its construction must be such that it is not possible to damage aircraft wheels or markers during use. The surface marked with markers must be visible from the air, i.e. visible to pilots as a rectangle with a visible area of $20cm^2$. Taxiways on unpaved tracks will be marked with cone-shaped markers.

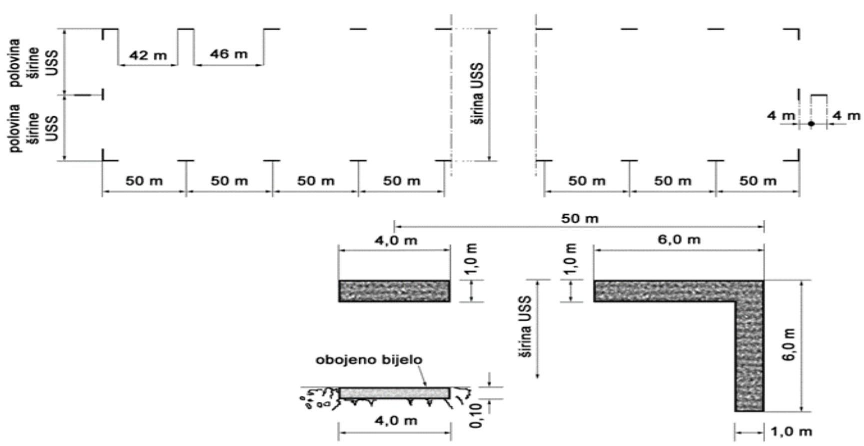

Figure 5. Edge Markers on Unpaved USS

Source: [12].

All mobile devices and vehicles should also be marked and illuminated. Boards, stones, and cones located in non-use areas should be prominently marked such that the cones should be at least 0.5m high, flag 0.5m ? 0.5m high, and 0.9m mark marked in red, orange, or yellow color combined with white color. [12]

2.2.4 Communication Systems

In the initial phase of category development, the aerodrome will not require air traffic control service according to its usage. The need for radiotelephone communications at the aerodrome and the aerodrome zone will be answered by the Skopje tower, and the person who will fly the flying activities should have a license for at least sports aviation pilots aircraft and recognition of sufficient knowledge of aviation phraseology. During the flight, responsibility for the security of the aerodrome of operations to initiate and prevent unauthorized movement of persons and vehicles would rest with the aerodrome manager. The instructions for the movement of aerodrome vehicles are contained in Annex 14, Volume 1, Appendix A, Paragraph 18. Since Bitola aerodrome is categorized for non-instrument flying, apart from visual signaling and aeronautical radio equipment, no other navigational equipment is provided. According to certain specifications, aerodrome functions, aerodrome visual signal signs would be flagrant and the letter T, navigation devices would not comply with the requirements, and means of communication that could be used were ICOM radios and mobile phones.

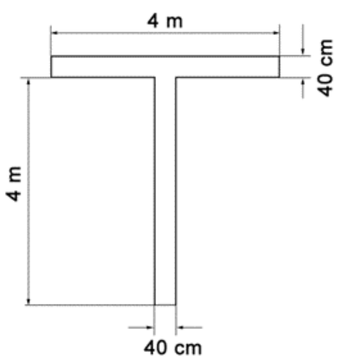

Figure 6. Edge Markers on Unpaved USS

Source: [12].

The T signal is recommended to be used on the left side according to the normal take-off or landing page of the aircraft. In accordance with the regulations, the T signal is white or orange, 4.4 m wide, 4 m wide and 0.4 m thick. [12]

2.2.5 Aerodrome Area and Flight Procedure

The boundaries of the aerodrome zone will include the airspace at an altitude of 4000ft AMSL defined by the approach and departure runways according to the designated USS direction. Flying activities above 1500 m MSL should require approval from competent air traffic control. The relative height of the aerodrome according to the permitted height of the school circle would be 300m and 250m respectively. The glider school circle can be east and west in relation to Bitola aerodrome. Departure and arrival procedures will follow the border points and outside the aerodrome zone, from which 850m MSL will start the procedure for entering the aerodrome zone.

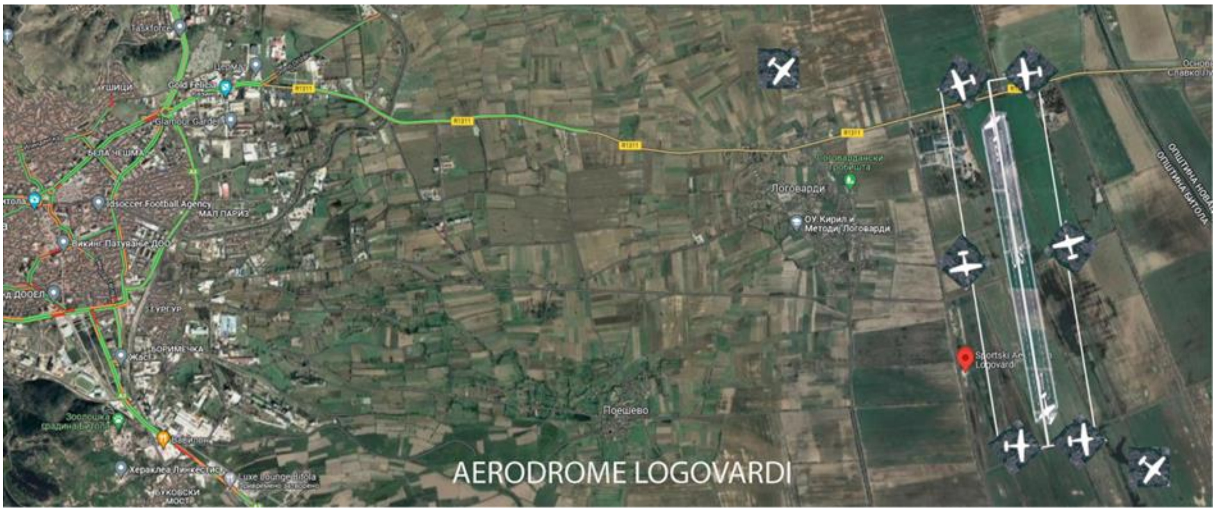

Figure 7. Aerodrome Circle in the Aerodrome Bitola

Source: author's picture.

