Lazarovska, Ana; Dancevska, Verica; Manevska, Violeta

Article

Improving Gevgelija Aerodrome of the most favorable location for runway with risk point of view

Reference: Lazarovska, Ana/Dancevska, Verica et. al. (2022). Improving Gevgelija Aerodrome of the most favorable location for runway with risk point of view. In: International journal of business & management 10 (1), S. 78 - 92.
https://www.iises.net/international-journal-of-business-management/publication-detail-116975?download=4.
doi:10.20472/BM.2022.10.1.004.

DOI: 10.20472/BM.2022.10.1.004

IMPROVING GEVGELIJA AERODROME OF THE MOST FAVORABLE LOCATION FOR RUNWAY WITH RISK POINT OF VIEW

ANA LAZAROVSKA, VERICA DANCEVSKA, VIOLETA MANEVSKA

Abstract:

The increase in air traffic has raised the necessity for several public new aerodrome infrastructure in the Republic of North Macedonia. One of the critical risk concerns is runway safety and the increasing demand for aerodromes without accidents which is often associated with environmental and pollution consequences. Risk assessment considers probability, location, and consequences of risk for accidents has been made. The proposed models empower engineers and aviation staff for an aerodrome in Gevgelija for usage with risk and environmental points of view. The main focus is on the decision-making process, context, and environmental impact on the ICAO regulations where the framework for runway development was confirmed. The elaborated model can be used for planning aerodromes and construction of aerodrome infrastructure. Choosing the most favorable location between the three locations, the choice of the most favorable was confirmed by the risk assessment kept in mind.

Keywords:

Aerodrome Safety, Runway, Risk, Aerodrome Design, Optimization, SAW

Authors:

ANA LAZAROVSKA, University St Kliment Ohridski Bitola, Faculty of Technical Sciences, Macedonia, Email: alazarovska@gmail.com
VERICA DANCEVSKA, University St Kliment Ohridski Bitola, Faculty of Technical Sciences, Macedonia, Email: verica.dancevska@tfb.uklo.edu.mk
VIOLETA MANEVSKA, University St Kliment Ohridski Bitola, Information and Communication Technologies, Macedonia, Email: violeta.manevska@uklo.edu.mk

Citation:

ANA LAZAROVSKA, VERICA DANCEVSKA, VIOLETA MANEVSKA (2022). Improving Gevgelija Aerodrome of the Most Favorable Location for Runway with Risk Point of View. International Journal of Business and Management, Vol. X(1), pp. 78-92., 10.20472/BM.2022.10.1.004

1. Introduction

Aerodrome infrastructure and aerodrome service are essential for economic and social development, despite benefits, accidents are often associated with severe environmental and pollution consequences that are of interest to engineers and are solved by the process of optimization. Increasing demand for the aerodrome developed while keeping in mind the environment and a sustainable development is the main goal for investigating the risk on runways and overall improvement. Rapid country development is linked to the efficiency of its transportation systems allocating more than 12.27 billion of the Gross Domestic Product (GDP) including different jobs in the aviation sector in Macedonia. Worldwide, aviation represents one of the key industries in terms of security, speed, and industry tourism. Runway as a key part of an aerodrome results can impact public health, overall functionality, and any service disruption in the case when there is an increased risk of accidents. Decreasing the possibility for an incident or accident around the runway is improving transportation safety. Obstacle identification, location constraints, and the question of optimal geographical location are among the essential requirements of each country expecting perfectly safe conditions during aerodrome operations. Meteorological conditions may affect risk increasing that can be divided into two main categories:
Runway Incursion (RI) and Runway Excursion (RE) with place for occurrence on the runway and other maneuvering areas.

In this paper, the risk will be elaborated during landing and take-off operations on the planned Gevgelija aerodrome location. Excluding the affordable geographical placement and including the pandemic conditions which affect the reduced air traffic, Macedonian aviation suffers from poor service quality, long service life, lack of advanced navigation system, lack of proper planning, etc. which is in line with the conditions in less economically developed countries. Due to the favourable geographical placement that this country has, aviation experts more than anything, should make their highest priority to develop risk assessment before building new aerodrome infrastructure that will be in line to the required aerodrome category. This can be done by writing a risk assessment to model the probability, location, and consequences of risky actions. The building and validation of the model was supported by the Library of the Economic Faculty in Zagreb, using data from the European Union Publications Office that contained barometer measurements performed by the European Union. For a practical examination of the models, the planned aerodrome in the vicinity of the city of Gevgelija is performed accurately by analyzing the planned runway and corresponding surfaces surrounding it. The special accent of this study is on the environmental after-effects of safety conditions. The content of this paper can be summarised in 5 chapter: after the introduction part follows the second part presenting the background. The third part presents the models and methods, the other part of the discussion of the result, and the final conclusion are in the fifth part.

2. Literature for risk point of view review

2.1. Risk Review

Risk represents assessment, where the predicted probability and severity, consequence(s) of a hazard including the worst possible situation are taken into mind. In the scope of this study a risk can be considered the wind which reaches the maximum allowed speed across the runway creating an uncontrollable aircraft during landing and take-off, and this as well represents one of the most protentional risks. The main goal is to present a balanced allocation of resources to address all risks with key components of the Safety Management Systems (SMS).

The Figure 1 below shows the Risk assessment cycle published by ICAO in which one of the key elements is gathering Data useful for Airman.

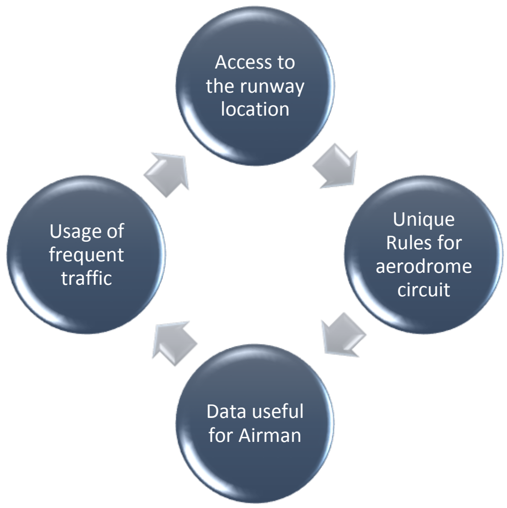

Figure 1. Risk of the runway
Source: the author and ICAO module no.5

2.1.1. Risk Elaboration

Taking the cost-benefit analysis into consideration the direct cost may be reduced by insurance coverage not addressing the safety of the protentional situation. The 5 fundamentals of Risk assessment according to ICAO are shown on Figure 2, and are described furhter in this chapter. The indirect costs are the uninsured costs which lead to business and reputation loss, staff productivity decreased, and Insurance rejection. The second fundamental risk represents the probability that any situation may affect the situation with risk. The third fundamental is risk severity are consequences that may result from any event on the environment, population, and equipment or condition with the worst scenario in the mind. Taking in mind that the acceptable level of risk as it currently stands is the first phase. The second phase is the tolerable risk based on mitigation where the cost-benefit analysis is required. Intolerable risk is the level of risk unacceptable at any risk. The second fundamental explains the risk probability where it is valued from 1 to 5 according to the probability of occurrence. The third fundamental explains the risk from A to E according to the level of risk severity. Forth fundamental explains the risk probability from 1 to 5 and risk severity from A to E represented in a matrix. The fifth fundamental is risk control or mitigation to measure the potential hazard situation for risk reduction. In this stage, any action has to be canceled because demand conditions are higher than the revenue. This situation is very important because in a case of lack of signalization and unfordable meteorological conditions and insufficient geographical capacity for aircraft activity. All aerodromes in the vicinity of the city Gevgelija can be used only by aircraft that are compliant to use aerodromes with category A1. Risk mitigation can be done with technology, training, and regulations defenses.

Safety risk management at a glance includes risk procedures at every level.

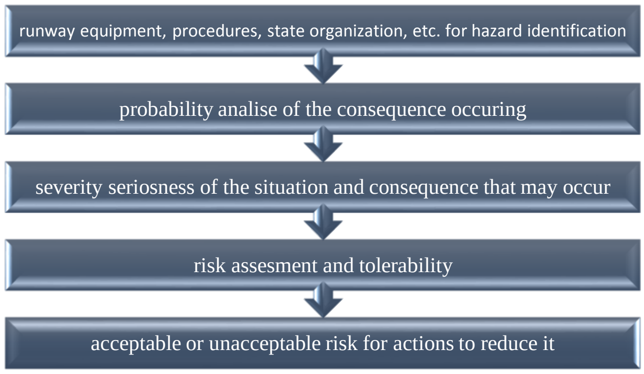

Figure 2. Risk assessment
Source: the author and ICAO module no.5

Aviation is not unpredictable to the field of safety with risk management to a level "as low as reasonably practicable" (ALARP). Risk mitigation must be balanced against time, cost, and difficulty for risk reduction. Effective risk management (as shown on Figure 3) seeks to maximize the benefits of accepting a risk while minimizing the occurrence of a risk situation.

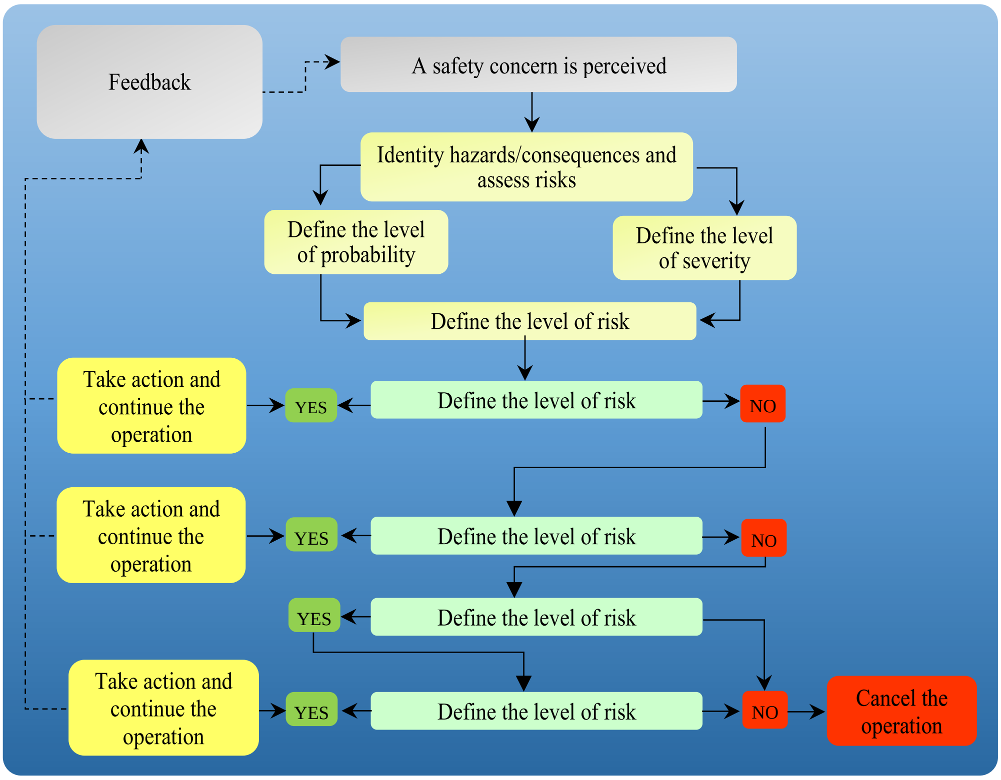

Figure 3. Diagram of Risk calculation
Source: the authors, ICAO module no.5

The diagram will be used further in the paper for risk evaluation on this new aerodrome infrastructure. This diagram is based on the ICAO Safety Management System in module number 5.

2.1.2. Risk Classification

The Gevgelija runway risk assessment evaluation is could face several challenge of conditions including air traffic, aircraft type, and quality, build quality of infrastructures, budget, maintenance quality, weather conditions, etc., where engineers need to model respectively. Due to the lack of practical experience for the planned aerodrome in Gevgelija, the author tried to make a theoretical evaluation for the most affordable chosen location with RSA risk model concerning only this aerodrome and a comparison to the Iran aerodrome. The model considers the sustainable development, risk analysis and determination of optimum location for constructing or developing runways into further categories. As referred into the assessment in: „Improving Aviation Safety through Modeling Accident Risk Assessment of Runway„ of most important risk assessment is presented in the US, ACRP Report 50. After reviewing the available data, the authors decided to base their location selection on the SAW process of the optimization method.

2.1.3. Error management (Reason theory) - Accident model

As a result of the risk that as a consequence for various reasons appears continuously from latent and minority defects is illustratively shown in Figure 4**Chyba! Nenalezen zdroj odkazů.**.

Design management at work could create a chain of events that leads to an accident. The operator's action can present openings as additional surfaces placed to break the risk chain. The defense systems have the same lack of performance, which reopened on the surfaces of the illustrative shown in the same figure.

The representation published in James Reason's book "Managing the Risks of Organizational Disasters" as the "Reason Model" emphasizes the claim that the active actions of risk results in latent states in the system. At first it reveals active acts and omissions in defense, latent states, and management decisions where is presented "trajectory of the accident" with an explanation of the "1: 600 rule".

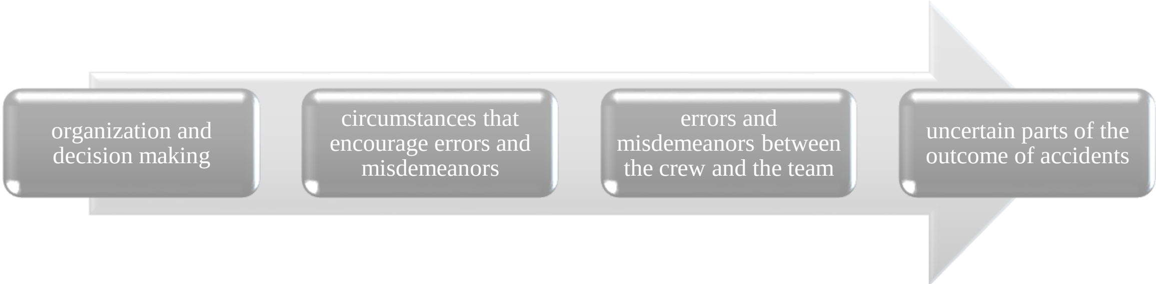

Figure 4. Investigation process according to the defensive measures set by the system
Source: references 9 ESSAR

ESARR 4 EUROCONTROL concerns explain the use of risk assessment and mitigation with hazard identification, in Air Traffic Management (ATM).

3. Engineering

The risk assessment is a defined problem for the design of the aerodrome in the vicinity of the city Gevgelija created by science with application to the real world of engineering. The benefit of the prevention is health protection and environmental benefits in line with the goal of sustainable development. In order for better design, evaluation, development, testing, modification, inspection, and maintaining the model of optimization will be elaborated.