Pilots should report to air traffic control at the mandatory reporting points before entering the aerodrome and maintain contact on the already established frequency and within the aerodrome zone to perform their navigation, in addition to visual navigation at Bitola aerodrome. The notification and approval of the flight will be carried out by the control of Skopje. Pilots will have to prepare for the flight and initiate and complete the flight themselves. [13]

3. Expansion of the Aerodrome Category for Bitola Aerodrome Based on Meteorological, Navigational, and Topographical Conditions

Having in mind the factors which influence the possible aerodrome extension for category development, the elaboration will be made considering the topographical, meteorological, and navigational conditions, and also urban space planning, civil engineering, geology, traffic, and other conditions kept in mind.

In order to determine the degree of development of the aerodrome in Bitola, the following will be elaborated:

- Meteorological conditions characterize the local atmosphere and represent a set of atmospheric conditions that prevail in a given area and as environmental conditions that influence the prediction of weather conditions and changes.

- Topographic conditions as a description of surface features and physical-geographic features determine the physical characteristics of an aerodrome's elevation, slope, and reference temperature.
- The interaction of these two conditions determines the navigational conditions necessary for the safe conduct of aerodrome traffic.

The selection of the required category will be determined according to the Internationally Uniform Flight Rules and the Common Reference Systems. For the time reference system, the Gregorian calendar and the coordinated (universal) world time (UTC) are set, which for the Republic of Macedonia is +2 hours. The World Geodetic System - 1984 (WGS-84) will be used as the reference (geodetic) reference system and all geographic coordinates (latitude and longitude) will be expressed in WGS-84. For mean sea level (MSL) which expresses the ratio of gravitational height (level) to a surface known as the geoid, using the height reference system. [10]

3.1 Meteorological Characteristics of the Possible Locations of the Aerodrome in Bitola

Bitola is located in the south western part and the Dragor River through the city. Bitola lies at an elevation of 615 meters above sea level, at the foot of Baba Mountain. Its magnificent Pelister mountain (2,601 m) covers an area of 1,798 km2 (694 sq mi). It connects the Adriatic Sea to the south with the Aegean Sea and Central Europe. The analysis of the meteorological data is also due to the definition of a series of data and their verification of how well they correspond to the provisions of Appendix 14 to the Convention on International Civil Aviation, the first part of the establishment of aerodromes and operations. Below, we will analyse the three most important meteorological features needed to determine the category increase of the aerodrome. [11]

3.1.1 Regime of Winds

According to the meteorological sources, the frequency and speed of the winds in the valley of Dragorsk á Kotlina blow in all directions, but mainly from the north, south, and south-east. However, the wind roses are such that the north and south winds dominate. Other winds occur less frequently and with lower intensity. During the summer the winds are generally weaker in intensity, while during the winter, late autumn, and early spring there is some intense intensity, the occurrence of the storm is very rare. The temperatures of the northerly winds are usually around 0 ℃ and the temperature during winter can drop to -10 ℃, the average wind speed is around 2.2m/s and the maximum speed is around 15.5m/s. Other winds occur rarely with a frequency of 130 ‰ More detail can be seen from the wind rose in Figure 8.