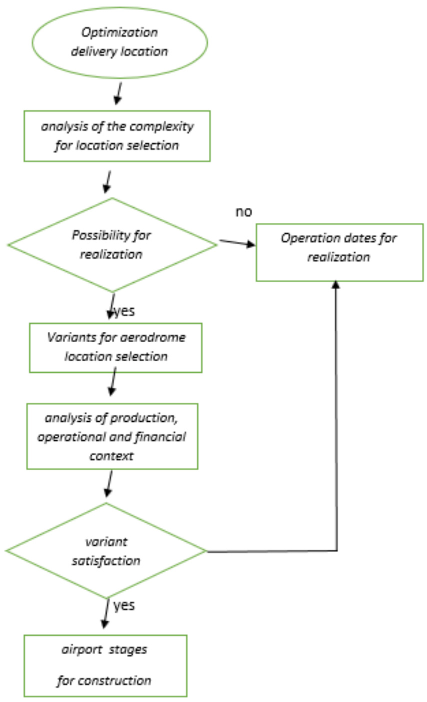

Figure 5. Diagram Potential optimized location selection
Source: author`s diagram

3.1. RESA explanation

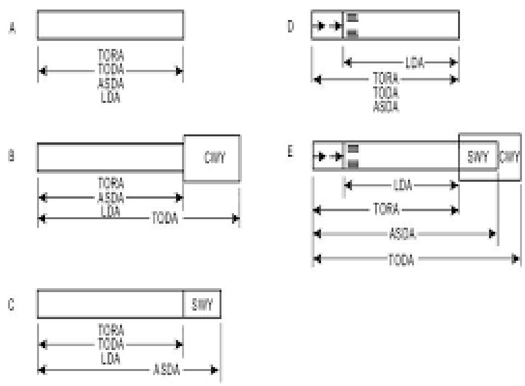

Figure 6. RESA(Runway safety end area)
Source: reference 10

Considering the Runway End Safety Areas will be elaborated the risk potential on the runway. Takeoff Run Available (TORA) – the runway length, Takeoff Distance Available (TODA) – TORA plus the clearway, Accelerate-Stop Distance Available (ASDA) –TORA plus the stopway, Landing Distance Available (LDA) distance for landing declared in ICAO, Annex 14, volume 1.

Considering that there are four risk classifications: operational risk, facility risk, aerodrome design, and third-party risk, the focus of this elaboration will be on runway risk and an optimal number of aircraft circuits.

The runway and other maneuvering and movement area can be seen depicted in **Chyba! Nenalezen zdroj odkazů.**.

The planning of the general aviation aerodrome includes the determination of the elements of the aerodrome surfaces and the areas for limiting the obstacles, the characteristics in this chapter are intended to establish safe and effective surface dimensions, the influences of the external factors, so that the aerodrome determines them. Based on the reference length of the railway line for the aerodrome of 600 m for smaller aircraft, the corrected RWY length of 840 m was calculated. The aerodrome has a rectangular shape with a size of 250 x 900 m, and the geographical reference point of the aerodrome is 41 ° 12'52.4 "N and 22 ° 29'16.9" E. The altitude of MSL at the selected most favorable location is 78 m, i.e. 255,906 ft.

In order to achieve the required length and width of the width and to comply with ICAO regulations, the following calculation shall apply:

knv = 7 x hnv : 300= 7 x 70 : 300 = 1,63
Tsa = hnv x 0,0065 °C = 70 x 0,0065 °C = 0,455
kt = Tref – Tsa = 15° – 0,455° = 14,555
kn = n x 10% = 2% x 10% = 20
D_0 = 600m
$D = D_0$ (1 + knv : 100) (1 + kt : 100) (1 + kn : 100)
$D = D_0$ (1 + 1,63 : 100) (1 + 14,555 : 100) (1 + 20 : 100)
D = 600 x (1 + 0,0163) (1 + 0,14555) (1 + 0.2)
D = 600 x 1,0163 x 1,14555 x 1,2 = 838,24 ≈ 840m

Figure 7, Aerodrome round in the area of L3 aerodrome
source: author and google maps

In this picture, this is only one plane positioned at different positions. The boundaries of the aerodrome zone shall include the airspace at the height of the GMD 4000ft AMSL defined by the access and departure lanes according to the direction of the RWY provision. Flying activities greater than 1500 m MSL must require authorization for competent air traffic control. The relative height in relation to the aerodrome according to the allowed height of the school circuit would be 300m and 250m respectively. The sailing school circuit can be east and west in relation to Gevgelija Aerodrome. The departure and arrival procedures at the aerodrome will follow the border points and outside the aerodrome zone, of which 850m MSL will start the procedure for entering the aerodrome zone. The pilots should report on 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 because the aerodrome in Gevgelija will have visual navigation. The announcement and approval of the flight will be done with the control of Skopje.

3.2. Risk Assessment of Runway Incidents

According to the M-NAV reports by the 31 of December 2020, M-Nav has implemented EUROCONTROL Communication Gateway (ECG), which replaced the previous AFTN system. ECG as a means of AMHS compliance satisfies the AFS requirements for Macedonia. Regarding ICAO requirements migration of OPMET Data Exchange of Traditional Alphanumeric Code to IWXXM, M-NAV plan to upgrade existing AFTN-AMHS switch with basic services to AFTN-AMHS with extended services with deadlines for implementation on the April of 2021. M-NAV has implemented the Eurocontrol Communication Gateway (ECG), which replaced the previous AFTN system. Related to aviation infrastructure regulations, the concepts for extended flight plan is pending the evolution of the concept. Enabling the aviation infrastructure has to be implemented in the new ATM system by the 31 of December 2021.

3.3. Accident Location Modeling

A study of the history of aerodrome incidents and accidents on Macedonian aerodromes shows that the eastern part of the state won`t have any significant problems using the given infrastructure. The largest aerodrome is Skopje International Airport and the smallest international aerodrome is the Ohrid airport. Considering the airport and en-route traffic, it is not predicted that here will be any difficulty for the new air network of the new aerodrome in the vicinity of Gevgelija. Around the runways of these two international airports, taking into consideration the new small aerodrome development can be carefully examined for risk and if necessary guided by the corresponding air traffic control. According to the evaluation in Macedonia accidents and incidents are caused by technical reasons, which means that according to the present number of air traffic and topographical conditions the factors that may cause risk is negligible.

3.4. Aerodrome in the vicinity of Gevgelija

The system of a large number of imaginary surfaces that rise and rise from the RWY baseline defines the limitations of aerodrome barriers.

The purpose of establishing restrictions on surface barriers is to ensure the highest level of air traffic safety, preventing the closure of the aerodrome due to the presence of dangerous obstacles to air traffic safety. The subject of this paper is to determine whether there is a possibility to build an aerodrome in accordance with the standards for sports and training type of aerodrome (A1) by analyzing the surface barriers.

The obstacle limitation area is determined by the maximum height of natural and man-made obstacles in the aerodrome area. According to ICAO, for non-instrumental traces of code number 1 the following boundary obstacles are required:

1. Accessible, flying surface,
2. Transitional surface
3. inner horizontal surface
4. conical surface.

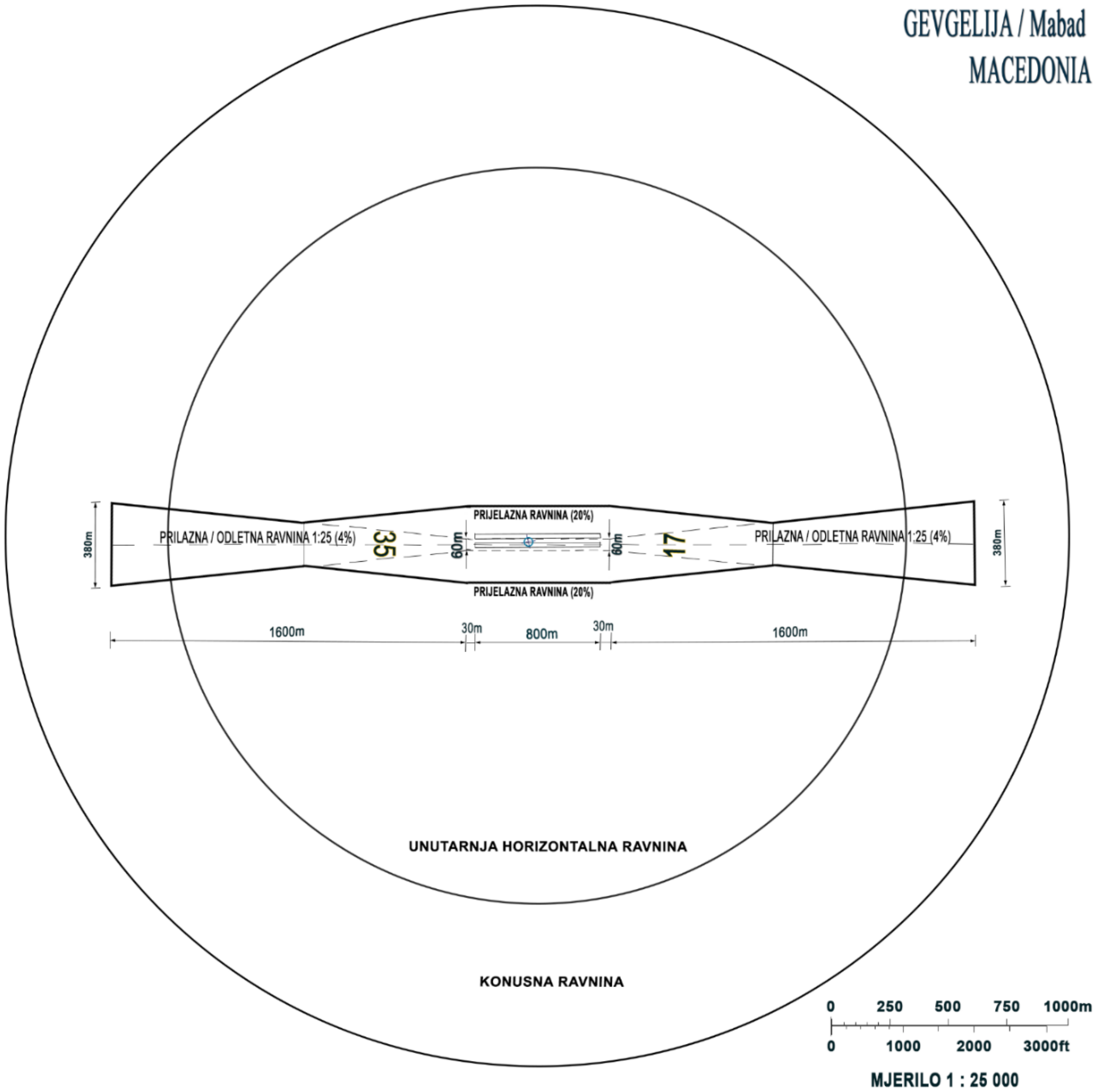

Figure 8. Imaginary surfaces around the most favorable runway location
Source: author`s picture

3.5. Process of planning for decision making

One of the basic tasks in determining the most appropriate location with the required construction category is to determine the optimal number of aircraft on the overhead network. Investment problems of this kind are very complex especially if there are a large number of aircraft in different categories, and below are models that can successfully help solve this problem. By nodes in the air transport network, we mean aerodromes that are connected by air routes. The planning and design process are strictly separate, adjusting the income and risk through procedures for dimensioning the elements of the air network. The basics of the planning process are shown below in Figure 9.

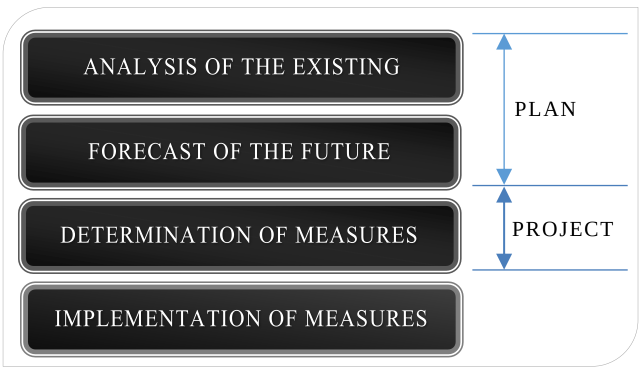

Figure 9. The basic planning process for aerodrome construction
Source: references 11

3.5.1. Criterion and multi-criterion optimization

3.5.1.1. The term Optimization

The use of the optimization method with several criteria brings a rational decision in the design and methodological support in the selection of the most favorable location and management, studying the way to achieve the optimal solutions for the maximum good or minimum bad solution of perception from the level of risk.[1]

Optimization as a complex process of making a final decision at the most favorable location will be presented in several stages of decision making:

1. Defining the goals of the aerodrome and identifying the ways to achieve the defined goals of safety and environmental protection;
2. Formal (mathematical) description of the site assessment and definition system;
3. Use of existing normative methods, which is actually optimization in a narrow sense;
4. Adoption of a final decision;
5. Changing the new information from the second step by redefining the task to reach a final solution.[2]

Knowledge of the system and measures to assess the final most favorable location is necessary for optimization in five stages:[3]

1) System formulation,
2) Development of a mathematical model,
3) Selection and application of methods and selection of algorithms,
4) Testing of the obtained solution,
5) Implementation of the best solution in real terms.[4]

3.5.1.2. Goal of the optimization

The task of optimization is to present the best alternative from a range of possibilities or favorable alternative locations based on criteria and constraints called the optimal solution to the optimization problem. The optimal solution is a compromise between desires and possibilities and the criterion is expressed by the function of a criterion for the best alternative to reach the global extreme, taking into account the limitations of achieving the goal of optimization.

3.5.1.3. Aim of the optimization

Optimization methods help in making decisions for the analyst to link all the data and relationships, and the result to enable the selection of a good optimal alternative and overcoming all the complexity. The purpose of the optimization method should be to provide good information indicating the consequences and impacts of the final solution.[5]

The mathematical model for the most favorable location was implemented in the following phases:

1. Definition of goals for runway without the potential for risk;
2. Research planning for possible risk situations;
3. Problem formulation of risk potential;
4. Creating a mathematical model for optimization;
5. Choice of solution method of the potential risk situation;
6. Programming and testing of the risk situation;
7. Data collection of potential risk;
8. Evaluation of the obtained results for the situation around the runway;
9. Implementation of the obtained results in real parameters.[6]

Basic definitions of decision theory:

→ *Definition 1.* Decision-making is a process that takes place between all available variants of solutions to a defined problem called strategy.

→ *Definition 2.* A decision is the result of a decision-making process aimed at meeting the objectives of a defined problem.

→ *Definition 3.* A decision-maker is an individual or group of people and a decision-maker is a decision-making entity and bears full responsibility for the conducted process.

The final decision does not depend on the number of alternatives and can be made even with exactly one alternative and when no choice is made between alternatives. Simpler problems require relatively simple analyzes in a relatively short time while more complex problems require the prior application of appropriate preparations and activities to the defined problem.

This concept is defined as:

→ *Definition 4.* The decision-making process is a series of interrelated and conditional activities that take place successively leading the process towards the fulfillment of the final goal, ie to justify the procedure, indicating the result to be achieved with the procedure.