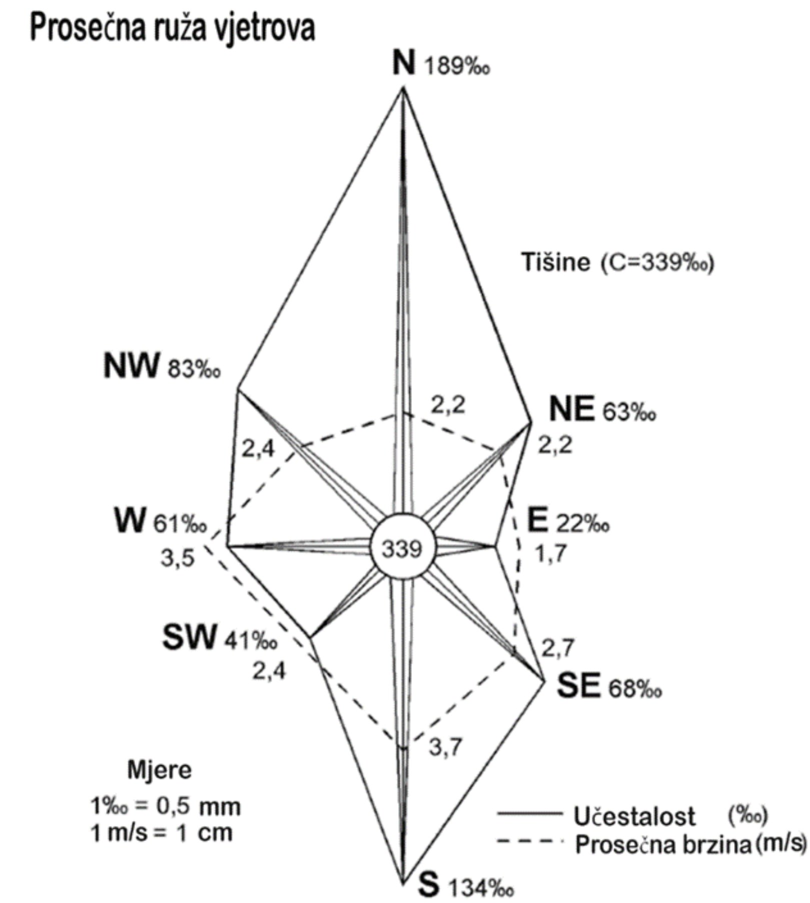

Figure 8. A Detailed View of the Wind Rose

Source: [17].

In a conclusion, the strongest winds are from the north and with less intensity from the west side. [17]

3.1.2 Temperature Characteristics

The average annual low temperature is about -4.5 °C, and January is the coldest month of the year with an average temperature, and July is the hottest month with an average temperature of 28.6 °C, SW wind at 14 km / h, average humidity form 56-83 during the summer and winter. According to the observed characteristics, the reference temperature should be 28 °C. When determining meteorological conditions that are typical for temperate continental areas, winter and summer are covered with rain, and winds are often, fog too. [17]

Climate data for Bitola (1961-1990, extremes 1948-1993) [hide]													
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Record high °C (°F)	17.2 (63.0)	21.2 (70.2)	31.2 (88.2)	30.0 (86.0)	32.5 (90.5)	38.0 (100.4)	40.6 (105.1)	39.0 (102.2)	36.0 (96.8)	30.8 (87.4)	26.1 (79.0)	19.4 (66.9)	40.6 (105.1)
Average high °C (°F)	3.3 (37.9)	6.5 (43.7)	11.3 (52.3)	16.5 (61.7)	21.7 (71.1)	25.9 (78.6)	28.6 (83.5)	28.5 (83.3)	24.8 (76.6)	18.3 (64.9)	11.5 (52.7)	5.3 (41.5)	16.9 (62.4)
Daily mean °C (°F)	−0.8 (30.6)	1.9 (35.4)	6.3 (43.3)	11.1 (52.0)	15.7 (60.3)	19.5 (67.1)	21.7 (71.1)	21.1 (70.0)	17.2 (63.0)	11.4 (52.5)	6.2 (43.2)	1.0 (33.8)	11.0 (51.8)
Average low °C (°F)	−4.5 (23.9)	−2.3 (27.9)	1.3 (34.3)	5.0 (41.0)	8.7 (47.7)	11.7 (53.1)	13.1 (55.6)	12.8 (55.0)	9.9 (49.8)	5.6 (42.1)	1.7 (35.1)	−2.6 (27.3)	5.0 (41.0)
Record low °C (°F)	−29.4 (−20.9)	−26.1 (−15.0)	−18.7 (−1.7)	−3.5 (25.7)	−1.6 (29.1)	3.3 (37.9)	5.4 (41.7)	2.6 (36.7)	−1.0 (30.2)	−6.1 (21.0)	−15.3 (4.5)	−26.7 (−16.1)	−29.4 (−20.9)
Average precipitation mm (inches)	50.1 (1.97)	49.9 (1.96)	51.2 (2.02)	43.8 (1.72)	61.0 (2.40)	40.4 (1.59)	40.2 (1.58)	31.2 (1.23)	35.0 (1.38)	55.9 (2.20)	73.2 (2.88)	68.0 (2.68)	599.9 (23.62)
Average precipitation days (≥ 1.0 mm)	8	8	8	7	8	6	5	4	5	6	8	9	82
Average relative humidity (%)	83	78	71	65	65	60	56	57	64	72	79	83	69
Mean monthly sunshine hours	81.1	106.9	155.2	199.2	250.5	291.3	334.0	312.2	241.0	176.5	111.1	75.9	2,334.9
Source 1: NOAA[6]													
Source 2: Deutscher Wetterdienst (extremes)[7]													

Figure 9. Temperature Characteristics for Bitola, Source Reference

Source: [17]

According to the requirements and the reference code, the minimum use of the aerodrome corresponds to the Visual Flight Minimum (VFR), and weather information can be obtained from the local meteorological service in Bitola.

The average number of days with fog occurrences in autumn and winter, and mostly in December.

3.1.3 Precipitation

The parameters conditioned by a certain climate are air pressure, air temperature, air humidity, state of the sky (cloudiness), horizontal visibility, the type and amount of precipitation, and winds.

In the development of meteorological conditions, the reference temperature of the aerodrome, the monthly average of the highest daily temperatures in the hottest month of the year, which has been blown over the last ten years, has been determined for the first time. The snowy period of the year lasts for 4.6 months, from November 6 to March 24, with a sliding 31-day snowfall of at least 1.0 inches, the most snow is December, with an average snowfall of 3.5 inches. The snowless period of the year lasts for 7.4 months, from March 24 to November 6, and no snowfalls of 0.0 inches during the summer. [17]

3.2 Topographic Conditions for the Possible Aerodrome Extension of the Aerodrome in Bitola

The topographic conditions characterize the relief morphology of the natural vegetation cover, the height of the obstacles, and the geological composition of the soil and the subsoil with an elaborate seismic map. The regional topographic parameter includes all those features that can affect the structure of the aerodrome. These include geotechnical and geological investigations (the composition of the soil and the substrate).

The actual condition of the soil at the selected aerodrome is known after specific surveys are carried out, and in the procedure for comparison and evaluation of different aerodromes, the rating will be based on field research, and aerodrome theory, and expert assessment. The topographical conditions are divided into three categories in which the leveling of the possible location is understood. The city of Bitola is located at an elevation of 650 m (2,130 ft). When analysing the topographical characteristics of the localities, the following conditions should be met:

- USS characteristic points (threshold, end, center),
- aerodrome reference point,
- height configuration,
- the height configuration of the terrain of the USS area,
- other facilities, as well as facilities and devices used for air traffic at the aerodrome (stops, wind, etc.),
- roads, canals, and housing around the aerodrome,
- the roads in the area and in the immediate vicinity of the aerodrome,
- aerodrome and aircraft parking area,
- other topographical and other details that are important for showing the terrain condition, airline map, and obtaining the necessary values for preparation. [17]

3.2.1 Tectonic and Seismic Characteristics

According to the morph tectonic characteristics of the space, the surroundings of Bitola is a terrain predisposed to seismic activity, today with a lower intensity. From this, it surely follows that the area is seismically active and that there is a danger of the impact of the earthquake. When choosing the profitability of the aerodrome category, the dynamics of the creation of the relief are taken into account, which leads to the appearance of a weaker characteristic intensity, according to the continuous scientific research of the Bitola epicentral area. From a practical point of view, the topographic relief of the region and the free land is dominated by entropic processes and therefore this aerodrome satisfies extended construction of the runway. [17]

3.2.2 Geomorphology and Orographic Features

The area covering the municipality and the city of Bitola has a simple geomorphological appearance. The central part of the area of Bitola is filled with fluvioglacial and alluvial deposits, in which two alluvial terraces are preserved, the upper part of which is covered with conical coatings. The outer parts of the city are represented by the surrounding hills which are intersected by deeply preserved wear terraces. The current geomorphological appearance can be viewed from several angles. Apart from the fact that in the eastern part and a single unit has been destroyed by rows and erosive processes that offer insufficient bearing capacity. With the generally observed geological and geomorphological characteristics of the urban environment and beyond, the relief is recognizable and simple. The area consists of a vast hilly area, plains, and fields that rise to about 600m above sea level, which are developed with alluvial-diluvial cement-brown soil and mountainous areas 600-2000 m above sea level dominated by acid-brown soil. In geological terms, the tracks are built primarily from gabbro and diabase, and partly from granite and carbonate. [17]

3.2.3 Hydrographic and Hydrogeological Characteristics

The hydrographic conditions in Bitola and its immediate surroundings are conditioned and determined by geological, geomorphological, and climatological characteristics. From the hydrographic features, the most important hydrographic object is the Dragor River with an average discharge of 100 - 225 m^3/s from the river that passes through the city of Bitola, and its impact on the land is the possibility of spillage. The R 1311 roadway and the railway line are located on the west side offering possibilities for easier multimodal traffic. [17]

3.3 Determination of Aerodrome Areas and Physical Characteristics

The planning of a sports/school aerodrome category development involved the construction of maneuvering surfaces for the purpose of conducting aircraft operations.

Figure 9. Micro Aspect Interpretation of Aerodrome Surfaces

Source: author’s picture.

The subject of analysis is to accurately conceptualize the Movement Area, which is divided into (parking lot) and Maneuvering area (maneuvering area), a further division into Runway (takeoff and landing track) and Taxiway (taxiway). The focus is on the USS which is also the most important area of the aerodrome as it is a small aerodrome that will primarily be used for aircraft take-off and landing and secondarily for aircraft maintenance and storage. [12]

3.3.1 USS Taxiways

The prepared area for the safe take-off and landing of the aircraft, which is rectangular and with connection areas, occupies a large part of the aerodrome complex. To meet the requirements of Annex 14 to the Convention on International Civil Aviation, Part One, Aerodrome Design and Operation defines the coordinates of the planned threshold USS, as well as the coordinates of the center of the hub and the reference point. Consequently, the coordinates for the aerodrome 2C9F+HQX, Logovardi are: 41°01′24.76″N 021°25′32.10″E. [12]

3.3.2 Number and Orientation of USS

Due to the circumstances (spatial, meteorological, and economic), the aerodrome will contain only one runway that could be used from both ends, with 95% wind direction and allowable side components of 10 kts and the associated taxiway. The course orientation (HDG) should be in the direction of the most common wind with the determination of crosswind components to determine the degree of utilization, of course taking into account the limitations for individual types of aircraft and crosswinds. The slope maneuvering surface (PSS) extends along the northwest-southeast direction, i.e. in the direction of 350 °-170 °, i.e., 35-17. [12]

3.3.3 Runway Length and Width of the Necessary Category Development

The USS length is based on the reach and mountain characteristics of the intended types of aircraft for this aerodrome while taking into account the following topographical characteristics of the takeoff and landing surface, slopes, altitude, temperature, and humidity, as well as geodetic characteristics. In order to achieve the required length and width and to comply with ICAO regulations, the following calculation will apply:

$KNV = 7 X HNV : 300 = 7 X 594 : 300 = 13,86$

$TSA = HNV X 0,0065\ ℃ = 594 X 0,0065\ ℃ = 3,861$

$KT = TREF – TSA = 15° – 3,861° = 11,139$

$KN = N X 10\% = 2\% X 10\% = 20$

$D_o = 1200M$

$D = D_o (1 + KNV : 100) (1 + KT : 100) (1 + KN : 100)$

$D = D_o (1 + 13,86 : 100) (1 + 11,139: 100) (1 + 20 : 100)$

$D = 1200 X (1 + 0,1386) (1 + 0,11139) (1 + 0.2)$

$D = 1200 X 1, 1386 X 1, 11139 X 1,2 = 1\ 822,21 \approx 1\ 800M$, *SOURCE: AUTHOR' CALCULATION*

The obtained results correspond to aerodrome category 3 which satisfies the present needs and requirements.