The result obtained can:

— to fully achieve the set goal;
— partially achieves the set goal;
— does not achieve the set goal. [7]

Decision-making is done by analyzing the most important factors, often with requests to achieve multiple goals that are influenced by a number of factors. There are two types of decision making:

1. Scientific or rational decision-making for decision-making based on quantitative analysis using multiple data and appropriate scientific methods;

[1] Vujošević M.: „Uvod u optimizaciju”, Beograd, 2012
[2] Nikolić I., Borović S.: „Višekriterijumska optimizacija”, p 3-88, Beograd, 1996
[3] Opricović S.: „Višekriterijumska optimizacija sistema u građevinarstvu”, Beograd, 1998
[4] Opricović S.: „Višekriterijumska optimizacija sistema u građevinarstvu”, Beograd, 1998
[5] Opricović S.: „Optimizacija sistema”, Građevinski fakultet u Beogradu, Beograd, 1992
[6] Vrednovanje i odlučivanje u projektovanju saobraćajne infrastrukture,skripta, 2014, Sarajevo
[7] Vrednovanje i odlučivanje u projektovanju saobraćajne infrastrukture, 2014, Sarajevo

2. Intuitive decision-making based on experiences of bad decisions.

Scientific decision-making is divided into several phases with numerous scientific projects where the analysis of the solution and the possible correction of the solution are neglected. In reality, there are situations where the already made decision does not remain in its original form and is supplemented, amended with a decision on another problem, presented in the scheme of the decision-making process[8]:

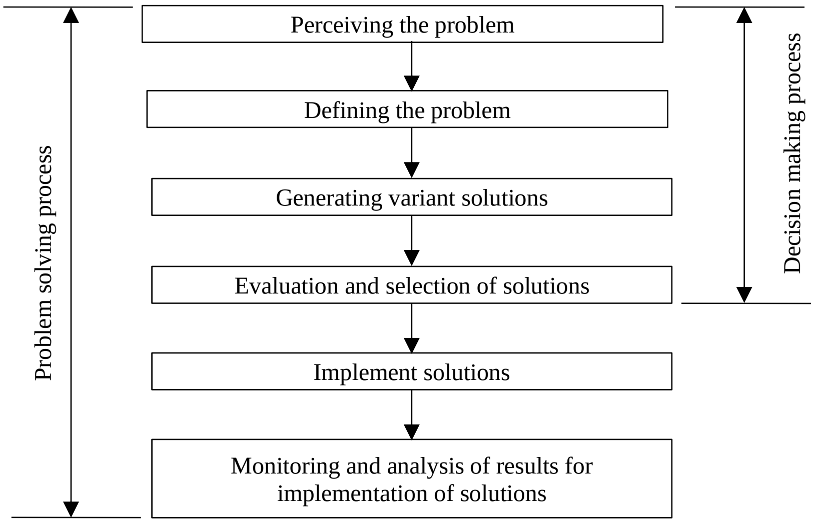

Figure 10. Diagram Flow in the decision-making process,
Source: reference 12

3.5.2. Basics of Multi-criterion optimization

Optimization covers only one part of the problem with planning or using the system in order to look at the problem from all angles and to better understand the prediction. Finding the best solution is a task of optimizing multicriteria with a high chance of being really the best in the end between different conflicting interests.

In the case of optimization with one criterion, the freedom to accept, change or reject the solution based on the mathematical model is implicitly reserved. Upgrading optimization with one criterion such as linear and nonlinear programming, game theory, dynamic programming, etc. in practice they are not applicable to very real problems between multiple alternatives with and without conflicts. The real criteria have some common features, numbers, and a variety of attributes as well as incomparable units of measurement, and the solution is to choose the best alternative from the defined alternatives. For a comprehensive and objective comparison between a number of alternatives with different relative meanings and with different requirements for minimization or maximization, it is necessary to use methods for optimization of multiple criteria. Consequently, the above-elaborated problem is reduced to determining the final ranking of alternatives.

When choosing the criteria included in the multi-criteria basis, care should be taken to obtain a comprehensive and objective picture with fewer different criteria, in accordance with the requirements of the analyst. Using multiple criteria that mean the same thing can easily turn into self-contradiction and distort the basic picture. The selection of criteria should be done through maximum selectivity and adaptation to a specific problem with great responsibility and creativity for the analyst.

The difference between single-criteria and multi-criteria models is that one target function is defined over a set of constraints, while problems in multi-criteria methods work with two or more target functions. The aim is to find optimal values for the most favorable solution in the given conditions and constraints where the probability of the best decision depends on the number of compared alternatives.[9] Depending on how and when the analyst gets involved in problem-solving, three groups of methods are distinguished:[10]

1) A posteriori approach;
2) A priori approach;
3) Interactive and cooperative approach.[11]

In the posterior approach, the analyst is involved in analyzing and solving the problem after determining the set of dominant solutions to select the best solution. Separating the set of dominant solutions from the

[8] Vrednovanje i odlučivanje u projektovanju saobraćajne infrastrukture, 2014, Sarajevo
[9] Opricović S.: „Višekriterijumska optimizacija sistema u građevinarstvu", Građevinski
[10] Vujošević M.: „Uvod u optimizaciju", Beograd, 2012
[11] Vujošević M.: „Uvod u optimizaciju", Beograd, 2012

permissible set is more of a theoretical approach than a practical one with two main reasons for this. The first is that the division into a subset of dominant solutions is an analytically often unsolvable problem for certain discrete tasks and for linear programming. Another reason is that the set of dominant solutions can be very wide so that the analyst can not easily choose a solution. In the a priori approach, the analyst should express in advance his / her attitude towards the criteria which is done by determining the priority or hierarchy of criteria, assigning weights to individual criteria, determining the relative relations between each of the two criteria, etc. Based on that, by solving the task, the analyst should propose a solution that best suits his expressed preferences. The disadvantage is that the analyst can hardly determine his attitude towards the criteria precisely from one attempt, by means of a certain mathematical model and method. He refuses to explicitly say in advance what the relationship is between the criteria, the only thing that is certain is a solution in a set of dominant solutions. By analyzing solutions for different weight groups, the analyst can identify the relationship between the criteria and the solutions at the core of the problem. The a priori approach is theoretically the most viewed and practically most often applied with developed many a priori VKO methods, which gives them great advantage for practical applications in special situations. [12]

3.5.2.1. Stages of multi-criterion optimization

The process of solving using multi-criteria optimization contains four basic stages:

I. The first stage is posing the problem - which is characterized by subjectivity in determining a set of alternatives and criteria.
II. In the second stage, importance is determined in two ways - by subjective judgment or by the use of techniques against subjectivism.
III. The third phase includes the selection of an adequate method of optimization of multiple criteria with the possibility of using experience in solving similar problems as well as the possibility of using professional systems with embedded databases with recommendations of the method of optimization of multiple criteria of a specific problem.
IV. The fourth stage in multi-criteria optimization is the study of the stability of the solution or the selected range of alternatives or subgroup of alternatives for changing input data. The stability of solutions to changes in the relative weight of criteria as a representative of subjectivism in multi-criteria optimization should be studied.[13]

Criteria are characteristics of alternatives that are relevant to the specific decision choice, as opposed to pre-defined alternatives. Their choice is subjective because the set of attributes reflects the individual attitude of the specific goals for defining a decision. The sets of criteria are different and they differ in number, content, and importance. The selection of criteria is a very important stage of decision-making with multiple criteria in which the order of realization of the set goals is decided with a complete and exclusive list of criteria. The completeness of the list implies the inclusion of all aspects of the problem, by performing a list of all sub-objectives for the realization of the main goal. The exclusivity of the criteria to be formulated so that there will be no overlap of their content is important because the doubling in the process of evaluating the alternatives causes a greater impact than the real one.[14]