The reference length is 1200 m and the width is 18 m, corresponding to the reference code C3, with a mandatory correction of the USS length due to temperature, altitude, and land slope. For another phase of construction, there is no need regarding the present conditions. According to the determined dimensions of length and width, USS is intended for use in visual metrological conditions and in further use with control tower or instrument control conditions. The need is for a constructive runway and the current use requires equipment for instrument operations.

Aerodrome specifications such as longitudinal and transverse sections, of USS, dimensions for the basic flight path with transverse and transverse sections, facilities in the aerodrome area, taxiways, and parking areas should be governed by the dimensions according to Annex 14 ICAO.

A system of a number of imaginary surfaces that rise and rise from the baseline USS defines the limits of aerodrome barriers.

The purpose of establishing surface barrier restrictions is to ensure the highest level of air traffic safety, preventing aerodrome closures due to the presence of dangerous obstacles to air traffic safety. By analyzing the barriers on the surface of the required category according to ICAO Annex 14, we determine the possibility of building an instrument aerodrome in accordance with the standards. The obstacle limitation area is determined by the highest height of natural and man-made obstacles in the aerodrome area, according to ICAO for non-instrument tracks of code number 3, the following boundary obstacles are required: approach, departure area, transitional surface, internal horizontal surface, conical surface. [12]

3.4 USS Capacity and Area

The load capacity of the non-structural USS must be sufficient to maintain the continuous traffic of the aircraft, along the length of the landing and increase in length and the entire length of the USS. Soil density and drought were previously determined by geological surveys. Normal landings and takeoffs should not have any effect on the landing surface, taking into account the increased pressure caused by an exceptional landing or poor landing.

The USS surface should be properly designed to avoid adverse effects on aircraft performance during aircraft maneuvers. Excessive surface irregularities that would cause vibration, increased coefficient of friction, or other difficulties in the operation of the aircraft should be avoided. Given the requirements for a short landing of the composition and surface USS requires extreme care, a rough composition should be used for an increased coefficient of friction.

The aquaplaning analysis should satisfy the construction of the grooves in the further construction phase. According to the grass regulations, the aerodrome in Bitola must meet the conditions and criteria prescribed by ICAO. Reversal of movement surfaces on the unstructured pavement is acceptable for up to 3cm on stabilized surfaces and up to 5cm on grass surfaces. The permitted height of the grass is up to 15cm on the moving surfaces and up to 30cm on the main track. According to the surrounding cities and villages, regarding the ICAO requirements, there is no danger of ecological damage. [11]

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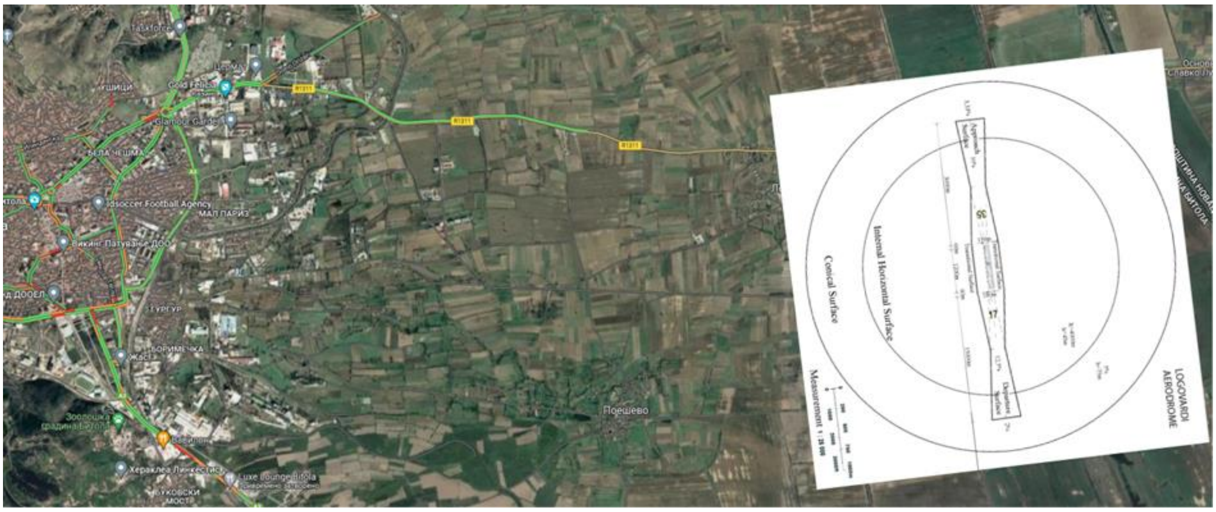

Figure 10. Micro Aspect Interpretation of Aerodrome Surfaces

Source: author’s picture.

4. Physical Characteristics and Planned Possible Development

Due to the complex socio-economic factors, it is necessary to determine the construction phases in the development of the aerodrome site. In addition to the physical geographical characteristics of the planned development and the influence of other elements, here comes the expressive degree of development and urbanization of the city. What degree of development the aerodrome can develop and in how many years the need for an instrument aerodrome will increase will take into account the established and planned routes and economic profitability.

There is a lack of small and medium-sized aerodromes according to the size and importance of the city Bitola, which will be open throughout the year, due to favorable weather conditions, in the first phase, a constructive runway of the existing aerodrome is foreseen. Grass USS is planned in order to confirm all the conditions that have already been worked out due to the fact that the aerodrome in Bitola will operate during the whole year, which means that the needs of most sports and school aviation commercial services can be met and provided in the second year after construction.

The potential site, in addition to meeting all the conditions for the construction of the reference code of the C3 aerodrome, also meets the conditions that satisfy the need for further development including of modern control tower and instrument flights.

After the construction, after a certain period of use, confirming the determined parameters and in practice, despite the fact that the aerodrome category is the most favorable, it provides the opportunity for further development, such as the instrument flights of the maneuvering surfaces of the asphalted runway, the associated facilities, and surfaces.

In order to achieve aerodrome conditions throughout the year and in poorer visual conditions, the recommendation is to build a USS with an asphalted runway, of course, the maneuvering and moving areas will be joined. Due to the limitation of summer activities only in the visible part of the day, it is recommended to meet the conditions for night flying. It certainly implies equipment, and night marking should be increased to maintain maneuverability and other areas at a higher level.

These financial investments will contribute to the further development of air traffic in Macedonia and the development of the region itself and Bitola as a center. [2]

4.1 Optimization for the Planned Aerodrome near the City of Bitola

In the network graph, the Nash equilibrium determines the expected traffic flow in the network, traveling from A to D.

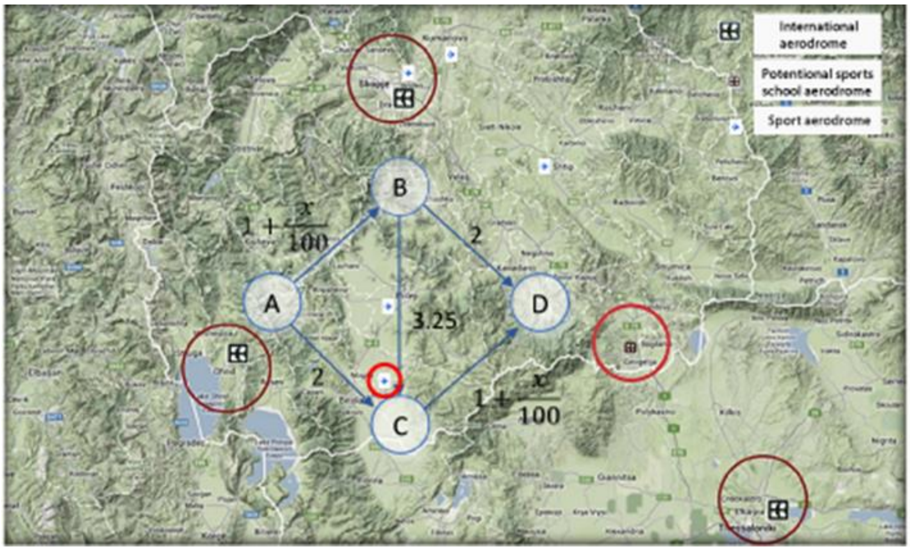

Figure 11. Locations of the Existing Aerodromes within the Airspace, Author's Picture

The situation is modeled as a "game" where each player has 3 strategies, where each strategy is a path from A to D (one of ABD, ABCD, or ACD), where the aircraft travels through ABD exceeds the travel time of (1 + x / 100) +2, and x is the number of aircraft per edge AB with the goal to minimize the travel time. Equilibrium occurs when the time on all tracks is the same, and where no pilot has an incentive to change lanes, as this increases travel time. If out of 100 aircraft travel from A to D, each passenger now has a total travel time of 3.25 which leads to the conclusion that this distribution is optimal. When 25 aircraft choose the ABD route, the flight length will be 1 + 0.25 + 2 = 3.25, 50 aircraft on the ABCD route will fly 1 + 0.5 + 0.25 + 1 + 0.5 = 3.25 and on the ACD route 25 aircraft will fly 2 + 1 + 0.25 = 3.25 then it would be an equilibrium by another possible way reducing the efficiency of a system known as the Braess paradox." [1]

4.2 Theory of Equilibrium for Sustainable Aerodrome Category Development Profitability Ratio

The profitability ratio is a way of analyzing efficiency and performance that compares the Income Statement, Balance Sheet, and Cash Flow Statements to generate profit and cash flow. The following profitability ratios have been used for profitability analysis. [16]

1. RETURN OF FUNDS TO COMMON SHAREHOLDERS

A profitability ratio that measures the return on the money that shareholders have invested shows how efficiently the invested funds have been used. A higher percentage is better

2. RETURN ON INVESTED CAPITAL

A profitability ratio that measures the return on money of the total investment capital that shows how efficiently the available capital base is used to generate earnings. The higher percentage shows the profitability of the investment capital.

3. REFUND

A profitability ratio that measures the return on money from an investment in assets shows how efficiently it uses its total assets to generate earnings and profits. The higher the percentage showing that the funds are performing, the better.