3.5.2.2. Mathematical model for multi-criteria decision making

The decision model with several criteria is presented with a mathematical formulation:

$$Max\{f_1(x), f_2(x), \dots, f_m(x)\}, \qquad m \geq 2,$$
$$x \in A = [a_1, a_2, \dots, a_n],$$

where:
m – number of criteria (attributes), j =1,2,...,m ,
n – number of alternative (action), i =1,2,...,n ,
f_j - criteria (attributes), j =1,2,...,m ,
a_i - alternatives (action) for reflection, i =1,2,...,n ,
A – sum of all alternatives (action).[15]

For known values f_{ij} each criterion f_j obtained from possible alternatives a_i :

$$f_{ij} = f_j(a_i), \forall(i,j), \quad i = 1,2,\dots,n; \quad j = 1,2,\dots,m$$

Each attribute provides a means of estimating the level of a criterion, and most attributes characterize each action (alternative) and they are selected based on the criteria.[16]

The VKO model is represented by a decision matrix of criterion values for individual alternatives:[17]

$$\begin{pmatrix} a_1 \\ \cdots \\ a_n \end{pmatrix} = \begin{pmatrix} f_{11} & \cdots & f_{1m} \\ \vdots & \ddots & \cdots \\ f_{n1} & \cdots & f_{nm} \end{pmatrix}$$

On a certain notion and relations for VKO models:[18]

- Alternative a_s is dominant over the other alternatives if it is

$$f_j(a_s) \geq f_j(a_k) \; \forall_j = 1,2,\dots,m \qquad и \quad \forall k = 1,2,\dots,n; \quad s \neq к$$

[12] Vujošević M.: „Uvod u optimizaciju", Beograd, 2012
[13] Nikolić I., Borović S.: „Višekriterijumska optimizacija", p 3-88, Beograd, 1996
[14] Nikolić I., Borović S.: „Višekriterijumska optimizacija", p 3-88, Beograd, 1996
[15] Nikolić I., Borović S.: „Višekriterijumska optimizacija", p 3-88, Beograd, 1996
[16] Nikolić I., Borović S.: „Višekriterijumska optimizacija", p 3-88, Beograd, 1996
[17] Nikolić I., Borović S.: „Višekriterijumska optimizacija", p 3-88, Beograd, 1996
[18] Nikolić I., Borović S.: „Višekriterijumska optimizacija", p 3-88, Beograd, 1996

where the alternative a_s is better by one criterion than all the others and by no other criterion is it worse.

If there is a dominant action, then there is an optimal - a solution to the VKO model and the problem with multiple criteria decision-making does not arise for the choice of an alternative. Problems usually do not have a dominant alternative, ie. even when it exists, a request for further and more complex analysis can be made. An alternative may dominate one or more but not all of the alternatives considered. [19]

- Alternative a_q is an effective alternative if it is not dominated by any other and if there is no other a_v to which it applies:

$$f_j(a_v) \geq f_j(a_q)\ \forall_j = 1,2,\dots,m \quad и \quad \forall_v = 1,2,\dots,n; \quad v \neq q$$

or

$$f_j(a_v) \geq f_j(a_q) \quad for\ at\ least\ one\ j$$

Alternative a_q is such that there is no other a_v that is better by at least one and at the same time a_v is not bad by any of the remaining criteria, or, the effective alternative has a better value for one criterion only if the value of at least one deteriorates, ie incomparable in terms of dominance. Alternatives a_t and a_v are equivalent if they have the same values for all criteria:[20]

$$f_j(a_t) = f_j(a_v)\ \forall_j = 1,2,\dots,m$$

- Alternative a_r is ineffective or dominates if it is dominated by at least one of the sum of the remaining alternatives:

$$f_j(a_v) \geq f_j(a_r)\forall_j = 1,2,\dots,m$$

or

$$f_j(a_v) \geq f_j(a_r) \quad for\ at\ least\ one\ j$$

By choosing only one alternative, it is necessary to reduce the model by retaining one of the equivalent alternatives and omitting all ineffective alternatives in order to define a solution with multiple criteria. One possible definition is that the solution is the sum of all effective activities - incomparable alternatives in the sense that no one dominates over another that has no practical value because the sum of all effective activities is a model of multi-criteria decision making. [21]

3.5.2.3. Multi-criterion optimization methods

Forming a mathematical model for a real problem takes into account several goals that are being developed in the field of multicriteria optimization (VKO). The reason that VKO problems are different in nature from problems with a single criterion is that all the factors that influence the decision are seen as criteria whose values should be optimal. The optimal solution is the one that is best according to all the criteria considered at the same time partially or completely in conflict with each other in decision making.

Methods for analyzing multiple criteria in a conceptual sense are not particularly complex, which is absurd to be easier to understand in classical single-criterion optimization. It is characteristic that they were developed in the period of rapid development of the spread of information technologies based on computerization.

Multi-criteria optimization methods are classified into five groups:[22]

1. Methods for determining non-inferior solutions in the set and it remains for the analyst to make the final decision as a set of methods includes:
   - → weight coefficients,
   - → limitation in the space of the criterion functions,
   - → Multi-criteria *Simplex method*.
2. Methods with a predefined preference for forming a synthetic criterion function, for solving how single-criterion methods are:
   - → PROMETHEE,
   - → Targeted programming,
   - → ELECTRA,
   - → Value exchange method.
3. Interactive methods in which the decision-maker specifically expresses his choice by interactive use of methods include:
   - → Method STEM,
   - → Method SEMOPS.
4. Stochastic methods as indicators of uncertainty in the optimization model with a representative PROTRADE.
5. Methods of non-inferior solutions for narrowing the set by introducing additional elements in the decision-making process.[23,24]

4. Results and Discussion

The lack of this assessment is that the aerodrome in the vicinity of Gevgelija is a plan and all this elaboration is part of the risk sensitivity analysis necessary for the construction. Elaboration of the actual air traffic in the country is taken for category confirmation necessary for risk assessment.

The presented data are from the EU official page and data from the LSSIP assessment for the Republic of

[19] Nikolić I., Borović S.: „Višekriterijumska optimizacija", p 3-88, Beograd, 1996
[20] Nikolić I., Borović S.: „Višekriterijumska optimizacija", p 3-88, Beograd, 1996
[21] Nikolić I., Borović S.: „Višekriterijumska optimizacija", p 3-88, Beograd, 1996
[22] Nikolić I., Borović S.: „Višekriterijumska optimizacija", p 3-88, Beograd, 1996
[23] Vujošević M.: „Uvod u optimizaciju", Beograd, 2012
[24] Opricović S.: „Višekriterijumska optimizacija sistema u građevinarstvu", Građevinski

North Macedonia with the presentation for air traffic on a national level. The risk that causes accidents and incidents during the defined period of time is caused by technical reasons but not by runway problems. The lack of information about some of the accidents and incidents has made it difficult in this research to predict the risk in the new aerodrome construction. A total presentation of air traffic presentation has been collected and classified according to the public published data.

SAW method for decision making of the most favorable location for development

This section discusses the problem of choosing the most favorable location for a sports aerodrome near the city of Gevgelija. In the higher criterion decision for location selection, the SAW method is used, after which a complete ranking of the obtained alternatives is performed, an analysis of the obtained results is performed on the basis of which a decision is made for the most favorable location for a sports aerodrome. Emphasis is placed on basic theoretical assumptions about the problem of site location with special emphasis on the characteristics of the process. The results show that SAW can be used very successfully in solving cost-benefit analysis problems.

The name SAW is an abbreviation of English "Simple Additive Weighting". It is one of the most well-known and most commonly used methods in the problem of higher criteria decisions. for which individual variants Vi are taken according to individual criteria (values of base matrices D). Dimensional elements

The normalized matrix R is obtained as follows:

→ for criteria "benefit" relation

$\boldsymbol{r_{ij}} = x_{ij}/X_{jmax}$

→ for criteria "costs" relation

$\boldsymbol{r_{ii}} = X_{jmax}/X_{ij}$

where i is the variant designation and j is the criteria designation.

The total number of points for individual variants is obtained by multiplying the values of the normalized matrix (R), where the particular variants are taken by the individual criteria, by the weight values of the corresponding criteria, and thus the WJ products obtained by the individual variants. they gather together. The end result is a calculated sum of the variants and the best variant is the one with the largest final sum in the matrix.

Selection of the most favorable variant of location for sports aerodrome from the city of Gevgelija to the village Prdejci 3 locations for the aerodrome are analyzed: V1; V2; i V3, according to the following criteria:

X$_1$ - *L* -length of the runway (m) (-)

X$_2$ - *LT* -criterion of total construction costs and operating costs reduced for the first year (10^6) (-)

X$_3$ – *ISR* – internal rate of return (%) (+)

X$_4$ –spatial / urban and ecological aspect (points) (+)

BASE MATRIX **(D)** - the values taken by individual variants according to individual criteria are given in the following table:

Table 1

Base matrix 1

LOCATION	**CRITERION**			
	X_1 (-)	X_2 (-)	X_3 (+)	X_4 (+)
L1	872	59 *10^6	10.60	92.40
L2	809	57 *10^6	13.39	97.60
L3	840	55 *10^6	13.30	99.30

Source: the authors

elements (r_{ij}) – the dimensionless matrix (R) are given in the following table:

Table 2

Base matrix 2

LOCATION	**CRITERION**			
	X1 *(-)*	X2 *(-)*	X3 *(+)*	*M* *(+)*
L1	0.9277	0.9322	0.7916	*0.9305*
L2	1.00	0.9649	1.00	*0.9828*
L3	*0.9631*	*1.00*	*0.9932*	*1.00*

Source: the authors

Weights are given (Wj) according to individual criteria:

W_1=0.15 W_2=0.30 W_3=0.35 W_4=0.20

(*L* Wj = 1 – the weights are determined by the ranking method).

The calculated average values for the variants are:

*LJ=i*r1j · *Wj* = 0.9277 · 0.15 + 0.9322 · 0.30 + 0.7916 · 0.35 + 0.9305 · 0.20 =0.8819 · 100%=88%

L]=i r2j · *Wj*= 1.00 ·0.15 + 0.9649 · 0.30 + 1.00 · 0.35 + 0.9828 · 0.20 = 0.9860 ·100%= 98%

L]=i r3j · *Wj* = 0.9631 · 0.15 +1 · 0.30+0.9932 · 0.35 +1.00 · 0.20 =0.9920 ·100%= 99%

Based on the obtained results, the best variant is L3 0.9950, and the relative order of the diluted variants is:

I L_1 88% **II** L_2 98% **III** L_3 99%

Methods are being developed for the analysis of multiple criteria applied in order to enable the greatest possible, creatively active, systematic involvement of decision-makers in the process of making optimal decisions. Using a multi-criteria analysis method for reliable results facilitates the work and saves time.

The SAW group of methods is one of the most widely used methods in multiple decision criteria. The project presents the basic theories illustrated in case of a problem with location selection. Based on the set goal of the work and defined research content, as well as on the basis of processed literary data, it is possible to conclude that the analysis of multiple criteria can be successfully applied in solving the problem of site selection.

Using the Net Present Value Method and determining profitability rates, compare the two projects with the input data given in the following table. The exploitation period is 8 years, and the discount rate is 0.12.
Solution:

The discount factors, as well as the SVT and SVP amounts for both projects, are the easiest to calculate in a table, which in this example is done and presented in the following table. We are starting from L3 according to the meteorological, topographical, and navigational conditions.

1/t = -(1 *)t* – дисконтна стапка

r = 0,12 – discount rate
l+r

Table 3

SVT calculations for the locations

God.	L3			L2			L1			*T/t*	L3		L2		L1	
	To	Ti	Pi	To	Ti	Pi	To	Ti	Pi		*Tt . T/t*	*Pt · T/t*	*Tt . T/t*	*Pt · T/t*	*Tt . T/t*	*Pt · T/t*
0	57	-	-	59			55	-	-	1,00000	57		59	-	55	-
1		35	39		30	37		27	40	0,89286	31.2501	34.82154	26.7858	33,04	24.10722	35.7144
2		37	42		40	40		39	47	0,79719	29.49603	33.48198	31.8876	35,87	31.09041	37.46793
3		40	47		45	43		44	52	0,71178	28.4712	31.31832	32.0301	37,72	31.31832	37.01256
4		42	50		50	45		40	57	0,63552	26.69184	31.776	31.776	39,40	25.4208	36.22464
5		49	52		55	49		54	60	0,56743	27.80407	30.64122	31.20865	40,48	30.64122	34.0458
											200.71324	162.03906	212.68815		197.57797	180.46533
											SVT L3	**SVT L3**	**SVT L2**	**SVP L2**	**SVTL1**	**SVPL1**

Source: the authors

SV L3 = 200.71324- 162.03906= 38.67418 EUR
NSV_8 = 18,10 EUR (NJ)
We will now determine the profitability rates:
200.71324 : 162.03906 = 1.23862 is the profitability rate for the L3

212.68815 : 186.510= 1.14036 is the probability rate for the L2

197.57797 : 180.46533= 1.094825 is the probability rate for the L1

Since all three coefficients for location L3 are more favorable, so project L3 itself is the most favorable because for the L1 and L2 construction according to the estimated values, years will need extra financing to appropriate development. In 5 years, the project paid off.

Project profitability assessment based on the following data:

To= 38 674 180 euro
D = 40 - 20 = 20 euro
n = 5 years
R= 0 and r=0,12

In this example:

$$a_\tau = T_0 \frac{r\,(1+r)^n}{r\,(1+r)^n - 1} = 1$$

38 674 180 * (0.21148100198 : 0.7623416832) = 29482939.4776 = 29,5 *10^6 EUR

4.2. Accident Probability Model

Due to the lack of a suitable database for aerodrome in the vicinity of the aerodrome in Gevgelija, it is not possible to build a model for the probability of risk actions that may be performed on the planned runway. Therefore, the studied two international aerodromes is analyzed based on the national statistical data for air traffic.

4.3. Risk Assessment of Gevgelija aerodrome because of the terrain

According to the topographical representation, there is no risk of the terrain, illustrated with the 3d animation around the planned most favorable location. The simulation has been made using „Mapbox“. The main task is to illustrate the aerodrome circuit around the planned location and at the same time to prove that there is no obstacle around the runway that may cause increased risk.