4. OPERATING PROFIT MARGIN

A profitability ratio that measures the return on money from its production costs shows how effectively it controls its variable costs to generate operating profit (Peavler), and depending on how high the percentage is, it shows the efficiency of the performance

5. NET PROFIT MARGIN

A profitability ratio that measures the return on money from production costs shows how effectively a company controls its overhead costs to generate net profit with a higher percentage showing profitability of revenues.

Graph 1: Profitability rates, Source: [16].

According to profitability ratios, the aerodrome is in a profitable position with efficient operational performance.

The following calculations are made according to the overall air traffic data in Macedonia.

Table 1. Profitability Rates at the Aerodrome Near the City of Bitola, author's Table

	1990- 2000	1991-2000	1992-2000	1993-2000	1994-2000
Return of Common Fund to Shareholders	(3.37%)	(7.755%)	(0.605%)	7.04%	14.605%
Return on Capital Employed	0.895%	(2.02%)	(0.605%)	0.035%	0.975%

Return of Funds	(0,41%)	(1.14%)	(0.8%)	0.855%	1.95%.
Net Operating Profit	7.245%	12.195%	14.81%	16.405%	19.365%
Network Net Profit	7%	(6.785%)	(4.265%)	2.52%	6.11%

Analyzing the profitability ratios, the aerodrome is in a profitable position with efficient operational performance.

Table 2. Aerodrome Logovardi Efficiency Ratios for a Ten-Year Period, Author's Table

	2016	2017	2018	2019	2020
Income from sale of capital per employee	0.065	0.065	0.071	0.07	0.08
Sales revenue per employee	93877.05	121199.4	133562	135529.05	158064.15
Turnover of long-term assets	0.06	0.065	0.07	0.071	0.075
Operating costs per passenger	825	8.77	8.055	8.205	10.025
Aeronautical revenue per passenger	5.605	6.035	6.565	7.555	9.535
EBITDA* per passenger	4.49	5.15	5.935	6.72	8.485

Analyzing the profitability ratios, the aerodrome is in a profitable position with efficient operational performance.

Table 3. Aerodrome Logovardi Efficiency Ratios for a Ten-Year Period, Author's Table

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Operating costs per passenger	825	8.77	8.055	8.205	10.025
Aeronautical revenue per passenger	5.605	6.035	6.565	7.555	9.535

EBITDA* per passenger	4.49	5.15	5.935	6.72	8.485

Table 4. Ten-Year Aaerodrome Logovardi Liquidity Rate, Author's Table

	2016	2017	2018	2019	2020
Current ratio	0,22	0,43	0,18	0,155	0,195
Acid-Test ratio / short-term liabilities	0,22	0,425	0,175	0,15	0,19
Cash ratio	0,095	0,215	0,035	0,045	0,045

Table 5. Rates of Change at Logovardi Aerodrome for Ten Years, Author's Table

	2016	2017	2018	2019	2020
Transmission ratio	43.275%	42.275%	42.705%	41.795%	42.7%
Interest coverage ratio	0.99	-1.77	-0.5	0.23	0.605
Debt ratio	43.87%	42.64%	43.46%	43.93%	43.315%

Table 6. Horizontal Analysis of the Income Statement for Logovardi Aerodrome, Author's Table

	% промени 2000-2016	% промени 2000-2017	% промени 2000-2018	% промени 2000-2019
Income	1.085%	3.335%	2.185%	8.595%
Operating profit / (loss)	35.975%	58.995%	68.14%	106.555%
Funding	4455.555%	4683.335%	3.566.665%	3855.555%
Profit / (Loss) pre taxation	(165.14%)	(82.49%)	(31.23%)	1.155%
Consolidated profit / (loss) for the 1st year	-	-	-	-

Table 7. Change in Consolidated Profit / (Loss) for the First Years of Using This Aerodrome, Author's Table

	промени 2000-2016	промени 2000-2017	промени 2000-2018	промени 2000-2019
Consolidated profit / (loss) for the 1st year	68	32.5	120	217.5

Table 8. Horizontal Analysis of the Balance Sheet of Logovardi Aerodrome, Author's Table

	% промена од 2000-2016	% промена од 2000-2017	% промена од 2000-2018	% промена од 2000-2019
Total long-term assets	(1.395%)	(3.445%)	(5.655%)	(3.08%)
Total Current Assets	(3.84%)	(11.645%)	(2215%)	(14.465%)
Total Long-Term Liabilities	(0.265%)	(2.725%)	(2.395%)	(3.78%)
Total Current Liabilities	(26.265%)	(2.61%)	(10.03%)	(9.315%)
Total Share Capital	8.465%	1.95%	(2.555%)	0.84%

Table 9. Vertical Analysis: Balance Sheet for the Logovardi Aerodrome, Author's Table

	2016	2017	2018	2019	2020
Total long-term assets	47.62%	47.97%	45.94%	44.485%	48.37%
Total current assets	2.12%	2.03%	168.5	1.245%	168%
Total funds	100%	100%	100%	100%	100%
Total long-term liabilities	39.08%	40.285%	38.285%	3919.5%	39.105%
Total current liabilities	4.78%	2.35%	470%	4.025%	4.21%
Total share capital	6.075%	7.36%	6.54%	6.07%	668.5%

During the first years, the financial operation is at a low level, due to the economic decline, operational problems and service disruptions. The period from the following years is of operational performance that contributes to the strong financial performance. From the analysis of profitability ratios, efficiency ratios, liquidity ratios, debt ratios, horizontal analysis and vertical analysis of Logovardi aerodrome within ten years, the following changes have been considered:

- In profitability ratios, the increase in return on shareholders' funds and operating profit contributes to profitability.
- In terms of efficiency, the increase in sales revenue per employee, aeronautical revenue per passenger and EBITDA per passenger contribute to efficiency.
- Liquidity has a significant decrease in the cash ratio, which leads to a problem.
- In the gear ratios, there is a significant decrease in the interest coverage ratio which indicates a high readiness.
- In the horizontal analysis in terms of profitability, there is a change in the consolidated profit for the year and a reduction in total current liabilities.