4.4. List of the recommended aircraft suitable for the planned runway

Table 4

Aircraft with a shorter length of USS for take-off and landing

								RWY (м)	**USS (м)**

AIRCRAFT ICAO TYPE	AIRCRAFT WEIGHT (KG)	NUMBER OF PASSENGERS	LENGTH (M)	WING SPAN (M)	HEIGHT (M)	UNDERCARRIAGE WHEELS DISTANCE (M)	WIDTH OF MAIN UNDERCARRIAGE (M)	TAKE OFF FROM 50FT	LANDING FROM 50FT
AN74	34 500	40	28,07	31,89	8,75			STOL perf.	
AP 68 TP 600	2 850	9	10,85	12,00	3,64	3,51	2,17	460	500
BN 2 B	2 993	9	10,86	14,94	4,18	3,99	3,61	371	299
CASA212-300	7 700	28	16,20	20,28	6,30	5,55	3,10	782	519
CESSNA 188								296	386
CL 215 T	19 868	26	19,82	28,60	8,98	7,23	5,28	703	768
CN 235	14 400	44	21,35	25,81	8,18	6,90	3,90	687	585
DH 6 300	5 670	20	15,77	19,81	5,94	4,53	3,70	360	457
DH 7 100	19 958	50	24,54	28,35	7,98	8,38	7,16	688	594
DO 228 200	5 700	19	16,56	16,97	4,86	6,29	3,30	750	620
HARBIN Y 1211	5 300	17	14,86	17,23	5,57	4,70	3,60	425	500
LET L 410 UVP E	6 400	19	14,40	19,98	5,83	3,67	3,65	686	480
NAL ASUKA	38 700		33,15	30,60	10,17	9,33	4,40	STOL perf.	
PIPER PA 23								427	419
PZL AN 28	6 500	17	13,10	22,00	4,90	4,35	3,40	360	315
SKYTRADER SCOUT	4 536	16	12,80	16,80	5,80			305	290
SKYTRADER 1 400	5 896	19	14,90	16,80	5,80			466	165

Source: the …

The evaluation of the listed aircraft can be used on the runway as shown in the table above. After setting the risk possibilities it is possible to make decisions and budget estimations for the next development and further categories for development. For example, the acceptable risk at the aerodrome at the planned location may be the mountain terrain by the southwest side, but only when inappropriate navigation calculations will be made. The risk of the runway surface will be eliminated because the surface will be made by constructive pavement and according to the ICAO recommendations. Therefore, the models presented in this paper are an illustration where the number of aircraft taking off/landing is optimized and set according to the optimized model. The circuit model around the runway is a good criterion for evaluating the obstacles around the runway generally to prevent unprofessional, unsafe, and uneconomical decisions made by the pilots in a lack of aerodrome control during visual conditions. These risk assessment models improve the performance of the air transportation system in the Republic of North Macedonia, considered by safety and economic evaluation of the planned aerodrome. In other words, this model helps engineers for making optimal decisions keeping in mind the safety and economic situation. The models presented helped to eliminate the permanent lack of a proper risk on the runway necessary for further evaluations at Macedonian aerodromes or any aerodromes with evaluations like this one.

5. Conclusions

The aerodrome runway as the main physical part represents the head of the imaginary body infrastructure influences the category reduction damaging human lives and the environment. Therefore, designing safer runways of the planned aerodrome in the vicinity of Gevgelija includes the known possibilities for expected and unexpected risk. The primary goal of this article evaluation is to achieve a risk assessment model of RSA established only in the United States for assessing the risk of accidents and incidents resulting from the aerodrome operation on the maneuvering area.

Examining predictive models of the probability of occurrence, location, and consequences with obstacles, with lack of documentation, access and no suitable database for the planned location led to the inability to build a model of the probability of risk. In the location and consequences models, the model presented in a manner as the model presented for Iran, calibrated for Macedonia allows the runway risk assessment to be done more accurately. The risk of obstacles around the Gevgelija runway using the model for a presentation led to the decision about them based on the level of risk and location. The new aerodrome location can also be a factor of the least risk in the event of aircraft circuit what is very important because it can have a significant impact on the continuity of aerodrome services helping the increase public health and protecting the environment.

The most important limitation was the lack of access to flight data because this aerodrome is just a plan with suggestions for designing and setting up an accurate system for recording all the necessary information. The model of the probability of risk can be calibrated for Macedonia compared with Iran with a belief by the authors that the elaborated required category such as A1 for the aerodrome in Gevgelija in future studies can help make models and make them more comprehensive according to the sustainable development goals.

Thanks to the Economic Faculty of Zagreb for using the library for writing and using the literature to increase the quality of my second article with impact factor. Thanks to the ICAO seminar for the green aerodrome to point the main purpose of the environmental impact. I thank my co-authors for advising me in all phases of doing this article. Thanks to my parents for full support in doing my second article with the impact factor.

Conflicts of Interest

The authors declare no conflict of interest.

REFERENCES

1. https://www.icao.int/safety/afiplan/Documents/Safety%20Management/2008/SMS%20Workshop/Modules/ICAO%20SMS%20Module%20N%C2%B0%205%20%E2%80%93%20Risks%202008-11%20(E).pdf
2. https://www.icao.int/nacc/documents/meetings/2015/grepecaspf2/grpecasf2-p09.pdf
3. https://skybrary.aero/articles/risk-assessment-incidents-and-atm-specific-occurrences
4. https://skybrary.aero/articles/risk-analysis-tool-rat
5. https://skybrary.aero/articles/regulation-3902013-performance-scheme-air-navigation-services-and-network-functions
6. https://www.slideserve.com/amir-burgess/module-n-5-risks
7. https://favpng.com/png_view/health-swiss-cheese-model-health-care-accident-png/r5duiV6u
8. https://www.eurocontrol.int/sites/default/files/2020-03/eurocontrol-lssip-2019-north-macedonia-level1.pdf
9. https://www.eurocontrol.int/publication/esarr-4-risk-assessment-and-mitigation-atm
10. https://www.icao.int/nacc/documents/meetings/2015/grepecaspf2/grpecasf2-p09.pdf
11. https://www.projectmanager.com/project-planning
12. Vrednovanje i odlučivanje u projektovanju saobraćajne infrastrukture, 2014, Sarajevo
13. https://online.hbs.edu/blog/post/how-to-calculate-roi-for-a-project
14. Vujošević M.: „Uvod u optimizaciju", Beograd, 2012
15. Opricović S.: „Višekriterijumska optimizacija sistema u građevinarstvu", Građevinski Fakultet
16. Nikolić I., Borović S.: „Višekriterijumska optimizacija", p 3-88, Beograd, 1996

Authors' biographies

Ana Lazarovska was born at Gevgelija, Macedonia. She is doing her Ph.D. thesis in Aviation Engineering Management at the University of St Kliment Ohridski Bitola, Faculty of Technical Sciences. Her first circle of education is finished at the Faculty of Transport and Traffic Sciences in Zagreb, the second circle of education at the Faculty of Traffic and Communications, and currently, is a student at the Faculty of Technical Sciences in Bitola. Ana Lazarovska's field of interest includes the following: mathematics, air traffic control, navigation, and aerodromes.

Verica Dancevska is a full professor at the Faculty of Technical Sciences, University St Kliment Ohridski Bitola. She did her Ph.D. thesis in Transport Economics at the Faculty of Technical Sciences and, University St Kliment Ohridski Bitola. Her research interests are in the domain of transport economics, traffic psychology, basics of marketing. She has taught courses at all study levels (B.Sc., M.Sc., and Ph.D.).

Violeta Manevska is a full professor at the Faculty of Information and Communication Technologies, St. Kliment Ohridski University in Bitola. She did her Ph.D. thesis in Mathematics and Informatics Management at the Faculty of Natural Sciences and MathematicsTechnical Sciences, University of Ss. Cyril and Methodius University in Skopje. Her research interests are in the domain of applied statistics and probability, and theoretical computer science. She has taught courses at all study levels (B.Sc., M.Sc., and Ph.D.).