- In the vertical analysis, there is a marginal increase in the total shareholders' equity, which highlights the improved earnings and profits that put the planned development of the aerodrome near the city of Bitola in a profitable position with high efficiency. Although the liquidity ratios reflect poor financial health, the aerodrome will manage to meet its obligations in step with the growing cash reserves in aviation thanks to the upgrading and development of the aerodrome category and instrumentality.

4.3 Theory of Equilibrium for Sustainable Aerodrome Category Development

In project management, game theory is used to model the decision-making process of players which is critical for the success of projects and making scenarios well-suited to be modeled by game theory. The investor usually has several options and must decide how much is necessary to push the project case without jeopardizing the whole project. The main decision is the best timing and strategy for category development so that it can gain maximum traction in the face of benchmarking during the process of implementation. The required decisions depend on the decisions of supply and demand, ideally modeled by the game theory.

To allocate specific aerodrome maximizing level of category knowledge and profit the category development index may be expressed by the equation:

CDI=(Percentage of the total product category: Percentage of a total estimation of a project)*100

Figure 12. Steps for Aerodrome Development

Source: [8].

When choosing a category of the aerodrome in Bitola, the design zone satisfies the choice of aerodrome C3 which due to its geomorphological composition is ideal for such facilities. The overall current political and social situation, as well as the development of air traffic, justify this choice of aerodromes for sports schools. The facility satisfies the need to serve in the coming years with modifications. Having in mind the correctly estimated topographic characteristics, the very favorable meteorological position, and the proximity to the surrounding aerodromes, the choice is feasible, expected, and tolerant in terms of the following structural, institutional and financial consequences in the region of Bitola. The present situation satisfies sustainability without the possibility of unexpected or uncontrolled defects.

The game theory as a study of the mathematical model intended for strategic selection among rational decision-makers is used for aerodromes decision representation where the level of development according to sustainable development is been made for final decision making. The choice of three aerodromes A1, A2, and A3 will be considered through the example of a simultaneous three-aerodromes game. The A1 results presented in the first entry of upper-left cells in the two matrices is 0.1, the highest first entry of upper-right cells is 1.1, and we get 1 respectively 0.1 for the lower-left respectively lower-right cells. The highest second entry in the first column is 0, in the second column is 1.1, in the third column 1, and in the fourth column 0.1. For L3, the highest third entry in the first row of the first matrix is 2.1 and in the second row of the first matrix is 1. In the second matrix third entry in the first row is 1.1, and in the second row 2.

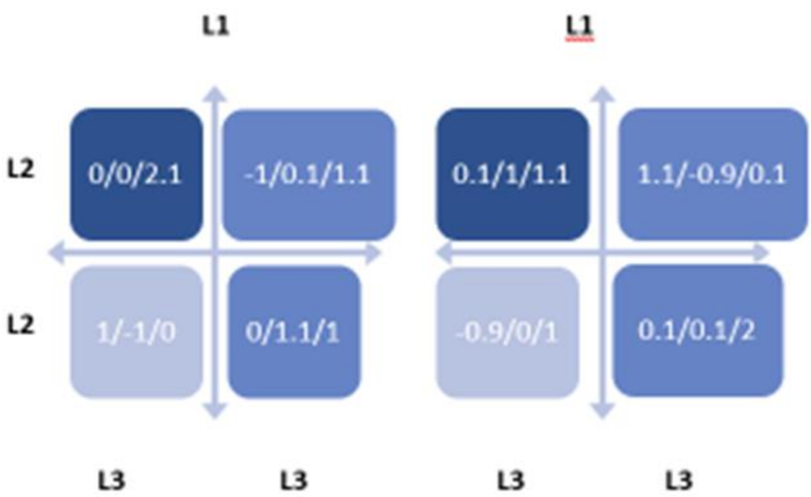

Figure 13. Game Theory Matrices for Location Selection

Source: [1]

Figure 14. A Venn Diagram for Aerodrome Category Development

Source: author's "Codex on the sustainable aerodrome development".

Any aerodrome infrastructure category can be developed or built according to this author's representation. According to this Venn diagram the necessary level category is given for the Logovardi Aerodrome in the vicinity of Bitola. All aerodrome construction development should go on the same path for improvement. Any other way for elaboration may affect the loss of time and financial and what is worse everything, no adequate result. Good luck to all future engineers who are going to work with aerodrome infrastructure as the key factor for the aviation world's existence and development.

5. Conclusion

The development of air traffic and the lack of aerodrome infrastructure in Macedonia leads to the question of planning an aerodrome category development for general aviation in the vicinity of Bitola city. The selected aerodrome is mainly based on the conditions: topography, meteorology, and navigation as well as geology, traffic, urban, and ecology are also taken into consideration. The most favorable category aerodrome for the needs in Bitola city satisfies construction off the paved runway and further expansion with control tower and instrument equipment.

Conflicts of Interest

The authors declare no conflict of interest.

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